169 | DECEMBER 1975

COMMISSION OF THE EUROPEAN COMMUNITIES

INTERNAL INFORMATION on AGRICULTURE

The production of fruits and vegetables meeting taste-quality standards

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DIRECTORATE-GENERAL FOR AGRICULTURE

Directorate for Agricultural Economics – Division «Balance-sheets, Studies, Statistical Information»

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The production of fruits and vegetables meeting taste-quality standards

F O R E W O R D

The present study has been carried out within the framework of the study-programme of the Directorate-General for Agriculture, Commission of the European Communities, by

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Original : French

INTRODUCTION

The main feature of the changed pattern of consumer demand for fresh fruit and vegetables in Europe in the years following the end of the second World War was a considerable increase in consumption per capita, reflecting the upward movement of incomes. This seemed to indicate a high level of income elasticity of demand for these products.

The overall increase in consumption involved a certain number of product substitutions, with a tendency to move up the scale of quality. Thus, potatoes first took over from the more traditional root vegetables, and then it was the turn of potatoes and dried vegetables to be replaced by green vegetables.

By 1965-70, however, it was evident that overall demand for fresh fruit and vegetables was tending to level off, and this development has been followed in the past few years by a marked fall in average consumption per head of population. It can thus be assumed that after a period of quantitative expansion this sector of the food market has entered a far more quality-conscious phase in which consumers will attach greater priority to the nutritional and organoleptic properties of the produce under study.

Furthermore, the new pattern of distribution, with supermarkets taking an increased share in total sales, is changing the consumer/product relationship at the moment of purchase. The trend is towards consumer decisions based on a reference number or a distinctive trade mark rather than on the sort of personal judgment which is becoming increasingly difficult to make.

This report is an attempt to collate the available information on the objective parameters for defining the organoleptic properties of these products so as to make them known to consumers by means of an identification mark or an informative label, and to put forward general conclusions that are valid for all the Member Countries of the European Community.

The report also contains comprehensive information about the effects of environmental factors, cultural techniques and methods of storage and marketing insofar as they affect the production of top quality fruit and vegetables and the preservation of that quality after harvesting.

The study was undertaken as part of the programme of the Directorate-General for Agriculture of the Commission of the European Communities. The author, Monsieur Jean THIAULT, is Chief Agronomic Engineer at the Centre Technique du Génie Rural des Eaux et des Forêts (which falls under the aegis of the French Ministry of Agriculture) at Aix-en-Provence.

The work was coordinated by the Division responsible for statistics, balance sheets and general studies. Among the other DGA divisions which participated in the work was the Environment and Consumer Protection Service.

Use was made of a wide bibliography. To avoid overburdening the text, the names of authors have not been quoted ; each reference is given only by number, in the order in which it is listed in the bibliography annexed to the report.

The author extends his thanks to all those who have kindly replied to his requests for information, as well as those persons who have suggested modifications or additions to various parts of the text.

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TABLE OF CONTENTS

Le créateur, en obligeant l'homme à manger pour vivre, l'y invite par l'appétit et l'en récompense par le plaisir.(+)

BRILLAT-SAVARIN (1)

1 - THE DIFFERENT ASPECTS OF QUALITY

The concept of quality of fruit and vegetables is rather complex and unclear in the minds of consumers. They may even interpret the term quite differently from those who are professionally involved in the commercial network.

For wholesalers and retailers the essential factor is the avoidance of losses during transport and storage, to the extent that the professionals sometimes consider the keeping quality of the produce in the course of distribution to be the most crucial criterion of all. But they also need a ready market, and this means the produce must be attractive in appearance and well adapted to consumer preferences.

For the consumers, the essential factor is one of attraction, but the degree of this attraction and its exact form can vary considerably from individual to individual, for psychological and cultural reasons.

(+) The Creator, by making man eat to live,
invites him to do so with appetite and rewards him with pleasure.

Larousse Gastronomique

The three main elements of consumer motivation may be listed as follows :

- gastronomic satisfaction, derived by the individual from eating the product ;
- concern for nutrition, depending on the degree of familiarity with nutritional values, at an individual or family level, leading the consumer to seek out a given product for the nutrients it can provide ;
- attribution of a symbolic value to the natural fresh produce, which ensures an element of contact with nature and also provides an opportunity for that pleasure of giving and sharing which is so much a feature of human relations.

Thus, the housewife will pick out top quality fruit to please the household, in the hope that pleasure gained from eating it will measure up to the initial appeal it may have exercised.

One or other of these different motives may override the others when the decision is made to buy the product, but they nevertheless remain bound up with each other in a rather complex fashion. Their effects can be more easily analyzed if a distinction is made between three main types of product qualities : (x)

- commercial qualities
- nutritional qualites
- organoleptic qualities

1.1 : COMMERCIAL QUALITIES

The criteria of quality to which the commercial operators pay most attention are mainly related to the external appearance of the product.

Appearance can assume a symbolic value, conjuring up the idea of freshness associated with the natural product, and the colour may be reminiscent of sunshine ; but appearance also consists in a whole collection of signs which the consumer believs will help him to discern the intrinsic qualities of the product.

It is not enough, therefore, for the product to the attractive : it has to retain its attraction, unimpaired, in the course of the different stages of distribution.

For this reason, the ability to withstand transportation and storage should therefore stand high in the list of commercial quality criteria.

(x) N.B. The term "quality" is intended to designate a certain state of the fruit or vegetable, the target condition, which is expressed in the properties of the product, while the term "criteria" refers to the various yardsticks by which quality can be measured.

1.11 : Appearance and presentation

The external appearance of the product can be taken as the first criterion of quality. It is the basic element of the product standardizations which have been harmonized by OECD and the Economic Commission for Europe in Geneva, and has also served as the basis for the Regulations laid down by the European Economic Community.

This standardization consists primarily in a language code to facilitate economic transactions in a European context while still protecting the consumer against fraudulent names or methods of presentation.

These standards, which have been set down in detail for each of the main types of fruit and vegetables grown in the European Community, fall under three headings :

- Criteria of elimination, which serve to protect the consumer against serious quality defects, which are likely either to entail heavy losses of the product in the course of distribution or to be harmful to health.

That is why the EEC norms require the product to be intact, sound and clean (i.e. practically free from visible extraneous matter), free from excess external moisture and foreign smell and/or taste and sufficiently developed and sufficiently ripe to meet commercial requirements.

- Criteria of classification and identification, ensuring the presentation of these productsin a hierarchy of classes : Extra, Class I, Class II and in certain cases Class III.

These standards are based, essentially, on shape and on colour, and on the possible presence of certain defects which are not likely to have a serious effect on the intrinsic quality of the product or to jeopardize its keeping quality.

- Sizing norms, which allow the introduction of a subdivision into each class, so as to guarantee the homogeneity of the product in a given package.

A minimum size is fixed for each class.

All these criteria are codified in the precise description which must appear on the outside of each package.

In addition to these quality requirements, which may be considered as the minima, various additional demands are often made by the primary buyers, wholesalers or retailers who wish to come as close as possible to meeting their customers' individual requirements.

Thus, in the case of various fruits and vegetables, it is often claimed that preferences for different shapes, colours and varieties are peculiar to the consumers in a specific region.

The objectivity of such assumptions is open to some doubt. Thus, although the inhabitants of northern Europe certainly have a higher preference for acidity in fruit than do those of southern Europe, and although they consider greenness to be indicative of such acidity, the various attempts at objective measurement of these parameters have revealed that the commercial operators tended to exaggerate their importance whenever quality in distribution could be more easily maintained as a consequence.

Consumers commonly become accustomed, as a result, to certain types of produce, and it is difficult to distinguish between the part played by the real preferences of the consumer and the part played by habits that are more or less imposed by the commercial operators when the range of produce offered for sale does not provide a particularly wide choice.

However, when fruit or vegetables are in glut, some of the demands made by the commercial operators reflect the desire to apply more rigorous parameters to the selection of horticultural produce.

Thus, the splitting of the stone to which certain early varieties of peach are susceptible in certain years can constitute a criterion of elimination that is more strictly applied by the trade than is required by the Community norm.

1.12 : Ability to withstand transportation and storage

The commercial operators (despatchers, wholesalers, retailers, etc.) place these two qualities at the head of the list of desirable qualities in fruit and vegetables.

This preoccupation with ability to withstand transportation and with keeping quality reflects the increaing importance of the appearance of fruit and vegetables and of their commercial qualities.

There is evidence of a changing pattern of distribution, with operators being increasingly obliged to gain access to markets located at ever greater distances from the farm. There is also a need to comply with the statutory norms and to extend the season of the varieties which appear to be satisfactory in and accepted by the market.

In practice, this development has affected production in two different ways : it has influenced the choice of varieties and it has also changed the dates of picking :

1) The choice of variety is almost entirely dictated by commercial considerations, so that consumers are offered a diminishing number of the varieties which can best withstand transportation and which also keep particularly well.

   A host of examples spring to mind. We shall examine two of the most typical cases. In the Manche department of France, until a few years ago, the growing of carrots was based on varieties that had been selected for the tenderness and fine quality of their flesh and for the excellence of their flavour.

   When a certain number of mechanical washing facilities were installed, the result was a rapid change in the varieties grown, with increasing emphasis on varieties with a rather lignified central cylinder, of a type whose roots could be washed without breaking. Needless to say, the change has meant a deterioration in the cooking and eating qualities of this vegetable.

   Peaches are another example. Following a period of preference for the yellow-fleshed varieties, which are not only firmer than the more aromatic white-fleshed varieties but also tend to be ready for harvesting at an earlier date, the present generation of new varieties is tending to bear fruit which is even firmer than the varieties favoured over the past decade and a half. Firmness would seem to be the main quality that hybridizers are looking for, together with external colouring, with no consideration whatsoever for the organoleptic properties of the fruit.

2) The trend towards far earlier harvesting, accompanied by various moves to rationalize the process has been imposed by the buyers :

Fruit is thus picked increasingly in advance of the date of physiological maturity, with an eye on the duration of storage or transport. Unfortunately, at his stage, the fruit has not usually reached the optimum stage of development of its various organoleptic properties.

Furthermore, at the level of the grower, there is a trend towards harvesting the entire crop in a single operation, at a date which meets the most stringent requirements of the market and of the distribution chain.

In France, for example, the picking of Golden Delicious apples is tending to become increasingly concentrated at a stage when the apples are still very green, to meet the requirements of importers in nothern Europe, in spite of the fact that exports to that area do not constitute the whole of the market.

As a result, most of the crop is insufficiently ripe when picked, and quality is less uniform.

The deterioration that can result from fungal attacks or physical breakdown during transportation, entailing losses which the market operators are increasingly reluctant to bear in current market conditions, has strengthened their preference for varieties that are particularly resistant, so that less attention has been paid to other characteristics.

Thus, there has been an increasing tendency to abandon the high-quality varieties and to concentrate on growing those that keep well.

Another way of reducing the losses that can result from fungal attacks or physiological deterioration is to treat the fruit with chemical products, either by spraying on the tree or by immersion after picking.

We shall give further consideration to this aspect at a later stage in this report, and will show how such treatments can alter the organoleptic properties of the fruit or leave residues which consumers are increasingly unwilling to tolerate.

Last not least, the virus diseases which affect most varities of fruit can render them more susceptible to the deterioration referred to. Quite apart from the physical deformities they may cause in the fruit, some of these virus diseases can raise the rate of contamination by fungal diseases to a far higher level than would occur in fruit from healthy trees. This is particularly true of certain virus diseases of the peach which can lead to the development of cracks across the suture line through which the fruit can be invaded by various fungi (2).

1.13 : Economic consequences

It is therefore the current commercial practice to give a substantial mark-up to fruit and vegetables on the basis of external appearance, which depends on the characteristics of the individual variety, the type of packaging, the method of display and the keeping quality of the product in relation to the conditions of transport.

Very marked differences in price can thus be observed, depending on the class into which the product falls and on the factor of size.

These differences are made even greater by the factors of packaging and display.

• Price differences between classes

The official quotations on the different markets of the European Community reveal an average price difference of 8-15 % between one class of produce and the next in the hierarchy when both classes are displayed in identical conditions.

This is clearly illustrated by graphs 1 and 2 (opposite), showing the trend of apple and pear prices on the Rungis (Paris) market during the 1972/73/74 seasons.

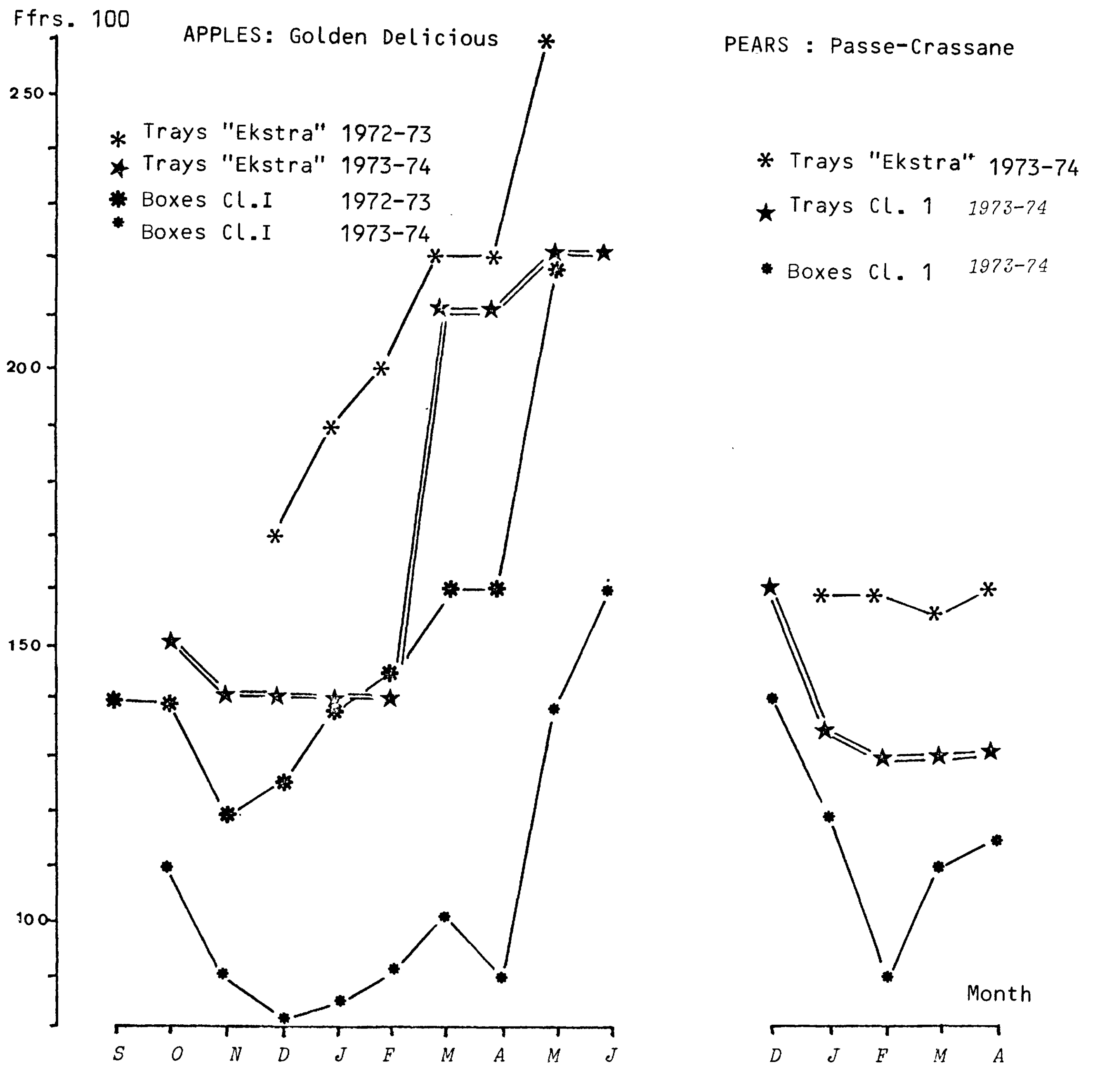
• Price differences based on size

The price differences based on the size of fruit and vegetables are neither proportional nor constant. Thus, for example, the differences in peach prices attributable to size are more constant when measured in terms of absolute value than they prove to be when measured in relative terms. The result is that the prices of all sizes are improved when prices are high, whereas the price of smaller sized peaches tends to fall more rapidly than that of the larger sizes when the market is weak.

In fact, the difference in price between one size grade and the next is often 15 % of the lower price, but differences of 25 - 30 % may also be encountered (3).

TRENDS IN FRUIT PRICES
ACCORDING TO GRADE AND PACKAGING

Average monthly prices - Rungis



The mark-up is not always proportional to size. Thus, the maximum price is obtained for fruit of the largest size that is considered desirable, and is lower for the over- and undersized fruit for which the market demand is less pronounced.

In the case of Cox's Orange Pippin apples, for example, the maximum value is placed on the 70 - 75 mm size range, while the largest mark-ups for Belle de Boskoop and Golden Delicious are for sizes of 75 - 80 mm.

Furthermore, these differences are not always equally large. For Cox's, the size obtaining the most ready sale is priced 12 % higher than the size immediately below it, but for a variety like Golden Delicious the margin may be as great as 25 % (4).

. <u>Packaging and presentation</u>

The cost of packing operations and careful presentation of the products leads to variations in the selling price of those products. For the normal types of presentation (boxes or trays), it is generally conceded that the cost of handling and packing, sorting and presentation represents 42-45 % of the value of the product at the despatching stage. When apples are selling badly, because of a glut, the figure may even be in excess of 50 %.

But it is possible to observe a relationship between the cost of handling and packing and the selling price of the product. This is particularly apparent in the case of products of everday consumption, such as apples, but the observation also applies to pears. The packaging can enhance the monetary value of the appearance of the produce, and can ensure a proportional increase in price that more than compensates for the additional cost incurred for the packaging (5).

. <u>The quality/price relationship</u>

Various surveys of fruit and vegetable consumption have shown that consumers commonly treat price as a criterion of quality.

This can be taken to mean they are convinced there is a normal relationship between the price of the produce and its quality, so that if a particular product is offered for sale at a higher price than another it must, in principle, be of superior quality. So the decision to buy the product will be all the more positive if this impression is strengthened by the appearance of the product and the method of display.

The only situation in which the consumer will actually prefer a lower price is when the products' external characteristics are considered to be identical.

This concept of the price/quality relationship was clearly revealed by a survey carried out in Italy in 1969 (6); consumers showed greater preference for fruit at the lower end of the price range for the "Extra" class than they showed for the lower prices in the other classes.

Obviously, the exercise of these preferences can be restricted by the purchasing power of the consumer, and they can only be expressed to the full when the product is in abundant supply so that prices are kept sufficiently low.

For some time, however, it has also been clear that consumers no longer consider appearance to be a guarantee of quality. When an opinion poll was carried out in France in 1973 (7) by the Centre Technique Interprofessionnel des Fruits et Légumes, 59 % of those questioned were of the opinion that fruit was more attractive than formerly, but that appearance was not matched by flavour.

The same survey also showed that the perception of quality depends on the place of purchase and on the presentation of the product, and that consumers prefer to buy fruit and vegetables from the local market or from specialist retailers rather than from non-specialist outlets, irrespective of size.

The extent of consumer preference for finely flavoured fruit was also highlighted by an experimental sale of apples with known flavour ratings that was carried out in southern and eastern France in 1972 and 1973 by the French Ministry of Agriculture.

In this experiment, in which the consumers were in a position to appreciate the excellence of the products, they were prepared to pay 20 - 30 % more than for otherwise comparable fruit with a nondescript flavour.

The consumer would also appear to be more inclined to pay a higher price if he considers the retailer is a specialist (8).

This qualitative preference also applies to traditional basic foods, such as the potato.

A joint study carried out in France by the Institut Technique de la pomme de terre and the Centre d'Etude de la qualité (9) has shown that the market for potatoes is changing, and that potatoes are increasingly being treated similarly to other vegetables, with a consequential demand for higher quality.

Quality heads the list of motives for purchase (40 % of responses), closely followed by price (38 %). But 80 % of those questioned said they hoped for an improvement in the quality of potatoes, and 63 % hoped for better information on the cooking properties of the different varieties.

Consumers were apparently very much attracted by presentation under a label offering a guarantee. Thus, for a product of a very ordinary nature, for which a high price would seem to be incompatible with its being a staple food, there would seem to be a marked consumer demand for higher intrinsic quality and better information.

It would seem therefore, that the present-day consumer will accept wide differentiations in the prices of fruit and vegetables based solely on the criteria of appearance and presentation, and that the cumulative difference may be as great as 25 - 30 % if the effects of product standardization and product size are added together.

However, the instinctive association of higher quality with higher price often leads to disappointment when the product is eaten.

Consumers, then, wish to be more fully informed about product quality, and would seem to be quite ready to pay an extra amount for quality at least equal to the premium which is paid today for appearance.

This is a highly significant observation, as far as the grower is concerned, because it is easy to calculate that a 25 % price-difference at the retail stage is equivalent to at least 40 - 50 % of the absolute value of the product at the moment of despatch, and it is therefore at least comparable with the amount currently spent on packaging and storage.

One can therefore concur in full with the conclusion of FRANCOIS (10) that quality provides a sure defense against economic competition, and that consumer decisions are increasingly motivated by considerations of quality. The product must therefore be distinguished from the mass by its objective and measurable characteristics, which should be reasonably clear to the consumer.

1.2 : NUTRITIONAL QUALITIES

The nutritional and even therapeutic functions of fruit and vegetables are increasingly taken into consideration by consumers as their knowledge about nutrition increases.

Sometimes even, it is the nutritional value of certain fruits and vegetables which is taken to be the main reason for eating them. This can apply, for example, to apples, oranges and bananas, as well as to potatoes and salad vegetables (7) (9) : but on the other hand, the increasing use of chemical products for plant protection has made consumers fearful of the toxic residues that might be present. As far as consumer attitudes are concerned, therefore, the value of fruits and vegetables consists of positive elemements (the desire for nutritional value) and negative elements (the desire for hygiene).

1.21 : Nutritional value

Fruit and vegetables are one of the main sources of human nourishment (11). Not only do they provide the three main groups of substances used by the human organism : proteins, carbohydrates and fats, but they also contain other substances such as vitamins, of which they are major providers.

Fruit and vegetables thus contribute to three essential functions of the organism :

- structure and maintenance, by providing proteins, water and mineral subtances ;
- energy, by providing carbohydrates and fats ;
- protection, by providing vitamins, mineral salts and organic acids.

It is obviously not the aim of this study to examine the nutritional role of fruit and vegetables in any depth. It nevertheless seems pertinent to outline their main nutritional and biological properties, and to indicate the extent to which they affect the organoleptic properties of fruit and vegetables.

It does indeed seem that the substances which are the basis of organoleptic sensation can also be major sources of nutrition, as with sugars for example, or that their functions can be similar to those of certain substances which have a mainly dietetic role to play, such as carotene, vitamins, etc. ..... (12).

. Water

Water is one of the main constituents of fruit and vegetables, and has a particularly beneficial effect on the human organism. At the same time, it serves as a carrier for the main nutritional substances. Apart from the vegetables and fruit grown for their seeds, most of these products have a water content of 70 – 90 % of their total weight.

. Carbohydrates

Obviously, it is the sugars present in varying concentrations in all fruit and vegetables that account for the major proportion of the carbohydrates. They thus provide valuable energy, in the form of simple sugars (fructose, glucose) which can be directly assimilated. Their low calorific value makes them a highly valued element of modern diets.

In addition to these sugars, one should also mention the nutritional value of certain constituents of the cell walls of fruit and vegetables, namely pectins and cellulose, which can have a very ›neficial effect on the digestive and intestinal functions.

. Lipids

These substances, commonly known as fats, are present in relatively small amounts in fruit and vegetables except in the dry fruits grown for their seeds (almonds, walnuts, hazelnuts) and, in a very few fleshy fruits such as avocados.

But their presence is nevertheless important, especially as they are the carrier substances for the fat-soluble vitamins.

. Proteins

Nitrogen compounds, the basic factor in all human nutrition, are found in relatively small amounts in fruit and vegetables, except again in dry fruit and in the seeds of legumes such as peas and beans.

However, the leaves of certain vegetables, especially Brussels sprouts, contain far from neglible amounts of proteins, as do potato tubers.

But although they cannot be described as rich in protein, fruit and vegetables do satisfy about 10 % of human food requirements.

. Organic acids

Because of their interaction with bases to form organic salts (malates, citrates, tartrates), the organic acids play an extremely important role in the human diet.

In the human organism, the acid fraction of the molecule is burned up by oxidation, and this liberates the alkaline component, which has the particularly important property of balancing the acidifying action of cereals and foods of animal origin.

For that reason, analysts often determine the ratio of organic salts by measuring the alkalinity of the dry matter (13).

. Essential oils and pigments

These complex substances, which are often present in very small amounts, are the basic components of aroma and colouring in fruit ; they are vitally important factors in nutrition, either because of their direct contribution or because they are precursors or protectors of vitamins (14).

They thus fulfil the role of metabolic regulators.

. Vitamins

These compounds, which are indispensable for all animal species and for man, who cannot synthesize them, are provided entirely by fruit and vegetables.

Vitamins and sugars are incontrovertibly the most important nutritional factors as far as the consumer is concerned. Fruit and vegetables are a major source of the vitamins which serve to protect the human organism ; they are rich in water-soluble vitamins, e.g. vitamin C (ascorbic acid), which is abundant in many fruits and vegetables (e.g. blackcurrant, strawberry, orange, cabbage, tomato, turnip) (15).

In the group of fat-soluble vitamins, vitamin A is provided by carotene which is particularly abundant in apricots oranges, tomatoes, cabbage, carrots, salad vegetables and legumes.

Vitamins of the B complex are important in carbohydrate metabolism (B1 = thiamin ; B2 = riboflavin ; PP = nicotinic amid), their haemopoeitic action (folic acid) or in protein metabolism (B6 = pyridoxine). They are present in varying quantities in all fruit and vegetables.

Vitamins E (anti-sterilitic) and K (anti-hemorrhagic) are present in particularly large quantities in green vegetables (spinach, cabbage, salad vegetables).

- Mineral salts

The mineral salts present in fruit and vegetables are very important for their alkalinizing effect. In this context, the most marked characteristic of fruit and vegetables is the presence of potassium and, at the same time, the almost total absence of sodium.

Potassium as a stimulant of the myocard is one of the most essential elements required by the human body. Phosphoric acid, which plays a role in the retention of calcium, calcium itself, magnesium, manganese or iron and copper are also not to be neglected, particularly iron for the anti-anaemic role it gives to green vegetables.

1.22 : Health and safety

The rapidly developing use of synthetic chemical substances to combat pests and diseases has not only caused difficulties over the past few years as far as the agricultural environment is concerned, but has also raised the problem of the direct or indirect effects of the residues present on fruits and vegetables when they are eaten.

Multiple precautions are taken in the various Member States to ensure the official registration of plant protection products. These registrations were initially based on the high toxicity of these products, and the permitted concentrations reflected the various levels of toxicity.

But there has been growing awareness, over the past few years of the serious risks associated with the metabolites resulting from the degredation of certain pesticides, which might be more harmful than the product itself (e.g. DDT).

The dangers of acute toxicity are thus compounded by the indirect effects, which are increasingly being taken into account, so that many products which were formerly permitted have now been prohibited.

The authority to use such products normally includes a statement of the maximum permitted concentration, but their application is also prohibited for a specific period before the harvesting of the crop, depending on the degradability of the toxic substance consequent upon exposure to rain and solar radiation.

The precautions thus taken by the main European countries are intended to keep the toxic residues below a recognized threshold of danger to human health.

But in certain cases, depending on methods of application, or on climate, or sometimes even on the growers' ignorance of the regulations, the stipulated concentration limits may be exceeded.

Also, over the past few years, the market has been flooded with various products for the protection of fruit after picking, either by immersion or by coating, and these are yet another source of toxic residues.

That is why, in addition to the purely preventative regulations which were initially imposed, there are now precise definitions of the maximum permitted residues of the main products which are allowed on fresh fruit and vegetables.

One may consider, therefore, that these new rules and regulations are intended to provide an effective reinforcement of consumer protection against the risks arising from the presence of products that are harmful to health.

But chemical substances may not be the only hazards of this type. In fact, certain parasites, such as the cherry fruit fly, or many types of fungus can be the cause of organic disorders, and it should therefore be pointed out that the use of chemical substances to eliminate these pests and infections is far from being only negative as far as human health is concerned.

The solution lies, therefore, in the intelligent exercise of control over the use of these substances.

It is relevant to mention these problems in a study of this type, devoted to the organoleptic properties of fruit and vegetables, because it is becoming increasingly evident that consumers who insist on gustatory quality are also very hygiene-conscious.

1.23 : Consumer perception of nutritional qualities

The nutritional and hygienic qualities of these foods can therefore encourage the consumer to eat fruit and vegetables in the fresh condition, or they can have the opposite effect.

The various "notions" that circulate among consumers are often extremely vague and far removed from reality. Many respondents to one survey on the quality of fruit were convinced, for example, that fruit could be "treated" with injections (7).

Toxicity is all the more feared because the severe restrictions imposed on the use of chemical substances are not well known to the public at large, and this fear inhibits consumers from selecting natural products of which fruit and vegetables are steadily becoming one of the few surviving representations in our urban civilization.

The notions in the consumer's mind are rather complex : there is a vaguely symbolic association with the idea of nature, which reinforces the desire for produce that has not been interfered with, thus heightening the consumer's misgivings about the presence of chemical substances.

The existence of this desire for the natural product has resulted in the abuse in recent years, of such terms as "biological" or "natural", which were often quite unjustified and even amounted in some cases to absolute fraud.

New regulations in most countries have recently clamped down on the use of such descriptions. But it should not be forgotten that the various aspects of hygiene can provide the basic motivation for the purchase of fruit and vegetables, and that the health-giving properties are increasingly associated in the consumer's mind with the unique sensory pleasure to be derived from eating them.

1.3 : DEFINITION OF ORGANOLEPTIC PROPERTIES

AFNOR (16) has defined these properties as the totality of the properties of a given food product, considered as a stimulus of the various sensory receptors concerned, before, during and after its consumption, while CHEVREUL (17) was already using the term in about 1860 to mean the properties perceived by the sense organs.

TREMOLIERES (18) has pointed out that man does not accept a strictly rational code when feeding himself, and that pleasure is the main impulse. He lists the alimentary senses as vidual, olfactory, tactile, gustatory, digestive and general, but the senses which identify foodstuffs, recognize them and recall in memory the pleasure resulting from their consumption are oral, visual, olfactory and gustatory.

The organoleptic properties therefore correspond fairly closely with the impressions that are received orally. This can be rendered by the term "flavour" (derived from the Old French word "flaveur").

AFNOR has likewise used the term to define "the totality of the sensations perceived by the olfactory organ, the taste buds and the buccal cavity, including the tactile sensations, chemical sensations and pain".

1.31 : Tactile sensations

Under this heading we can group all the impressions felt in the mouth when a fruit or a vegetable is eaten. These impressions can be analyzed by means of rheology, the science of the resistance to deformation and flow of visco-elastic solids and viscous liquids when measurable forces are applied to them.

In practice, the perception of these phenomena (texture) is expressed by adjectives describing the flesh of fruit and vegetables, such as :

tender, fine, melting,

as opposed to firm, coarse, granular or fibrous.

These impressions of cellular texture can be combined with an appreciation of juice content and may thus be expressed in terms such as :

crisp or juicy

as opposed to pasty or mealy

The consumer simultaneously appreciates the firmness of the flesh, its structure and its juice content. This term designates the amount of juice in the product, but it is often employed to denote a complex combination of the three characteristics.

1.32 : Gustatory sensations

Of the four primary tests perceived in gustation, i.e. sweet, acid, bitter and salty, only the first three are significant in the case of fruits and vegetables. The sweet and acid tastes are of paramount importance, sometimes in association with bitterness.

These sensations are registered in the mouth, by the taste buds, but they are not perceived independently or objectively.

There is a clear dividing line between these primary tastes, with no intermediate forms, because of the morphological dissociation of the taste receptors. But certain interactions can be observed (19).

The intensity of perception of sweetness or acidity in the food depends on the concentration of cell sap responsible for these tastes, but it also depends on their relative levels. Thus, a fruit may appear to have a more acid taste for a given concentration of acids if the sugar content is low. Conversely, the perception of sweetness will obviously depend on the concentration of total sugars, but the more the acidity is reduced, the more the sensation of sweetness will increase.

Gradually, as eating habits develop, the taste becomes more sophisticated and gets used to certain types of balances between the primary tastes. The result is a variation in the level of gustatory pleasure which depends on the sugar/acid relationship and which can vary between individuals and from social group to social group.

Bitterness of taste, which is rarely significant in the staple fruits and vegetables, can be accentuated by the presence of acidity or, on the contrary, partly masked by sweetness.

Bitterness therefore tends to occur in conjunction with acids to balance higher levels of sugar. Thus, these three primary tastes, and especially sweetness and acidity, tend to balance each other, but the optimization of taste depends at one and the same time on the balance between the three and on their relative concentrations. As PONCELET wrote in the 18th century (20), the harmony between them must be as agreeable to the tongue as music to the ears.

For any given value of the sugar/acid ratio, the taste is considered to be better the higher the level of the two factors, until an optimum concentration is reached, beyond which the taste is considered too strong.

This optimum, which is variable according to individuals and eating habits, is not even constant for a single individual since he cannot appreciate it objectively.

In fact, these sensations depend to some extent on the consumer's surroundings and physiological condition at the moment of consumption. Appetite, for example, or a low temperature, can give rise to a craving for high sugar contents. But the need to perspire, which is often found in conjunction with raised ambient temperatures, may give rise to a craving for higher acidity.

But these two manifestations of taste can also be influenced by psychological factors. Knowledge already acquired (i.e. our recall of previous acts of consumption), or indeed visual impressions (especially of colours) may modify the perception of taste.

Thus for example, greeness in fruit is generally associated with acidity, while yellow pigmentation is generally associated with sweetness of taste.

The terms of reference for this report do not extend to a detailed study of these interactions with their subjective connotations (e.g. childhood memories), or simple digestive causes, but it nevertheless seems pertinent to emphasize their importance and the need to take them into account in the elaboration of tests for quality.

1.33 : The olfactory sensations

The sensations perceived by the olfactory organ, in the presence of fruits and vegetables, can be classified under two very distinct headings :

- Odour or scent, perceived before the product is consumed, from outside the body by nasal inhalation, depends on the amounts of the volatile constituents escaping through the epidermis and the cuticle of the fruit.

  In the case of certain fruits, this scent may be highly developed, as in peaches, strawberries and melons. In other fruits and in most vegetables, it can often be extremely weak.

- Aroma, by contrast, is perceived during the action of eating the product, by exhalation through the nose of the combination of volatile compounds liberated at that instant (21).

To the constituents of scent are now added the products liberated by the crushing of cells, by the immediate enzyme action in the saliva and by the temperature of the mouth.

The perception of aroma is extremely complex and difficult to analyze objectively, and it is often associated with the perception of taste proper.

1.4 : CONCLUSION : COMPLEXITY OF THE CONCEPT OF QUALITY

The organoleptic properties can thus be seen as a complex combination of olfactory, tactile and gustatory sensations, in which it is difficult to isolate the various components. The complexity of the concept is increased, in the cultural environment in which we live, by our recall of past visual and psychological sensations, which cause us to treat appearance and colouring as indicators of organoleptic or nutritional quality.

It is this complex combination of properties which determines the pleasure derived from eating (and subsequently digesting) a particular fruit or vegetable, and it corresponds, as far as consumers' expectations are concerned, with the notion of overall quality (22).

This clearly reveals the very limited extent to which the expectations of consumers will be met by the application of any definition of quality that is based on the parameters of external appearance alone.

COMPOSITION OF FRUIT AND VEGETABLES
per 100 g of the fresh matter

Name of Fruit or Vegetable		Calorific value	Water in grammes	Calorifacient constituents (grammes)			Cellulose in grammes	MINERAL ELEMENTS in MILLIGRAMMES											
				Protein	Fat	Carbohydrates		Sulphur	Phosphorus	Chlorine	Sodium	Potassium	Magnesium	Calcium	Iron	Zinc	Copper	Manganese	Iodine
Apricot	*Prunus armeniaca* L	44	86	0,8	0,1	10	0,8	6	24	2	1	300	11	15	0,4 à 2,5	-	0,12	-	-
Carrot	*Daucus carotta* L	42	88	1,2	0,3	9	1,1	22	37	50	50	300	15	39	1,2	0,3	0,14	0,6	0,009
Cherry	*Prunus cerasus*	77	80,5	1,2	0,5	17	0,3	9	21	3	3	250	12	18	0,4	0,15	0,13	0,03	0,002
	" "	56	85	0,9	0,5	12	0,3	9	20	3	3	250	12	18	0,4	0,15	0,93	0,03	0,002
Chicory	*Cichorium intybus* L	20	94	1,6	0,1	3	0,6	18	25	25	10	300	13	70	0,7	0,19	0,14	0,30	-
Lettuce	*Lactuca sativa* L	18	94	1,2	0,2	2,9	0,6	20	30	50	15	300	13	62	0,65	0,5	0,18	0,42	0,005
	Lactuca sativa romana	18	94	1,2	0,2	2,9	0,6	13	25	60	14	250	13	32	-	-	-	-	-
Melon	*Cucumis Melo* L	31	92	0,8	0,2	6,5	0,6	14	18	43	19	260	15	18	0,4	0,09	0,05	0,04	0,002
Peach	*Prunus persica* STOKES	52	86	0,5	0,1	12	1,4	7	22	3	3	230	10	8	0,4	0,02	0,05	0,66	0,002
Pear	*Pirus communis*	61	83	0,4	0,4	14	-	5	9 à 26	2	3	130	7	9 à 15	0,4	0,16	0,10	0,06	0,002
Apple	*Pirus malus*	52	84	0,3	0,35	12	-	6	11	3	2	120	5	6	0,4	0,10	0,10	0,04	0,002
Potato	*Solanum tuberosum*	86	77	2	0,1	19	0,5	30	60	50	5	500	30	15	1	0,30	0,15	0,10	0,003
Scarole	*Lactuca scariola* L	37	94	1,5	0,3	4	1	32	40	70	10	387	13	79	-	-	-	-	-
Tomato	*Solanum lycopersicum* L	22	93	1	0,3	4	0,6	11	27	40	3	280	10	11	0,60	0,24	0,15	0,12	0,007

COMPOSITION OF FRUITS AND VEGETABLES

Name of Fruit or Vegetable		VITAMINS in milligrammes: Ascorbic acid C	Thiamin B1	Riboflavin B2	Nicotinamide	Pantothenic acid	Pyridoxin B6	Active Carotenoids	Axerophtols A	Vitamins D	Tocopherols E	Calcium-Phosphorus
Apricots	*Prunus armeniaca* L	5 à 10	0,06	0,12	0,7	0,29	-	1 à 7	-	-	-	0,6
Carrots	*Daucus carotta* L	9	0,06	0,06	0,5	0,27	0,20	2 à 10	-	-	3	1
Cherries	*Prunus cerasus*	17	0,05	0,06	0,30	0,20	-	0,4	-	-	-	0,85
	" "	-	-	-	-	-	-	-	-	-	-	0,9
Chicory	*Cichorium intybus* L	10	0,07	0,12	0,40	-	-	1,8	-	-	-	2,8
Lettuce	*Lactuca sativa* L	10	0,08	0,12	0,5	0,36	0,20	1	-	-	0,6	2,06
	Lactuca sativa romana	8	0,04	0,08	0,20	-	-	0,30	-	-	-	1,28
Melon	*Cucumis Melo* L	10	0,02	0,05	0,20	-	-	0,30	-	-	-	1
Peach	*Prunus persica* STOKES	5 à 8	0,03	0,05	0,90	0,05	-	0;30	-	-	-	0,36
Pear	*Pirus communis*	3 à 10	0,02	0,05	0,20	0,025	-	0;01	-	-	-	0,7
Apple	*Pirus malus*	3 à 20	0,04	0,02	0,10 à 0,50	0,06	0,15	0,05	-	-	0,72	0,5
Potato	*Solanum tuberosum* L	40 15 5	0,12	0,07	1,50	0,50	0,40	0,04	-	-	-	0,25
Endive	*Lactuca scariola* L	6 à 20	0,10	0,20	0,30	-	-	2	-	-	-	1,9
Tomato	*Solanum lycopersicum* L	38	0,09	0,04	0,50	0,10 0,40	0,25	0,50	-	-	-	0,4

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2 - DETERMINATION OF THE MEASURABLE STANDARDS OF ORGANOLEPTIC QUALITY AND DEFINITION OF THE METHODS OF MEASUREMENT

Objective methods can be used to analyse the roles of the main components and to determine the relative weight that is given to each component when assessing overall quality. It is thus possible to lay down objective standards for measuring the intrinsic quality of fruit and vegetables.

2.1 : THE BASES OF SENSORY EVALUATION

One must begin by defining the methods adopted for the objective analysis of consumer opinions and for the subsequent determination of the relationships which may exist between these and the main components, either separately or in combination.

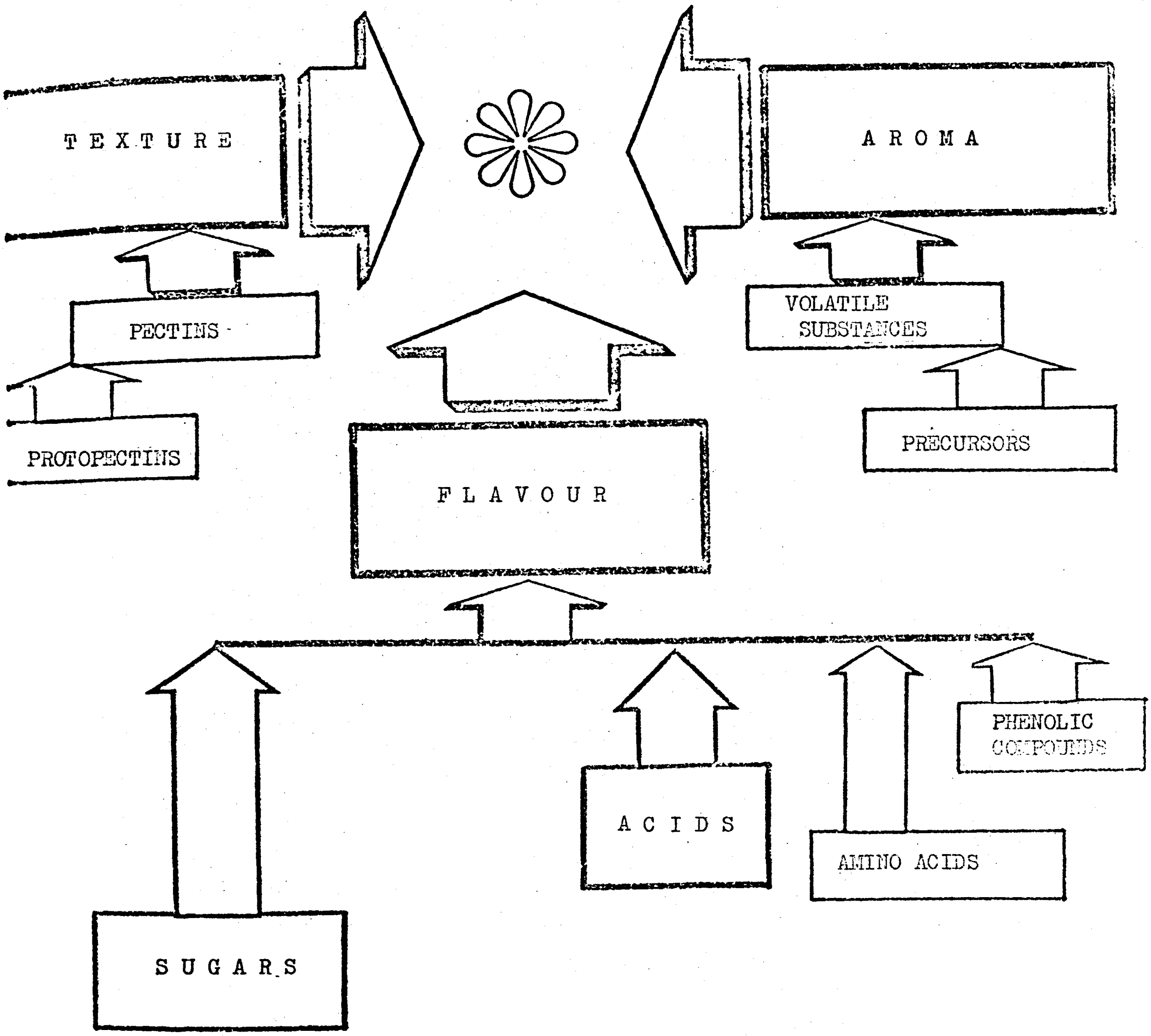
2.11 : Methods of analysis

The methods of sensory analysis applicable to fresh fruit and vegetables are based on the tasting, by a consumer panel, of products exhibiting one or several characteristics (variety, maturity, origin, etc....), followed by research into the possible relationships between the value judgments of the panel and the relevant measurable standards.

One must then check the relationships observed, by testing the consumers with products selected on the basis of the standards adopted, so as to make sure that they are easily identifiable.

- Composition of panels

Experience has shown (24) that taste panel members must be selected and trained for the purpose. In fact, a group of persons selected strictly at random can only give satisfactory results if the group is very large. Otherwise, some individuals do not find it easy to understand all the questions put to them and others experience difficulty in analyzing their sensations, in identifying them and in expressing their reactions.



THE SENSORY BASES
OF ORGANOLEPTIC QUALITY

It is therefore preferable to use a smaller number of panelists, but to make sure before commencing the tests that their sense of taste is acute and that they are capable of analyzing their impressions of taste.

Prospective panelists are therefore screened for their ability to identify the four primary tastes by the presentation of aqueous solutions of control substances of a given concentration.

They are then tested for their threshold of identification of the primary tastes.

In fact, for fruit and vegetables, this second series of tests can be limited to the two tastes, sweet and acid, which are really abundant in these products.

Various norms for the determination of acuity of taste have already been published, notably by AFNOR (25).

As far as testing schedules are concerned, it is best to impose a unity of time, place and action, so that all the panelists work in identical conditions, and it is generally agreed that mid-morning (10 - 11 a.m.) is the best time.

To exclude the possibility of panel members influencing each other's decisions, each judge is given a separate tasting booth in a purpose-designed room.

In practice, good results can be obtained with properly trained panelists in an ordinary room, as long as panel members avoid communicating or showing their reactions.

The main difficulty as far as fruit and vegetables are concerned, and especially for fruit, is that of presenting tasters with samples that are sufficiently homogenous and representative of each batch being tested. It thus seems often to be more efficient to present the entire sample consisting of a number of units, and to get individual tasters to test several units from a given sample.

- <u>The parameters of assessment</u> employed by taste panels can be divided into three categories : absolute, comparative and preferential (26).

For absolute judgments, a list of criteria for selection is imposed, and panelists have to relate their assessment to it. The method is relatively difficult to apply, because it can result in a rather wide spread of scores unless the tasters are requested to isolate only a single characteristic.

Comparative judgments lead to ranking. The idea is to classify several samples of fruit in relation to a fixed criterion, so that each sample is ranked in relation to the set of samples.

Preferential judgments can be based on appeal to concepts of sensitivity to, acceptability of or preference for a given attribute, and are necessarily expressed in terms of a scale of values.

For this purpose, panelists may be asked to record their assessment of a given characteristic according to a numerical scale, or they may be provided with a list of descriptive terms and requested to place a mark against the term considered to be most applicable to the sample.

The results can be numerically analyzed with the aid of a prepared scale on which the linguistic terms are each given a numerical value.

This last method would seem to have certain advantages in the case of fruit and vegetables, because it avoids undue spread of the numerical values consequently assigned.

- Analysis of data

Various statistical methods are available (27) for analyzing the data gathered from taste panels. The aim is to bring together the results of one or several tests, and to express them in tabular or numerical form.

The methods adopted must therefore include some means of determining the consistency and homogeneity of the value judgments expressed by the panelists.

Two types of statistical method can be used, depending on whether there are only two samples or more than two.

If two samples are used, it is possible to carry out paired identification or comparison tests, by asking the panelists which of the two samples exhibits a given characteristic or in which sample the intensity of the characteristic is more marked, or else triangle tests can be applied, by presenting three samples in which two are identical and merely asking the panelist to identify the odd sample or compare the three.

In the case of fruit and vegetables, the two-sample techniques are mainly used for checking the results already obtained.

Although more complicated, the multiple sampling techniques are those which are most frequently applied to fruit and vegetables.

The optimum number of samples for presentation to a taste panel would appear to be six, and eight should be a maximum. Beyond that point, the panelists' judgment becomes less acute and they may experience difficulties in separating samples with fairly similar characteristics.

Various statistical tests can be applied to check the significance of the results obtained by the panel. The Chi squared test (as proposed by Friedman) (28) is the easiest to apply, and gives good results for panels with a minimum of fifteen members.

This test can be used for checking the reliability of the entire testing procedure, and if the result is significant the significance of the scores achieved by the different samples can then be tested pair by pair.

It is then possible to place the samples in series showing the significance of differences in the testers' scores.

One of the difficulties lies in matching the results of tastings by different panels or those carried out by the same panels on separate occasions.

One way round this difficulty is to introduce one or two controls, to which constant values are assigned, into each series of six or eight samples.

Differences between sample scores and controls can then be expressed as a percentage of the average (difference), so as to establish the relationship between the different tastings.

This system only gives good results when sufficiently homogenous lots of the products are available as controls and if the range of variation in quality of the various lots submitted for evaluation is also constant from one tasting to another. Otherwise, the scoring of the samples can be influenced by the presence, in any series, of samples which are particularly good or particularly bad.

Properly trained panelists can be asked to give an absolute score to each lot and then to relate the lots to each other by comparing the scores obtained.

To correlate the qualitative results of tastings with the numerical results of the various analyses of fruits from the same lots, one can compare the analytical values with the scores provided by the tasters. The standard statistical procedures for calculating simple or multiple correlations can then be used to compute the variance ratios (Fisher's F-test) and/or the correlation coefficients.

- Verification of results by consulting consumers

The significance of the various objective tests can be established by analyzing the correlation coefficients, and it can then be checked whether the fruit and vegetables rated according to these tests are found by the taste panel or consumers to be classified in a similar order.

A sample group of consumers can be used for the test, and the method of testing will be that of duo-trio difference tests.

But consumer preferences can also be ascertained by test marketing This is done by offering the products for sale with an informative label and measuring the preference expressed by consumers in terms of the quantities of the product sold in the different quality ranges, and it is also possible to vary the differences in price between an ordinary quality and a selected quality so as to find out the difference in price that is acceptable to the consumer once the difference in quality has been recognised.

A test market of this type has already been successfully carried out in France, with Golden Delicious apples. (8).

One can also supplement this quantitative information by opinion surveys at the point of sale among the final buyers of the product, thus adding further comments on quality to the statistical information already gathered.

2.12 : Firmness and flesh texture

The texture of any particular food is that combination of the characteristics of its solid state (or rheological properties) which contributes to the sensations provoked by eating it (29).

- Biochemical development of the tissues

The texture of fruits and vegetables is directly influenced by the thickness of the cell walls and their cohesion, which determine the rigidity of the vegetable tissues.

This rigidity depends on the development of the pectin compounds which impregnate the cell walls.

In immature fruit, these substances are present in the form of insoluble protopectins which bond the cells together.

As a result of enzymatic processes, these protopectins are transformed into soluble pectins which then form colloidal gells between the cell walls enabling the cells to slide against each other.

The texture of the fruit then becomes soft, and even melting, as a result of the disintegration of the cell walls (30).

In practice, therefore, the development of the pectins is reflected in lessening firmness of the tissues, so that the measurement of firmness is an objective method for evaluating texture.

But certain vegetables whose roots or leaves are eaten, and sometimes certain fruits, may also be subject to lignification, so that the products develop a fibrous texture which does not mature as advantageously, but tends to harden as the tissues age.

Finally, in certain fruits, certain cells can harden through the accumulation of mineral substances, especially calcium, and form granulations which remain hard throughout the process of maturation.

This deterioration is frequent in certain varieties of pears.

- Methods of measuring texture

Texture is in fact the end product of rather complex phenomena, but because the main characteristics of texture develop concurrently a simple measurement is all that is required (31).

As far as fruit is concerned, the most characteristic indication of firmness may well be obtained by quantitative analysis of the pectins, but this is quite a complicated process. Hence the preference for physical tests, which mostly consist in the evaluation of flesh firmness.

These physical tests can be carried out empirically or they may take the form of rheological tests carried out in the laboratory (29).

The aim of the empirical tests is to reproduce the movement of the teeth in penetrating or crushing the product. As they always destroy the product they have to be conducted on a sampling basis.

The simplest method consists in measuring the firmness of the tissues with the help of a dynamometric apparatus known as a penetrometer.

This apparatus measures the force required for penetration of the flesh of the fruit or vegetable by a metal cylinder of a fixed length with a flat head of fixed cross section.

Various mechanical devices have been perfected for the purpose. They are of two different types, but the results are fairly similar. In the case of the Magness-Taylor penetrometer, developed in the United States, the force required for penetration is indicated on a dial : in the linear models used in France (Bellevue or Dupaigne models) it is shown by a sliding indicator on a graduated scale.

These different models normally use a head of identical section (0,5 cm^2), and in that case give comparable results.

This equipment is handy for use in the field or the packhouse. One of the snags is that measurements may vary with the skill of the user.

Similar methods are used in the laboratory, but the penetrating movements and the forces required for penetration are electrically controlled.

Tests involving the compression of a cube of flesh of measured dimensions, or the measurement of the force required for shearing are also carried out in the same conditions and of course these give more precise results than are obtained by manual measurement ; but they require complex equipment which can only be used in the laboratory.

Because the rheological tests do not usually destroy the product they can be used in practice to test the quality of an entire batch.

Such equipment has been developed in the United States and is currently being studied by various European makers, with a view to the total mechanization of grading operations based on the firmness of the product.

This equipment applies different physical principles, either by measuring the transmission of vibrations through the whole fruit or vegetable (32), or by measuring the correlation between the biochemical composition of the tissues and their rigidity, which affects the transmission of light through the product (33).

In addition, the parallel development of external colour and ripeness in fruit means that sorting methods can be based on the reflectance properties of the skin (285) or on the presence of bruising (286).

2.13 : The biochemical components of flavour

Sugars and acids are the main substances responsible for the gustatory sensations perceived when consuming fruit and vegetables, to which may be added, to a lesser degree, the effect of substances with an astringent quality, such as tannins or more rarely alcaloids or phenolic compounds which give a bitter taste.

213.1 - Sugars

Carbohydrates are the basis of the entire metabolism of plants because they are the only substances which are directly synthesized in the leaf by photosynthesis.

They therefore play an essential role in the formation of the other constituents, including not only the organic acids which result from the oxidation of sugars but also the aromatic substances.

Sugars are classed in two main groups :

Simple sugars (monosaccharides), which are directly absorbed by the organism, and idisaccharides which are transformed into simple sugars by hydrolysis.

- The simple sugars present in fruit and vegetables are still called reducing sugars, by reference to their capacity for reducing FEHLING's solution, which was the traditional method of analysis. The main simple sugars in fruit and vegetables are glucose (or dextrose) which is abundant in certain stone fruits and in grapes, as well as in carrots, and fructose (or levulose) which is predominant in fruits with pips.

These two sugars are generally found in association, but the proportions vary greatly, and it should be emphasized that fructose has almost twice the sweetening capacity of glucose. Maltose produced by the hydrolysis of starch is rather rare in fruit, but it is sometimes found in relatively large concentration in carrots (34).

- The disaccharides are mainly represented in fruits and vegetables by sucrose, and by starch.

The sucrose accumulated in vegetable tissues can be regarded as constituting a reserve. The level of sucrose increases substantially on the approach of maturity. Its sweetening capacity is midway between that of glucose and fructose, and it would not appear to play any special role in this context. However, its presence is often considered important for the flavour of a product, and in most cases this is probably because it is an indicator of the biochemical activity which precedes maturation.

It can be almost totally absent from certain fruits such as cherries, grapes and tomatoes, or it may be present in varying proportions in association with reducing sugars, either in lesser quantities as in apples and pears or in equal or even greater concentration than simple sugars, as in carrots and certain varieties of peaches.

Relative sweetness of different sugars	
Fructose	1.73
Sucrose	1.00
Glucose	0.74
Xylose	0.40
Maltose	0.32
Galactose	0.32
Lactose	0.16

source : J. LE MAGNEN

Starch constitutes a reserve. In fruit it is only present when the product is immature, but it is always present in potatoes.

The starch content of fruit may thus be taken as a criterion of immaturity, whereas the starch content of potatoes is the very basis on which they are graded for quality.

In addition to the sugars, certain fruits also contain related carbohydrates, especially sorbitol, which is present in limited but far from neglibible amounts in apples and more particularly in pears and cherries.

Sorbitol does not seem to play a role in flavour, but it is a significant component of the total soluble matter measured by refractometry (35).

The fact that it disappears in the course of maturation would seem to indicate its transformation into glucose by oxygenation (30).

• Methods of measurement

Many methods, of varying reliability, can be used to determine the sugar content of fruits and vegetables.

The most simple procedure makes use of the polarizing capacity of solutions of sugars to provide an instant measurement of the soluble dry matter content of such a solution by means of an optical instrument known as a refractometer (36).

This percentage of soluble solids is very close to the percentage of total sugars. Conversion tables have been established for certain fruits.

When expressed in percentage terms the refractometric reading is called the refractive index. It is a reliable indication of total sugar content.

To determine the levels of the different sugars present in fruits and vegetables rather complex laboratory methods are required, but now that automated equipment is available these analyses can be carried out in series. Colorimetric measurements can be made, based on the reducing capacity of simple sugars, and the degree of correlation varies according to the sugar content.

The procedure for measuring sucrose content is to calculate by difference, by promoting the inversion of this substance to simple sugars. The difference between the pre- and post-inversion readings is a reliable indication of the sucrose content.

The exact quantities of the various sugars present in fruit can be determined by chromatography.

Starch content can also be determined in the laboratory by the enzymatic method, the starch being transformed into glucose following dispersion, the glucose then being measured by spectrophotometer. But a more simple method is to calculate the specific gravity ; this form of rapid quantitative analysis is sufficiently precise for measuring the dry matter content of potatoes (37).

This method can also be used for fruit (38), but in this case the refractometric measurements give more precise results.

On the other hand, one can estimate the amount of starch in fruit, as a test of immaturity by cutting the fruit equatorially and by daubing the flesh with a solution of iodine. The parts of the fruit containing starch then turn dark blue in colour.

213.2 - Acids

Fruits and vegetables contain mainly organic acids, while the mineral acids are only present in very small quantities.

Part of the organic acid content takes the form of salts with different cations.

When measuring acidity therefore, a distinction is made between the free acid, which corresponds to the titratable acid and the total acidity which includes both the free acidity and the fraction present in the form of salts as measured by the alkalinity of the dry ash.

The sensation of acidity is mainly attributable to the ionic acidity measured by the pH, and thus depends on the relationship between the titratable acid and the alkalinity of the dry ash (13).

The concept of acidity can thus be seen to be rather complex, both in terms of its expression and in terms of the methods adopted for measuring it, so that it is very important to specify the type of acidity in question and the method of quantitative analysis adopted if one is to be able to compare the various products.

The acidity of fruits and vegetables is mainly attributable to three organic acids :

- Malic acid, which is particularly abundant in fruit, especially in pears and apples, from which it draws its name (apple tree = Malus domestica);

- Citric acid, also present in variable quantities in all fruits and particularly abundant in citrus fruits, tomatoes and certain stone fruits (peaches, apricots);

- Tartaric acid, which is not so common as the other two acids and is chiefly to be found in grapes.

In addition to these main acids, many others are to be found, often only in traces ; but they may have an important role to play in the gustatory quality of certain fruits and vegetables.

A case in point is succinic acid, which is only present in small quantities in apples and cherries, but which constitutes the main component of the acidity of carrots (34).

Oxalix acid, which is mainly present in the form of salts (oxalates), is particularly common in young fruitlets. The levels of this acid fall as fruit ripens, but in certain vegetables (beet, spinach) it accumulates in the leaves in the ageing process. Salicylic and quinic acid are among the many others which are commonly found in fruit and vegetables.

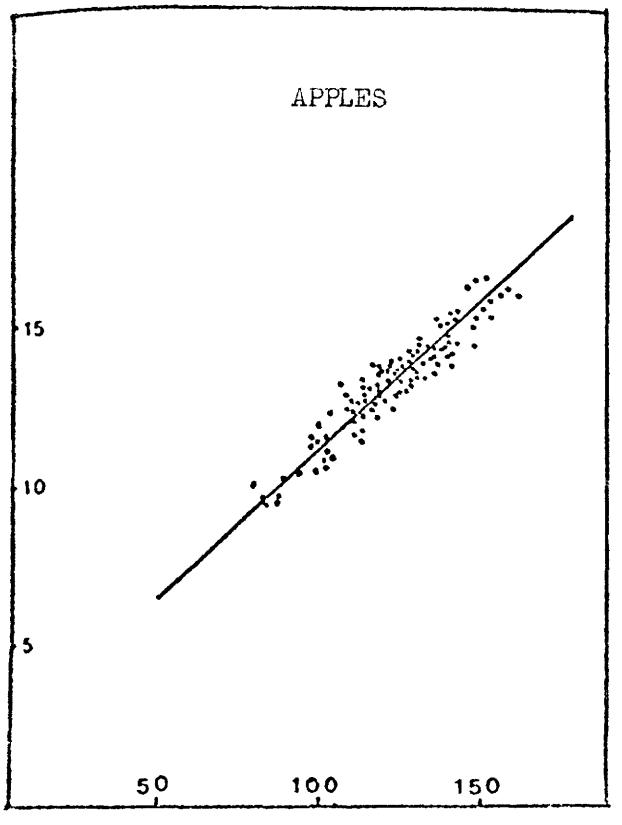
All these acids, and especially the first two, are present in varying degrees of concentration depending on species and variety.

The balance between the malic acid content and the citric acid content is considered to be a key element in the sensation of acidity perceived by the consumers.

Thus, for example, citric acid is dominant in tomatoes and certain varieties of peaches and apricots, while malic acid is overwhelmingly dominant in apples and pears.

The sensation of acidity of malic acid is generally considered to be more persistent than that of citric acid (39). On a weight for weight basis, therefore, this sensation should be stronger with fruits which mainly contain malic acid. But the proportion of the total acidity which is present in the form of salts is more often than not greater when malic acid is dominant than when there is a preponderance of citric acid. In those conditions the ratio of titratable acidity to alkalinity of the ash approaches unity or even falls below that value, the pH rises and the sensation of acidity is thus in reality weaker (13).

CORRELATION OF REFRACTIVE INDEX
AND TOTAL SUGAR



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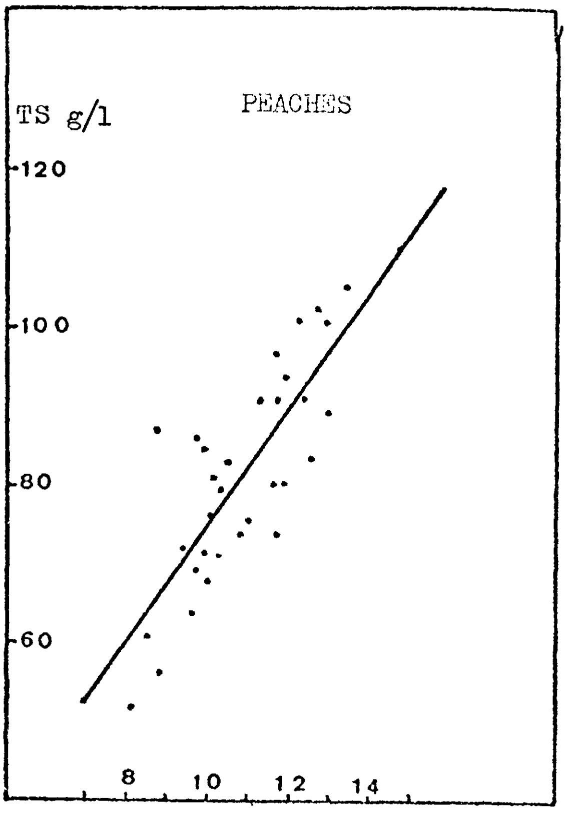
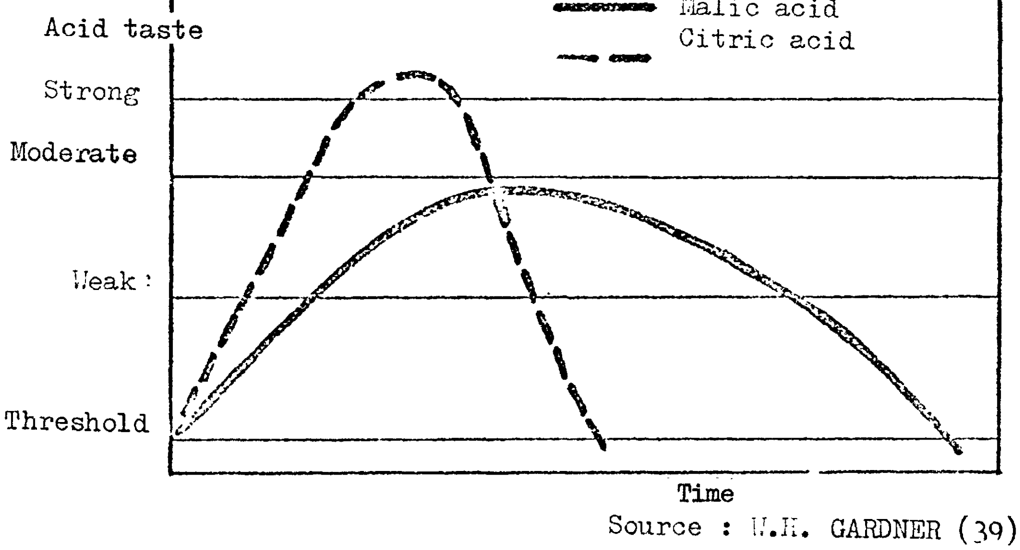


source : M. SCUTY (88)

PERSISTENCE OF ACID TASTE



Source : W.H. GARDNER (39)

Malic acid also deteriorates more rapidly as a result of oxidation, whereas citric acid seems to resist the effects of the respiratory activity of the fruit over a more extended period. The result is that the acid content of fruit in which citric acid is dominant, falls more slowly after picking. Thus, although the acid taste of malic acid is more persistent than that of citric acid, most of the fruits in which the latter is dominant are nevertheless perceived as more acid, because they contain more free acid and because the decomposition of the acids as a result of respiration takes longer to occur after picking.

The quantitative analysis of the amount of free acid present can be carried out by neutralizing a given volume of juice with a caustic soda solution in the presence of coloured indicators. For colourless solutions, the standard indicator is an alcoholic solution of phenolphthalein, which changes from colourless to carmine red when the solution reaches pH 8.2 or over.

The electrometric measurement of pH is a direct method of determining the hydrogen ion content of fruits or vegetables but the pH of these products varies within fairly narrow limits and can only be precisely measured by sophisticated equipment which is difficult to use in everyday conditions.

There is however, a very simple way of measuring pH, by means of papers impregnated with coloured indicators, to find out rapidly if the juice of a fruit is above or below a certain pH value. This may be a fairly crude classification, but it is nevertheless useful, particularly in the rapid selection of new varieties of fruit obtained by hybridization (40).

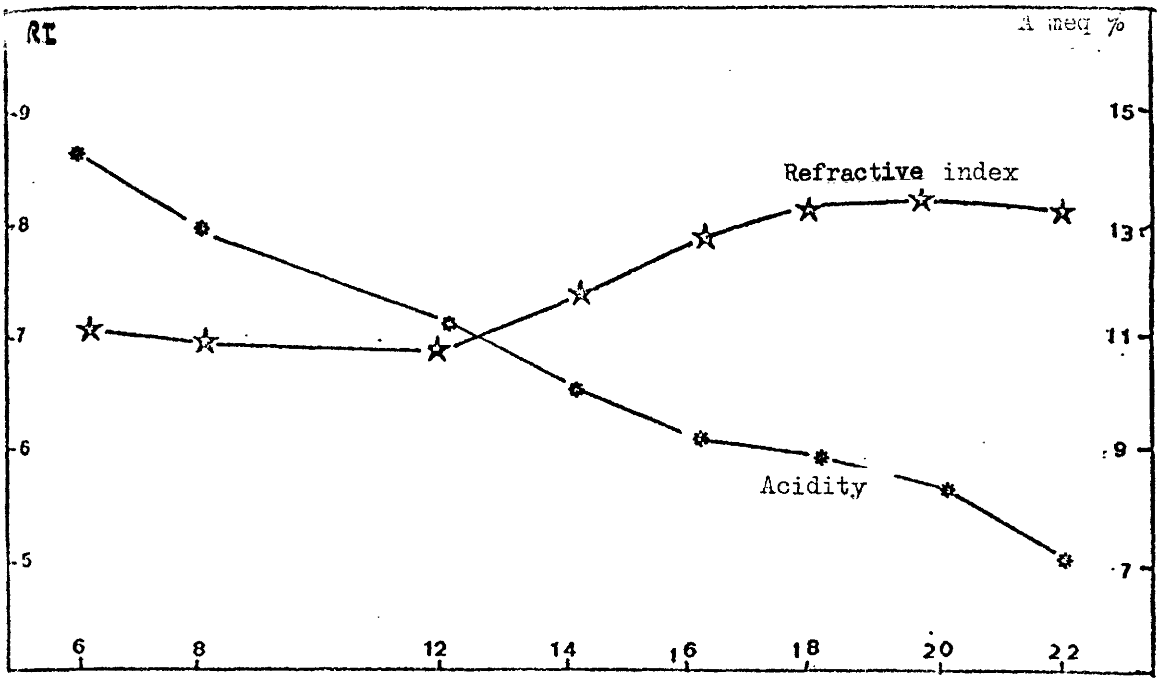
Total acidity can be determined by summing the alkalinity of the ash and the titratable acidity. The ash is obtained by firing the dry matter, and the alkalinity is measured by the amount of acid necessary to dissolve the carbonates thus obtained.

213.3 - The sugar/acid ratio

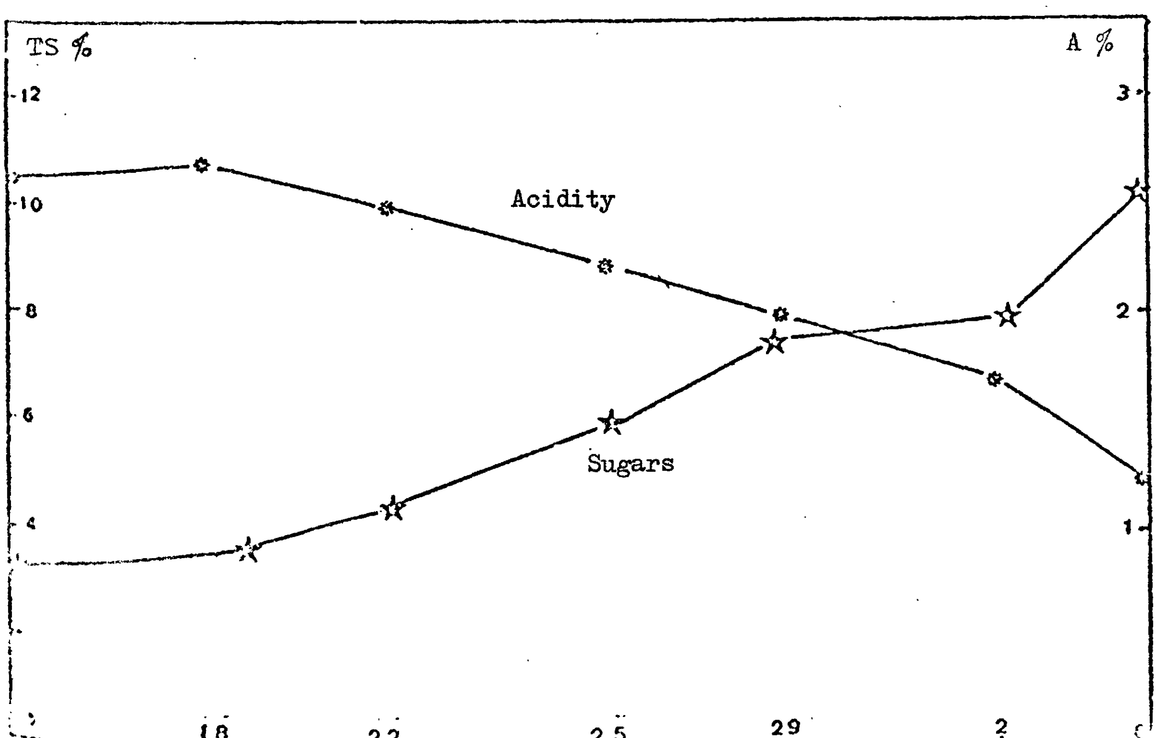
Sweetness and acidity, as perceived by the organs of taste, may balance each other. The development of these two components, and the balance between the two, are therefore vital aspects of the gustatory quality of fruit and vegetables as perceived by the consumer.

Internally, a given fruit or vegetable will show an increase in the one component as the other decreases.

EVOLUTION OF SUGARS AND ACIDITY



PEACH (Springtime) - June 1973



APRICOT (Canino) - 1965

Source : *M. SOUTY*

The carbohydrates increase slowly in the early stages of growth of the fruit, by the accumulation of simple sugars and the formation of starch, but then the starch content begins to decrease, and this decrease corresponds with a rapid increase in the sugar content. As the fruit approaches maturity the proportion of sucrose increases.

At the same time as this development is taking place, it has been observed that the rate of respiration of the fruits gradually falls between fruit set and picking. But in certain species the rate of respiration suddenly picks up again for a short period as maturity approaches in what is known as the climateric crisis, in the course of which the fruits produce ethylene, which plays a key role in triggering off the ripening processes.

When this climacteric crisis takes place, there is a rapid fall in sucrose, but the level of total sugars remains stable.

The acid content increases rapidly at the fruitlet stage, soon reaches a maximum and then falls at a steady rate throughout the growing period of the fruit. This regression also continues after picking if respiration is not slowed down by controlled storage.

Over time, therefore, the sugars steadily increase and the acids steadily decrease. It may therefore be said that the sugar/acid ratio steadily increases, so that its value at a certain point in time will be right for the consumer to feel that the flavour has become agreeable.

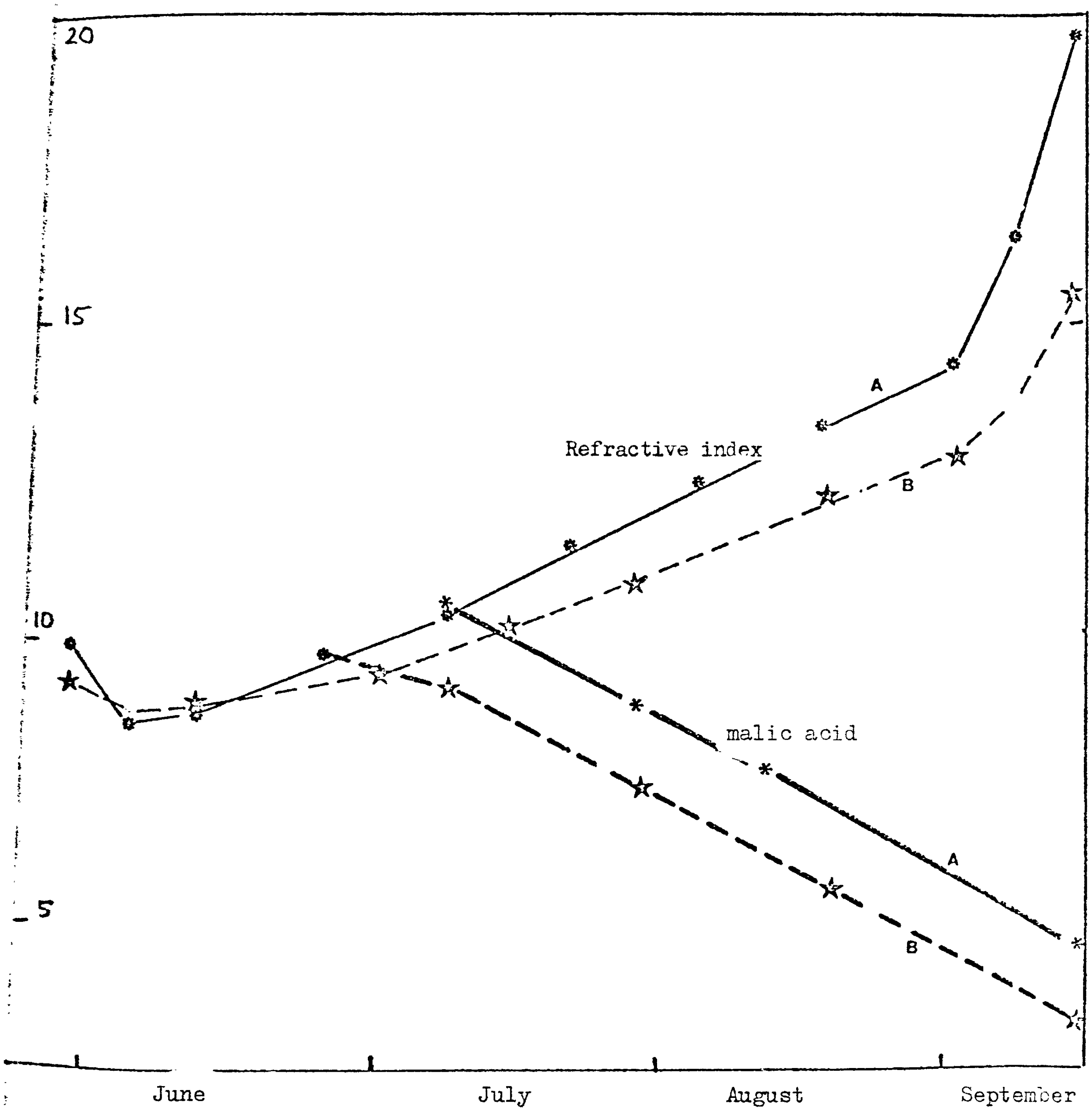
The achievement of this balance is a sine qua non of quality: if it is too low, the flavour is held to be over-acid, but if it is too high, the flavour is considered to be sugary or too sweet.

If, instead of concentrating on the development of sugars and acids in a single fruit over time, we consider their relative levels in fruits picked from different trees at the same stage of development, we can observe in general that higher sugars tend to coincide with higher levels of acidity.

In practice, therefore, it can be assumed that total acidity and total sugars in fruit can rise or fall in parallel, depending on climatic or cultural conditions (41).

EVOLUTION OF SUGARS AND ACIDITY
IN TWO ORCHARDS

Golden Delicious / M IX 1971



Assuming this to be so, one can record comparable sugar/acid ratios, although the individual values of both terms may be different. In this case, the higher the concentrations of acids and sugars, the more acceptable the consumer will find the flavour perceived.

Consequently, if the sugar/acid ratio is a basic test of the quality of fruit, this grading process depends above all on the sum total of acids + sugars when the ratio has attained a certain value. The reader is reminded, however, that the acceptability threshold for this sugar/acid ratio not only varies between individuals but also varies according to the individual's physiological condition and eating habits.

213.4 - The phenolic compounds

The phenolic compounds present in fruits and vegetables include pigments (flavonols, anthocyanins) whose role in flavour formation would appear to be very limited ; but they also include the tannins responsible for the astringency of certain fruits and vegetables.

These tannins, which are particularly abundant in certain fruits such as medlars, persimmons and bilberries, for example, disappear when the sugars accumulate, particularly as maturation approaches.

They are also responsible for the browning of the flesh after damage suffered by fruit and vegetables in the course of packing or transportation. Tannins therefore play a double role, as far as quality is concerned, because they change the appearance of the products by registering any bruising that may occur and they also influence the gustatory quality of the product by the astringency they impart to the flavour.

The extent to which they are present would appear to be related to the presence of pectin compounds, and tannin content therefore depends on the date chosen for picking.

It has been shown, particularly with peaches, that when the fruits are picked unripe the regression of the tannins does not occur after picking as it does in the fruit which remains on the tree (42).

213.5 - The nitrogen compounds

The nitrogen compounds in the form of amino acids have an important role to play in the composition of living matter.

They are mainly formed in the young tissues at the beginning of their growth, but their formation in fruit is also reactivated at the time of the climacteric crisis, because their systhesis depends on the rate of respiration.

Increasing importance is being attached to the role of amino acids in the gustatory sensations, e.g. aspartic acid and glutamic acid (43), which are particularly abundant in carrots and tomatoes, in which their presence has already been indicated (44).

2.14 - The components of aroma

The sensation of aroma is more complex than that of taste, both for the number of substances involved and for the way in which they are synthesized.

214.1 - Formation of aromas

The synthesis of the volatile compounds which form aroma is affected by the same external factors, as are the major constituents of fruit and vegetables such as sugars and acids, etc....

The processes leading to the development of aroma can be divided into three types (19) :

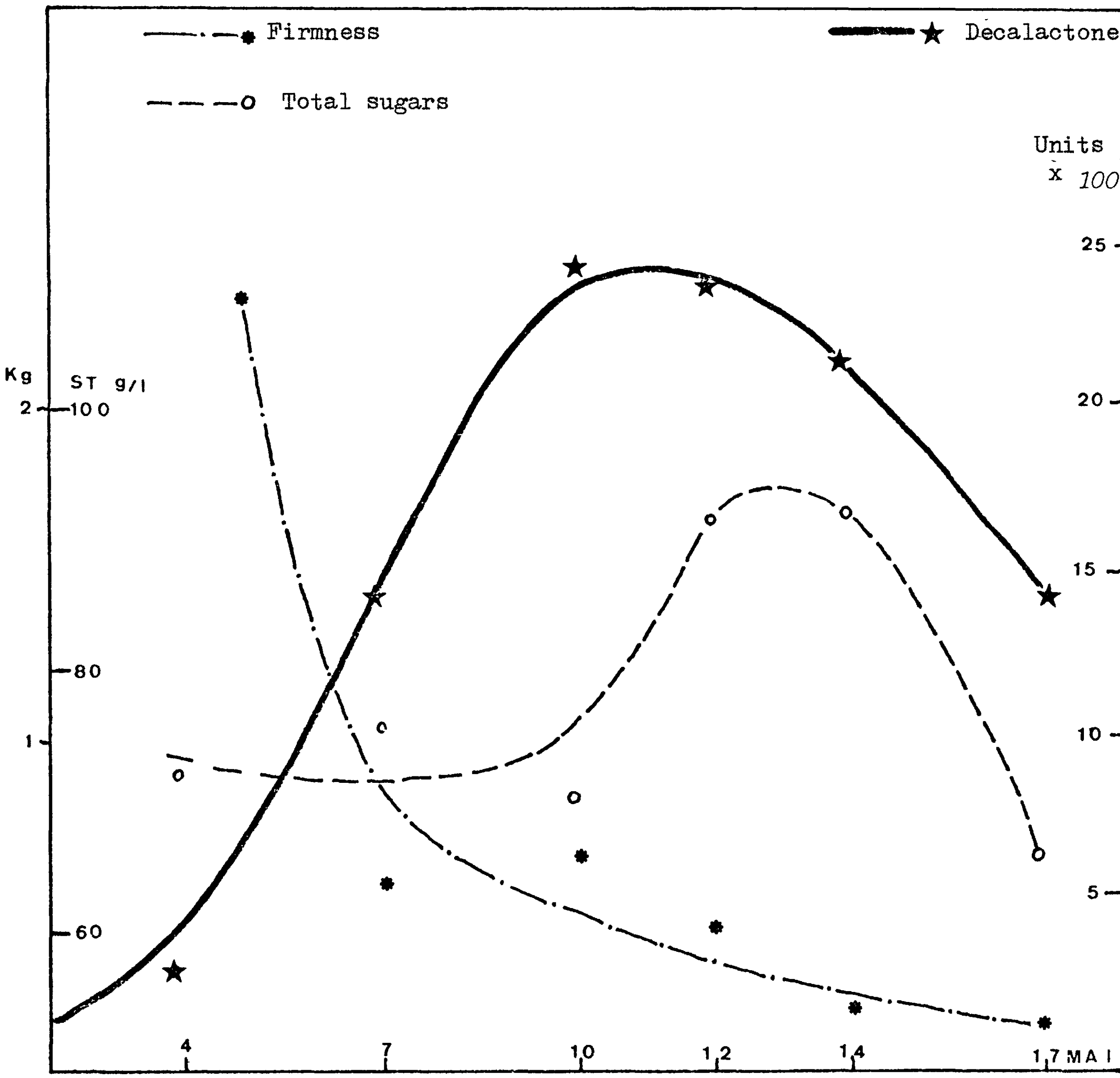
- continuous production, generally by secretion of aromatic substances through the glands to be found in the leaves of herbs such as thyme and bay and also in the leaves of carrots and French beans.

  In this case, the aroma secreted by the young organs is identical to the aroma secreted at the end of the growing period.

- production of the aroma at a particular physiological stage, as is generally the case with all fruits.

  In this case, the formation of the volatile substances depends on a number of physiological processes which begin when the fruit starts to ripen, as revealed by the regression of chlorophyll, the accumulation of sugars and the softening of the fruit as a result of the transformation of the pectin compounds.

- synthesis of aroma at a later stage, independently of the plant, as the result of an enzymatic process when the cells are crushed in the mouth. This applies in particular to the vegetables used for seasoning, such as the onion, garlic or mustard. In this case, the aroma exists in the product only in the form of precursors.



EMMISSION OF AROMA BY PEACHES

Cultivar : Springtime 1974

(Source : C. BAYONOVE (54)

214.2 - Methods of identification and quantitative analysis

The main constituents of aromas can be separated and identified by gas chromatography. The results are expressed in a graph known as an aromagram, the successive peaks of which are an indication of amounts of the different substances present, as they are successively separated by distillation.

The aromagram reveals the whole range of aromatic substances, starting with the most volatile products and ending with the heaviest.

Long lists of volatile products can thus be established, and it is difficult to pinpoint those which are the most representative of the aroma whose characteristics are being determined. The chromatogram can only serve to differentiate, whereas the olfactory organ is an integrator (45).

The method of odour description which consists in impregnating a filter paper with each substance at the time of emission and then attempting to recognize the aroma by sniffing is extremely empirical and subjective.

It has recently become possible, with the aid of the computer, to obtain a simultaneous graphical comparison of several aromagrams, but the qualitative assessment and more particularly the quantitative analysis of the volatile products which really contribute to the sensation of aroma is still a difficult matter.

The various volatile substances can be precisely identified by the techniques of chromatography and mass spectrometry applied in linked sequence.

The problem is then to distinguish between the products which are specific to the aroma being analyzed, and those which are not. The major components are often not particularly significant, because of their high perception threshold (46), whereas certain substances that are present in very low concentrations may have a significant effect on the characteristic aroma of a given variety.

The aromatic substances are therefore a field in which the state of scientific knowledge is not improving very rapidly, because of the extremely complex methods exployed, especially as far as practical applications for the selection of fruits and vegetables are concerned.

Certain specific substances have been shown to be particularly important, either because they are highly characteristic components of the aroma of certain fruits and vegetables or because they can serve as quantitative indicators of total aroma.

Thus, in the case of William pears, a connection has been traced between aromatic concentration and the presence of a particularly characteristic product (trans : 2 - Cis : 4 decadienoic acid).

The coincidence of formation of decadienoate with the climacteric phase has been demonstrated (47).

As it can be quickly determined by spectrometry, the level of concentration of this substance can be used for following the changes in the product which occur during the industrial processing of this variety of pear, which is much used in the canning industry.

In peaches, the lactone group of compounds, and especially gamma decalactone, have been identified as significant components of the aroma, but other volatile compounds must also be involved.

In apples, two main groups have been observed :

- the group in which the aromagram is dominated by esters, as in such varieties as Cox's Orange Pippin, Jonathan or Golden Delicious;
- a second group, in which alcohols dominate, as in the different varieties of Reinette (46).

214.3 - Methods of capture

Because the volatile substances undergo rapid changes, either in the product on maturation or as a result of the crushing of the cells in the mouth, the methods employed to capture these substances prior to their chromatographic analysis can have a major influence on the resulting aromagram.

These methods of capture can be divided into two groups : those which leave the fruit intact and are based on the collection of evaporated gases and those which involve the collection of volatile products by extraction after crushing (48).

Ripe fruit can be placed in a closed atmosphere, and direct samples of the volatile products can then be taken by means of a gas syringe.

It is also possible to concentrate the volatile products in a cold trap, to obtain an essential oil, or to proceed by adsorption on activated charcoal followed by desorption by heating under vacuum or extraction with various solvents.

PAILLARD (49) has developed a simplified method of salting out the volatile compounds with various salts and sulphates of ammonium anhydride from pieces of fresh fruit frozen in liquid ammonia and then crushed.

This only reveals the major constituents of the aroma. But one advantage of this technique is that small samples are quite satisfactory, whereas far larger quantities of the product are needed for the adsorption method of analysis. Nor is it possible to obtain a valid chromatogram by sampling the gas in the headspace around the ripe fruits.

2.2 : NON-DESTRUCTIVE TESTS

The non-destructive tests which are the first stage in the qualitative selection of fruit and vegetables can provide an indication of quality which may then justify the application of techniques of a more sophisticated and more destructive nature, and they can also facilitate the grading of the product.

By their very nature fruits and vegetables are a collection of individuals ; it is necessary to determine their variation round an average with a maximum degree of precision. That is why, from a practical point of view, the non-destructive tests can serve a very useful purpose.

These tests can be based on entirely empirical observations, mostly of a visual nature (colour, form) which result in subjective judgments.

Through the application of modern techniques we are steadily reducing the risk of subjectivity and increasing the objectivity of the non-destructive tests of colour, firmness, etc. But all the non-destructive tests which are based on the external appearance of the fruit depend primarily on the variety, precisely because the parameters adopted are those which are used for defining the varietal norm. In addition, certain criteria such as colour or form can be considerably influenced by natural conditions, and particularly by climate.

It must therefore be made clear from the outset that the non-destructive tests which are based on the appearance of the product are only valid for fruits of the same variety grown in the same climate under identical cultural conditions.

This means that although one can assess the quality of the product by means of visual criteria, the tests can only be applied with complete validity to successive batches of the product from the same parcel of land.

This confirms the utility of visual tests for the grading of fruit but it also confirms their limitations in this respect.

2.21 : Colour

Assessment of the colour of fruit and vegetables is one of the commonest non-destructive tests, because colour is closely linked with quality in a variety of ways.

221.1 - Colour in fruit

Colour always appears at a late stage of development and coincides with the biochemical changes which are characteristic of maturation. This process involves two interrelated biological processes : on the one hand chlorophyll diminishes when ethylene is produced, so that the green colour disappears or at least becomes paler, while on the other hand there is a process of accumulation of yellow or red pigments (carotenoids or anthocyanins), depending on the nutrients available to the fruit and on climatic conditions.

The two phenomena combine to produce a certain intensity of colour that is typical for the variety, and at the same time they ensure its uniformity.

One should therefore distinguish between two methods of appreciating the colour of fruit, one of which mainly involves the disappearance of the green colour, which can be observed by noting the basic colour of the epidermis, while the other may involve the appearance of highly coloured patches resulting mainly from the presence of the anthocyanin pigments which determine the development of colours varying from red-orange to deep red.

The basic colour depends mainly on the biochemical changes which accompany maturation, whereas the intensity of pigmentation of the more highly coloured patches is very greatly influenced by the climatic and nutritional factors (50).

A very close correlation has often been observed, between the colour of the epidermis or the flesh and the amounts of sugars present.

Thus, for example :

.... In Golden Delicious apples, there would appear to be a close correlation between the intensity of the yellow pigmentation in the epidermis of the ripe fruit and the total sugars (51), depending on the amount of light received by each fruit. Colour and sugars vary in the same direction (35).

But different sugars have different effects, as far as pigmentation is concerned. Fructose and glucose have a high and constant effect on coloration, whereas the effect of sucrose increases as the season advances. A generous supply of calcium has also been shown to have a beneficial effect on colour, and a synergistic effect has also been noted, in that sugars and calcium together produce a more intense coloration than is provided by the sum of their two separate effects (52).

The colour of the flesh, which is due to the complete disappearance of chlorophyll, is an even more characteristic criterion of the intrinsic quality of fruit, especially in the case of those which are naturally highly coloured (53).

In peaches, the rapid development of colour closely coincides with the phase in which sucrose accumulates, and with the commencement of biosynthesis of aroma.

The area and intensity of red pigmentation therefore provide a fairly precise indication of the ripeness of the fruit (54).

As in apples, the colouring of peach flesh is also related to maturation and to the amounts of sugars present (55). But it is important to remember the extent to which peach colour can be affected by latent viruses which can cause the colour to be less uniform and the epidermis to be less regular than in fruits from healthy clones (2).

In pears, the effect of the chemical composition of the fruits on their colour is partly masked by the natural greeness of many varieties, which may be accompanied by a marked russeting of the epidermis, as in the Conference and Passe-Crassane varieties for example.

Colour is nevertheless a good indication of maturity and quality in pears (as in apples) for those varieties which develop a pale yellow epidermis on maturity (56). In the same way, the presence of red-pigmented patches can also be taken to be an additional indicator of quality.

.... In melons, the regression of the green pigmentation of the epidermis is considered to be a criterion of maturity ; in addition, in all varieties of melons, the internal colour of the flesh can be treated as a sign of quality.

.... In tomatoes, the appearance of the red colouring is a very clear indication of maturity, and the homogeneity and intensity of the red pigmentation are related to the amounts of sugars present (57).

221.2 - Colour in vegetables

In the case of vegetables other than those grown for their fruits, colour can also be used as a primary indicator of quality.

In carrots, the carotene content is obviously correlated with the intensity of the orange-red colour of the root. In the case of salad crops, and especially in lettuces, a slight change of intensity in the green colour, tending towards a paler shade, is a clear sign of what the French call "un bon stade de maturité".

By contrast, the presence of excessive yellow pigmentation is held to be an indication that the vegetable has reached an advanced state of maturity

221.3 - Methods of measuring colour

Subjective methods based on personal expertise have been used from time immemorial to assess the ripeness of fruit on the basis of colour.

A few years ago, a first attempt was made to codify these methods by the use of special charts showing the typical colours of Golden Delicious apples at the different stages of maturation.

These charts are in the form of panels, covering the whole range of shades between dark green and yellow, and are very widely used in the trade in this variety of apple within the European Community (58).

As far as laboratory work is concerned, equipment has been available for several years for measuring both the external colour of the fruit and the internal development or regression of chlorophyll in the flesh.

Mechanical sorting equipment based on the same principles, has also been developed, and has now reached the stage at which it is possible to consider installing such equipment in packing stations, with a view to sorting fruit on the basis of several different intensities of pigmentation.

This equipment is based either on the measurement of the degree of reflectance of the external colour of the fruits, especially in tomatoes and peaches (59), or on measurement of the optical density to determine the chlorophyll content of the flesh (60).

2.22 - Morphological criteria

The relationship between form and appearance in fruit and vegetables results from the close connection between their harmonious development and the nutritional factors which determine their intrinsic quality.

221.1 - Form

The first point to be stressed about the external form of fruit and vegetables is the fact that it is constant for each variety.

This outward appearance may nevertheless be influenced by climatic factors, which may cause a certain amount of variation in quality. Hence the need for strict definition of the norms for each variety and each cultural environment.

In apples, for example, the effect of light starvation as a result of haziness of the atmosphere can increase the correlation between the axial and equatorial dimensions of individual fruits and can also reduce the depth of the stalk cavity (61).

In warmer regions, the combined effects of high temperatures and increased exposure to Spring sunlight tend to provoke a flattening of the fruit and therefore a marked fall in the ratio of axial to equatorial dimensions (62).

In the same climatic conditions, it has nevertheless been shown that quality is better when the axial/equatorial ratio is nearest to the normal value for the variety than when the correlation is too close at the northern end or not close enough at the southern end of the range of cultivation (63). It should also be pointed out that this ratio can vary in relation to the number of pips and is therefore influenced by the pollination factor (64).

It is therefore clear that although the relationship between external form and intrinsic quality in apples has been irrefutably demonstrated, this criterion can only be validly applied if the conditions of climate and pollination are strictly identical.

In peaches, and in stone fruits in general, the lateral swelling of the fruit, i.e. the increase in its equatorial diameter measured at an angle of 90° to the suture line, is a development which occurs at a later stage of maturation, and this development is more rapid than that of the other parts of the fruit.

Thus the shape of those fruits which are insufficiently developed is often dumpy and asymetrical and very different from the morphological norm for the variety (65).

In carrots, the length of the root and the relationship between the diameter of the root and the diameter of the core may also be used as a criterion of quality (66).

In melons, as in other fruits, a poor equatorial diameter can be taken as evidence of insufficient development and therefore as an indication that quality may well be inferior also.

As far as salad crops are concerned, the form of the head, and especially any elongation, is considered to be an indication that the product has passed beyond maturity, to the detriment of quality.

222.2 - Development of various parts of fruits and vegetables

The equatorial diameter always reflects the amount of nutrition absorbed by the product. Thus, in fruit trees, the fruits which are favourably located develop more rapidly than the others, and this is reflected in their superior size on maturity and in higher intrinsic quality.

For fruits and vegetables of different origins, this criterion obviously loses its significance because certain cultural practices such as excessive irrigation can bring about a substantial increase in the volume of these products, with an adverse effect on quality.

It is therefore only within the confines of a specific parcel of land that the quality of the product can be validly determined on the basis of size. In such conditions, however, both size and colour can be extremely useful in practice for separating the products into batches of clearly differentiated quality.

Size is a criterion which can also be measured in terms of average weight and is therefore related to the concentration of sugars in the fruit, in apples (67) (68) and in peaches (65), to name but two examples.

But this relationship is also influenced by the volume of the crop. Thus in a good year, with a high yield, the effect of competition between the fruits limits the relationship between average weights and total sugars ; but in a poor year the correlation between the two is far more striking (69). This explains why the relationship has not been very clearly demonstrated in some cases (70).

The pistil cavity in which the "eye" of the fruit is located, and the stalk cavity both show variations in depth and breadth which are closely linked with the conditions under which the fruits are grown.

These measurements are often used as a criterion of quality in different species of pipped fruits (apples, pears) (67). Thus, for example, the depth and breadth of the pistil cavity are closely correlated with the concentration of sugars in many varieties of apples (68) and pears (71).

- Lenticels

In the case of fruit, and especially in the case of apples, the suberization of the stomata in the epidermis leads to the formation of lenticels; their density in the region of the calyx can be taken as a reliable indication of good development.

Lenticel deficiency, or an over-abundance of lenticels is always an indication of abnormal development of the fruit (63).

- Leaf ribbing is also taken to be an indication of the over-development of salad vegetables, or of some nutritional disturbance, which is always detrimental to quality.

2.23 - Firmness and turgidity

The relationship between the firmness of the fruits and the biochemical changes inherent in maturation have already been idicated.

The measurement of diminishing firmness is therefore the most satisfactory test of maturity in fruit. But in the past, because it relied on penetrometers, the method could not be classified as non-destructive.

Methods have recently been developed for testing firmness by transmitting vibrations through the fruit. So we now have the prospect of automatic and non-destructive grading of fruit based on the degree of maturity (32).

In addition to the biochemical changes which lead to loss of firmness after the product has been picked, there is also a loss of turgidity which can be directly attributed to transpiration. The more water the product contains, and the more the conditions of storage favour evaporation, the more rapid the loss of turgidity will be.

This loss of water is reflected in a wilting process, which is fairly slow in fruit and finally results in a wrinkled epidermis, which at the same time becomes more elastic.

In vegetables, the wilting process first affects the foilage, which becomes limp and dull and begins to turn yellow as a result of the regression of chlorophyll.

This appearance is considered to indicate the absence of that "freshness" in the product to which the consumers attach the greatest importance,, especially in vegetables, and this applies a fortiori to products grown for their leaves, as is the case with salad crops.

Assessment of the freshness of fruit and vegetables must therefore be treated as one of the major non-destructive tests of quality.

2.3 : ANALYTICAL TESTS OF ORGANOLEPTIC QUALITY

The non-destructive tests which we have described can be applied to each individual fruit and vegetable. But the evidence of quality they provide is only of a presumptive nature, and their validity depends on the origin of the product.

These tests must therefore be supplemented by objective and quantified measurements for appraising the value of different batches of fruits and vegetables having different origins.

In principle, each and every component of the product can be treated as a criterion of quality. But it is not always possible to measure them all, or to establish their scale of values.

Thus, for example, among the various criteria which are taken into account for the selection of different varieties or for hybridizing purposes, the greatest significance may be attached to certain aromatic substances or to substances likely to produce an unplesant flavour, such as bitterness, by simply comparing the analytical results for different clones.

One can also proceed by selecting clones for their particularly high concentration of fundamental substances, such as sugars, on condition that this does not affect the balance with the other components of flavour and providing there is no adverse effect on the cultural and commercial qualities of the clones.

In this context, there is every indication that the quality of fruit and vegetables will be improved in future by genetic selection and the breeding of new varieties; but this is a long-drawn-out process, fraught with numerous difficulties, and it requires the joint application of quantitative and qualitative parameters.

For the time being, the principal aim should be to improve the products which have emerged from a whole range of varietal selections which have mostly been based on productivity.

The analytical and destructive tests that have been described are thus intended to provide a simple system of qualitative selection which is easy to apply "en masse" to the products offered to the consumers.

They rely on a certain number of chemical tests or physical measurements which mostly have a destructive effect on the products tested. One must therefore destroy the smallest possible amount, after first making sure that the sample is truly representative.

2.31 : Sampling

. Minimum sample size

The natural heterogeneity of fruits and vegetables is such that their quality cannot be homogenized to the extent that this is possible with liquids such as milk and wine.

Fruits and vegetables remain in essence a multitude of separate individuals, and their homogeneity must be measured in terms of their approximation to the qualitative norms adopted.

This can be done by means of non-destructive visual tests, such as those of colour and size in particular, to determine the degree of heterogeneity of these products in bulk.

In practice, the number of fruits or vegetables which have to be analyzed to obtain sufficiently accurate results for the purposes of a test is given by the formula

$$N = \left(\frac{2\ s}{p} \right)^2$$

in which 2 s corresponds to twice the standard deviation from the mean and p equals the degree of precision required.

Experience has shown that a sample of at least 50 apples or 75 peaches is required if a test which is based on the variance of the sugar or acid content of the fruit is to be valid if the lots of fruit are unselected ("tout venant"), but that the number can be reduced to 30 when the products are first sorted on the basis of colour and size (62).

Samples can be taken in the orchard, just before or just after picking, or from the bins in the packing station.

If the first procedure is adopted, one should select a minimum number of fruits, from all parts of the trees, with a uniform spread of selection over the whole parcel of land.

If the samples are taken direct from the trees, due account must be taken of the variation of the product as between the different parts of the tree, and especially of the varying degrees of exposure to light, which is at a maximum at the top of the tree and at a minimum among those lower branches which are shaded by the outer foliage.

The fruits sampled must therefore be collected from the zone of average exposure of the crown, on the outside of the tree and on at least two opposite sides (65).

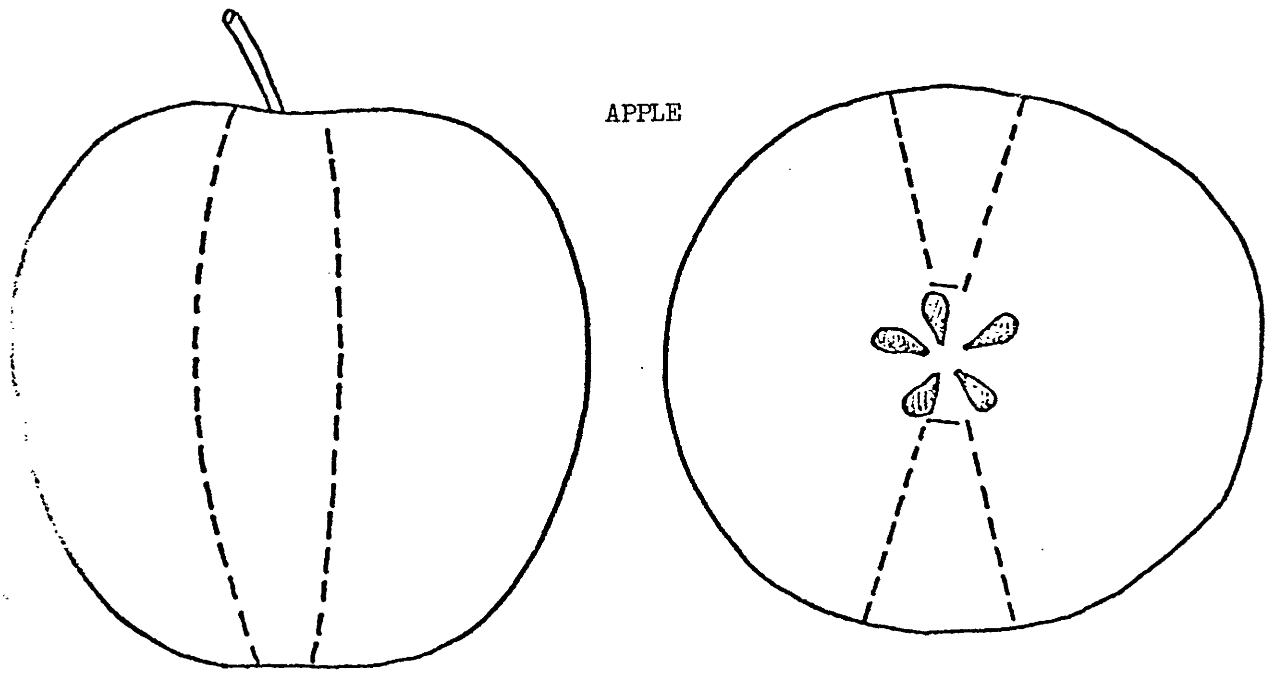
Fruits of abnormal size or colour are excluded from the sample, as are the trees which carry an excessive or insufficient crop in relation to the average carried on the parcel of land in question.

If the sampling process is carried out after picking, one should first check the degree of uniformity with the naked eye. If more than 20% of the products are markedly different from the most frequent type the products must be sorted before any samples are taken, to ensure uniformity.

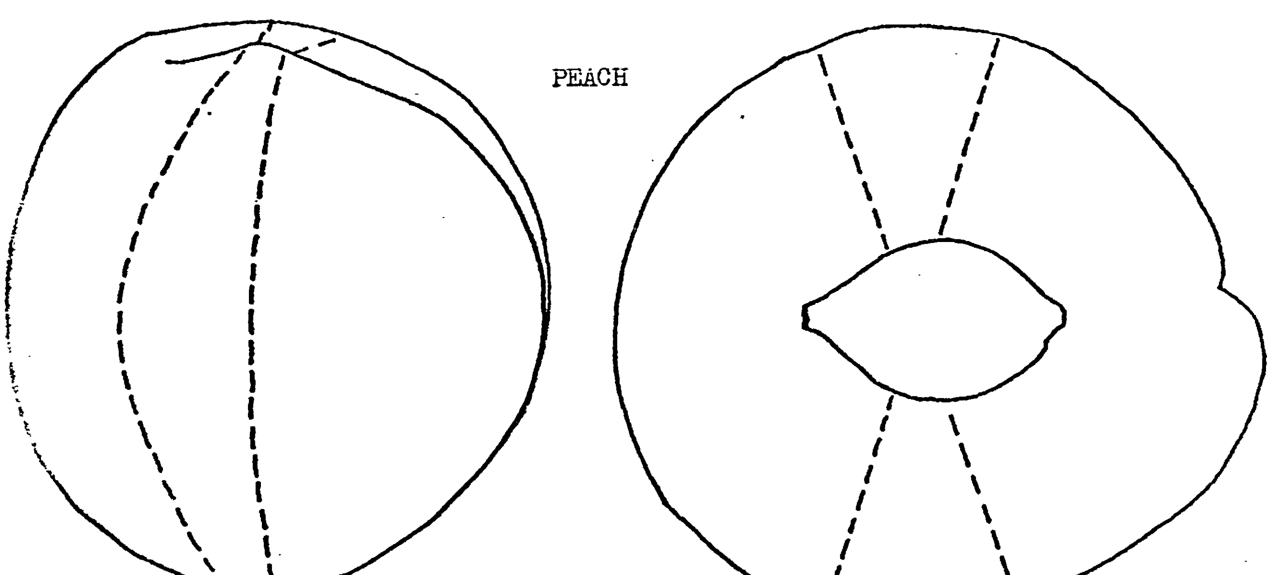
When this has been done, the samples are selected at random from a number of packages selected from the batch, but this number should not be less than $\frac{1}{4}$ of the number of pieces setting up the sample.

SAMPLING

APPLE



PEACH



. Extraction of juice

The juices extracted from fruit and vegetables can all be analyzed by simple techniques. They can be extracted by using an ordinary domestic centrifugal machine.

The various components, particularly the sugars and acids, can vary within each individual fruit or vegetable.

In fruit, for example, the sugar content is more concentrated towards the epidermis and also increases between the stalk and the pistil cup.

The components also vary between the part of the product exposed to the sunlight and the part that is not so exposed. In addition, the absence of pips from part of the fruit may result in lower sugar in that part of the fruit (64).

To obviate the need to extract large quantities of juice, which involves the crushing of whole fruits, one can extract the sample from a fragment, providing the latter is representative of the whole product.

In most cases, the extraction of two sectors in the same vertical plane from opposite sides of the product will ensure the representativeness of the sample, on condition that this section cuts through the most highly coloured and the least highly coloured part of the product if such a difference exists (72).

In the case of large fruits, e.g. melons, it is enough to extract two cylinders of flesh from opposite sides of the fruit, at the level of maximum cross-section.

If the separated juice is sufficiently clear, it can be analyzed at once; but if it is clouded by the presence of pulp in suspension it must be filtered through a nylon gauze or filter paper. But to ensure the availability of sufficient juice for the purpose in view it is best to wait until all the juice has been extracted from the sample. It must then be thoroughly mixed by shaking before any sample is taken for analysis, so as to avoid the risk of sedimentation.

In certain low-acid juices, a brown colour may develop very rapidly after the juice is extracted. This can be avoided by adding a pinch of thiourea when commencing the extraction process.

If required for complex analyses, such as the quantitative determination of sugars, the juices may be kept in a deep-freeze, in plastic flasks, provided they are frozen immediately.

2.32 - Measurement of firmness and texture

The importance of measuring firmness as a test of maturity has already been emphasized. Automated non-destructive tesing may be feasible for the packing stations, but otherwise the simplest test of firmness damages the fruit.

The test normally consists of measuring with a penetrometer the force required for a cylinder of given cross-section and length to penetrate the flesh of the sample (cf. 2.12).

The force opposing this penetration depends on the cohesion of the cells, which will vary with the pectins, and the presence of the other constituents of the cell walls (73).

But this force can also depend on the loss of water by dessication, which causes the tissues to become somewhat elastic, so that the values registered on the penetrometer are artificially increased (74).

The penetrometer readings are only valid, therefore, if they relate to fruits that are in a good state of turgidity.

In the special case of fruits with carpel cells which are more or less filled, as in tomatoes, the penetrometer will only determine the firmness of the flesh itself, whereas such fruits can be pushed out of shape to an extent which depends both on the firmness of the flesh and the size of the carpel cells (75).

Various more or less simple instruments can be used to measure this deformability.

2.33 : Quantitative analysis of sugars

It is generally agreed that the quantitative analysis of sugars is the most important and most widely applicable test of the gustatory quality of fruit and vegetables.

This test is important not only because the sugars impart sweetness but also because they serve as an indicator of the metabolic processes which produce all the other substances contained in the plant (76).

A correlation can be observed in very many cases between the level of sugars and the other components of flavour (53). Thus, for example, the components of the aroma of apples are related to the amount of total sugars (67). In the same way, it has been observed that an increase in the amount of soluble sugars in melons corresponds with a higher level of vitamin C (77).

. Importance of the different forms of sugars

The different sweetening capacities of the three main sugars that are encountered in fruit and vegetables, i.e. glucose, fructose and sucrose, determine the variations in the sensation of sweetness, because this sensation depends on the amounts of each sugar present. But this is mainly a varietal characteristic and can only be used by the breeders.

The proportion of sucrose is also significantly affected by cultural and climatic conditions. In fact it generally accumulates in fruit and vegetables at a late stage of their development, on the approach of maturity, and it is therefore a very good indicator of the biochemical development of these products (278).

In this context, the ratio of sucrose to the reducing sugars can be used as a test of maturity (78). Similarly, the variation of this ratio about the average value for the variety, for a given date of picking, is certainly the most precise standard of measurement of gustatory quality (79).

Its close correlation with the formation of aroma, as in peaches (54), or its evolution in the course of the canning process (80) are further reasons for taking this factor into consideration.

In fact, sucrose is steadily transformed into simple sugars in the canning process. But this inversion becomes slower at a certain point and the resultant change in the inversion curve will coincide with the over-ripeness of more than half the fruits in the batch (81).

Unfortunately, the quantitative analysis of sucrose is still a complicated operation requiring the use of specialized equipment of a scale which makes it difficult to carry out in normal practice, and it is therefore mainly restricted, at the present stage, to laboratory experiments. But it might be a practical proposition for any packing station large enough to carry the financial burden resulting from the purchase of such equipment, providing the higher price obtained for the top quality fruits thus selected were sufficient to justify the outlay.

. Total sugars

The close correlation which can be observed between sucrose and total sugar at the time of picking is a partial compensation for the trouble which has to be taken with quantitative analysis.

In fact, the increase in the amount of total sugar which can be observed in the final weeks before maturation is largely due to the accumulation of sucrose. Consequently, in addition to its contribution to the sensation of sweetness, total sugar also gives a fairly precise indication of the sucrose content.

Fruits stored under refrigeration after picking lose some of their sucrose; this is transformed into reducing sugars without affecting the level of total sugar, which remains very stable.

For the abovementioned reasons, total sugar has always proved to be closely correlated to the flavour ratings established by flavour panels, as well as to the other components of quality.

We have already quoted the results of a number of studies on this question. It is pertinent to add a comment on the relationship observed in apricots, in which sucrose is the very component which is responsible for a sudden increase in total sugar at the time of maturation (82), so that the fruit can be graded on the basis of soluble solids (83). In cherries also the measurement of total sugar and of colour is a fairly precise objective test of quality (84).

Likewise in melons, total sugar and external colouring can be taken together as tests of acceptability (85) and of ripeness (86); so this value can be included in the grading programmes, together with the other desirable characteristics of the fruit (87).

In peaches, the level of sugar is not only a quality in itself, but also appears to be related to the fruit's capacity for aroma synthesis (88).

In the main varieties of pears, total sugar is more closely correlated with quality than is any other characteristic, and this is particularly true of late varieties such as Passe Crassane (89), especially when the crop is not very acid (90).

The same correlation can also be observed in apples of all varieties; it applies with equal validity to early cultivars such as Gravenstein (91), long-keepers such as Golden Delicious (92) and late varieties such as Granny Smith (68).

In tomatoes, although acidity would seem to play a major role in the assessment of quality, the sugars are also closely correlated with the intensity of the flavour (44) and can therefore be measured as objective criteria of quality (93).

This relationship, which can be observed in all the fruits studied can also be found in vegetables. In carrots, there is a substantial increase in sucrose as harvest time approaches (94), and the same applies to salad vegetables, in which sweetness is one of the criteria of acceptability.

The simplest way of measuring total sugar is by refractometer. This instrument provides a rapid evaluation of sugars by measuring the dry matter content of the juice, of which the sugars are the main constituent. The correlation between the refractometer readings and the actual amounts of sugar present can vary amongst species.

Thus, for example, in cherries and gooseberries, the refractometer readings are 18 - 22% higher than the actual amount of dry matter. Nevertheless, for readings relating to the same species, the comparative values thus obtained are quite adequate for the use to which they are put (95).

Before measuring the dry matter by the refractometric method, the juice should be completely homogenized before a few drops are extracted for placing on the prism of the refractometer.

The juice must be clear enough to ensure good polarization and an accurate reading. By using a hand-instrument graduated from 0 - 30% one can read off the percentages of soluble dry residues. At the same time, the temperature is recorded by means of the thermometer incorporated in the instrument to facilitate the temperature corrections by which the refractometric reading is adjusted to correlate with a temperature of 20°C.

. <u>Starch</u>

The insoluble fraction of the dry extract, which is mainly represented in fruit and vegetables by the starch content can obviously not be subjected to quantitative analysis by the refractometric method.

In fruit in general, the presence of starch is an indication that the crop is insufficiently mature for picking. There is no need for quantitative analysis of starch at this stage, but the presence of the starch can easily be shown by smearing the flesh of the fruit with a solution of iodine.

The area of the patch of colour which thus develops gives one a good idea of the amount of starch still in the fruit.

In potatoes, the starch content is about 70% of the total dry matter. It makes the tubers mealy when cooked. The more mealy the potato, the less acceptable it is to the consumer (96).

The dry matter content is therefore an important objective criterion for assessing the quality of potatoes, but the optimum dry-matter content of the tubers varies according to the intended culinary applications.

A low starch content is sought in potatoes intended for steaming or sautéing, and this also applies to canning potatoes. Higher starch contents are preferred for soups and purees, but the highest starch requirements of all are for chips or crisps (97).

A sufficiently accurate measurement of the dry matter content of potatoes may be obtained in a simple manner, by measuring the specific gravity (37).

2.34 : Quantitative analysis of acidity

The part played by acidity in the determination of organoleptic quality in fruit and vegetables has already been emphasized, as has the importance of maintaining a balance between sugars and acids.

Depending on the acceptability threshold of the individual, excess acidity is always considered to be a defect in fruits such as apricots, cherries, and peaches, which are eaten immediately after picking.

This excess acidity is less of a handicap for fruits that are stored for long periods. Indeed, because the acids slowly decrease as a result of respiration, the longer the period for which it is intended to store the fruit, the higher the acidity must be when the fruit is picked, so that the quantitative analysis of acids can be seen to be a significant objective test. In many cases, even, it is indispensable (98).

The rate at which acidity decreases during storage would appear to vary from fruit to fruit, and it seems that these variations can be attributed to differences in cultural or climatic conditions. But the determining factors have not yet been clearly identified. Measurement of the rate of loss of acidity during storage therefore constitutes an important objective test of the degree of retention of gustatory quality : this observation is equally valid for apples (81) and for pears (90).

A simple method of smeasuring acidity is by quantitative analysis of the free acid, with the aid of an $\frac{N}{10}$ solution of sodium hydroxide to which has been added a coloured indicator, which is usually an alchol solution of phenolphthalein.

The volume of sodium hydroxide required to change the colour of the indicator serves as the basis for calculating the total acidity of the juice.

If the juice itself is highly coloured, as in cherries, it is not possible to use an indicator dye, so that the pH of the solution must be measured continuously as it is brought up to 8.2, the point at which phenolphthalein changes colour.

2.35 : Expression of results

The analytical results can either be applied as they stand, as absolute values, or they can be incorporated in more or less complex indices. The disadvantage of expressing these results in the form of indices is that part of the information is lost if the values of the various parameters composing the index can vary independently of one another.

For this reason, where the qualitative analyses are intended to provide information for scientific and technical research, and especially where this involves the calculation of correlations, it is always preferable to use the individual values of each parameter, so as to preserve the integrity of the various data.

However, in the case of qualitative analyses for the purposes of commercial selection, it is often far more practical to express the results in a simplified way, in the form of a quality index.

The calculation of such indices can itself be simplified by listing the values of the different criteria in a special table from which it is only necessary to read off the corresponding value of the quality index.

235.1 - The simple indices

Sugars and acids are the main criteria for determining quality, and they are often considered separately as simple indices.

• Sugars

Quantitative analysis of total sugar by the refractometric method provides a direct reading of the soluble dry matter content, expressed as a percentage. This index has been given a variety of names in the literature, including refractive index (RI), dry soluble extract (SE) or soluble solids (SS). For certain fruits, this index can form the basis of a table or scale from which the total sugar content (TS) can be read off.

This is particularly true of the juices of apples and grapes, for which the same table can be used (62).

The results of quantitative analyses by the colorimetric method are either expressed in grammes of sugar per litre of juice or in grammes of sugar per 100 g of the fresh matter of the product.

• Acidity

Titratable acidity can be expressed either in milliequivalents or in grammes of acid.

The milliequivalents represent the number of millilitres of Normal alkaline solution required for neutralizing 100 g or 100 ml of the product.

The advantage of expressing acidity in the form of milliequivalents, which is standard practice for tests carried out for research purposes, is that it constitutes an objective statement of acidity, without taking any account of the variety of acids of which the acidity of the product is composed.

When the tests are applied for commercial purposes, however, the results are often expressed in terms of grammes of acid, because this is a more direct expression of acidity for the persons using the figures.

In the latter case, the volume of alkaline solution needed to neutralize the acidity is converted into grammes of acid per litre of juice (or per 100 grammes of the fresh product) usually expressed in terms of the main acid in the product in question.

Thus, for example, malic acid is taken into account for apples and pears, citric acid for citrus fruit and tartaric acid for grapes.

For this purpose, each acid has its own coefficient. Thus, for example, in the case of malic acid the calculation of acidity in grammes per litre uses the following formula :

$$V \times 0.0067 \times \frac{1\ 000}{Vo}$$

in which V is the volume in millilitres of the $\frac{N}{10}$ solution of sodium hydroxide.

Vo is the volume in millilitres of the sample utilized. This means, in practice, that if a 10 ml sample is taken, the volume of alkaline solution required will be multiplied by 0.67.

To express the results for citric acid, one applies the coefficient 0.64 in the same way, while for tartaric acid the coefficient is 0.75.

In certain cases, instead of using the $\frac{N}{10}$ solution of sodium hydroxide, a slightly different titration is carried out, with a sample having its volume so fixed as to ensure that the acidity of the juice, as expressed in grammes per litre of the acid chosen, is directly represented by the volume of solution required, so as to avoid the need for calculations.

Thus, for example, for grape juice, the procedure is to employ a 33.3% Normal solution with a juice sample of 12.5 ml, to give a direct reading of the results in grammes of tartaric acid per litre (99).

For citrus fruit, by taking a 15.63% Normal solution and a sample of 10 ml, the results can be expressed directly in grammes of citric acid per litre (100).

In the case of malic acid, one could use a 14.92% solution (containing 5.96 g of soda per litre, instead of 4 g for the 10% Normal solution) and a sample of 10 cm^3 of juice.

These methods for obtaining direct readings of acidity can be used for many types of measurement to facilitate the recording of results which have to be expressed in grammes of acid per litre, but the snag is that the sodium hydroxide solutions required for the purpose are different from the 10% Normal solutions that are commercially available.

It is therefore the standard practice to use the 10% Normal solution.

235.2 - The complex indices

In practice, it is often useful to express results in a combined form, in a single numerical index, i.e. a value extracted from the data by addition, subtraction, ratio or correlation of the figures obtained from the tests.

But every effort should be made in such cases to ensure that the parameters incorporated in the index are all expressed in compatible units of measurement.

- The sugar/acid ratio

The ratio of total sugar to the titratable acidity of the fruits is often used as an index of maturity and can be considered as an indication of minimum quality.

It can be expressed in the form total sugar/total acid (TS/A), and in that case the two values must be expressed in the same units, i.e. in grammes per litre or in grammes per 100 grammes of the fresh matter.

If no tables are available for converting the refractive index into total sugar, one can use the value of the refractive index or the figure for dry soluble extract (RI/A or SS/A).

If the refractive index is used without the coefficient, the resulting value is a percentage, and in this case the corresponding value for acidity must be expressed in grammes or in milliequivalents per 100 grammes of the fresh product or 100 ml of juice.

If, on the other hand, the acidity is expressed in grammes per litre or in milliequivalents per litre, the expression used will be 10 RI/A

- Relationship between the various sugars

For certain more sophisticated analyses, it is often necessary to determine the levels of the various sugars, especially the simple sugars which are collectively known as reducing sugars (RS) and sucrose (Su).

In this case, the method of achieving comparability of results is to express the amounts of these different sugars either as percentages of the total sugars present or by the ratios RS/TS, Su/TS or Su/RS.

. <u>The sums or differences</u>

When several parameters are simultaneously taken into account for expressing a given standard, they can be grouped into an algebraic expression which makes it possible to establish a global index of quality which is easier to use in everyday practice.

These indices are generally based on calculations of multiple correlation and are normally a simplification of the value obtained by such calculations.

However, they should only be used to the extent that the parameters which are included represent measurements of a comparable nature. Thus, for example, it seems quite logical to include sugars and acidity in a single expression, as in the formula TS + 10 A, as had been suggested for Golden Delicious apples. By contrast, there would appear to be little logic in combining a value for sugars in grammes per litre with a measurement of firmness taken by penetrometer or with an index of coloration, for example, even if the calculation of such a correlation has shown a connection between these different indices of quality.

In this case, they will be used separately and each index will correspond to a separate stage in the selection process, in a way that can be likened to the passage of a granular mixture through successive sifting devices with meshes of steadily increasing fineness.

2.4 : RECOMMENDED VALUES FOR THE MAIN QUALITY CRITERIA

At the present stage of research into the organoleptic properties of fruit and vegetables, it is not possible to lay down equally precise definitions of the recommended values for each of the main criteria. Nevertheless, in a field which is as subjective as the study of organoleptic qualities, it is by using the criteria in the context of individual markets that more information will be brought to light and the quality aspects of demand more clearly defined.

The studies of gustatory quality in fruit have been concentrated on a small number of clearly defined varieties, and the criteria studied must be considered as specific to those varieties. There would nevertheless seem to be a case for applying the same standards to similar varieties, for the express purpose of observing consumers' reactions, with a view to fixing the standards to be applied in each case.

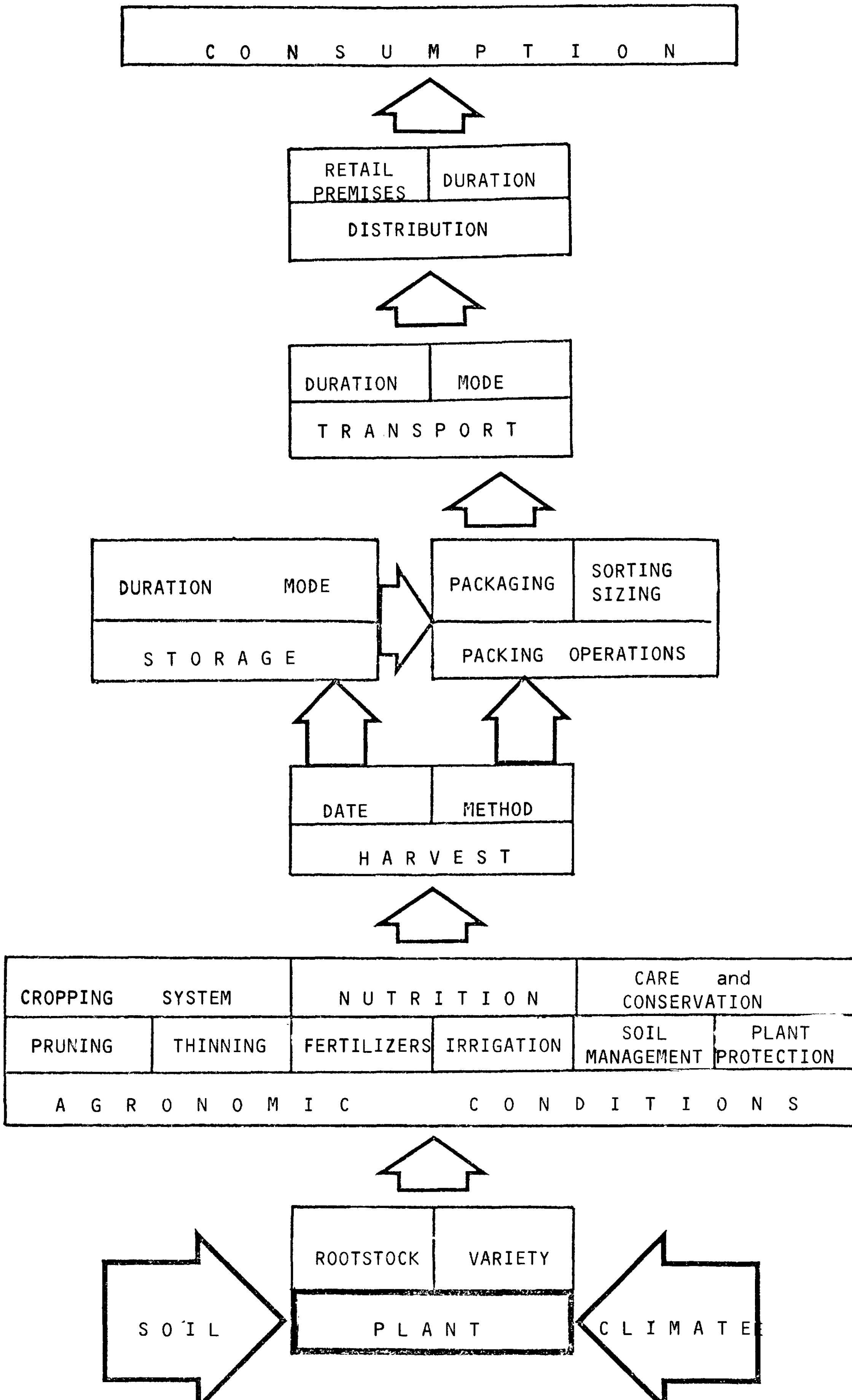
Research into the organoleptic properties of vegetables has not been so extensive as in fruit, and in many cases no recommended values have yet been worked out for the main criteria. Pending the availability of further data resulting from studies still to be carried out, the author's proposals should be viewed as guidelines of an indicative nature.

Annex 1 contains a classification, product by product, of the values which can currently be recommended as a result of research carried out in most countries and which cannot therefore be held to apply solely to the population of a particular region.

3 - DESCRIPTION OF THE TECHNIQUES ENSURING THE PRODUCTION OF FRUIT AND VEGETABLES OF ACCEPTABLE GUSTATORY QUALITY

The ultimate quality of fruit and vegetables results from the influence which is exerted on the natural characteristics of the plant by the complex interaction of a number of factors: environment, cultural techniques, methods of storage and transport. They may all pull together in the same direction, or they may be entirely at odds.

It is far from easy, at the current stage of scientific investigation of the organoleptic properties of fruit and vegetables, to set down these factors in any other order than that of their chronological occurrence, and it is in that order, therfore, that we shall examine their influence on quality. We shall assume that all plants are genetically endowed with a certain qualitative potential which can be realized to a greater or lesser degree, depending on the environment, and that the techniques of cultivation, followed by harvesting and storage, and finally marketing, are likely to bring about successive modifications of the potential result to be expected from the association between the plant and its milieu.



THE HIGHROAD TO QUALITY

3.1 : FACTORS OF FRUIT AND VEGETABLE PRODUCTION

Between the point in time when the plant is chosen, with due regard for the natural environment, and the point when the application of the various cultural techniques produces a product that is ready for picking, all the factors of fruit production can have an effect on quality.

3.11: Selection of stock

It goes without saying that the basic qualitative potential of the product is determined by the characteristics of the plant, i.e. the cultivar, or the cultivar and the rootstock together in the case of fruit trees.

So the search for better varieties, by selection, mutation or hybridization is certainly the main and most rewarding area of long-term improvement of the intrinsic quality of the product.

But so many parameters have to be taken into account by the breeder when developing a new variety that this phase of development is very slow and fraught with difficulty.

. Choise of cultivar

The influence of the choice of cultivar on the final quality of the product will depend on the ability of the particular variety to synthesize the main components of quality; but it will also depend on how well the cultivar can adapt to the environmental conditions in which it is grown.

In many cases, therefore,the origin of an inferior product can be traced to the choice of the wrong cultivar for a particular climate or a particular type of soil.

For example, when apples such as Granny Smith, with a long vegetative cycle, are planted in regions with a short growing season, they will generally produce immature fruits in which there is a lack of balance between the acids and the sugars and a low level of emission of volatile products.

The environmental conditions must suit the cultivar if a top quality product is to be obtained.

311.1 : Specific quality

In a given environment, with identical ripening conditions, there are often major differences in the chemical composition of the various cultivars.

This applies, for example, to sugar content, which is normally related to the length of the vegetative cycle. Thus, the late ripening cultivars consistently show higher sugars than the earlier varieties.

The phenomenon can be observed both in fruit trees, e.g. apples (101), and in annual plants such as tomatoes (102).

It can also be observed in the groups of cultivars which ripen at the same time, although the variation between the cultivars is less than that between the groups which mature at an earlier or later date.

In some species, the relative levels of the various sugars, especially sucrose may be quite dissimilar. In the case of melons, for example, there is one group of cultivars in which the sucrose accumulates only at the final stage of development of the fruit, just before maturity (as with most fruits), and a second group of cultivars in which the sucrose accumulates at a much earlier stage (103).

Very great differences in the sucrose content of the juice can also be observed in peaches, generally corresponding to different groups of cultivars. In many varieties of Pavia (clingstone peaches) both total sugars and sucrose are appreciably higher than in freestone table peaches (88).

Variations in acidity between cultivars are generally more pronounced than variations in the sugars. Observations have shown that acidity can vary in a given environment in the proportions of 1 : 3 and even in the proportions of 1 : 4 between fruits ripening at the same time (104).

The acidity of Granny Smith apples is 50% greater, on average, than that of the Golden Delicious variety when grown in the same conditions (68).

This variation would appear to be far more marked in the late-maturing varieties, in which the acidity at the time of picking depends on the rate of regression of the acids, which depends in turn on the rate of respiration of the fruit (101).

VARIATIONS IN THE REFRACTIVE INDICES AND ACIDITY

BETWEEN CERTAIN VARIETIES OF PEACH AND APRICOT

APRICOTS source : M. SOUTY (105)
(1966 harvest - Domaine des Garrigues - MANDUEL - Gard Department)

VARIETIES	Refractive index RI	Acidity meq./100 g	Ratio RI/A
Hâtif Colomer	8,7	33	0,26
Canino	14,1	29	0,49
Muscat de Provence	15,2	29	0,52
Moniqui	14,5	28	0,52
Monaco	15,4	27	0,57
Rouge du Roussillon	14,7	27	0,54
Polonais	13,7	17	0,81
Poisat	13,6	29	0,47
Bergeron	12,1	28	0,43

PEACHES source : J. NICOLAS (104)
(average values recorded in 1973 - Pyrénées-Orientales Department)

VARIETIES	Refractive index RI	Acidity meq./100 ml	Ratio RI/A
Springtime	9,9	13,6	0,72
Robin	10,5	3,7	2,84
Cardinal	9,5	12,7	0,75
Merril Gem Free	10,1	14,5	0,69
Nectarine Crimson Gold	11,1	12,2	0,91
Redhaven	10,5	10,0	1,05
Fairhaven	11,5	11,8	0,97
Redwing	12,5	5,8	2,16
Nectarine Rhône Gold	13,6	20,1	0,68
Nectarine Nectared 4	11,3	14,7	0,77
Southland	12,0	10,4	1,15
Impero	13,0	11,8	1,10
Merrill Franciscan	12,7	12,3	1,03
Nectarine Nectared 6	13,6	16,2	0,84
Early Elberta	10,2	7,6	1,34
Michelini	11,0	9,9	1,11
Pavie Babygold 6	11,2	6,4	1,75
Merrill 49	10,9	7,9	1,38
J.H. Hale	12,2	14,5	0,84
Merrill Pacifica	14,7	12,7	1,16

Perceived acidity can also vary, depending on the relative proportions of the main acids present.

In peaches for example, and more particularly in apricots, the dominant acid may be citric or malic, depending on the varieties, and this will strengthen or weaken the sensation of acidity at a givan stage of maturity.

Because malic acid regresses more rapidly than citric acid, the cultivars in which malic acid is dominant, such as Hâtif Colomer, will tend to lose their acidity more rapidly after picking than will those in which citric acid is dominant, such as Rouge du Roussillon (105).

In tomatoes, by contrast, the differences between varieties are more marked in terms of sugars than in terms of acids (106).

. Aromatic substances and other constituents

Although there are significant variations, both qualitative and quantitative, in the levels of the sugars and acids which are the main constituent substances, the most striking differences between the various cultivars are to be found in the secondary constituents and particularly in the aromatic substances.

For example, the bouquet of a Reinette is easily distinguishable from that of other varieties. Yet the aromatic substances are always present in all the different varieties of apples, and the research carried out so far would not seem to indicate any single constituent which is peculiar to a particular variety. It is mainly the variation of the proportions of the aromatic substances which determines the differences in aroma.

Thus, as far as the esters are concerned, the acetates are the most characteristic components of the aroma of Calville Blanche and Golden Delicious apples, while the butyrates are more dominant in Canada Blanc and Belle de Boskoop. The main esters present in Reinette du Mans, Richared and Starking are those of propionic acid (107) (107 bis).

Pears also provide remarkably similar aromagrams, and the most abundant volatile substances are those which are also found in apples. So the characteristic aroma of each variety is clearly attributable to the varying proportions of the constituents.

In addition to this quantitative variation, one can also observe a very pronounced difference in the rate of development of the aromatic substances depending on variety and the point reached in the process of maturation.

In William pears, for example, the aroma appears at an early stage, and quickly acquires its final composition, in which the two most characteristic components are ethyl-acetate and ethyl-alcohol. By contrast, Passe Crassane pears develop very little aroma for a considerable period after picking, while the main constituents are butyl-acetate and hexyl-acetate (108).

In peaches, gamma decalactone is considered to be the most representative constituent of the aroma. It is present in large quantities and can therefore be used as the main indicator of total aromatic emission.

In some cases, however, the differences in aroma between the varieties can depend on the presence of certain specific substances in rather limited quantities. Redhaven peaches, for example, are clearly differentiated from the Cardinal variety by virtue of their substantial fraction of linalol (109).

This rule also applies to vegetables. The differences in carrots are again more quantitative than qualitative, and here it seems that the characteristic aroma of the different varieties is determined by the individual concentrations of terpenes (110).

In addition to the variations in the aromatic substances in the different varieties one can also detect significant differences in the amounts of certain other components such as the alkaloids which impart a certain degree of bitterness. Tomatin, for example, which is the characteristic alcaloid of the tomato, is found in varying degrees of concentration in the fruits of different varieties.

This is also true of lactucin and lactucopicrin, which give a bitter taste to the main plants in the compositae family, which also vary considerably in amount, especially in the cultivated varieties of lettuce and chicory (111).

. <u>Vitamins</u>

The vitamins and biocatalysts do not seem to affect flavour to any great extent, but insofar as it may be desirable in future to establish a connection between top gustatory quality and improved nutritional properties it should nevertheless be emphasized that they too can vary in concentration from variety to variety.

Unfortunately, it is far from easy to find these two qualities in association in the varieties of fruit that are currently grown for mass consumption. But although they are few and far between these cases do exist. It seems that the breeders will have to make a sustained effort in future to develop new varieties in which yield and appearance are matched by high concentrations of the various vitamins (especially ascorbic acid) and superior organoleptic quality (112).

But one should not lose sight of the fact that cultural techniques and the age of the tree have a greater effect on the level of vitamins than does the choice of variety.

This means it is possible, up to a point, to compensate for the low level of vitamins in certain varieties by adopting the right cultural techniques, which may also improve the organoleptic quality of the product.

. Pollination and the function of pips

Many varieties of fruit trees are self-sterile, or else their self-fertility is relatively low, and this means that two varieties have to be grown side by side to guarantee sufficient pollination.

This self-sterility is almost total in certain varieties of Bigarreau cherries, and the percentage of self-fertilization is relatively low in some varieties of apples and pears.

When the spring flowering conditions are poor, i.e. when temperatures are lower than normal and the pollinating insects (mainly bees) are less than usually active, the number of fertilized pips may be very limited in apples and pears.

The problem is that pips play an important role in determining the quality of the whole fruit (64). Many researchers have thrown light on the correlation between the weight of individual apples and the number of pips, each pip being capable of adding 3 - 5 % to the weight of the fruit, apparently as a result of the greater activity of the fruit at the phase of cell multiplication which occurs in the 4 - 6 weeks following fruit set.

The absence or insufficiency of pips will reduce the diameter of the fruit, and this will change the axial/equatorial ratio. This fact should be emphasized, because the ratio has been described as a visual criterion of satisfactory development ... with the obvious proviso that this morphological characteristic must not be derived from inadequate fertilization.

When fertilization is only partial, the change in the relationship between the number of cells and the number of pips will cause the fruit to become misshapen.

Finally when there are no active pips or when these are lacking in part of the fruit, the hydrolysis of the starch is delayed, the reducing sugars are less concentrated and the fruit is firmer. This slower development may well delay the apple harvest by up to a fortnight.

In a badly fertilized orchard, therefore, the shape and quality of the fruit are extremely varied. The under-fertilized parts of the fruit wither more rapidly during storage (113) and a positive correlation can be observed between the absence of pips and susceptibility to physiological disorders.

Parthenocarpic tomatoes also have a disturbed chemical composition and are less acid than fruits containing seeds (114).

Insofar as total or partial self-sterility is peculiar to the variety, this characteristic can have a rather marked effect on the organoleptic properties and especially on the homogeneity of the product.

. Firmness

The levels of the various pectins can vary considerably between cultivars, and this applies in particular to the concentration of the protopectins in the ripe fruit, which depends on the rate at which the pectins become soluble.

There is a clear diffenence in this respect between freestone table peaches and the Pavia varieties, the latter remaining very firm when ripe (88).

Although not so striking, similar differences have also been noted between the different varieties of apricots, and this is reflected in varying ability to withstand transport and greater or lesser suitability for canning in syrup (105).

In tomatoes, the size of the hollow space inside the carpellary locules will affect the overall firmness of the fruit.

It is largely on the basis of their varietal characteristics that tomatoes can be graded as very firm (e.g. Heinz 1370), average (e.g. Montfavet 63-4 and 5), and soft (e.g. Campbell 1327) (115).

. In conclusion, the individual characteristics of the separate varieties endow them with a certain qualitative potential, and this can vary considerably.

By matching the variety to the environment in which it is cultivated one can promote the optimum development of this potential, so that the consumers may opt for an individual product on the basis of its origin.

311.2 - Rootstocks

The rootstock can either have a direct effect on quality, by influencing the composition of the fruit, and especially the concentration of acids and sugars, or it may have an indirect effect, through the modification of the balance between foliage and fruit which differences of rooting habit can bring about.

Thus, for example, a dwarfing rootstock such as apple EM9 is more likely to be affected by variations in climate or water supply than a deep-rooting variety will be.

Such dwarfing rootstocks generally produce fruit with higher sugars and lower acids (116). In the vigorous rootstocks such as Franc, the elements favouring vigour and yield would not seem to be detrimental to quality, which does tend to deteriorate, however, when the nutritional conditions reduce the production potential (117).

When there is a certain degree of incompatibility between the rootstock and the graft a collar forms at the level of the graft, and this has the same effect as a ringed incision in slowing the circulation of the substances produced by the rootstock. This can improve the quality of the fruit under the combined effects of reduced vigour and concentration of carbohydrates. In many cases, however, the yield will be considerably reduced.

As with the selection of the different varieties, it is by trying to find the best rootstock for the soil conditions in which it is to be grown that the qualitative potential of the rootstock can be fully realized.

311.3 - Plant health

There are many viruses and fungal infections which not only reduce the potential yield but also have a direct effect on the presentability and organoleptic qualities of fruit (118).

In certain cases, the resulting loss of vigour and yield can lead to the production of larger fruit with higher sugar (Dwarf plum = PDV). But many other diseases can have a serious effect on the quality of the fruit. One example is "Sharka" (plum plox) which attacks plums, apricots and peaches and leads to the formation of round blotches and sunken patches of skin, so that the fruit becomes unfit for sale.

The peach virus which causes malformation of the stone, PD peach little peach virus, can reduce the size of the fruit and lead to the development of wrinkles and fine cracks along the suture line, through which the various fungi can more easily invade the fruit.

In cherries, the little cherry virus (a mycoplasma disease) inhibits the swelling of the fruitlets and also holds back the ripening process.

In pears, stony pit is a very serious virus infection; the fruits are puckered, deformed and of inferior size, and there is no market for them. A brownish "grit", with a bitter taste, develops inside the pear (119).

In apples, the virus diseases known as green crinkle (puckered fruit), star crack and chat fruit (atrophied fruit) can affect the external appearance, although the organoleptic qualities of the fruit do not seem to suffer (120). In the same way, various latent viruses render Golden Delicious more susceptible to russeting (121).

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The intrinsic quality of the product can be seen to depend, therefore, on the qualitative potential of the plant, and the key role would appear to be played by the genetic characteristics of the cultivar. In the case of fruit trees it also depends on the compatibility of the rootstock and its suitability for the local soil conditions; but all these elements can be profoundly affected by the general health of the stock.

It would therefore be utterly futile to attempt to apply the techniques intended to produce top quality fruit to a tree that is without potential for genetic reasons, or is unsuited to the locality, or is in poor health.

3.12 : Environmental conditions

From time immemorial, of course, the quality of horticultural produce has been known to be a function of environment, soil and climate. Hence the notion of the "cru", the use of which term is controlled by the regulations relating to "appellations d'origine".

The notion of the "terroir" has found its widest application in the grape-growing sector. But soil and climate are no more than conditions favourable to the realization of quality, and it must be stressed that the authorization to employ an "appellation d'origine" has always been based on the cultivation of specific varieties and the application of a certain number of techniques derived from traditional practices and confirmed by recent experiments.

It should not be forgotten, therefore, that although a good environment is a prerequisite for the growing of quality produce, it is not sufficient per se. Particularly in the case of fresh fruit and vegetables, the techniques of cultivation and marketing can play a major role in determining the final result.

312.1 - Climate

The effects of climate on the quality of fruit and vegetables are exercised through the two main functions of plant physiology: photosynthesis and mineral nutrition.

Photosynthesis, which is directly responsible for the formation of sugars and consequently for the various metabolites which result, depends on the radiated light reaching the plant and on the temperature. But the supply of water and minerals can modify the intensity of this process.

. Effect of temperatures

It is universally agreed that temperatures have an important contribution to make to the quality of fruit and vegetables. This is partly because of their obvious effect on vegetative growth, but also because they are easily measurable climatic factor for which long-term statistical records are freely available.

That is why a large measure of importance is generally given to the concept of the sum total of the temperatures occurring between the time when the fruit sets and the time when it is harvested. This can be expressed as the sum of the differences between the maximum and minimum temperatures and a threshold temperature considered to be the minimum for vegetative growth, according to the formula:

$$S = \left\{\left[(M - 0_s) + (m - 0_s)\right]\right.$$

Some authors prefer to use the method of temperature coefficients:

$$S = \frac{M}{Q_{10}} + \frac{m}{Q_{10}}$$

The term Q_{10} expresses the relationship between the rate of development at a given temperature $t^o 0$ and at $t^o 0 + 10$.

The advantage of this formula is that it gives more constant results for the periods of development in which the temperature is fairly low, below 15°C; but between 16 and 30°C development approximates to a straight line and the first formula is preferable (112). In the case of peaches, for example, the accepted threshold temperature is 10°C, and an average margin of 1.221 degrees per day, calculated according to the first of these two formulae, is needed to ensure the complete development of the fruit of the cultivar Elberta, which corresponds to a growing period of 136 days at an average temperature of 18.8°C. For later-maturing cultivars such as Merril Sundance or Rubidoux, this average temperature is 18.6°C for 150 days, from 1 May to 30 September.

If peaches are to mature satisfactorily in such conditions, the temperatures in Autumm must be fairly high (88).

Similar sums of temperatures have also been computed for apples, mainly in the regions where temperature totals might fall short of the minimum in a cold Summer,

Thus, in Norway, the quality of Gravenstein apples is determined by average temperatures over the period from May to September, and quality is higher when the average temperature is 14°C than in the years when it is below 12°C (123).

Although temperature considered as a result of exposure to sunshine can be taken as a good overall indication of the factors governing the assimilation of chlorophyll, the measurement of solar radiation in calories per cm^2/second (124) is gradually becoming the standard procedure.

In those species in which the sugars accumulate at a later stage, near to the time of picking, climatic disturbances in the weeks which precede the harvest may affect the rate of synthesis.

In apricots, for example, a sudden fall in temperature in the week preceding picking has been shown to have a very marked effect on the sugar accumulation curve (105).

In tomatoes, the dry matter content and particularly the sugars are closely correlated with the sum of the temperatures of the 40 days preceding picking (125).

But maximum photosynthesis depends on optimum temperatures. Excessive temperatures can act directly to lower the rate of biosynthesis of the various sugars, or they can have an indirect effect through the imballances which may develop between the rates of evaporation/transpiration and the rate of water intaker.

Excessive temperatures can also have an adverse effect on colouring, because the synthesis of ethylene is inhibited by the greater intensity of solar radiation. In tomatoes, for example, when the temperatures are above 30°C, there is a deterioration in colouring round the stalk, and the fruits do not ripen satisfactorily (126).

Climatic conditions, especially in the weeks immediately before the harvesting period, not only affect the synthesis of the major components, the acids and the sugars, but also have a major influence on the production of aroma. In apples, for example, temperatures and exposure to sunlight in the final month of growth can provoke greater variations in the synthesis of the aromatic substances than in the accumulation of the sugars.

The minimum amount of solar energy necessary for the development of the typical flavour of the Golden Delicious apple would appear to be 170 calories/cm^2/day (127).

The climatic conditions which favour the development of the aromatic substances are the same as those which favour the development of the anthocyanin pigments, and one can therefore lay down a fairly precise definition of the most favourable climatic conditions for the production of high quality apples that are also suitably coloured. On the one hand, diurnal temperatures must be sufficiently high, and good exposure to sunlight is indispensable. On the other hand, if the diurnal temperature exceeds 25°C, the production of anthocyanins is blocked. Daytime temperatures of 20 - 25°C (with a marked fall at night) and low air humidity in Summer are both very conducive to the development of colour and the synthesis of aromatic substances.

Experiments have also shown the importance of ultraviolet radiation. These effects are particularly marked in orchards located at medium altitudes, and they explain the generally recognized quality of the fruit grown in mountain areas (50) (x).

Temperatures can also have a major effect on shape, especially in the weeks that follow the setting phase, when the fruitlets are going through a process of cell multiplication. High temperatures increase the number of cells so that in the subsequent phase in which the cells increase in size the fruits develop greater equatorial dimensions than they would in cooler conditions.

Hence the more flattened form of fruit produced in hot and lowlying areas and the generally lower axial/equatorial ratios than in fruit grown in cooler locations or at higher altitudes.

. Uptake of water

Adequate water must be available for the translocation of the minerals drawn from the soil by the roots and for the replacement of moisture lost by transpiration.

Variations in water supply can therefore lead to major differences in the total amount of dry matter produced by the plant. But in view of the increasing importance of irrigation in the cultivation of fruit and vegetables the detailed examination of this relationship will be postponed until it is considered in the special chapter devoted to the influence of irrigation on the quality of fruit.

. Micro-climates : glasshouse culture

In regions of mixed relief, the climatic factors create a multiplicity of micro-climates in which exposure to sunlight, temperature and humidity are subject to great variation depending on the topography and orientation of the site.

The resulting differences in quality can be considerable. It has been shown that maximum sunlight is received by slopes of 25° - 48° facing south-east. Over the 90° between east and south, such slopes receive an average of 18 % more solar energy than a horizontal site (at 46° latitude north). By contrast, a slope with a south-westerly to northerly aspect is at a disadvantage compared with a flat plain. These variations obviously depend on the amount of sunlight falling on the region, and the micro-climatic factor becomes particularly important in locations where there is little atmospheric haze (128).

(x) Slopes at medium altitude and hillsides in general can offer the right combination of climatic and soil conditions : sunlight, temperature differences, ultraviolet radiation, workable soil, rough texture and high permeability.

Glasshouses are a typical example of micro-climates, because they are a means of limiting the effects of natural factors on plant growth and especially of controlling the relative temperature and humidity of the ambient atmosphere. By means of what is known as a glasshouse climate one can produce a large amount of dry matter over a minimum period of growth. Hence the frequently encountered assumption that glasshouse products and especially glasshouse vegetables are of inferior quality.

It should be emphasized that glasshouse cultivation in cold climates is a device for raising the average temperature, so as to create a climatic situation which favours the synthesis of sugars, providing of course that the optimum temperatures are maintained.

Detailed research has shown that the amounts of vitamins present in tomatoes and lettuce grown under glass were equal and even sometimes superior (in the case of thiamin) to the vitamin concentrations present in crops grown in the open air (129). It is axiomatic that temperature schedules for glasshouse crops must be worked out with a great deal of precision, because the problems associated with excessive temperatures, to which we have already referred, can very easily arise under glass. If temperatures are too high, the sugars will be less concentrated than in crops grown in the open air and colour will also be poorer (130).

312.2 - Soil

Soil affects quality in two ways, through its physical characteristics and its chemical composition.

The physical characteristics of the soil are mainly measured in terms of granular size and permeability, Both are very important for perennial plants such as apple trees, because of their effect on root development, which can vary considerably depending on the depth and make-up of the soil.

Generally speaking, fruit-growing soils must be at least about 60 - 80 cm deep, and their texture must be sufficiently rough to ensure the adequate ventilation of the whole medium and a good root spread.

It is generally agreed that the ideal soil for establishing an orchard should have a medium-fine surface texture, such as will provide a minimum reserve of fertilizing elements, and that the underlying layers should become increasingly coarse in texture so as to avoid the accumulation of water in the soil. Thus, it has been observed that trees grown on soils with a high proportion of fine particles, especially of clays, often produce mediocre fruit when adult (117).

This occurs less often in young trees, because the preparation of the soil ensures for a time that the top layer does not become compacted, and the roots are still confined to this layer, Indeed, the fertility of finely grained soils can encourage young trees to grow vigorously and produce good quality fruit. The fertility of coarsely grained soils, by contrast, is limited by the lack of colloids, which has an adverse effect on quality, except when the yields are substantially reduced.

These combinations of factors, which are very important for fruit trees, can also effect annual plants, because their growth is also affected by the compactness of the soil.

Thus, the concentration of sugars in melons would appear to reach a maximum on soils that are sufficiently rich in particles but which nevertheless remain permeable. The lowest sugars are found in melons grown in sandy soils and in heavy soils with very compact substrata (131).

Likewise, the quality of carrots, in terms of carotene and sucrose is higher in light soils containing plenty of humus than in ordinary soils (132). By contrast, peaty soils would seem to be less favourable (133).

Generally speaking, them, it would seem that the best soils for balanced growth and high quality products are those which are deep and fertile but also permeable.

The chemical characteristics of the soil are the main measurement of its fertility and crop quality is therefore closely bound up with the methods of fertilization adopted. But certain constituents, and especially lime, can have a marked effect on product quality. The first point about lime is that some plants like it and others do not, depending on whether they are calcicolous or calcifugous.

In peaches, for example, the fruits are of optimum quality when the amount of lime in the soils is just sufficient for a pH reaction of about 7 ; but the proportion of active lime should not be greater than 7%, because this might cause chlorosis and a consequential lowering of the rate of photosynthesis, to the detriment of quality.

Experiments with nutrient solutions containing lime have shown that a calcium content slightly below the danger level for peaches can have a favourable effect on fruit quality. Trees with a lower intake of calcium bear smaller fruit of inferior colour which are given a lower rating by the consumers. The very best peaches appear to be grown on soils which can provide a calcium content of approximately 2 % by weight of the dry matter of the leaves (135).

Even in plants that are less sensitive to its presence, calcium can also have a major effect on the quality of the product. It regulates the rate of respiration and can also limit the adverse effects of excess nitrogen (134).

Summer spraying with calcium nitrate not only reduces the incidence of bitter-pit in the storage phase but also encourages the development of sugars and acids (136).

Fruits containing a high level of calcium are generally ranked highest by consumer panels (137). It has even been shown that combined applications of calcium and boron can have a synergistic effect on quality (117).

For the reasons referred to, high calcium is an indication of good storage properties. Thus, for example, when the calcium content of apples falls below 3 mg %, the result is rapid deterioration in storage, whereas the risk of bitter-pit is much reduced when the calcium content is greater than 5 mg % (138).

Superficial scald is also encouraged if the calcium content of apples is too low (139).

3.13 : Cultural techniques

When fruit is grown for consumption in the fresh state, without any processing, the techniques of cultivation adopted can have a major effect on the potential quality offered by the plant and by the environment in which it is cultivated.

The manner in which cultivation is planned and executed will affect the rate of photosynthesis and the intensity of the competition for nutritive elements which can develop between plants or between the fruits of a single plant.

So the density of planting and the appropriate staking, tying, pruning and thinning operations can lead to major variations in quality.

313.1 - Density of cultivation

Variations in density of cultivation have a double effect : they fix the volume of soil available for each plant, possibly reducing its potential nutrition, and they determine the total amount of light that falls on the foliage.

Plants that are widely spaced cannot be described as competitive, so that the potential quality of the crop is only limited by natural conditions, but when the distance between two plants is less than their maximum potential spread, the double competition occurs in the soil and in the air.

Clear-cut examples of the way in which competition for soil can affect the quality of the product, and especially the level of the various sugars, can be found among annual plants.

In melons, there is a major improvement in the level of sucrose when the distance between the plants is increased from 25 to 37 cm, but when they are planted even further apart the increase in sugars is negligible. One can therefore lay down a precise definition of optimum density, both for quality and for yield (140).

In root crops such as carrots, however, in which quality is highly dependent on the physical characteristics of the product, it is disadvantageous to space the rows too far apart : the optimum spacing for the Nantaise variety would appear to be 22 - 30 cm (141).

In such cases, the relative proximity of the plants can affect the form of the roots, which remain more cylindrical when the plants are close enough together, especially in the case of early varieties (142).

As far as fruit trees are concerned, it is now a standard practice to encourage competition between the roots, so as to restrict growth and therefore facilitate the process of picking from smaller trees, by obviating the need for ladders and elevator trucks.

Of course it is possible, by adopting the right techniques of fertilization and irrigation for these high densities, to limit the extent to which quality is adversely affected by competition between the roots for mineral nutrition. But high densities can seriously reduce the amount of sunlight which impinges on the tree if its development is not corrected by adequate pruning operations.

It is generally agreed that the fruits exposed to the maximum amount of sunshine are firmer and richer in sugars than fruit from the shady side of the tree (143).

The better position improves their organoleptic properties and their colour, as well as their storability, and they are less likely to wither or to succumb to core rot. In apples, however, it may increase the incidence of bitter-pit which is associated with calcium deficiency (144).

The amount of light falling on the tree not only affects the photosynthetic activity of the leaves but also has a direct effect of the growth and metabolism of the fruits.

The effects of the shadow cast by one tree on another can be reduced by suitable methods of training and pruning, so as to ensure the optimum penetration of sunlight throughout the tree (145).

313.2 - Training

As far as fruit-trees are concerned, the extent to which the structure of the tree can affect the quality of the product depends primarily on the dimensions of the vegetative organs. Many experiments have been carried out in an attempt to compare the performance of bush trees and low hedges.

Varied results have been obtained, and the evidence has not always been conclusive, because of the diversity of the various cultural environments and the complexity of the factors affecting quality.

Thus, comparisons between the performance of fruiting hedges and bushes with a vertical axis (spindlebushes) in Federal Germany showed that the amount of light reaching the whole tree depended on the variety. In Jonathan apples the bush form received more light than the hedges. There was also found to be a greater difference in temperature and light absorption between the top and lower branches and between the two sides of the hedge when the latter ran from east to west (146).

Similar findings have been reported from Yugoslavia in respect of Golden Delicious apple trees. In the latter case, the hedge form produced a lower yield and lower quality fruit than the trees trained in bush form with a vertical axis (147).

By contrast, there is evdidence that peach trees trained in the "goblet" form, with an open centre in which the upper branches cast shade on the lower half of the tree, can give poorer results than the palmette or Californian types (148).

Exposure to sunlight can also be artificially reduced by the plastic nets which are hung over orchards to avoid damage from hail. There is a 10 - 15 % loss of colour and a slight reduction in the average diameter attained by the fruits, and the total amount of solar radiation falling on the tree is cut by 20 % (149).

The various experiments all serve to illustrate the importance of adopting a system of training and pruning that suits the environmental conditions as well as the growth potential of the tree and exposes the whole of the crown to the maximum amount of light.

In bush apples the intensity of light reaching the interior of the tree may be less than 20 % of the total intensity measured at the outer extremities of the crown (150).

These findings have been confirmed by trials carried out in France, over a three-year period, which showed that espalier forms must be cut back hard if the best quality is to be obtained (117).

Mechanical pruning can accentuate these qualitative variations by encouraging the proliferation of twigs in the upper part of the crown, unless this is corrected by large scale dehorning.

313.3 - Pruning and thinning

Variations in the quality of the fruits on a single tree are closely correlated with their position, which determines their nutrition. This nutrition is determined, in turn, by the intensity of the competition which occurs between the individual fruit and the other fruits on the same tree, and by the competitive relationship with the vegetative organs.

Quality depends, therefore, on the type of branch which carries the fruit and particularly on its capacity to carry the assimilates to the fruit. That being so, the pruning and thinning operations must be aimed not only at establishing a balance between vegetation and fruiting at the level of the entire plant but also, and especially in the case of trees, at providing the best possible supports for the development of high quality fruit.

. The translocation of assimilates

The perforated tubes which form the phloem (or bast) have a basic role to play in the supply of sugars ; they ensure the translocation towards the receiving organs of the assimilates produced by photosynthesis in the leaves.

The supply of nutrition by the shortest circuit, from the leaves next to the receptors, would seem to be the general rule, but the movement of the synthesized substances is a constantly changing process in the life of the plant, depending on the growth cycle. The supply of nutrition depends mainly on the interconnections between the vessels of circulation, on the stimulus received from the growing receptors and on the proximity of the organs providing these substances to the organs which receive them.

In the adult tomato plant, for example, the roots are nourished by the lower leaves and the top is fed by the leaves in the upper part, while the trusses which are spaced at intervals along the stem are mainly fed by the nearest leaves, whether these are immediately above or immediately below the truss, with a certain degree of overlap (151).

This principle of the nutrition of the fruits by the nearest leaves can also be observed in the ligneous perennials. Thus it is that the effects of competition are often first revealed at the level of the fruiting twig or branch, so that when a particular part of the tree is carrying an exceptionally heavy crop the size and quality of the fruits borne by the most overloaded branches will be inferior to that of the fruits carried by the rest of the structure.

Nevertheless, if one source of nutrition is hard pressed, the other parts of the tree can partly compensate for the deficiency. Experiments on apple trees in Germany (152), in which the area of foliage per fruit was reduced from 200 to 100 cm^2 and the supply of assimilated nutrients from other parts of the structure was completely cut off by ringing the bark of the fruiting branch, showed a marked reduction in sugars and average weight and a slightly less striking reduction in acids as a result.

On the other hand, the differences were far less pronounced when the bark was not ringed in this way.

The practical inference to be drawn from these observations is that pruning and thinning should be aimed at ensuring the optimum distribution of the crop, not only at the level of the entire tree but also at the level of every part of the structure.

. Position of the fruits on the tree

As far as the fruit trees are concerned, several factors act together to determine the total nutrition received by each individual fruit. The most important among them are the following (153) :

- the age of the fruiting wood ;
- the angle of inclination of the bearing shoot ;
- the quality of the twig supporting the fruit ;
- the intensity of the light falling directly on the fruit.

As far as the age of the fruiting wood is concerned, a distinction must be drawn between species fruiting on one-year-old wood, as is the case with the mixed shoots of certain stone fruit trees (e.g. peach) and species fruiting on permanent wood, as with the multiple buds of stone fruit trees and the short fruit shoots of trees producing fruit with pips.

In the first-mentioned case, the question of age differentials does not arise, because the fruiting wood has always been formed in the preceding year ; but in the second case the average age of the fruiting wood may be anything between 2 and 7 or even 8 years.

Thus, depending on the variety, it would seem that the best quality apples and pears are carried on shoots that are still sufficiently young and vigorous to produce adequate new wood without reducing the supply of nutrition to the developing fruits.

The readily-branching varieties of apple, such as Golden Delicious, appear to fruit best on two- and three-year-old wood, while those which branch less readily, such as James Grieve or Reinette du Canada produce their best quality fruit on four- or five-year-old wood (154).

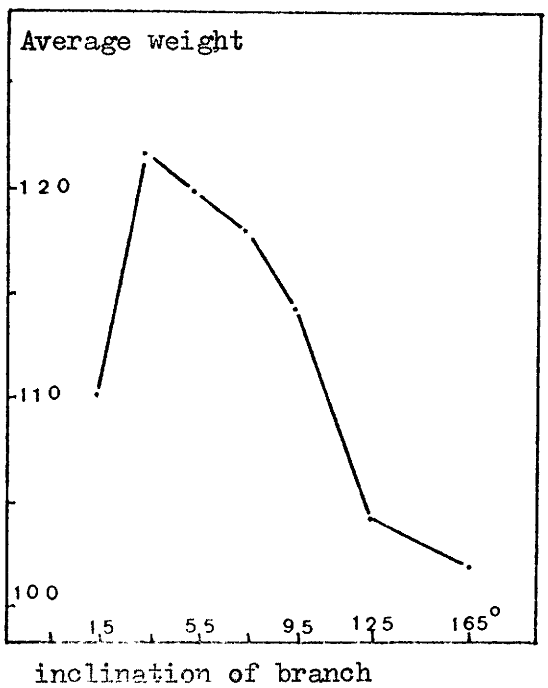
Special mention should be made of the species in which some varieties readily fruit on one-year- old brindles ending in a fruit bud (known in French as "brindilles couronnées").

This applies to Golden Delicious apples, and to Dr. Jules Guyot and William pears. The fruits carried on these brindles always develop more rapidly than the fruits borne on the other parts of the tree and they are therefore not only more mature at the time of picking, but also larger and better flavoured (155). For these varieties a special method of pruning is adopted, which systematically encourages fruiting on this type of wood.

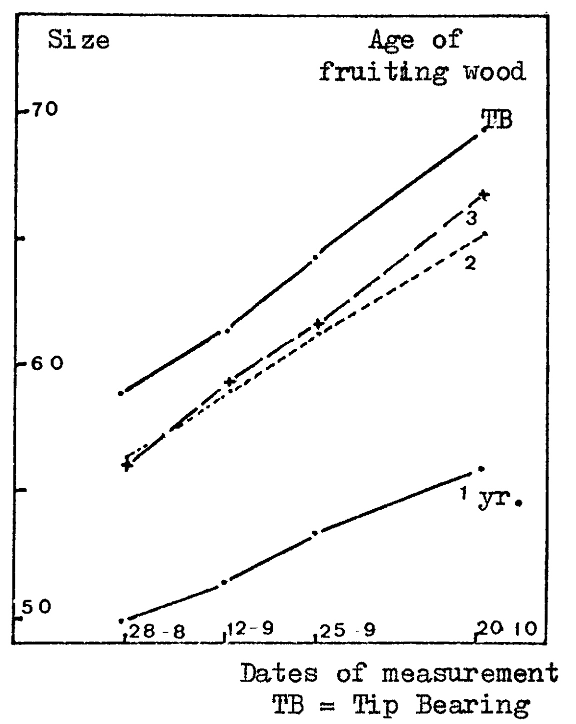
The inclination of the bearing shoot to the horizontal influences the potential development of the leaf twigs on the same branch, so that the branches which are most inclined bear smaller fruit with less sugars.

INFLUENCE OF POSITION AND NATURE OF SUPPORT ON THE DEVELOPMENT OF INDIVIDUAL FRUITS

APPLE : Golden Delicious

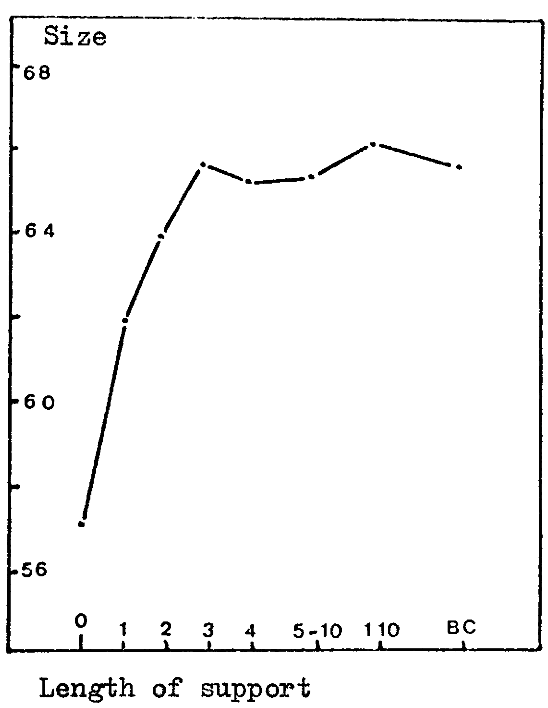


APPLE : Golden Delicious

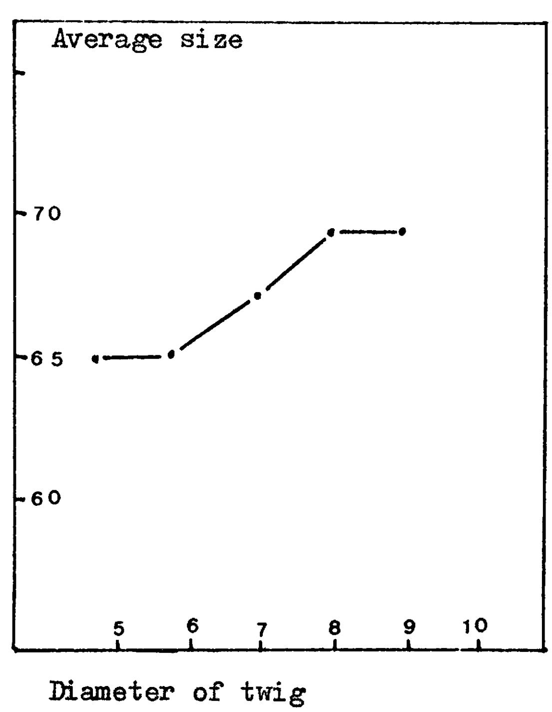


source : LESPINASSE

APPLE : Golden Delicious



PEACH : J.H. Hale



One can observe this difference each time the branch is pulled 10° out of the vertical by the weight of the fruit. So a strong leader and suitable tying or staking are clearly important factors in the protection of quality (153).

The quality of the flower bud and that of its support will also influence the quality of the fruit. Experiments have shown that flowering cannot be induced until the reserves of carbohydrate and mineral substances have reached a certain level in the bud. The nourishment reaching the bud is related to the number of leaves in the support. The diameter of the support, as well as its vigour, has an influence on the quality of the fruit (156). In apples and pears, significant correlations have been recorded between the diameters of the fruit spurs and the diameters of the fruits themselves. Size of fruit increases rapidly when the length of these spurs increases from 1 to 3 cm (157).

The quality of the support is also an important factor in trees which fruit on one-year-old wood. Thus, in the case of peaches, a correlation has been established between the diameter of the mixed twig, at its base, and the average diameter and sugar content of the fruit borne on that twig.

Trials with the J.H. HALE variety revealed that the average diameter of the fruit increased by 5 mm when the diameter of the fruiting twig increased from 6 to 8 mm (88).

The amount of light falling directly on the fruit will also have a marked effect on the sugar content, on the development of the aromatic substances, and on colour.

As far as apples are concerned, fruits fully exposed to sunlight develop approximately 10 % more sugars than fruits affected by shade (35).

Sample studies of Redhaven peaches showed that 65 % of the fruits of above-average size were situated in the upper half of the tree and that the same fruits were more highly coloured and richer in sugars (88).

One of the objects of pruning should therefore be to expose all the parts of the tree to sunlight and also to eliminate the fruiting organs that are too highly shaded.

The ratio of fruits to foliar surface : thinning

In tree fruiting varieties, pruning may be sufficient to ensure a proper balance between fruiting and general vegetative growth.

But it is impossible, by long pruning alone, to regulate the density of the fruit on the fruiting twigs and branches.

Size of fruit and sugar content would appear to be closely bound up with the number of photosynthetically active leaves adjacent to each fruit. The expression of this relationship in terms of the number of leaves is obviously only an approximation, because the rate of photosynthesis depends on the intensity of the light falling on the fruit as well as on the total active foliar surface.

Experiments in the climatic conditions of the Loire Valley, in France (28), have shown that sugars gradually increased as the number of leaves per fruit increased from 14 to 45, as did sucrose and average size of fruit, although the extra size achieved with 40 leaves was not very much greater than that achieved with 30.

Thinning regulates the number of fruits in relation to the number of leaves. Chemical thinning is based on the toxic effects which certain chemicals can have on the youngest fruits. Thus, by choosing the date of treatment, one can control the extent of the thinning effected. The practice is common with apples, but is rarely used on pears. In the case of peaches, the technique has not yet been perfected.

The chemical method can be replaced or completed by manual thinning with the advantage that a choice can then be made of which fruits to leave on the tree, on the basis of position and appearance.

Quality can be greatly influenced by the thinning operation, which should be carried out as early as possible so as to minimize the effects of competition between the fruits and to ensure that the development of the following year's flower-buds is not inhibited by the presence of too many seeds on the tree.

In the case of early peaches, the fine timing of this operation is particularly important. Experiments with the Cardinal variety have shown a substantial differene between the quality of fruits thinned within twenty days of flowering and the quality of those thinned more than 45 days after flowering (88).

. Optimization of yields

The overall effect of these pruning and thinning operations is to restrict fruiting to an optimum level related to the total sugar potential of the foliage as a whole.

The resulting yields can of course vary, depending on climatic conditions and the physical characteristics of the tree. Thus, in the South of France, in a survey of more than 100 orchards, repeated over a period of several years, quantity was found to have an adverse effect on quality when the yield exceeded 45-50 t/ha in the case of the Golden Delicious variety (117). In Belgium, with less sunlight, the same threshold was reached around 25-30 t/ha (145).

These findings only relate to specific orchards and to yields over a relatively short period ; it does indeed seem desirable to work out the maximum yields per hectare compatible with quality at the level of the individual plot of land.

So then, the grower can best control the yield by pruning and thinning. The more vigorous the growth, and the better the spacing of the fruit throughout the crown of the tree, the greater will be the influence of these techniques on the quality of the fruit.

3.14 : Nutritional factors

The amount of mineral nutrition taken up by the tree, and therefore its photosynthetic capacity, depends on a number of factors, including the physical composition of the soil which determines its permeability and water-retaining properties and its chemical composition which determines its fertility. But fertilizers and irrigation can considerably modify the natural characteristics of the soil.

314.1 Soil management

As far as perennials are concerned, the upkeep of the soil can be ensured either by maintaining a grass- and weed-free surface or, in complete contrast, by permanently grassing the alleys between the rows of trees.

Swards are becoming more popular in European orchards, because the use of grass as a ground cover makes for easier upkeep, which simply consists in mowing, facilitates the movement of equipment in all weathers and improves the permeability of the soil, in which the roots can spread further.

But the nutrition taken up by the grass must be replaced by additional fertilizer, especially in the form of nitrogen compounds, and with additional water (157).

In a humid climate, grassing can bring about a marginal improvement in quality, in the form of higher sugars, probably resulting from the competition for nourishment between the grass and the fruit tree. The improvement varies from variety to variety, however, and would seem to be greater with Golden Delicious than with Cox and Jonathan (158).

It nevertheless remains true that competition reduces yields, and that is probably why it has a beneficial effect on quality (159).

In a Mediterranean climate, it is important to ensure a proper balance between the amounts of water and the amounts of nitrogen. Various trials, particularly on peaches, have shown that the best quality can be associated with a bare surface and a moderate amount of nitrogen, or alternatively with a grassed surface accompanied by larger applications of nitrogen fertilizers. The intermediate combinations, i.e. bare surface + large applications of nitrogenous fertilizers, or grassed surfaces + low applications of nitrogenous fertilizers produced less favourable results.

In certain cases, grassing can bring about a marginal increase in the acidity of the fruit, both in peaches and in apples. Numerous trials have shown that this solution of the soil management problem can have a very beneficial effect on quality, providing a judicious balance is maintained between mineral nutrition and water supply. In one particular case, the incorporation of a large amount of marc in the soil of an orchard of Cardinal peaches led to a considerable rise in the acidity of the fruit.(88).

At the same time as more orchards are being grassed, the use of chemical herbicides to eliminate weeds from under the trees has become standard practice, and the same applies to the soil between the rows of vegetable crops.

Depending on whether the herbicides are applied around trees or around annual plants, the risks to quality are quite different : the effects on perennials can only be indirect, but annual crops can be directly contaminated by these chemical products.

The indirect effects of herbicides are reflected in an increase in the nitrogen content of the leaves (160), but this phenomenon does not seem to have any very marked effect on the quality of the fruit. When there is more nitrogen in the leaves there is normally less sugar in the fruit, but some herbicide trials have shown an increase in total sugars, particularly in peaches (161).

Equally divergent results have also been obtained for vegetables. Although the utilization of herbicides around tomatoes after planting has sometimes reduced both sugars and acids, a more generous application has sometimes resulted in higher concentrations of sugars and ascorbic acid in the fruit (162).

As far as carrots are concerned, the use of certain herbicides, and especially of linuron, has been shown in certain cases to inhibit the development of carotene (163), but elsewhere it has been shown to have the opposite effect of increasing the carotene content (164). Here again, the discrepancies between the results may well be attributable to variations in the amounts applied (165).

Potatoes are a special case, because the use of chemical defoliants is specifically recommended, to destroy the green top and thus to prevent the synthesis of excess starch in the tubers. Seen from this angle, the use of chemical herbicides would appear to be beneficial. It has been shown, however, that the application of chemical defoliants can lead to necrosis of the vascular ring, leaving a thin brownish layer inside the potato (166).

This would not seem to impair the gustatory quality of the tubers. It is also worth adding that shape and taste are more seriously affected by auxins than by triazines or the derivatives of urea (167).

314.2 - Fertilizers

The scale on which mineral fertilizers have been used on fruit and vegetable crops has been matched by the numerous investigations of their effects, and some of this research has been devoted to the quality aspects. Because of the many possible interactions between the main mineral elements on the one hand, and factors such as environment, soil, or climate on the other, the results do not always tally.

Nevertheless, there are two fertilizing elements which constantly affect the quality of fruit and vegetables ; these are nitrogen and potassium and so extensive is the bibliography on this subject that their effects on the individual fruit and vegetable species can be described separately.

. Effects of nitrogen

Because of its effect on the development of the vegetative parts of plants, nitrogen is an indispensable factor in the development of quality, but an excess of this element can soon cause harm. In fact, an adequate supply of nitrogen is needed for the foliage to develop sufficiently to keep the rate of photosynthesis at a level which will be favourable to quality.

Nitrogen deficiency, leading to chlorosis of the leaves, can slow the development of the growing parts of the tree, and can therefore be considered harmful to quality.

Because this element is highly mobile in the soil, regular applications are necessary. But excess nitrogen is one of the most frequent causes of physiological disorders and changes in the composition of the product. So it may have an adverse effect on quality (281).

In apples, increased applications of nitrogen generally result in higher acids and chlorophyll at the time of harvesting, as well as diminished colour, less successful synthesis of the volatile components, and more rapid ageing of the fruit, reflected in reduced firmness and lower keeping quality (168).

Generally speaking, there seems to be a negative correlation between quality and high levels of nitrogen in the fruit and leaves (137). But close investigation of the effects of stepping up the rate of application has shown that moderate doses of nitrogen have the most beneficial effect on the concentration of sugars in the fruit. As has already been emphasized in the chapter on soil management, the negative effects on quality can be almost entirely offset by grassing over (169).

The most significant effects of excess nitrogen would seem to be the slower regression of chlorophyll and the lower concentration of anthocyanins in the epidermis (170).

Excess nitrogen therefore delays the ripening process and interferes with the synthesis of aroma. By contrast, because this element has a major influence on the synthesis of the amino acids, which are considered to be the precursors of aroma, it can make a positive contribution to the synthesis of flavour when applied in moderation (46).

Immoderate doses of nitrogen can also have an adverse effect on shape : the proportion of nitrogen compounds, compared with the proportion of other mineral elements, is relatively greater in malformed specimens than in normal fruit (171).

In fruit nutrition trials in France it was shown that optimum fruit quality is obtained when nitrogen is applied at the rate of 150-190 units per hectare (117).

In peaches, nitrogen fertilizers also encourage the development of sugars, providing the applications are not excessive, particularly when the orchard is grassed. There are conflicting reports on the effect of nitrogen on the regression of acidity, the process being slowed down in some cases and accelerated in others.

There is ample evidence that nitrogen is a key element in the cultivation of peaches, and that applications of 150 - 250 kg/ha per annum, depending on whether the soil is bare or grassed over, will not impair quality and will also have the positive effect of promoting vegetative growth (88).

As far as the relative contribution to quality of different nitrogen fertilizers is concerned, it has been reported that COU (crotonylinede diurae) is more beneficial than sulfate of ammonia.

In the case of apricots, the excessive application of nitrogen fertilizers can lead to irregular ripening not only of the fruits on a single tree but also between the stalk and pistil areas of the fruit (287).

Tomatoes respond to nitrogen in the same way as fruit trees; but the age of the plant is very important, because the entire life cycle is completed in a single year. At the end of the growing cycle, the fruits contain less nitrogen and potassium, but more vitamins are present. Generally speaking, however, the composition of tomatoes is not significantly changed by varying the amounts of nitrogen fed to the plants (129).

Heavy applications of nitrogen fertilizers seem to provoke the early development of sugar, but not to result in the accumulation of more total sugars than are produced by moderate doses (174).

It is most important to apply the dressing at the right stage of the plant's development, and there is clear evidence that late applications, when the fruits are swelling, can affect the gustatory quality of the tomatoes by slightly increasing their acidity and reducing the total sugars (175).

Foliar feeds of urea have been shown to improve both total sugars and vitamins C (176).

Melons react well to nitrogen fertilizer during fruit growing, but the total sugars are reduced when the application coincides with the first signs of maturation.

Melons seem to respond better to nitrates than to ammonia compounds (263). Cultural techniques, and especially the application of fertilizers, would seem to have less influence on general quality and total sugar than is exercised by variations in the climatic conditions from one year to the next (264).

In carrots, the use of nitrogen fertilizers has little effect on the amount of carotene, which would only appear to be slightly increased by heavier applications which tend to reduce the sucrose content without affecting total sugar (177).

But when applied late in the growth cycle, the nitrogenous fertilizers, and particularly the nitrates, not only have a generally adverse effect on the level of sugar but can also lead to the accumulation of nitrites after storage or processing and this can be particularly dangerous for human health (72).

With salad crops, the protein content of the leaves is increased by nitrogenous fertilizers, especially if ammonia compounds make up 20 % of the total. Dressing with ammonia, if not overdone, will improve the concentration of vitamins (129).

Potatoes are a special case, compared with other products, because higher quality is achieved by reducing the dry matter content and consequently the total sugars.

Thus, in this particular instance, the negative influence of nitrogen on total sugars would appear to add to quality, by bringing down the starch content of the tubers in direct proportion to the amounts of nitrogen administered (178).

But nitrogenous fertilizers also affect the development of the amino acids and the overall protein content of the tubers. Over-generous feeding can depress this development (179), while moderate applications of 100 - 150 units/ha, depending on the variety, would seem to produce the highest protein content (180).

It should also be mentioned that susceptible varieties of potatoes fed with large amounts of nitrogenous fertilizers will also show a greater tendency to blackening of the tubers after cooking (181).

. <u>The compensatory role of potassium</u>

Potassium fed to peach trees mainly affects the acidity of the fruit. It increases the concentration of organic acids and also raises the pH by increasing the proportion of total acidity represented by the basic salts of these acids (13). Feeding with potassium has also been shown to enhance weight and sugar content (182).

Apple trees respond to potassium in a comparable manner, but here again there is danger in excess. An annual dressing of 200 - 300 units/ha would appear to maximize total sugar, but the effect on older trees is less marked, because the potassium tends to accumulate in the leaves (117).

In addition, the application of excessive amounts of potassium may cause calcium deficiency in the fruit, thus encouraging the development of storage disorders, especially bitter pit.

Tomatoes. like fruit trees, develop increased acidity when fed with potassium (183), and total sugar is also improved (184). Some experiments have also shown higher vitamin C, providing the dose is not excessive (185) (282).

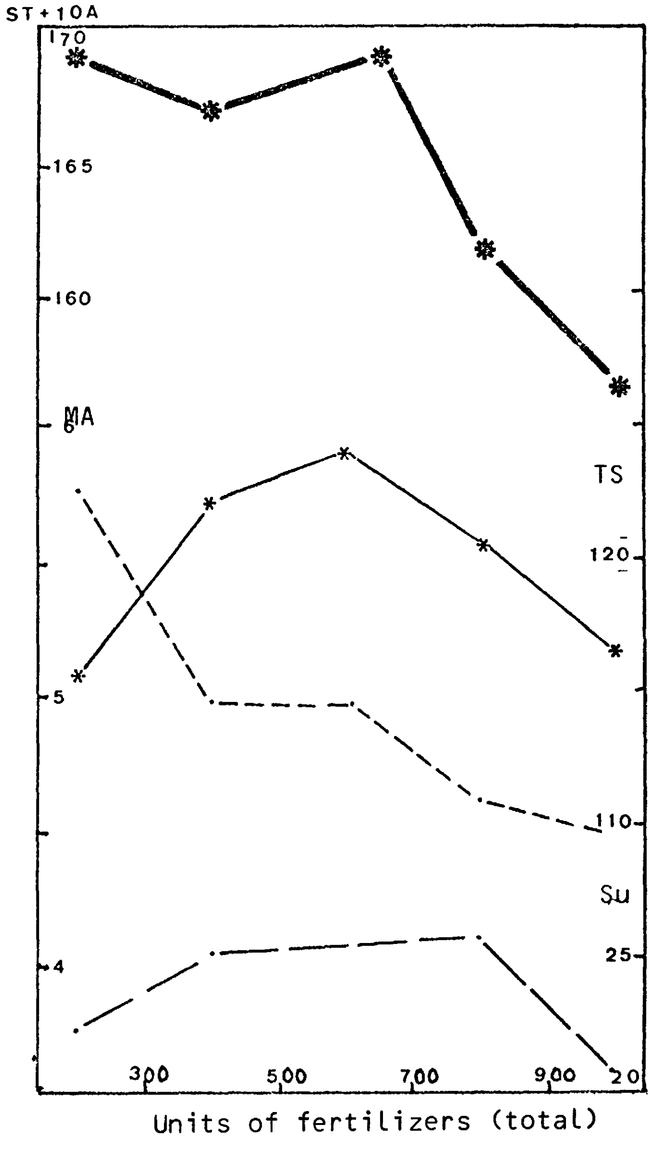
There is also evidence of higher concentrations of carotenoids, and thus of improved colour (186). The optimum concentration of potash in the soil, as far as the organoleptic qualities of the tomato are concerned, is estimated at about 700 ppm (187).

Potash fed to potatoes brings down the dry matter content of the tubers and increases the amount of nitrogen (188). By reducing the concentration of phenolic compounds in the tubers it reduces their susceptibility to internal discoloration as a result of bruising (189).

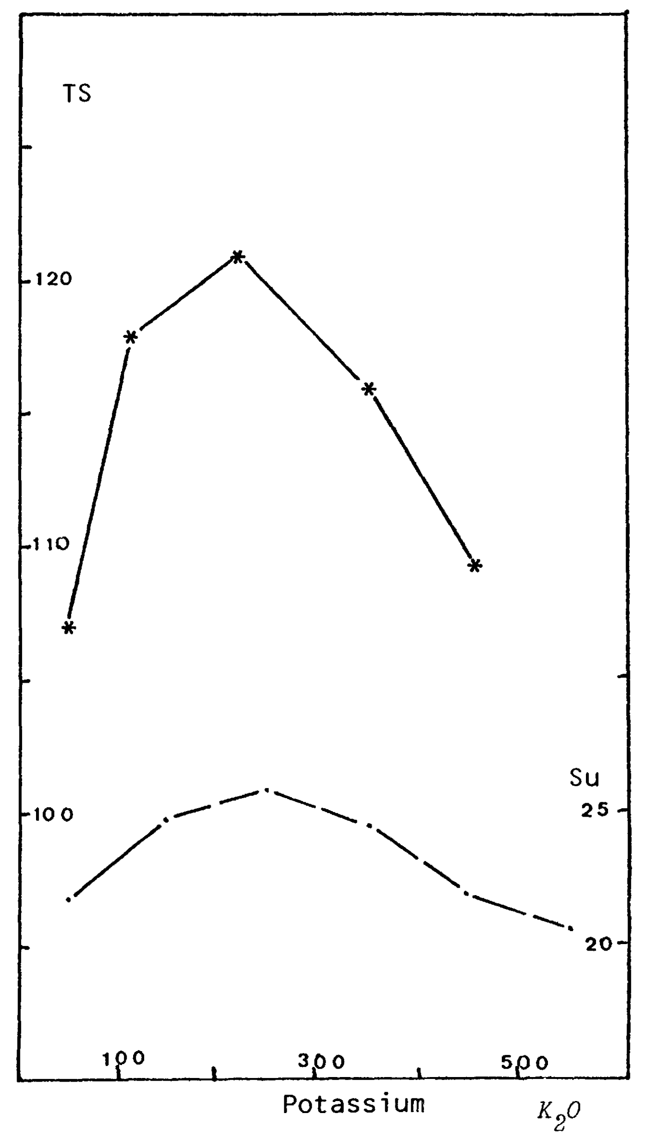
Trials in the Netherlands have shown that by analysing the potassium content of the foliage at the phase of maximum development of the plant (70 - 90 days after planting), it is possible to forecast the tubers' susceptibility to blackening. When the total potassium content of the dry matter is greater than 5 %, there will be little blackening, but this tendency will be very strong if total potassium falls below 4 % (190).

INFLUENCE OF THE APPLICATION OF FERTILIZERS (117)

Variation of components according to amounts of fertilizer



Variation of sugars according to amounts of potassium fertilizers



Quality index $ST + 10\ A$

Total sugar g/l

Malic acid g/l

Sucrose gl

. Other elements

The influence of other elements on quality has often received less attention than that of nitrogen and potash. Phosphoric acid, for example, is rarely mentioned, but is always a favourable element in any balanced fertilizer (191). Shortage of the trace elements, zinc, boron and magnesium may lead to the development of deficiency symptoms and impair the quality of the product.

In the case of tomatoes, for example, the addition of zinc to the water supply for deficient soils has been shown to improve total sugar and total acidity (192). Similarly, the addition of boron has been shown to have a favourable effect on total sugars in apples (117).

By virtue of its important role in the synthesis of chlorophyll, magnesium has an indirect effect on the development of the sugars. It is important to maintain the right balance between magnesium and total potassium. This balance between the two elements is essential for the optimum development of vitamins in lettuces (129).

In conclusion, in spite of the widespread prejudice against the practice, the provision of nutrients in the form of mineral fertilizers does not appear to harm the quality of fruit and vegetables. Indeed, if the balance is right and if due regard is paid to the requirements of the plant being fed, they can make a significant contribution to the organoleptic and nutritional quality of the crop.

Nitrogen, which is essential to photosynthesis, must nevertheless be administered in moderate doses and at an early stage of the vegetative cycle, i.e. when the leaves are growing. If applied too late, it impairs the quality of fruit and vegetables, and on root crops can also be harmful to health.

The presence of potash is always beneficial, providing it is not applied in excess, and it can offset the adverse effects of excess nitrogen (193).

In short, fertilizers can enhance the quality of horticultural produce, but their influence is generally less than that of the various climatic factors. Optimum quality will never be obtained by inadequate or excessive applications of one or other of the elements referred to, but it can be obtained by ensuring the properly balanced satisfaction of the various nutritional requirements of the individual crop (194).

314.3 - Growth regulants

The most significant progress in recent years in the field of plant biochemistry has certainly sprung from the discovery of the growth regulants, very small doses of which can affect the physiological development of the plant and control its rate of growth.

These substances have been precisely identified, and many can now be produced industrially and put to a number of uses. Their pratical applications have been particularly strongly developed over the past few years in the sector of ornamental horticulture. A number of experiments have also been carried out on fruit and vegetables, and some of their effects on product quality have already been investigated.

These substances can be divided into two main categories, depending on their effects : those which mainly control the process of cell development and directly influence the vegetative growth of the plant and its fruit, and those which have a direct effect on the fruits as they ripen.

It should be added that some of these substances can have both the abovementioned effects, depending on when they are utilized. The observations which follow will be confined to the substances which have a direct effect on the quality of horticultural produce.

. Growth inhibitors

This general term includes a number of different substances which can reduce the rate of development of the plant and thus exercise a certain dwarfing effect by reducing the distance between two points of leaf formation, known as the internodal distance.

It is therefore possible, without reducing the total surface area of the leaves, to develop a more compact plant resembling the clones of the "spur" mutations of the main varieties of apple which have been developed, in particular, in the United States.

But these substances also encourage the development of flower buds. Floral induction is in fact regulated by substances known as gibberellins, which are secreted by the seeds (i.e. by the pips and the kernels) which are responsible for a certain amount of variation from one year to another in the yield of certain species.

Growth inhibitors reduce the inhibiting effects of the gibberellins, so that their application to fruit trees not only reduces their spread but also increases floral induction.

If the trees are sprayed with these substances too early or too late in the season, this can result in the developement of smaller fruit, which may also be misshapen.

In apples, for example, an application of SADH (Alar) between 60 and 70 days after full flowering encourages the development of the fruit and helps to ensure that they develop more colour, ripen earlier and are less susceptible to pre-harvest drop. If spraying is carried out earlier, the size of the fruit is reduced. By contrast, trees sprayed between 100 and 120 days after flowering bear misshapen fruit the following year (195). The effect on flavour would seem to depend on the doses used. There is evidence that 2 000 ppm can have an adverse effect, but that flavour does not suffer with concentrations of 500 - 1 000 ppm (196).

SADH sprayed on peach trees improves the colouring of the flesh and of the epidermis. Some experiements have also shown a reduction in total sugars and an increase in acidity (197). Colour is improved because this product stimulates the production of anthocyanins, and a fillip would also seem to be given, in certain cases, to the synthesis of the aromatic substances which occur at exactly the same time as the peach becomes red (198).

SADH sprayed on cherries will accelerate the development of the red colouring without improving the gustatory qualities, which remain comparable to those of untreated cherries (266).

As far as the effect on quality is concerned, therefore, the application of growth inhibitors is an extremely delicate technique to operate, so that the dates and rates of application of these products must be worked out with maximum precision.

Gibberellic acids

Besides inhibiting flower formation, the main function of the gibberellic acids is to stimulate the elongation and lateral development of the cells. For that reason they can be used to encourage the growth of parthenocarpic fruit. They can be sprayed on pears, for example, when low temperatures have destroyed the stamens and prevented any fertilization ; or on glasshouse tomatoes when daylight hours are short and the fruit will not set very easily.

Pears grown in this way have no pips, and their form is more elongated than the standard form for the variety. In tomatoes, there is some evidence that sugars and acida can be slightly affected, but the results have been far from uniform. Certain varieties show an increase in total sugars (199), but sugars and acids have fallen slightly in others, as a result of the enzymatic action of the oxydase (200).

Because they can stimulate cell development they are also used in combination with similar substances, the cytokinins, to retard senescence of the leaves so that they remain on the tree for a longer period (201).

. Auxins

Under this name are grouped various natural substances which have already been known to science for a considerable time, such as indoleacetic acid (IAA), indolebutyric acid (IBA) naphthaleneacetic acid (NAA) and naphthylacetamide, etc. ....

These auxins have long been used in the propagation of cuttings, to stimulate root formation. When sprayed on fruit trees, at the phase when the fruitlets are beginning to set, they throw the regulating mechanisms out of gear and cause the youngest fruits to fall from the tree. They are used for this purpose in the chemical thinning of the most prolifc varieties.

Auxins have mainly been used in the treatment of apple trees. They constitute a simple means of maintaining a suitable balance between fruiting and vegetative growth, and may therefore be said to have a beneficial effect on quality.

IAA, which is synthesized by the apex, is sometimes applied to salad crops to improve head weights. Another auxin, 2.4-D, which is mainly used as a herbicide, can cause malformations of the leaves if it is used for the same purpose (202).

The generators of ethylene

Ethylene is naturally present in ripe fruit. It is associated with the biological changes in the tissues which enable the fruit to develop the characteristics of ripeness. Certain products, such as ethephon, can trigger off the synthesis of ethylene at an earlier stage than would normally occur in nature. This property of ethephon is used to bring forward the date of picking, to provoke a more uniform development of colour and to synchronize the ripening of all the fruit on the tree.

In yellow fruit, it affects the flavonols in the yellow pigments and the rate at which they are revealed by the regression of chlorophyll. In red fruit or in fruit with red markings, it provokes a very marked increase in the anthocyanin pigments.

Sprayed on apples a week or fortnight before picking, at the maximum concentration of 500 ppm, it brings about a substantial reduction in acidity and a slight increase in sugars, at at the same time greatly adds to the red pigmentation. But the average weight is slightly lower than that of untreated fruit (203).

The effect of this product is obviously more marked when the natural conditions are less favourable to good colouring in the fruit. Thus, the greatest differences in colour have been observed at low altitudes, and it is there that the greatest increase in total sugar has been recorded (204).

Thus it would not seem that the use of ethylene generators has any adverse effect on the quality of the products, providing the concentrations used are not so great as to have an opposite effect to that intended.

In the case of tomatoes, however, the increased synthesis of the anthocyanins is not accompanied by any regression in total starch or, more particularly in the solanin and tomatin which are responsible for bitterness of taste.

314.4 - Irrigation

The photosynthetic process, which we have already described as a vital factor in the development of quality, depends on the amount of water in the plant. All this water is actively needed, so it may not be considered as constituting a reserve. In summer, in less than an hour, the plant can begin to wilt as a result of loss of water if the water supply is cut off.

- Evaporation/transpiration and the quality of fruit and vegetables :

These losses of water occur, first and foremost, in the form of transpiration through the leaves, where the water passes from the liquid to the gaseous state in the stomata, thus permitting the plant to regulate its temperature, in the same way as in animals.

The rate of evaporation/transpiration via the stomata depends on the intensity of solar radiation, on the tension of the water vapour in the air and on wind speed. These different factors provoke a need for evaporation, to which the plant responds by transpiring. But if the amount of water drawn in via the roots does not meet this demand, the plant will react by more or less completely stopping the opening of the stomata so as to offset the shortage of water by reducing the level of transpiration.

In such circumstances, the exchanges of gases are reduced or even stopped during the hottest part of the day and the photosynthetic processes are correspondingly reduced.

Thus, photosynthesis is independent of water supply, so long as the diffusion pressure deficit (DPD) in the plant remains lower than 5 or 6 atmospheres. Photosynthesis decreases in intensity as DPD increases above this level, and ceases entirely when the DPD reaches 12 - 15 atmospheres (205).

But a shortfall in water supply can greatly reduce the synthesis of dry matter and can therefore have a serious effect on the quality of horticultural produce.

By contrast, if the plant's uptake of water is at a maximum, either because the climate is very humid or because the soil is so cultivated as to retain the maximum amount of water, or even as a result of these two factors together, there is a major increase in the dimensions of the cells and a certain amount of dilution of the synthesized substances (279).

It is therefore by providing the plant with the right amounts of water during the most important phase of cell activity, which coincides in fruit with the phase of cell multiplication, that one can provide the optimum conditions for balanced development of the various components of organoleptic quality.

. Determination of the plant's water requirements

The water requirements of plants grown for their fruits can vary according to the phase of the vegetative cycle. In those fruits in which growth is considerably reduced as maturity approaches, as in berries such as grapes, the rationing of water supply in the last phase will bring about a substantial increase in the amounts of organoleptic substances in the fruit. In fruits such as apples or pears, whose growth is moderately reduced at this time, a certain reduction in water supply can also lead to a slight improvement in total sugars and acids. By contrast, where the rate of growth increases as maturity approaches, as in peaches for example, it has been found that the sugar content is more stable and that curtailment of the water supply will not have any effect unless it is spread over a protracted period, thus having an adverse effect on the yield.

The plant's water requirements, at all the different stages of the vegetative cycle, must therefore be known in detail if the irrigated water supply is to be so adjusted as not to jeopardize the quality of the products.

Various methods are available for measuring the theoretical amounts of water required, as a function of climate, in which allowance is made for the intensity of solar radiation, temperature, wind velocity etc. One can therefore determine, for a given point in time, a theoretical value for potential evaporation and transpiration (PET) (206). By comparing these theoretical values with the real consumption of water by plants kept in lysimeters one can work out PET coefficients for each phase of growth and each species so as to meet the evaporation/transpiration requirements as measured. (MET).

Research has been undertaken in many countries to determine these coefficients and to study the effects of the various coefficients on the quality of the fruits produced.

. Effects of irrigation

In areas where the climate is particularly arid, irrigation can be considered as beneficial to quality, always assuming the supply of water is adjusted to the requirements of the crop. Thus, in the United States, the effect of successive increases in the supply of irrigated water on sugar levels in fruit has been shown by experiment to be only marginal, and in peaches the level was only changed significantly when the supply of irrigated water was completely cut off. By contrast, plums grown for transformation into prunes showed slightly higher sugars when the water supply was stepped up (207).

Experiments in France, which are still in the initial stages, have already produced similar results. Comparison of the effects of doses representing under 30 %, 60 % and 80 - 100 % of PET reveals that the fall in the level of total sugar attributable to irrigation is more marked, in apples and pears as well as in peaches, between the low and medium doses than between the medium and high doses. This also applies to acidity, in comparable proportions.

Firmness, by contrast, is more or less the same in the fruit receiving the average and low doses, but is greatly reduced in those receiving the maximum. There also seems to be a long-term effect on the percentage of fruits which set, and in this respect the lower doses do not make such a good showing. As far as fruit size is concerned, the effects are somewhat contradictory, because the size-enhancing effects which ought to ensue from stepping up the supply of water are counteracted by the increase in the total number of fruits.

If due weight is given to all the factors which contribute to quality, including the characteristics of appearance as well as the organoleptic properties, the average doses of irrigated water can be said to constitute the optimum, because they ensure a fair yield, in which size is also often at a maximum, without reducing the organoleptic qualities to any significant degree (116).

Similar effects have been observed in annual crops. Thus, in the South of France, a moderately increased supply of irrigated water has been shown to improve the organoleptic properties of melons (208) especially if the supply is administered during the period of maximum vegetative growth.

In glasshouse tomatoes, because of the special microclimatic conditions, the reduction of the amount of water reduces the yield and average size of the fruits and in particular increases the total sugars. A tendency to increased acidity has also been recorded. It would seem therefore, that water supplies in the greenhouse must be even more carefully adjusted to the real needs of the plant than when tomatoes are grown in the open, if the intention is to avoid harming the gustatory quality of the product (209).

Effects of irrigation techniques

Finally, as far as potatoes are concerned, the starch content of the dry matter can reduce the gustatory quality of the product, so that irrigation is clearly beneficial. By avoiding the sudden changes in vegetative growth which can be provoked by periods of drought, the spraying of crops in regions where irrigation does not appear to be absolutely necessary for good growth can prevent the formation of secondary tubers or excrescences and reduce the incidence of cracks in the skin (210).

The method of irrigation adopted can also affect quality. For example, the sprinkler system would appear to improve the yields and size of apples without adverse effect on their quality (211). Similar observations have been made in France, and have also shown a slight improvement in the rate of ripening and in gustatory quality. Low-volume spraying of the foliage during the hottest hours of the day has been shown to exercise a very beneficial influence on quality when the temperature of the air rises above 30°C, because it holds down the temperature. This also enhances the colour of the fruit and improves the sugar content (212) (280).

Irrigation would therefore appear to be favourable to quality, providing the amounts are carefully worked out so as to meet the requirements of the plant at the different stages of its growth.

Irrigation becomes harmful only when water is administered in excess or at irregular intervals.

Not enough is yet known about the real water requirements of the various plants, and every experiment which can be undertaken in this field will certainly be a useful contribution to harnessing these techniques for the growing of quality produce.

3.15 : Crop protection

The methods adopted for protecting crops against parasites can have a major influence on the quality of the product. On the one hand, plants must be adequately protected if crops of acceptable quality are to be grown, but on the other hand certain pesticides can have the direct effect of communicating an unpleasant taste to the product, or the indirect effect of reducing quality by modifying the metabolism of the various sugars.

315.1 - Consequences of attack by parasites

Attack by parasites is harmful to quality, and the deterioration may be caused directly, by the parasites themselves, or it may be caused indirectly, through the disturbance of the plant's physiological processes.

The most clearly visible forms of direct attack by parasites are those which result in malformation of the product, and this is particularly true of fruit. Thus, for example, the punctures made in the skins of young fruits by bugs or thrips or the development of fungal infections such as scab can harden the cell walls at the point of attack, so that the growth of the affected parts of the fruit is slowed or even arrested, thus rendering it misshapen and entirely unfit for sale.

Attack by parasites can also lead to deterioration of the epidermis, by causing the development of patches of more or less scarred tissue which mar the appearance of the fruit, or to flesh wounds through which ordinary moulds (monilia, penicillium) can get into the fruit and cause it to rot.

The most frequent causes of this type of damage are fungal rot, e.g. scab or powdery mildew, or attack by insects such as the caterpillars of the tortrix moth.

Certain insects whose larvae develop inside the fruit not only spoil its appearance but also cause it to rot, as a result of penetration by secondary moulds. This applies in particular to apples and pears attacked by codling moth caterpillars, to peaches troubled by the oriental tortrix moth, and to potato tubers infested with click beatles.

In addition, some of the moulds which develop on fruit as a result of fungal attack can be a health hazard for the consumer, because of the toxic substances they liberate (213).

This applies in particular to the various penicillin moulds, such as the green mould (P. digitatum), blue mould (P. italicum) or P. expansum, which can attack apples and cause sarcoma of the skin as a result of the liberation of patulin. Brown rot in tomatoes (alternaria), and dry rot in potatoes (fusarium solani) are also toxic moulds.

Certain insect larvae can also liberate toxic substances or substances which irritate the mucous membranes. This applies to the cherry fruit fly, the presence of whose larvae in the fruit has been known for centuries to cause aphtha of the mucous membranes of the mouth.

The encroachments of insects or mites can also have an indirect effect on quality, by disturbing the photosynthetic processes as a result of the diseases of the foliage which are provoked by these parasites. Scab and powdery mildew in fruit trees, mildew in potatoes, leaf miners and red spider mites, to name but a few of these pests, can drastically reduce the total active leaf surface, with dire results for the rate of photosynthesis. The preservation of healthy foliage is absolutely essential, therefore, if the fruits are to receive a balanced supply of nutrients.

In the same way, the activities of leaf-borers and leaf-sucking insects such as fruit flies, fruit suckers and scale insects can cause very serious nutritional disturbances, as well as leading to the development of a sooty mould on the parts of the fruit on which these assailants deposit their honey dew, forming a blackish layer that does nothing to improve the appearance of the product.

This brief enumeration of the many serious consequences of attack by parasites, as far as quality is concerned, serves to illustrate the illusory nature of the notion of exceptional quality which some people associate with "natural" products, untouched by any form of plant protection. It cannot be denied that a minimum of intervention is indispensable in modern cultural conditions, in which the concentration and specialization of production encourage the development of parasitic attacks.

315.2 - Secondary effects of certain pesticides

Plant protection with the aid of chemical products must nevertheless be carried out with due care, to avoid disturbing the metabolism of the sugars or the synthesis of aroma.

There is evidence, in fact, that certain chemical products can inhibit the development of dry matter, as in the case of aldrin applied to carrots to combat carrot fly, which can reduce the dry matter content by 10 % and the carotene by 20 - 25 % (12).

The use of pesticides late in the season to combat scab, which is a common practice in countries with a damp autumn, can affect the aroma of apples and may even render the flavour slightly "metallic" or "mouldy". These effects on flavour do not appear to be specific to the products employed, and the risk would appear to be avoided if the latest treatments are carried out 40 - 50 days before picking (214).

In certain cases, other substances in the product may have an adverse effect on gustatory quality, although the active substance itself is not the cause. This has been observed in experiments in the Netherlands, with products based on carbaryl, which were applied in the fortnight before picking, with varying effects on gustatory quality, depending on the origin of the product (215).

Certain pesticides can give an unpleasant flavour to fruits and vegetables in general. This applies in particular to HCH and its isomer Lindane, as well as to toxaphene, endrin, malathion and PNCB.

Some pesticides may not harm flavour when applied separately and yet still give rise to a foreign taste when incorporated in mixtures, as a result of interaction between the products (216).

But in other cases the use of certain plant protection products can improve the quality of the fruits, by eliminating the physiological disturbances caused by the parasites they are intended to combat. In apples, for example, it has been observed that total ascorbic acid has increased as a result of the application of various insecticides and acaricides (217).

Applications of nematicides prior to the sowing of carrots, to combat eelworm, have increased the amount of the dry matter and the carotene content of the carrots grown in the soil thus treated (218).

The earlier and more uniform ripening of cherries which is ensured by spraying the fruit with a mixture of white oil and benomyl a fortnight before commencement of picking can also be considered as an improvement in quality (219).

It would seem, therefore, that the treatment of fruit and vegetables with chemical products can modify their gustatory quality, sometimes to advantage but sometimes otherwise. However, except in the case of pesticides which directly impart a foreign flavour to fruits and vegetables, these effects are often wellnigh impossible to assess objectively, because of the complex relationship between the environmental factors, the ingredients of these products and the methods adopted for their application.

315.3 - Limits to the use of pesticides

Because the assessment of the secondary effects of pesticides on the flavour and aroma of fruit and vegetables is fraught with ambiguities, the orchardist must find his own solution which is based on a prudent assessment of the potential results, by only using the products with a proven record of success in the sector in question and by keeping chemical treatment to a minimum,especially in the weeks immediately before picking.

This attitude will be dictated by respect for the maximum tolerances laid down for toxic residues, and it will also reflect the vague association which exists in the mind of the consumer between the hygienic factors and the overall organoleptic quality of fruit and vegetables.

It is commercially advantageous, therefore, for the many reasons referred to, to attempt to control the employment of chemical products and above all to apply the principles of integrated plant protection.

The implementation of these principles will involve the whole range of agronomic resources, from the application of balanced fertilizers to the growing of resistant varieties suited to local conditions, so as to avoid the need to apply chemicals except when attacks by parasites look like reaching a dangerous level; and even in such circumstances the grower should make every effort to employ a specific pesticide or any biological technique that may be available.

The concept of a parasite tolerance threshold, on which the whole concept of plant protection is based, assumes the acceptance of slight blemishes in the product as a result of attack by parasites, providing they have healed, and this is incompatible with the idea of absolute preventive protection, aimed at eliminating all possibility of damage by parasites rather than containing the threat below a minimum nuisance threshold, which is often still the rule applied to many crops.

3.2: IMPORTANCE OF THE HARVESTING PHASE

3.21: Evolution of components

Within the fruit, the final weeks before harvesting are marked by the intense biochemical changes which herald the ripening process.

The ripening period is the phase of development which brings the fruit to the stage of maturity at which it is ready to be eaten. The process can be completed while the fruit is still on the tree, and will then be accompanied by a more or less rapid fall in the rate of growth. By contrast, in the case of fruit intended to be stored for a certain period, the process of maturation will occur mainly after the fruit has been picked, quite independently of its physical growth.

In certain cases indeed, if the fruit is allowed to remain on the tree, this can temporarily inhibit the start of the ripening process, which can only occur after picking. In any case, the ripening process can only take place if the fruit has attained a certain size and, what is more, it can only occur in optimum conditions when the fruit is sufficiently mature. This shows just how important it is, for the quality of the products, to time the harvest correctly.

The phenomena associated with the ripening phase are the following:

- The fruit's rate of growth follows a sigmoid curve and thus falls away in the days which precede picking.

Thus, in Golden Delicious apples, the maximum rate of growth is attained around the 107th day after fertilization, and gradually falls away as maturity approaches (220). Agronomic conditions or environmental factors can change the point at which this slowing of growth begins.

In peaches, the growth curve is more complex. After a first inflection, when the stone is hardening, the rate of growth picks up again in the fortnight preceding maturity, only to fall away sharply in the last few days before the fruits attain full eating-ripeness (88).

The lower rate of growth is accompanied by changes in the shape of the fruit, and these can be treated as visible signs of approaching maturity.

- Starch regression is also affected by the onset of maturation. The process is gradual, starting at the centre and moving progressively towards the skin. Starch disappears more rapidly from the parts that are well-stocked with active pips than from the poorly fertilized parts of the fruit.

- The rise in total sugars, and especially the change in the relative concentrations of sucrose and the reducing sugars, is also a reliable sign of imminent ripeness.

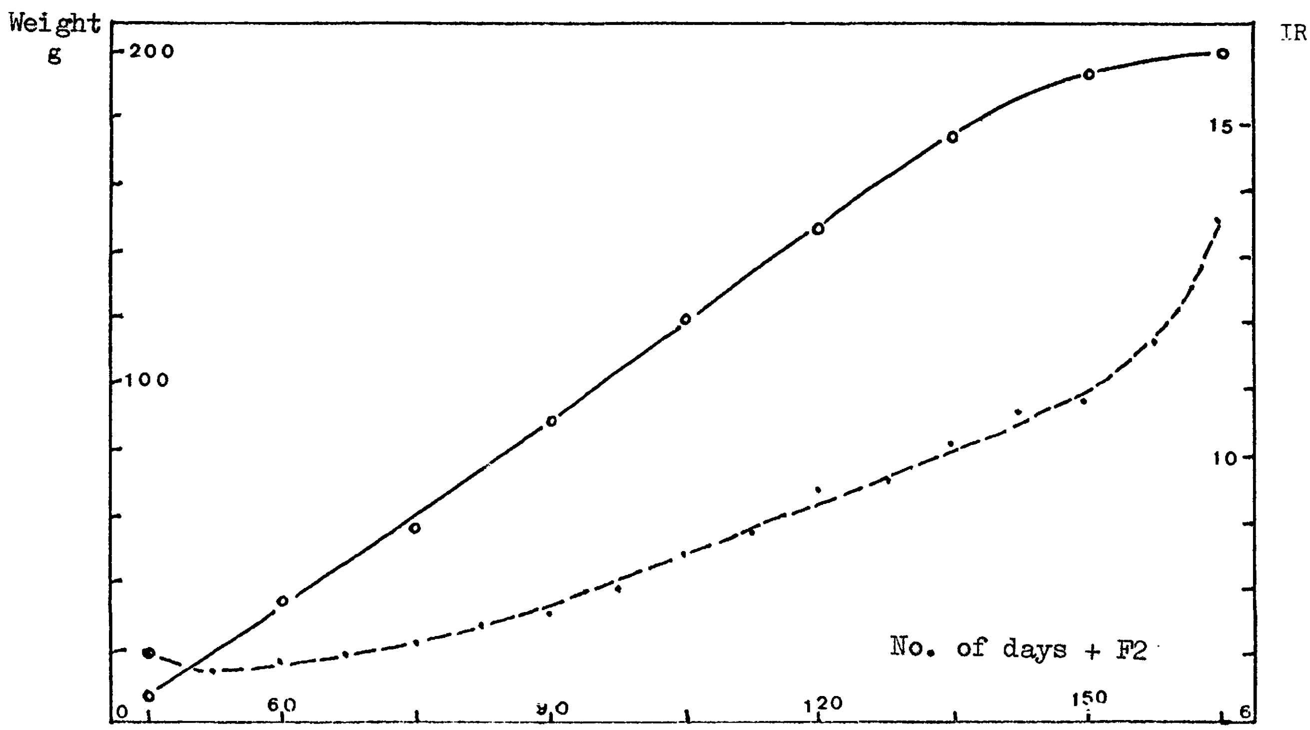
In Golden Delicious apples, the sucrose appears about 80 days after full flowering and accumulates at an increasing rate up to the time of picking (221). But the rate of accumulation varies, and often slows down at the end of September to be followed by a further subsequent increase (78).

The late accumulation of sucrose is a fairly general phenomenon in most fruits and even in certain vegetables such as the carrot (94).

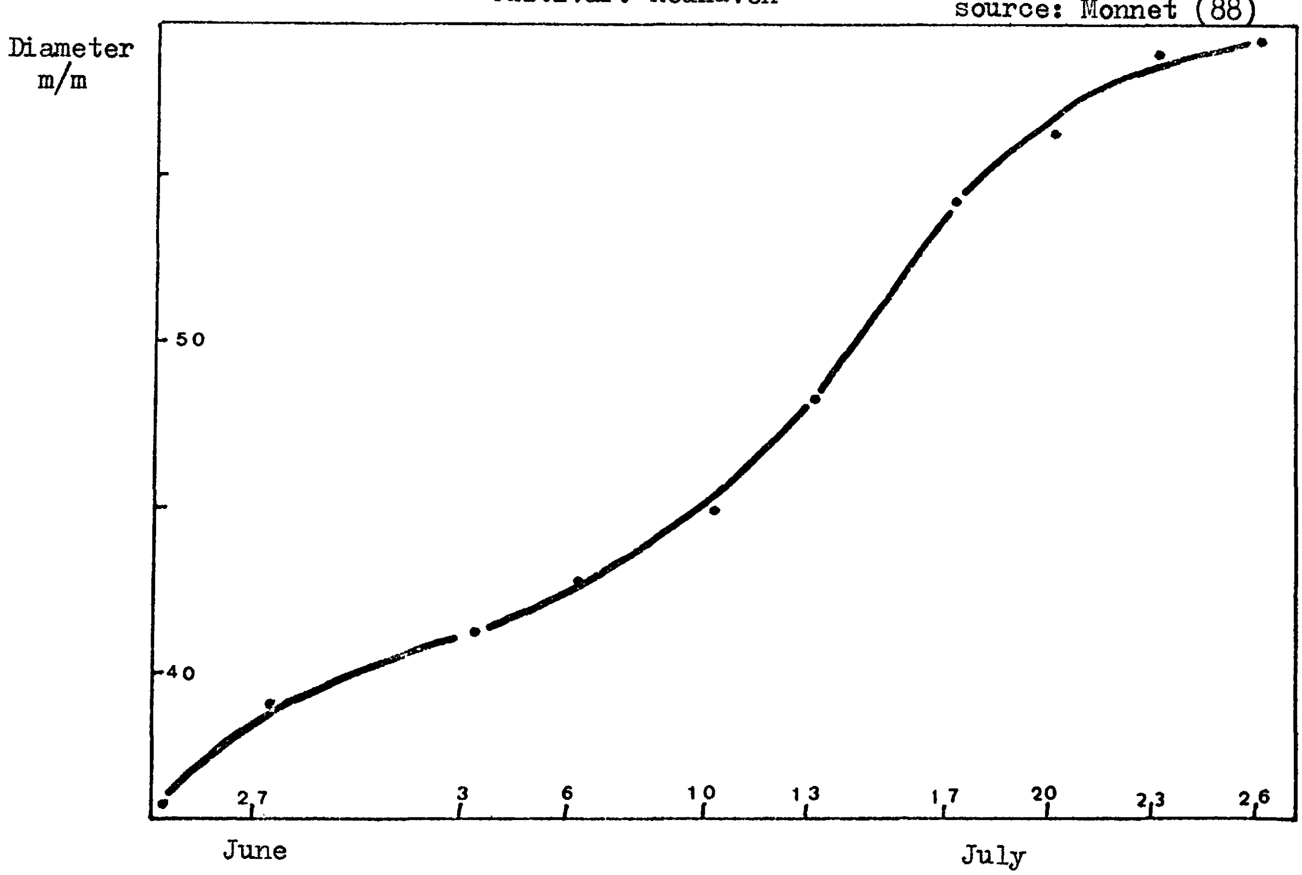
- The regression of acidity is not generally taken as a criterion of approaching ripeness, because after attaining a maximum fairly early in the growth of most fruits, it subsequently decreases at a regular rate. In tomatoes, however, the maximum level of acidity would appear to be reached at a far later stage, and this coincides with the commencement of coloration (222).

- The transformation of protopectins into soluble pectins can be traced as the origin of diminishing firmness, and this is also one of the most visible signs of the approach of complete maturity.

EVOLUTION OF AVERAGE WEIGHT AND REFRACTIVE INDEX
and Golden Delicious apples / M IX 1971



GROWTH RATE OF PEACHES
Cultivar: Redhaven
source: Monnet (88)



- The appearance of synthesized ethylene in certain cells of the fruit marks the start of the ripening process. The synthesis of endogenous ethylene gradually progresses to all the cells of the fruit and is followed shortly afterwards by a sudden increase in the rate of respiration, which has been named the climacteric crisis.

This sudden surge of respiratory activity is the most characteristic symptom of the phase of maturation, because it indicates an additional consumption of energy connected with the metabolism of the compounds which are characteristic of the ripe fruit. For this to take place, the tissues must be sufficiently permeable for the exchanges of gases, and in this connection the lenticels have an important role to play when the cuticle is rendered highly impermeable by a waxy layer.

This metabolism involves both degradation and synthesis.

- The synthesis of aroma is the result of intense enzymatic activity following the start of the climacteric crisis, and the rate of biosynthesis depends on the intensity of this enzymatic activity and on the availability of precursors. It is therefore closely bound up with the stage of development reached by the fruit at the time of picking.

There is a marked change in the colour of the skin, as ripeness approaches, because the chlorophyll regresses and unmasks the yellow or red colour of the carotenoid pigments and the anthocyanin pigments begin to appear.

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These phenomena of the ripening phase of fruit and vegetables can vary in intensity from species to species, and the time taken by the various processes will depend on whether the varieties are early or late maturing. But this is always an important phase of activity, and a few days more or less of life on the plant can considerably affect the organoleptic properties of the fruit.

The timing of the harvest can also be crucial for the keeping qualities of the fruit over a more or less prolonged period of cold storage. The best time to pick the species that are eaten immediately after picking is certainly the moment when the synthesis of flavour has reached its maximum intensity and when the balance between the sugars and the acids has become an agreeable one.

For fruit intended for keeping, the storage process is all the easier if the fruit is picked at an earlier stage of its development. The best time for picking apples for storage without harming the organoleptic properties of the fruit is generally the beginning of the climacteric phase.

Similar changes occur in vegetables, e.g. carrots, which may become woody when over-ripe.

3.22: Optimum harvesting dates

As has already been pointed out, the choice of optimum harvesting date is a key factor in determining the final quality of the product. Various objective tests can be carried out to fix this optimum, but none of these tests will do the job on its own. This is because the main criteria are continously changing, and several have to be measured at once to ensure the right timing.

- The interval of time between flowering and picking is a relatively constant figure which can indicate the point in time at which one must begin checking the other criteria. The length of this period is considered to be fairly constant for apples and pears in a given environment.

Nevertheless, in certain early varieties of pear such as Dr. J. Guyot, the fruit acquires its ability to ripen off the tree at a very early stage, even though it can remain there for several weeks without improving its qualitative potential, because its rate of growth remains fairly regular during the whole of this period (155).

The calculation of harvesting dates on the basis of a constant interval between flowering and picking depends on the availability of a precise reference date for full flowering. The definition generally adopted is that of flowering stage F2, which corresponds to the opening of all the flowers on 50% of the corymbs. This entails daily blossom counts, which are far from easy operations. What is more, the vagaries of climate and - variety can greatly extend the flowering period, thus increasing the margin of uncertainty. Hence the frequent use of a date midway between the commencement of flowering, i.e. the opening of the first flower buds (F1 stage) and the end of flowering, i.e. petal fall (F3 stage), although the latter date may also be difficult to pinpoint when the flowering period is very protracted.

In addition, in any one year, the rate of growth in summer depends partly on the weather. So the average duration of the vegetative cycle can vary as a function of flowering dates and summer temperature. Therefore, although it can serve as a rough guide to the date of picking, the average cannot be applied on its own to fix the optimum date for harvesting top quality fruit.

As far as vegetables are concerned, the process of development is more protracted, and the choice of an optimum harvesting date boils down to a compromise between obtaining a high yield and maintaining sufficient quality. Thus, with potatoes, the procedure is to stop the vegetative growth of the plant, by artificial means, to prevent the over-development of dry matter in the tubers (223).

- Measurement of units of heat, i.e. the sum of the daily temperatures between flowering and picking dates, is often used as an indicator for species which develop rapidly, such as stone fruits (peaches, cherries, apricots). For the Bigarreau varieties of cherries, for example, the sum of the temperatures above $+5^{\circ}$ C required between flowering and maturity is approximately $450 - 850^{\circ}$ C (265).

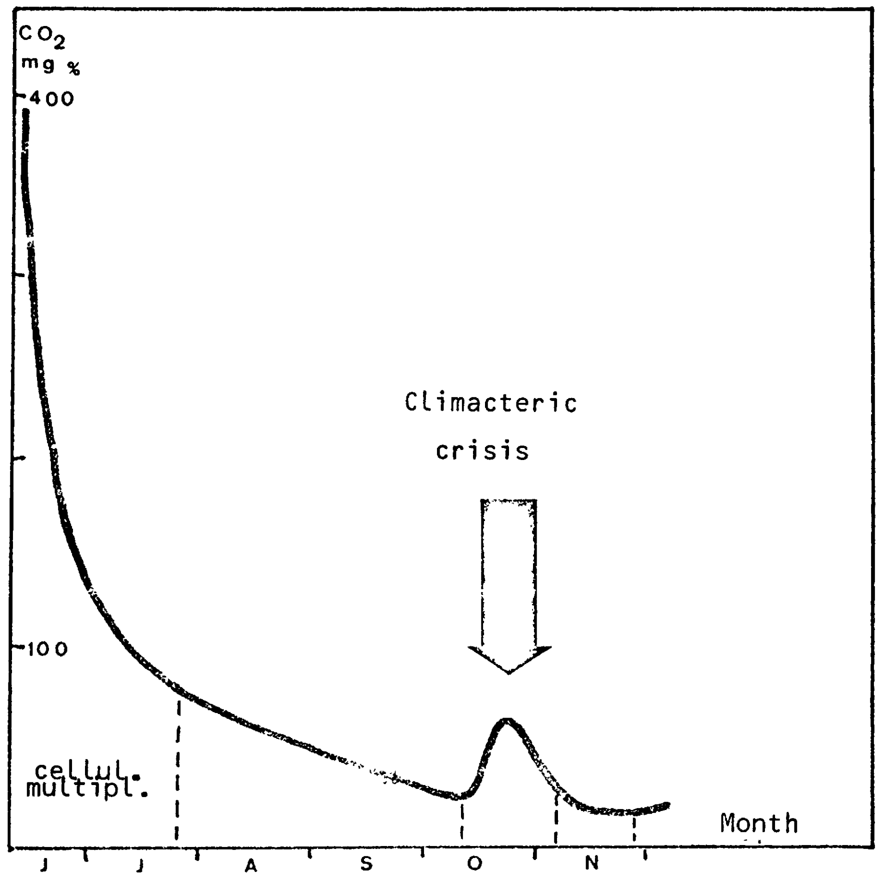
Although fairly reliable in the abovementioned case, the method is not very practical, because of the need for recording equipment and daily calculations.

- Measurement of the rate of respiration, in species that pass through a marked climacteric crisis, such as the apple for example, is the best available test of the onset of the ripening process. This can be done by taking successive samples on the approach of what is considered to be the optimum period and by quantitative analysis of the carbon dioxide or ethylene emitted by the fruit over a specific period of time.

When the rate of emission of one of these two gasses increases it may be assumed the climacteric phase is beginning. The optimum picking date is then taken to be 10 days after the emission of ethylene is first detectable. But, the longer the intended period of storage, the more the date of picking must be brought forward, although the fruit must not be picked before the start of the climacteric crisis.

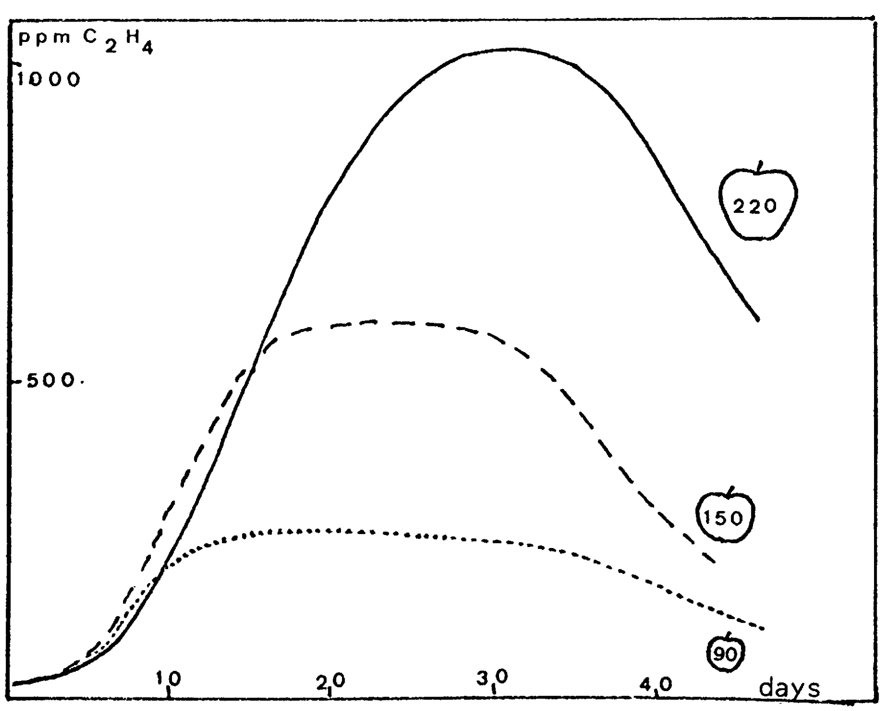
EVOLUTION OF THE RATE OF RESPIRATION
of Reinette du Canada APPLES

source: *LEBLOND et PAULIN (267)*



SYNTHESIS OF ETHYLENE in Golden Delicious APPLES
IN RELATION TO THEIR WEIGHT WHEN HARVESTED

source: *LEBLOND*



This method obviously requires the use of special equipment. However, the controlled atmosphere storage houses are well-equipped for carrying out the quantitative analysis of carbon dioxide, and all they need to do is to place a sample of 2 kg of fruit in an airtight 10-litre barrel for 14 hours at 21° C and then to extract a sample of the atmosphere from the barrel with a hand pump. The amount of ethylene can be measured quite easily, with portable equipment of the type used for measuring air pollution (224).

In areas where the growing of fruit is sufficiently concentrated, the growers can group together to carry out these measurements in each microclimatic zone.

- The measurement of starch regression by smearing an equatorial section with an iodine solution has already been suggested as a method of assessing the maturity of apples and pears.

When the zone that becomes blue in colour is restricted to the part of the fruit immediately under the skin, it may be considered that the fruit has reached a satisfactory stage of development. Regression is a very protracted process, however, and the test can only be used as supporting evidence.

- Brown colouration of the pips is also often related to the optimum period for picking apples and pears.(79).

When 50 - 90% of the surface of the pip has become brown in colour, the fruit may be considered to have reached its optimum period for picking. Comparative colour charts are available to growers applying this test (225) (226). It seems, however, that this colour can appear prematurely in hot dry climates, and that poor fertilization of certain fruits, especially pears, can make the test difficult to apply to certain varieties.

- Skin colour, measured either in terms of regression in relation to yellow, or else by the area and intensity of red pigmentation, is certainly the most common test of all, both for fruit and for vegetables.

The colour of fruit can be assessed by reference to the universal colour code of SEGUY, or to individual colour charts of the type published in various countries for Golden Delicious apples (227)(58).

But the colour of the epidermis can also be changed by variations in temperatures, as well as by drought, which means that this test also can hardly be applied on its own to fix the optimum harvesting date. To complicate the matter, certain new and highly coloured varieties take on their colouring some time before the phase of maturation begins, so that growers are often mislled into picking too early, to the detriment of quality. This applies in particular to certain varieties of nectarines and to Spur varieties of apples.

- Measurement of decreasing firmness is another way of assessing the degree of maturity of fruits such as summer pears and peaches, which ripen largely on the tree. The test can be extremely precise when applied to such fruits in a specific environment in which the development of firmness has been previously recorded.

- Chemical tests of sugars and acidity, to calculate the relationship between the two, are also very useful for assessing whether the fruits have passed the threshold value for this relationship, beyond which the consumer finds the flavour acceptable (228). But the sugars and acids are subject to so many variations that are quite independent of the stage of maturity attained by the fruit that this ratio cannot be used to fix the date of picking. Nevertheless, in the more general context of concern for quality, the test in an indispensable method of checking the development of the components of flavour.

- The morphology of certain fruits which develop sufficiently rapidly at the time of maturation can also constitute a visual standard for assessing the stage of maturity attained. This applies in particular to stone fruits, especially peaches, in which the axial/equatorial ratio which is well above 1 before maturity, tends to approach unity or even to fall lower than unity at the optimum point for picking, because of the increased rate of growth of the equatorial parts of the fruit (65).

- The choice of the optimum date of picking will therefore have to be based on the various measurable criteria. The results of these measurements must be in agreement. Thus, if the aim is to obtain a quality product, full account must be taken of the interval between flowering and picking, of the colour of the skin and the pips, and also of measured firmness. But the regression of starch and the sugar/acid ratio must also be checked, to make sure the fruit has attained a satisfactory qualitative standard.

The levels fixed for the threshold values, for each of these tests, will depend on conditions in the agronomic environment and on the commercial objectives in view. Each individual grower must therefore attempt, on the basis of observations over a period of several years to fix his own threshold values, in the light of local growing conditions and with due reference to the markets serving as an outlet for his produce.

3.23 : Harvesting techniques

Harvesting operations, especially in the case of fruit, mark the culmination of the efforts accomplished by the grower in the course of an entire season to obtain a quality product. It would be pointless to be in a favourable environment and to have applied the proper agricultural techniques to a crop that is potentially of high quality if the choice of the wrong date of harvesting or careless picking were to jeopardize in a single day the qualitative potential thus accumulated.

323.1 : Risks of damage at the harvesting phase

These risks mainly result from bruises, abrasions and wilting, and their scale is related to the fragility of the product.

The effort to time harvesting at the optimum stage of maturity, which is indispensable if quality is to be satisfactory, means that the products are more fragile, so that special precautions must be taken at the time of picking. Above all, manual picking is required, because this ensures more care is taken to preserve the quality of the product than to increase the hourly rate of picking, and the fruits must be moved in containers of a suitable volume for the degree of firmness of the fruits in question.

Although it is certain that firm fruits such as late season apples and pears can be transported without damage in "pallox" containers, which can take 250 kg of fruit, the same does not apply to summer fruits, which are generally less firm. Peaches in particular must be placed in shallow packages on picking, so that the fruit remain in shallow layers, protected both underneath and at the sides to avoid bruising.

Even with potatoes, care must be taken at the time of harvesting. Bruised tubers blacken internally, so any sudden spillage from a height of more than 0.50 m should be avoided (189).

The least well-protected fruits can also become dehydrated while standing at the side of the orchard or in the course of transportation to the packhouse. This is particularly true of cherries, salad crops and carrots. Every effort must therefore be made to stack the containers in the shade when filled to avoid long waiting periods and to ensure they are properly covered when moved from the orchard to the packing station.

323.2 - Staggered harvesting

On a single tree, the different rates of development observed in the different fruits, depending on their position, lead to the necessity of staggered picking.

This goes against the present tendency to gather all the fuit in one operation, so as to reduce the cost of picking.

To ensure the optimum quality of fruits such as peaches which ripen at a far from uniform rate, at least three separate pickings are required.

With apples and pears, simpler methods can be adopted, such as harvesting in two stages, the first concentrating on the upper half of the trees where the fruits have been more exposed to the sunlight and are slightly more advanced, with the second concentrating on the lower half and the inner branches of the crown. The choice of fruits to be picked when this method is adopted must be based on very simple visual criteria, allowing the picker to make rapid decision without slowing his work.

The choice can best be made by applying three visual criteria at once : size, form and colour. All three are obviously variable from variety to variety and also depend on micro-climatic conditions, but the parameters can nevertheless be fixed with a fair degree of precision by adopting the methods already described (cf. 3.22) which enable the pickers to be shown the standards of assessment for each specific parcel of land.

Without staggered harvesting, the marketing of a quality product requires a major sorting operation in the packhouse at a later stage, to separate the fruits that are suitably mature from those that are insufficiently developed to provide any guarantee of organoleptic quality.

3.3 : STORAGE AND PRESERVATION OF QUALITY

The potential quality of fruit and vegetables may be said to be at a maximum at the time of harvesting if the optimum contribution has been made, up to that point, by all the relevant factors.

But such is the system of distribution that the products have to be held in short- or long-term storage, either to ensure that market supplies are properly regulated or else to ensure the availability of fresh fruit and vegetables outside their normal season of production.

The imperatives are economic or commercial, and the basic principle which underlies the various methods of preservation is that they must not change the final quality of the product or at least have only a marginal effect.

3.31 : Effect of temperatures on organoleptic qualities

Low temperatures have a double effect on fruit and vegetables : they reduce the rate of respiration and consequently put a brake on the metabolism of maturation ; they also inhibit the synthesis of ethylene.

Cold storage is therefore the most frequent method of preservation, and the most easily applied. It can justifiably be considered as a safeguard of quality. In certain cases, indeed, cold storage can be a vital phase in the full maturation of fruit requiring a certain degree of exposure to low temperatures, such as Passe Crassane pears.

But each species and each variety has a different degree of sensitivity to low temperatures, which can provoke irreversible physiological disorders if they are applied for too long a period, so that the quality of the product may be totally destroyed as a result.

The choice of storage temperature must therefore be adjusted to suit each species and each variety, with special allowance for the stage of development attained and even for the specific conditions in which the produce has been grown.

. The speed at which products are brought down to the optimum storage temperature is a very important factor in the preservation of quality.

Two types of situation may occur :

- The need for minimum delay in cooling applies not only to fruit with good keeping qualities, such as apples and pears, but also to fruit requiring a very short period of cold storage which will not take them anywhere near the phase at which physiological disorders will develop.

For this purpose, considerable freezing capacity must be available to cool the products as quickly as possible. This cooling process depends on the mass per volume unit of the product and its rate of respiration, which determine the amount of heat which must be drawn off. For products whose temperatures must be rapidly cooled, the recommended process may be prerefrigeration (a tunnel or cold chamber), or hydrocooling (cold water bath), or possibly vacuum cooling.

The more sensitive the product is to the loss of water, the shorter the prerefrigeration period must be. The temperature of apples and pears must be brought below 5°C within 24 - 36 hours. With vegetables such as salad crops, the utmost rapidity is required, and in this case excellent results are obtained by prerefrigeration under vacuum because the process can be completed in less than an hour and even indeed in a few minutes.

- For fruits which do not keep so well, by contrast, the standard practice is to keep the products at ambient temperature (15 - 21°C) for a certain period. This applies in particular to stone fruits, in which low temperatures can disturb the activity of the pectic enzymes. As a result, the fruits develop a fluffy texture after a certain period in cold storage ; this process is irreversible and prevents the peach from ripening normally when its temperature is subsequently raised (229). Peaches held at a temperature of 25°C for a period of 48 hours before cooling are less susceptible to this type of deterioration. A similar effect has also been observed in Doyennée du Comice pears.

. The optimum cold storage temperature must be carefully worked out for each product, and efficient storage depends on keeping this temperature within finely drawn limits, with fluctuations not exceeding ± 1°C in any part of the cold chamber. Success depends on :

- adequate freezing capacity ;
- efficient insulation ;
- rapid circulation of the air in the cold chambers.

Good circulation of air depends on how the products are stacked and on the existence of an air propulsion system in the cold chamber.

Generally speaking, quality is better preserved by storage at the lowest safe temperature for the species or the variety than by picking too early.

Thus, for the storage of most pome fruit, i.e. pears and those varieties of apples that are not particularly sensitive to cold conditions, a temperature of 0°C is about right, because fruit picked at the optimum stage can then be stored for a long period under favourable conditions and in a normal atmosphere. Storage at slightly higher temperatures is successful only when the fruits are picked at an immature stage, before they have developed their qualitative potential to the full, or else the period of storage must be shorter. For sensitive varieties of apples, such as Jonathan or Cox, the optimum temperature is significantly higher, between + 3°C and + 4°C.

Stone fruits, such as apricots, cherries and peaches cannot stand cold storage very well, and rapidly develop a fluffy texture and internal browning of the flesh. These fruits are at maximum risk in cold-store temperatures of 2 - 10°C, so every effort must therefore be made to keep them as near as possible to 0°C, and they can even be cooled to below freezing point to - 1°C, if their sugar content is around 18 % (230).

The most sensitive varieties are best kept at 25°C for a certain period prior to refrigeration. Even better results are obtained by raising the temperature to 20°C or 40°C for 15 hours per week. This reduces the risk of internal browning, but the method is relatively difficult to apply in practice, because all the fruit must be taken out of the cold chamber for the rapid rewarming process.

Tomatoes are undeniably the most sensitive fruits in this respect. When they are completely red and almost fully ripened they cannot withstand storage below 8°C, and when they are only 1/3 coloured they can only be kept at 12°C.

Potatoes are also sensitive to low temperatures, which raise the sugar content of the tubers. The recommended method of dealing with this problem is to store them at 10-12°C. Before going into storage they should be kept for a time at 15°C, under good conditions of ventilation, so as to ensure the satisfactory cooling of the tubers and reduce the incidence of breakdown during storage (231).

In every species of fruit, the biosynthesis of the aromatic substances tends to be slowed by cold storage. In peaches, for example, the emission of gamma decalactone is considerably reduced at low temperatures (109).

It is fair to state that cold storage often has deleterious effects on the organoleptic properties. Every effort should be made to alleviate this risk by keeping the period of storage within limits, so as to avoid the premature picking which long storage often entails and which might disturb the metabolic processes and impair the quality of the fruit.

So, the optimum temperature concept must always be applied with one eye on the period of cold storage envisaged.

Two specific cases in which the benefits of cold storage are beyond any doubt are vegetables, especially leaf vegetables, in which the maximum retention of freshness is one of the main aspects of quality, and fruits such as Passe Crassane Pears, which cannot mature satisfactorily without first being exposed to cold for a certain period. The fruits of the abovementioned variety remain firm, acid and without any aroma if they are stored at 15°C after picking, although they can acquire a yellow colour. When they have been grown in regions where they have acquired an induced need for substantial exposure to low temperatures (232) they can only achieve normal ripeness after 11 weeks at 0°C.

3.32 : Relative atmospheric humidity

One of the main aims of cold storage is to keep the turgidity of the stored fruit and vegetables as near as possible to their state of turgidity when harvested.

A relative humidity must therefore be maintained in the cold storage chamber to prevent wilting, but the great disadvantage of excess humidity is that it can encourage the spread of fungal infections and can also lead to a certain loss of flavour.

It should therefore be possible to hold the atmospheric humidity of the cold store within fairly strict limits. Generally speaking, the recommended relative humidities are 85 - 90 % for sensitive fruits such as peaches or tomatoes, 90 - 92 % for apples and pears and 90 - 95 % for vegetables and especially for potatoes.

3.33 : Effects of controlled atmospheres

The entire metabolism of the ripening process depends on the maintenance of sufficient respiratory activity. It can therefore be retarded by regulating the composition of the atmosphere in the cold chamber, by reducing the proportion of oxygen and by increasing the proportion of carbon dioxide or nitrogen.

Hence the use of controlled atmospheres, which can be allied with low temperatures to improve storage conditions and extend the duration of storage. But the level of oxygen should not be allowed to fall below 1%, because that is the point at which alcoholic fermentation could begin.

Similarly, if the amount of carbon dioxide is increased the gas can more easily gain entry to the fruit to accumulate in the cells, where it slows down the process of oxidation and interferes with the metabolism of the organic acids. Above certain concentrations, generally 7 or 8 %, it can inhibit certain enzymes, and it can also lead to the appearance of abnormal flavours or physiological breakdown (233).

Thus, when storage is in a controlled atmosphere, the organic acids tend to remain stable, or even to increase slightly, and this can be considered a qualitative advantage in low acid fruit. But the acids regress very rapidly as soon as the fruit is removed from the cold chamber, and the rate of regression is all the faster the longer the produce has been in store (234).

Lack of oxygen will also bring down the rate of biosynthesis of the volatile components of the aroma. It would seem, however, that the adverse effects of oxygen shortage on the synthesis of aroma in apples can be counteracted by raising the carbon dioxide content of the controlled atmosphere to 5 % (235). In apricots, by contrast, it seems that flavour is better preserved with a carbon dioxide content of about 3 % (236).

One of the incontestable qualitative advantages of using a controlled atmosphere for the storage of fruit lies in the diminished risk of internal breakdown or superficial scald.

Controlled atmospheres provide a means of increasing the temperature of storage, and thus of counteracting the effects of excessively low temperatures on the metabolism of the fruit. Thus, in the case of Passe Crassane pears, which are particularly susceptible to this disorder, the combination of a higher temperature, around + 7 or + 8 °C and a carbon dioxide content of 10 % will reduce the incidence of internal breakdown (237).

As far as vegetables are concerned, controlled atmosphere storage has not yet been commercially developed to any great extent, except in the context of long-distance transportation. The effects are comparable with those observed in fruit : slower metabolism, inhibited synthesis of ethylene, reduced incidence of fungal infections and good preservation of the components of flavour, especially acidity. But such storage can also bring about changes in metabolism, leading to physiological disorders and to lack of flavour, not to mention the acquisition of a taste that is foreign to the variety.

When the part eaten grows above the soil, there seem to be less problems than with vegetables grown for the part below the soil. Likewise, the products with a long growth cycle give better results than those with a short cycle (238). It would appear, however, that the quality of certain vegetables, such as carrots for example, is better protected by storage in controlled atmospheres than by storage under atmospheric conditions (239). What is more, it seems that an increase in the carbon dioxide content of the controlled atmosphere can increase the level of carotene in certain cases (240). By contrast, the level of sucrose falls during controlled atmosphere storage especially in atmospheres that are rich in oxygen and carbon dioxide (241).

In short, a controlled atmosphere is a reliable means of storing quality fruit and vegetables, because it reduces the loss of turgidity and acidity. But the preservation of quality depends on the duration of storage. The longer the storage the greater the risks of oxygen starvation, which can have a serious effect on the synthesis of aroma.

3.34 : Duration of storage

The notion of a specific period of storage is therefore the sine qua non of the preservation of potential quality, and this depends on the conditions of storage and the stage of ripeness attained by the fruit thus stored.

It may safely be stated that quality will be preserved providing the period of storage does not extend beyond the threshold in time at which the various physiological disorders will appear.

The problem of storage is more easily solved by exploiting the natural keeping qualities of the different varieties, so as to ensure the maintenance of a steady supply over the longest possible period, than by attempting to stretch out the season for one particular variety by dint of excessively long storage.

A typical example of the impairment of quality which can result from stretching out the season is provided by the Golden Delicious apple, which can either be picked before full maturity and artificially ripened or marketed after more than 6 months' storage. Experiments have shown that although the sugar/acid balance only deteriorates after 180 days in a controlled atmosphere, half the fruits are already unpalatable after 130 days (81).

The problem of loss of flavour as a result of storing fruit for slightly too long a period is only too often compounded by the early onset of physiological breakdown, which clearly shows that the length of time for which any fruit can be stored is dependent on its degree of maturity. Thus, in the case of early-picked pears of the Passe Crassane variety, the risk of internal breakdown is negligible when the ratio of the refractive index to malic acid is greater than 3.5 but becomes very real when this ratio falls below 2.5 (242). The best way to combat breakdown would be to postpone the harvest, but the degree of risk would also appear to be related to climatic and soil conditions (243).

3.35 : Other methods of storage

In addition to, or as a replacement for, the stabilization of fruits by cooling them or controlling the atmosphere in which they are stored, certain new techniques are available, including partial vacuum, ionizing irradiation and treatment with various chemical products.

. Partial vacuum storage, also known as the hypobar system, is presently at the experimental stage ; its high cost has so far prevented its being widely adopted, so that insufficient evidence is available on its effects on the organoleptic qualities of fruit and vegetables.

. Gamma ray irradiation, which has been applied to a variety of products over the past few years, is another technique which has not yet been adopted in Western Europe, for technical and financial reasons. Nevertheless, precisely because of its novelty, a number of experiments have been carried out, and particular attention has been paid to the biochemical changes which can occur as a result of this process.

Gamma radiation is employed in the storage of potatoes to inhibit the germination of the tubers. Irradiation temporarily disturbs carbohydrate metabolism and stimulates respiration in the 48 hours following treatment, but there is no evidence of adverse effects on the intrinsic quality of the product. The changes in the sugar content of tubers exposed to doses of 7.5 - 15 krads are similar to those which occur in tubers stored under comparable conditions without irradiation. There is a marked rise in the level of sucrose and reducing sugars over the storage period (231).

Tomatoes treated experimentally with doses of 50 - 200 krads have shown similar results (244). Colour is unchanged, and there is even evidence of improved organoleptic quality, providing the fruit has already attained a certain degree of maturity at the time of treatment (245).

In peaches, a dose of 200 - 300 krads does not modify the composition of the fruit, but there is some evidence that texture is affected, as a result of degradation of the protopectins (246).

Irradiated apples stored at $0^{\circ}C$ in a controlled atmosphere after exposure to doses of 5.5 or 200 krads showed no change in their physical characteristics, but the rate of respiration increased and the organoleptic quality of the fruit deteriorated (247).

The main cause could well be the reduced rate of biosynthesis of volatile compounds during the process of maturation. None of these is preferentially degraded, but it can be assumed that modified enzymatic activity is responsible for the change in the quality of the aroma (248).

These changes are particularly serious when fruit is stored in plastic wrappings. Irradiation in a nitrogen atmosphere will reduce these effects on the organoleptic properties, but the treatment must be of sufficient duration to eliminate almost all the oxygen from the internal atmosphere of the fruit (249).

There are still many gaps to be filled in our scientific knowledge of the effects of irradiation. So a certain degree of caution is required in the use of this technique, which has sometimes been found to have a deleterious effect on the organoleptic properties.

. Chemical preservative agents. Sprays or baths containing chemical fungicides or antioxidants are being used on an increasing scale to prevent the storage losses attributable to the development of physiological disorders such as superficial scald and the spread of parasitic fungi. Certain products even do both jobs at once ; this is the case with diphenyl amine (DPA), which is used for treating citrus fruit but is not authorized on fruit grown in cool temperate regions.

Various products are in general use, and are either applied alone or in mixtures. The standard fungicide in Europe is Benomyl, while ethoxyquin is the product most usually employed to reduce the incidence of superficial scald. Trials carried out in Switzerland have shown that these products can have an adverse effect on the organoleptic quality of apples (250).

For this reason, it is preferable to avoid using these products on fruit in the top quality bracket. The various threats to quality would appear to be lessened in any case by the methods adopted for harvesting and storing such fruits. The incidence of superficial scald is greatly reduced by picking at the optimum stage of development and by keeping the period of storage within reasonable limits, as is recommended for top quality fruit. Furthermore, the fact that acidity must be sufficiently high to preserve the agreeable flavour of highly graded fruit is itself an excellent protection against attack by gloeosporium, which thrives in low acid conditions.

Practical tests have been developed for the early diagnosis of incipient physiological disorders and fungal attack, and they could be used for avoiding the protracted storage of those losts of high gustatory quality which were found to be most seriously at risk in this respect (251).

3.36 : After-ripening

Fruit removed from storage must always be kept in conditions conducive to satisfactory ripening, so as to enable the product to ripen to perfection before it is offered to the consumer. In fact, in the case of certain early varieties, some of the biochemical changes of the ripening process can be triggered off earlier than they would otherwise occur.

. Accelerated ripening is obtained by combining a temperature of 20 - 25°C with an oxygen-enriched atmosphere (up to 50 %), to which 1 % of ethylene may have been added. But the fruit must have attained a sufficient degree of maturity (x) to ensure a normal ripening process and normal biosynthesis of the different components, or final quality will suffer.

This applies in particular to J. Guyot pears, which can be harvested at a very early stage of development without affecting the organoleptic properties, providing the equatorial diameter is at least 60 mm and the skin colour has begun to change from dark green to a somewhat paler shade. Although such fruits continue to grow when they are left on the tree, the levels of sugars and acids remain the same, so that the organoleptic properties remain more or less unchanged over a period of 2 - 3 weeks (155).

(x) Excessively high temperatures, above 30°C, can seriously inhibit the internal synthesis of ethylene, and the fruits cannot then be ripened artificially without the addition of this gas (283).

This also applies to Passe Crassane pears, which generally need to be exposed to cold conditions for a certain period after harvesting before they can ripen normally. They can be rapidly placed on the retail market at the start of the season, after a very short period of cold storage, if they are pre- ripened for a fortnight in air at 12°C, to which 1°/oo of ethylene has been added, and are then kept at 0°C until the regression of measured firmness to 3.5 kg (Bellevue penetrometer) (232). But if these pears are picked too far ahead of the optimum harvesting date, and especially if this is done to ensure they do not exceed a certain size, they will not attain top gustatory quality (253).

In peaches, the combination of premature harvesting and artifical ripening can throw the aromatic substances out of balance ; gamma decalactone may become more dominant than usual, to the detriment of flavour (254).

In addition, the levels of the main components are strikingly lower than in the fruit allowed to remain on the tree and ripen normally (255).

In the case of fruit of controlled gustatory quality, therefore, the use of artificial ripening processes must remain exceptional ; it must be restricted to a few special cases, such as the J. Guyot and Passe Crassane varieties of pears. And it should also be pointed out that the potential quality of J. Guyot is never superlative in any case.

After-ripening, at the end of the storage period, is an indispensable treatment for top quality fruit, which must be brought to the precise stage of ripeness at which it is most acceptable to the consumer. Cold storage has the effect of holding back the climacteric crisis, which coincides with the synthesis of the volatile substances (108). This crisis must be provoked by a short period of after- ripening before the fruit is placed on the retail market (250).

But the ripening temperature must not be too high for the physiological condition of the fruit, because that would become yet another cause of imablance among the components. In fact, as this temperature rises, the rate of development of the pectin compounds tends to be faster than the regression of the chlorophyll pigments (256). The shorter the period of storage, therefore, the lower the recommended ripening temperature. At the start of the storage period, artificial ripening requires a temperature of 10 - 15°C, but it may be effected at 20°C at the end of 6 months' storage. The time spent ripening at this temperature must be controlled by the use of a penetrometer to check the regression of firmness.

Artificial ripening is particularly necessary when fruit has been stored for a long period in a controlled atmosphere with little oxygen. On removal from gas storage, such fruit must be allowed a period of oxygenation to ensure the satisfactory development of all the organoleptic properties. A temperature of 20°C is recommended in such cases for apples and pears.

3.4 : THE PROTECTION OF QUALITY DURING DISTRIBUTION

In spite of the precautions taken in the transportation and packaging of the product, quality remains highly at risk during distribution. This is because the operators involved in the successive handling operations have neither the knowledge nor the incentive to attend to all the causes of product deterioration.

3.41 : Packaging

The packaging of fruit and vegetables must facilitate handling and protect the products from physical injury; but top quality products must also be provided with a micro-climate inside the package, so as to safeguard their quality.(257).

The more fragile the product, the greater the need for strong packaging and protection against injury. Top quality fruit must be marketed at the right stage of maturity, and the packaging must provide a greater measure of protection than is given to more run of the mill products. Packages of smaller dimensions can be used for the purpose, with special protective linings at the bottom and sides, or the fruit can be arranged in moulded "tray-packs" whose dimensions are perfectly adjusted to their size, and it is also possible to wrap each fruit or to wrange it with a tissue paper.

Care must be taken to ensure that cardboard packaging retains its shape during transportation, and the use of special-purpose cardboards would appear to be desirable.

The micro-climate created by the packaging may be a protection against harm from outside, but in certain cases it can also have a harmful effect on the evolution of the product.

Although the packaging, by virtue of its mass, should protect the contents against variations in the temperature of the external atmosphere and against excessive ventilation in the course of transportation and subsequent distribution, it must not be too hermetic to permit the necessary exchanges of air. It is vital to avoid the creation inside the package of any low-oxygen atmosphere enriched with volatile substances which would be likely to affect the rate of metabolism and the ripening process.

When pallet boxes are used, the area of the air vents should be at least 15 % of the area of the base of the box.

Special care must be taken with fruit such as cherries and peaches, when despatched under refrigeration immediately after harvesting, to ensure their packaging does not prevent the entry of the refrigerated air. This is particularly true of polystyrene, which acts as an insulator to impede the efficient refrigeration of the products in the packages when they have not been precooled.

These precautions, which are recommended for all fruit and vegetables, are particularly important for top quality products, whose ripeness on sale determines their organoleptic properties.

Finally, the materials employed for packaging must be completely neutral and must not taint the fruit with any foreign odours or flavours. Certain types of wood contain resins that have too strong a smell, and certain plastic materials can also impart a disagreeable odour to the product.

3.42 : Risks of deterioration during transport

The deterioration to which fruits and vegetables are subject during transportation may be mechanical in origin, in the form of bruising, or biochemical, as a result of unsuitable temperature, overlong transportation, or insufficient moisture.

Protection against impact is of course a matter of general concern in the fruit and vegetables sector, but its importance for products which are near to the optimum stage of ripeness for consumption needs to be emphasized.

Temperature plays a major role in stabilizing or slowing down the biological evolution of fruit and vegetables during transportation. Because top-quality fruit must be picked when it is at a sufficiently advanced stage of ripeness on the tree, and because top-quality vegetables must be kept in a state of pristine freshness, they must be transported under refrigeration. When ice is used, care must be taken to ensure that enough ice is loaded at the start of the journey and that enough is available en route to keep the temperature of the vehicle within the desired limits.

When loading for transportation, it is essential to avoid raising the temperature of any perishable products. Every possible precaution should be taken ; the products and the containers should be precooled and the products should be moved from the cold store to the container via a mobile lockchamber, so as to prevent their temperature being raised by contact with the outside air.

The rate at which highly perishable products such as stone fruits or leaf vegetables deteriorate in the course of long-distance transportation can be held within reasonable limits by the use of sealed containers with a low-oxygen atmosphere (258).

Products which mature more slowly or which only need to be transported over short distances can be moved at normal air temperatures, providing excessive ventilation is avoided, because this could result in the products' losing too much moisture. In such circumstances, the time of transportation is a period of natural ripening, and when such fruit needs to be after-ripened, the travelling time must be taken into account as part of the overall ripening time.

When the products have been stored in a cold chamber, steps should be taken to prevent the condensation of atmospheric moisture on the product and inside the packages as a result of higher ambient temperatures.

For example, when the relative atmospheric humidity is a mere 40 %, a product with an internal temperature of 5 °C will be affected by condensation when the temperature of the ambient atmosphere reaches 20 °C. To prevent this happening, the product must be warmed gradually, with sufficient ventialtion to avoid condensation. A conversion table can be used for working out the appropriate temperatures for the warming-up process, as determined by the humidity and temperature of the ambient atmosphere (259).

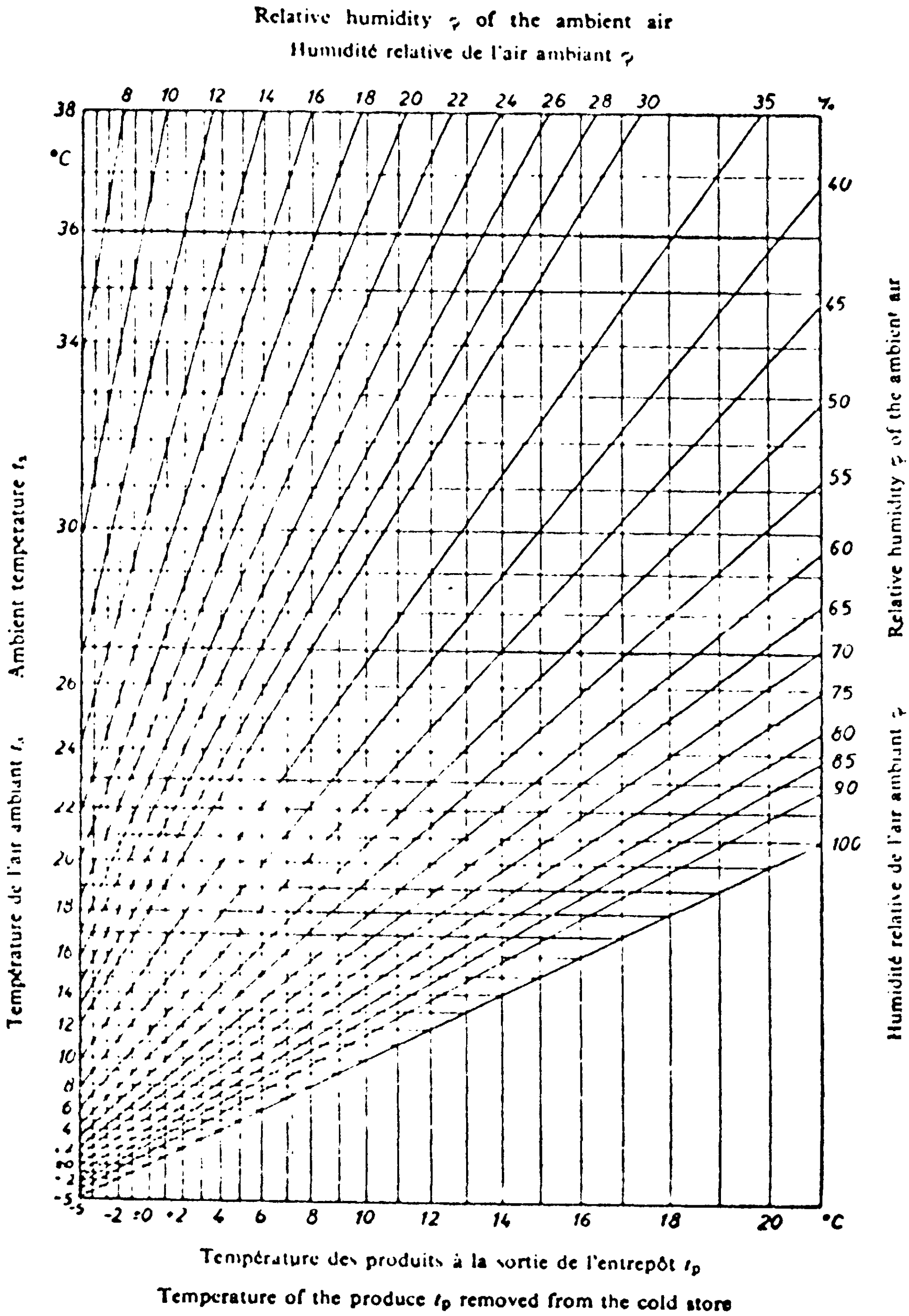


Fig. 2 - Conditions of condensation at the surface of refrigerated produce.

Extracts from recommended conditions of cold storage of perishable products, I.O.F., 1967 (p. 20).

3.43 : Protection at the point of sale

A certain number of precautions which ought to be taken to protect the quality of fruit and vegetables displayed for sale are in fact neglected. These precautions are particularly important for products whose gustatory qualities are a major factor in attracting the consumer.

At the very least, the following rules should be observed :

- Maintenance of an average temperature between 15 and 20°C, so as to allow the normal development of the product without the risk of over-rapid degradation ;

- Avoidance of contamination by fungal infections, especially of the monilia and penicillium types, which can develop on fruit and vegetables during transportation and which must be eliminated from the packages as soon as the first attacks become apparent, because the adjacent fruits can be attacked in turn and this could lead to fungus developing on the products after purchase by the consumer ;

- Avoidance of exchange of odour during display at the point of sale, or in temporary storage facilities, especially in the case of vegetables with a powerful aroma, such as cauliflowers, or of citrus fruits treated with DPA (250);

- Limitation of the period spent in the shop, to avoid wilting and over-ripening, by restocking the shelves several times a day. This will reduce the harm done by excessively high temperatures and lack of moisture ;

  Leaf vegetables, which are particularly badly affected by evaporation should be finely sprayed with water ;

- Potatoes, and above all new potatoes with their thinnest of skins, can begin to show greening of the tubers after only a few hours of exposure to light, especially electric light in a shop. Unfortunately, apart from the changed appearance and the browning of the flesh when cooked, this greening reveals the build-up of solanin, which has a bitter taste and thus impairs the organoleptic quality of the product.

Special care must be taken with the display of top-quality produce, and here the retail distributors must apply the methods adopted for entirely new lines. The consumer's attention is always caught first by the visual appeal of the product ; so appearance should be publicized as an outward and visible sign of immanent quality. Once this has been recognized and appreciated by the consumer, the latter will be drawn back to the product .... and product loyalty will have been established (8).

4 - ECONOMIC AND ECOLOGICAL CONSEQUENCES OF APPLYING THE RECOMMENDED TECHNIQUES FOR GROWING TOP QUALITY FRUIT AND VEGETABLES

The various techniques for growing top quality produce, as described in chapter 3, can have a direct economic effect on production ... and they can also have an indirect effect, through the workings of the Community norms for the standardization of fruit and vegetables.

It is therefore necessary to work out the minimum difference in price which top quality produce must command in order to cover the additional cost per unit of output, and to examine the changes which may need to be made in the regulations relating to quality standards.

Furthermore, from the ecological point of view, the production of quality fruit and vegetables can prove beneficial not only to the human species, because of the connections which may exist between the gustatory quality of the product and its nutritional value, but also to the agricultural environment, through the influence of the techniques adopted for growing such produce.

4.1 : EFFECTS ON PRODUCTION

Compared with mass production, based on maximum yields and the systematic attempt to reduce costs, the growing of fruit and vegetables of guaranteed quality leads to an increase in unit costs of production, partly because of the cutback in total output and partly because of the increased costs, not only of cultural operations in the orchard, but also of storage and marketing (268).

4.11 : Output

The production of fruit and vegetables with superior organoleptic qualities necessitates the stabilization of yields at a level which falls short of the maximum capacity of the plant as far as the synthesis of carbohydrate is concerned. The factors which determine the level of output can vary with local conditions; so it is hard to quantify.

The level of output depends on the enviroment, the characteristics of the variety and the fluctuations in yield which may occur from one year to another :

- Unsatisfactory environmental conditions can greatly reduce the yield without resulting in any significant improvement in quality, either because of mineral deficiencies or because of inadequate photosynthesis.

- Whenever the conditions are favourable to fruit set, some of the most prolific varieties tend to pass the threshold beyond which quality is impaired by the volume of the crop. The resultant irregular bearing is itself a cause of major variations in quality, which may be superlative when the crop is light and mediocre when the yield is high.

- The tendency to irregular bearing varies from species to species, and also between varieties.

With Golden Delicious apples from example, the range of fluctuation in yields may be as great as 40 - 50 % and in varieties which are more susceptible to irregular bearing, such as Reine des Reinettes, the fluctuation may be anything up to 60 - 70 % of the average.

The first step to be taken to ensure a top quality crop is therefore to stabilize the yield at the highest level compatible with the preservation of potential quality. In the case of fruit trees, the desired result is obtained by the combined effect of pruning and thinning, suitably geared to planting densities and nutritional conditions. As far as vegetables are concerned, the density of sowing and the spacing of the plants are key elements in the final result. But the crucial factor, in both cases, is the suitability of the plant from the specific environmental conditions and the season in which it is grown.

The extent to which output is reduced by the application of such techniques can best be quantified when growing conditions are at their best, so that the observed differences of yield can be substantial enough for their effect on quality to be fully appreciated.

The limited amount of information available on this subject mainly relates to fruit trees, and mainly to apple, pear and peach.

In the growing conditions referred to, the differences in yield between orchards producing high class fruit and those producing a larger but consequently inferior crop in the same year are often of the order of 40 - 50 %.

But because of the irregular bearing which can be observed in the orchards with the highest yields, differences of this magnitude do not occur in every year over a long period. Thus, where the environment suits the species, the reduction of the volume of output entailed by the application of the techniques intended to guarantee the attainment of a satisfactory organoleptic standard does not average more than 25 % in comparison with the crops grown on those parcels of land on which the sole aim is to obtain the maximum gross yield per hectare.

This margin it should be added, is an average figure which has been worked out on the basis of a wide range of observations, with a very wide spread of individual values. Among apples, the Golden Delicious variety has attracted most attention in this respect ; in the conditons of the southern half of France, for example, quality has been shown to be greatly enhanced when yields are held below 45 tonnes/ha, compared with an average of 61 tonnes/ha for orchards producing low quality fruit.

4.12 : Additional costs

Unit costs of production in agriculture can vary greatly from one to another depending on the conditions of cultivation, even though, generally speaking, the overall averages very often remain rather stable.

This extreme variability is particularly true of the production of fruit and vegetables, which is labour-intensive. The coefficients of variation of the time spent on orchard operations may be up to 40 - 60 % of the mean value and more than 100 % of that value in the case of vegetable growing. So it is not easy to attach any significance to the mean values. The phenomenon can be attributed to variations in natural conditions, to human factors, or to a far from typical spread in the statistical results.

For example, in a study of the use of manpower in French orchards, extending over a period of several years, the number of observations in which man-hours spent on cultivation of the soil were of limited duration was very much greater than the number relating to longer periods of cultivation. The mean value worked out at 31 hours per hectare, while the mode, i.e. the class which included the largest number of observations, was 11 - 15 hours, immediately followed by the class of 16 - 22 hours.

In the same study, the weight of fruit harvested per man-hour was surprisingly varied. Around a mean value of 92 kg per hour, there were as many observations in the 51 - 60 kg class as there were in excess of 120 kg.

These examples serve to illustrate the weaknesses of calculations based on averages ; but there is no way round the problem. Comparisons at an international level are rendered even more difficult by the considerable monetary fluctuations which may occur in various countries from year to year. It therefore seems preferable to work out quantitative norms relating to specific tonnages, which will make it possible to compare the effect of the recommended techniques in raising unit costs.

The following table, which is based on comprehensive data collected in the southern half of France, reveals a wide range of variation in the extra cost incurred in the production of crops of superior gustatory quality, depending on the species.

In the case of the five species of fruit and vegetables which have been taken as a standard for comparison, the variable cost coefficient(1) for top quality produce works out at 127, compared with a value of 100 for crops of average quality, whereas the same coefficient for crops grown for maximum productivity may fall as low as 68.

The cost differential between crops grown for quality and crops grown for quantity seems to be very large ; but it should not be forgotten that variable costs represent an average of 60 % of total costs of production. Assuming that the remaining 40 %, which represent fixed and structural costs, are independent of the cultural factor, the total cost coefficients are as follows :

top quality	:	116
intensive culture	:	81
average quality	:	100

It goes without saying that growers who concentrate on the production of top quality fruit and vegetables must be remunerated at a level which is at least equivalent to the average ; so the price of their produce must be at least 16 % higher than the average market price.

But if the production of top quality fruit and vegetables is to be an attractive proposition, the growers who opt for quality must be sure of better-than-average returns, on a par with those of their fellows who opt for maximum output and whose costs of production are 19% below the average. Thus, the prices paid to the growers of quality produce ought to be 16 - 35 % higher, if they are to be encouraged to abandon their concentration on high yields in favour of superior quality.

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(1) For the purposes of calculating the coefficient, the unit costs of products, services, labour and equipment have been given the weights obtaining in France in 1974, as follows : man-hours : 1 ; units of fertilizer : 0.15 ; machine-hours : 1.5 ; plant health products (active ingredients/ha) : 6.

COMPARISON OF VARIABLE COSTS PER TON

FOR

THREE HYPOTHETICAL GRADES OF FRUIT

I = Top Quality
II = Average quality
III = Intensive culture

	Peaches			Pears			Apples			Melons			Tomatoes		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Yield in tonnes/ha : T	15	16	20	22	28	35	34	44	62	12	16	20	36	45	60
Man-hours : h	60.8	49.3	30.6	32.1	22.1	14.5	29.7	18.3	13.2	102	84	63	63	46	16
Mechanical equipment:h	3.93	4.31	3.6	2.68	2.61	2.31	2.03	1.75	1.4	5.0	4.0	5.0	2.6	2.1	2.0
Fertilizers : units	30.00	36.00	30.12	18.18	16.96	14.29	14.71	13.07	10.00	40.00	50.00	50.00	16.00	17.00	15.4
Active ingredients :no	0.93	1.16	1.25	0.68	0.93	0.94	0.41	0.50	0.45	2.00	1.87	1.5	0.17	0.18	0.20
Weighted sum (1)	76.8	67.5	47.3	42.9	34.1	25.8	37.5	25.9	19.5	127.5	108.72	87.0	70.3	52.8	21.0
Relative value II = 100	113	100	70	126	100	75	145	100	75	117	100	80	133	100	39

(1) M/h = 1 ; Mech./e. = 1.5 ; Fertilizers = 0.15 ; Active ingredients = 6

4.13 : Transportability

It is concern for gustatory quality which leads to the harvesting of fruit when it is near enough to full ripeness ; but with vegetables, and especially in the case of salad crops, in which freshness is vital, the same motive can lead to harvesting at a rather earlier stage. Both these practices serve to increase the fragility of the product and therefore tend to lessen its transportability.

In fact, the concept of ability to withstand transport is meant to cover a whole series of physical movements to which horticultural produce can be subjected, not only in the course of loading and unloading but also en route, depending on the type of transport used and the duration of transit.

The conditions of fruit and vegetable transport have been vastly improved over the past few years, by better protection against changes in temperature, improved vehicle suspension, faster transit and the development of certain specialized facilities such as refrigerated and controlled atmosphere containers.

But this improvement has lead to a rather paradoxical situation, because instead of producing a systematic improvement in the quality of the products offered to consumers, it has mainly served to extend the radius of the area supplied. This has led to the practice of earlier harvesting, timed to maximize resistance to mechanical damage in the course of the various handling operations and to ensure the intercalation of a sufficiently long interval between harvesting and maturity to eliminate all risk of loss in the course of distribution.

So the improved transport facilities have mainly been used to enlarge the area served by the despatchers. But the developement of increasingly distant markets has also led the growers to simplify their harvesting operations, to comply with the most rigorous standards of ability to withstand transport. As a result, the nearest markets are supplied with fruit which has not only not yet attained its full organoleptic potential, but which is in fact offered for sale at a stage of preripeness at which it is quite unfit to eat.

The marketing of high quality products thus entails the diversification of transport facilities, to cater for varying degrees of fragility, backed by an effort to ensure that time spend in transit is sufficiently short to be compatible with the length of the after-ripening process. In the EEC market, in current conditions, the time factor would not seem to constitute an obstacle to the marketing of top quality produce, because the time of transit from the centres of production to the major markets is never more than 48 hours.

In the case of those fruits which evolve very rapidly, such as peaches and cherries, or in the case of vegetables, in which the freshness is the key element in quality, the efficient organization and coordination of the different procedures adopted for moving the product from the orchard to the consumer will enable it to retain all its qualities during transport. Thus, for example, the maintenance of a low temperature from beginning to end of the chain of distribution will improve the sales prospects of the most perishable products.

Handling operations have also changed in ways which have favoured the marketing of quality produce ; the general adoption of mechanical systems, including pallets and even containers, has improved the level of protection against damage in the course of handling and in this respect there is no difficulty in coping with the requirements of quality produce.

Although the overall result of concern for quality is a tendency to increase the fragility of the product, it is safe to assume that the abovementioned requirements will be met by the generalized adoption of modern transportation and handling systems without resulting in any exorbitant increase in costs.

4.14 : Keeping quality

The problem of longer-term preservation of the quality of the product arises only when the season for its consumption stretches far beyond the harvesting period, as is the case with apples and pears or carrots and potatoes.

By contrast, when the product is eaten soon after harvesting, because it is perishable, as is the case with peaches, apricots, cherries or salad crops and tomatoes, the problem of preserving quality is restricted to the phase of distribution, and especially to the time spent in transit. In the latter case, therefore, the problem of ability to withstand storage is inextricably bound up with that of transportability.

Long-term storability depends to a great extent on the stage of development attained by the product when harvested. In the case of certain vegetables, such as carrots and potatoes, the ability to withstand storage depends on the maturity of the product, and this may entail the reduction of quality, as when carrots become woody or potatoes develop too much starch. With fruit, on the other hand, the maximum duration of storage depends on harvesting at the earliest feasible stage of maturation; so fruit which is destined for a long period of storage may have to be picked before it has developed its maximum organoleptic potential.

The length of time for which high quality fruit and vegetables can be stored therefore depends on the possibilities offered by the optimum harvesting date, and on the acceptance of a shortend period of storage which will only be prolonged to the extent that this can be ensured by physical means such as a controlled atmosphere.

Thus, for example, although it is perfectly feasible to keep Golden Delicious apples in cold storage for 6 months in a normal atmosphere, providing they are picked early enough, this period is reduced by at least one month when the variety is picked at the optimum harvesting date.

Premature harvesting can be avoided in the abovementioned case by storing in a controlled atmosphere. But experiments have shown that oxygen starvation blocks the biochemical processes ; so the fruit must be harvested later for controlled atmosphere storage than for storage in a normal atmosphere if the aim is to keep the organoleptic properties of the product at a satisfactory level (267).

To ensure a steady flow of produce on to the market, it is best to make the most of the possibilities offered by the different methods of storage, by applying them to the varieties endowed with natural keeping quality, thus widening the selection available. This will doubtless have a favourable effect on the quality ratings given by the consumers.

Concern for quality is therefore a factor in the improvement of storage conditions, because it reduces the period of storage required. There is a proven correlation between an excessively low level of acidity and susceptibility to fungal infestations and physiological disorders, and it may therefore be stated that measures to safeguard gustatory quality, which are specifically intended to ensure that acidity remains sufficiently concentrated to maintain a satisfactory balance with the sugars, can play a positive role in the reduction of storage losses.

Obviously, this curtailment of the season for individual varieties may tend to reduce the length of the consumption period in general ; so it goes against the trend which has been observed over the past few years. This problem can only be solved, in the medium term, by the selection of new varieties which keep well without being intrinsically inferior in quality.

4.2 : IMPLICATIONS FOR THE SYSTEM OF STANDARDIZATION

The compulsory standardization of fruit and vegetables in the EEC has encouraged trade in these products by providing a precise common language for the description of commercial quality. But the growers who market their produce at the orchard gate denounce the system as so much red tape, and it is also inveighed against for distorting competition between the organizations engaged in the selling of elaborately marketed products and the growers who sell their own product in the local market.

Standardization also gives rise, on occasion, to mutual mistrust between growers and wholesalers, vis-a-vis the possibility of mixing products of different grades or even of substituting one class of produce for another at the retail end of the chain of distribution. Thus, for example, many growers fail to see the point of laying down precise definitions for grading and labelling when the products are often removed from their original packaging before they are retailed ; and they are also convinced that the controls carried out at the retail stage fail to prevent the occurrence of irregularities which make a mockery of all their preparatory efforts.

That, of course, is the view of the market operators, faced with a system of controls which necessarily imposes a certain degree of restraint on them. But the situation which so much irks them would appear to be attributable, in the main, to their own deliberate or involuntary laxity in the application of these same regulations.

For all the reasons which have been touched upon, the growers' organizations generally treat the concept of organoleptic quality as something of an extra, which can only be associated with a trade name or the mark of a growers' cooperative, cannot be obligatory and must be entirely controlled by those who use it.

This leads to the observation that a system of grading based on the criteria of gustatory quality can serve two very different purposes :

- the elimination of fruit and vegetables of inferior gustatory quality, so as to improve the general level (as with the alcoholic strength of wines and the butter-fat content of milk) ;

- the selection of part of the supply on the basis of measurable standards of superior quality.

In the first case, the system can be applied through the mechanism of an individual or collective trade mark or by tightening the norms of quality. It would not appear to be feasible, in current circumstances, to impose more rigorous quality standards, because the official services would not be able, for practical reasons, to carry out the required controls and because the decision would probably be very badly received by the growers. Such a step might nevertheless be contemplated in the special case of the "Extra" class, because the very word is evocative of a whole collection of qualities, both apparent and intrinsic.

In the second case, the only practical solution would be the adoption of a distinctive trade mark or informative label for marketing the product ; the system would have to be entirely voluntary, and would be controlled by a professional or interprofessional organization.

But in both the abovementioned situations, some of the provisions laid down in the standards can constitute the first step towards the implementation of a policy on selection according to quality while others may serve to hold down the quality rating of certain products.

It is therefore necessary to differentiate between those elements of the grading system which are compatible with selection based on quality and those which are not.

4.21 : Compatible parameters

The Community norms for fresh fruit and vegetables are broken down into three sets of requirements :

- "minimum requirements" for all classes ;
- "quality requirements", which vary between classes ;
- "size requirements"

Under the last two headings, certain tolerances are allowed, depending on the class of produce.

Many of these requirements are common to all types of fruit and vegetable. In particular, the produce must be :

- intact
- sound
- clean
- free from all abnormal external moisture
- free from foreign smell and/or taste
- sufficiently ripe to meet market requirements or normally and sufficiently developed.

The characteristics of fruit that is clean and intact obviously lend themselves to a system of selection based on organoleptic quality. Indeed, the criteria of cleanness and absence of foreign smell or taste are particularly important elements of that selection.

It is also quite evident that the parameters of ripeness are not incompatible from the abovementioned point of view, all the more so because the standards applied by the market operators are generally less rigorous than those laid down in the regulations relating to top quality produce, and the same observation applies to the stipulation that produce must be carefully picked by hand, when this is required by the norm, as no other means of picking could possibly be envisaged for top quality fruit.

The concept of "normal" or "sufficient" development is too vague, confused and it would now be quite feasible, in the interests of quality, to lay down a precise definition of the analytical procedures for determining the exact condition of horticultural produce. Nethertheless, if this vaguely formulated stipulation implies the elimination of poorly developed fruit (which is never of a very high standard from the organoleptic point of view), it does constitute a timid first step in the direction of selection on the basis of gustatory quality, as does the elimination of fruit with symptoms of physiological breakdown, such as apples affected by bitter-pit, or storage rot.

The freshness of appearance prescribed for certain products such as salad vegetables and cherries ties in well with the concept of organoleptic quality ; so there is no conflict between the effort to improve that quality and the minimum standards already set, many of which can be viewed, indeed, as the first steps in the type of selection envisaged.

- The existing quality standards for each class of horticultural produce relate to the characteristics of shape, size and colour, which must be typical of the variety in all but every case, or at least only slightly different from the norm.

The visual standards employed for selecting produce of superior gustatory quality are based on the observation of precisely the same criteria ; so there is no contradiction between the regulations and the production of fruit and vegetables of the quality referred to. Indeed, it is absolutely necessary to standardize such produce if the general level of organoleptic quality is to be maintained. None of the minimum standards is in any way an obstacle to improvement, and they must in fact be strictly enforced, as a guarantee of uniformity.

- Sizing norms are an important aspect of quality standardization ; experience has shown that those fruits which develop most rapidly on a particular tree or in a particular plot of vegetables are in most cases the largest and the best.

Thus, the elimination of products that are undersized and poorly developed is entirely in keeping with the requirements of gustatory quality.

Here again, in the context of special selection based on the organoleptic properties of the product, there is a general need for more rigorous standards. So the sizing of fruit and vegetables is perfectly compatible with the concept of organoleptic grading and can often serve, indeed, as a reliable indicator of gustatory quality when applied to products from the same origin.

4.22 : Incompatible parameters

In the common standards, the various types of divergence from the norm are listed as "defects", and some of these are quite incompatible with the standards of superior gustatory quality ; but in other cases there is no connection between the two sets of parameters, and the so-called defects may indeed be more frequent precisely when the cultural and climatic conditions are most conducive to the production of top quality fruit and vegetables.

This applies to the skin defects which have no effect on quality, such as the russeting of the epidermis of Golden Delicious and other varieties of which this is not a natural characterestic. The presence of russeting is partly attributable to variations in temperature during the phase of cellular multiplication of the fruitlet, before the fruit has developed its protective waxy layer, when it is more vulnerable to the effects of climatic conditions. Such variations occur quite regularly in the fruit-growing areas in which the climate is suitable for the production of top quality apples (272) (273). Yet the presence of reticular russeting on less than 1/5 of the area of the skin entails the downgrading of the product from the "Extra" class to class I, and if more than 1/5 and less than 1/2 of the surface area is affected the fruit is downgraded to class II, while beyond that tolerance it will be placed in class III.

The result is a substantial reduction in the selling price commanded by such fruit in the market as currently organized, although its intrinsic quality is certainly not impaired and may indeed be excellent.

Only a very small part of the superior quality of the product is directly related to the suberization of the epidermis know as russeting, which leads to a slightly higher rate of evaporation through the cuticle ; otherwise the connection is indirect, because the climatic factors which favour quality also favour the development of this modification of the skin.

In peaches, the developement of certain cracks in the suture line and certain colour defects can be attributed to the presence of certain viruses ; but they often have no bearing on gustatory quality.

Healed traces of damage by insects, by physiological disorders or light hail automatically entail the downgrading or elimination of fruit ; but they are nearly always totally unrelated to the intrinsic quality of the product. In fact, they may exceed the maximum tolerance if the plant protection programme has been less intense, in accordance with the policy of integrated pest control. There is hardly any direct link between the gustatory quality of the product and the application of these techniques which are applied to meet the demands of consumers who are increasingly inclined to associate the organoleptic properties of fresh fruit with the health-giving properties of the product.

Hence the conclusion that strict application of the quality standards can entail the downgrading of certain products, and that this can reduce their commercial value in spite of the fact that their gustatory qualities are unimpaired.

So the economic result of downgrading can be the total disappearance of any price differential which may be allowed for fruit of guaranteed gustatory quality. In the first chapter of this report, it was emphasized that downgrading reduced the market price by an average of 8-15 %, so that if the value of the product is taken to include the cost of packing and despatch the price obtained by the grower is reduced by 15 - 30 %. This margin of fluctuation, it should be noted, is equivalent to the estimated additional cost of production of fruit and vegetables of superior gustatory quality, so that the effect of downgrading can be to wipe out the additional margin which might be earned by produce marketed under a quality label.

On top of the abovementioned difficulties which may arise when produce is sold under a distinctive indication of quality, such as a label or a collective trade mark, mention must also be made of the extent to which certain consumers are struck by the discrepancy between the term "Extra" applied to the highest grade and the flavour of some of the products so graded.

In the minds of many consumers, in fact, the term "Extra" conjures up the idea of something more than the simple grading of fruit and vegetables according to the parameters of external appearance.

In their minds, the use of this term evokes a certain process of selection based on intrinsic qualities, which are of course conspicuous by their absence or only present by chance when there happens to be a link between the criteria of external appearance and the gustatory quality of the product.

Hence their bafflement, and a degree of disappointment which is all the more acute because of their initial assumption that such fruit must be of above average flavour.

Although this is obviously a relatively minor problem, and one which has no direct connection with the difficulties which have been pointed out as likely to arise in the case of products granted the benefits of a special mark of high gustatory quality, there are good reasons for emphasizing its significance in the context of this report.

In the case of the "Extra" class, and of fruit sold without any special label, the problem might be solved by imposing a minimum standard of gustatory quality which might be determined in the case of fruit by measuring the refractive index.

In short, as far as the consequences of standardizing fruit and vegetables on the basis of measurable standards of gustatory quality are concerned, the first point to be stressed is that the system of standardization currently applied in the European Community is compatible, in the main, with the implementation of a policy aimed at promoting this type of produce.

It just so happens that many of the standards of quality laid down in the Community norms are also the visual criteria which are used for assessing the intrinsic quality of fruit and vegetables when these are produced on a single plot of land.

Obviously, when the produce is from different origins, any comparison based on these criteria would be devoid of significance. It therefore seems desirable to modify the Community regulations, so as to facilitate the classification of fruit and vegetables attaining a measurable standard of gustatory quality in a single category and to avoid the systematic downgrading of produce for skin defects which have not the remotest connection with the internal qualities of the product.

In view of the possible obstacles to any far-reaching amendment of the existing regulations, which are the result of long-drawn-out legal discussions, not only within the EEC but also at a general international level, these changes could be brought about simply by extending the limits of the tolerances for certain skin defects.

But in the discussion of the system of standardization, and quite apart from the problems of marketing produce under a distinctive mark of gustatory quality, it has also been pointed out that serious confusion is caused in the minds of certain consumers by the use of the word "Extra" in connection with the top grade.

Without in any way underestimating the difficulties involved in any modification of the relevant regulations, it nevertheless seems pertinent to emphasize the benefits which would result from the addition of minimum standards of intrinsic quality to the visual standards applied to the "Extra" class of fruit.

4.3 : ECOLOGICAL CONSEQUENCES

The ecological consequences of applying the recommended techniques for growing fruit and vegetables of guaranteed organoleptic quality are considered in the broadest sense of the term ; so it includes the effects on the agricultural environment and on the relative nutritional value of the various products.

4.31 : The relationshop between organoleptic and nutritional qualities

It has already been pointed out, in chapter 1 of this report, that horticultural produce is eaten for two sets of reasons, sensory and nutritional. But the selection of certain varieties and the application of certain cultural techniques intended solely to maximize the output of eye-catching produce have been much criticized for their negative influence on nutritional and dietetic quality. In certain cases, even, the risk of the presence of toxic residues is a factor which weighs in the balance against consumption of such produce in the fresh state.

But when the nutritional value of the produce is degraded in this way, it is also substandard from the organoleptic point of view. In fact, these two types of quality both depend on the balanced growth of the plant and therefore develop in parallel.

This happy coincidence can result from the parallel development of the substances considered important by hygienists and those which form the basis of organoleptic quality ; but it can also reflect the harmonious development of the components of organoleptic quality, such as sugars and acids, which are the basis of nutritional value.

. The direct relationships

The basic criteria for the assessment of organoleptic quality are the balance between sugars and acids, at the optimum level of concentration of both components, and the degree of eating-ripeness attained by the fruit following the transformation of the pectin compounds. So there is an undeniable link between the nutritional value of the simple sugars, and especially that of the fructose which is so abundant in fruit and which is a key factor in the gustatory sensations, and the overall nutritional value of the product.

The organic acids hold second place in the hierarchy of organoleptic sensations. In fresh produce they are present in quantity in the form of salts. This enables them to release the alkalinizing faction of the molecule in the human organism, and thus to maintain the pH at a satisfactory level. So this is a clear case of a direct relationship between organoleptic quality and nutritional value.

The state of ripeness required in top quality fruit means that such products can provide human the organism with soluble pectin compounds which are highly valued for their effect on the intestinal functions. This does not happen when immature fruit is eaten, before the cellulose compounds are sufficiently broken down, and their consumption may even lead to digestive difficulties and intestinal troubles.

Good colouring is another manifestation of the state of ripeness referred to, and it has already been pointed out that intensity of colour can be used as a test of superior gustatory quality. But in certain species of fruit and vegetables this intense colouring is matched by a high level of carotene, which provides the body with vitamin A. So the satisfactory ripeness of top quality fruit reveals the very direct relationship between nutritional value and organoleptic quality.

From the nutritional point of view, the calcium provided by fruit and vegetables is extremely important, and it is considered that horticultural produce can provide 25 % of human calcium requirements. The connection between a balanced supply of calcium and organoleptic quality has been established, both by observing its effect on colour and aroma and by noting the influence of this substance on storage quality through the reduced incidence of certain physiological disorders such as bitter-pit and superficial scald.

. The indirect relationships

One of the indirect results of producing top quality fruit and vegetables can be the enhancement of certain constituent substances ; but it is important to exclude the possibility of negative effects.

Numerous studies have shown that fruit and vegetables which are highly rated for their gustatory quality generally contain higher levels of vitamin C and amino acids, which develop in parallel with the main constituents of flavour (271) (275). The degradation of vitamin C after harvesting, as a result of oxidation, can be fairly rapid. So all the precautions taken to preserve the organoleptic properties and the freshness of the product also limit the loss of vitamin C.

Generally speaking, fresh fruit and vegetables are not particularly rich in proteins on a weight-for-weight basis ; but the amounts consumed by the human species are so great that they cannot be completely ignored as a source of dietary protein, because they contribute an estimated 10 % of total human requirements in a form which is highly prized for its superior biological value.

Finally, fruit and vegetables contain minute quantities of certain substances associated with the pigments and volatile compounds, as well as certain enzymes, which are nevertheless of great importance, as dietitians are increasingly coming to realize.

It may therefore be stated that the organoleptic properties of the produce, taken together, can be accepted as evidence of superior nutritional value, and although it would not be correct, because of the highly specific nature of certain nutritional qualities such as a high level of vitamin C, to claim that this is the direct result of concern for gustatory excellence, it must nevertheless be emphasized that the two types of quality are not in any way opposed to each other and that they do tend, in fact, to develop in parallel.

The aim in future should be to apply the techniques of hybridization and varietal selection to the breeding of new varieties in which appearance, organoleptic properties and nutritional quality are present in association.

4.32 : Effects on the agricultural ecosystem of the adoption of techniques intended to improve organoleptic quality

The grower who concentrates on growing produce of high gustatory quality will try to ensure the balanced development of the plant and to avoid the application of over-intensive cultural techniques. In so doing, he will make a highly significant contribution to the campaign for agricultural methods which show a greater respect for the ecological environment.

The effects of these techniques on the ecosystem mainly involve the functions of nutrition, growth, protection and production, but it is the interrelation between these factors which should be most emphasized.

It has already been pointed out that quality in fruit and vegetables can mainly be attributed to the use of suitable techniques to optimize the conditions of photosynthesis. In this respect, the key factor is the penetration of air and light throughout the structure of the plant.

This observation has a very direct effect on the choice of seeding and planting densities and, as far as trees are concerned, on the methods of training and the severity of the approach to pruning. It means the outright rejection of any system which will encourage the development of excessively dense or over-luxuriant foliage which can be an obstacle to efficient photosynthesis. The first direct effect is to reduce the overall rate of absorbtion of carbon dioxide and the rate of emission of oxygen from the trees in question.

But this type of excessively dense vegetation favours the development, within the crop, of micro-climates in which temperature, humidity and exposure to sunlight can show a considerable range of variation, and this is precisely the sort of situation which can encourage the development of pests and diseases. To avoid the harm which these can do to the crop, the grower is obliged to step up his rates of application of chemical pesticides, and these in turn can upset the balance of the agricultural ecosystems and increase the level of chemical pollution of the environment.

This chain of events can usher in a phase of ecological imbalance, leading to the use of increasing quantities of pesticides, and the concentrations may even become so great in certain cases that the production of a certain species may have to be completely abandoned.

From the nutritional point of view, it is always advisable to adjust the amounts of fertilizer to the normal need of the plant, especially as far as nitrogen is concerned, if the aim is to grow produce of superior gustatory quality. This obliges the grower to calculate the rates of application, to avoid all excess and therefore to reduce the risk of mineral substances being carried away by the drainage water. What is more, the reduced application of nitrogen fertilizers improves the plants' resistance to fungal diseases and to certain sucking insects such as aphids and mites.

Indirectly, this reduces the need for chemical pesticides, the risks of which have already been referred to in the preceding paragraph.

When vegetables are grown under glass, the rates of application of nitrogen fertilizers can be regulated to suit the lighting conditons, providing the air and soil temperatures inside the greenhouse are kept under perfect control. In this way, it is possible to avoid the over-vigorous growth which has already been pinpointed as an encouragement to the proliferation of certain pests, and it avoids the accumulation of nitrates in the soil, which can be a further contributory factor in this respect. Finally, it reduces the risk of surplus fertilizer seeping into the drainage system.

Another important factor in the production of quality fruit and vegetables is the controlled application of irrigated water. Experience has shown that whereas a reasonable supply of water, calculated in relation to the real needs of the plant, can provide conditions favourable to the maximum expression of the plant's potential, the result of any excess is to impair the gustatory quality of the product. But excess water also has serious ecological repercussions, because it throws the growth of the plant out of gear and therefore encourages the development of pests and diseases. Directly, this excess water can carry surplus chemicals and their residues from the surface of the soil down into the subsoil and into the natural drainage systems.

Limitation of the use of chemical pesticides is also an integral part of the programme of measures to be taken to encourage the production of quality fruit and vegetables. It is prompted in the first place by the risk of direct impairment of organoleptic quality by certain products, especially in the case of those fungicides which can reduce the rate of emission of the volatile substances ; but it can also be very much encouraged by the double demands of the consumers for produce that is enjoyable to eat and at the same time beneficial to human health.

The complexity of consumers' ideas about quality has already been stressed in chapter 1 of this report, and it was also pointed out that those who insist on gustatory quality also attach great importance to the nutritional and hygienic properties of the product.

In their efforts to meet these requirements, the growers quite naturally cut back the rate of application of pesticides, by adopting the methods of integrated plant protection, and this helps to preserve the balance of nature within the cultural environment at the same time as it reduces the risk of pollution.

4.33 : Effects on the ecological individuality of the region

As has been pointed out, the influence of the natural environment on the organoleptic properties of horticultural produce is particularly marked in handicapped zones in which certain factors favour the development of quality by reducing vigour.

This may be brought about by lower soil fertility, due to the slope of the site or the physico-chemical composition of the soil, or by the climatic factors which shorten the vegetative cycle or increase the differences between diurnal and nocturnal temperatures.

The solar radiation falling on certain elevated areas of production can also serve to enhance quality.

All the abovementioned conditions determine the ecological individuality of each of these areas. Unfortunately, their potential output is reduced by the prevailing natural conditons, and in many cases they can no longer achieve a level of profitability comparable with that obtained in the zones of production where more intensive methods are applied.

Measures aimed at promoting the sale of produce of superior gustatory quality would partially restore the balance that has thus been lost, and would therefore foster the continued production of "typical" produce of the very highest quality, the supreme expression of the ecological diversity of the European continent.

In conclusion it should be stressed that opting for improvement of the organoleptic properties falls under the heading of ecological measures, because it is based on concern for the harmonious and balanced development of the plant.

The option leads the grower, without detracting from the contribution of scientific knowledge and know-how, to adapt the latter to the natural environment without endangering the ecological balance.

The grower is thus induced to put quality before quantity and to pay far more attention to what happens to the product beyond the orchard gate, along the chain of distribution which connects him with consumers who may be far away and who are almost certainly unknown to him.

Growers who want their produce to be distinguishable from the mass become more conscious of their responsibilities and of the ecological consequences of their activities.

So this is a means of slowing the development of the over-intensive methods of production which tend to throw the natural environment and the market out of balance.

From a social point of view, the option impels the growers to improve their knowledge, because the diversity of natural conditions is so great that each situation must be separately interpreted without resorting to ready-made formulae for the application of cultural techniques. As far as the growers are concerned, therefore, it is an undeniable means of cultural improvement.

5 - DEFINITION and DESCRITION of the PRACTICAL MEASURES TO BE TAKEN TO ENSURE THE PRODUCTION OF FRUIT AND VEGETABLES OF MEASURABLE GUSTATORY QUALITY: TECHNICAL SPECIFICATIONS AND RECOMMENDED TECHNIQUES OF PRODUCTION AND STORAGE

The quality of fresh fruit and vegetables largely depends on the natural factors of soil and climate, on the characteristics of the plant and on its suitability for a given environment. But, as was explained in chapter 3, the natural potential can be modified, for better or for worse, by the various cultural techniques.

So a favourable environment will not guarantee the quality of the product. This must not be jeopardized by the techniques adopted, which must indeed encourage the expression of natural potential.

5.1 : THE OBJECTIVES OF TECHNICAL CONTROL OVER PRODUCTION

Application of the various cultural techniques may be voluntary or mandatory, depending on the system adopted for the commercial exploitation of the qualities thus developed.

In fact, if the products are only identified by a trade mark, the owner of the mark is more or less free to apply the techniques he considers most likely to achieve the commercial targets he has set himself. In that case, the recommendations in Annex 2 will only serve as a guide from which the grower can adopt all or part of the information, as he sees fit.

But when it is a question of marketing product of a clearly defined quality, guaranteed by a label or a collective trade mark, this implies the acceptance of a common system of technical regulations, voluntarily accepted by the grower, who agrees to comply with the rules. In that case, the organization granting the authority to employ the label or collective trade mark is obliged to provide a formal definition of the minimum requirements for produce covered by the mark in question.

These minimum requirements may simply involve a limited number of tests, as proposed in Annex 1 ; but in most cases the right to use a specific label depends on compliance with a certain number of rules relating to the technical aspects of production.

The exact nature of the minimum conditions will depend on the uniformity of the cultural environment, and therefore on the size of the area of production covered by the growers' mark or label.

The severity of the rules will depend on the commercial aims of the growers' organization providing the guarantee.

The objective tests and the minimum technical rules must therefore constitute the basic and obligatory elements of a code of good practice ; but the technical rules can be supplemented by a whole collection of recommendations which, without being obligatory, can provide the growers with a compendium of information concerning the most suitable methods for growing produce of superior gustatory quality.

A complete summary of the available information is contained in Annex 2, in the form of a separate schema for each species of horticultural produce examined in this report, and these constitute the most comprehensive technical recommendations which can be put forward as a means of improving the gustatory quality of fruit and vegetables.

These recommendations are based on the large number of documents referred to in the bibliography, most of which have already been quoted in the preceding chapter. The references relate not only to all the EEC Countries but also to North America, Central and Eastern Europe and indeed to a whole range of temperate zone countries.

Obviously, the degree of detail depends on the extent to which the results of research have been published for the various species ; hence a certain lack of balance, which is attributable to the fact that scientific knowledge is more advanced in some fields than in others. The recommendations are based on data received up to early 1975, and the literature published since that date will already be helping to fill in the gaps.

These recommendations are to be treated as an inventory of those items of knowledge which are considered to be the most relevant ; but their application must always be considered in the light of the technical and cultural conditions prevailing in the local environment.

5.2 : TECHNICAL RECOMMENDATIONS APPLICABLE TO FRUIT TREES

• Soil and climate

The recommendations relating to soils and climate for fruit trees are mostly of a general nature, the main aim being to remind the reader of the natural factors which are most conducive to the production of quality fruit and vegetables, with an occasional reminder of the limits beyond which certain factors can begin to have an indirect negative effect on the organoleptic properties of the product. For that reason they are to be treated more as optional guidelines than as harsh imperatives, and they should be given a broad interpretation in which every allowance is made for local conditions.

• The plant

It is worth stressing, at this juncture, that all the technical recommendations will necessarily affect the potential quality of the whole plant, but that this potential is also partly governed by the combination of characteristics provided by the rootstock and the scion variety.

So the final quality of the product will depend on the precise choice of these two components of the tree, the rootstock which must be suitable for the soil and the variety which must not only be suitable for the climate but also compatible with the rootstock.

Some varieties are highly adaptable, but others give poor results if they are grown outside a specific environment.

Any code of practice ought to include a detailed list of authorized varieties (and possible rootstocks), taking full account of local conditions.

• Cropping systems

As far as gustatory quality is concerned, the most important recommendations on cropping systems are those which affect the photosynthetic prooess. But planting densities, types of pruning and extent of thinning operations can only be recommended and not imposed, because they must all be continuously adapted to each particular situation.

The same applies to the nutritional factors. The recommendations relating to fertilizers and irrigation, although they are often formulated in precise terms of units of fertilizer per hectare and percentages of satisfaction of the requirements of the crop in terms of evaporation/transpiration as provided by irrigation, must also be constantly adapted to the particular conditions of the parcel of land and the year in question.

. Harvesting and storage

The satisfactory distribution of the photosynthetic products and the conditions and more particularly the date of harvesting are the two main factors in the attainment of gustatory quality.

Some of the prescriptions for quality have been precisely worked out, and in those cases it is possible to envisage the inclusion of obligatory rules in the code of practice.

5.3 : VEGETABLES

In the case of vegetables, generally speaking the influence of cultural factors on organoleptic quality has not been investigated in the same depth as in the case of fruit trees. Furthermore, the life cycle of vegetables is much shorter ; they are less affected by the conditions obtaining in the natural environment, from which they can even be totally isolated in the case of greenhouse crops.

So the recommendations annexed to this report are above all a statement of the optimum condtions for the development of vegetables, on the assumption that flavour depends for the most part on the harmonious and regular development of the plant.

. Soil and climate

The recommended conditions of soil and climate are limited in most cases to a summary statement of the most favourable elements, interspersed with a number of precise indications regarding the optimum temperatures for growing certain vegetables in greenhouse conditions.

. The plant

In the case of vegetables, more even than with fruit trees, the choice of a variety which is well adapted to the natural conditions is one of the main factors in the development of organoleptic quality.

Such is the pace of varietal improvement, with new cultivars appearing every year, that it is essential for groups of growers interested in the idea of guaranteed quality to test the qualities of each new variety in their local growing conditions, so as to maintain an up-to-date list of authorized varieties.

. Cropping systems

As with fruit trees, the recommendations relating to soils, densities, fertilizers and irrigation are to be treated as general guidelines of an indicative nature, to be adapted to the special conditions obtaining at the level of each parcel of land.

. Harvesting and storage

The recommendations on this subject are less detailed than for fruit. In complete contrast with fruit, the earliest harvested vegetables tend to have the finest flavour.

6 - MARKETING PROBLEMS

The marketing of fruit and vegetables attaining a measurable standard or organoleptic quality must be so organized as to allow the consumer to exercise a preference, i.e. to distinguish such produce from the mass.

For this, the consumer must be well-enough informed to exercise the preference and thus to create a selective demand for this type of produce, and the demand must be reflected in a price differential in favour of the products of guaranteed quality. Experience with the distribution of certain products typical of a limited growing area has shown that the differential can only be obtained if the product is clearly associated with its "terroir" or if the system of quality control which justifies the differentiation is applied with sufficient rigour to ensure that the product is always up to standard as far as the consumer is concerned.

In this context, and especially in the case of fruit and vegetables, there does not seem to be any clash between the consumer's demand for produce of guaranteed quality and the interests of the growers, who take a pride in optimizing the quality of their produce. The various intermediaries can either make a positive contribution to the promotion of quality produce or act as a sort of screen to prevent the growers and the consumers from perceiving their mutual motivations.

Marketing therefore plays an extremely important role in the production of fruit and vegetables of guaranteed quality. The problems inherent in this situation mainly involve the identification of the product and its legal protection by means of a label in the course of the various commercial operations. But this protection must be extended as far as the consumer, as a safeguard against fraud. Hence the inevitability of state control.

It should be added that all the growers' efforts to improve quality would be labour in vain if that quality were impaired in the course of transport and retail marketing. So the physical protection of fruit and vegetables and the preservation of potential quality are yet another aspect of the general problem of marketing the product.

6.1 : IDENTIFICATION AND PRESENTATION OF FRUIT AND VEGETABLES OF GUARANTEED QUALITY

There are two main aspect to identification. Firstly, from the consumer's point of view, it must be a means of recognition enabling him to exercise his preference ; but it must also provide a legal basis for the various controls which protect him against possible fraud. So the difficulties posed by identification are of two separate orders, legal and practical.

6.11 : Legal problems of identification

As far as the legal aspect is concerned, the growers of produce of guaranteed quality can mobilize a whole range of legal safeguards, which may be described as a graduated scale of severity in selection or in limitation of the area of production.

• Trade marks

In all countries, the simplest means of protecting the identity of a product is to use a registered trade mark. The undertaking which registers the mark is its legal owner and is responsible for its use. The advantage of the system is that it allows complete autonomy to the growers' or distributors' organization, and enables it to adjust its standards of selection, without delay, to fit in with its commercial policy.

The method can prove quite effective, providing the mark enjoys the widest possible exposure and is backed by vigorous advertizing. But there is a limit to such publicity in certain countries, including France, where it is forbidden to describe the qualities of fruit and vegetables in terms other than those allowed under the grading system.

Furthermore, the very flexibility of the system also constitutes its limitation. Undertakings which are not subject to any control tend to be more easily tempted by fluctuations in the market, and not to apply their selection procedures with constant severity. What is more, they do not provide the consumer with any legal guarantee, other than good faith.

When applied to staple products which are not selected on the basis of superior quality, this method of marketing nevertheless satisfies the consumer. Its advantages are to be found more in the establishment of product loyalty, and therefore in the provision of a sure outlet, than in the procurement of a substantial increase in the price of the product.

. The label or the collective trade mark

When a certain number of growers get together on a voluntary basis, to form an agricultural producer group, they can enjoy the benefits of official protection, in the form of a collective trade mark which is intended, over and above their individual labels, to provide the consumers with a guarantee of authenticity.

Providing there is a certain measure of official control, this collective mark can become a genuine label of quality, which the growers' organization is authorized to issue to its members, subject to their voluntary acceptance of a code of practice approved by the competent authorities.

The disadvantage of these collective marks is that they are often limited to a rather circumscribed area, or to an insufficient number of growers, and their share of the market remains very small. In such conditions, publicity is difficult and the system is often almost or entirely unknown to the public.

The effective use of this type of identification, which gives every guarantee to the consumer, therefore requires a sufficiently large grouping of producers to create an adequate demand for the labelled product, reflected in an appreciable difference in price.

. Designation of origin

In all the countries of Europe, designations of origin are used to set the stamp of official approval on the reputation of certain regional products ; the regulations are extremely strict and their application is rigorously enforced. By contrast with labels, which merely oblige the grower to follow the relevant technical rules, products which are protected by a designation of origin must comply with the double conditon of technical control and limitation of the area of production. If this is too restricted, the product may encounter similar difficulties to those which have been pointed out as likely to occur under the label system when the volume of output is low.

But if the connection with a particular growing area is very close, the designation of origin is the best possible form of publicity, as with Champagne wines.

. In short,

the legal basis for the identification of horticultural produce must be adapted to the commercial objectives of the growers or wholesalers. In the case of a staple product selected for a level of quality which only guarantees the elimination of substandard produce, the trade mark would appear to be the most suitable support, providing the methods of selection ensure a certain uniformity of quality.

If the product can be identified with a specific origin or a special cultural technique, and providing the zone of production is sufficiently large for its output to meet a substantial demand, the collective mark can be the best method for publicizing the product. At the end of a certain period, a label could officialize the level of quality attained.

A designation of origin is useful when the product can be very closely identified with a strictly circumscribed area of production (fr. "terroir") ; but this does not often apply to fresh fruit and vegetables, so that there is only limited scope for marketing them under such designations.

6.12 : Practical methods of ensuring identification

In the past, the informed consumer could identify the product simply by reference to the criteria of external appearance and origin, but this possibility is becoming increasingly rare with the standardization of varieties and presentation. So it is mainly by reference to the label and possibly to the package that the consumer can recognize the product which he has found to be acceptable on previous occasions.

. The packaging, if the design is original, can often be the best means of identification. This is the case with certain processed products, such as wine and cheese ; but the possibility is not so common with fruit and vegetables. There are still a few traditional practices which can create an image simply on the basis of the packaging, as in the case of cherries from the region of Vignola in Italy, which are presented with the greatest of care in highly distinctive "cassetta".

But even among the more standard forms of package, the choice of a uniform type of packaging and presentation can itself be a means of identification. It is therefore recommended that organizations seeking to market products which are distinguished from the mass by their quality should choose a single type of presentation.

This standardized presentation can sometimes be the direct result of interprofessional cooperation, in the form of an agreement between the producer group and the distributors, especially in the case of certain integrated retailing organizations which demand a specific packaging.

. Labelling can be the most precise means of identification, because it is also the support for the grower's guarantee of the quality of the product.

Firstly, the label must bear the particulars which are obligatory under the EEC regulations ; but if the products are selected for their gustatory quality it must also be informative, to the extent that this is allowed under the regulations relating to indications of quality, and in that case the particulars may also include the registration number of the label, the name of the issuing organization, a description of the product and some indication of the organization responsible for control.

It is also possible to include more detailed information, by numbering the packages and by stating the dates of packing and expiry of the guarantee.

The two last-mentioned items of information are particularly important in the case of fresh fruit and vegetables which mature in the course of transit and distribution, because they set a limit on the original guarantee of quality-based selection.

Obviously, produce can only be marketed in this way with the tacit or preferably contractual agreement of the various inter-professional groups involved in the process of distribution.

Even in the case of the most sophisticated packaging, there is the additional problem of ensuring that the original label is still present when the product reaches the consumer. In fact, except when the fruit is sold in its original packaging, there is a risk that the consumer will not be given any change of seeing the label for himself.

To provide the consumer with this opportunity, two systems are technically feasible in present conditions :

- Prepacking in retail units, which can only be carried out with the agreement or, more probably, at the behest of the operators in the distribution circuit ;

- Ticketing or individual marking of fruit, by stamping a mark on the skin or by sticking a label on each individual fruit.

It is relatively easy to stamp citrus fruit, but with other species it is extremely difficult and even impossible, because of their fragility or shape. Even the use of a sticky label for each fruit, which also entails a considerable increase in costs, is fraught with technical difficulties ; stickers will not stick to peaches, because of the bloom, and they cannot be used with small fruits such as cherries.

6.13 : Methods of protection

Fruit and vegetables are protected by the package and the packaging. The role of the package as a means of identification has already been emphasized, but it is also necessary to check its efficiency in protecting quality produce which is, ipso facto, extra-fragile.

So the strength and form of the package must guarantee the protection of the product in the course of distribution.

. Pre-packing in retail sales units would appear from the double standpoint of protection and consumer information to be a particularly suitable means of meeting the requirements of produce selected on the basis of quality. In fact, it ensures adequate protection because the produce is untouched by hand between pre-packing and consumption, and because it is a means of bringing the label to the direct notice of the consumer it is also a first class support for identification.

The guarantee which can be printed on an informative label is in fact the best way of overcoming the doubts which appear to exist in the consumers' minds vis-a-vis pre-packed fruit and vegetables. Some consumers do indeed seem very sceptical about the quality of such produce which they can neither touch nor see directly, except for example through a plastic film.

A guarantee of quality, linked with a collective trade mark or a label, or even implicitly provided by a commercial seal of quality, can serve to boost the consumers' confidence and to foster the development of this type of marketing procedure which is steadily gaining ground in the process of industrialization of the fresh fruit and vegetable sector (277). Furthermore, as far as the consumer is concerned, the guarantee of quality can also serve as a justification for the marginal extra price which is invariably charged for pre-packed produced at the retail stage.

The definition and control of quality would seem to be a logical and indeed an indispensable element of the development of modern methods of ditribution of fruit and vegetables by integrated retail outlets and supermarkets.

Pre-packing is therefore suitable for every level of quality selection, and can just as well be applied to fruit and vegetables of average quality as to top quality produce.

. The traditional packaging of top quality produce does not need to be entirely discarded, however. The small specialist retailers, whose intimate acquaintance with the quality of the product enables them to provide the consumer with a personal guarantee, still have an important role to play in the distribution of fruit and vegetables. The adoption of objective methods for assessing quality would enable such specialists to base their recommendations on scientific certainty, and their sales of "typical" produce from specific areas of production, specially selected for its superior quality, which the most demanding consumers know they can obtain from this particular channel of distribution, could be correspondingly increased.

The consumer can add to the verbal information obtained as a result of direct contact with the specialist by exercising his own faculties, by looking closely at the product or even by touching it, and this can be an important psychological factor in some cases.

The guarantee provided by an informative label would strengthen the consumer's confidence, although it would not alter the slightly emotive nature of the decision to purchase the product.

6.14 : Methods of sale

The foregoing examination of the problems posed by the identification and presentation of fruit has revealed the existence of two types of distribution network for horticultural produce of guaranteed quality, and their objectives can be quite different.

. The traditional network, in which the operators are craftsmen, tends to supply the market with produce which already attains certain standards of quality through the intervention of experts at many points in the chain linking the grower with the specialist retailer, whose customers are nearly always demanding and may even be connoisseurs.

But this method involves a certain degree of restriction in supplies, and depends on the direct exchange of information between the professional operators, on a basis of mutual trust, and such a network rarely enables the producers to dominate the market, save in a few cases where they have managed to establish a highly personal image.

The introduction into this system of objective methods for defining and controlling the intrinsic quality of fruit and vegetables would doubtless enable the growers to ensure they received a larger share of the extra price which the consumer is willing to pay at the retail end of the chain of distribution. At present, the main beneficiaries of the differences in price which can be found at the retail level are those middlemen who are sufficiently well acquainted with certain areas of production to be able to obtain quality produce that will be acceptable to their customers although the prices they pay for their supplies are practically the same as those paid for the general mass of produce. The introduction of a system for defining quality can enable the growers to realize the intrinsic value of their produce and therefore to be more demanding with their prices.

The traditional system does not necessarily entail the massive concentration of products, and is able to accomodate a multitude of marks and labels, because it is mainly the nature of the point of sale which determines the consumer's recognition of quality.

. Modern distribution is an industrialized process which streamlines the relationship between two sets of activities : (277)

- upstream operations, comprising production, pre-packing and despatch ;

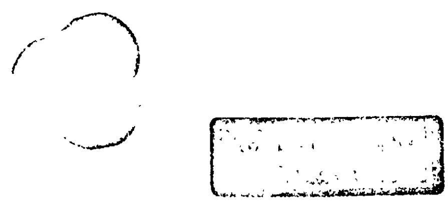
- downstream operations, comprising dispersal to the points of sale and presentation to the consumers.

The model for this approach is manufacturing industry, in which products and quality are standardized and guaranteed ; but the system stands or falls on the ability of the upstream operators to put together lots which are sufficiently large and uniform, of a quality which is recognized by the consumer on the basis of the individual or collective trade mark.

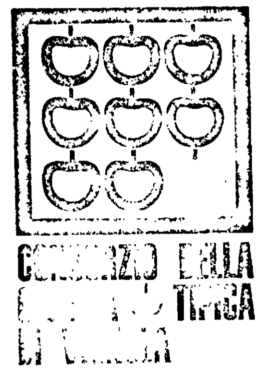
For this to occur, the consumer must be provided with a steady flow of information, not only at the point of sale but also in a larger context, in the course of his everyday life, exactly as is done with industrial products, and the growers must be able to meet the increased demand resulting from such publicity and to guarantee the maintenance of adequate supplies of acceptable quality.

This has proved a major stumbling-block for a certain number of regional trade-marks and over-localized labels. The requirements of the modern system of distribution can only be met, it would seem, by national marks or labels, or at least by those of a large-scale inter-regional organization. It is nevertheless the modern side of distribution which offers the best prospects of increasing demand for guaranteed produce (the more traditional network remaining geared to the requirements of a loyal bank of connoisseurs). But the development of a genuine market in quality produce calls for considerable outlays on consumer-orientated publicity to create the demand which will encourage the growers to concentrate on this aspect of fruit and vegetable production.

A FEW EXAMPLES OF LABELLING

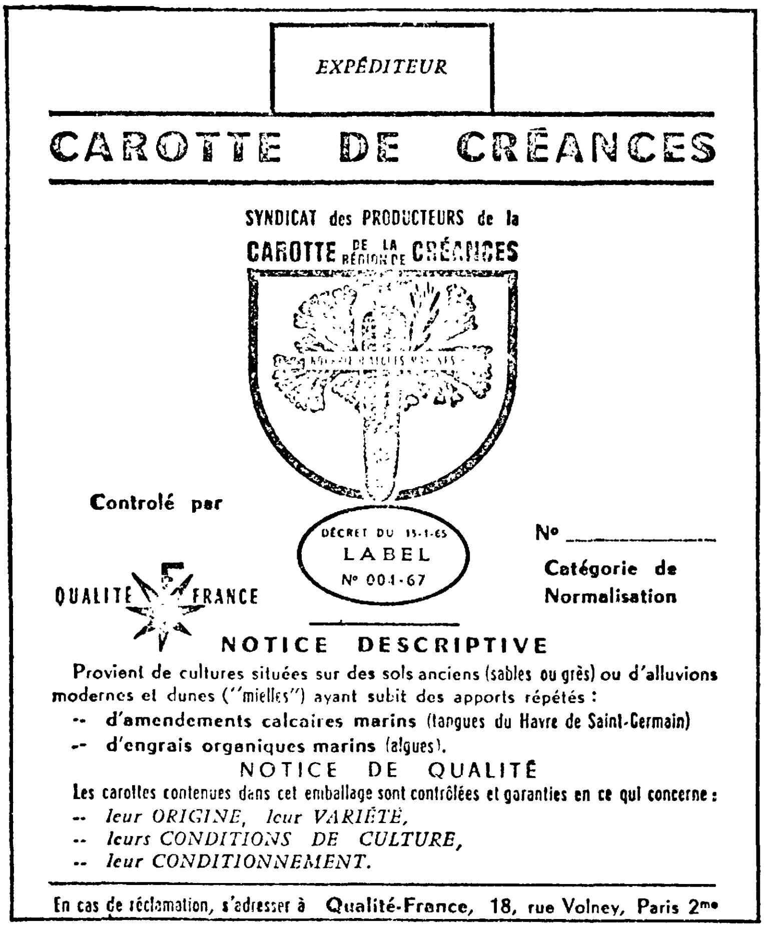


Marque commerciale

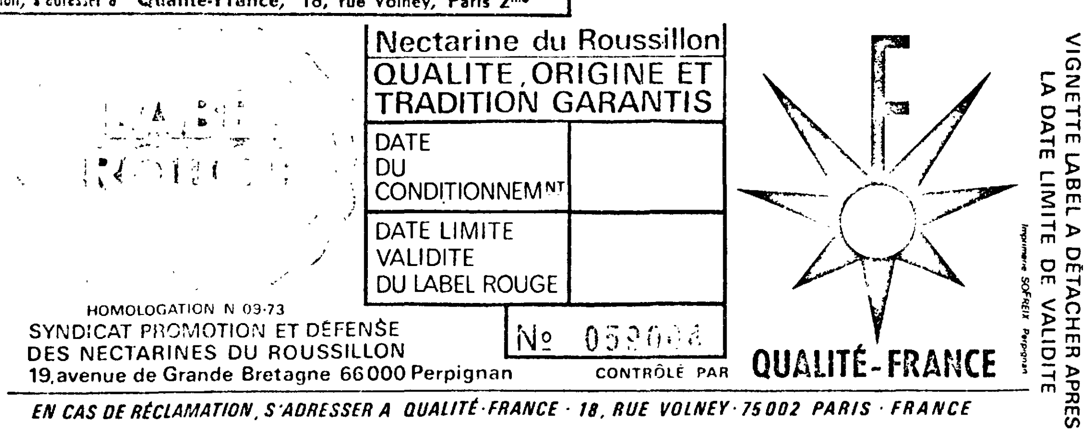


Verband der Vignoleser Kirsche
Syndicate of the cherry of Vignola

Marque collective



Labels syndicaux



6.2 : PRACTICAL RECOMMENDATIONS FOR PRESERVING THE QUALITY OF FRUIT AND VEGETABLES IN THE COURSE OF TRANSIT AND DISTRIBUTION

These recommendations are intended to ensure that product quality, which may have been brought to perfection after the harvesting phase, does not deteriorate in the course of the various operations along the chain of distribution leading to the consumer.

Many of the existing rules and regulations apply to every type of horticultural produce. In addition, the EEC standards for fresh fruit and vegetables already contain a certain number of obligatory provisions. That is why the individual species have not been treated separately.

6.21 : Packaging

The detailed rules for the packaging of fruit and vegetables are already laid down in the EEC regulations. In the absence of specific indications in this text, the reader is advised to refer to the EEC norms, or to the national regulations in the case of produce which is not yet covered by Community arrangements. However, in the case of produce of guaranteed quality, it may be necessary to impose greater severity of selection for certain parameters.

- Classification

The strict application of the standards for the "Extra" and class I categories is no obstacle to the selection of fruit and vegetables on the basis of organoleptic quality. It would not be advisable to apply the system to class II vegetables, because the defects which are tolerated in this category may well be evidence of inferior gustatory quality. But as far as fruit is concerned, the skin defects which often lead to the produce being place in class II do not impair its intrinsic quality and may indeed, in certain cases, be inseparable from it.

- Sizing

Because of the close relationship observed between size and gustatory quality, there is a general need for stricter definitions of minimum sizes than those laid down in the Community norms. Furthermore, the Community sizing norms vary with the class of produce, whereas it would be desirable to limit the definition of intrinsic quality to a specific stage of development. This would entail the imposition of a single minimum size, irrespective of class.

Recommended minimum sizes are contained, by way of example, in Annex 3.

. Packaging

The degree of uniformity and the standard of packaging must be strictly in conformity with the norms.

To enable the consumer to identify the produce more easily, a limit should be set on the types of package permitted. Packages in general should not be too voluminous, and any which do not ensure the perfect protection of the product should be eliminated. Their dimensions should fit the standard pallet systems, to facilitate mechanical handling.

Examples of suitable packaging are described in Annex 3.

. Marking

In addition to serving as a means of identification, the particulars marked on the outside of each package of produce of guaranteed organoleptic quality must also constitute a source of information for the commercial operators and the consumers.

The EEC norms for the presentation and quality of fresh fruit and vegetables already stipulate that each package must bear a certain number of particulars marked on the outside. But in the case of produce of guaranteed gustatory quality, these requirements need supplementing and amending to facilitate the operation of controls and to keep the consumer fully informed.

The details which ought therefore to be marked on the outside of all packages of fruit and vegetables are listed on page 177. In addition to the particulars which are already obligatory under Community legislation (marked +), the list includes those which are optional extras and those which should be included in any regulations relating specifically to produce of guaranteed quality, as adopted by the organizations which market such produce.

List of particulars to be marked on the outside of packages of fruit and vegetables attaining a fixed standard of gustatory quality[(1)]

- Identification:

  . Individual or collective trade mark.

  + Name and address or code mark of the packer and despatcher

  . Name of cooperative or producer group (in the case of a collective trade mark or label).

  . Registration number (in the case of an official label).

- Nature of the produce:

  + Name of species.

  + Name of variety (the existing obligation to name the variety, which already applies to the "Extra" class, and in certain cases to class I, should be systematically extended to every level of guaranteed quality grading).

  . Designation of quality, in the terms permitted by the relevant regulations, perhaps in the form of a printed description.

- Origin of produce:

  + Country and district or origin, and national, regional or local trade name.

- Commercial specifications:

  + Class

  + Size or number of individual fruits or vegetables.

- Controls:

  . Number of label (in the case of a label or a collective trade mark).

  . Name of controller and address for complaints.

  . Date of packing and date of expiry of the guarantee of quality.

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(1) . = optional, or specific to produce of guaranteed quality.

+ = obligatory under EEC regulations.

6.22 : Transport

The time taken up by transport and handling, and the nature of these operations must be such as will not impair the intrinsic quality of the produce.

. Handling operations

The loading and unloading operations must be so organized as to ensure rapidity of movement without damaging the packages. The use of pallets or standard containers reduces the number of handling operations and therefore the risk of damage to individual packages.

The packages should not be left in the sun or exposed to wind. Refrigerated produce must be carefully protected against condensation. When such produce is loaded for transport, a lock chamber should be used, so as to avoid the effects of sudden variations in temperature and internal warming which would cause the quality of fruit and vegetables to deteriorate in transit. Care should be taken, with ice-cooled transport, to ensure that sufficient ice is loaded on the vehicle at the start of the journey and, if necessary, en route, to keep the produce at the required temperature. Produce destined to be transported at normal temperatures should be progressively rewarmed prior to loading, in a ventilated room, at a temperature which is regulated in relation to that of the ambient atmosphere so as to avoid condensation (see table, p. 138).

When loading, space should be left to ensure the adequate circulation of air inside the vehicle.

. Time limits

The time allowed for transit must be geared to the length of the ripening period, at the end of which the quality of the produce is at a maximum. Due allowance must be made for the maximum time of transit when choosing the means of transport, so as not to jeopardize quality. Furthermore, in contrast with an all-too-prevalent practice, the produce should not be harvested prematurely, when it is insufficiently developed to retain its quality until it reaches its destination.

In the case of fruit which needs to be after-ripened, the time allowed for transit and subsequent distribution to the consumers must be included in any calculation of the time required for optimum maturation.

6.23 : Preservation of quality in the course of distribution

The methods of preservation and the conditions under which produce is kept at the point of sale can bring about a rapid deterioration in quality ; so precautions must be taken to reduce these risks.

• Conditions of temporary storage

- A cold room must be available for the temporary storage of produce that has been transported under refrigeration. It must be kept at a temperature of about +1 or +2°C;
- When refrigerated produce is placed on the display shelves, precautions must be taken to avoid the condensation referred to in paragraph 6.22 (conditions of transport) ;
- A special room is needed for the storage of fruit that has been transported at ambient temperature, which continues to develop and ripen in the course of distribution. It must be kept at a temperature of +12 to +15°C, with a relative humidity of 80 %.

• Ambient atmosphere of the point of sale

- The ambient atmosphere for fruit and vegetables displayed for retail must be kept at a temperature of 15 - 20°C;
- Dessicating draughts must be avoided, and in hot dry weather all the green parts of the produce should be finely sprayed with water several times a day ;
- Potatoes should not be exposed to light for too long, to avoid greening.

• Display

- Produce should not be piled too high, so as to maintain ventilation and avoid bruising the lower layers, and for this reason fruit and vegetables should be kept as far as possible in their original packages ;
- It is important to check the hygienic condition of every commodity when it is placed on the shop shelf, and to eliminate any produce with symptoms of fungal attack or internal breakdown which may have developed in the course of transport or temporary storage, so as to avoid the risk of further contamination.

- Great care should be taken to separate the species with a strong odour which may be transferred to other produce, and to avoid the mixtures of odours which may be unacceptable to the consumer, so that cauliflowers, for example, should be well-separated from strawberries, while citrus fruits which have been treated with diphenyl should also be segregated from other species.

• Shelf life

- Time spent on the shop shelf should be kept to a minimum, and this can be ensured by restocking the shelves several times a day, with reduced quantities on each occasion ;

- Unsold produce must be returned to the temporary storage room at the end of the day ;

- Produce sold under a label bearing a date of expiry of a guarantee of quality must be sold sufficiently short of the limit to be consumed before the date specified.

7 - DEFINITION AND DESCRIPTION OF CONTROL PROCEDURES

The production of fruit and vegetables of a measurable standard of gustatory quality is a voluntary activity, which relies on the acceptance of a common code of practice and a system of discipline which is accepted by the growers without any coercion.

But from the marketing point of view, the system of discipline must be extended to cover all the operators in the distribution circuit if the produce is to retain all its organoleptic properties until it is offered to the consumer. So the rules adopted by the growers must be supplemented by contractual arrangements between the professional market operators.

7.1 : CHECKS ON GROWERS, PRIOR TO THE ISSUE OF QUALITY LABELS

The controls which accompany the authorization to use a quality label must therefore be carried out at several levels.

7.11 : Organization of controls

Obviously, the first controls are carried out at the production end of the chain, either by the growers themselves, if only to make sure of the development of the characteristics of quality before the crop is harvested or, and this is more often the case, by a group of growers, through its officials. In that case the growers' organization is an authorizing agency, which certifies the standards of quality defined by the collective label, for which it is legally responsible.

If the produce is sold under an individual trade mark, it is obviously the firm itself which carries out the first check.

But as far as the consumer is concerned, the credibility of the guarantee of quality depends on the voluntary submission of the growers' organizations to validation of their control operations by outside and independent bodies.

These can operate at the despatching stage or at the level of the various operators along the chain of distribution, within the framework of contractual arrangements between the professional market operators.

Finally, at a higher level, to protect the consumer, the official services must ensure the validity of the controls carried out by both types of organization, by taking samples and otherwise keeping a check on their operations.

With that end in view, these operations must be verified by special committees within the organizations, whose function is to provide incontrovertible evidence that the controls have been carried out and the results are genuine. This entails the establishment of a certain number of obligatory registers in which the required information can be recorded.

It is therefore necessary to distinguish between the control operations carried out by the growers' organizations and those effected by the control board, to which must obviously be added the necessary intervention of the competent government services.

The growers' organization may delegate some of its work to the control board, on a contractual basis, especially at the despatching stage, thus streamlining the system.

This officialization of the controls carried out at the despatching stage should eliminate the need for frontier controls on guaranteed produce in transit within the European Community, thus serving to accelerate the distribution of produce that is rendered all the more fragile by the effort to guarantee maximum gustatory quality.

7.12 : Controls by the growers' organizations

The growers or their organizations must check the potential quality of their produce and make sure the minimum standards are complied with at the moment of despatch. They must also take the necessary steps to ensure their produce remains identifiable and to prevent fraud.

To do this, the growers' organizations must collect the relevant information concerning the conditions under which the produce has been grown, so as to make sure the code of practice has been respected, and they must provide the necessary facilities for checking the amounts of produce submitted for quality control.

. Control of conditions of production and storage

The growers' organizations must be able to call upon up-to-date information regarding the producers, the areas under cultivation and the conditions of production.

For that purpose, it must :

1°) Maintain a register or a numbered file of member growers, with a description of the environmental conditions and locations of each parcel of land ;

2°) Ensure the application of the technical regulations laid down in the code of practice, throughout the growing season, by periodical inspections of each parcel of land for which a grower's declaration has been made for the purpose of obtaining the label or collective mark. To facilitate this task, each grower must keep a register or record card for each parcel of land. In this document he sets down the details of work carried out in the course of the year, together with any relevant comments.

The list of members and the results of the periodical inspection are submitted to the technical committee appointed by the board of the growers' organization. Representatives of the competent authorities serve on this committee, side by side with growers nominated by the board, and the committee's proceedings are recorded in the official minutes of each meeting.

• Quality control

The produce grown on the parcels of land on which the conditions of production have been inspected and approved is tested for quality when it is harvested ; so the grower must declare the crop, state the exact quantities submitted for approval, and confirm his strict adherence to the code of practice. The grower's declaration is recorded and the quality of the produce is tested on a sample basis; the values of the main quality criteria are noted against the various quantities and a certificate can then be issued to the grower.

• Identification

After comparing the grower's declaration with the results of the various checks on the conditions of production and the quality of the produce, the technical committee or its agents can issue a certain number of certificates (Fr. "vignettes") or labels to the growers who apply for them, corresponding to the number of packages necessary for the tonnage declared by the applicant.

The issue of these certificates, which should preferably be numbered, is recorded in a special register, in which a note is also made of any certificates returned unused.

7.13 : Controls by independent organizations

The quality control operations carried out by the growers' organizations, or by individual growers, can be validated by their submission to spot checks, on a sample basis, by an outside organization.

This outside control can be based on a contractual agreement between the growers or their organization and an association established for this specific purpose. In France, for example, controls of this type are carried out by the "Qualité France" association and by "comités économiques de fruits et légumes".

The functions of these independent organizations may also include control operations at the level of the wholesalers who have received the produce covered by the mark or label providing the guarantee.

The control board's function are :

1°) To check the registers or record cards kept by the growers or their organization, and to check their control operations ;

2°) To ensure, by taking samples, that the quality of the produce at the moment of despatch is up to the standard require under the terms of the code of practice. An official report on the control operation is made on each separate occasion. But if the control boards has been instructed by the growers' organization to carry out its quality control operations at the moment of despatch, this operation is obviously no longer necessary.

3°) To ensure, by sampling the produce at various points in the chain of distribution, both at wholesale and retail level, that the produce is up to standard and that the interprofessional contractual agreements have been respected. An official record is kept.

4°) To receive and process any complaints which may be received, either from distributors or from consumers ; to carry out the necessary enquiries and to check the causes and justification of such complaints.

Complaints can be recorded in a special register, and the results of any investigations communicated to the growers' association to be dealt with, and possibly also to the authorities responsible for quality control, for information.

In short, the organization of controls requires the intervention of two types of organization :

. A growers' organization, responsible for controlling quality at the moment of despatch and possibly responsible for controlling the condition of production ;

The quality of the product is confirmed by a collective mark or a label, which may be supplemented by a printed description.

. A control board, to check the work of the growers' organization, which thus guarantees the validity of the growers' control operations. In certain cases the board may carry out control operations on behalf of the growers' organization at the time of despatch. It is also responsible for controls in the course of distribution and deals with any complaints.

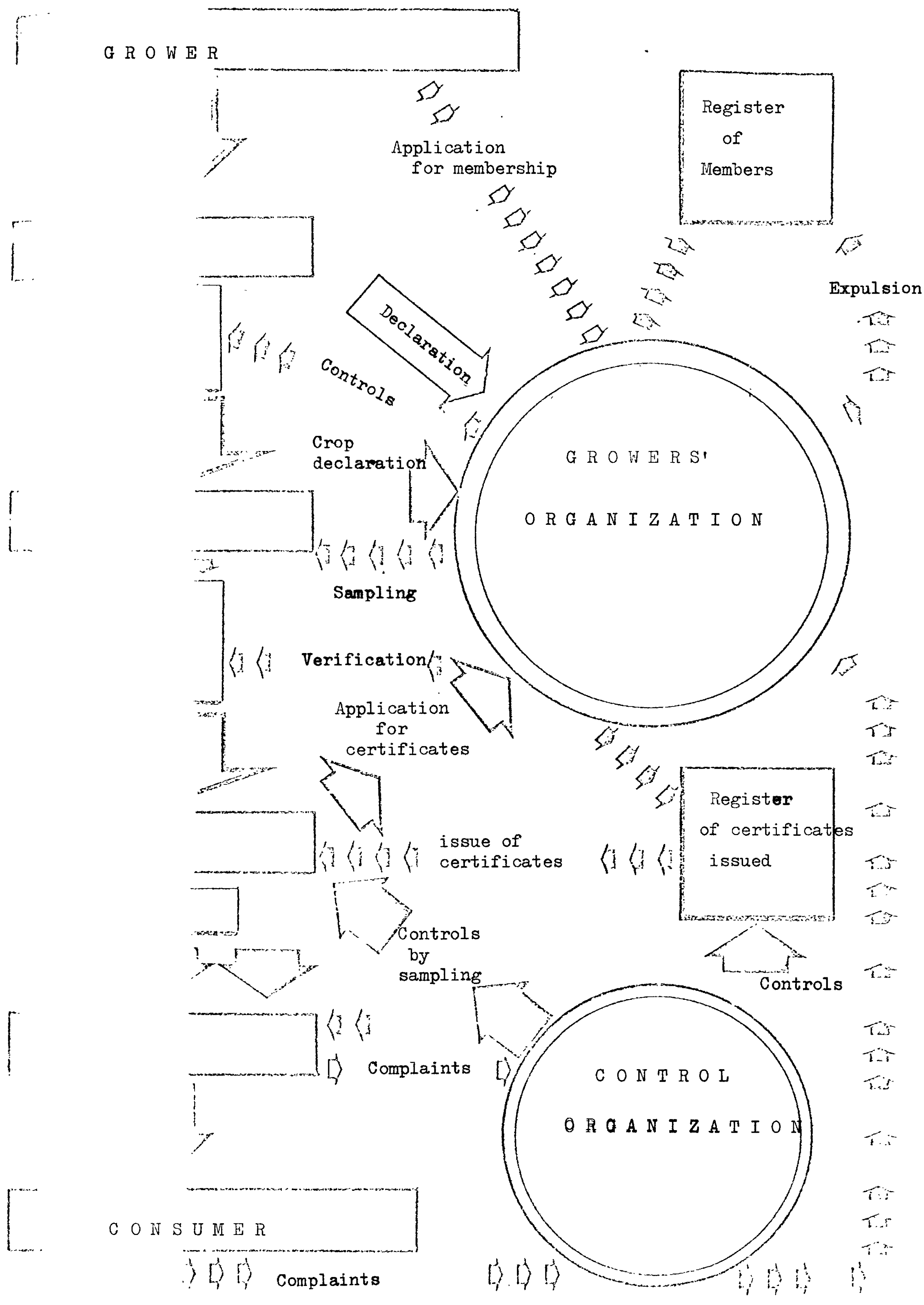
. The authentication of produce is ensured, between the point of despatch and the point of retail sale, by a certificate ("vignette") which is preferably numbered and which bears the mark or the label appearing on the outside of the individual package, for which the growers' organization is legally responsible.

Synoptic table of the main formalities involved in applying for a label of quality for horticultural produce

	Formalities to be completed		Official record or certificate
	By the individual grower	By the growers' organization	
1	Initial application for membership	Grant of membership after approval by general meeting	Register or membership file (kept by the growers' organization)
2	Declaration of crop	Control of conditions of production in the course of the crop year	Parcel record card (kept by the grower)
3	Declaration of outpat	Quality control (samples)	Control certificate (issued to the grower)
4	Application for certificates or labels	Verification of preceding controls and issue of certificates	Record of certificates issued (kept by the growers' organization)
		Formalities to be completed by the control board	
5	Despatch	Quality control before despatch (samples)	- List of consignees (kept by despatcher) - Formal report on each control operation
6		Quality control in the course of distribution	Formal report in each case
7		Receipt of complaints	Register of complaints

N.B. : The system can be simplified if formality No. 2 is made optional and formalities 3 and 4 are combined. If formality No. 3 is carried out by the control board prior to despatch, operation No. 5 is not needed.

ORGANIZATION OF CONTROLS



7-14 : Methods of quality control

The natural heterogeneity of fruit and vegetables is such that the methods of sampling and quality control must be strict enough to ensure, with a reasonable degree of certainty, that the produce is sufficiently uniform in quality to comply with the parameters set.

But the methods must be simple and rapdd, so that they can be applied without any difficulty in the normal course of commercial operations in the fruit and vegetables sector, in which time is at a premium.

. Sampling

The validity of the tests depends on the nature and rigour of the sampling procedures on which the measurements are based. To ensure the samples are sufficiently representative, the number of individual fruits or vegetables in the sample must be suitably related to the total numbers in the lot from which they are selected and to the probability of variation from the norm.

Control by sampling is necessarily carried out on produce which has already been graded or prepared for sale, and it therefore serves two purposes. On the one hand, it assesses the conformity of the lot to the minimum standards laid down in the regulations, which may be the existing Community standards or the special regulations which may apply to the selection of fruit and vegetables of guaranteed gustatory quality.

On the other hand, limited samples can be taken for the purpose of carrying out the destructive tests of quality.

To test conformity with the standards, random samples must be taken from a number of packages related to the size of the lot.

A certain number of fruits or vegetables are taken from each package, to make up a limited sample which is submitted for measurement and analysis.

For that purpose, it is often necessary to extract the juice from fruit and from certain vegetables. In view of the number of units making up the limited sample, the juice can be extracted by a simplified procedure, from a fraction of each unit, by cutting two opposite sectors in the same vertical plane including, where appropriate, the most highly coloured part of the fruit or vegetable (see p. 57). In the case of large fruits, such as melons, the samples can be taken by extracting two cylinders of flesh from opposite sides of the fruit, at the level of its equator.

The juice can be extracted by means of a domestic separator and rapidly filtered, if necessary, on paper or nylon gauze. If the measurements or analyses cannot be carried out immediately, the juice can be preserved by immediate freezing to $-18^{\circ}C$.

Checks on conformity with the grading regulations

These controls are intended to ensure that the common quality standards or the special quality standards set by the growers' organization meet the minimum requirements. So they mainly concern :

- the grade assigned to the produce under the grading system ;
- average weight or average size, within the limits of the authorized tolerance ;
- the presence of defects and the appearance of the produce (form and development) ;
- the colour of the produce, to be assessed for uniformity but also, in the case of products selected for superior quality for its intensity.

All these controls are nothing new, and no special prescriptions are needed. For measuring colour, it may be possible to use the colorimetric scales available for each species and variety.

. Tests of gustatory quality

When the parameters of gustatory quality have been defined, the restricted samples selected according to the procedures described in the preceding paragraph must be analysed for compliance with the minimum standards. This involves four simple measurements : ripeness (on the basis or firmness), sugars, dry matter or acidity.

- The tests of ripeness are carried out with a manual penetrometer or with mechanical apparatus based on the transmission of vibrations or light through the fruit.

When firmness is measured with a penetrometer, the head of the plunger should be of the standard size for models graduated in English pounds or in kilos, i.e. 0.5 cm^2. To ensure the comparability of the results, all the penetrometer readings must be made by the same person. Before the measurement is taken, a patch of skin is removed from the fruit at the intended point of application of the penetrometer. If only one measurement is made per fruit, it is made at the equatorial level, in the least highly coloured zone, so as to obtain sufficiently constant results.

- Measurement of sugars is most easily carried out with a hand refractometer, using a drop of juice from the restricted sample (which must first be shaken).

Two readings must be taken, and possibly more if the first two results do not agree. After correction for temperature, the result is most often expressed as the refractive index, which is more or less the same as the percentage of soluble dry matter contained in the juice. If a conversion table is available (e.g. apples, grapes), the result can be expressed in grammes of sugar per litre.

- Total dry matter can be measured to evaluate starch content of potatoes, and this can be done very rapidly with special apparatus for measuring the specific gravity of the tubers.

- The acidity of fruit can be measured by neutralizing 10 cm^3 of juice with a solution of sodium hydroxide. $\frac{N}{10}$ solutions are used, and the results for the various species can be expressed in miliequivalents or in grammes per litre (see pp. 65 and 66).

In order to work out certain indices, such as the sugar/acid ration, it is necessary to express the two values in comparable units, in % or in ‰ (see p. 67).

The following tables contain a summary of the different proposals put forward in this report for controls of conformity and of gustatory quality applicable to the various species of fruit and vegetables.

MAIN CONTROLS OF THE QUALITY OF FRUIT TO BE CARRIED OUT AT THE DESPATCHING STAGE

FRUIT	Controls of conformity				Parameters of gustatory quality			Main storage risks
	Classification and packaging	Size or average weight	Shape and development	Colouring	Maturity	Sugars	Acidity	
APRICOT	"Extra" 1 or 2 layers	Min. = 30 mm Uniformity $\pm$ 25 mm	Typical shape	Intensity Orange-yellow on more than 1/2 the skin Uniformity	Colour of epidermis	RI $>$ 12-14 depending on organoleptic grade	Ratio RI/A meq % $>$0.5	Monilia Browning around the stone, cottony flesh
CHERRY	"Extra" Loose	Min. = 20 mm Uniformity under 10% $<$ 20 mm $>$17 mm	Av. weight $>$ 680 g for 100 fr. Typical shape	Uniform bright red	Colour, no pale patches and no dark red	RI $>$ 15 early var. $>$ 18 late var.	Not necessary for Bigarreaux	Monilia Botrytis Dry stalk
PEACH	"Extra" I or II Single layer	Min. 56 mm before 10/07 62 mm after 10/07 Uniformity $\pm$ 3 mm	Axial/equatorial ratio - 1	Typical red blush	Penetrometer Yellow fl. $\leq$ 2 kg white fl. $\leq$ 1.5 kg	RI $>$ 10 early var. $>$ 11 late var.	Ratio 10 RI/A meq ‰ $>$ 0.95	Monilia Internal browning Cottony flesh
PEAR	"Extra" I or II Single layer	Min. = 60 mm Uniformity $\pm$ 5 mm	Typical shape Eye cavity broad and deep	Typical intensity Presence of anthocyanins Uniformity	Penetrometer reading on despatch = 2-3 kg depending on var. and transit time	RI $>$ 10 summer var. $>$ 13 autumn var. $>$ 14 late var.	Ratio 10 RI/A mal. between 50 and 100	Fungal diseases Internal browning Scald Wilt
APPLE	"Extra" I or II Layers or loose	Min. = 65 mm Uniformity $\pm$ 5 mm	Typical shape Eye cavity broad and deep Axial/equatorial ratio between 0.93 and 1 for Golden	Typical in tensity Presence of anthocyanins Uniformity	Skin colour Penetrometer reading between 3.5 kg and 4 kg	RI $>$ 13 Index TS+10 A for Golden $>$180 after harv. $>$155 after 6 m.	A g/1 $>$4.5 on harvesting $>$3 after 6 mths	Fungal diseases Internal Browning Scald Bitter pit Wilt

MAIN CONTROLS OF THE QUALITY OF VEGETABLES TO BE CARRIED OUT AT THE DESPATCHING STAGE

VEGETABLES	Controls of conformity				Parameters of Gustatory Quality		Main storage risks
	Classification and packaging	Size or average weight	Form and development	Colour	Sugars or dry matter	Acidity	
CARROT	"Extra" or I Loose	Min. = 20 mm or 50 g Max. = 40 mm or 150 g Uniformity : max. tol. 20 mm or 100 g	Typical form Straight, regular Heart tender Heart/total diameter ratio $\leqslant$ 0.33	Light red Green or purple collar on 1st max.	RI $\geqslant$ 10	Ratio RI/A meq % $\geqslant$ 10	Cracks Wilt Rotting
MELON (Cantaloup) Var. : Charentais	No EEC norm Single layer	Min. = 450 g Uniformity max. tol. 150 g	Regular spherical shape or slightly flattened	Typical and well developed	RI $\geqslant$ 12	-	Anthracnose Cladosporiose Wilt
POTATO	No EEC norm Loose	Min. = 35 mm Max. = 70 mm Uniformity max. tol. 20 mm	Typical regular shape, smooth, not cut	Typical Absence of green or blackening	Dry matter $\leqslant$ 18 %	-	Frost-sprouting Common gall Mildew Rots Wilt
SALAD VEGETABLES	Cl. I Arranged	Min. : Lettuce 350 g Curled-leaved endive 400g Broad-leaved endive 800 g Max.tol. : Lettuce and Curled-leaved endive 100g Broad-leaved endive 150 g	Lettuce : tight round head Broad-leaved endive: flattened shape Height/diameter ratio 0.4	Lettuce : light green Endives : central part (at least 1/3 of plant) yellow	-	-	Botrytis Bremia Wilt
TOMATO	"Extra" or I 1 or 2 layers	Min. = 40 mm Max.=80 mm Uniformity	Typical regular shape	Turning to red on 1/3-1/5 of the fruit depending on temperature	RI > 7	A meq.% $\geqslant$ 10 Ratio RI/Ameq% $\geqslant$ 0.5	Mildew Alternaria

7.2 : INTERPROFESSIONAL AGREEMENTS TO PRESERVE THE QUALITY AND IDENTITY OF PRODUCE IN THE COURSE OF TRANSIT AND DISTRIBUTION

Although the guarantee of quality is most often provided at the start of the process of distribution, by a growers' organization, the main beneficiary is the consumer. It is therefore necessary to ensure the preservation of the potential quality of the product and to state the limits of the guarantee. Of course, the conditions of the guarantee can simply be included in the invoice addressed to the despatching or distributing wholesalers, and in that case the growers' organization has absolutely no say in their conditions of sale.

It would therefore seem preferable for the producer groups to seek out wholesalers who are themselves interested in promoting the sale of produce of guaranteed quality, who will thus be more ready and able to organize publicity at the points of sale by ensuring the distribution of material provided by the growers' organizations.

The exact scope of these contractual arrangements will be decided after discussion, with due regard for the commercial objectives in each case. The different points which might be covered by such agreements are listed in the following paragraphs.

7.21 : Agreements which can be signed by the growers' organizations

The organization granting the guarantee, especially if it is a growers' organization, must first provide the distributors with a precise and formal definition of the quality guaranteed. Generally speaking, that is the very purpose of the technical regulations of these organizations. The conditions of the guarantee may also include an indication of minimum quantities and a despatching schedule.

The conditions of packing must also be formally defined, especially when the product is pre-packed, or standardized for a given type of commodity or a specific group of distributors.

7.22 : Undertakings which can be signed by the distributors

Besides protecting the produce, these agreements also cover such aspects as presentation and the prohibition of sale beyond a certain date.

. Special handling procedures may be imposed for the most sensitive produce, and containerization may be mandatory.

. Conditions of storage, i.e. premises, duration, temperatures and levels of moisture may also be specified when the produce is particularly fragile (see para. 6.2).

. In the majority of cases, the maximum shelf-life should be specified, to allow for deterioration through over-ripeness or wilting. In the case of fruit which needs to be after-ripened, it may be necessary to stipulate a minimum and a maximum period, so as to make sure the produce reaches the consumer when it is exactly eating-ripe.

. The conditions of display and the rate of restocking of the shelves can also be prescribed, to avoid the piling up of produce and the inadequate replenishment of the shelves in the course of the day.

. The agreements must obviously cover the conditions of publicity at the point of sale and provide for the distribution of appropriate material supplied by the growers' organization.

. The distributors must also undertake, in every case, to accept the inspections and controls carried out by the guarantor's appointed agents.

7.23 : Methods of establishing prices

An interprofessional contractual agreement relating to defined qualities and quantities, and possibly to specific dates of delivery must necessarily include provisions relating to the methods of establishing prices.

Because the produce is to be separated from the mass, three possible solutions may be envisaged :

. A firm and definitive price for the entire period covered by the contract. The formula is simple but inflexible, and can only apply to deliveries which are spread over a sufficiently short period.

. A basic price, with provision for variation over time. This basic price is a minimum fixed for the first deliveries at the beginning of the season, payable for produce that is either supplied unpacked or packed according to agreed specifications, with provision for fixed percentage increases at fixed intervals of delivery, or the price can be tied to one of the official indices of the cost of living, and especially to those relating to the cost of labour and raw materials as required for the packing operations.

. A reference price based on the prices quoted in the "reference markets" of the European Community, or on some other official quotation. A fixed margin is added to the reference price as laid down in the contract, to allow for the guaranteed quality of the produce.

The difference between the two systems is that the basic price is fixed and the supplementary amount is variable over time, whereas the reference price is mobile and indexed to an official quotation and the margin, by contract, is fixed.

Thus, the basic price can only follow an upward trend over the season, whereas the reference price can move up or down in sympathy with the trend of market prices.

It is also possible to envisage various types of mixed arrangements, such as the "fifty/fifty" system (fr. "compte à demis), which provides for part of the price to be fixed and part to be variable according to the official quotations. Under such a system, the positive and negative differences are shared between the two interprofessional parties.

Finally, as far as the problems of price are concerned, the growers' organizations may possibly ask for a ceiling to be fixed on the distributors' margins, so as to preclude the risk of speculation in their produce, which would harm their image and jeopardize future sales.

7.24 : Settlement of disputes.

In spite of all the precautions that are taken, fruit and vegetables are so perishable that disputes often arise between sellers and buyers, in conditions in which the two parties cannot confront each other in the presence of the produce in dispute. So there is a need for interprofessional aggreements as to the machinery for settling such disputes, possibly naming the independent organizations empowered to carry out expert examinations or act as arbitrators.

8 - METHODS OF PUBLICITY AND INFORMATION

The novel idea of defining the quality of fruit and vegetables in terms of measurable organoleptic quality is opposed by the market's reluctance to adopt new methods of grading. Publicity and information must therefore be aimed at every link in the chain of distribution, but especially at the commercial growers at the start of the chain and the consumers at the other end.

It is in fact highly important to create a strong specific demand for produce of guaranteed quality, both by informing the consumers and by providing the interested growers with the technical information they need if they are to grow produce of a standard which will satisfy this demand.

One cannot overemphasize the importance of coordinating these two activities. Any publicity which is aimed solely at the growers will only gain them a very marginal advantage, because very little information will filter through to the consumers at the other end of the chain of distribution. In the same way any publicity that was aimed solely at the consumer would rapidly lead to disappointment if the growers were not able to cope with the resulting increase in demand.

8.1 : INFORMING THE CONSUMER

Consumer-orientated publicity must serve a double purpose :

- to create a genuine market in produce of measured organoleptic quality, by showing the consumers how they can benefit from the application of objective methods of selection ;

- to combat the harmful effects on the market of misleading information and received ideas, so as to remove the over-subjective elements from consumer behaviour.

8.11 : Suitable media

- On-the-spot publicity, particularly in the form of posters or promotion campaigns which may require the services of a specialist, are often used to bring a new product to the notice of the public or to expand the sales of products already on the market. The technique is quite effective at the point of application and can give good results in the promotion of top quality produce if it is not used alone and if it serves as a backing to some more general form of publicity.

- Articles in the press, and especially in the trade press or weeklies, can provide an important part of this more general publicity, because the subject can be treated in greater depth than is possible in a simple publicity campaign ; but such articles must be presented with a certain degree of objectivity, with no hint of commercial advertising ; so they can only emanate from collective organizations or official agencies.

The daily press can also be used as a support. The cost of the campaign, which may either have a general theme or be geared to the promotion of a single mark, will obviously depend on the scale of the publicity and the circulation of the newspapers chosen for the purpose.

- Television is without any doubt the most effective means of attracting the consumers' attention to a specific product or to a new organization promoting fruit and vegetables of guaranteed quality.

A TV campaign is most effective when it is backed by articles in the press and by publicity at the point of sale ; but the combination of these three techniques for informing the consumer is extremely expensive and can only be envisaged by very large commercial undertakings which can cope with the increased demand resulting from such a campaign. But television appears to be the only means of achieving a rapid psychological breakthrough, vis-à-vis the consumers, and of creating a genuine market for fruit and vegetables of guaranteed quality at a national or European level. Such publicity is so expensive that it can only be envisaged at the level of a national or indeed international label or collective trade mark.

In addition, television involves all the operators in the fruit and vegetable market, in both types of circuit, traditional and modern ; so it depends on large-scale collaboration prior to the launching of such a programme of information.

- Agricultural shows and food fairs are a traditional means of popularizing produce of recognized quality. They mainly publicize products that are closely identified with a specific zone of production (Fr. "terroir"), which often has only a limited output ; so they are an appropriate form of publicity for the craftsmen who operate on a relatively small scale. They make a far from negligible contribution to the consumers' knowledge of certain products ; but they will not suffice without other backing to create a specific market for the produce in question. They also serve as a very useful meeting-place for the wholesalers and the growers' organizations ; but the relevant information will never reach the consumers if the distributors themselves are not interested.

8.12 : The elements of information

The action taken to inform the consumers should take full account of all the aspects of quality. The attraction exercized by produce of guaranteed gustatory quality can be attributed to the nutritional and dietary qualities of this class of produce ; it therefore seems important not to separate the two aspects and indeed to base any campaign precisely on the theme of this link which exists between the various aspects of quality.

. Organoleptic properties

In this context, it is important to emphasize the connection between external appearance and flavour, by showing that beauty can be more than skin-deep. The limitations of visual appreciation should be pointed out, so as to highlight the advantages of the objective standards of quality which can be applied by the growers' organisations.

It is important to stress the concept of ripeness, by demonstrating the connection between this stage of acceptable maturity and the formation of aroma when the flesh acquires an agreeable texture.

. Health-giving quality must not be forgotten in a campaign of this sort, because it must be shown that produce selected for its organoleptic quality is also imbued with optimum nutritional quality.

This aspect of publicity must exploit the symbolic aspects of the consumption of fresh fruit and vegetables, as well as the consumers' knowledge of nutrition and rational dieting.

The importance of the links between the various types of quality can be brought home to the consumer not only by pointing out the scientifically demonstrable correlations but also by adducing the growers' motives in opting for quality rather than quantity. For that purpose, the grower must obviously keep a sharp eye on all the intrinsic qualities of his crop. This type of publicity must expose the incoherence of certain received ideas and especially the entirely erroneous notion that it is difficult to find produce that looks attractive, has an acceptable flavour and is not harmful to health.

8.2: HOW TO APPROACH THE GROWERS AND DISTRIBUTORS

If the effort to popularize the product among the consumers is not to be wasted, the methods of selecting produce on the basis of organoleptic quality must also be popularized among the mass of growers and distributors, so as to prevent the middlemen from stifling the contact between the growers and the consumers.

8.21: Sensitizing the growers

Obviously, the growers must be the main target of the campaign of popularization, which must be aimed at three objectives in particular:

- to familiarize the growers with the tests and objective standards used in assessing the organoleptic quality of fruit and vegetables, and with the simple methods by which they are applied. It must be brought home to the growers that these methods are easy to understand and do not require any specialized knowledge beyond the mental grasp of any horticulturalist who has received a normal education.

- to define the most suitable techniques for attaining the minimum commercial standards set by the growers. These standards are formulated either by the growers' organization or by the individual grower if he is attempting to promote a personal mark of quality.

Some of these techniques are already well-known, either from experience or from the results of recent experiments and they can now be made available to individual growers in a detailed form which can be adapted to the micro-climate of each holding. But there are still many gaps in the available knowledge, so that the campaign of popularization will succeed only if it is accompanied by a comprehensive programme of experiments embracing not only the whole range of factors of production but also the techniques of storage, packing and transport.

- to promote the application of these techniques and test procedures, by providing technical assistance for groups of producers wishing to specialize in the production and selection of fruit and vegetables on the basis of their organoleptic quality.

The methods to be employed would not be strikingly different from those that have long been used for the dissemination of information in the agricultural sector.

. Articles in the specialized journals must be a source of precise and basic information and must also serve, in a general way, to sensitize the growers and prompt them to examine the possibilities of setting up specialized groups.

. Additional impetus can be given by one-day conferences, when there are signs of positive interest in the production of quality produce. They serve to attract other growers to the nucleus formed by those initially sensitized to the issues involved, and they are a useful channel for the dissemination of information, especially when supporting literature can be distributed to the participants.

. Personalized information for the technicians employed by the growers' organization and their advertizing agents, in the form of specialized documentation and special courses, is an indispensable adjunct to the more general activities outlined above. It is only by sending out detailed information to those who are most directly concerned that one can provoke the feedback of personal comments which must lead to a better understanding of the problems involved.

In short, it would be perfectly feasible to embark on such a programme of familiarization, based on the existing corpus of knowledge about the various factors which govern the intrinsic quality of fruit and vegetables, and it seems clear that the implementation of such a programme is the only way of spreading this knowledge which will make it possible to detect the multitude of practical problems which may arise as a result of the application of the recommended techniques.

There is in fact a threshold beyond which scientific knowledge cannot pass without the feedback provided by the application of principles in extensive practice.

8.22: Informing the distributors

The effort to familiarize the distributors with intrinsic quality should accompany the effort to sensitize the growers, to enable the middlemen to act as a more positive link, as far as the preservation of quality is concerned, between the producer and the consumer.

The main aim should be to inform the distributors about the tests and parameters of appreciation that are used in the selection of fruit and vegetables on the basis of gustatory quality, so as to establish the common language of the interprofessional dialogue. They should also be familiarized with the entire range of precautions to be taken to preserve quality until the produce reaches the end of the chain of distribution, the sine qua non for the success of any venture in the direction of selling horticultural produce under any sort of label or guarantee.

There is an overlap between the approach to the consumers and the approach to the distributors, who must be able to meet the extra demand resulting from the information thus disseminated. But like the growers, the entire wholesaler/retailer nexus can be sensitized by articles in the trade press and in the newspapers which publish the official prices, as well as by one-day courses.

The growers' organizations can also contribute, in the course of their normal search for outlets, by providing the distributors with suitable material for the promotion of top quality produce.

In short, the campaign to popularize organoleptic quality must be extremely thorough, waged on several fronts and suitably adapted for the various sections of the professional circuit and the final consumers, the aim being to create an immediate wave of interest in the effort to grow produce of guaranteed quality, so that the differentiation of prices on the basis of real and measurable quality can lead to the development of a genuine specialized market. Only the existence of such a market will induce the growers to be more quality-conscious in their methods of production.

9 - SUMMARY AND CONCLUSIONS
RECOMMENDATIONS FOR COMMUNITY ACTION

Over the past few years there has clearly been a new trend in consumer attitudes to fresh fruit and vegetables. In the 20 years following the second World War, the demand for these commodities rose in volume terms; but it has been clear for some time that supplies are more than adequate for the satisfaction of essential needs, and that quality is now the key factor in a phase of market development in which concern for gustatory quality is allied with sounder knowledge of nutrition and increased concern for the preservation of health, so that the term "quality" has now become a very generalized concept.

Past failure of the growers and traders in fruit and vegetables to pay equal attention to the various aspects of quality

The concept of quality in fresh fruit and vegetables results from a whole series of impressions involving the gastronomic sensations, the satisfaction of a need for nutrition, and various cultural motives which are often of a symbolic nature.

But if they are to remain sufficiently fresh to attract the consumer, fruit and vegetables must be imbued with a whole series of commercial qualities which are closely related with external appearance.

The commercial qualities are defined in the common quality standards of the EEC, and by different sets of commercial customs, and they have unfortunately come to dominate the grading system for fresh fruit and vegetables. This has led to the selection of varieties mainly on the basis of their ability to withstand transport, and has also encouraged the growers to pick their crops before they attain optimum ripeness, thus reducing their intrinsic quality, while at the same time the maximization of yields has become the main criterion of profitability.

Hence a certain measure of consumer disappointment, which is one of the reasons for the downtrend in the consumption of fresh fruit and certain fresh vegetables recorded over the past few years.

. The dietetic quality of fruit and vegetables is partly a matter of nutritional quality, which mainly depends on the presence of sugars, acids and vitamins; but quality-conscious consumers are also increasingly concerned about the possible presence of toxic pesticide residues.

. Organoleptic quality is itself derived from a number of sensory perceptions, involving the integration of tactile impressions of the structure and texture of the flesh, gustatory sensations derived from the perception of the sweet and sour components, and olfactory sensations which are mainly perceived when the volatile constituents of the aroma are released, when the product is eaten.

The consumers' expectations, as far as quality is concerned, are therefore wrapped up in a global concept embrasing a fairly wide range of factors to which the growers and the professional operators have not always given balanced attention.

It seems the consumer will no longer be satisfied by the quality standards that are currently applied, either in the Community regulations or by hallowed commercial custom, which are only concerned with ability to withstand the hazards of transportation and distribution.

In a situation which seems on the surface to result more from the interplay of subjective and psychological factors than from any concern for rationalization, the consumers may well continue to be disappointed in their expectations if doubt is allowed to persist as to the possibility of fixing a certain number of simple parameters for defining the intrinsic quality of horticultural produce in general and its organoleptic quality in particular.

Objective parameters of gustatory quality have already been worked out for the main species of fruit and vegetables.

Various methods of sensory analysis can be used for measuring the relative contribution of the main constituents of fruit and vegetables to the consumer's global appreciation of the product.

Appreciation of firmness and flesh texture depends mainly on the enzymatic evolution of the product, in which the components of the cell walls are transformed into soluble pectins. Texture can be measured objectively in a number of ways. In practice, these individual measurements are made with a penetrometer, but there are prospects of mechanizing this operation by the use of electronic sorting systems based on the measurement of light or vibrations passed through the product.

The main biochemical components of flavour are the sugars, which can be measured with a refractometer, and the organic acids which can be analyzed either by neutralization with a soda solution or by evaluation of the pH. The main acids present in fruit and vegetables are citric and malic. They are not perceived with the same degree of intensity, and they are not equally persistent in the mouth.

In the course of development and ripening, the sugars increase and acidity diminishes. So the sugar/acid ratio is the first basic test of flavour. But for a given value of the ratio, the value of the two terms can be very different, because they tend to develop in parallel on a specific plot or from one year to the next. Hence the adoption, for certain fruits such as apples, of the concept of the sum of sugars + acidity which can constitute a more progressive criterion of quality than the relationship between the two.

The volatile substances i.e. the constituents of aroma, are generally formed very late in the life of the fruit, during the phase of biochemical change which constitutes the ripening process. The qualitative and quantitative analysis of some of these substances can be carried out by gas chromatography. The use of such apparatus is still very limited, but it could quite rapidly become standard practice as simplified portable equipment becomes available.

The material in this report is based on a number of studies carried out in the main European countries, and especially in Belgium, France, Italy the Netherlands and Switzerland.

Research into the correlation between the opinions of consumers in these countries and the scientific measurements and analyses of the same samples has made it possible to define a number of parameters for the assessment of quality. They can be subdivided into two main groups : on the one hand there are non-destructive tests which can be applied to commercial lots on an unlimited scale, and on the other hand, there are a number of destructive tests requiring the selection of a representative sample from the lot.

The non-destructive tests are essential for ensuring the uniformity of the lots when marketed, but they cannot be used for any other purpose, because the values observed can be modified by a large number of external factors. They measure the colour of the skin and the shape of fruit and vegetables. Colour is measured in terms of area and intensity, and especially in terms of yellow and red pigmentation, the development of which is linked with the biochemical changes of the ripening process. Shape, which is mainly expressed in terms of the axial/equatorial ratio of fruit and certain vegetables, can provide an indication of more or less balanced development.

The analytical tests, which are necessarily destructive can only be carried out on samples of a size and nature which guarantee the representativeness of that sample vis-a-vis the lot. The measurements are generally made on the juice extracted from the sample, and in order to avoid processing over-large quantities, the juice is extracted only from part of each unit in the sample, in the form of a vertical section from the most highly coloured and least highly coloured sides of the fruit.

The results of the analytical tests are first expressed in simple indices such as the refractive index which records the percentage of soluble dry extract and closely corresponds, in most fruit and vegetables, with the percentage of total sugar. Acidity is also often measured ; it is expressed in milliequivalents or in grammes of dominant acid, such as malic acid or citric acid.

But use is also made of complex indices such as the sugar/acid ration, the sum of these two values or their difference. Individual values can already be recommended for these indices, corresponding to a satisfactory standard of organoleptic quality.

Admittedly, many of these tests are somewhat incomplete, in view of the differences between species, varieties and cultural environments. In addition to this, the minimum requirements may vary according to the category of consumer. But the only way to fill in the gaps is to put the initial results to the test. It will thus be easier, as a result of the application of rationalized systems of measurement, to discern the real wishes of the consumers, depending on their standard of living and their eating habits.

At presents, the consumers' wishes can only be perceived indirectly, through the interpretation that is placed upon them by the operators in the chain of distribution who are not, one fears, in the best position for defining these preferences with sufficient precision and may even be inclined to over-emphasize those aspects which are most likely to facilitate the accomplishment of their own specific function.

Currently applicable techniques for growing produce of guaranteed quality

In spite of the gaps which still exist in our scientific knowledge of the extent to which quality is influenced by the various factors of fruit and vegetable production, it is already possible to define a certain number of techniques with sufficient precision for their adoption in everyday practice.

The potential quality of a fruit or vegetable at the moment of despatch depends mainly on the varietal characteristics of the plant, its adaptation to the cultural environment, and harvesting at an optimum stage of the ripening process.

The influence of the cultural environment is revealed in the synthesized products whose metabolization is the origin of the whole range of biochemical components of quality. The intensity of solar radiation, the extent to which it can be absorbed by the plant, the regularity of the supply of water and the ambient temperature are all factors which can be crucial in determining the quality of the produce through their influence on the photosynthetic balance. Light is required by the entire plant, and particularly by the fruits ; so planting densities and methods of training such as the pruning and thinning of fruit trees are of vital importance.

The nutritional factors which are often blamed for reducing the quality of horticultural produce play a fairly modest role when the normal nutritional requirements of the tree are satisfied. Excess nitrogen may lead to the impairment of quality in fruit, but potassium certainly plays a very important balancing role. No harm is done by irrigation, unless it is excessive or irregular, and it seems indeed that judicious satisfaction of the evaporation/transpiration requirements of the plant will normally contribute to the development of optimum quality.

But it is impossible to over-emphasize the importance of harvesting the produce at the optimum date, to allow the full expression of all its potential quality, as determined by the environmental conditions and the cultural techniques applied to the plant. For certain species of fruit, in particular, the optimum harvesting period is extremely short, and it can be identified by the application of exact scientific tests.

On harvesting, the product can be said to be endowed with a clearly defined potential quality. But the realization of this potential may depend on the provision of suitable conditions for the after-ripening process. In any case, the potential referred to must be preserved by appropriate storage conditions and by precautions at the packing stage to avoid the deterioration of the product in the course of transport and subsequent distribution.

The application of the recommended techniques for growing fruit and vegetables of guaranteed quality can affect production, the conditions of distribution, and the ecological environment.

As far as output is concerned the most direct consequence is the stabilization of total yields at a reasonable level, to ensure a balance between the plant's capacity to synthesize sugar and the volume of the crop. The stabilization of yields adds to unit costs of production, which are further swollen.

by the cost of the special techniques for growing fruit and vegetables of guaranteed quality and especially by the cost of additional labour. A global calculation, based on a certain number of examples, has shown that costs of quality production are 16 % higher than those incurred under average cultural conditions. At the same time, the costs of production of crops grown for maximum yields may be 20 % below the same average.

It is therefore clear that any policy aimed at the promotion of quality must ensure a 16 - 35 % increase in growers' selling prices if it is to attract their support.

From the marketing point of view, the improvement of quality will render the produce more fragile in the course of transit and possible storage. But it should be possible to harness the improved techniques of transport and storage which have been developed in recent years (and which have mainly been exploited to enlarge the delivery area) for the benefit of top quality produce.

The same comments apply to the overlong storage of refrigerated products, which tends to impair their quality. It should be possible, by a process of varietal diversification, to harmonize the period of storage with the requirements of quality.

The presentation of fresh fruit and vegetables is subject to various grading regulations, some of which are quite compatible with the concept of selection on the basis of intrinsic quality, and can thus be justified because they correspond with the visual criteria of selection; but others would appear to be quite incompatible with the abovementioned concept, and serve to penalize top quality produce because notwithstanding their total irrelevence as far as intrinsic quality is concerned, they nevertheless entail the downgrading of the produce.

This applies in particular to certain healed skin lesions, which may be caused by climatic conditions (e.g. the russeting of Golden Delicious apples ; marks left by hail) or by various pests (e.g. when the intensity of the plant protection programme is reduced). It therefore seems desirable to amend the norms by extending the tolerances for this type of defect in the case of produce covered by a guarantee of gustatory quality.

The ecological consequences are of crucial importance for the future of horticultural production. In addition to their direct effect on human nutrition, via the close link which can be observed, in the majority of cases, between the biochemical characteristics which form the basis of any assessment of organoleptic quality and the nutritional quality of fruit and vegetables, the recommended techniques also contribute indirectly to the preservation of the environment by fostering the harmonious and balanced development of the plant. It can also be said that growers who decide to concentrate on the production of fruit and vegetables which are distinguishable from the mass will become increasingly aware of the ecological consequences of their activities and of their responsibilities vis-à-vis the human species and the entire natural environment.

Practical recommendations for growing fruit and vegetables attaining a measurable standard of gustatory quality are included, by way of example, in Annex 1, and these could well serve as a basis for drafting codes of practice for the production and preservation of quality produce.

The marketing of fruit and vegetables of guaranteed quality raises special problems of identification and presentation.

From the legal point of view, the growers and despatchers can protect the identity of their produce in a number of ways ; these legal safeguards can be classified according to the severity of selection.

The trade mark appears to be the best support for staple products selected to provide an "average" level of quality resulting from the elimination of all that is sub-standard.

The label or the collective trade mark may be preferred, however, when the product can be linked with a specific origin or with a specific cultural technique which is subject to special rules. But the volume of output must be large enough to meet a substantial demand.

The designation of origin, which is rarely used for fresh fruit and vegetables, can only be attached to high quality produce of which the value is closely bound up with a strictly limited growing area, and this obviously limits the volume of output.

In practice, identification can be ensured by the choice of a specific type of packaging, bearing a label on which the quality may be stated in addition to the particulars which are obligatory under the European grading regulations. But however exact the labelling of the package may be, there is still the problem of informing the consumer on whom it cannot have any direct impact failing the adoption of a system of pre-packing in retail sales units or the individual labelling of every single fruit or vegetable.

Pre-packing would seem to be particularly suitable for top quality fruit and vegetables, especially for the integrated retailers and supermarkets, by virtue of its similarity to the methods adopted for the distribution of industrial products. But, the traditional packing arrangements are still quite suitable for the channels of distribution which pass through specialist retailers, most of whom enjoy the full confidence, as far as quality is concerned, of even the most demanding consumers.

Examples of recommended packing techniques and methods of transport and distribution designed to protect the quality of horticultural produce may be found in the annexes to this report.

The practical methods of control must ensure that the guarantee of quality applies to the entire chain of distribution

The implementation of a system of informative identification, and especially the use of a label, collective mark or designation of origin, must be based on the application of a whole range of controls to provide the consumer with a guarantee of clearly defined quality characteristics.

In practice, these controls require the intervention of two independent organizations :

- a growers' organization, which guarantees the quality of the product and affixes the distinctive mark or label after carrying out the necessary controls at the time of despatch and perhaps at an earlier stage, when the crop is growing ;

- a control board, which keeps a check on the activities of the organization providing the guarantee, carries out quality control operations at various points in the chain of distribution, and also receives and processes any complaints.

The activities of these two organizations must obviously be subject to the overall control of the competent official services, within the general framework of legislation relating to consumer protection.

Specific methods of control have been suggested, with particular emphasis on the techniques to be adopted for sampling fruit and vegetables, which must allow for the natural heterogeneity of these commodities.

In short, because the final quality of the product depends on the conditions under which it is marketed, the various professional operators must take special care of its preservation throughout the process of distribution. With that end in view, it is suggested that the quality and identity of horticultural produce can best be protected during transport and distribution by the interprofessional contractual agreements proposed in this report.

The methods of popularization and dissemination of information must be on a sufficient scale to create a specific market for fruit and vegetables of guaranteed quality.

The implementation of a policy of marketing fruit and vegetables of guaranteed quality is an entirely new approach, and its adoption could be held back by the weight of acquired habits. In fact, in spite of the determination of certain producers or commercial operators to expand the market in this type of produce, it will not be possible to develop any major movement in the desired direction, accompanied by an adequate price differential, without the creation of a substantial and specific consumer demand.

The activities intended to popularize the recommended techniques among the growers and distributors must be supported by a campaign to sensitize the consumer, and maximum use must be made of audiovisual media, especially the press and TV, to back up the efforts made at the various points of sale.

A policy based on the promotion of produce of guaranteed gustatory quality can lead to the attainment of ecological and economic objectives

The most far-reaching implications of a policy aimed at promoting the gustatory quality of fresh fruit and vegetables are those which involve the ecological objectives. The ecological concept is to be taken in its broadest sense, and must include, in particular, the idea of improving the quality of human life.

It is in fact necessary to determine the conditions which will encourage a return to less intensive methods of production, so as to eliminate the risks of pollution of the natural environment attributable to certain cultural practices which are entirely aimed at the maximization of yields.

The production of fruit and vegetables of superior gustatory quality is based on the stabilization of yields at a moderate level. This entails the exercise of strict control over the rates of application of the various fertilizers and a general effort to establish a balance between the plant and its environment. The logical extension of this approach is the reduced application of pesticides and the adoption of plant protection programmes conceived in the spirit of integrated control.

But the gustatory excellence of top class fruit and vegetables is indirectly linked with better-than-average nutritional value ; so the quality of life is improved for the consumer in three ways :

- reduced pollution of environment ;
- improved nutritional quality of the product ;
- organoleptic satisfaction at the moment of consumption.

Although the recommendations for Community action in this context are mainly intended to serve the general purpose of encouraging less intensive methods of fruit and vegetable production, they can also lead to the achievement of specifically economic objectives.

If the supply of fresh fruit and vegetables selected on the basis of objective criteria could be sufficiently diversified, it would be possible to differentiate between prices on an objective basis.

In current market conditions, the range of retail prices for most varieties of fresh fruit and vegetables is extremely broad. Although the highest prices sometimes coincide with the highest quality, because of the expert knowledge of certain areas of production which is enjoyed by particular professional operators, this happy coincidence is still relatively rare. Furthermore, with the development of the modern channels of distribution, fruit and vegetables are being drawn into an industrial type of circuit, in which they are increasingly treated as industrial products and in which they must conform in particular with standards of intrinsic quality which are sufficiently precise, unfform and constant.

To define the objective parameters of gustatory quality is to create a touchstone for the consumer, to justify the existence and scale of price differentials, and to provide the modern distributive organizations with the precise definitions of quality they require.

The application of techniques of production which are orientated more towards quality than towards quantity can contribute to the regulation of the market in fruit and vegetables.

The techniques for growing produce of high gustatory quality are intended to stabilize yields at a level which is compatible with the potential of the plant. In the case of fruit trees, it has been observed that concentration on maximum yields can lead to variations in yield of the order of 30-35 % from one year to the next, even in the absence of any climatic catastrophe. There are two main causes of biennial bearing : the hormonal effects of the seeds present on the tree at the phase of floral induction, which occurs too early in the season, and the depletion of the reserves of nutrients when the tree carries too heavy a crop.

In years when conditions are not conducive to the production of a large crop, because of climatic factors such as frost or because of serious attacks by certain pests, the whole orchard may be at risk in this respect. If the trees are not severely pruned and and drastically thinned the following year, the orchard may be caught in a perpetual cycle of biennial bearing which can only be interrupted by a further natural calamity.

Concern for balanced growth, with a view to obtaining top quality produce, leads to the adoption of the very forms of pruning and thinning which reduce the risks of irregular bearing, except when these are caused by the weather.

In the case of vegetables, the biennial phenomenon is entirely economic. Following a year of shortage of a given vegetable, which forces up their prices to an above-average level, a greatly increased acreage is planted in the following year. If the weather conditions are favourable there is a glut ...... and the prices collapse.

Growers who opt for the production of vegetables attaining a fixed standard of quality have to respect the rules of crop rotation and good husbandry which are totally incompatible with that sort of variation in cropping areas from one year to the next.

Thus, for a variety of reasons, the growers' concern for the production of top quality fruit and vegetables can be a major factor in reducing the short term-fluctuation of supplies, i.e. from one season to the next.

But this influence can also be exerted over a far longer period, especially in the case of fruit trees which have a productive cycle in excess of 10 years. In the long run, the total area devoted to the production of fruit tends to become stabilized at a level of potential output corresponding to the satisfaction of demand in the years of lowest output. The scale on which prices increase when the harvest is poor will obviously tempt the growers, so that the total area planted will automatically increase in the following winter. This psychological attitude can lead to structual overproduction in an entire region, vis-à-vis the capacity of the market to absorb the total output.

The reduced fluctuation of total output which can be expected to result from the application of the techniques intended to foster the improvement of quality is likely to facilitate the adjustment of productive capacity to the requirements of the market.

As a result of the reduced fluctuation in overall output, variations in price will be even less marked and their psychological effect will therefore be reduced. At the same time, the improved average quality of the crop may stimulate consumption and also contribute to the maintenance of a more stable equilibrium between supply and demand.

<u>The recommendations for possible action at a Community level are intended to be regulatory, economic and scientific.</u>

Action to encourage the production of quality fruit and vegetables can be the expression of two entirely different policies :

1) Improvement of the quality of the mass of produce, simply by eliminating any which does not attain the minimum standards of intrinsic quality. Such action will necessarily take the form of regulations, along the lines already followed in certain countries in respect of other agricultural products such as wine or milk.

2) Selection of the best produce and its identification by a special mark or special label covered by a Community guarantee and subject to such obligatory controls as the Community may see fit to impose.

<u>The regulations</u> to be adopted depend on the choice of one or other of the two policies described above.

Various practical steps can be taken in the implementation of a policy based on the elimination of fruit and vegetables failing to attain a minimum level of quality. For example, it is possible to adjust the values of the minimum quality criteria in relation to the forecast size of the crop, so as to eliminate the possible excess. With improved statistical forecasting at a European level, it would be possible to consider such a policy, but a long phase of preparation would obviously be needed before it could be put into effect.

Again in the context of regulations, it is recommended that minimum quality standards be introduced for the "Extra" class, in response to the consumers' complaints about the contradiction between the external appearance and the real quality of produce labelled "Extra" under the present system.

The implementation of a policy aimed at the promotion of top quality produce would be furthered by the amendment of some of the existing Community regulations. This applies in particular to the lowering of the tolerance thresholds for certain skin defects which do not affect the organoleptic qualities of the product and may even be more common when the natural conditions favour the development of high quality.

But the most important aspect of Community action under the heading of regulations in favour of produce of superior gustatory quality is the definition of conditions of issue applicable to the labels or distinctive trade marks which may be affixed by certain organizations which would lay down the minimum standards of production and distribution and which would also organize a system of objective quality control. That is the aspect of Community action which would appear likely to achieve the greatest economic impact.

From the economic standpoint, full account should be taken of the consumers' current expectations of improved quality in fresh fruit and vegetables, by creating the conditions in which this demand can be effectively expressed.

If the potential demand is to become a reality, it must be easy for the consumer to recognize produce of guaranteed quality, and to distinguish it from the mass; and in this the consumer must be assisted by a special sign affixed to the produce or to the package, in the form of a trade mark or label.

To create a genuine specialized market which is large enough to have the desired effect on the horticultural industry, the area of application of the marks or labels must extend to all the countries of the European Community so that every consumer throughout the Community can be adequately informed and thus enabled to exercise an objective choice.

Certain Member States have taken positive steps to recognize the use of regional or national labels or collective trade marks, but for the lack of a sufficiently developed market the policy has only had limited effects on the production side, and it is largely a closed book to the consumers, for want of information.

The problem can best be solved by an ambitious enlargement of the field of application of the abovementioned solutions and by providing the consumers with information on the same scale.

It seems that the provision of a Community definition of the conditons for granting official recognition of special marks or labels for produce of guaranteed quality would encourage the developemnt of organizations, both of growers and of professional operators, which would be large enough to shoulder the financial burden resulting from the necessary expenditure on publicity.

The guarantee of a growers' organization, recognized as such and subject to official control should enable their produce to benefit from simplified clearance through customs. This would serve to reduce the time spent in transit, which is currently an obstacle to the development of the despatching side of the trade in fruit and vegetables of the highest organoleptic quality.

From the scientific point of view, it may be concluded that the potential quality of a fresh fruit or vegetable mainly depends on the genetic make-up of the variety and its adaptation to the cultural environment. Recommendations ought to be made to the Member States to ensure that the teams working on varietal improvement are encouraged to concentrate on intrinsic quality, both organoleptic and nutritional, in their programmes devoted to the breeding of new varieties (1).

This effort could well be further stimulated by the organization, at a Community level, of working groups which would include researchers and representatives of interprofessional groups interested in expanding the production and consumption of produce of guaranteed quality, with a view to exchanging information and harmonizing their objectives.

(1) Reserve stocks of old varieties could be kept in existence, so as not to loose the potential represented by their genetic characteristics.

Economic, social and ecological consequences of the recommended course of action.

From an economic point of view, a clearer definition of the qualities of fresh produce is likely to improve the growers' returns, by directing towards them a certain proportion of the increased price which the consumers are willing to pay for the privilege of purchasing produce of clearly defined quality. The return to the growers of a larger proportion of the retail sales margin would provida a considerable fillip to investment in agriculture, by helping the growers to plan their production in relation to more clearly defined markets.

Socially, the policy of encouraging the production of high grade produce could prove advantageous to growers in less privileged areas, e.g. hill and mountain farmers, who are severely handicapped by the present emphasis on quantity because they cannot obtain high yields.

In fact, for a whole series of cultural reasons, the growers in such areas cannot hope to match the levels of output achieved in the more fertile plains. By contrast, the natural conditions at higher altitudes are often far more suitable for growing crops of superior nutritional and gustatory quality.

The differences between the economic results of these areas and those where productivity is greater could be significantly reduced if a specialized market could be created for produce of guaranteed quality. If such produce could be distinguished from the mass, it would command a higher price which would compensate for the economic handicaps under which such growers must operate.

Last not least, the ecological consequences are certainly the most important long-term justification for a programme of action in favour of produce of guaranteed quality.

From this last important standpoint, the consequences are threefold: reduced pollution of the environment, improved nutritional quality and heightened gustatory pleasure when the product is eaten.

A N N E X I

ANNEX I

Recommended values for the main quality criteria.

1°) FRUIT

• APRICOT

Total sugars and acidity are the main quality criteria for apricots, while maturity is indicated by the development of colour and the synthesis of aroma. The main recommended values are as follows :

- Colour : The orange-yellow colour characteristic of the variety on maturity, on more than half the fruit.

- Sugars : A refractive index of at least 12 can be adopted for fruit of acceptable gustatory quality and at least 14 for top class fruit.

The proportion of sucrose increases very rapidly as the fruit nears full maturity. Before this development, the sucrose/TS ratio of apricots of potentially acceptable gustatory quality is at least 0.70.

- Acidity : It may be necessary to measure acidity as the ratio of the refractive index to titratable acidity, expressed in milliequivalents per 100 g of the fresh matter (RI/A meq.), especially for varieties in which citric acid is dominant, such as Canino, Moniqui, Monaco, Rouge du Roussillon or Poizat. The ratio RI/A meq. should be at least 0.5.

. CHERRIES

The references to cherries only concern the group of varieties of the Bigarreau type (firm flesh and clear juice).

The size of the fruit, the colour of the skin and the refractive index provide sufficient evidence of the stage of ripeness attained and the level of quality.

- Average weight, in combination with size, is an indication of satisfactory development on the tree.

An average weight of $680g^{+}$ per 100 fruit would appear to be necessary for a good level of organoleptic quality.

- Colour : For varieties which develop a very dark red colour on maturity, such as Hâtif Burlat or Géant d'Hedelfingen, the optimun colour for harvesting is when the entire fruit has developed a bright red colour. Once the shade has darkened, the fruit is over-mature. On the other hand, the presence of a patch of very pale colour, close to white, is an indication of insufficient maturity.

- The refractive index must be greater than 15 to guarantee an acceptable level of gustatory quality in early varieties (Hâtif Burlat) and above 18 for later varieties (such as Géant d'Hedelfingen).

. PEACHES

The gustatory quality of peaches is based on the attainment of a sufficiently high level of total sugars, balanced by total acidity, as in other species of fruit. But the date of harvesting is all-important, because of the close correlation in time between the formation of the aroma and the full maturity of the fruit, and the links between the parameters of maturity and the parameters of quality, stricto sensu, are therefore even closer than in other species.

- Visual parameters : At the level of the individual tree, the largest, most highly coloured and earliest-ripening fruits are generally superior to those which remain small and ripen more slowly.

Colour must be assessed on a scale related to the characteristics of the variety, as it varies greatly from one variety to another, and there are also major differences in this respect between the white-fleshed and yellow-fleshed varieties.

The shape of the fruit is also an indication of the degree of ripeness when picked. The axial/equatorial ratio is near to 1 when the fruit is sufficiently ripe. This applies in particular to yellow-fleshed varieties such as Redhaven.

- Firmness : Measurement of the firmness of the flesh by means of a penetrometer is the best method of assessing the evolution of the fruit as maturity approaches (260).

In the case of yellow-fleshed varieties, the optimun harvesting date, which corresponds with the phase of maximun synthesis of the aromatic substances, coincides with a measured firmness of less than 2.5 kg, measured with a penetrometer with an 8 mm head (0.5 cm^2). For white-fleshed varieties, the measured firmness must be less than 1.5 kg.

- Total sugars : For a fruit picked at the optimun date, the gustatory quality may be described as good when the refractive index is more than 10 in the case of the early varieties which ripen before 15 July and more than 11 for the later varieties which ripen in August.

- Acidity : The ratio 10 RI/A meq., in which RI = refractive index and A = acidity in milliequivalents per litre of juice is near to or greater than 1 in good quality fruit.

. PEARS

The optimun date for harvesting pears can be precisely determined with the aid of a penetrometer. The refractive index can be used as a test of gustatory quality. Pears do not have a very high acid content ; so acidity is rarely taken into consideration, except in the case of Passe Crassane pears for estimating the risk of internal browning in the course of storage.

- Firmness : The longer the vegetative cycle of the variety, the greater the degree of firmness when the fruit is harvested, as measured with a penetrometer with an 8 mm head. The average readings are :

Dr Jules Guyot	:	3 kg
William	:	
Beurrée Hardy	:	4 kg
Doyennée du Comice	:	
Conference	:	5 kg
Passe Crassane	:	5.5 kg

- Sugars : Fruits of good gustatory quality have a refractive index greater than :

10 in the case of summer varieties (Dr Jules Guyot, William, Beurrée Hardy)
13 in the case of autumn-ripening varieties (D. Comice, Conference)
14 in the case of Passe Crassane

- Acidity : In the case of Passe Crassane, the ratio 10 RI/A mal., in which RI = refractive index and A mal. = acidity in grammes of malic acid per litre, must exceed 35, to minimize the risks of internal browning in the course of storage.

. APPLES

The most detailed attention has been devoted to the Golden Delicious variety, for which the visual and analythical criteria of quality have been thoroughly investigated. A certain number of analytical values are included for other varieties.

- Visual parameters :

. The fruit must be of a satisfactory size, with a diameter exceeding 65 mm in well-developed fruit.

. The axial/equatorial ratio, which shows the degree of development, should be slightly under 1 (0.93 - 0.96 in the case of harmoniously developed fruits of the Golden Delicious variety). In poorly developed fruit, grown in a cold climate, the ratio is greater than 1 and in a hot climate it is less than 0.90.

. The development of the area round the calyx (the "eye" of the fruit) is an indication of satisfactory development. The eye cavity must be broad and deep ; in top quality apples of the Golden Delicious variety it is more than 5 mm deep and more than 25 mm in diameter.

The present of well healed lenticels (density 15 - 30 per cm^2) is a further indication of balanced development. A lenticel count which is above or below this range can be considered unfavourable.

- Sugars : A refractive index greater than 13 is an indication of good gustatory quality in the main varieties.

A level of sucrose of at least 30 g/litre can also be taken as a criterion of well-developed organoleptic qualities.

- Acidity : Rarely considered excessive in the varieties of table apples currently grown in Europe, acidity can nevertheless be taken as an index of minimum quality for apples in storage.

It should also be noted that acidity is taken into account in the quality index TS + 10 A which has been perfected for the Golden Delicious variety.

Because of the loss of acidity by respiration in the course of storage, the minimum values of the indices of quality and acidity follow a downward curve over the period of conservation, as shown in the following table :

Recommended values for the index TS + 10 A and acidity of Golden Delicious (superior quality)		
Storage period	Quality index	Acidity g/l malic acid
Harvest	180	4.5
1 month	175	4.0
2 "	171	4.0
3 "	166	3.5
4 "	162	3.5
5 "	158	3.0
6 "	155	3.0

<u>N.B.</u> :

The recommended values for acidity at the end of the storage period are different from those indicated for the commencement of storage. As the loss of acidity is normally about 50% in 6 months in a normal atmpsphere, apples intended to be stored for a long period must have a higher total acid content when harvested than those which are put up for sale immediately after being picked.

2°) VEGETABLES

. <u>CARROT</u>

Flesh colour (indicative of a high level of carotenoids), total sugars and acids, and tenderness of the flesh are generally taken into consideration when assessing the quality of carrots. But no results of detailed studies are available for fixing the threshold values for these criteria with any degree of precision.

- Visual criteria (261) : The semi-long varieties such as Nantaise should have a root that is cylindrical and "bien boutée" (i.e. the end of the root must be regular and round). The shoulders must be rounded and there should be no cavity at the point of insertion of the leaves.

The collar must not be green. The diameter of the heart, measured in the lowest third of the root, must not exceed one third of the total diameter of the root, which must not be yellow or woody.

- Sugars : The refractive index should be at least 10.

- Acidity : Acidity should not be excessive, and should be balanced with the total sugars, so that the ratio RI/A meq. is at least 10.

RI = refractive index
A meq. = acidity in milliequivalents per 100 g of the fresh matter.

. MELON

The visual criteria for measuring the quality of melons are mainly intended to provide an indication of maturity. The refractive index is a precise objective criterion when applied to a single variety, but it is only of limited significance for the purposes of intervarietal comparisons because of the differences in aroma (262).

A refractive index of more than 12 is a criterion of superior quality for the best varieties of Cantaloup.

Generally speaking, a refractive index below 10 is indicative of inadequate quality in all varieties of melon.

. POTATO

The quality of potatoes has been studied in great depth, especially as regards their suitability for culinary purposes or industrial processing. From this point of view, there are major differences between varieties.

In all cases, the dry matter of the tubers, measured by the specific gravity, is the most precise criterion of quality. Depending on the method of cooking, the maximum dry matter content for good quality can be fixed as follows :

Method of cooking	Dry matter content %
Steamed	18
Sautéed	18
Purées	20
Chips	22

. SALAD VEGETABLES

The principal quality of salad vegetables consists in their freshness ; so the criteria of quality are mainly a question of appearance. But they also allow for a comparison between the visual criteria and the stage of development attained by the plant when harvested, which determines its sugar content and the degree of bitterness.

- Lettuces :

Lettuce heads should be large, round and fairly tight, the average weight should be greater than 350 g after trimming.

A head which is too tight and rounded in form is a sign of over-ripeness at the harvesting stage.

The general shape of the plant must be flat at the base and the ribs must be fine.

The leaves must be thick, firm and turgescent, and their colour must be a fresh shade of green.

- Endives :

The plant must be flattened in shape, and the maximum height must be 15 cm for a diameter of 40 cm after trimming.

Average weight must be greater than 800 g. The width of the leaf at the base, after trimming, measured at 10 cm from the point of insertion, must be at least 14 cm.

. TOMATO

The refractive index and total acidity can serve as a basis for defining the quality of tomatoes, in combination with the firmness and deformability of the fruits. But few references are yet available for fixing the minimum values for these different criteria.

Provisionally, the following values could be fixed for superior gustatory quality :

- refractive index greater than 7 ;
- acidity at least equal to 10 milliequivalents per 100 millilitres of juice ; but the ratio RI/A should not fall below 0.5.

A N N E X   2

A N N E X 2

Recommendations suitable for inclusion in the codes of practice for growing fruit and vegetalbes attaining fixed standards of gustatory quality (1).

1 : FRUIT

11 : Apricot

. Soil

This species particularly dislikes soils that are too humid or too heavy, in which mortality is high and the fruit is of inferior quality.

With apricots, the best results are obtained in orchards established on alluvial soils, of longstanding or recent origin, which are coarse in texture, especially in the lower layers, and well-drained.

. Climate

A warm dry spring, free from frost at the flowering phase, is indispensable if this species is to produce regular crops, because it has a natural tendency to irregular bearing.

Humidity in spring encourages the excessive development of monilia on the flowers, and this accentuates the tendency to biennial bearing. The aptitude of the different varieties must also be assessed in relation to the climate, especially as regards the need for exposure to low temperatures during the dormant winter period and for high temperatures during the period of vegetative growth, both of which can vary considerably between varieties.

. Varieties and rootstocks

Choice of variety mainly depends on adaptation to the local climate ; hence the predominance of a specific variety in each main zone of production. This may be taken to be the best cultivar for the local environment in present conditions and the one which most lends itself to a system of selection based on the intrinsic quality of the fruit.

In France, for example, the following varieties are well-adapted to specific regions :

- Rouge du Roussillon for the Pyrénées-Orientales plain,
- Polonais for the southern section of the valley of the middle Rhône, and Bergeron for the northern section.

In Italy, Reale d'Imola is the automatic choice for the Emilia-Romagna region.

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(1) These recommendations relate to the minimum values for the quality criteria proposed in Annex 1.

But the quality of some varieties, and particularly the early varieties such as Hâtif Colomer always leaves something to be desired, and does not justify any special selection of the fruit.

Other varieties such as Canino, Moniqui and Ananassa can do well in areas other than their zone of origin, and in localities where they are well-adapted these varieties could obviously be graded on the basis of gustatory quality.

A list must be established for each zone of production, based on local trials.

The rootstock must be carefully chosen, to meet the special soil requirements of this species. Free stock should be used when the soil is sufficiently permeable, but plum is to be preferred on heavier soils and whenever there is a risk of apricot verticilium wilt.

• Planting densities

Planting densities should be adapted to the variety, to ensure the adequate penetration of light to every part of the tree, because this species is very sensitive in this respect.

In the absence of data from experiments, high-density planting cannot be envisaged if the aim is to produce top quality fruit, and the rows should be planted at least 5 m apart.

• Pruning

The pruning system must be particularly well adapted to the branching habit of each variety, to ensure the penetration of light to every part of the structure and to regulate production so as to reduce the risk of biennial bearing.

This operation is an extremely important factor in the production of top quality fruit; when it is neglected, there may be a five-fold increase in the crop from one year to the next, and a heavy crop will obviously lead to the development of smaller and very inferior fruit.

• Thinning

This operation is seldom carried out in apricot orchards in the traditional growing areas where it would nevertheless be particularly beneficial, in combination with pruning, as a means of limiting the effects of the biennial bearing tendency in heavy crop years.

For the purposes of selection on the basis of intrinsic quality, thinning is vital as soon as the yield looks like exceeding the average by more than 20%.

It must be carried out very soon after flowering, when the dessicated calyx is still present at the extremity of the fruitlet. In the current state of the art, the operation can only be carried out by hand, by reducing the number of fruits in the clusters.

. Fertilizers

The mineral fertilization of apricot orchards is essential; but it must be kept within limits, so as not to upset the balance between vegetation and fruiting. The rate of nitrogen should not exceed 100 - 120 units/hectare which can be applied on a single occasion just before the flowering period. In the case of early varieties, part of this nitrogen can be held back until immediately after the crop is picked.

There is also a need for phosphoric acid and potassium, depending on the level of these elements in the soil, to balance the other nutrients vis-à-vis nitrogen. But when the accent is on superior quality, it is best not to exceed 80 units of phosphoric acid (P_2O_5) and 120 - 150 units of potassium (K_2O).

. Irrigation

Every effort should be made to avoid irrigation in the pre-harvest phase if the aim is to obtain a top quality product. In regions with a dry climate, the amounts of water should not be more than 50% of the estimated evaporation/transpiration requirements and irrigation should be stopped in any case 10 - 15 days before the date of harvesting.

By contrast, immediately after harvesting, the needs of the tree must be entirely covered, to limit the risks of biennial bearing.

. Soil management

The surface should be kept entirely free of grass and weeds with the aid of tillers. These must not penetrate the soil to any depth, to avoid the risk of contaminating the roots with verticillium wilt.

. Plant protection

Pest prevention prior to harvesting is mainly aimed at protecting the fruit against the various diseases to which it is susceptible : powdery mildew, coryneum and monilia. Especially in the case of monilia, any twigs and branches which are attached must be carefully cut out so as to restrict the size of the inoculum.

Good adaptation to the local climate is a key factor in reducing the incidence of these diseases whose development automatically leads to the application of excessive amounts of fungicides.

. Harvesting

Premature harvesting, which prevents the satisfactory development of the various sugars and the formation of aroma, is to be avoided.

A close watch must be kept on the development of acidity and the refractive index, so as to fix the optimum dates of harvesting for the level of quality required.

A ratio RI/A of at least 0.5 is recommended (RI = refractive index and A = acidity in milliequivalents per 100 g of the fresh matter). For the purposes of selection on the basis of quality, the refractive index of the crop must be above the minimum (see para. 2.41).

The harvesting process should be split into at least two stages if the aim is to obtain good quality. Apricots are picked to colour, which must be the characteristic orange-yellow shade of the variety on more than half the skin. The other half must be pale green, so that the fruit can develop the typical colour on all its surface at the precise time of offer for retail sale.

. Storage

The storage of apricots is a risky business, and generally requires harvesting at an excessively early stage, which would preclude any selection on the basis of intrinsic quality.

12 : Cherry

. Soil

This species requires deep, well-drained alluvial soils of ancient or recent origin, because it is very sensitive to excess moisture in the soil, even over short periods.

Cherry orchards are best sited on hillsides if top quality crops are to be grown.

. Climate

The climate must be sufficiently cold in winter, to provide the period of dormancy on which this species insists. But a warm dry spring is essential for the achievement of high quality and sufficient firmness to withstand transport without deterioration.

. Varieties and rootstocks

The only varieties worthy of selection on the basis of quality are those in the Bigarreau group (firm flesh, clear juice); this excludes the over-early varieties, whose fruits are too small, and those which are poorly adapted to local climatic conditions.

Depending on the type of soil, the rootstock may be wild cherry (prunus avium) or free stock, when the exchangeable calcium content of the soil is less than 7%, or the mahaleb cherry (prunus mahaleb) when the calcium content rises above this level.

. Planting densities

The cherry is a vigorous species, with a large potential spread, and it must be given sufficient space if it is to produce regular crops of high quality fruit.

The clusters of flower buds known in French as "Bouquets de mai" can continue to bear fruit over a long period, providing the sunlight can penetrate to all parts of the tree.

Thus, the distance between the rows must be at least 7 m.

. Pruning

Cherry trees need pruning to ensure their balanced development and the adequate penetration of light to all parts of the structure.

By thinning and shortening the branches, the yield can be regulated to ensure the crop is not so heavy as to impair quality and induce irregular bearing.

. Fertilizers

Amounts of nitrogen must be geared to the size of the crop.

The maximum rate of application should be 150 units per annum, 2/3 before the flowering period and 1/3 immediately after harvesting. It may be necessary to feed the trees with 50 - 60 units of phosphoric acid (P_2O_5) and potassium (K_2O) to balance the nitrogen, depending on the level of these elements in the soil.

In the case of cherry trees in particular, the chemical fertilizers can be partly or wholely replaced by organic manure.

. Irrigation

Cherries ripen early in the summer ; so no irrigation is needed before harvesting, save in exceptionally dry conditions, when rain after a period of drought could lead to the bursting of a large percentage of the crop.

Irrigation after harvesting is highly recommended as a means of ensuring regular bearing. But the doses should be moderate, because this species is extremely sensitive to any excess water.

. Soil management

When there is no irrigation, the surface must be kept under cultivation. Irrigated orchards should be permanently grassed over, and it is then desirable to step up the rate of nitrogen to cover the requirements of the sward.

. Plant protection

The main treatments before harvesting are intended to prevent the development of monilia and, in the case of the later varieties, to forestall attacks by the cherry . ruit fly.

If the growers can combine to fight this fly, by concerted spraying at the optimum moment, as indicated by the number trapped, the developing populations will be far more effectively controlled in all the orchards in a given area of production.

The pesticides employed must be free of any odour which may taint the cherries, and the latest date of application must be carefully worked out, to ensure that any residues are within the limits stipulated in the countries of destination.

. Harvesting

Harvesting must be split into at least two stages ; the fruit must be picked to size and colour.

For varieties which develop a dark red colour when fully ripe, the optimum stage of picking-ripeness is when the whole fruit is bright red, and the presence of a whitish or pinkish patch can be taken as evidence of insufficient maturity.

The selection of fruit of superior quality also entails the elimination of fruits that are red all over, because they will have become over-ripe before the consumer eats them.

Cherries must attain an average weight of 680 - 700 g per 100 fruit to be likely to achieve the minimum threshold for the refractive index fixed for the selection of fruit of superior quality.

. Storage

Cold storage does not suit this species, and the risk of deterioration in the organoleptic properties in the course of storage is so great that selection based on quality cannot be envisaged for cherries kept in cold storage for any period longer than that required for packing and transporting the fruit.

13 : Peach

. Soil

The range of possibilities offered by the different rootstocks used for this species is so broad that the production of top quality fruit can be undertaken on a variety of soils. But the main thing is to avoid soils that are too compact, and especially those with impermeable lower layers. Old or new alluvial deposits, which are deep and sufficiently coarse in texture and which also contain few fine particles in the lower layers are best for this species.

Lime is needed for the production of quality fruit, but the lime content must be low enough to preclude the development of chlorosis. 5 - 7% exchangeable calcium would appear to be the optimum level.

. Climate

The climatic factors are of crucial importance for the quality of the different varieties, and a sufficiently high temperature at the ripening phase is quite indispensable. Satisfactory ripening depends on daytime temperatures of 20 - 22°C in the two weeks prior to harvesting. Some varieties also need greater exposure to low temperatures during winter dormancy, and this factor must not be forgotten when assessing their adaptability to a particular climate.

The length of the period of high temperatures and the difference between winter and summer temperatures are the two main factors to be taken into consideration for choosing varieties capable of producing top quality fruit in a given climate. A substantial difference between diurnal and nocturnal temperatures is particularly favourable to the development of colour, shape and organoleptic quality in peaches.

It should also be remembered that strong winds can cause serious surface damage to the skins of nectarines and "brugnons" when these rub against the leaves.

. Varieties and rootstocks

A select list of varieties capable of producing fruit of guaranteed quality should be drawn up for each microclimatic zone ; it should be based on local results.

Varieties with a poor quality potential, and especially those with a high level of acids, must be eliminated, as must those whose temperature requirements cannot be met.

Peaches are very susceptible to chlorosis resulting from excess lime in the soil, and the rootstock must be chosen with this risk in mind.

Rootstocks which slow the rate of vegetative growth, such as damson or almond, will tend to produce fruit of slightly higher gustatory quality than is obtained from the more vigorous free stock and peach/almond hybrids.

. Planting distances

The trees would be planted far enough apart to allow the penetration of light to all parts of the tree, and especially to the fruits, so as to ensure they develop a satisfactory colour and sufficient aroma. Grown on vigorous rootstocks, the recommended distance between the rows is 5 m, but on plum rootstocks, 4 m will suffice.

. Pruning

The shape of the tree must be adapted to the vegetative capacity of the variety and the density of planting, so as to ensure that enough light falls on every fruit.

There is a close correlation between the size of the fruits, their gustatory quality and the diameter of the fruiting shoots. The aim in pruning must therefore be to select the strongest mixed shoots and to eliminate the slender brindles with wood and fruit buds and the multiple buds which invariably bear fruit of inferior quality.

Furthermore, the system of pruning must be severe enough to guarantee the development of vigorous mixed shoots for the next year's crop.

In the case of early varieties, summer pruning is recommended, partly to eliminate those organs of the mixed shoots which have born the current year's fruit, so as to encourage the development of the base shoots for the following year.

. Thinning

The new varieties of peach are so fertile that thinning is absolutely necessary, in combination with pruning, to regulate the yield and to ensure tha quality of the crop.

Pruning sets a limit on the total crop borne by the tree, and selects the best bearing wood. Thinning backs this up, by limiting the number of fruits on each mixed shoot with a view to ensuring balanced development.

Timing is vital. If the thinning operation is carried out too late, it will be too late to counteract the effects of the competition which will already have developed between the fruitlets themselves and also with the leaves ; and if it is carried out too early it will stimulate the vegetative development of the tree, to the detriment of the fruit.

As a general rule, the optimum time for thinning depends on when the variety ripens. Those which ripen in the first fortnight of the harvesting season must be thinned as early as possible, either towards the end of the flowering period or when the tree is in full flower.

For the later varieties, the optimum thinning date is between 10 and 20 days after flowering, depending on the date of maturity. In any case, the operation should be completed within three weeks of the end of the flowering period for all varieties.

To obtain fruit of guaranteed quality it is necessary to limit the number of fruits to 5 per mixed shoot, special care being taken to thin each cluster to a single fruit for each point of insertion, leaving those which are favourably placed for the developement of quality. Fruits which are too near the base of the shoot should be removed, because their development may be hampered by the adjacent wood.

In practice, the optimum spacing on mixed shoots would appear to be 10 - 15 cm. Fruit near the tip of the mixed shoot should also be removed, because the inclination of the shoot, pulled down by the fruit, would be detrimental to quality.

. Fertilizers

Because of the large amount of new fruiting wood which peach trees develop each year, the application of fertilizers, and especially of nitrogen, is extremely important for maintaining the balanced growth of the tree without any adverse effect on quality.

Bearing in mind the voluntary reduction of yields, which results from the effort to produce fruit of superior quality, and in order to avoid the risk of splitting of the stone to which certain varieties are susceptible (274), the rate of nitrogen must not exceed 150 - 200 units per hectare per annum ; the heaviest applications are needed on shallow soils that are coarse in texture.

In grassed orchards, an extra 50 units of nitrogen per ha are required, to meet the needs of the grass.

Depending on the characteristics of the local soil, it will also be necessary to feed the trees with potash and phosphates, to balance the effects of the nitrogen.

The nitrogen fertilizers should all be applied prior to flowering, but in the case of early varieties, 2/3 can be applied before flowering and 1/3 immediately after harvesting.

. Irrigation

Both the green shoots and the fruits of peach trees grow so rapidly that irrigation is absolutely necessary for the normal commercial production of peaches, which are always grown in areas with a Mediterranean climate, to meet their special climatic requirements.

Irrigation geared to the needs of the tree is essential, therefore, for balanced growth of all the parts of the structure, as required for the development of quality.

Quality is not impaired if this irrigation is uniformly spread over the vegetative period and is regulated to cover 60% of evaporation/transpiration requirements (PET).

On retentive soils, however, the rates of irrigation may be regulated in a different manner ; in particular, the supply may be reduced by 1/3 between the phase when the stone hardens and the harvesting date. This also reduces the risk of splitting of the stone (274).

By way of compensation, the rate of irrigation, calculated as a percentage of PET, can be sharply increased in summer, after the crop has been harvested. It may thus be stated that irrigation on the scale given below will slightly improve the quality of the fruit :

- from the beginning of the growing season until the stone hardens .... 60% of PET
- from the hardening of the stone to the date of harvesting .... 40% of PET
- after harvesting .... 80 - 90% of PET

Water must be administered at sufficiently regular intervals prior to harvesting to avoid major fluctuations in the amount of moisture available to the tree, and in particular the intervals between applications should not exceed two weeks in the pre-harvest period. In very hot weather, such an interruption could lead to impaired quality and reduced firmness.

It should be pointed out that localized daily irrigation, by one of the available drip-watering systems will improve fruit quality and encourage earlier ripening, providing the rates of application are suitably related to PET requirements.

. Soil management

A bare surface, shallow-worked, is the most common system of soil management in peach orchards, and gives the best results as far as quality is concerned.

However, because this species is very sensitive to the presence of fine elements in the soil, grassing may improve quality when the soil is compacted and difficult for the roots to penetrate.

. Plant protection

The phytosanitary protection of the peach, from the standpoint of the preservation of the organoleptic quality of the fruit, has three main aspects :

- The chemical fungicides used to combat leaf curl, monilia and powdery mildew must be carefully chosen so as to avoid throwing the ecosystem out of balance by encouraging the development of certain pests, especially mites, or by destroying the predators.

Thus, copper compounds are most suitable for treatments applied before the buds open, and sulphur or benomyl at a later stage.

- Peach aphids, especially green aphids, must be dealt with by means of a selective programme of treatment, to avoid the build-up of resistance to products administered too early in the season (e.g. organo-phosphorus). The frequency of such treatments can be greatly reduced if the aphicides are included in an integrated plant protection programme.

- The oriental tortrix moth, whose life cycle is similar to that of the coddling moth, can be more effectively controlled if a careful check is kept by sexual trapping. Here again, an integrated programme is not only the most effective, but also reduces the number of treatments required.

. Harvesting

Because peaches develop very rapidly in the final few days before attaining full ripeness, the stage of development reached when the fruit is picked is of great importance for the organoleptic quality of the fruit and especially for the synthesis of aroma.

To obtain good quality fruits, a close watch must be kept on their development in the fortnight preceding the estimated date of harvesting.

The main criterion is external appearance, and especially the reddening of the epidermis and the symmetrical development of the fruit around the suture line, depending on the characteristics of the variety.

When the rapid changes in external appearance show the approach of the date of maturity, samples are taken to measure the refractive index and the level of acidity. The readings are relatively constant in the final few days before the fruit is picking-ripe, and thus provide a means of checking whether the fruits are likely to attain the minimum quality standards for selection on the basis of this index (RI).

If quality is thus confirmed, the ripening process can be closely monitored by regular checks of the ratio 10 RI/A, in which A (acidity) is expressed in milliequivalents per litre. When the ratio approaches unity, the fruit has attained a degree of ripeness which is compatible with good quality.

At the same time, a precise check can also be kept on the ripening process by measuring the firmness of the fruit with the aid of a penetrometer. Optimum development corresponds with readings of 1.5 kg or less for white-fleshed varieties and 2 kg or less for the yellow-fleshed varieties.

. Storage

Cold storage can seriously impair the quality of peaches, and must therefore be considered incompatible with the production of peaches of guaranteed quality, except insofar as it is necessary to control the evolution of the fruit in transit.

In that case, the fruit should not be kept at a low temperature for more than 4 days.

14 : Pear

. Soil

The production of pears of guaranteed quality requires a deep fertile soil in which the trees can develop at a steady rate. If the soil is stony or infertile, the fruits tend to be astringent or susceptible to grit.

. Climate

In addition to low temperatures in winter, to provide the period of dormancy which is vital for certain varieties, and particularly for those which mature late in the season, the climate must also be warm enough in summer to ensure satisfactory ripening. On the other hand, excessive heat in summer may dessicate the foliage and throw the photosynthetic process out of gear.

So a select list of varieties capable of producing fruit of guaranteed quality must be drawn up for each climatic zone.

. Varieties and rootstocks

The organoleptic potential of pears is generally high, and most of the varieties that are grown commerically could meet the requirements of selection based on measurable quality. Nevertheless, the varieties which ripen in July, and certain new varieties selected for their resistance to diseases may not be able to meet the required standards.

Quince rootstocks, which are widely employed, are good for quality ; but free stock may be also suitable, especially in areas where the summers are hot and dry.

. Planting

The pear is certainly the most tolerant of trees as far as planting densities are concerned, and its organoleptic potential may even remain unaffected by reduced planting distances if the pruning system is severe enough to enable air and light to reach every part of the tree.

. Pruning

Pruning has a decisive influence on quality because it establishes a balance between fruiting and vegetative growth and ensures the selective renewal of fruit-bearing wood.

The aim must be to select the largest fruit buds on the young bearing organs, such as short brindles ending in a fruit bud, which are the most favourable supports for produce of high quality. If the surplus buds are pinched out in summer, this can ensure the development of good fruit buds the following year.

. Thinning

Pears rarely need thinning, because the percentage fruit set is nearly always well within the vegetative capacity of the tree. Nevertheless, if the crop is particularly heavy, it is necessary to carry out a rapid manual thinning operation to reduce the number of fruits per point of insertion to a maximum of two and if possible to a single fruit.

. Fertilizers

Pear trees are normally grown on fertile soils, and only require moderate applications of fertilizer, which should not cause any imbalance in the vegetative growth of the tree. The rate of nitrogen should not exceed 120 - 150 units per hectare, in two applications, before flowering and before the end of June.

Phosphorus and potassium may also be required, to maintain a balanced supply of nutrients, depending on their levels in the soil, the dressings being limited, on average, to 80 units of phosphoric acid (P_2O_5) and 150 units of potash (K_2O).

If the supply of nutrients is monitored by foliar analysis, the rates of application can be regulated to suit the real needs of the tree.

On average, the levels of the main elements must be in the following ranges :

N	:	1.80 - 2.00
P_2O_5	:	0.15 - 0.18
K_2O	:	1.60 - 1.80
MgO	:	0.28 - 0.33

. Irrigation

This species is particularly sensitive to shortage of water, and the supply must be kept as regular as possible. The needs of the tree, estimated at 60% of PET, must be coverdd by irrigation from the beginning of the vegetative period until 3 webks before harvesting.

Because pears are generally grown on retentive soils, the cessation of all irrigation in the 3 weeks preceding the date of harvest will make a very useful contribution to the quality of the fruit. Irrigation can recommence immediately after harvesting if this is justified by the climate and the earliness of the variety.

. Soil management

Permanent grassing, which encourages root formation, is not inimical to the development of top quality fruit ; but clean cultivation seems to suit the early and semi-early varieties.

. Plant protection

The three most redoubtable enemies of quality in pears are pear scab, the coddling moth and the pear sucker.

The only way of avoiding the over-frequent use of pesticides are the possible development of pesticide tolerance is to carry out a programme of integrated plant protection, in which the various chemical products are used in combination against a whole range of pests and especially against the pear sucker.

. Harvesting

The optimum date for harvesting pears can be precisely determined with the aid of a penetrometer. To ensure good gustatory quality, the fruit must be harvested when measured firmness is equal to or less than :

3.5 kg for early varieties ;
4 kg for middle-season varieties such as Beurée Hardy ;
4.5 kg for Doyennée du Comice ;
5 kg for autumn varieties such as Conference ;
5.5 kg for late-maturing varieties such as Passe Crassane.

The refractive index should also be measured, to check whether the minimum standards have been attained.

In the case of Passe Crassane, the ratio 10/A, in which A is expressed in grammes of malic acid per litre, must be greater than 35, to reduce the risk of internal browning in the course of storage.

The fruits must be very carefully picked by hand, and every effort must be made to avoid any rubbing which might result in blemished skim when the fruit reaches full maturity.

. Storage

Most varieties of pears have a certain ability to withstand cold storage, and this applies in particular to the late-maturing cultivars. Apart from a few varieties which are sensitive to low temperatures, cold storage should be at a temperature near to 0°C and may even be between 0 and minus 1°C.

Alexandrine Douillard must be stored at a slightly higher temperature, between + 2°C and 3°C.

Following cold storage, pears selected for their organoleptic quality must be after-ripened at a temperature of at least 15 - 18°C. In the special case of Passe Crassane, the methods of storage and after-ripening vary in relation to the estimated date of consumption, as indicated in the following table.

Controlled atmosphere storage reduces the risk of physiological disorders. The optimum conditions for storage at 0°C are an oxygen content of 2% and 3 - 5% of carbon dioxide. The quality of the Doyennée du Comice variety can be improved by 4 days' pre-ripening at a temperature of 15°C and a relative humidity of 80% prior to cold storage.

By contrast, the same treatment sometimes has an adverse effect on the quality of Passe Crassane pears.

PASSE CRASSANE PEARS

CONDITIONS OF STORAGE AND MATURATION

source: C. LEBLOND (232)

Marketing period	Pre-ripening	Storage	After-ripening (1)
mid-November	$T^o = 12^o$ air + 1 % ethylene 2 weeks	Air - $T^o = 0^o$	$T^o = 10^o$
early December	$T^o = 12^o$ air 2 weeks	Air - $T^o = 0^o$	$T^o = 10^o$
mid-December mid-January	none	Air - $T^o = 4^o$	$T^o = 10^o$
January February	none	Air T^o increasing 8 weeks = 0^o 5 weeks = 2^o finishing = 4^o	$T^o = 10^o$
March April	none	Contr. atmosphere $T^o = 6^o$ $CO_2 = 5$, $O_2 = 5$	$T^o = 20^o$

(1) Firmness must dininish, on average, from 3.5 kg on commencement of maturation to 2 kg for despatch.

15 : Apples

. Soil

Soils which are badly drained or too heavy must be avoided if the intention is to grow top quality apples;; in particular, if the clay content of the fine soil submitted for granular analysis in greater than 50%, this does not augur well for quality, especially in old trees.

Coarse soils which are short of colloidal elements cannot provide sufficient nutrition and are therefore unsuitable for the production of top quality fruit. Hillside soils, which are well drained and well exposed, generally provide the optimum conditions of growth, providing they are at least 60 cm deep.

. Climate

Z Zones of production situated at medium or high altitude, with a substantial differeance between diurnal and nocturnal temperatures in the final weeks of development of the fruit, with a maximum temperature of 20 - 25 °C and a moderate amount of water vapour in the air, provide a combination of the best conditions for quality.

. Varieties and rootstocks

It is essential to take full account of climatic conditions when choosing the variety, and there can be no question of growing high quality apples if the vegative cycle required for satisfactory ripening is too long for the period free from frost. The heat requirements must also be met, but not by excessive summer temperatures which favour the development of the vegetative organs to the detriment of quality in the fruit.

Rootstocks must be selected with due regard for the characteristics of the soil and local climate, so as to avoid any imbalance between growth and fruiting. Growers are recommended to plant virus-free stock.

. Planting

Planting densities should be based on potential vegetative development, which depends on the scion variety, the rootstock, soil and climate.

High density planting is quite feasible, providing the trees are so trained as to allow the adequate penetration of light to every part of the structure. Conditions are so diverse that it is not possible to set any general limits on planting densities because each planting operation must be carefully worked out in relation to the local environment.

. Pruning

The pruning system must be adapted to the fruiting habit of the variety, so as to maintain a balance between fruiting and vigour in all parts of the tree, by cutting out those organs which are vegetatively unsuitable and incorrectly positioned for bearing fruit of the required quality, and by ensuring the production of sufficient new bearing wood.

On the readily branching varieties, such as Golden Delicious, the best fruits are born on young and vigorous shoots, and the pruning system is intended to encourage fruiting on one year old brindles ending in a fruit bud and on young fruit shoots on 2- and 3- year-old wood. The less readily branching varieties, such as James Grieve or Reinette du Canada, are pruned less severely, so as to encourage the development of new wood and to ensure that fruit is also borne on 4 - 5 year old wood. Branches inclined at more than 60° to the vertical should also be removed.

. Thinning

Free fruiting varieties must be thinned if regualr crops of satisfactory quality are to be obtained. The correct balance must be maintained between the number of leaves and the number of fruits on each fruiting shoot, with a minimum of about 30 leaves per fruit. The balance can be achieved by chemical thinning, by applying the right product at the right moment. The fruit can be further thinned by hand, after the June drop, to eliminate any that are deformed or growing too far inside the crown of the tree and to reduce every cluster to one or two fruits, depending on the degree of selectivity required.

Yields must be regulated by the combined effects of pruning and thinning, so as never to overstep a threshold that is compatible with the standard of quality required. The threshold may vary between 30 and 45 tonnes per hectare, depending on the orchard, and must be fixed in each individual case on the basis of annual measurements of sugar and acidity when the crop is harvested.

. Fertilizers

Apple trees invariably respond to organic fertilizers, but it is important to avoid massive applications which might quickly affect the balanced growth of the tree and thus impair the quality of the fruit.

The rates of application of chemical fertilizers must respect the balance of the main elements, as indicated by the chemical analysis of the soil.

Nitrogen should not be applied in excess of 150 - 190 units per hectare, and should be supplied entirely before flowering or in the following fortnight at the latest.

Foliar analysis of adult leaves should not show more than 2% of nitrogen. Dressings of potash will also be needed, depending on the potassium content of the soil, but should not exceed 200 - 300 units of potassium (K_2O) per hectare, to cover the requirements which can be checked by foliar analysis and must not show more than 1.85 or 2.00% of this element.

Summer spraying with calcium, perhaps in combination with boron, may be needed if the natural conditions favour the development of bitter-pit.

. Irrigation

Water must be supplied whenever the satisfaction of evaporation/transpiration requirements is prevented by any irregularity in the local climatic conditions. But excessive irrigation is to be avoided.

Irrigation must cover 60% of the evaporation/transpiration requirements whenever the natural conditions prevent this level being reached ; but the supply of irrigated water must be stopped three weeks before the crop is harvested.

. Soil management

The orchard can be clean cultivated, or it may be grassed over and the soil round the trees kept grass and weed free by chemical means.

When a sward is grown, the trees need extra water and nitrogen, on a scale related to local climatic conditions.

• Plant protection

The use of any fungicides and insecticides which might communicate a foreign flavour to the fruit must be prohibited over the whole period from fruit set to harvest.

The programme of pest control must ensure the maximum reduction of the number of chemical products called upon and the avoidance of any systematic treatment which is not justified by the development of the insect population beyond a certain tolerance threshold.

• Harvesting

The crop should be harvested at an optimum date which is related to the normal length of the growing period of each variety but which can change from year to year, depending on variations in flowering dates and the vagaries of the climate in summer. So it is preferable to monitor the development of the fruits over the last two weeks of growth. The most reliable tests involve the assessment of colour, both of the epidermis and of the pips :

- measurement of changes in skin colour ;
- browning of pips on more than 3/4 of their surface area.

In addition, it is possible to check the regression of starch and the lessening firmness of the fruit :

- regression of starch is measured by cutting the fruit transversely and smearing the section with iodine ; the blue colour should appear only in the centimeter of flesh immediately under the skin ;

- lessening firmness is measured by penetrometer : the reading must be more than 3.5 kg, measured with an instrument with a head of 0.5 cm^2.

Finally, in the case of fruit of guaranteed gustatory quality, the levels of total sugar and acidity at the time of harvesting must comply with whatever minimum marketing standards may have been set.

In practice, it has been observed that the refractive index rises from 0.7 to 1.0 and that acidity falls by 0.5 to 0.8 g/l of malic acid per week as the date of maturity approaches. Depending on the parameters laid down for the control operations, a refractive index of at least 14 and a level of acidity of 5 g/l are required when the crop is harvested if a satisfactory level of quality is to be attained.

The fruits on a given tree do not all ripen simultaneously ; so staggered harvesting is essential to the production of top quality fruit. In practice, the fruit can be picked from the top half of the tree before clearing the interior of the crown and the lower branches. But the quality of the first picking will be higher.

. Storage : For Golden Delicious, Starking, Richared and Granny Smith :

- For storage in a normal atmosphere, the recommended temperature for fruit picked at the optimum stage of maturity is about 0°C, with a maximum variation of ± 0.5°C and a relative humidity of 90 - 95%.

Loss of weight during storage must be carefully checked, and must not exceed 1% per month after the 2nd month in store. The period of storage should be short enough to preclude serious risk of the development of physiological disorders.

By measuring firmness and acidity at regular intervals it is possible to check whether quality is still at a satisfactory level. If firmness falls to less than 3 kg, or if acidity falls at a rate of more than 8% per month, immediate marketing is indicated.

- Controlled atmosphere storage. Fruit kept for more than 5 months must be stored in a controlled atmosphere, in order to preserve its acidity. The recommended storage temperature is 2.5°C ± 0.5°C, with a gas content of 5% carbon dioxide, 3% oxygen and 92% nitrogen. If the temperature is held below 2.5°C the carbon dioxide content of the controlled atmosphere must not be more than 3%.

To counteract the effects of oxygen starvation in the course of storage in a controlled atmosphere, the fruit must be after-ripened for ten days before it is put on the retail market ; this requires a temperature of 10 - 15°C if the fruit is not too ripe, or a lower temperature if it has already attained an advanced stage of the ripening process.

The varieties which are not very tolerant of cold conditions are stored at higher temperatures :

- Reinettes (Reine des Reinettes, Reinette du Canada : between + 4° and + 5°C
- Cox's Orange Pippin, Belle de Boskoop, Johathan, Calville Blanc : between + 3° and 4°C.

2 : VEGETABLES

Because their life cycle is short, vegetables are less dependent on the natural environment than are perrenial plants, and the potential quality of the various cultivars is therefore all the more important.

In addition, the process of varietal selection is more rapid and it can safely be assumed that the organoleptic properties of vegetables in general will be improved over a shorter period, than is possible with fruit, by breeding new varieties.

21 : Carrot

. Soil

To grow good quality carrots the soil must be light, sandy and rich in humus, without coarse elements which might distort the roots. But the soil must be properly balanced and sufficiently retentive of moisture. Chalk and clay should be avoided.

The presence of light substrates, in the form of river sand or calcareous marine deposits, as well as organic improvements in the form of marine algae such as seaweed, are particularly favourable to the growth of a top quality crop.

. Climate

A gentle climate, free from excessive fluctuations in temperatures, combined with a sufficiently humid atmosphere, will favour the growth of carrots. The choice of varieties and of growing periods is determined by the local climate.

There are two types of growing season :

- The period when the days are shortening and the growing conditions steadily become less favourable to the plant. This permits the development of the sugars to a satisfactory level, but it means the late-maturing varieties must be able to stand a certain amount of exposure to low temperatures ; carrots are spoiled by frost if the temperature falls to about $- 7^{o}C$.

- The period when the days are lengthening, as with spring sowings in favoured areas of production or where the seedlings can be protected from frost in the early stages of growth, in conditions in which precautions must be taken to prevent bolting.

. Varieties

The quality of the crop is highly dependent on the choice of a variety which is suitable for the local climate and for the length and type of growing season.

The smaller varieties are of the highest quality, but the yields are lower.

If quality is to be optimized, it is essential to keep up-to-date lists of authorized varieties for the different zones of production.

. Preparation of the soil

A fine tilth must be prepared, deep enough to allow the free development of the roots.

The seeds must be sown quickly but carefully, to obtain regular spacing and rapid growth. The best densities for maximizing quality are obtained when the rows are 20 - 25 cm apart (and certainly not more than 30 cm), and the optimum spacing within the rows is 3 cm. Incorrect sowing may need subsequent correction by hand thinning at the points in the row where densities are excessive.

But it may be necessary, in mechanized conditions, to space the rows 50 cm apart and to increase the density within the rows ; this means sowing 3 - 4 kg of carrot seed per hectare in the case of semi-long varieties of the Nataise type.

. Fertilizers

Rates of manuring and methods of application depend on the season. Carrots grown in the early part of the year need supplementary nitrogen, to compensate for the winter leaching of nitrates.

In that case, nitrogen must be applied at a maximum rate of 180 units per hectare, in three phases : the first dressing should be timed just before sowing, and the last should be completed at least two months before the crop is harvested. This last application must not include the types of nitrogen compound which can lead to the accumulation of nitrates in the roots.

When the crop is grown in the latter half of the year, and particularly in the zones of production where the climate is hot and dry in summer, it is important to allow for the accumulation of nitrates in the hot months and to reduce the rate of application, again in three phases, to a maximum of 120 units per hectare.

The rates of application of phosphatic fertilizers and potash will depend on the level of these elements in the soil. Over-generous applications of potash should be avoided, however, in the light soils in which carrots are grown, because the phosphates may find their way into the drainage channels. The required rate of application may be up to 200 units per hectare.

In any case, dressing with organic material, in the form of approximately 20 tonnes of well-rotted farmyard manure per hectare, is highly recommended.

. Irrigation

The crop should never be short of water, but care should also be taken to avoid the administration of excess water at certain periods. Depending on the climate, and on the season, the crop must be sprayed at frequent intervals, the exact rate of supply being based on the evaporation/transpiration requirements, so as to maintain a satisfactory balance of moisture between the upper and lower levels of the soil, because any imbalance may cause malformation and bursting of the roots.

. Soil management

Quality is improved by the use of chemical herbicides, before and after germination, because this precludes the development of competition with weeds in the early stages of the plants' development.

But the chemicals must be selective; they must not be phytotoxic as far as the carrots are concerned or taint the produce with any foreign flavour, and the rates and times of application must be such as will ensure that any residues present when the crop is harvested are within the limits laid down in the relevant regulations.

If the soil is loosened the roots are encouraged to thicken, and if the rows are slightly ridged the risks of green collar are reduced.

• Harvesting

The roots must be harvested when they are sufficiently developed to retain their turgicity and have developed the required concentrations of sugars and carotene.

The main criteria for determining the stage of development attained by carrots are the minimum diameter, which varies according to the cultivar, the firmness of the flesh, which must be sufficient to preclude breakage, and the colour of the root, which must have attained its specific intensity.

It is also important not to overstep the optimum harvesting date so as to avoid bursting and green collar and the risk of lignification of the heart at the end of the winter.

• Storage

Storage can be envisaged only for crops which are ready for harvesting in winter, and only for roots which are perfectly healthy. Storage in a controlled atmosphere is the best way to preserve quality, especially in terms of carotene content.

The optimum storage conditions are :

- temperature : between 0.5°C and 1°C
- relative humidity : 95%
- CO_2 : 3 - 5%
- O_2 : 2 - 3%

Carrots should be taken out of store as soon as the first buds emerge from the heart.

22 : Melon

• Soil

The best soils for growing melons of guaranteed quality are light, well-drained and easily warmed (sandy or pebbly) ; but they must be sufficiently retentive of moisture when the crop is not irrigated.

Melons can only ripen well in a hot climate with a dry atmosphere. In greenhouse conditions, the minimum temperature should be 16 - 18°C and the maximum 26 - 28°C, depending on the intensity of the lighting conditions.

. Varieties

The choice of varieties for growing top quality melons depends on the cultural techniques adopted and on the length of the growing cycle. In each case, there is a need to establish up-to-date list of cultivars of acceptable quality which are sufficiently rich in sugars and capable of a high rate of output of the aromatic substances.

. Preparation of the soil

A well-ventilated medium is required, to encourage root formation. The seeds may be sown in situ, or on soil blocks which are then planted out. In the latter case, the substrate must be satisfactorily serated, sufficiently compact, and the pH value must be between 6.5 and 7.

This technique favours the development of quality, because planting out can be timed for a favourable climatic period. Straw mulches and plastic tunnelling provide greater warmth in the soil and preserve the supply of water, and are therefore also beneficial to quality.

Recommended planting densities :

- 8 500 - 10 000 plants/hectare maximum in the open

- 15 000 - 25 000 plants/hectare in greenhouses

. Pruning

Pruning is essential to quality, and must be carried out sufficiently early to avoid eliminating the adult leaves which have a role to play in the formation of dry matter.

With Cantaloup melons, three separate pruning operations are required : topping at 2 leaves, pinching-off at 4 - 6 leaves and final pinching-off at 3 leaves.

. Fertilizers

An early dressing of nitrogen, at the time of planting, and a good balance between phosphorus and potassium encourage flowering and the development of sugars.

The best way to apply phosphorus and potash is in localized soluble form when the soil is being prepared ; the exact rates are determined by the levels of these elements already present in the soil.

A sharp lookout should also be kept for any risks of deficiencies, especially of magnesium, which exercises a major influence on flowering and photosynthesis.

The rates and dates of application of the various elements depend on the type of soil and the cultural conditions :

- In non-irrigated conditions a single dressing of nitrogen is applied at the beginning of the vegetative period, at a maximum rate of 80 - 100 units per hectare. For normal soils, the balance with the other elements is usually N = 1 ; P_2O_5 = 1 ; K_2O = 1.5.

- In irrigated conditions, in alluvial soils with an adequate proportion of fine particles, the nitrogen is also provided in one application, at a maximum rate of 150 units/hectare. For light pebbly soils, the rate is raised to 180 units, and three applications are required : 1/2 before planting, 1/4 when the first female flowers appear and the remaining 1/4 at the very latest within a fortnight of fruit set.

The recommended balance vis-à-vis the other elements is approximately as follows : N = 1 ; P_2O_5 = 0.75 - 1 ; K_2O = 1.25.

• Irrigation

When melons are grown under irrigation, the supply of water must be geared to the stage of development attained by the plant.

Between planting and fruit set, the supply must be steadily increased from 45 - 50% of PET, and to 70% while the fruits are swelling, until one month before harvesting, when the supply must be reduced to 40% of PET.

• Plant protection

The main plant protection operations are aimed at preventing the development of leaf mildew and contamination of the fruits with anthracnose and cladosporium. The foliage must be kept completly free from disease throughout the growing period if high quality fruits are to be grown.

The best way to combat fusarium disease is to grow resistant varieties. The incidence of virus infections can be reduced by spraying with aphicides.

• Harvesting

Top quality melons must be carefully harvested at the optimum stage of ripeness, as determined by the appearance on the fruit, around the end of the stalk, of a ring of finely cracked skin, and by the increased curvature of the stalk, which becomes tendrilled and woody while the skin changes colour and develops a lighter mottling.

This visual assessment can be confirmed by measuring the firmness of the fruit.

. Storage

The refrigerated storage of this species is a risky technique which can only be applied to top quality melons to slow their development in the course of transit. The recommended storage temperature is + 1 °C.

23 : Potato

. Soil

Potato-growing soils can be sandy, peaty, or even moderately loamy, and they should not be hydromorphic. Heavy or compacted soils, and those with a clay content of more than 25% are to be avoided ; otherwise, the quality of the tubers will suffer.

. Climate

The climate for growing high quality potatoes should be gentle, humid and moderate. Hot climates should be avoided, and so should the hottest period of the year in the zones of production located in the south of Europe.

. Varieties

The starch content of potatoes varies considerably between varieties. Only the varieties with a low dry matter content, equal at most to the starch content of the Bintje variety, for example, can qualify for marketing as high quality produce. As a guide, the gustatory ratings of the potatoes to be found in the official French list of varieties have been set down in the following table :

Classification of the relative gustatory quality of certain varieties of potatoes (269) (270)

Very good :

Belle de Fontenay
Rosa

Good :

BF 15
Keltia
Roseval
Rosine
Stella

Very satisfactory :

Arnica	Hansa
Aura	Kerpondy
Bintje	Prima
Donor	Radosa
Eba	Trophée
Eersteling	Viola

Satisfactory :

Aniel	Eba
Apollo	Early Rose
Bea	Jose
Binova	Lenor
Caterina	Ostara
Daroli	Resy
	Sirtema

. Preparation of the soil

The soil must be well worked, clean, and free from couch grass. The seed potatoes must be small and carefully selected, and the stock must be renewed at least every second year.

Planting densities should allow for minimum distances of 62 - 65 cm between the rows and 35 - 40 cm between the plants.

. Fertilizers

Tubers of satisfactory quality can only be grown if the plants are provided with an adequate supply of nitrogen and potassium.

The rate of application of nitrogen must be between 120 and 180 units per hectare, with 100 units of phosphoric acid and 180 units of potassium, depending on the richness of the soil. The rate of potash must keep the level of potassium in the leaves above 5% of the dry matter, 70 - 90 days after planting, so as to reduce the susceptibility of the tubers to internal blackening when bruised.

. Irrigation

A regular supply of water is essential to quality. Moderate amounts may be given at regular intervals in hot regions of production or in dry periods.

. Plant protection

Effective protection must be provided against click beetles, colorado beetles and mildew. But the products used must not communicate any foreign flavour to the tubers.

. Defoliation and harvesting

The tops must be destroyed long enough before the harvest, with due allowance for the climatic conditions in each individual year, to prevent the development of too much dry matter.

Chemical defoliants must only be used on humid soils, and not when the weather is too hot. After treatment, the tubers should be left in the ground for a period of 2 - 4 weeks before harvesting, to reduce the dry matter content and to permit the suberization of the skin.

With mechanized harvesting, care must be taken to protect the tubers from mechanical damage in the course of lifting and transport, and it is particularly important to avoid spillage from a height of more than 50 cm, so as to preclude the risk of internal blackening before the potatoes reach the consumer.

. Storage

The tubers must be stored in clean and well-ventilated conditions, at a temperature of 8°C to avoid the development of sugar. Chemicals such as CIPC and IPC (1) must be used to inhibit the germination of potatoes stored for a protracted period.

Before the crop is harvested the storage premises must be disinfected with products which will not communicate any foreign odour to the tubers.

24 : Salad vegetables

. Soil

Typical vegetable-growing soils, with a good structure, are essential for the production of high quality salad crops ; they must be permeable, fertile and rich in organic matter.

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(1) CIPC = chlorprophame
IPC = prophame

. Climate

Climatic factors decide the choice of variety, which depends in particular on the duration of daylight and on maximum and minimum temperatures.

Generally speaking, the climate for growing quality salad crops should not be subject to sharp fluctuations, so as to avoid the effects of sudden changes in the rate of growth which can seriously impair the quality of the leaves.

As far as greenhouse culture is concerned, the temperatures must be kept suitably low. No extra heat should be given in autumn, beyond what is needed as a protection against frost. In winter and spring, the temperature must be kept down to 6 - 8°C at night and to 10 - 18°C in the daytime at the start of the growing period, and then lowered to 2 - 6°C at night and 8 - 12°C in the daytime, when the heads are beginning to develop and the leaves cover the surface of the soil. Permanent heating must be stopped as soon as the days become noticeably longer in January. Nevertheless, the temperature in cool greenhouses should not be allowed to fall below - 2°C, to avoid the danger of crinkled leaves.

. Species and varieties

The suitability of the variety for the cultural conditions is a key factor in the quality of salad vegetables.

- Lettuces grown in the open air can be divided into two categories :

. Those grown when daylight hours are shortening, which must be resistant to cold conditions. The leaves are generally well-coloured and sometimes develop anthocyanins; the blades are thick and somewhat curled. The plants develop slowly, and can achieve top quality ; one example is Trocadero, grown in the open in areas with a mild winter, which can be distinguished by its slightly "acid" taste compared with the sweetish flavour of certain other varieties ;

. Those grown when daylight hours are lengthening, which develop more rapidly, have a finer texture and are paler in colour.

- Greenhouse lettuces are also of two types :

    - White-hearted varieties with slightly curled leaves and a fairly firm head, mainly grown in heated greenhouses in northern areas;

    - Green lettuces, with smooth thick leaves and a well-formed head, of higher average weight, mainly grown under unheated cover in southern regions of lettuce production.

- Endives, both broad and curled-leaves, are mainly grown in the open air as a late-season crop.

A select list of cultivars suitable for the various types of cultural conditions must be kept if the aim is to grow high quality produce.

. Preparation of the soil

Salad crops can be sown in situ or they can be grown on blocks. If the seeds are sown direct, the soil must be carefully prepared, to ensure uniform germination and adequate density.

The best results can be obtained with pelleted seed. If blocks are used, the supply of nutrients can be controlled from the outset, and planting-out can be timed to coincide with optimum conditions for vegetative growth.

Optimum densities for growing high quality salad crops are as follows :

- Greenhouse lettuces : 14 - 16 plants per m^2
- Open-air lettuces : 8 - 12 plants per m^2
- Endives : 6 - 8 plants per m^2

. Fertilizers

Salad crops grown under cover need supplementary nitrogen, at a maximum rate of 100 units per hectare. Grown in the open, they require up to 150 units of nitrogen, balanced by phosphorus and potash in the following proportions : $N = 2$; $P_2O_5 = 0.5$; $K_2O = 1 - 1.5$, depending on the levels already present in the soil.

1/5 of the nitrogen is applied at the time of sowing or planting out, 2/5 two weeks later and the remaining 2/5 when the heads are beginning to develop, but only if the temperature is above 12°C.

Special care must be taken to compensate for deficiencies in specific trace elements, especially magnesium, boron, molybdenum and zinc.

. Irrigation

Sudden accelerations or decelerations in the rate of vegetative growth are to be avoided if the aim is to produce salad crops of satisfactory quality. The right balance of moisture must be maintained at all times, depending on the requirements of the crop calculated at 70 - 80% of PET, both under glass and in the open.

Water should be applied at intervals of not more than one week.

. Soil management

Chemical herbicides can be applied before and immediately after germination, and on the blocks before planting out ; they should not leave any toxic residues on the young plants.

. Plant protection

When salad vegetables are grown under glass, a close watch on ventilation and maximum temperatures, combined with low planting densities, will prevent the proliferation of disorders such as botrytis, bremia lactucae and sclerotinia disease.

By taking these precautions, one can reduce the intensity of treatment with pesticides. The dates of application and the characteristics of the chemical products must be carefully chosen, to ensure that any toxic residues, and especially any carbamates, that are present on the leaves when the crop is harvested do not overstep the permitted limits.

Special precautions must be taken when treating seedbeds and in the early stages of the vegetative cycle, so as to reduce the need for treatment with pesticides at too advanced a stage in the vegetative cycle.

. Harvesting

The crucial characteristic of salad vegetables is their freshness ; so every precaution must be taken to avoid wilting, by not harvesting in the hottest hours of the day and by not watering in the 48 hours before harvesting, which should be timed to coincide with optimum development, as determined by average weight, size and possibly the shape of the head.

When the crop is harvested, the base leaves must be trimmed off, and the produce must not be piled too deep in the packages.

The produce must be moved rapidly, to avoid the risk of rising temperatures and the development of bacterial fermentation.

. Storage

The freshness of salad vegetables must be preserved ; so they must be kept in cool conditions. For long-distance movement, vacuum cooling is a particularly useful technique for preserving quality, and may be combined with an nitrogen enriched atmosphere (284).

25 : Tomato

. Soil

Top quality tomatoes can only be grown in soils that encourage root formation, e.g. moist sandy loams with at least 2% of organic matter. Heavy or clayey soils are unsuitable.

. Climate

The tomato is a plant of tropical origin, and it needs a hot climate with a minimum soil temperature of 15°C if it is to grow satisfactorily. But temperatures above 30°C inhibit fertilization and tend to impair colour, especially around the stalk cavity. The growing season must therefore be timed with those two requirements in mind, or the quality of the crop will suffer.

Glasshouse temperatures must be adjusted to the intensity of illumination. When daylight hours are limited, the temperature of the soil must be kept between 15°C and 18°C (276) and the air temperature at about 15°C ; then, as the days lengthen, the night temperature should gradually be raised to 13 - 17°C and the daytime temperature to 17 - 24°C, with a relative humidity of 70%.

Early crops of tomatoes grown under plastic tunnelling need good ventilation to prevent the development of excessively high temperatures during the daytime. The most effective system consists in piercing a hole, 10cm in diameter, at intervals of 1m along the ridge of the tunnel and then doubling the number of holes when high temperatures make this necessary.

. Varieties

There are many different varieties of tomatoes, of widely differing habit. The varieties of indeterminate habit can grow into extremely large plants, while those of determinate habit will be limited to a certain number of trusses per stem.

The production of high quality tomatoes depends on the careful choice of the right cultivar for the local climatic conditions and growing season. The sixe of the fruit varies greatly, depending on the number of locules.

Generally speaking, the potential of small tomatoes with 2 or 3 locules is rather limited. If the aim is to produce high quality fruit, the grower must choose a medium-large variety that is regular in shape, firm and attractively coloured, with a minimum of green colouring around the stalk.

. Preparation of the soil

As soon as growth begins, the young plants must be given the best possible growing conditions and encouraged to form a good rooting system. So they must be raised on blocks in a nursery, avoiding any check to growth when the seedlings are planted out.

For plants grown in the open, the planting-out operation must be carried out when the temperature is high enough to ensure a good start.

. Densities

To produce high quality fruit, the plant must receive adequate light, and it is therefore advisable to avoid excessively high densities. These must be adapted to the local climate, and depend on the extent to which conditions are favourable to growth. Thus, when the plants are grown at the beginning of the season, when the days are long, greater densities are possible than with crops grown when the days are shortening.

The following maximum densities are recommended :

Under glass :

spring crop, varieties of determinate habit ; 3 - 3.5 per m^2

spring crop, varieties of indeterminate habit : 2.5 - 3 per m^2

autumn/winter crops : 2 - 2.5 per m^2

Open air :

early : 3 per m^2

maincrop : 2 - 2.5 per m^2

late season : 1.3 per m^2

. Pruning

Disbudding and proper training are essential operations in the production of high quality tomatoes. The aim is to optimize the spacing of the fruits and to maintain the right balance between fruiting and vegetation.

The training technique consists in encouraging the development of a single stem and in stopping growth at 3 - 6 clusters of flowers. In the greenhouse or under cover, the plants develop more vigorously and the top is pinched out of the single stem after 6 - 8 clusters.

Disbudding must begin as soon as the axillary buds provoked by pruning begin to appear.

The removal of surplus leaves, especially from greenhouse crops, is a practice which always has a favourable effect on the quality of the fruits, which are better aerated and receive more light. The operation consists in progressive removal of the senescent leaves from the base of the plant, as soon as they begin to turn yellow, after the 3rd and 4th trusses have flowered. This removal stops short at 1 or 2 leaves below the first truss in which the fruits change colour by blanching when maturity approaches.

The more vigorous the variety, the more leaves must be removed.

. Improvement of fruit set

To obtain regular crops of high quality, it is necessary to ensure very good fertilization of the maximum possible number of seeds in each fruit. Although tomatoes are self-fertile, the level of fertilization can be adversely affected by lackoof light, by temperatures that are too high or too low, by excessive applications of nitrogen or by excess humidity.

Under glass, when one of these problems arises, the rate of fertilization can be improved by provoking the liberation of pollen by means of electrically-induced vibration (twice) of each cluster of flowers, by shaking the cluster with the aid of a pneumatic spray or by agitating the entire plant by tapping the stem with a supple cane.

. Fertilizers

Tomatoes bear very large crops when the environmental conditions are favourable, especially under glass.

Tomatoes require very large amounts of fertilizer, but these must be provided in moderate doses at frequent intervals. It is important to maintain a balance between nitrogen and potassium. Depending on the cultural conditions, the rate of application of nitrogen should be limited to 150 - 200 units per hectare, and the doses of phosphoric acid and potassium should be carefully regulated so as to ensure the right balance between the three elements, which is approximately : $N = 1$; $P_2O_5 = 0.5$; $K_2O = 2$.

Magnesium is also very important, and any deficiency of this element can be detected by foliar analysis.

. Irrigation

To ensure uninterrupted growth, any shortage of water must be made good by irrigation, which must be as regularly spaced as possible.

When tomatoes are cultivated entirely in the open, 60% of PET requirements must be met by irrigation between planting out and the formation of the 3rd cluster of flowers, after which 80% of PET must be provided up to the start of the harvesting period, when the supply must be reduced to 60%.

Under glass, irrigation must increase progressively from 60 to 80% of PET, as the plants grow from 40 to 75 cm. After the 4th cluster of flower has opened, 90% of PET must be provided.

. Plant protection

As far as quality is concerned, the most serious diseases of the tomato are vascular, viral ar bacterial in origin, while certain fungi such as mildew or blight can also wreak havoc.

The best method of protection is to grow the resistant varieties which the breeders are developing from year to year and to ensure that the development of the various diseases is not encouraged by the cultural conditions. In particular, rates of irrigation and the supply of nitrogen must be regulated to suit the temperature and lighting conditions.

In such conditions, it is possible to reduce the frequency of application of chemical products. The type of product chosen, and the rate of application must be such as will preclude the persistance of excessive residues when the crop is harvested.

. Harvesting

Tomatoes attain maximum organoleptic quality if they are picked just when they are beginning to redden.

The fruits remain tasteless if they are picked when they are still too green, and become mealy if they are picked in too ripe a condition. The optimum moment for picking is when the colour is "turning", i.e. when the rosy-red blush is beginning to develop in the area of the pestil.

Depending on the ambient temperature, the red colour must have developed on 1/5 - 1/3 of the total surface area of the fruit.

. Storage

The storage of tomatoes is fraught with difficulty, low temperatures upset the evolution of the fruit. There should be no cooling beyond what is required to regulate the development of the product in the course of movement and marketing.

Tomatoes must be stored at relatively high temperatures : 12°C for fruits that are "turning" and 10°C for fruits that are already entirely red.

A N N E X   3

ANNEX 3

Practical recommendations for the preservation of quality in the course of transport and distribution

Recommended minimum sizes for all classes
of fruit and vegetables for guaranteed gustatory quality

Fruit	Minimum size	Tolerances	
		by number	Maximum difference in a single package
Apricots	30 mm	10 %	± 2,5 mm
Cherries	20 mm	10 %	- 3 mm
Peaches			
- before 10/07 - after 10/07	56 mm 62 mm	10 %	± 3 mm
Pears	60 mm	10 %	± 5 mm
Apples (x)	65 mm	10 %	± 5 mm

Vegetables	Minimum size or minimum unit weight	Maximum size or maximum unit weight	Maximum difference in a single package
Carrots for storage	20 mm ou 50 g	40 mm ou 150 g	20 mm ou 100 g
Melons	450 g	-	150 g
Potatoes	35 mm	70 mm	20 mm
Salad vegetables:			
- lettuce (open air)	350 g	-	100 g
- lettuce (greenhouse)	250 g	-	100 g
Endives:			
- broad-leaved	800 g	-	150 g
- curled-leaved	400 g	-	100 g
Tomatoes	4o mm	80 mm	10 mm

(x) Only applies to large-fruited varieties (in the absence of research results for small-fruited varieties).

A N N E X 3

Main types of packages suitable for fruit and vegetables of measured gustatory quality

Fruit	Type of package	Capacity or dimensions	Characteristics
Apricots	Baskets or boat-shaped containers with handles	0,500 kg to 2 kg	Loose
	Trays	40 x 30 cm 50 x 30 cm 60 x 40 cm	1 or 2 layers
Cherries	Baskets or boat-shaped containers with handles	0,500 kg to 2 kg	Loose
	Small boxes	2 - 4 kg	Loose, arranged with stalks underneath
	Trays	40 x 30 cm 50 x 30 cm	Loose, stalks underneath
Peaches and Pears	Boat-shaped containers	3 - 10 fruits	In rows
	Baskets or boat-shaped containers with handles	1 - 2 kg	1 layer
	Trays	40 x 30 cm 50 x 30 cm 60 x 40 cm	1 layer with moulded tray or protective cushion
Apples	Boat-shaped containers	3 - 8 fruits	In rows
	Baskets or boat-shaped containers	1 - 3 kg	1 layer
	Trays	40 x 30 cm 50 x 30 cm 60 x 40 cm	1 or 2 layers
	Cardboard boxes	bushel or 1/2 bushel	Layers, tray-pack or loose for cat. I & II

Vegetables	Type of package	Contents or dimensions	Characteristics
Carrots	Bunches with leaves Cotton net bag or perforated plastic bag Trays, cardboard boxes or net bags	10 - 20 0,5 - 2 kg 10 kg	tied loose loose
Melons	Trays	50 x 30 cm 60 x 40 cm	1 layer
Potatoes	Cotton net bag or perforated plastic bag Cardboard boxes or net bags	1 - 3 kg 15 kg	loose loose
Salad vegetables	Perforated plastic bags Trays	units 50 x 30 cm 60 x 40 cm	- in rows, face to face
Tomatoes	Boat-shaped containers Baskets or boat-shaped containers with handles Trays or cardboard boxes	6 - 12 fruits 1 - 2 kg 40 x 30 cm 50 x 30 cm 60 x 40 cm	in rows in rows 1 or 2 layers

Recommended sampling procedures

Control of representativity

The minimum numbers of packages to be checked can be determined according to the following table :

Number of packages constituting the lot	Number of packages to be checked
less than 100	5
100 - 300	7
300 - 500	9
500 - 1000	10
1000^{+}	15

Number and composition of limited samples

Limited samples taken from produce that has already been sorted and sized must comprise at least 30 units of fruit or vegetables. This number is raised to 50 if the produce is unsorted after harvesting, provided the composition of the lot is sufficiently uniform. If not, a preliminary sorting operation is necessary.

Depending on the size of the lots, a limited sample can be taken per fraction of 5 000 kg of fruit from the same origin, up to 15 000 kg. Above that tonnage, the first control can be limited to three samples, if the three results agree ; but if one of the results is significantly different from the other two, further samples must be taken at the rate of one sample per 15.00 kg. The final statistical result is the mean value of the results obtained from all the restricted samples.

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