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OSMO-AIR DEHYDRATION OF OVERRIPE 'KOLIKUTTU' BANANA

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Abstract: Processing conditions were established to produce a ready-to-eat product from overripe 'Kolikuttu' banana by osmotic dehydration followed by air-drying. Changes in moisture content, water activity, total soluble solids (TSS), crude protein and colour during the process were determined. The acceptability of the product was tested by using a consumer panel and a nine-point Hedonic scale. A suitable packaging material for storage of the product was selected. Dipping banana slices in a 70° Brix sucrose solution in a fruit:syrup ratio of 1:4 maintained at 50°C removed about 50% moisture in 5 hours. Air-drying of the osmotically dehydrated banana slices at 65°C at an air flow rate of 18 m. min^{-1} for 8 h. reduced the moisture content from about 38% to 3.5% and water activity from 0.80 to 0.59. Increase in TSS, decrease in crude protein and no change in colour was evident during osmo-air dehydration. The estimated medians for colour, taste, crispness and overall acceptability were above the point 'like moderately' in the ' 9-point Hedonic scale'. The product could be packaged in pouches made out of aluminium foil laminated with low-density polyethylene and stored for 8 months without any change in water activity and product colour. Thus, overripe 'Kolikuttu' banana could be processed into a ready-to-eat product with good organoleptic quality and storability.

Key words: air-drying, Banana, osmotic dehydration

INTRODUCTION

Post-harvest losses of banana are reported to be about 20 to 80% in Sri Lanka.[1] Early ripening is an inherent character of 'Kolikuttu' banana, which shortens the post-harvest life. As consumers dislike overripe bananas, processing such fruits into a value-added product could help in reducing post-harvest losses.

Removal of water from fruits is well known to help in extending storage life. The drying conditions need to be established to minimise colour, flavour and textural changes during dehydration. In osmo-air dehydration, about 50 % moisture is removed by osmosis[2] and further reduction in the moisture content is by air-drying. Sucrose is the most commonly used osmotic agent for fruits.[3,4] High sugar concentrations used in osmotic dehydration preserve flavour, colour and texture of the product to a great extent[4,5] and prevent microbial spoilage.[3] Osmotic dehydration is a less energy intensive process than air or vacuum drying.[4,6,7] Long drying time is reported to be one of the disadvantages of osmotic drying.[8] The product subjected to an osmotic process should be further processed by air, freeze or vacuum drying to obtain a shelf-stable product.[4,7]

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This study was carried out to optimise processing variables for osmo-air dehydration of 'Kolikuttu' banana and to identify a suitable packaging material for the dehydrated product. The acceptability of the product as a snack was tested.

METHODS AND MATERIALS

Preliminary experiment: Over-ripe 'Kolikuttu' bananas free of microbial diseases, which correspond to the stage 8 of the van Loesche scale, were used for the study. The fruits were hand-peeled and cut longitudinally into slices of 0.15, 0.3 and 0.5cm thickness. The slices were immediately transferred into a 1 % calcium chloride solution containing 750 ppm potassium metabisulphite (KMS) in 1:5 weight-volume ratio (g ml^{-1}) for 15 min followed by steam blanching for 1, 2 and 3 min. The blanched slices were immersed in 70^0 Brix sucrose solutions containing 0.5 %, 1.0 % or 1.5 % sodium bicarbonate and kept in an oven at 50°C for 6 h. The initial fruit to sugar syrup ratios was 1:4 (g.ml^{-1}). After osmotic dehydration, the slices were drained, rinsed with water and air dried at 60, 65 and 70°C for 12 h. in a cross-flow air cabinet dryer (Phoenix TK Mini-10). An air flow rate of 18 m.min^{-1} was used as recommended by the manufacturer of the dryer. The appearance of the product was observed at 3 h. intervals during the 12 h. drying period. A drying temperature of 65 °C was chosen based on the appearance. Drying curves were constructed to determine the time required to remove about 50% of moisture by osmotic dehydration and to reduce water activity below 0.6 by air-drying at 65°C. Based on the texture, colour and taste of the dehydrated product, 0.15 cm slice thickness, 3 min. steam blanching and 1 % sodium bicarbonate in sugar syrup were used in the preparation of the snack.

Preparation of the snack: The processing steps used for the preparation of 'Kolikuttu' banana snack are given in Figure 1.

Analytical methods: Moisture and crude protein contents of the fresh and dehydrated products were determined in triplicate according to the standard methods of AOAC.[9] The dehydrated product was kept in a desiccator soon after removal from the dryer and used for moisture determination. The total soluble solid content (TSS) of the fresh and dehydrated product was determined in triplicate using a refractometer.[10] The dehydrated product was ground using a Stein laboratory mill (Model M-2). The powder (5 g) was vortexed in 5 ml of distilled water and centrifuged at 6,000xg for 10 min. The TSS content of the supernatant was measured. Water activity of the fresh and dehydrated product was determined in triplicate according to the method of Karel[11] by measuring the equilibrium relative humidity using a hygrometer (Testo 635, accuracy ± 0.03). An incubator (Yamato, IC 600) was used to obtain a constant temperature, 27°C, for water activity measurements. The colour of the product was measured in triplicate using a colour difference meter (2E 2000 Nippon Denshuku).

Overripe 'Kolikuttu' banana

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Hand peeling

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Slicing, 0.15 cm

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Immersing in 1 % $CaCl_2$ + 750 ppm KMS, 15 min

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Draining

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Steam blanching, 3 min

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Dipping in 70°Brix sucrose + 1 % $NaHCO_3$, 50°C, 6 h.

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Draining, rinsing

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Loading in trays and drying at 65 °C, 4 h.

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Turning the slices

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Drying at 65 °C, 4 h.

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Packaging

Figure 1 : The processing steps for osmo-air dehydration of 'Kolikuttu' banana slices

The dehydrated product was tested for colour, taste, crispness and overall acceptability by a consumer panel consisting of thirty panellists and a nine-point Hedonic scale (1-extremely dislike,9-extremely like). The data of the sensory evaluation were analysed by the sine test. The dehydrated product was ground using a Stein laboratory mill (Model M-2), and the ground sample (10 g) was used for determination of the residual sulphur dioxide content according to the Sri Lanka standard 729:1985.

Storage study: The dehydrated product was heat-sealed in triplicate in polypropylene pouches (150 and 200 gauge), and aluminium foil laminated with low-density polyethylene (LDPE). The packages were stored at room temperature, and the water activity and colour of the product were analysed after 1-, 2- and 8-months in storage.

RESULTS AND DISCUSSION

Results of the preliminary experiment revealed that the texture of the dehydrated product was affected by the slice thickness (Table 1), where thickness of 0.15 cm resulted in a crisp product. Dipping in 1 % calcium chloride immediately after slicing may also have contributed to the crispness. Similarly, a requirement of a 1 % calcium chloride treatment prior to blanching of papaya slices to maintain textural properties of the osmotically dehydrated product has been reported.[12] It was observed that KMS treatment immediately after slicing the fruits was necessary to prevent enzymatic browning until the tissues were subjected to steam blanching. It was also revealed that immersing the tissues in 750 ppm KMS alone was not sufficient to preserve the colour as indicated by improvement of product colour with increase in blanching time (Table 1). This is probably due to further inactivation of enzymes responsible for enzymatic browning during blanching. A treatment with 1 % sodium bicarbonate successfully removed the acrid taste of the product (Table 1).

Table 1 : Effect of slice thickness and blanching time on product quality.

Treatment	Observation
Slice thickness:	
0.15 cm	Crisp in texture
0.3 cm	Slightly hard in texture
0.5 cm	Hard in texture
Blanching time:	
1 min	Dark brown in colour
2 min	Light brown in colour
3 min	Yellowish brown in colour
Sodium bicarbonate concentration in sugar syrup:	
0.5 %	Acrid in taste
1.0 %	No acrid taste
1.5 %	Soapy taste

Three samples from each treatment were observed for texture, colour and taste.

Air-drying followed by osmotic dehydration is commonly used in tropical countries for producing 'semi-candied' dried fruits.[13] A 50 % weight reduction of fruits is achieved by using sugar syrup as an osmotic agent.[2,5,14] Immersion of fruit pieces in different concentrations of sucrose ranging from 30 to 70^0 Brix maintained between 30 and 50 °C have been reported.[15] Pokharkar et al.,[16] recommended dipping banana slices in a 70^0 Brix sucrose solution in a fruit: syrup ratio of 1:4 and keeping at 50 °C for 5 h. to remove about 45% moisture. Under similar conditions, it was possible to remove about 50 % moisture from 'Kolikuttu' banana slices in 5 h. (Figure 2). Air - drying of osmotically dehydrated papaya slices at 65-70°C for 8 h.,[12] pineapple and apple slices at 70°C for 7 h. and 5 h. respectively[14] and mango slices at 80°C for 1 h. followed by further drying at 65-70°C for 6-8 h.[17] has resulted in shelf-stable dehydrated products. Air drying of osmotically dehydrated banana slices at 65 °C at an air flow rate of 18m min^{-1} for 8 h. reduced the moisture content to 3.5 % (Figure 2). The osmo-air dehydration process (Figure 1) has resulted in reducing the moisture content and water activity (Table 2) to a level which is considered to be low enough to prevent the growth of microorganisms.[12, 18]

Table 2 : Physico-chemical properties of fresh and dehydrated "Kolikuttu" banana.

Property	Fresh fruit	Dehydrated fruit
Moisture content %	70.0±0.6	3.5±0.1
Total soluble solids ^{0} Brix	54.0±0.0	84.0±0.0
Crude protein %	3.8±0.1	2.1±0.0
Colour "b" value	15.2±0.4	14.5±0.5
Water activity	0.81±0.01	0.59±0.01

Data are presented as mean±standard deviation of triplicates. TSS and crude protein contents are given on dry weight basis.

Increase in TSS during osmo-air dehydration (Table 2) is probably due to transfer of sucrose from the sugar syrup into the fruit pieces.[13,15] Decrease in crude protein during osmo-air dehydration (Table 2) may be due to loss of water soluble proteins, in different processing steps where immersing in aqueous solutions and washing were employed, and alkali soluble proteins during exposure to the osmotic agent containing sodium bicarbonate. The yellow saturation index of the product given by the 'b' value did not change significantly during dehydration (Table 2) indicating that processing parameters and the steps (Figure 1) were successfully established in this study to minimise changes in quality attributes. The same was reflected in the mean preference scores of thirty randomly selected consumer panellists (Figure 3). The estimated medians for colour, taste, crispness and overall acceptability were above the point 'like moderately', which corresponds to number 7 of the ' 9-point Hedonic scale' (Figure 3). The range for colour was 6-8 and for taste, crispness and overall acceptability was 7-9. The protective effect of sugars on colour and flavour during dehydration[5] may also have contributed to good organoleptic quality of the banana snack.

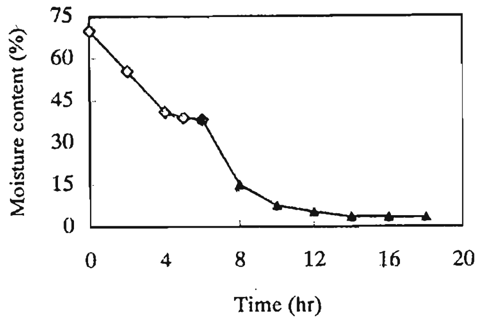

Figure 2 : Drying curve for osmo-air dehydration of "Kolikuttu' banana. The banana slices were osmotically dehydrated at 50 °C for 6 h. (◇) and air dried at 65 °C(▲).

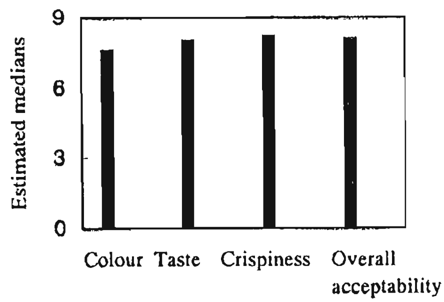

Figure 3: Estimated medians for sensory attributes of osmo-air dehydrated 'Kolikuttu' banana snack.

Aluminium pouches have been reported to be the best for packaging of osmotically dried fruits as the sugar-based products are hygroscopic.[2] Polythene and polycell bags of various gauges allow moisture absorption to a certain extent, which results in deterioration of the textural properties of dehydrated products.[2] In this study, packaging of the banana snack in pouches made out of aluminium foil laminated with LDPE did not change the water activity and the colour of the product during storage for 8 months (Table 3). Polypropylene, though popularly used in Sri Lanka for packaging of dehydrated products, was found to be unsuitable for storage of the banana snack as indicated by increase in water activity of the product (Table 3).

Sulphites are widely used as anti-microbial agents and to control Maillard[19] and enzymatic browning of foods.[20] KMS is allowed as a preservative in foods by the Sri Lanka food (preservatives) regulations, the maximum allowable level of residual sulphur dioxide in crystallised or glazed fruits being 100 ppm.[21] The residual sulphur dioxide content of the 'Kolikuttu' banana snack was 74 ppm which is within this limit. Thus the product could be used as a ready-to-eat snack item.

Table 3: Changes of colour and water activity of dehydrated 'Kolikuttu' banana during storage at 27±2 °C.

Storage period	Packaging material	Colour 'b' value	Water activity
One month	Aluminium foil/LDPE	14.5±0.4	0.59±0.01
	PP (200 gauge)	14.2±0.4	0.61±0.01
	PP (150 gauge)	14.0±0.4	0.62±0.01
Two months	Aluminium foil/ LDPE	14.5±0.4	0.60±0.01
	PP (200 gauge)	14.1±0.4	0.69±0.01
	PP (150 gauge)	13.4±0.4	0.70±0.01
Eight months	Aluminium foil/LDPE	14.5±0.4	0.60±0.01
	PP (200 gauge)	13.9±0.4	0.71±0.01
	PP (150 gauge)	13.0±0.4	0.72±0.01

The data are presented as mean±standard deviation of triplicates.

The processing technology established in this study could be commercially attractive. However, the possibility of using the remaining sugar syrup as the filling solution in fruit canning needs to be studied, and other possible applications need to be identified. As overripe banana is made into a value-added product, introducing this technology to cottage level industries could help in reducing post-harvest losses of banana.

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