Methods for assessing quality characteristics of non-grain starch staples. (Part 2. Field Methods.)

Methods for Assessing Quality Characteristics of Non-Grain Starch Staples

PART 2.
FIELD METHODS

NRI
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Overseas Development Administration

Methods for Assessing Quality Characteristics of Non-Grain Starch Staples

Part 2. Field Methods

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Natural Resources Institute

Overseas Development Administration

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Cover illustration. Clockwise from top left. Banana (*Musa* spp.), cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*). *Drawings reproduced by kind permission of the Royal Botanic Gardens, Kew.*

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Section 2.1 Physical composition

COLOUR MEASUREMENT

Introduction

Colour is a key quality characteristic of fresh produce and processed products. It can also give an indication of deterioration, disease, infestation and/or contamination. The method described here is suitable for both the semi-quantitative and the quantitative determination of colour.

Rationale

Market quality and consumer acceptability of fresh produce and processed products is highly influenced by the visual appearance of the produce/product. Similarly, in the judgement of the efficacy of a post-harvest treatment under development, consumer acceptability will have to be taken into account.

Colour is a major component of the visual appearance of produce/products; it is therefore an important indicator of quality.

Suitability

The method described here allows the semi-quantitative determination of colour by manual field analysis. For a more precise determination of colour, a portable electronic, colour meter can be used to give an integrated assessment that can be converted into the Munsell notation system.

Limitations

The manual procedure described is limited because of individual human perceptions of colour. This is often complicated when the sample is heterogeneously coloured. Deviation from normal colour vision has been quoted as 8% among males and 0.4% among females (Judd and Wyszecki, 1975). Improved accuracy requires the use of a colour meter to provide an integrated measurement of colour over a given area of the sample.

Principles

Communicating a perception of colour requires an evaluation, a description and a means to relay the result in a systematic way. Colour charts or colour measuring instruments are tools used for this purpose. A simple system may be developed using readily available materials. This is more appropriate for a commodity-specific colour quality grading system. Alternatively, a standard colour notation such as the Munsell notation system may be used to obtain relative values for colour.

Standard colour notation systems generally divide colour into three elements.

- *Hue* is the term for the classifications of red, yellow, green, blue.
- *Value* or *Lightness* separates colours into bright and dark.
- *Chroma* or *Saturation* indicates the vividness of a given hue.

Other colour charts such as the Royal Horticultural Society (RHS) chart use similar definitions of colour. Alternatively, the instrumentally obtained co-ordinates follow the Commission Internationale de l'Eclairage (CIE) system, L*a*b* (referred to as L star, etc.). This system provides information directly on lightness (L*) but requires conversion to yield values of chroma and hue.

Requirements

Equipment

There is a choice of colour chart options:

- tailor-made charts prepared from available text or materials, e.g. paint colour charts, non-perishable samples, pictures of a range of samples;
- Munsell Plant Tissue Charts or Book of Colours; and
- RHS colour charts.

The optional use of a colorimeter to obtain quantitative data is possible:

- Chroma meter, e.g. Minolta Chroma Meters CR100 or CR200 (both have an 8 mm measuring head).

Consumables

- Plastic bags

Procedure

Preparation of colour chart system

When using the Munsell or RHS colour chart system, choose the chips or tiles that represent the range of colour exhibited by the commodity under analysis.

Alternatively, using previous knowledge of the sample colour range, prepare a tailor-made colour chart by one of the following procedures:

- collect portions of sample representing the full range of possible colours and store in a container. Develop a simple numeric grading scale. This is limited to samples which are stable in colour; or
- obtain coloured sections from text, e.g. paint colour charts, excerpts from colour magazines, photographs. Prepare cards covered in a protective cellophane coating. Develop a simple grading scale.

Determination using colour charts

Place a randomized sample in a suitable container or plastic bag. When determining colour, use natural light, avoiding the early morning and late afternoon as colours will appear to change according to the height of the sun in the sky. Use a neutral hue background. Limit the visual field to the sample and only those colour chips being used in the evaluation. Avoid reflection of the light source from either the colour chip or sample.

Compare the sample with the colour system. Record the code or grade of the card/chip of corresponding colour. Take replicate readings as appropriate.

The factors listed below may influence the accuracy of colour measurement when the chart systems are being used:

- light source differences, i.e., natural light at various times of the day, fluorescent or tungsten light;
- observer differences, i.e., perception of colour varies from one person to another and with the age of the observer;
- size differences, i.e., the colour of larger objects appears to be more vivid than smaller ones;
- background differences in colour alter the apparent colour of the object being tested; and
- directional differences, i.e., the direction from which the object is being viewed.

It is therefore important to keep the above parameters as constant as possible when colour is being measured.

Determination using a colour measuring instrument

Calibrate the colour meter as outlined in the user's manual before each measuring session. Follow the guidelines to colour measurement that are particular to the instrument being used.

Analysis of results

A graded scale may be linked to quality, such as the stages of banana ripening, as shown in Figure 2.1 below.

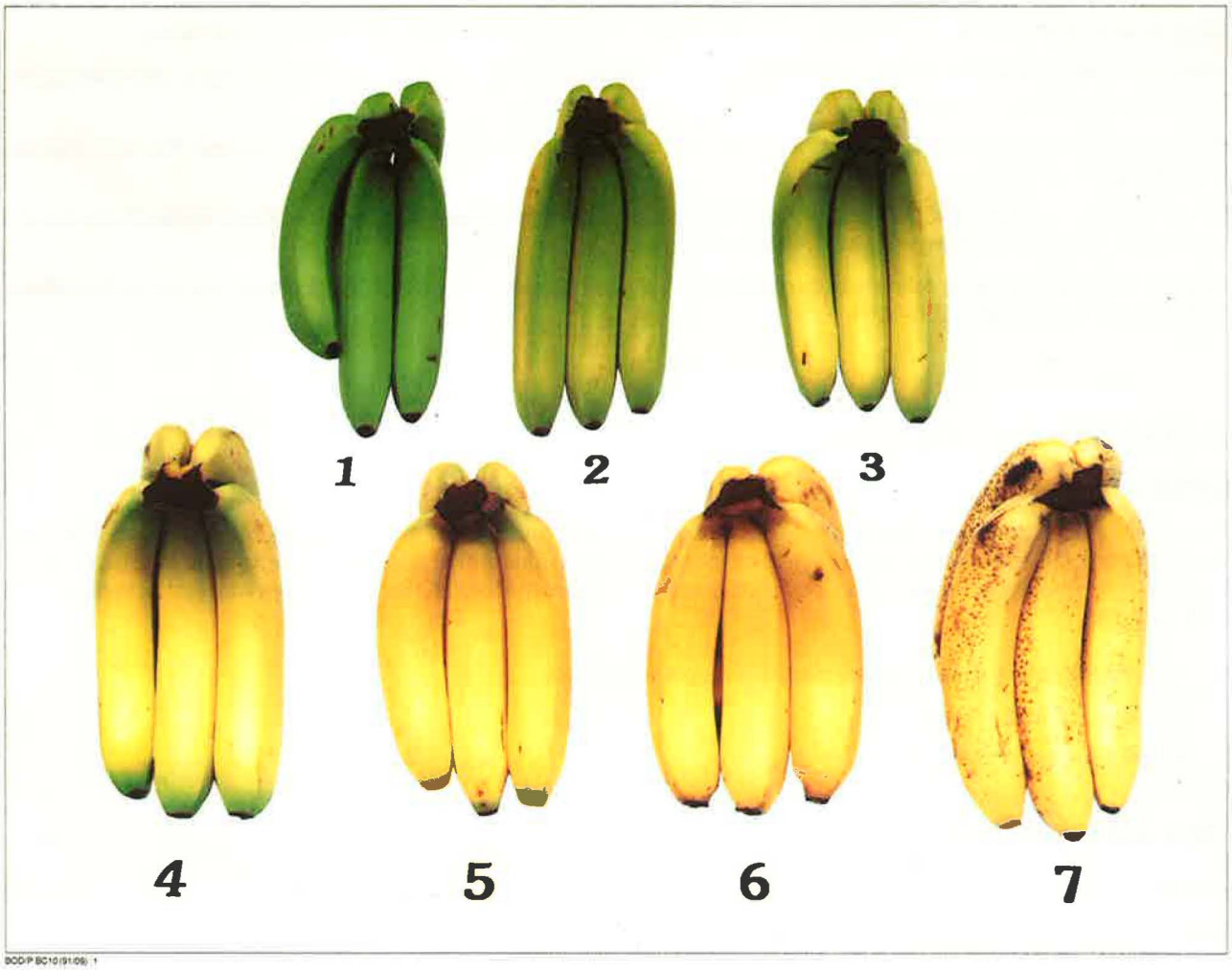

Figure 2.1 Example of a colour grading system (*Reproduced by kind permission of Geest, UK*)

Table 2.1 Colour quality grading

Grade	Score
1–3	High quality
4–6	Medium quality
7–9	Poor quality

Refer to the colour measuring instrument concerning the specific colour notation system and the calculations required to inter-convert from one system to the next.

Significance

Quality acceptability may be linked to numerical colour measurements obtained from either a chart system or, for greater accuracy, the colour measuring instrument. Once a scale has been developed, it may be used as a survey tool for market quality.

International standards

None known.

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VOSS, D. H. (1992) Relating colorimetric measurement of plant colour to the Royal Horticultural Society Colour Chart. *Horticultural Science*, **27**: 1256–1260.

EXTRANEOUS CONTAMINATION

Introduction

Production of dried processed products of NGSS by non-industrial methods presents some risk of contamination by soil, stones, and vegetable and animal matter. Simple methods of examination will provide a basis for ranking the quality of the products. If the findings can be related to local consumers' perceptions of acceptability, the assessment might be included in a grading system.

Separate procedures are needed for two classes of processed product:

- chips and larger pieces;
- flours and granules.

Chips and larger pieces

Introduction

Rationale

Most contaminants of the chips and larger pieces will have smaller sized particles than the processed product and can therefore be separated by sieving; the procedure is analogous to the determination of foreign matter in many cereal grading procedures. The nature of the processed product, however, makes it impossible to draw a representative sample from a sack or other large container by the methods used for grains. It is therefore suggested that whole sackfuls are inspected using a sack sieve.

Suitability

The equipment required means that the procedure is suitable for use by a purchasing centre or a trader.

Limitations

Contaminants which are of a similar size to chips and smaller pieces, and which are not visually distinctive, are not easily detected. Small particles of processed product passing through the sieve are regarded as contamination.

Principles

The contents of a weighed sack of the processed product are passed over a 5 mm round-hole sieve; material passing through the sieve is collected and regarded as foreign matter. Large pieces of obvious foreign matter which do not pass through are removed from the sieve by hand and added to the sievings; the whole is weighed.

Requirements

Equipment

- Sack sieve – the frame and stand can be constructed by a local carpenter; the perforated metal screen (approximately 2 x 1 m) would have to be purchased
- Sack scales – would be expected to be already available at a trading centre

- Scales with a capacity of at least 1 kg and a readability of 1 g for weighing sievings
- Brush

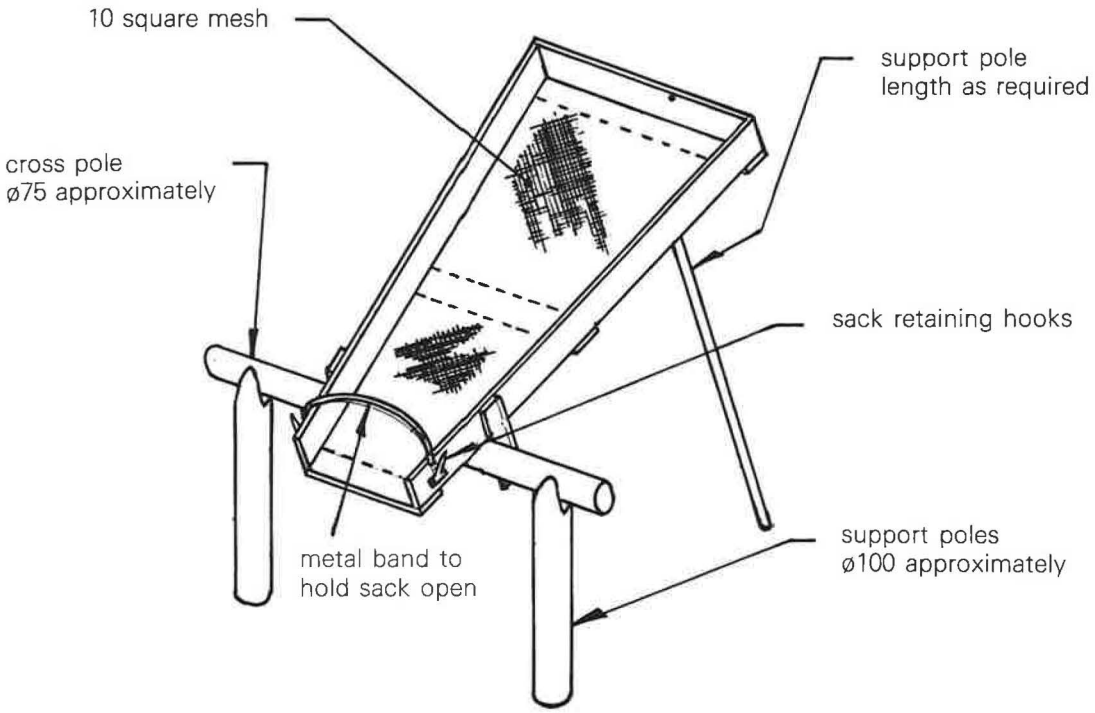

Figure 2.2 Sack sieve

All dimensions in mm

Consumables

- Sample bags

Procedure

Weigh a sack of processed product and tip the contents slowly onto the higher end of the sieve. Inspectors should then move the product down the sieve by hand if necessary (preferably with one inspector on each side of the sieve). Remove any large foreign matter and pick out any defective processed product (for example, stained or mouldy pieces) which will be recorded separately. Product reaching the lower end of the sieve should pass into a collecting sack. When the whole sackful has passed over the sieve, remove the collecting tray and transfer the sievings to a bag, together with any large foreign matter, and weigh. Express the weight of 'foreign matter' as a percentage of the total weight of processed product.

Analysis of results

Background data, obtained by testing samples from several producers, are required to set standards against which results can be evaluated.

Table 2.2 Example of record table

Sample code	Weight of sack (kg)	Weight of sieving (kg)	Foreign matter (%)
J01	3.56	0.45	12.64

International standards

None known.

References

No direct literature references have been identified, but sack sieves are understood to have been used in Ghana for the inspection of cocoa and in Malawi for maize.

Flours and granules

Introduction

Rationale

Foreign matter present in flours and granules that is larger than the processed product will be determined during the sieving for particle size analysis required for classification of gari according to Codex Standard 151–1985, and can be used for similar products. These guidelines apply when the contaminating particles are of a similar size to those of the product, and sieving is ineffective for separation.

The contaminant may be darker in colour or denser than the processed product and therefore is able to be distinguished visually or separated gravimetrically. An assessment of the frequency of contaminating particles will then provide an indicator of quality which can be calibrated by consumer perceptions.

Suitability

The suggested procedure will allow rapid assessment at a purchasing centre or in a market, for example.

Limitations

The visual method applies when there are small numbers of specks in the product, which can readily be counted within a defined field. Higher levels of contamination require an alternative technique, such as comparison with standard samples. The method does not give a value for the quantity of contaminant, and requires validation according to consumer acceptability.

The gravimetric method relies on contaminating particles (such as sand) being denser than the processed product.

Principles

A sample of processed product is spread to give a flat surface. A frame of standard area is placed at random on the surface, and the specks of contaminant visible within the frame are counted.

For determination of denser particles, e.g. sand in gari, the sample is suspended in water and the denser contaminants retained by decanting the water and samples.

Requirements

Equipment

- Tray e.g. a baking tin about 300 x 200 x 15 mm in area
- Plastic scoop, or small tin
- Wooden or plastic strip, e.g. a 300 mm ruler
- Inspection frame – sheet of thin card with square aperture 100 x 100 mm in area
- 1 l flask

Procedure

Visual method

Place a representative sample of the processed product on the tray and level using the wooden strip. Place the viewing frame at random on the product surface. Determine the number of specks of contaminant visible within the frame. Repeat the procedure as necessary.

Gravimetric method

Place 100 g of sample in a 1 l flask and add water. Mix thoroughly and allow to rest for 1–2 min. Decant the water and product and repeat the procedure until only the sand/contaminants remain. Transfer all the sand to a filter paper, dry and weigh.

Analysis of results

Following preliminary trials, quality designations should be established based on the number of specks visible/100 cm^2.

Table 2.3 Example score table for visually grading extraneous material

Score	Specks
Good	0
Fair	1–4
Poor	5 or more

For gravimetric determination of extraneous contamination, express results as percentage of sand/contaminants.

Table 2.4 Example record table for gravimetric determination of extraneous material

Sample code	Weight/percentage of sand/contaminants (g)
KW1	25

International standards

None known, but see Codex Standard 151–1985 for sieve analysis of gari.

PARTICLE AND PIECE SIZE

Introduction

NGSS can be processed into many products of which size of particle or piece can be a key quality characteristic. For example, particle size in gari is important to consumer acceptability in West Africa.

Rationale

Particle size is related to the efficiency of grating or milling. For dried pieces, size is related to the rate at which they dry.

Particle or piece size as a quality parameter can be used to allow market assessment studies or acceptability of post-harvest treatments.

Suitability

These methods allow the field determination of particle size and piece size of processed products.

Limitations

Sample size is a key problem for particle and piece size analysis. Small sample sizes may not be representative of the material being analysed and errors in collection and weighing may be exaggerated. Large samples take too long to analyse. In particle size analysis, the likelihood of clogging the mesh is high and damage may be caused to the sieve surface.

Accuracy of measurement is affected by non-laboratory conditions. High humidity can cause clogging of fine mesh sieves in particle size analysis. The accuracy of weight measurements taken in the field is therefore limited.

Principles

For processed products such as flours and gari, the use of sieves of decreasing mesh size allows products to be size-fractionated and quantified. The sieve series recommended in *Specific recommendations for gari and cassava flour* below are in accordance with the Codex Alimentarius.

Piece size is determined by a straightforward gravimetric procedure.

Requirements

Equipment

- Portable balance accurate to two decimal places
- Brushes for cleaning sieve plates
- Sieves of various mesh sizes in a principal series of preferred numbers, as listed in Table 2.5, or produced locally using standard specifications and mesh apertures listed in *Specific recommendations for gari and cassava flour* and *Particle size distribution* below. For field use, Pocket Interchanger Sieves (10 cm diameter) produced by Endecotts Ltd, United Kingdom, are suitable.

Table 2.5 Principal series of preferred numbers in mm (taken from BS 2045:1965)

R10		R20		R40	
1.00	3.15	1.00	3.15	1.00	3.15
				1.06	3.35
		1.12	3.55	1.12	3.55
				1.18	3.75
1.25	4.00	1.25	4.00	1.25	4.00
				1.32	4.25
		1.40	4.50	1.40	4.50
				1.50	4.75
1.60	5.00	1.60	5.00	1.60	5.00
				1.70	5.30
		1.80	5.60	1.80	5.60
				1.90	6.00
2.00	6.30	2.00	6.30	2.00	6.30
				2.12	6.70
		2.24	7.10	2.24	7.10
				2.36	7.50
2.50	8.00	2.50	8.00	2.50	8.00
				2.65	8.50
		2.80	9.00	2.80	9.00
				3.00	9.50
	10.00		10.00		10.00

Consumables

- Plastic sample bags

Procedure

Recommendations on choice of sieve mesh and sample size

The mesh aperture and sample size required are highly dependent upon the sample under analysis. Recommendations as to how to determine the necessary requirements are given below.

In general, less than 5% of the sample should be retained by the coarsest sieve, or pass through the finest sieve. Once the top and bottom sieves are chosen, the intermediate range can be decided upon. The intermediate sieves must never be selected at random; a preferred series e.g. British Standard Series R10, R20 and R 40 as listed in Table 2.5 should be used. The following examples indicate some choices between 5.00 and 2.50 mm.

R40/3:	5.00		4.25		3.55		3.00	2.50
R20/2:	5.00	4.00		3.15				2.50
Random:	5.00			3.75	3.55	3.15	3.00	2.80	2.50

Random selection leads to difficulty in interpretation of data.

The test sample size depends on the sieve size and aperture and the density and size distribution of the particles. For the best result, underload the coarser sieves to avoid overloading the finer sieves. If particular fractions do not contain a representative amount of sample, repeat sieving incorporating different mesh sizes.

Specific recommendations for gari and cassava flour

The Codex Alimentarius recommend the following mesh sizes:

- for gari: 2.00 mm; 1.25 mm; 1.00 mm; 0.50 mm; 0.25 mm;
- for cassava flour: 1.20 mm; 0.60 mm.

Particle size distribution

For field use, the Pocket Interchanger Sieve Set is easy to transport and handle. Alternatively, the more standard 20 cm sieve sets may be used.

Randomize the sample and weigh out a pre-determined test quantity into the lid of the Pocket Interchanger Sieve Set. Insert the largest mesh size into the frame and weigh to two decimal figures; then record the weight and mesh size. Place the sieve over the retriever. Transfer all of the sample onto the sieve using the brushes. It is important to reduce losses during transfer steps. Cover with a lid.

Sieve the flour until no more passes through the mesh. Use a circular and tapping motion. This may take up to 3 min. Ensure that no flour remains on the base of the sieve and weigh it. Record the sieve mesh size and weight of sieve plus sample, and calculate the weight of sample retained to two decimal places.

Continue with the next sieve in the series as above, transferring all of the sample that passed through the previous sieve. Finally, determine the weight of material in the retriever after using the finest mesh.

In the absence of the Pocket Interchanger Sieves, assemble a nest of 20-cm diameter sieves in descending aperture size. The number of sieves required depends on the sample characteristics or the recommended standard. Transfer the whole or a portion of the sample (each portion to be tested separately) to the uppermost sieve and cover with the lid. Cradle the nest of sieves in the crook of the arm and tap at a rate of 120 time/min with the flat of the hand. After 30 taps, i.e., four times a min, rotate the sieves through 90° to a horizontal position, give a sharp vertical shake and a hard tap. The sieving time is dependent on a number of factors such as the characteristics of the sample, sieve size, humidity of the air, and so on. Consequently it is important for comparative reasons to determine a set time period prior to routine analysis.

Piece size determination

Take approximately 20 pieces of dried processed product. Weigh the pieces individually to two decimal places and record the weight of each.

Analysis of results

Record table for particle size analysis

Table 2.6 An example of a record table for particle size analysis

Sample	Mesh aperture (mm)	**A**. Weight of sieve (g)	**B**. Weight of sieve + sample (g)	**C**. Weight of fraction retained (g)
G1	2.00	5.00	7.21	2.21

Calculation for particle size analysis

In order to calculate C in Table 2.6, B is subtracted from A.

There are several ways to tabulate particle size data; the most widely used are described below and illustrated in Table 2.7.

Table 2.7 Tabulation of sieve set data in particle size analysis

Sieve aperture (microns)	Weight percentages		
	Retained	Cumulative oversize	Cumulative undersize
1700	1.1	1.1	98.9
1180	5.6	6.7	93.3
850	20.6	27.3	72.7
600	26.4	53.7	46.3
425	18.5	72.2	27.8
300	10.8	83.0	17.0
212	5.9	88.9	11.1
150	3.9	92.8	7.2
106	2.7	95.5	4.5
–	4.5	–	–

Fractions retained by each sieve can be represented as a percentage of the total sample weight. Percentage cumulative oversize and undersize are running totals and give the percentage of material greater or smaller than a particular mesh size. Graphical representation of these data allows easy comparison during routine analysis. The most common method is using ordinary graph paper and plotting percentage retained fraction against mesh size

Calculation for piece size analysis

Standard deviation from the mean can be calculated from the data collected.

Significance

The particle size as a quality attribute of processed products allows classification of market produce.

International standards

Codex Regional Standard classifications for gari (CODEX STAN 151–1985) are:

Extra-fine grain gari:	100% passes 0.50 mm, <40% passes 0.25 mm mesh.
Fine grain gari:	100% passes 1.00 mm, <40% passes 0.5 mm mesh.
Medium grain gari:	100% passes 1.25 mm, <40% passes 1.00 mm mesh.
Coarse grain gari:	100% passes 2.00 mm, <40% passes 1.25 mm mesh.
Unclassified gari:	Not classified by sieve method.

Codex Regional Standards for cassava flour are:

Fine cassava flour:	>90% passes through 0.6 mm mesh.
Coarse cassava flour:	>90% passes through 1.20 mm mesh.

References

CODEX ALIMENTARIUS (ABRIDGED) (1989) *African Regional Standard for Gari*. Part C, 17.1–17.2.

TEST SIEVING MANUAL (1989) London: Endecotts Publication.

POST-HARVEST LOSS ASSESSMENT

Introduction

All those involved in the generation, sale and consumption of horticultural goods are in some manner affected by the perishability of fresh produce and the quantitative, qualitative and economic losses that are incurred following harvest. In the continuing quest to devise methodologies to increase the efficient utilization of horticultural crops and their residues, it is important that those working in the agro-industrial sector are able to identify and quantify different categories of loss, thereby highlighting those areas that may benefit from technical or procedural interventions. The methodology described

suggests a means of assessing the quality of fresh cassava and sweet potato and differentiating between various forms of depreciation.

Rationale

Following harvest, all forms of horticultural produce undergo a series of bio-physiological changes. The nature and speed with which these occur will be influenced by the innate characteristics of the individual crop and the environment to which the material is exposed.

By observing these processes over time, and by diagnosing and attempting to quantify the external factors that lead to qualitative changes in the produce, it is possible to identify a characteristic commodity 'profile' that may be used to predict the likely quality, shelf-life, market value and probable economic losses engendered by a particular product. By taking steps to engineer a different 'profile' (i.e., by instigating different post-harvest handling and storage techniques), it is possible to capture different markets for the produce in question and to increase the efficiency of utilization.

Suitability

The methodology requires minimal equipment and may be undertaken at any point during storage to characterize the quality of produce at that time. To assess the absolute rate of depreciation of a consignment, comparable observations are necessary at two or more dates throughout a given storage period.

Limitations

The assessment of produce quality characteristics in terms of numerical scores often requires the subjective judgement of an evaluator. If a given consignment is to be assessed on a number of occasions, the same evaluator should undertake the scoring throughout. If a team of evaluators is required, the members should come to a common understanding as to how to score various symptoms etc.

Principles

When carrying out the assessment techniques it is assumed that within a given community, broadly similar appraisal procedures are adopted by those who routinely handle a given commodity to differentiate between various grades of quality or acceptability. Scoring systems attempt to define and extend these grades in terms of numbers or classes. For a given set of criteria such as general appearance, surface damage (mechanical and/or pest and disease related), internal physiological and microbial/insect disease status, sprouting, texture, cooking quality, weight loss etc., samples of a commodity are taken and scores assigned. These scores, when expressed as means, provide a sample profile of the commodity which may be used to assess the likely condition of the entire consignment and, by extrapolation, the loss of material from one accepted grade to another.

Requirements

Equipment

- Scales (capacity 25–50 kg)
- Weighing basket
- Sharp knives (approximately 20 cm long)
- Penetrometer
- Refer to *Colour measurement* above
- Refer to *Texture and cooking quality* below

Consumables

- Sample sacks to hold 10 kg of roots
- Chopping blocks
- Labels, string, marker pens, record sheets etc.

- Refer to *Colour measurement* above
- Refer to *Texture and cooking quality* below

Procedure

Assessments of damage and deterioration

The storage potential, ease of processing and sensory quality of roots and tubers are greatly influenced by their general condition, extent of dehydration, incidence of superficial wounds and condition of internal tissues. Assess the roots and tubers at the time of harvest or at points during the storage period roots for the following:

- general surface appearance;
- surface damage;
    - mechanical damage (cuts, cracks, abrasions, bruises, gashes etc.);
    - insect damage (bore holes, burrows, wounds etc.);
    - rots (wet or dry discoloured areas);
    - miscellaneous pest damage (bite marks etc.);
- internal deterioration;
    - physiological deterioration;
    - microbial deterioration;
    - insect infestation;
- sprouting;
- texture;
- water loss.

Table 2.8 Scores and definitions for the external appearance of root crops

SCORE:	General surface appearance	Surface damage			
		Mechanical (percentage of surface area)	Insect (no. of insect holes)	Rots (percentage of surface area)	Pest (percentage of surface area)
1	Very good	0	0	0	0
2	Good	1–25%	1–5	1–25%	1–25%
3	Moderate	26–50%	6–10	26–50%	26–50%
4	Poor	51–75%	11–15	51–75%	51–75%
5	Very poor	76–100%	16+	76–100%	76–100%

In all cases except those involving an assessment of texture and water loss, grade and score the quality of the produce subjectively by an evaluator. A score of 1 in any category denotes no significant departure from the healthy, commercially acceptable 'norm'. Scores greater than 1 indicate increasingly severe departures from this base-line condition. Tables 2.8–2.10 suggest appropriate score categories for these observations.

To assess the extent of any internal deterioration, dissect storage organs using the following procedure. Irrespective of the length of an individual root or tuber, cleanly cut the sample organs into four segments. Make the first cut at the mid-point along the axis. Make two further cuts at points approximately one-eighth of the way up or down the axis of the organ from both the top and bottom ends. In this fashion, make an assessment of the quality of each organ at three points along its entire length. Make a more detailed inspection at the cuts at either end than at those at the centre, to accommodate the fact that physiological and microbial deterioration in root and tuber crops often travels along the vascular system from either end of the organ. Note the location of the cuts in relation to the peduncle (top) end of the organ.

Table 2.9 Scores and definitions for the sprouting of sweet potatoes

Score	Sprouting	
	(No. of areas showing sprouting activity)	(Proportion of sprouts longer than 1 cm)
1	0	0
2	1–5	1–5
3	6–10	6–10
4	11–15	11–15
5	16+	16+

Assess the texture or turgidity of intact roots and tubers by making measurements using a hand-held penetrometer. When the organ is intact, hold the instrument at right angles to a sample site and depress. A reading indicating the force required to depress the head of the penetrometer into the cortex of the storage organ provides some indication of the cohesiveness of these tissues. Take at least three readings from each of the roots or tubers sampled: one reading from the equatorial region; one from a zone towards the stem end of the root; and one from the lower end of the root. Additional techniques advocated to determine the texture and acceptability of material may be found in *Texture and cooking quality*, below.

To measure water loss from roots or tubers, take repeated collective weighings of the same sample roots at convenient points during their period of storage. Mark the sample roots in some manner following the initial weighing process, disperse into the store and recover as required. In all other respects, treat these sample organs in the same manner as the remainder of any consignment. On weighing, however, gather together the individual components of the sample and weigh *en masse*.

An example of an experimental record sheet is shown in Table 2.11.

Table 2.10 Scores and definitions for microbial deterioration (a); physiological deterioration and insect damage in sweet potato (b); and cassava (c)

SCORE	a) Symptoms of microbial deterioration	b) Symptoms of physiological deterioration in sweet potato	c) Symptoms of physiological deterioration in cassava	Insect damage (No. of insect holes)
1	No symptoms of rot	No discoloration	White cortex with no vascular discoloration	0
2	Certain discrete yellow discoloration that extends over 1 to 25% of the cross-sectional area of the cortex	Discoloration 1–25% of cut area	Cortex acquires a cream coloration	1–5
3	Discrete discoloration which extends over 26 to 50% of the cross-sectional area of the cortex	Discoloration 26–50% of cut area	Cortex exhibits a faint indefinite blue coloration	6–10
4	Discoloration extends over 51 to 75% of the cross-sectional area of the cortex	Discoloration 51–75% of cut area	Striking blue coloration in cortex accompanied by brown vascular colouring	11–15
5	Discoloration extends over 76 to 100% of the cross-sectional area of the cortex	Discoloration 76–100% of cut area	Extensive blue-grey discoloration with darkened vascular tissues	16+
6	Not applicable		Moribund tissues exhibiting grey-black vascular discoloration	

Table 2.11 Post-harvest root crop characterization record sheet

DATE:		SITE:	SCORE:					MEAN:
CATEGORY:		SAMPLE LOCUS:	ROOT No. 1	2	3	4	...etc.	
Surface	Appearance:							
Surface damage	Mechanical: Insect: Rots: Pests:							
Sprouting	Active areas: Sprout length:							
Internal deterioration	Microbial Physiological Insect	Cut No. 1 (top) Cut No. 2 (centre) Cut No. 3 (bottom) Cut No. 1 (top) Cut No. 2 (centre) Cut No. 3 (bottom) Cut No. 1 (top) Cut No. 2 (centre) Cut No. 3 (bottom)						
Texture	Root head Root equator Root base							
Weight loss	Sample of 6 roots:							

Analysis of results

Mean scores from representative samples taken from consignments of roots and tubers should provide serviceable profiles.

Following preliminary trials, the appraisal of a commodity, by means of a profile, for possible different end user, should be confirmed with those groups intimately associated with the utilization of the commodity.

Significance

The sample profiles generated provide static representations of the likely condition of a consignment as a whole. How closely these findings correlate with the absolute condition of larger consignments will depend on the sampling regimes adopted.

International standards

None known.

References

BOOTH, R. H. (1974) Post-harvest deterioration of tropical root crops: losses and their control. *Tropical Science*, **16**(2): 49–63.

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MCFARLANE, J. A. (1982) Cassava storage. II. Storage of dried cassava products. *Tropical Science*, **24**(4): 205–236.

OJE, K. (1993) Moisture content determination for cassava: development of direct and indirect methods. *Agricultural Mechanization in Asia, Africa and Latin America*, **24**(1): Special issue, 51–54.

INSECT-DERIVED WEIGHT LOSS

Introduction

In many parts of the tropics, cassava is stored as chips which are attacked by a wide range of insect pests. Loss assessment allows an evaluation of the physical losses suffered to be measured.

Rationale

Loss assessment is a useful tool for evaluating the impact of insect pests in stored cassava and the consequent effects on food security. It can also be used for direct comparisons between different systems (e.g. storage techniques or insecticide treatments) to measure the relative merits of each, and to provide a qualitative indication of consumer acceptability and/or market value.

Suitability

The method allows a field assessment of losses to be made using a minimum of equipment, that can be undertaken at any stage of the storage season, with no requirement for base-line data or moisture content measurements. For absolute determinations of loss, there is no alternative to weighing the chips at the moment of storage, re-weighing on removal for evaluation, and then adjusting for any changes in moisture content.

Limitations

The method relies on the evaluator being able to match cassava samples to one of a set of pre-arranged photographs showing chips with different damage levels. The test is therefore subjective, but original observations of repeatability suggest that results between operators is good (Compton *et al.*, (in press)). There is also a need to confirm whether the damage classes are common between cassava varieties and for different pest spectra.

Principles

The rapid assessment technique works on the principle that the external appearance of a cassava chip, i.e., the extent of insect holing on the chip's surface, is related to the weight loss that has been suffered by that chip. Chips are allocated to one of five damage classes each with a pre-derived level of percentage weight loss that has been determined in the laboratory using a weigh-in, weigh-out technique.

Requirements

Equipment

- Calculator

Consumables

- Set of photographs showing typical examples of chips in each of the damage classes
- Sample bags with labels if the chips cannot be assessed in the field

Procedure

Take a sample of 20 chips from the store that is being sampled (for a full discussion of sampling see Drew *et al.*, 1978 and Boxall, 1986). Compare each chip, in turn, with the reference set of photographs and allocate a damage class (1–5). The colour

and size of the cassava piece are unimportant; evaluate the density of holes on the surface only. Record the number of chips in each damage class on a data sheet.

To calibrate this method, refer to section 3.1 on the weigh-in, weigh-out technique for the assessment of insect-derived weight loss. This allows percentage weight loss to be assigned to a particular damage class.

Analysis of results

Visual damage scale for cassava
(Class 1 – undamaged – not shown)

(a) Class 2 – light damage

(b) Class 3 – medium damage

(c) Class 4 – medium-high damage

(d) Class 5 – severe damage

Figure 2.3 Examples of insect damage classes for cassava

Calculation of sample weight loss

Multiply the total number of chips in each damage class by the imputed loss level for that class. Repeat this for each damage class and sum the results. Calculate the mean percentage weight loss by dividing the summed result by the number of chips in the sample, as shown below:

$$\frac{N_1D_1 + N_2D_2 + N_3D_3 + N_4D_4 + N_5D_5}{N_T} = \text{mean \% weight loss}$$

where: N_1 = number of chips in damage class 1
D_1 = imputed weight loss for damage class 1
N_T = total number of chips in sample (= $N_1+N_2+N_3+N_4+N_5$).

Significance

The result obtained shows the mean percentage weight loss of the sample taken. How well this reflects the mean weight loss in the store will depend on the sampling regime employed.

International standards

None known.

References

BOXALL, R. A. (1986) *A critical review of the methodology for assessing farm-level grain losses after harvest*. Report G191, Tropical Development and Research Institute (now NRI, Chatham).

COMPTON, J. A. F., WRIGHT, M. A. P., GAY, C. and STABRAWA, A. (In press) A rapid method for loss assessment in stored maize and dried cassava. *International Journal of Pest Management*.

DREW, B. A., GRANOVSKY, T. A. and LINDBLAD, C. J. (1978) Representative sampling, interpretation of results, accuracy and reliability. Pp. 45–57. In: *Post-Harvest Grain Loss Assessment Methods*. (HARRIS, K. L. and LINDBLAD, C. J. eds). New York: American Association of Cereal Chemists.

SPECIFIC GRAVITY OF CASSAVA ROOTS

Introduction

Specific gravity is related to the density of fresh produce. It can be used to estimate other attributes, such as starch and dry matter content, that influence consumer acceptability. The method described allows the field determination of specific gravity of cassava roots.

Rationale

The specific gravity determination can provide an estimate of the dry matter and starch content of cassava.

Suitability

The method has only been verified for fresh cassava roots.

Limitations

Conversion tables allowing dry matter and starch content to be estimated from the specific gravity values are given below. It is important to note that calibration of this method is required for fresh cassava grown under diverse conditions of environment, soil type, age at harvest etc.

Principles

Through the determination of the weight of a commodity in air and in water, the specific gravity may be calculated. This can then be correlated with dry matter content and starch content by means of conversion tables.

Requirements

Equipment

- Lever-arm balance weighing up to 3 kg with a precision of 0.1 g

- Watertight vessel, e.g. half a petrol drum large enough to contain the basket, roots and water
- Wire basket to hold approximately 3 kg of roots
- Plastic string measuring 2 m
- 'S'-shaped hook
- Board to support balance with a hole cut directly beneath the balance base
- Table frame, e.g. 50 x 50 cm sides, 75 cm height

Consumables

- Marker pen
- Plastic or paper bags of sufficient size to hold 3 kg of roots

Procedure

Measurement of specific gravity should be taken as soon after harvesting as possible, i.e., in the field. Take 3–4 representative roots for each batch or variety of a total weight greater than 3 kg. Trim and clean the roots. Pack in labelled bags and transport to the measurement site.

Set the measuring equipment up in a draught-free area. Weigh the fresh roots in air and take a reading for each individual root. To avoid misreading, take 3 kg of whole or part roots for each batch, noting down the exact weight to obtain the *air reading*. Re-pack the samples in their respective bags.

To weigh the fresh roots in water, set the equipment up as follows: place the balance on the supporting board over the table frame; suspend the wire basket from the string; completely submerge the wire basket in water; attach the hook to the string; pass the hook through the hole in the supporting board and attach it to the lower part of the balance plate; ensure that the basket and string are not touching anything and that the basket is freely suspended; tare the balance to zero.

Place each sample in the basket so that it is completely submerged and note the *water reading*.

Analysis of results

Calculation

Specific gravity of the variety or batch may be calculated to four decimal places using the following formula:

$$\text{Specific gravity} = \frac{\text{Air reading}}{\text{Air reading–water reading}}$$

Table 2.12 Suggested recording table for specific gravity determination

Batch	Air reading (kg)	Water reading (kg)	Air–water reading (kg)	Specific gravity
RS23	2.9000	0.4500	2.4500	1.1836

In the example given, using Table 2.13, values of 45.07% for dry matter and 42.68% starch content are obtained.

Significance

Tables have been prepared by CIAT to relate specific gravity to dry matter and starch content. An important point to note is that data within tables 2.13 and 2.14 were calculated from information on cassava harvested between 10 and 12 months in age, grown under standard growth conditions present in Colombia. Variation in growing conditions, climatic type or harvesting time would necessitate calibration of the relationship for the prevailing conditions.

Table 2.13 Conversion of specific gravity into percentage dry matter (DM) and starch content (SC) for cassava

Specific gravity	Dry matter DM(%)	Starch content SC (%)	Specific gravity	Dry matter DM(%)	Starch content DM(%)
1.0200	19.53	17.73	1.0505	24.29	22.38
05	19.61	17.80	10	24.37	22.48
10	19.60	17.88	15	24.45	22.54
15	19.76	17.96	20	24.53	22.61
20	19.84	18.03	25	24.61	22.69
25	19.92	18.11	30	24.68	22.76
30	20.00	18.19	35	24.76	22.84
35	20.08	18.26	40	24.84	22.92
40	20.15	18.34	45	24.92	22.99
45	20.23	18.41	50	25.00	23.07
50	20.31	18.49	55	25.07	23.15
55	20.39	18.57	60	25.15	23.22
60	20.47	18.64	65	25.23	23.30
65	20.54	18.72	70	25.31	23.37
70	20.62	18.80	75	25.39	23.45
75	20.70	18.87	80	25.46	23.53
80	20.78	18.95	85	25.54	23.60
85	20.86	19.03	90	25.62	23.68
90	20.93	19.10	95	25.70	23.76
95	21.01	19.18	1.0600	25.78	23.83
1.0300	21.03	19.25	05	25.86	23.91
05	21.17	19.33	10	25.93	23.99
10	21.25	19.41	15	26.01	24.06
15	21.33	19.48	20	26.09	24.14
20	21.40	19.56	25	26.17	24.21
25	21.48	19.64	30	26.25	24.29
30	21.56	19.71	35	26.32	24.37
35	21.64	19.79	40	26.40	24.44
40	21.72	19.86	45	26.48	24.52
45	21.79	19.94	50	26.56	24.60
50	21.87	20.02	55	26.64	24.67
55	21.95	20.09	60	26.71	24.75
60	22.03	20.17	65	26.79	24.82
65	22.11	20.25	70	26.87	24.90
70	22.18	20.32	75	26.95	24.98
75	22.26	20.40	80	27.03	25.05
80	22.34	20.47	85	27.10	25.13
85	22.42	20.55	90	27.18	25.21
90	22.56	20.63	95	27.26	25.28
95	22.57	20.70	1.0700	27.34	25.36
1.0400	22.65	20.78	05	27.42	25.44
05	22.73	20.86	10	27.50	25.51
10	22.81	20.93	15	27.57	25.59
15	22.89	21.01	20	27.65	25.66
20	22.97	21.09	25	27.73	25.74
25	22.04	21.16	30	27.81	25.82
30	23.12	21.24	35	27.89	25.89
35	23.20	21.31	40	27.96	25.97
40	23.28	21.39	45	28.04	26.05
45	23.36	21.47	50	28.12	26.13
50	23.43	21.54	55	28.20	26.20
55	23.51	21.62	60	28.28	26.28
60	23.59	21.70	65	28.35	26.36
65	23.67	21.77	70	28.43	26.43
70	23.75	21.85	75	28.51	26.51
75	23.82	21.92	80	28.59	26.59
80	23.90	22.00	85	28.67	26.66
85	23.98	22.08	90	28.74	26.74
90	24.06	22.15	95	28.82	26.81
95	24.14	22.23	1.0800	28.90	26.89
1.0500	24.22	22.31			

Table 2.13 *continued*

Specific gravity	Dry matter DM(%)	Starch content SC (%)	Specific gravity	Dry matter DM(%)	Starch content DM(%)
1.8005	28.98	26.96	1.1085	33.36	31.24
10	29.06	27.04	90	33.44	31.31
15	29.14	27.11	95	33.51	31.39
20	29.22	27.19	1.1100	33.59	31.46
25	29.30	27.27	05	33.67	31.54
30	29.37	27.34	10	33.75	31.62
35	29.45	27.42	15	33.83	31.69
40	29.53	27.50	20	33.90	31.77
45	29.61	27.57	25	33.98	31.03
50	26.69	27.65	30	34.06	31.92
55	29.77	27.72	35	34.14	32.00
60	29.84	27.80	40	34.22	32.07
65	29.92	27.88	45	34.29	32.15
70	30.00	27.95	50	34.37	32.23
75	30.08	28.03	55	34.45	32.30
80	30.16	28.11	60	34.53	32.38
85	30.23	28.18	65	34.61	32.46
90	30.31	28.26	70	34.69	32.53
95	30.39	28.34	75	34.76	32.61
1.0900	30.47	28.41	80	34.84	32.69
05	30.55	28.49	85	34.92	32.76
10	30.62	28.56	90	35.00	32.84
15	30.70	28.64	95	35.08	32.91
20	30.78	28.72	1.1200	35.15	32.99
25	30.86	28.79	05	35.23	33.07
30	30.94	28.87	10	35.31	33.14
35	31.01	28.55	15	35.39	33.22
40	31.09	29.02	20	35.46	33.30
45	31.17	29.10	25	35.54	33.37
50	31.25	29.17	30	35.62	33.45
55	31.33	29.25	35	35.70	33.52
60	31.41	29.33	40	35.77	33.60
65	31.48	29.40	45	35.85	33.68
70	31.56	29.48	50	35.93	33.75
75	31.64	29.56	55	36.01	33.83
80	31.72	29.63	60	36.09	33.91
85	31.80	29.71	65	36.16	33.98
90	31.87	29.76	70	36.24	34.06
95	31.95	29.86	75	36.32	34.14
1.1000	32.03	29.94	80	36.40	34.21
05	32.11	30.01	85	36.48	34.29
10	32.19	30.09	90	36.55	34.36
15	32.26	30.17	95	36.63	34.44
20	32.34	30.24	1.1300	36.71	34.52
25	32.42	30.32	05	36.79	34.59
30	32.50	30.40	10	36.87	34.67
35	32.58	30.47	15	36.95	34.75
40	32.65	30.55	20	37.02	34.82
45	32.73	30.62	25	37.10	34.90
50	32.81	30.70	30	37.18	34.97
55	32.89	30.78	35	37.26	35.05
60	32.67	30.85	40	37.34	35.13
65	33.05	30.93	45	37.41	35.20
70	33.12	31.01	50	37.49	35.28
75	33.20	31.08	55	37.57	35.36
80	33.28	31.16	60	37.56	35.43

Table 2.13 *continued*

Specific gravity	Dry matter DM(%)	Starch content SC (%)	Specific gravity	Dry matter DM(%)	Starch content DM(%)
1.1365	37.73	35.51	1.1635	41.94	39.64
70	37.80	35.59	40	42.02	39.71
75	37.88	35.66	45	42.10	39.79
80	37.96	35.74	50	42.18	39.86
85	38.04	35.81	55	42.26	39.94
90	38.12	35.89	60	42.33	40.02
95	38.19	35.97	65	42.41	40.09
1.1400	38.27	36.04	70	42.49	40.17
05	38.35	36.12	75	42.57	40.24
10	38.43	36.20	80	42.65	40.32
15	38.51	36.27	85	42.72	40.40
20	38.59	35.35	90	42.80	40.47
25	38.66	36.42	95	42.88	40.55
30	38.74	36.50	1.1700	42.96	40.65
35	38.82	36.58	05	43.04	40.70
40	38.90	36.65	10	43.12	40.78
45	38.98	36.73	15	43.19	40.86
50	39.05	36.81	20	43.27	40.93
55	39.13	36.88	25	43.35	41.01
60	39.21	36.96	30	43.43	41.08
65	39.29	37.04	35	43.51	41.16
70	39.37	37.11	40	43.59	41.24
75	39.44	37.19	45	43.66	41.31
80	39.52	37.26	50	43.74	41.39
85	39.60	37.34	55	43.82	41.47
90	39.68	37.42	60	43.90	41.54
95	39.76	37.49	65	43.98	41.62
1.1500	39.84	37.57	70	44.06	41.70
05	39.91	37.65	75	44.13	41.77
10	39.99	37.72	80	44.21	41.84
15	40.07	37.80	85	44.29	41.92
20	40.15	37.87	90	44.37	42.00
25	40.23	37.95	95	44.45	42.07
30	40.30	38.03	1.1800	44.52	42.15
35	40.38	38.10	05	44.60	42.22
40	40.46	38.18	10	44.68	42.30
45	40.54	38.26	15	44.76	42.38
50	40.62	38.33	20	44.83	42.45
55	40.69	38.41	25	44.91	42.53
60	40.77	38.49	30	44.99	42.61
65	40.85	38.56	35	45.07	42.68
70	40.93	38.64	40	45.15	42.76
75	41.01	38.71	45	45.22	42.84
80	41.08	38.79	50	45.30	42.91
85	41.16	38.87	55	45.38	42.98
90	41.24	38.94	60	45.46	43.06
95	41.32	39.02	65	45.54	43.14
1.1600	41.40	39.10	70	45.61	43.22
05	41.48	39.18	75	45.69	43.29
10	41.55	39.25	80	45.77	43.37
15	41.63	39.33	85	45.85	43.45
20	41.71	39.41	90	45.93	43.52
25	41.79	39.48	95	46.00	43.60
30	41.87	39.56	1.1900	46.08	43.67

Source: Tomado de CIAT (1978) Cursa de Producción de Yuca. Ed. Pre. (1): 353–356.

Table 2.14 Summary table for conversion of specific gravity to dry matter (DM) and starch content (SC) for cassava assuming that the air reading is 3 kg

Water reading	Dry matter DM (%)	Starch content SC (%)	Water reading	Dry matter DM (%)	Starch content DM (%)
58.8	20	18	296.0	34	32
77.4	21	19	311.8	35	33
95.8	22	20	327.4	36	34
112.6	23	21	342.8	37	35
130.6	24	22	359.0	38	36
148.3	25	23	371.9	39	37
165.8	26	24	386.7	40	38
183.1	27	25	401.5	41	39
198.9	28	26	416.0	42	40
215.8	29	27	430.4	43	41
232.5	30	28	443.5	44	42
248.9	31	29	457.6	45	43
265.2	32	30	471.5	46	44
280.1	33	31	–	–	–

Source: Tomado de CIAT (1979) Manual de Producción de Yuca. Ed. Pre. E-79.

International standards

None known.

References

TOMADO DE CIAT (1978) Cursa de Producción de Yuca. *Ed. Pre.* (1): 353–356.

TOMADO DE CIAT (1979) Manual de Producción de Yuca. *Ed. Pre.* E-79.

SWELLING CAPACITY OF GARI

Introduction

Gari is a partially gelatinized cassava product common in West Africa. One of the characteristics of gari is that it expands in water. This method gives a standard procedure for measuring the expansion.

Rationale

The expansion or swelling of gari when in contact with water is a desirable characteristic of the product.

Suitability

This method is only suitable for gari from cassava and is suitable for either laboratory or field use.

Limitations

Gari should be in the dry form.

Principles

The expansion ability of gari can be estimated by measuring the volume by which a known volume of product expands in a known volume of water. The method is modified from Ajibola *et al.* (1987).

Requirements

Equipment

- 50 ml measuring cylinder (glass, but polythene preferred for use in field)

Consumables

- Water (at room temperature)

Procedure

Fill a 50 ml measuring cylinder with gari to the 10 ml mark. Add distilled or clear tap water at room temperature to give a total volume of 50 ml. Cover the top of the measuring cylinder tightly and mix by inverting. Invert again after 2 min. Leave for a further 3 min (5 min total time) and record volume occupied by gari.

Analysis of results

Calculation of swelling capacity

Table 2.15 Record table for the swelling capacity of gari

Sample code	Volume of gari (ml)	Volume of gari in water (ml)	Swelling capacity
G1	10.0	30.0	3.0

The following calculation is used:

$$\text{Swelling capacity} = \frac{\text{Volume of gari in water}}{\text{Initial volume of gari}}$$

Significance

A swelling capacity of 3.0 is the general accepted level for gari (Sanni, 1991).

International standards

There are no known standards for swelling capacity.

References

AJIBOLA, O. O., MAKAMJUOLA, G. A. and ALMAZAN, A. M. (1987) Effects of processing factors on the gari produced by steam gelatinisation technique. *Journal of Agricultural Engineering Research,* **38**: 313–320.

SANNI, M. O. (1991) Delineating the quality of gari. pp. 133–137. In: *Traditional African Foods—Quality and Nutrition.* WESTBY, A. and REILLY, P. A. J. (eds). Stockholm: International Foundation for Science.

TEXTURE AND COOKING QUALITY

Introduction

Texture is one of the most important quality characteristics determining consumer acceptability in fresh and processed products of NGSS food crops.

Rationale

The textural properties of a commodity and changes during post-harvest processing undoubtedly influence its final market quality. It is therefore important to measure texture objectively during production and post-harvest utilization.

Suitability

To obtain quantitative data it is usually necessary to use instrumental methods or a trained sensory panel. Portable measuring devices are suitable for field and laboratory use. For simple comparison of samples, texture can be qualitatively assessed by observation and feel.

Limitations

For quantitative instrumental assessments, a texture-measuring device such as a force gauge or penetrometer is required. Most modern instruments are capable of good resolution and accuracy, and are generally portable.

Most simple instrumental methods can be applied to both uncooked and cooked NGSS. Very soft processed products can only be assessed by using laboratory-based extrusion methods and equipment.

Principles

The texture of food is a composite attribute resulting from a combination of factors such as water turgor, and structural/storage components of tissues and cells. Any individual physical assessment procedure can only provide a limited indication of these textural properties. Most routine texture-measuring devices determine aspects such as compressibility, deformation or rupture of a test sample.

Requirements

Equipment

Requirements listed below are dependent on the method used; refer to the procedural requirements.

- Mechanical or electronic balance
- Mechanical or electronic force gauge
- Drill stand
- Chart recorder (optional)
- Appropriate diameter round-ended probes
- Cooking vessels, steaming rack
- Stop-watch or domestic timer

Consumables

- Knives/blades for cutting samples
- Thermometer
- Slotted spoon

Procedure

Sample preparation

Measure the texture at the same relative position on a commodity and apply consistent procedures to enable valid comparison. Anatomical zones and interfaces exist in root and banana tissue; make measurements at points where the starchy parenchyma appears uniform.

Prior to instrumental measurement of roots, remove the peel/skin from a small test area and use a sharp knife in order to make a clean cut. For hard samples such as root crops, hold the intact root on the bench or test stand.

In the case of plantain/cooking banana, apply measurements to a transverse section cut from the intact fruit. If possible, use a home-made, twin-bladed knife with blades set 1 cm apart to obtain 1 cm thick transverse sections.

Determination of cooking quality

Use a large vessel to minimize the delay in the water returning to the boil on addition of the sample. Fill the cooking vessel with potable water and bring to the boil. Confirm that the water is boiling vigorously and measure the temperature with a thermometer.

Where applicable, use the traditional method of preparation, e.g. boiling or steaming. For steaming, place the sample on a perforated rack and pass the thermometer through a hole in the lid of the cooking vessel. When conditions are correct, proceed to cook and start the stop-watch.

To assess cooking quality, first determine the cooking time appropriate to the commodity/product. Remove duplicate samples at given time intervals, e.g. 1, 3, 5, 10, 15, 20 and 30 min. Allow to cool and make texture measurements. Determine a suitable cooking time for use in comparative or quick field tests.

Simple quantitative instrumental method

Use top-pan mechanical or electronic scales with an appropriate range. Place the sample on the pan and using a suitable probe (e.g. cylindrical, rounded or flat-ended), apply a downward perpendicular force to obtain a maximum reading corresponding to the point at which the tissue ruptures. For hard tissues, use a blade to obtain a reading of the force/weight required to cut the tissue.

To determine the force/weight required to rupture the tissue, use one of the following methods:

- note the maximum reading by eye;
- use a freeze facility on an electronic balance;
- record the measurement by means of a chart recorder;
- using mechanical scales with a dial face, attach a thin, free-moving wire pointer to register the maximum force (this is pushed round by the normal weight indicator) and manually reset after recording the reading.

Quantitative determination using penetrometers

Use portable hand-held gauges such as the Magness-Taylor pressure tester and the Effegi penetrometer. For bananas/plantains, use a 6 mm round-ended probe; for roots and tubers, use a probe of 6 mm or less.

Select a penetrometer with an operating range in line with the commodity under investigation, conforming to the manufacturer's recommendation. As a guide, a 0–10 kg instrument (using a 6 mm probe) should be adequate for plantain/banana cultivars, some root crops and cooked material. Harder roots and dried material may require a higher range instrument such as 0–20 or 25 kg.

The force required to puncture a sample is influenced by the size and geometry of the probe. A smaller diameter probe will allow measurement on a lower capacity instrument which would otherwise have been over-range. Where possible, use the same shape and size probe throughout an investigation to enable comparisons to be made.

When using a hand-held instrument, hold the sample firmly in one hand against a firm surface. When measuring the pulp rupture force of a transverse section, place the sample on a Perspex or similar platform with a hole slightly larger than the probe diameter (this reduces the risk of damaging the probe or force gauge).

Take care to apply a steady, continuous, non-jerking motion to minimize variability. Record the maximum reading registered by one of the methods described above.

Perform duplicate measurements for each sample with sufficient space between measurement positions to avoid effects from weakened tissue. Obtain a third reading if a difference of more than 5% is observed.

More expensive and sophisticated mechanical or electronic instruments include the Chatillon Push-Pull Gauge and the Mecmesin Electronic Force Gauge. These are hand-held or stand-mounted and are fully portable. Electronic instruments use a transducer or load cell to measure the applied force and output to a chart recorder or computer. Operator error can be reduced by adapting a home workshop drill stand to mount these types of penetrometer and allow a steady application of the probe to the sample.

Analysis of results

Recording textural data

Texture measuring devices frequently express compression/rupture values in Newtons (N) or kilogram (kg) forces. For reference, always quote the diameter and shape of the probe used and penetration rate if applicable.

Table 2.16 Suggested table for recording textural data

Sample or cultivar	Replicate number	Reading 1 (kg)	Reading 2 (kg)	Reading 3 (kg)	Mean reading (kg)
AZ	1	0.025	0.026	0.025	0.025

Significance

Hard texture or high rupture values in fresh commodities may indicate freshness or under-ripeness. Post-harvest deterioration or over-ripened commodities may correspond to a reduction in rupture values. In cooked samples, hard glassy textures and elevated rupture values generally indicate poor quality commodities.

International standards

There are no official standards for measuring texture or for texture values of commodities. Texture measurement of certain commodities is undertaken by some wholesale and retail distributors to assess fruit maturity and ripeness. Data are used to set internal guidelines or standards for suppliers within the trade.

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Section 2.2 Chemical composition

CYANOGENIC POTENTIAL

Introduction

Cassava contains cyanogenic compounds which, when hydrolysed by endogenous enzymes, release hydrogen cyanide. The method described allows the rapid, semi-quantitative determination of the cyanogenic potential of the cassava fresh root.

Rationale

The method described allows the categorization of fresh cassava roots by their approximate cyanogenic potential. This is a useful technique for preliminary screening of cassava varieties within breeding trials and may also be of potential use both to traders and to small farmers.

Suitability

The method is appropriate for the analysis of fresh cassava roots. It can be readily performed in the field and can easily provide a high throughput of samples at low cost.

Limitations

The assay is a semi-quantitative method. A reasonable degree of reliability (70%) has been recently reported (O'Brien *et al.*, 1994). However, it has been observed to overestimate cyanogen levels in some cassava roots of low cyanogenic potential (0–50 mg HCN/kg fresh weight basis).

This method is not suitable for the *accurate* determination of cyanogen levels in cassava fresh root. Nor is it suitable for the determination of cyanogens, accurate or approximate, of processed cassava products due to the reduced activity of the endogenous enzyme linamarase which is an integral part of the assay. Refer to Part 3 for a quantitative procedure for determining cassava cyanogens.

Principles

A semi-quantitative determination of cyanogenic potential is obtained by means of a rapid colorimetric indicator strip test. The change in colour of the strip is dependent on the amount of hydrogen cyanide released during hydrolysis by endogenous enzymes. A scale related to colour change may be set to allow categorization of cassava varieties by cyanogenic potential of the fresh root.

Requirements

Equipment

- Balance accurate to 0.1 g
- Knife
- Small knife or scalpel
- Glass tubes 12 cm long with tightly fitting rubber stoppers
- Ruler
- Colour chart

Consumables

- Measuring cylinder
- Filter paper, e.g. Whatman No. 1, 6 cm x 1 cm strip
- Picric acid
- Sodium carbonate, anhydrous

- Toluene
- Distilled water
- Dropper bottle
- Protective gloves

Hazardous chemicals

Picric acid: *risk of explosion by shock, friction, fire or other source of ignition; forms very sensitive explosive metallic compounds (with Pb, Hg, Cu or Zn); harmful if taken internally; contact with skin and eyes to be avoided.*

Toluene: *highly flammable; harmful vapour; breathing vapour and contact with skin and eyes to be avoided.*

Procedure

Preparation of alkaline picrate solution

Take 5 g of moist picric acid and 25 g of anhydrous sodium carbonate and dissolve in distilled water. Make up to 1 l.

Note: Picric acid is explosive when dry, so the crystals are therefore supplied moist as a solid. Prepare the alkaline pictate solution before leaving for the field. Wear gloves when handling the chemical and solution.

Picrate test

Test cassava roots as soon after harvesting as possible. In the event of a delay, avoid analysing damaged or deteriorating roots.

For each root to be tested, measure the longitudinal length and remove a 1 cm-thick disc section from the longitudinal, central point. In the freshly-removed disc, pinpoint the halfway point between the peel and the centre of the parenchyma. Then, using a knife, cut a straight piece out of the disc, with the halfway point at the centre, so that the removed piece has 0.5 cm either side of this point (i.e., 0.5 cm towards the peel and 0.5 cm towards the centre). From the centre of this straight piece of parenchyma, remove a 1 cm cube.

Place the cube in a tube and place five drops of toluene on the sample. Take a strip of filter paper (Whatman No. 1) 1 x 6 cm. Dip the strip into the alkaline picrate mixture until saturated, remove excess and suspend in the sample tube above the cube by means of a tightly fitted rubber stopper. Avoid contact between the strip and sample or side of the tube. After a period of 10–12 h, compare the colour of the picrate strip with that of a pre-set colour scale of 1–9.

Scoring system

Originally, the picrate assay operated with the score structure shown in Figure 2.4.

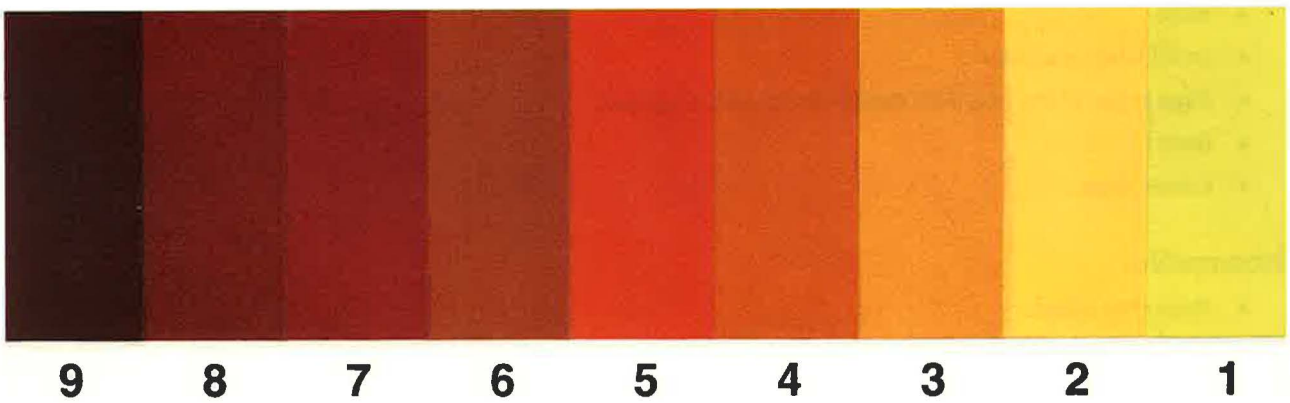

Figure 2.4 Picrate scoring colour chart

Table 2.17 Original picrate score structure

Score	Cyanogenic potential (mg HCN equivalence/ kg fresh weight)
1 Pale yellow	<10
2	10–15
3	15–25
4	25–40
5	40–60
6	60–85
7	85–115
8	115–150
9 Dark brown	>150

More recently, the scores have been grouped as shown in Table 2.18.

Table 2.18 Recommended picrate scoring structure

Range	Score	Cyanogenic potential (mg HCN equivalence /kg fresh weight)
1	1–4	0–50
2	5–6	50–100
3	7–9	>100

Analysis of results

Calculation

No calculation is required for determination of cyanogenic potential on a fresh weight basis.

Significance

Inter-root, inter-plant and inter-varietal variation contribute to a great variability in the cyanogenic potential of fresh roots. However, this semi-quantitative method allows the categorization of varieties into low, medium and high cyanogenic potential by a rapid, high throughput method.

International standards

No standards are known for fresh root cyanogenic potential.

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DRY MATTER DETERMINATION

Introduction

Moisture content is an important quality characteristic in both fresh roots and processed products. It is also required for the calculation of other quality characteristic determinants such as cyanogen content. The method describes a means by which a

sample of fresh roots and processed products, that are not dry, can be stabilized in the field and transported to a laboratory for moisture content determination.

Rationale

A low moisture content in a processed product is a requirement for a long storage life. The moisture content of a fresh root is related to the dry matter content and therefore to the yield obtained from a particular crop or cultivar.

Suitability

The method allows the preparation of fresh roots and processed products to a form in which they can be stored until transportation to a laboratory or suitable oven for completion of the dry weight procedure.

Limitations

The results obtained will not be as accurate as laboratory determination (see Part 3).

Principles

The fresh root and processed products are homogenized in a preserving medium. The presence of benzoic acid limits the growth of micro-organisms that could interfere in the accurate determination of dry matter, especially for fresh roots and moist processed products. The prepared samples may then be stored for up to 3 months or until they can be transported to the location of a suitable oven for drying.

Requirements

Equipment

- Portable balance, 200 g to an accuracy of 0.01 g
- Hand-held blender or food blender plus power supply
- Mincer (as used for meat)
- Oven to operate between 70 °C and 105 °C
- 5 gallon water carrier to hold extraction medium
- 100 ml measuring cylinder
- 250 ml bottles (polypropylene) for transporting samples
- Wash bottle containing extraction medium
- Wash bottle containing distilled water
- 1000 ml volumetric flask
- Knife
- Basin or bucket

Consumables

- Benzoic acid
- Foil or glass dish for drying sample
- Labels
- Orthophosphoric acid
- Distilled water

Hazardous chemicals

Benzoic acid: may be harmful by inhalation, ingestion, or absorption through skin; causes eye and skin irritation; contact with eyes and skin to be avoided.

Orthophosphoric acid: causes burns; contact with eyes and skin to be avoided.

Procedure

Preparation of extraction medium

To 500 ml distilled water in a 1000 ml volumetric flask add 56 ml of orthophosphoric acid. Add 10 g of benzoic acid. Dissolve by adding a quantity of warm distilled water to the volumetric flask. Make up to 1000 ml with distilled water.

To 8 l of distilled water in a 5 gallon polythene container add the 1000 ml of acid/benzoate solution. Use a further 1000 ml of distilled water to wash out the volumetric flask and add this to the polythene container. Seal and mix well.

Preparation of fresh root sample

Weigh dry homogenizer pot. Record weight. Weigh out approximately 30 g of diced roots to two decimal places into homogenizer pot and record the weight. Add 80 ml of extraction medium and homogenize to break up roots.

Weigh 250 ml container and lid for transport. Record weight. Add the slurry to the 250 ml container and wash out the homogenizer pot and homogenizer into the 250 ml container with a minimum amount of extraction medium in a wash bottle.

Weigh the 250 ml labelled container (with lid) and sample. Record weight. Mix contents by shaking. Transport sealed container to laboratory/oven.

Preparation of processed product sample

If necessary, grind any pieces using a mincer.

Weigh 250 ml transport pot with lid. Record weight. Weigh out approximately 50 g of product and record the weight of the container plus sample. Add 100 ml of extraction medium, weigh and record the weight of the container, sample and extraction medium. Shake well. Label the container. Transport sealed container to laboratory.

Determination of dry weight

Label foil dish and weigh. Record weight. Using distilled water, transfer sample from transport bottle into foil dish. Dry to constant weight (typically, overnight at 70 °C followed by overnight at 105 °C). Record the final weight.

NOTE: A low temperature for the period of drying allows the evaporation of moisture without gelatinizing the starch. Higher temperatures then finally dry the sample.

Analysis of results

Calculation

Table 2.19 Example of a suitable data recording table for dry weight

Sample code	S1				
A Weight of homogenizer pot (g)	10.00				
B Weight of homogenizer pot + sample (g)	40.02				
C Weight of 250 ml container (g)	15.00				
D Weight of container + sample + acid (g)	150.00				
TAKE TO LABORATORY AND DRY IN OVEN	–	–	–	–	–
E Weight of aluminium foil container (g)	5.13				
F Weight of foil container + dried sample (g)	15.29				
MOISTURE CONTENT (%)	63.36				
DRY MATTER (%)	36.64				

Refer to the results in Table 2.19 for the code letters used below.

Wet weight of sample = B–A

Weight of extraction medium = (D–C)–(B–A)

Weight of dry matter = F–E

If the weight of any residual matter in the extraction medium is ignored, the percentage moisture content will be:

$$\text{percentage moisture content} = \frac{(B–A)–(F–E)}{(B–A)} \times 100$$

Accounting for the residual matter of the extraction medium, the calculation will be:

$$\text{Residual matter from extraction medium (RM)} = 0.008 \times ((D–C)–(B–A))$$

$$\text{Percentage moisture content} = \frac{(B–A)–(F–E)–RM}{(B–A)} \times 100$$

$$\text{Dry matter content (\%)} = 100–(\%\ \text{moisture content})$$

Significance

Fresh roots typically have moisture contents of 60–80%. Processed products vary depending on the processing method used. For a dry processed product to store well, the moisture content should be less than 12% in order to avoid fungal contamination.

International standards

Codex Regional Standard for gari (CODEX STAN 151–1985) states that the moisture content should not exceed 12% m/m.

Codex Draft African Regional Standard for edible cassava flour (ALINORM 91/28) states that the moisture content should not exceed 13% m/m.

pH AND TITRATABLE ACIDITY

Introduction

The pH value gives a measure of the acidity or alkalinity of a product. Total titratable acidity gives a measure of the amount of acid present.

Rationale

The pH value and titratable acidity are good measures of the degree of fermentation. Acid fermentations typically reduce the pH value to about 4.0. Mould growth and the consequent release of ammonia results in an increased pH value. The pH value is also a determining factor in the stability of cyanogens in processed products.

Suitability

The method allows the determination of pH value and total titratable acidity (TTA) in the field situation with the minimum of equipment. The technique is suitable for any root or tuber crop product.

Limitations

The pH meter recommended is designed for field use but has a lower degree of accuracy than a laboratory pH meter. The phenolphthalein method of titratable acidity is dependent on a colour change from colourless to pink. This pink colour can be difficult to see with highly coloured products. For the calculation, it is assumed that lactic acid is the only acid present.

Principles

The pH value is determined using a portable pH electrode. TTA is determined by titration of the product with sodium hydroxide to the phenolphthalein end point and calculation of acid present as lactic acid.

Requirements

Equipment

- pH meter (range 0–14, resolution 0.1 or more; accuracy 0.2 or more; manual or automatic calibration, battery operated) or universal indicator paper
- Burette (25 ml, polypropylene automatic self-zeroing recommended)
- Burette stand
- Balance (suitable for weighing to 1.0 g)
- 250 ml clear polypropylene conical flasks
- 100 ml and 200 ml volumetric flasks (glass acceptable for laboratory use)
- Wash bottle with distilled water
- Dropping bottle for dispensing indicator
- Measuring cylinder
- Mill or mortar and pestle
- Funnel

Consumables

- pH 7.0 and pH 4.0 buffer powders
- Polythene bags (reasonable thickness for blending samples)
- 0.1 m sodium hydroxide (purchased as volumetric solution or as ConvoL solution for dilution – do not make from NaOH pellets)
- Phenolphthalein indicator (solid)
- Ethanol
- Distilled water
- Universal indicator paper (optional)

Hazardous chemicals:

Ethanol: *highly flammable; breathing vapour in high concentrations to be avoided.*

Phenolphthalein: *clinical overdosage causes gastro-intestinal problems and skin eruption; contact with skin and eyes to be avoided.*

Sodium hydroxide: causes severe burns; contact with eyes and skin to be avoided.

Procedure

Preparation of buffer solutions

Prepare buffer solutions as directed on the container or instruction sheet. Store in suitable containers in the refrigerator.

Preparation of reagents

Dissolve 1.0 g of phenolphthalein in 100 ml of ethanol. Store in dropping bottles until required.

To prepare sodium hydroxide, follow instruction given on package unless purchased as a prepared volumetric solution not requiring dilution. Solution must *always* be stored in a sealed container.

Calibration of pH meter

Follow instructions provided with the particular pH probe in use. Use the pH 4 and 7 solutions to calibrate the meter.

Measurement of pH value

Mill any chips before starting. Weigh out exactly 10 g of sample into a polythene bag. Add 20 ml of distilled water. Mix well. Further aliquots of water may be required in order to obtain a slurry.

Wash the pH electrode with distilled water and place it in sample. Allow a few moments for reading to stabilize. Record pH value. Wash pH electrode back into sample with distilled water.

Semi-quantitative pH measurement

In the absence of a pH meter, use universal indicator paper. Dip the paper into the prepared sample and compare the colour change with the chart given on the indicator packaging. Identify the corresponding colour and note the pH.

Measurement of titratable acidity

Transfer the sample for pH measurement into a 250 ml conical flask. Wash out polythene bag into flask with an excess of distilled water. Add 4–5 drops of phenolphthalein indicator. Fill 25 ml burette with 0.1 n sodium hydroxide. Titrate with 0.1 n sodium hydroxide until the indicator just turns pink/red. Record the titre volume of sodium hydroxide added.

Analysis of results

Table 2.20 Example of a typical data recording table for TTA

Sample	pH value			Titratable acidity			
	Rep 1	Rep 2	Average	Titre (ml) Rep 1	Titre (ml) Rep2	Average	* % TTA
W1	4.0	4.0	4.0	18.7	18.7	18.7	1.68

*Calculation of percentage total titratable acidity (% TTA) as lactic acid is obtained by multiplying the titre volume by 0.09.

Significance

Fresh roots/unfermented products typically have neutral pH values of about 6–7. Acid-fermented products typically have pH values in the range of 3.5–4.5.

Titratable acidity gives a better measure of degree of fermentation since the decrease in pH value is restricted by the buffering capacity of the acids produced (pKa of lactic acid is 3.87).

International standards

Codex Regional Standard (CODEX STAN 151–1985) classifications for gari state that the total acidity shall not be less than 0.6% nor more than 1% m/m, determined as lactic acid.

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