

## OECD GUIDANCE ON OBJECTIVE TESTING TO DETERMINE THE RIPENESS OF FRUIT

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### A B S T R A C T

Trading fresh fruit and vegetables means that the produce has to be graded, packed and labelled according to international marketing standards. UN/ECE, OECD, CODEX and EU are international bodies working on such standards. To harmonise the work of the inspection services the OECD "SCHEME for the Application of International Standards for Fruit and Vegetables" elaborates explanatory brochures for the standards and guidelines for quality control operations and the "Guidance on objective tests for determining the ripeness of fruit".

In order to verify the compliance with the minimum maturity requirements; it is an important goal to have, beside the morphological appearance and the taste of the produce, objective measurable criteria which constitute a suitable tool to determine the optimal ripeness or the sufficient development. The Guidance is currently under revision and would describe those methods of objective testing of fruits that have turned out to be beneficial to both, inspection services and the fruit industry in general, in determining acceptable levels of ripeness to identify the right harvesting time and/or the optimal point of sale.

**Key words:** OECD Guidance, OECD Scheme, marketing standards for fruit and vegetables, ripeness of fruit, quality inspection

The fruit and vegetable market has become an international market. Consumers demand well developed produce at the peak of ripeness. International marketing standards are needed in order to avoid problems in trading fruit and vegetables on national and international markets.

Marketing standards are being drafted by various international bodies, including three UN agencies: UN/ECE, CODEX and OECD.

The European Union has published its own EU-Marketing Standards which are binding not only for trade within the Community, but also for the import and the export of fresh fruit and vegetables. These standards are fully harmonized with the Standards of UN/ECE and CODEX.

#### UN/ECE – United Nations / Economic Commission for Europe:<sup>1</sup>

The standards are discussed in the Specialized Section on Standardization of Fresh Fruit and Vegetables. Those accepted by the Working Party on Agricultural Quality Standards are in force for trade into and within the UN/ECE Member States. There are also standards for dry and dried fruits and ware potatoes. Meetings take place every year in Geneva. UN/ECE has 55 member countries, including non-European countries such as the USA, Canada and Israel. Some other countries, including New Zealand, Brazil, Chile and Thailand, participate as observers.

#### CODEX Alimentarius:<sup>2</sup>

The Codex Alimentarius Commission develops food standards, guidelines, codes of practice and related publications as part of the Joint FAO/WHO Food Standards Programme. The main purposes of this Programme are to protect the health of consumers, to ensure fair trade practices in the food trade, and to promote the coordination of all food standards by international governmental and non-governmental organizations.

Members are all UN Member States. The CODEX COMMITTEE ON FRESH FRUIT AND VEGETABLES currently meets every one-and-a-half years in Mexico City. Where UN/ECE standards exist, they serve as the starting point for further discussions.

#### OECD - Organisation for Economic Co-operation and Development:<sup>3</sup>

Within the OECD, the SCHEME for the Application of International Standards for Fruit and Vegetables adapts quality standards to current production, trade and marketing conditions, promotes uniform quality control procedures, and disseminates quality assurance guidelines. To harmonize and distribute the work, the UN/ECE standards are recognized and accepted. The SCHEME focuses on publishing explanatory brochures and guidelines, but also deals with topical questions arising from the fruit trade.

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<sup>1</sup> Web-site address: [www.unece.org/trade/agr/welcome.htm](http://www.unece.org/trade/agr/welcome.htm)

<sup>2</sup> Web-site address: [www.codexalimentarius.net](http://www.codexalimentarius.net)

<sup>3</sup> Web-site address: [www.oecd.org](http://www.oecd.org)

European Union:

Within the European Union, EC-marketing standards have been enacted which are binding for trade within the Community as well as for imports from and exports to third countries. A group of experts is responsible for standardization and inspection of commercial fresh fruit and vegetable quality. This group discusses and elaborates marketing standards before they are adopted by the Management Committee.

Council Regulation (EC) No 2200/96 on the common organization of the market in fruit and vegetables<sup>4</sup> is the legal basis for enacting marketing standards. UN/ECE standards are taken into account. Therefore, the different international standards are well harmonized.

Close cooperation among these standard-setting bodies is the key to worldwide harmonized marketing standards.

After this short review, I would like to discuss the

OECD SCHEME FOR THE APPLICATION OF INTERNATIONAL STANDARDS FOR FRUIT AND VEGETABLES.<sup>5</sup>

22 countries currently participate in the SCHEME. The plenary meeting usually takes place every year in Paris. Observers include international governmental organizations, such as UN/ECE and CODEX, and NGOs, such as the European Fresh Produce Association, CLAM<sup>6</sup> and COLEACP<sup>7</sup>. Working groups will be set up to write explanatory brochures and guidelines and to prepare work on different topics.

The objectives of the Scheme are:

- to promote the use of an internationally recognised control certificate;
- to improve conditions for maintaining the quality of produce during transport and handling;
- to promote international standardization of packaging<sup>8</sup> and labelling<sup>9</sup>;
- to improve conditions and quality assurance operations.

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<sup>4</sup> Council Regulation (EC) No 2200/96 of 28 October 1996 on the common organization of the market in fruit and vegetables; Official Journal L 297, 21/11/1996 p. 0001 – 0028.

<sup>5</sup> Document C(99)10/FINAL.

<sup>6</sup> Liaison Committee for Mediterranean Citrus Fruit Culture (CLAM).

<sup>7</sup> Liaison Committee for the Promotion of Tropical Fruits and Out-Season Vegetables derived from ACP Countries (COLEACP).

<sup>8</sup> Recommendation of the OECD Council on the Standardization of Packaging for the International Transport of Fresh and Refrigerated Fruit and Vegetables (Doc C(76)124 final).

<sup>9</sup> Recommendation of the OECD Council concerning General Provisions for the Labelling and Identification of Fresh Fruit and Vegetables (Doc C(72)100 final).

The Scheme helps producers, traders and quality inspectors in:

- developing and revising standards in cooperation with the UN/ECE;
- developing explanatory brochures for standards with photos;
- developing tools to determine skin color in various products;
- providing guidance in applying quality assurance and inspection systems.

More than twenty explanatory brochures are currently published. Until 2000, they were available only as bound publications. Since 2000, they are also available in loose-leaf and electronic format:

Avocados (2004), broccoli (2000), carrots (2000), plums (2002), lettuce and endives (2002), asparagus (2000) and tomatoes (2003).

The following explanatory brochures are in preparation and will be hopefully be published in the next two or three years:

Apples, pears, citrus fruits, strawberries, kiwi fruit, table grapes, beans, cucumbers, cultivated mushrooms and potatoes.

To coordinate the work of the inspection services, the SCHEME has published “**Guidance for quality control operations for produce exported under the SCHEME**”<sup>10</sup>. These guidelines are fully compatible and consistent with Commission Regulation (EC) No 1148/2001, which deals with checking for conformity to the marketing standards applicable to fresh fruit and vegetables<sup>11</sup>.

### **OECD Guidance**

To harmonize testing methods for internal fruit quality, the SCHEME published “**Guidance on Objective Tests for Determining the Ripeness of Fruit**”<sup>12</sup> in 1998. The reason for elaborating this Guidance was an increased awareness that, from the point of view of the consumer, fruits have to be at the right stage of ripeness and possess the organoleptic characteristics expected for the species and variety. The Guidance describes objective measurable parameters:

- to determine the correct time for harvesting,
- to determine the optimal time for selling, and
- to assist the inspection body.

### **Minimum requirements**

In all marketing standards, minimum requirements are defined:

“The produce must be sufficiently developed, and display satisfactory ripeness, depending on the nature of produce.

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<sup>10</sup> Annex II of Council Decision C(99)10/FINAL.

<sup>11</sup> OJ EC, L 156, 13.6.2001, p.9.

<sup>12</sup> Doc AGR/CA/FVS(1993)11/REV6.

The development and condition of the produce must be such as to enable them to withstand transport and handling, and to arrive in satisfactory condition at their destination.”

Depending on the fruit, objective measurable **maturity requirements** are defined for different standards, such as:

- total soluble solid as sugar content (refractive index),
- juice content,
- firmness (penetrometric index),
- dry matter content,
- skin color,
- sugar/acid ratio,
- moisture content.

In the standard for apples, which is currently under discussion in UN/ECE and EU, the draft text concerning the minimum maturity requirements reads as follows:

“In order to verify minimum maturity requirements, several parameters should be considered, including morphological appearance, taste, firmness and refractive index. If refractive index of the flesh is measured, the Brix degree must be greater than or equal to 9°. However, for the varieties ‘Annurca’, ‘Cripps Pink’, ‘Fuji’, ‘Golden Delicious’, ‘Pinova’, ‘Rafzubex’, ‘Rafzubin’, and their mutants, this value must be greater than or equal to 10°.”

Depending on the fruit, different minimum or maximum criteria are defined in the standards to guarantee ripeness or satisfactory development. The Annex contains a list of standards with given maturity requirements.

The Guidance describes those methods of objective testing of fruits which have turned out to be useful to both inspection services and the fruit industry in general in determining right harvesting and selling times. In the current Guidance, only four testing methods are described: iodine solution, total soluble solids (TSS), and fruit acids by titration.

The SCHEME is currently revising the Guidance. These four methods will be revised and new methods will be added. The new draft of the Guidance comprises the following eight methods which can be carried out easily by inspectors during import, export, packing, wholesale distribution and retail sale:

1. TOTAL SOLUBLE SOLIDS (TSS) by refractometry;
2. FIRMNESS of fruit by penetrometer;
3. FRUIT ACIDS by titration and calculation of the SUGAR/ACID RATIO;
4. JUICE CONTENT;
5. DRY MATTER CONTENT by laboratory method or quick microwave-oven method;
6. TOTAL SOLUBLE SOLIDS (TSS) by VIS-NIR;

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7. STARCH CONTENT of apples and pears using an iodine solution;
8. SKIN COLOR using OECD color charts.

### **1) Total soluble solids (TSS) by refractometer**

Sugar content is a good indicator of the developmental stage of many fruits, including apples, pears, peaches, nectarines, strawberries, plums, melons and watermelons. Refractometry can be carried out in an easy, fast and flexible way and that it does not have to be performed in a laboratory.

### **2) Firmness**

For some fruits, the market sets minimum and maximum acceptable firmness for fruit flesh. Apples should be firm. On the other hand, peaches, nectarines and avocados should not be too firm. Firmness is therefore a good and practical indicator of the stage of ripeness.

### **3) Fruit acids and TSS/acid ratio**

Acid content is an important parameter for different fruits. A well-balanced and harmonious ratio between sugar and acid indicates that the fruit is at the optimal stage of ripeness. The TSS/acid ratio is particularly useful for citrus fruits and table grapes.

### **4) Juice content**

Juice content is a main criterion for juice fruits like citrus fruits. Oranges and mandarins which contain less than the minimum juice content are dry and flavourless.

### **5) Dry matter content**

For several fruits, dry matter content is a good indicator of ripening potential, especially in avocados and kiwi fruit. This method entails some difficulties, as a laboratory is required and it takes a long time until the results are available. In addition to the laboratory method, a quicker method using a microwave oven will also be described in the Guidance.

### **6) VIS-NIR**

Non-destructive methods are the future in fruit quality testing. Because these methods are currently prohibitive in terms of practicability and cost, the Guidance will only briefly describe these methods and explain in a very general way how optical spectroscopy in visible (VIS) and near infrared (NIR) spectrum work. Later, these methods may be included in the Guidance.

### **7) Starch index**

Determining starch content by using an iodine solution is a quick and useful method to check ripeness in apples and, to a lesser extent, pears at

harvest time. Starch content increases rapidly after harvest, even in underdeveloped and unripe fruits. Therefore, starch content is useful only if measured at harvest time and is not useful if measured later in the marketing chain.

## 8) Skin color

Skin color, background color and blush are among the characteristics perceived first by the consumer. In the apple standard, a minimum blush is defined for a large number of varieties. Color is a reliable indicator of ripeness in various fruits, including tomatoes and bananas. To ensure uniformity within a package, skin color has to be more or less uniform. The OECD and the private sector have developed a wide range of color charts.

Because I cannot mention all methods specified in the Guidance in this presentation, I would like to explain the structure with the example of determining TSS content by refractometer.

### How to take a sample

To get a result which is representative for the whole lot, attention must be paid to correct and objective sampling. An introductory chapter of the Guidance will summarize the sampling method describe in “Operational Guidelines for the Control of the Quality of Produce Exported under the SCHEME”<sup>13</sup>.

Proper quality control means assessing bulk samples at random from different places in the lot to be inspected. It assumes that the quality of the bulk sample reflects the quality of the whole lot.

In the first step, a given number of individual samples (Primary sample) have to be taken from the lot. The minimum numbers are:

Packed produce		Produce in bulk	
Number of packages in the lot	Number of packages to be taken (primary samples)	Quantity of lot, in kg or number of bundles in the lot	Quantity of primary samples to be taken in kg or numbers of bundles*
Up to 100	5	Up to 200	10
101 to 300	7	201 to 500	20
301 to 500	9	501 to 1000	30
501 to 1000	10	1000 to 5000	60
over 1000	15 [min]	over 5000	100 [min]

\*In the case of bulky fresh fruit and vegetables (over 2 kg per unit), the primary samples should be made up of at least five units.

In the second step, a representative quantity is taken from the bulk sample which is large enough to allow the assessment of certain individual criteria

<sup>13</sup> Document AGR/CA/FVS(98)REV1.

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(Reduced sample). These reduced samples are checked for degree of development and ripeness. With destructive testing, the size of the reduced sample should not be larger than 10 percent of the bulk sample.

The Guidance specifies the methods for testing in the following order:

- Instrumentation,
- Checking, using and calibrating instruments,
- Sample collection,
- Sample preparation,
- Measurement, and
- Recording results.

Whenever possible, illustrative photographs will be included for clarity.

### **Sampling**

A sample of at least ten random fruits of each size class from the reduced sample is needed to evaluate the lot selected for inspection. With small fruits such as strawberries and cherries, at least four fruits from ten sales packages are necessary. For some methods, the minimum number of fruits is larger.

Fruits should be free from defects which may have affected the normal ripening process, such as sun scorch, pest damage and disease damage.

I will explain the methods presented in the Guidance using measurement of refractive index as an example.

### **Sample preparation**

Specific methods for sample preparation or juice extraction given in marketing standards or OECD brochures should be followed.

In the absence of such guidelines, sample preparation and juice extraction should be performed as follows:

#### **Apples, pears, peaches/nectarines:**

From each fruit two longitudinal slices from stem to calyx are taken, one from the side with the most intense color, and the other from opposite side. Each slice is squeezed longitudinally to get a mixture of juice from all regions.

#### **Kiwi-fruit:**

(OECD brochure): Cut the stem and blossom ends 15 mm from each end of the kiwi fruit. Extract juice from each cut end.

#### **Melons:**

Using a small diameter metal borer (1-4 mm), take a core at the equator. Discard each end of the core, that is the skin and the flesh area immediately



beneath it, and the soft pulpy seed area. Extract juice from the central portion of the core.

### **Watermelons and an alternative method for melons:**

Two longitudinal slices from stem to calyx are taken, one from the side that was in contact with the ground during growth and one from the opposite side.

### **Measurement**

The method of measurement will be described in detail.

An equal number of drops of prepared fruit juice or the prepared fruit are placed on the refractometer prism plate. The reading on the prism scale is recorded to one decimal place. After each test the prism plate is rinsed with water and wiped dry with a soft tissue.

More complicated methods for determining dry matter content, juice content and acid content will be explained in greater detail.

## **RESULTS AND INTERPRETATION**

Each method will describe how to recalculate and reinterpret data collected from individual primary samples in order to obtain data for the whole sample:

Data are recorded for each individual fruit. The mean is calculated on the basis of all readings and is rounded to one decimal place.

- If the juice is taken from two parts of the fruit such as longitudinal slices and equatorial cores, both readings are averaged for each individual fruit. The mean is calculated on the basis of all data for each individual fruit and is rounded to one decimal place.
- Data should be recorded to one decimal place. All details concerning method, variety and stage of maturity and ripeness should also be recorded.
- If the average readings of all fruits are equal to or greater than the lower limit specified in the standard, the lot has reached the minimum maturity level.
- If the average readings of three or more of the ten fruits are at least 10 percent below the limit specified in the standard, a second sample should be taken and analyzed with other fruits of the reduced sample or from a new sample. If the average of the two samples is below the limit specified in the standard, the lot fails the minimum maturity level and should be rejected without reservation.

## CONCLUSION

Objective measurable criteria are important in determining optimal ripeness and proper development in fruits. On the basis of these criteria, the proper harvest time can be calculated so that producers can harvest fruits when they are ripe, fully developed and marketable.

Packers and traders need reliable data to calculate the right selling time so that they can offer consumers optimal quality. Quality normally goes hand in hand with price. Packers and traders will suffer fewer losses due to non-marketable fruits.

The consumer will benefit from the greater selection of ripe and well-developed fruit available in the shops. Because the fruits are more attractive, consumers will be encouraged to consume more of them, which will improve their overall health.

A worldwide coordination of testing methods means that testing will be carried out in the same way by different inspection bodies with the same results. Misinterpretations of standards and rejections of deliveries can be avoided.

The OECD Guidance on objective tests for fruit ripeness will help harmonize methods and standards. The revised Guidance should cover the most common methods currently used in research stations and laboratories. This is one of the hardest tasks in developing the Guidance. Testing methods and sampling are currently not harmonized. There are no agreed-upon laboratory guidelines for certain methods. Internationally recognized methods and standards should be worked out. Sample preparation should also be harmonized. The sample must be representative of the whole fruit.

Fruit quality testing should yield reliable and consistent data, regardless of the methods used. These data should be acceptable to everyone: producers, traders and consumers. Threshold values for developmental stage and ripeness should be defined and incorporated into the marketing standards. Reliable data will also help inspectors decide whether or not a product meets market standards.

Introducing non-destructive methods will be a large step forward towards raising food quality.

## ANNEX

### Marketing standards with given maturity requirements

Produce	Parameter	UN/ECE	EU
Apples	soluble solids [%]	9/10% <i>(trial period from end of 2005)</i>	9/10% <i>(in discussion)</i>
Avocados	dry matter content	21/20/19%	21/20/19%
Kiwi fruit	soluble solids [%] dry matter content	6.2/9.5% 15%	6.2/9.5% 15%
Melons	soluble solids [%]	8/10%	8/10%
Peaches & nectarines	soluble solids [%] firmness	8% <i>below 6.5 kg</i> <i>(trial period until Nov. 2006)</i>	8% <i>below 6.5 kg</i>
Table grapes	soluble solids [%] TSS/acid ratio	12/13/14% <i>trial period starting 2006:</i> 12/14% 18 : 1	12/13/14%
Water melons	soluble solids [%]	8%	8%
Hazelnuts	moisture content	max. 12% whole nuts max. 7% kernels	max. 12% whole nuts max. 7% kernels
Walnuts	moisture content	max. 12% whole nuts max. 7% kernels max. 20% fresh nuts	max. 12% whole nuts max. 7% kernels max. 20% fresh nuts

### Citrus fruits:

Parameter	Species	UN/ECE	EU
Juice content	lemons mandarins oranges limes grapefruits	20/25% 33/40% 30/33/35/45% 42% 33%	20/25% 33/40% 30/33/35/45% (no standard) (no standard)
Soluble solids [%]	grapefruits pummelos (shaddock)	9% 8%	(no standard) (no standard)

## ZALECENIA OECD DLA OBIEKTYWNYCH TESTÓW DO OZNACZANIA STADIUM DOJRZAŁOŚCI OWOCÓW

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### S T R E S Z C Z E N I E

Sprzedaż świeżych owoców i warzyw pociąga za sobą konieczność sortowania, pakowania i oznaczenia produktów zgodnie z międzynarodowymi standardami. UN/ECE, OECD, CODEX i EU są międzynarodowymi organizacjami opracowującymi te standardy. Dla zharmonizowania pracy służb inspekcyjnych w ramach projektu "System stosowania międzynarodowych norm dla świeżych owoców i warzyw", OECD opracowuje broszury interpretacyjne dla stosowanych standardów i wytyczne dla procesu kontroli jakości oraz „Poradnik obiektywnych testów do oznaczania dojrzałości owoców”.

W celu sprawdzenia zgodności z minimalnymi wymaganiami dojrzałości, ważne jest, aby oprócz wyglądu morfologicznego i smaku produktu, posiadać obiektywne, mierzalne wskaźniki, stanowiące odpowiednie narzędzie do określania optymalnej dojrzałości lub dostatecznego rozwoju owoców. Poradnik jest obecnie w korekcie i będzie opisywał te metody obiektywnego testowania owoców, które okażą się korzystne zarówno dla służb inspekcyjnych, jak i dla przemysłu owocowego, do określania akceptowalnych poziomów dojrzałości przy wyznaczaniu odpowiedniego terminu zbioru i/lub optymalnego momentu sprzedaży.

**Słowa kluczowe:** poradnik OECD, OECD system, standardy handlowe dla owoców i warzyw, dojrzałość owoców, kontrola jakości