VII. ASSESSMENT OF FRESH PRODUCE QUALITY

Introduction

Fruit and vegetable consumption is growing globally. At the same time, consumers are becoming increasingly conscious of the quality of the fruits and vegetables that they consume. Satisfying consumer demand and assuring the markets for fresh fruits and vegetables therefore necessitates that produce is of optimum quality in terms of the state of ripeness, organoleptic quality and variety.

Quality is made up of many attributes, both intrinsic and extrinsic (Jongen, 2000). Intrinsic features of a fresh produce item include key external attributes such as colour, shape, size and freedom from defects, as well as internal attributes such as texture, sweetness, acidity, aroma, flavour, shelf-life and nutritional value (Hewett, 2006). Intrinsic components are the most important components of the subjective approach used by the consumer in deciding what to purchase. Extrinsic factors on the other hand, refer to production and distribution systems.

1. Measurement of quality

Determination of total soluble solids (TSS) using a refractometer

Introduction

During fruit development, nutrients are deposited as starch. As fruit ripen, these starch deposits are converted to sugar, leading to increasing sugar levels, which correspond to the 'taste' of the fruit. The measurement of total soluble solids (TSS) is therefore a suitable index for assessing the degree of ripeness of fruit of significant sugar content.

TSS is measured as °Brix using a refractometer. Some refractometers compensate for temperature change, while others may be calibrated for accurate measurement at 20°C.

Purpose

The purpose of this task is to determine the total soluble solids content of fruits using a refractometer.

Materials

The materials required are:

- A refractometer; and
- Fruit.

Procedure

Sampling fruit

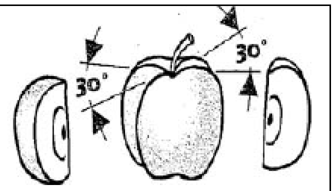
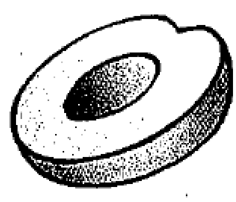
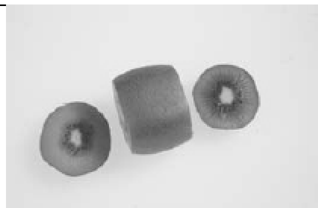
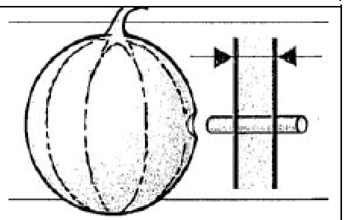
In order to evaluate a lot selected for inspection, a sample of at least ten fruits must be selected at random from the batch. In case of small fruits such as lychee, strawberries or cherries, ten sales packages must be withdrawn and at least five fruits must be sampled from each package. In situations where the fruit are bulk packaged, ten primary samples of fruit must be withdrawn. The fruits must be free from defects such as sun scorch as well as pests and diseases.

Sample preparation

Different sample preparation techniques apply to different commodities, as shown in figure 2.

Extraction of the juice sample for measuring soluble solids must take into account natural differences in the distribution of soluble solids within the fruit, for the species concerned. Although it is not possible to lay down precise sampling preparation guidelines for all produce, the overriding criterion is that the juice sample is, as far as possible, representative of the whole fruit.

Figure 2. Recommended juice extraction procedures for obtaining a representative sample of juice

Apples, Pears, Peaches and Nectarines	From each fruit two longitudinal slices (from stem end to calyx-end) are taken, one from the most coloured side and one from the opposite. The core is removed. The slice is squeezed longitudinally to get a mixture of juice from all regions.	
Apricots, Plums	Cut the fruit in half. Each half is measured to get a mixture of juice from all regions.	
Kiwifruit	Cut the stem and blossom ends at a distance of 15 mm from each end of the fruit and squeeze the two slices separately.	
Melons	Using a small diameter metal borer (1 – 4 mm) a core of melon should be extracted from the equatorial axis area. Each end of the core should be discarded i.e. the skin and the flesh area immediately beneath it and also the soft pulpy seed area. The remaining flesh should be used to extract the juice for testing.	

Melons – Two longitudinal slices are cut from the stem end to calyx-end: one from the side that touched the ground during growth and one from the opposite side. A sample of fruit flesh is cut off from the middle of each longitudinal slice, with the core and peel removed. This sample is squeezed to extract the juice for testing (see figure 3, below).

Figure 3 Sampling of fruit flesh from a melon

Table grapes and small fruits such as cherries, litchis, strawberries – At least five berries are taken from each bunch or sales package at different locations within the package. The berries can either be squeezed and tested individually or can be squeezed together for testing.

Citrus fruit – Each fruit must be cut in half, crosswise, and squeezed to extract all of the juice.

Tomatoes – Two slices must be cut longitudinally from the stem end to the calyx-end of the fruit. The slices must be squeezed longitudinally to yield a mixture of juices.

Measurement of soluble solids content using a hand-held refractometer:

- Place an equal number of drops from the prepared fruit juice or the prepared fruit on to the refractometer prism plate
- Close the prism lid and turn the instrument towards the light
- If necessary, the eyepiece is focused until a clear image appears; the position at which the demarcation line between the light and dark regions crosses the vertical scale gives the percentage of soluble solids
- The reading on the prism scale is noted to one decimal place. After each test, the plate must be cleaned with distilled water, wiped with soft tissue and calibrated to 0.0

Measurement of soluble solids content using a digital refractometer

- Calibrate the refractometer:
    - Place several drops of distilled water on to the prism surface; this should give a reading of zero
    - Readjust the meter to zero if the reading is not zero
    - Wipe the prism dry using lint-free cloth
    - Place several drops of a 6 per cent sucrose solution on the prism – the reading should be 6 per cent; if not, the refractometer must be recalibrated by the supplier
- Place several drops of fruit juice on the prism
- Press the ‘read’ button to obtain a digital value

Recording the results

- Record the reading to one decimal place as well as the details of the cultivar, stage of maturity and ripeness
- Each reading for individual fruit bunches and sales packages must be noted; the sum total of all readings is averaged and rounded to one decimal place to give a meaningful figure
- If the juice is taken from two different parts of the fruit, the final reported reading is the average of that for the individual fruit
- If the average readings for all fruit are equal to or greater than the limit specified by standards, the lot has reached the minimum maturity level
- If the average readings for three or more of the ten fruits, bunches or sale packages are at least 10 per cent below the limit specified in the standard, a second sample must be taken

2. Measurement of fruit firmness using a penetrometer

Introduction

The firmness of a fruit is linked to the state of maturity and ripeness. Firmness may be influenced by fruit variety, as well as the region of production and growing conditions. This exercise describes an objective test to determine the firmness of fruit with the use of a penetrometer. A penetrometer is used by producers, packers and distributors for determining the stage of ripeness of a fruit, as well as by the retail trade to determine palatability and shelf life.

Firmness measurements are based on the pressure required to push a plunger of specified dimensions into the pulp of the fruit up to a specific depth. Penetrometers are calibrated in both metric (kg) and imperial (lbs) units and can cover different pressure ranges in accordance with the variety and stage of ripeness of the produce to be tested.

A plunger having a diameter of 8mm is generally suited to testing softer produce (e.g. peaches, nectarines, plums etc.), while one that is 11mm in diameter is generally used for testing firmer varieties of produce (e.g. apples and pears). A pointed plunger is used in the case of avocados.

The penetrometer must be bench-mounted on a fixed rigid drill stand to ensure that pressure is applied at a steady controlled rate and at a constant angle to the fruit. This is more difficult when using a hand held penetrometer.

Purpose

The purpose of this exercise is to determine the ripeness of fruit using a penetrometer.

Materials

The materials required comprise:

- Fruit; and
- A penetrometer.

Procedure

Sampling

Take a random sample of at least ten fruits when evaluating a lot for inspection. These fruit must be free from defects.

Sample preparation

- Remove an area of peel (only skin depth) of up to $2cm^2$ from two opposite sides of the equatorial area of the fruit
- When the fruit has a peel of mixed colours, e.g. apples, the tests should be carried out where possible between the highest and lowest coloured portion of the surface

Measurement

- Hold the fruit firmly with one hand and rest it on a rigid surface
- The choice of plunger size and scale range used will depend on the type and the variety of the produce being tested and its stage of maturity and ripeness
- Adjust the penetrometer reading to zero and place the head of the plunger against the flesh in the peeled area of the fruit
- Apply steady downward pressure until the plunger has penetrated the flesh of the fruit up to the depth mark (half way up) on the plunger; slow, steady pressure is essential as sharp uneven movements may give unreliable results

- Remove the plunger and note the reading on the penetrometer dial to one decimal place
- Repeat the process on the opposite side of the same fruit after adjusting the penetrometer reading to zero
- All tests must be conducted as uniformly and carefully as possible in order to allow an accurate comparison of results
- Record the reading to one decimal place, as well all the details such as the maximum puncture force in Newtons, plunger size, cultivar or variety and stage of maturity tested

Calculations

- Average the readings for each individual fruit, then obtain an average of the sum total of all average readings to one decimal place
- If the average readings of three or more of the ten fruits are at least 10 per cent below the limit specified in the standard, the lot has reached the minimum maturity level
- If the average readings of three or more of the fruits are at least 10 per cent below the limit specified in the standard, a second sample needs to be taken and analysed 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 must be rejected

3. Measurement of pH

Introduction

The taste and flavour of fruits is greatly influenced by pH. Fruits in general have a pH of around 4.5. However, the pH of the fruit varies in accordance with cultural practices (fertiliser application), handling (microbial decay could result in a pH change), conditions of storage and transport and the storage environment of the produce.

Purpose

The purpose of this task is to determine the pH (acidity) of the fruit juice.

Materials

The materials required are:

- A pH meter; and
- Fruit.

Procedure

Sample preparation

- Three replicate samples, each replicate containing ten fruits, must be selected from the packaging or at the sampling point if the fruit size is small
- Depending on the type of produce, either cut the fruit in half and squeeze out the juice with an extractor or a juice-press – with citrus fruits, for example – or homogenise the flesh into a pulp
- Combine all of the juice extracts/homogenates collected from each fruit variety, and filter through muslin cloth to remove solids and peel
- Using a clean, dry 20ml pipette withdraw 20 ml of each sample in triplicate and transfer to a 50ml beaker.

Measurement of pH

- Follow the manufactures instructions
- Allow the pH meter to warm up for at least 30 minutes
- Remove the electrode from the cap containing potassium chloride (KCl) solution and rinse with distilled water in a cleaned beaker
- After drying, place the electrode in a pH7 buffer solution and calibrate the instrument. Later on, after rinsing the electrode with distilled water, calibrate with the second buffer pH4. Calibration must be done at 25°C
- During calibration or taking the readings make sure that the electrode does not touch the sides or bottom of the beaker
- Measure the pH of the fruit juice; record the reading to the first decimal point
- Remove the electrode and rinse it again in distilled water; dry and place the electrode tip back into the cap containing KCl solution

Recording results

- Readings must be taken for each of three samples; the final pH will be reported as the average of these three readings
- In situations where the final pH reading deviates from the standard value, the sampling process must be repeated.

4. Measurement of fruit acids by titration and calculation of the total soluble solids (TSS) to acid ratio

Introduction

The sugar to acid ratio is used a quality index for many fruits. This ratio is generally used to determine the maturity at harvest, on the packing line or at the point of export. This ratio has a significant influence on the taste and the flavour of the fruit and provides an indication of its commercial and organoleptic ripeness. At the beginning of the ripening process, the sugar to acid ratio is low, owing to the low sugar and high acid content of the fruit. During ripening, fruit acids are degraded, the sugar content increases and the sugar to acid ratio increases. Over- mature fruits have very low levels of fruit acids and lack characteristic fruit flavour.

Fruit acids are determined by measuring titratable acidity.

Purpose

The purpose of this exercise is to determine the maturity of fruit using the ratio of sugar to acid.

Materials

The materials required for the task comprise:

- A laboratory burette of 25 or 50ml capacity; alternatively an automatic burette can be used;
- A 10ml pipette, a beaker (250ml), a filter (muslin cloth) and an extractor or homogeniser;
- A bottle of distilled water;
- Sodium hydroxide (NaOH) – a standard solution of freshly made sodium hydroxide solution (either 0.1 M or 0.5 M) must be used. A 0.1M solution of NaOH solution can

be prepared by dissolving 0.4 g NaOH in 100 ml of distilled water); a 0.5M NaOH solution can be prepared by dissolving 2 g NaOH in 100 ml of distilled water) NaOH;

- Phenolphthalein – a 1 per cent solution of phenolphthalein is prepared by dissolving 1 gram of phenolphthalein in 100 ml of a 95 per cent v/v solution of ethanol. A 95 per cent v/v solution of ethanol is prepared by measuring 95 ml of 100 % ethanol into a 100ml volumetric flask and adding distilled water up to the 100 ml mark; and
- A pH meter – as mentioned above.

Procedure

Sampling
To evaluate the lot selected for inspection, take a sample of at least ten fruits of each size at random from the sampling points. Select fruits without defects.

Sample preparation

- Record details of the fruit cultivar, level of maturity and ripening stage
- Prepare samples as described above in the section on pH measurement

Titration

- Transfer 10 ml of juice to a beaker, using a pipette
- Add three drops of phenolphthalein indicator to the juice using a dropping pipette
- Fill the burette with 0.1M NaOH solution to reach the zero mark
- Slowly titrate the NaOH into the juice; care must be taken to ensure that the NaOH is dropped directly into the solution and does not adhere to the glass, otherwise the reading may be incorrect
- During the titration, continuously swirl the flask and observe closely. Phenolphthalein indicator changes very rapidly from colourless to a pink end point, which can be easily missed. It is therefore recommended that NaOH be added one drop at a time and the solution is thoroughly mixed by swirling after the addition of each drop closer to the end point of the titration
- The indicator is stable for a brief period of 30 seconds and is light pink in colour when viewed against a white background. The shade of the indicator can, however, vary according to the nature of the juice product being tested. If the point of neutrality is missed, i.e. the colour of the indicator is too dark; the test must be repeated. An indicator strip should be used to avoid the end point of pH 8.1
- The volume of NaOH used (titre) on the burette must be recorded
- Three titrations must be performed for each juice sample

Calculation of the TSS to acid ratio
Brix (TSS) values must be recorded prior to the titration. Calculations for determining the ratio of TSS to acid for all types of produce are similar. Different fruits, however, contain different concentrations of acids in different proportions. A multiplication factor (acid factor) specific to the predominant acid is, therefore, used.

Factors for common fruit acids:

Citric acid:	0.0064 (citrus, lychee)
Malic acid:	0.0067 (apple, pineapple, mango)
Tartaric acid:	0.0075 (grapes)

Using citric acid as an example:
1ml of 0.1M NaOH is equivalent to 0.0064g citric acid.

Results expressed as percentage acid:

$$\text{Percentage acid} = \frac{\text{Titre x acid factor x 100}}{\text{10ml juice}}$$

$$\text{The TSS/acid ratio} = \frac{\text{TSS}}{\text{\% acid}}$$

For example, the results can be expressed as:

Percentage citric acid

$$\text{Percentage citric acid} = \frac{\text{Titre x 0.0064 x 100}}{\text{10ml juice}}$$

Formula is simplified to:
Percentage citric acid = titre x 0.064

$$\text{TSS/acid ratio} = \frac{\text{TSS}}{\text{Percentage acid}}$$

Reporting the results

- Results must be reported to one decimal place. If the TSS/acid ratio reaches the limit specified in the standard, then the lot has reached its minimum maturity
- If the observation is at least 10 per cent below or above the limit specified in the standard, a second sample test must be carried out. If the average of two samples is below or above the limit specified in the standard, the lot fails the minimum maturity level and must be rejected

5. Impact of handling

Purpose

The purpose of this task is to demonstrate the importance of packing and packaging of different commodities.

Materials

The materials required are:

- Fresh fruit; and
- Packaging material.

Procedure

This task can be carried out as a group exercise, with different groups packaging different fruits for different target markets.

- Identify a fruit or vegetable
- Identify a target market for the fruit
- Select appropriate packaging materials
- Pack the fruits

Discussion issues

- Who is the target market?
- Why was this type of packaging selected?
- What were the main considerations in selecting the packing configuration chosen?

6. Impact of ineffective cold chain management

Purpose

The purpose of this task is to demonstrate the impact of ineffective cold chain management.

Materials

Fresh fruit is the only material required.

Procedure

- Store different commodities at two different temperatures: optimum storage temperature and in a hot environment

Evaluate the quality parameters of the products using any of the above tests

Discussion issues

- Note the quality differences between the fruit