Development, Production, Properties, and Acceptability of Snacks and Weaning Food Made from Extruded Cooking Banana (ABB)

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Several cooking banana (ABB) cultivars were recently introduced into West Africa as a rapid means of providing farmers with a source of Musa *planting material with resistance to the fungal leaf spot disease, black sigatoka. Although cooking bananas provide high yields and are more drought tolerant than plantain, the bunches are generally considered to be of lower quality than plantain and currently attract a lower price in the market than plantain. This study aimed to increase the utilization of cooking bananas and add value to the fruit by developing new, higher value, processed products. Extrusion cooking was used to develop expanded snacks and high protein, low cost weaning food from different combinations of cooking banana, maize, and soybean flour. The most attractive products were evaluated for physicochemical properties, nutritive values, acceptability, storage stability, and cost. Results showed that cooking banana snacks were highly acceptable when assessed by taste panelists. Extrudates had an acceptable yellow-creamy color. Snacks fortified with partially defatted (10%) soybeans were denser, crispier, and more acceptable than snacks from 100% cooking banana and maize. These products were also higher in nutritional value. Snacks made from 20% cooking banana, 70% maize, and 10% soybean scored higher (P = 5%), than other products due to a high quality texture. Moisture content of the products was stable during a period of 4 months. Cooking banana-based weaning food had a brown-creamy color and reconstituted easily in both hot and cold water. The products also had lower viscosities than the commercially available weaning foods Cerelac and Nutrend which were used as the standards. Protein, minerals, fat, energy, and antinutritional factors of the products met the recommended values for a weaning food. Most assessors found the paste prepared from the cooking banana weaning food acceptable, but mothers preferred paste made from Cerelac because of its vanilla flavor and sweeter taste. The production costs of 1 kg of cooking banana-based snack food and weaning food made from 20% cooking banana, 70% maize, and 10% soybean were estimated at US $0.27 and US $0.75, respectively.*

Introduction

Cooking bananas (ABB) were introduced into Nigeria from southeast Asia by the International Institute of Tropical Agriculture, High Rainfall (Onne) Station, in 1989 as a short term strategy to overcome the threat of black sigatoka. Black sigatoka is a fungal disease caused by the pathogen *Mycosphaerella fijiensis* which can reduce the yield of plantain by up to 35% in the plant crop and by more than 50% in the ratoon crop (Vuylsteke et al. 1993). Cooking bananas are significantly more resistant to black sigatoka than plantains and have a higher yield and shorter growth cycle compared to plantain landraces (PBIP 1993).

Despite their agronomic advantages, cooking bananas have shown a slow rate of farmer adoption and market acceptance. A preliminary market survey of cooking bananas in southern Nigeria has shown that of the 14 cooking bananas introduced, only two cultivars, viz. Cardaba and Bluggoe, are consistently sold in a limited number of markets (Ferris et al. 1996). This study

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revealed that the market value of cooking bananas was less than half that of plantain and farmers have commented that it was difficult to find a good market for their cooking banana fruits.

Although taste panel tests have shown that cooking bananas have reasonable fruit quality, a major reason for low market acceptance is because the appearance of the bunches is conspicuously different from traditional plantains and bananas. Consumers commented that they avoided buying the fruit, because they were also unfamiliar with how to prepare it (Ewujowoh 1994). Transporters also suggested that due to the shape of the bunch, more fingers were damaged during loading and transportation than with plantain.

To overcome these problems and to increase the rate of adoption of cooking bananas, IITA held a series of village level training demonstrations on how to use cooking bananas in traditional foods a: how to cook new products. These activities were aimed to promote the use of cooking bananas at the household level and to show farmers that this crop was valuable for the family as food or a primary resource for processing into simple snacks which could be sold in the market.

A second aspect of this work involved developing more sophisticated processed products for the urban markets. Processed foods have several advantages compared with selling fresh fruit, including easier access to new markets, longer storage ability, and higher value. The demand for processed food is also increasing rapidly in developing countries due to the rural-urban shift and many processed goods are currently imported to meet this demand. Processing locally available crops will reduce product costs, increase agricultural demand, provide employment, and also avoid the problems associated with foreign exchange.

Within the field of food processing, this study concentrated on extrusion cooking and the production of expanded savoury snack foods and baby weaning products. The extrusion technology provides a rapid means of cooking a product at high temperature and pressure. The advantages of extrusion are speed, product uniformity, high standards of hygiene, and a continuous feed process. Extrusion also reduces antinutritional factors such as the trypsin inhibitor in soyflour which is incorporated to raise the protein content of extruded products. Hence, the aim of this study was to produce novel high value products which would increase the demand for cooking bananas, by developing cheap, high protein snack foods and weaning foods and conducting a preliminary profit analysis.

Materials and methods

This research was carried out at the IITA High Rainfall Station, Onne, Port Harcourt, Nigeria. Bunches of the cooking bananas cultivar Bluggoe were harvested from uniform yield trials and maize and soybeans were supplied from trials at IITA, Ibadan, Nigeria. All other products were purchased from local markets.

Green cooking bananas were prepared by peeling in water to avoid browning. The pulp was sliced into 15 mm thick discs and oven dried at 60°C to a moisture content of 8–10%. The dry flakes were milled using a hammer mill with sieve size of 0.05 mm. Soybeans were soaked for 24 h, dehulled, washed, and dried in an oven. A mechanical screw press was used to defat the soybeans. The beans were toasted and pressed to express the oil which reduced the fat content to approximately 10%; the resulting soycake was then milled. For snack foods, the soybeans were defatted as fat reduces starch puffing during extrusion and also causes rancidity problems during storage. Soybeans used for weaning food formulations were milled without defatting. Maize grits were produced by milling and the maize was not degermed prior to milling.

The flour formulations used to produce a range of snacks and weaning foods are shown in Table 1. The recipes used were based on the work of Ogazi and Adeyemi (1989) with modifications. Five blends of *Musa*-based snacks were developed after preliminary processing. The blends were flavored or seasoned with sugar, salt, chilli, shrimps, and monosodium glutamate (MSG). Four blends of flour mixture were used for weaning food. The weaning food formulations were prepared after extrusion cooking of flour mixtures and milling of the extrudates. After mixing, the weaning food powder was dried further in an open tray to reduce the moisture content to a level of 4–5%.

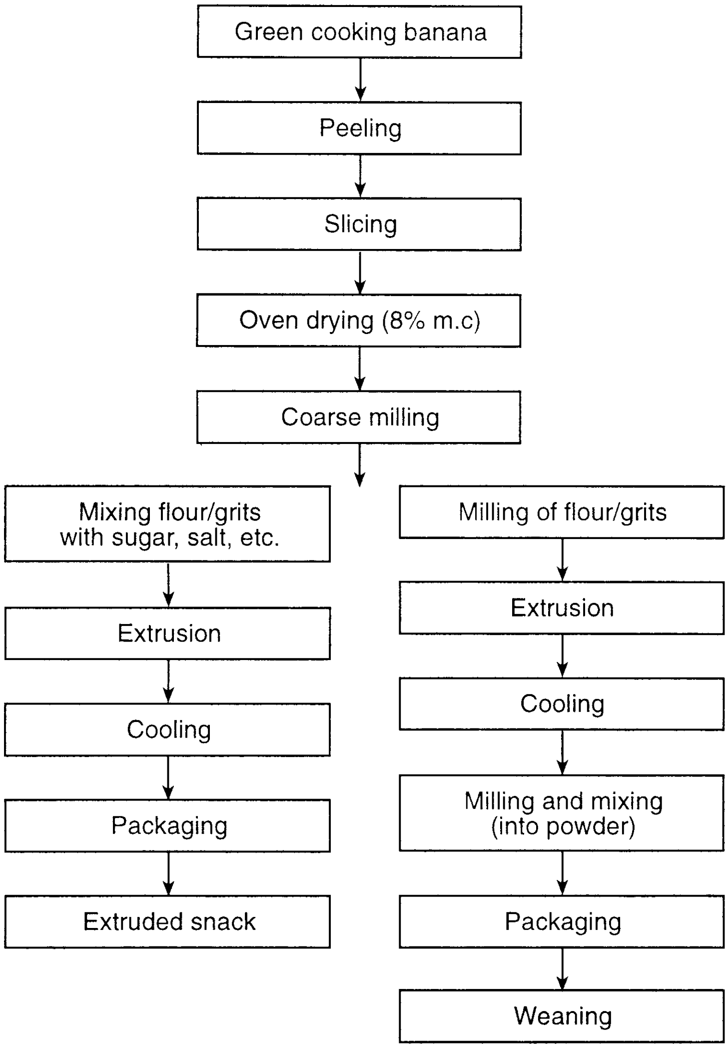
The flow chart for the production of extrudates is shown in the Figure. Prior to extrusion, the ingredients were thoroughly mixed in a bowl and water was added to increase the moisture content to 18–20%. A commercial single screw extruder was used. The extruder had a screw speed of 300 rpm and residence time of 10 seconds. Preliminary trials showed the most suitable temperature for the extrusion was between 100 and 110°C, a lower temperature compared to that used for maize extrusion (120–150°C). Products were extruded using a 3 mm diameter die.

Bulk density of the weaning foods was determined using AOAC methods (1970). Twenty-five g of extrudate powder was weighed into a 100 ml graduated cylinder, tapping the cylinder 10 times against the palm of the hand and expressing the final volume as g/cm^3. Specific gravity was measured as weight of extrudate divided by volume. Cool and hot water dispersability was estimated by stirring 10 g extrudate powder into 100 ml cool and hot deionized water separately, and subjectively noting the ease of dispersion. Water binding capacity was determined using the modified method of Lin and Humbert (1974). Two g of extruded powder were mixed in 20 ml of distilled water. The samples were stirred with a magnetic electric stirrer and allowed to stand for 1 hour at room temperature (25°C) before centrifuging at 2000 rpm for 25 min-

Table 1. Recipe formulation for cooking banana-based extruded snacks and weaning foods

Blend	Percent flour*			Sugar*	Salt*	Chilli	Shrimps*	MSG	Milk*	Vitamin*	CaCO³*	Veg.oil*
	C. banana	Maize	Soybeans									
711s	100	-	-		15	1	0.1	0.1	0.01	-	-	-
771s	-	100	-	15	1	0.1	0.1	0.01	-	-	-	-
811s	50	25	25	15	1	0.1	0.1	0.01	-	-	-	-
821s	20	70	10	15	1	0.1	0.1	0.01	-	-	-	-
831s	90	-	10	15	1	0.1	0.1	0.01	-	-		-
731w	30	50	20	10	0.22	-	-	-	5	0.15	0.85	4
741w	50	25	25	10	0.22	-	-	-	5	0.15	0.85	4
751w	50	35	15	10	0.22	-	-	-	5	0.15	0.85	4
761w	20		60	20	10	0.22	-	-	5	0.15	0.85	4

Notes:
s: blend used for snack production
w: blend used for weaning food formulation
MSG: Monosodium glutamate
* Values are expressed as % of flour mixture
Ingredients for weaning food formulation were added after extrusion and milling of extrudates
Salt, sugar, and natural flavors were used for flavoring; monoglycerides to prevent product sticking in the mouth.



Flow chart for the production of extruded snacks and weaning foods from cooking banana fruit

utes. Excess water was decanted by inverting the tubes over filter paper placed in a volumetric flask. The samples were allowed to drain dry for 35 minutes. The weight of water bound was determined by the difference.

Gelation was determined using the Coffman and Garcia (1977) least gelation concentration (LGC) method with modifications to determine the gelation of extrudates. Sample suspensions of 5, 10, 15, and 20% (w/v) were prepared in 5 ml of distilled water. The test tubes containing these suspensions were heated for 1 hour in a boiling water bath followed by rapid cooling in cool water. The test tubes were further cooled for 2 hours at 4°C. The least gelation concentration was determined as that concentration when the sample from the inverted test tube did not slip.

The moisture content, fat, ash, crude fiber, and minerals (calcium, potassium, iron, magnesium, copper, and sodium) were determined according to AOAC procedures (1970). Protein was determined by the Kjeldahl Nitrogen method (AOAC

Table 2. Physical and functional properties of extruded cooking banana snacks and weaning foods

Sample	Percent flour			Bulk density	Specific gravity (g/cm^3)	Water binding capacity (g/cm^3)	Dispersability		Gelation concentrate (%)
	C. banana	Maize	Soybeans				Cold water	Hot water	
711s	100	–	–	3.6	0.26	5.9	Poor	Poor	10
771s	–	100	–	2.1	0.42	5.6	Excellent	Excellent	10
811s	50	25	25	1.7	0.53	5.3	Fairly good	Good	15
821s	20	70	10	2.0	0.48	5.9	Good	Very good	15
831s	90	–	10	5.5	0.12	7.0	Good	Good	15
761w	20	60	20	2.0	0.42	3.7	Excellent	Excellent	10
731w	30	50	20	2.0	0.52	3.4	Excellent	Excellent	12
751w	50	35	15	2.0	0.51	3.4	Excellent	Excellent	9
741w	50	25	25	2.0	0.45	3.2	Excellent	Excellent	10
Nutrend	*	*	*	2.0	0.49	4.8	Excellent	Excellent	12
Cerelac	*	*	*	2.0	0.40	3.2	Excellent	Excellent	15

Notes:
s: snacks
w: weaning food after milling and mixing with other ingredients
* Values are expressed as % of flour mixture
Nutrend and Cerelac are commercial weaning foods.
For water binding capacity: higher values means greater absorption capacity.

1980). The product energy was determined using the Atwater formula (FAO/WHO 1973). Fat, protein, and carbohydrate supplied 9, 4, and 3.75 kcal/g, respectively. Tannin content determination was done by the method of AOAC (1980).

Sensory evaluation was obtained by means of a taste panel for the extruded snack products. These tests were conducted at the IITA Ibadan and Onne stations using 30 adult judges. Primary school pupils (ages 8–12) in Rivers State, Nigeria were also used for sensory evaluation. The adult panelists received no specific training relevant to these products, but had earlier experience in sensory evaluation of other food products. They were required to evaluate products in terms of color, flavor, taste, texture, and overall acceptability on a nine point hedonic scale (9 = like extremely; 1 = dislike extremely). They were also instructed to comment freely on the samples. Visual aids together with a five point hedonic scale (5 = super good and 1 = super bad) were used for the evaluation in the case of children. Children evaluated the products in terms of color, sweetness, texture, and appearance. In all evaluations, snacks made from 100% maize were used as the control. Mothers were randomly selected from Rivers State, Nigeria for the weaning food evaluation. Testers were encouraged to feed the new formulations to their babies. This was not considered to be a risk as the formulations were made from well-known food materials and the production was done under hygienic conditions. The cooking banana-based weaning foods were compared with the common commercial weaning foods Nutrend and Cerelac.

Economic evaluation was determined using the "internal rate of return on investment" to evaluate the profitability of producing snacks and weaning foods from cooking banana-based raw materials.

A study on the shelf-life of the products used the method of [illegible] for food products which deteriorate mainly by loss of crispiness. The snacks were weighed and sealed in 50 μm thick polyethylene bags and kept at ambient and laboratory (24°C and 78% RH) conditions for 15 days. Sensory tasting was used to determine the critical moisture content for the products. Shelf-life was estimated using the formula

(i) $CR/t = C/q - q/c$

C = capacity of product for moisture

R = measure of the pack's resistance to water vapor transmission

t = time of exposure

q = moisture gain in unit time

Shelf-life was determined by using T (shelf-life) instead of t (gain per day) and inserting the maximum acceptable moisture gain (Q) in the formula:

(ii) $CR/T = C/Q - Q/C$

T = shelf-life

Q = maximum acceptable moisture gain of the product

Results and discussion

Physical and functional characteristics of cooking banana-based snacks and weaning foods

Bulk density and specific gravity The bulk density and specific gravity of the extrudates were determined by the puffing properties. The puffing ability or the degree of expansion affects product density, fragility, and crispness. Normally expanded products have low density, because of their high volume and low moisture content. The data in Table 2 show that the 90:10 cooking banana:soyflour mix had a high powder density but produced the lowest density product in the expanded form. However, as the level of soybean was increased the density also increased. This finding was also observed by Faubion and Hoseney (1982) who found that adding up to 8% soy protein increased the level of expansion but further addition of soy protein beyond that level increased the product density. The higher fat level contributed by the soybean and maize flour in sample 811s may also have reduced the level of expansion. The soybeans used in the product formulation were only partially defatted.

The snack food made from 100% maize flour was denser than that made from 100% cooking banana. This was considered to be due to a higher amylose content and lower fiber level in cooking banana than maize. Fiber does not expand and merely acts as a solid filler, thus affecting the structure of extrudate by making it more dense and dry (Guraya and Toledo 1994). Also, maize contains more protein and fat than cooking banana which may also have affected the puffing ability of the starch. Gujska and Khan (1991) reported a negative relationship between starch expansion and protein content. The lower temperature used for the extrusion may have caused a further reduction in the maize expansion. In contrast, the cooking banana expanded well and according to Guraya and Toledo (1994), amylose starch expands easily. Cooking banana extrudates had irregular shapes and an uneven expansion which was considered to be caused by large air bubbles.

For the weaning food, all the samples had a bulk density value of 2.0 g/cm^3 and specific gravity range of 0.52–0.42 g/cm^3. The samples with higher % of cooking banana had increased specific gravity (lighter). This may be because the starch component of the extrudates was well expanded.

Water binding capacity and water dispersability The water binding capacity is an indication of the ability of an extrudate to absorb water, i.e., to moisten. Cooking banana increased the water binding capacity of extrudates whereas soybean (25%) decreased the water absorption capacity (Table 2). Sample 811s, which had the highest % soybean, had the least water binding capacity (5.3 g/cm^3). The higher water binding capacity of sample 831s compared with sample 711s may have been due to the nature of the protein-starch complexes formed. Water absorption capacity depends on availability of hydrophilic groups which bind water molecules and on the gel forming capacity of macromolecules. The higher water binding capacity of the cooking banana extrudates was probably a result of high dry matter content, low fiber, and low amylose starch (PBIP 1993). The cooking banana-based weaning foods, on average, absorbed more water than Cerelac, a commercial weaning food. This information indicates that cooking banana-based weaning foods provide a food with a higher dry matter content than Cerelac and also the dispersability of the cooking banana weaning foods was comparable with the commercial weaning food.

Gelation

Gelation is an index of water absorption capacity of extrudates and this is important for weaning foods. The gelation properties of the snacks and weaning foods are reported in Table 2. Snacks with soybeans formed a gel at a minimum concentration of 15% while those without soybeans formed a gel at 10%. The same pattern was observed for the weaning foods. Cooking banana-based weaning foods had a lower (9–12%) least gelation concentration (LGC), compared with the commercial products (12–15%). Sample 751w which contained the least % soybean also had the lowest LGC of 9%, i.e., was less viscous than the other formulations.

Nutritional composition

The data in Table 3 show the nutritional composition of cooking banana snacks and

Table 3. Nutritional composition of cooking banana extruded snacks and weaning food

Sample	Moisture %	Total ash %	Protein %	Fat %	Carbohydrate %	Crude fiber %	Tannin (mg\g)	Energy (kcal/100 g)
711s	5.99	1.43	7.7	1.07	85.8	0.85	0.12	362.2
771s	5.67	1.22	10.1	2.34	82.7	1.16	1.03	371.6
811s	5.35	2.41	11.6	1.10	81.5	0.67	0.19	362.8
821s	5.56	1.79	10.3	1.08	83.3	0.77	0.02	363.3
831s	5.12	2.19	8.8	0.98	84.9	0.32	0.01	362.4
761w	4.02	3.08	14	9.02	69.8	1.15	0.001	436.4
731w	4.11	3.51	13.8	9.02	69.5	1.13	0.01	434.4
751w	4.01	3.33	12.5	8.01	72.1	1.11	0.01	438.9
741w	4.01	3.72	15.1	9.10	68.1	1.12	0.002	435.2

Notes:
Values were calculated on a dry weight basis
Carbohydrates were calculated by difference
Energy was calculated by using Atwater formula
s: snacks
w: weaning food
711s:100% cb
771s:100% maize
811s: 50:25:25 cb:maize:sy
821s: 20:70:10 cb:maize:sy
831s: 90:10 cb:sy
761w: 20:60:20 cb:maize:sy
731w: 30:50:20 cb:maize:sy
751w: 50:35:15 cb:maize:sy
741w: 50:25:25 cb:maize:sy

weaning foods. Moisture content of the snacks ranged from 5.1 to 5.9% while that of the weaning food was from 4.0 to 4.1%; in general the lower the moisture content of a product the longer the potential storage life. The moisture levels of the products were adequate for product storage since growth of microorganisms, food spoiling agents, are hindered at such moisture levels.

Protein and fat contents of the snack products ranged from 6.6 to 11.6% and 0.1 to 2.34%, respectively, and energy and ash contents ranged from 354.8 to 371.6 kcal/100 g and 1.22 to 2.41 %. The snacks were, therefore, high in protein and had a low fat content compared with most similar snack foods which are fried in oil, thus having a higher probability of a longer shelf-life in terms of the onset of rancidity. The nutritional composition of the cooking banana-based snacks provides about 30% of the daily food requirements recommended for both school children and adults.

The protein, fat, and ash contents of the weaning foods ranged from 12.5% to 15.1%, 8% to 9%, and 3% to 3.7%, respectively. Carbohydrate and energy values ranged from 68% to 72.1% and 434.4 to 436.4 kcal per/100 g of product. The tannin content (0.001 to 0.1 mg/g) of the products was within recommended safety levels. This nutrient composition is in accord with the recommended allowance for infant foods as per FAO/WHO (1973) standards.

Product acceptability

Results from the sensory evaluation of the products were most encouraging. The acceptability of the snack foods showed approximately 80% and 70% acceptance by children and adults, respectively. About 60% of the tasters relished the chilli flavor of the snacks, while 30% wanted snacks with a higher sugar level. Mothers showed 90% acceptance of the weaning foods. Analysis of variance (Tables 4a, b) show that the snacks were significantly different ($P = 5\%$) from each other in terms of color, texture, flavor, sweetness, and acceptability.

Among all the snacks tested, code number 821s was preferred with scores of 7.1 and 4 in overall acceptability in both adults' and children's testing. The higher score of code 821s was considered to be due to its excellent crispy texture as reported by the testers. The cooking banana snacks were all accepted in trials conducted in both western and eastern parts of Nigeria (Table 5).

Cooking banana weaning foods, on average, were less preferred ($P = 5\%$) than the commercial weaning food, Cerelac (Table 6). However, sample code number 761w had the same ($P = 5\%$) score as Nutrend, a commercial weaning food, in most of the quality parameters. It was interesting to observe that cooking banana weaning food 761w scored higher than the commercial products in consistency quality. The major complaint from mothers was the light brown color of the cooking banana weaning foods. Mothers are accus-

Table 4a. Mean score of cooking banana extruded snacks by adult panelist using 9-point hedonic scale*

Sample	Quality attributes					
	Color	Appearance	Flavor	Texture	Sweetness	Acceptability
711s	6.5	5.8	6.2	6.3	6.2	6.2
771s	7.1	7.3	5.9	5.9	5.6	5.7
811s	5.3	5.9	6.5	6.9	7.2	6.7
821s	7.2	7.3	6.8	7.8	6.8	7.1
831s	5.8	5.9	5.4	5.1	5.1	5.1
C.V (%)	22	20	19	21	19	21
LSD (0.05)	3	2.8	1.5	1.6	1.5	1.6

Notes:
*Higher values indicate greater preference
711s: 100% cb
771s: 100% maize
811s: 50:25:25 cb:maize:sy
821s: 20:70:10 cb:maize:sy
831s: 90:10 cb:sy

Table 4b. Mean score of cooking banana extruded snacks by children panelists using 5-point hedonic scale*

Sample	Quality attributes				
	Color	Appearance	Texture	Sweetness	Mean
711s	4.6	3.5	3.3	4	3.8
811s	3.6	2.2	2.8	3.1	2.9
821s	4.1	3.8	4.2	3.8	4
831s	4.2	3.1	3.6	2.6	3.4
CV (%)	12	10	10	19	
LSD (0.05)	0.2	1	1	0.6	

Notes:
*Higher value indicates greater preference
711s: 100% cb
811s: 50:25:25 cb:maize:sy
821s: 20:70:10 cb:maize:sy
831s: 90:10 cb:sy

Table 5. Comparison of *P*-values of the sensory attributes of cooking banana snacks at Ibadan and Onne (western and eastern Nigeria)

Source of variation	DF	Color	Appearance	Flavor	Texture	Sweetness	Acceptability
Site	1	1	0.7	0.9	0.9	0.9	0.4
Treatment	5	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
Site × treatment	5	1	0.01**	0.08*	0.5	0.5	0.06
Error		140					
Total		179					

Notes:
* significant at 10.0% level
** significant at 5.0% level
*** significant at 1.0% level

Table 6. Mean scores of cooking banana and commercial weaning foods using 9-point hedonic scale*

Sample	Color	Flavor	Consistency	Sweetness	Acceptability
761w	7.9	7.9	7.9	8	8.2
731w	7.1	6.8	6.7	6.8	6.4
751w	7	6.9	7	7.5	7
741w	7	6.1	6.4	5	5
Nutrend	7.6	7.4	7.5	7.6	7.5
Cerelac	8	8	8.2	7.8	8.3
CV (%)	3	5.8	5.6	0.6	0.5
LSD (5%) columns	0.5	0.97	0.97	1.5	0.9

Notes:
*Higher values signify greater preference
Nutrend and Cerelac are commercial weaning foods
761w: 20:60:20 cb:maize:sy
731w: 30:50:20 cb:maize:sy
751w: 50:35:15 cb:maize:sy
741w: 50:25:25 cb:maize:sy

tomed to the milky color of commercial weaning foods and so it was not strange that they were hesitant to accept a product with a different color. Unlike the commercial weaning foods, the cooking banana weaning foods also did not have a strong vanilla flavor and this may also have contributed to their lower sensory scores. Sweetness and color had a prominent effect on sensory scores of the weaning foods (Table 7).

Table 7. *P*-value of the quality attributes of cooking banana weaning foods

Attributes	*P*-value	Error
Color	0.02**	0.2
Flavor	0.006*	0.3
Consistency	0.006*	0.3
Sweetness	0.001***	0.3
Acceptability	0.001***	• 0.5

Notes:
* significant at 10.0% level
** significant at 5.0% level
*** significant at 1.0% level

Shelf-life study

The expected shelf-life of the different extruded snacks packaged in sealed 50 μm polyethylene bags is shown in Table 8. The samples at a laboratory temperature of 24°C and an ambient temperature of 28–30°C had a shelf-life range of 95 to 180 days and 70 to 140 days, respectively. This level of shelf-life would enable sufficient time for distribution and retailing of the products. The longer shelf-life of the samples at reduced temperatures was expected because of the slow air movement/moisture diffusion coefficient at low temperatures.

Table 8. Expected shelf-life (days) of cooking banana snacks sealed in 50 μm thick polyethylene bags

Sample	Storage conditions	
	Ambient	Laboratory
711s	140	180
771s	74	98
811s	88	108
821s	70	99
831s	70	95

Notes:
Ambient condition: 28–30°C and 78% relative humidity
Laboratory condition: 24°C and 78% relative humidity

Economic analysis

The total investment required to start an extrusion processing project for snacks and weaning foods from a mixture of cooking banana, maize, and soybeans in 1995 was US $32,634 and $20,662, respectively. This estimate includes the cost of raw materials, packaging, labor, and distribution. One extruder can be used for the two projects and in that case, the investment is lower.

A factory producing cooking banana snacks is expected to produce 105,600 kg per annum and weaning foods of 39,600 kg per annum. Eighty percent efficiency is assumed to take care of machine breakdown, pilfering, and product damages/ overheads. Therefore 84,480 and 31,680 kg of snacks and weaning food, respectively, are expected to be produced and sold per annum. One kg of the snack is sufficient for 50 packets of 20 g each, and each packet has a sale value of $0.08, while 1 kg of the weaning food fills 2 packets of 500 g which retail at $0.80 each. Hence 1 kg of snacks and weaning food sells for $0.4 and $1.6, respectively. One kg of similar snacks and weaning food (Cerelac) sells for $1.0 and $5, respectively (Table 9).

The production of snacks and weaning foods from cooking banana 20%, maize 70%, and soybeans 10% had a break-even point of 48% and 24%, respectively. This means that for the projects to be profitable, 48% and 24 % of the snacks' and weaning foods' total annual production must be produced at the prevailing production cost and unit selling price. The by-products such as peels could be utilized for animal feed or in soapmaking to increase returns and efficiency. The annual rates of return on investments for the projects were 83% and 90%, while the unit costs of producing 1 kg of the products in 1995 were US $0.27 and $0.78 for snacks and weaning foods, respectively. This shows that the projects are economically viable.

Table 9. Market price of cooking banana and commercial weaning foods in Nigeria in 1995

Product	Market price (US$) per kg product
Extruded cooking banana	1.00
Nutrend	2.00
Cerelac	5.00

Conclusion

Cheap but nutritionally balanced snacks and weaning foods were developed from cooking banana ingredients. Sensory evaluation tests showed that all products were acceptable. The best snack was obtained from a mix of 20% cooking banana, 70% maize, and 10% soybeans. The best formulation for a baby weaning food was 20% cooking banana, 60% maize, and 20% soybean. Panelists could not determine the raw materials used for the products which indicates that the acceptance of cooking banana can be considerably improved by processing. Developing such methods in the marketplace will in turn enhance the economic value of cooking banana and so increase demand. Extrusion cooking also offers a means of overcoming the problem of early ripening in cooking banana as the extrudates and flours can keep for 4 – 6 months.

Cooking banana products, even at the 100% level, gave products with a good taste and texture; the large air bubbles which distorted the product shape were not a problem as panelists were not concerned about the irregular shape. Cooking banana flour can also be mixed with denser materials which do not have good expansion properties such as high fiber bran to obtain a crispy wholesome product. The addition of soybeans improved the nutritional (protein) level, flavor, and texture of cooking banana extrudates. Maize and soybeans supplied "body" to the extrudate, because they had better grit sizes.

The simple economic analysis of snacks and weaning foods produced from cooking banana-based ingredients through extrusion processing also indicated that this project has a viable economic base. The lower temperatures required for cooking banana extrusion cooking will also reduce equipment wear and running costs.

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