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Development and Mineral Properties of Energy Bars Made from Composite Flour of Cassava, Bambara Groundnut and Cashew Kernel Using Response Surface Methodology

[1]*Elochukwu, Chinwe. U., [2]*Nwosu, Justina N., [2]*Owuamanam C. I, and [2]Osuji, C. I.

[1]*Department of Food Technology, Federal Polytechnic, Oko, Anambra state.

[2]*Department of Food Science and Technology. Federal University of Technology, Owerri, Imo State Nigeria

[1]*Email: chielochukwu@yahoo.com

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ABSTRACT

The objectives of this research are as follows: to develop an "energy" snack bar from blend of high quality cassava; toasted bambara groundnut and roasted cashew kernel flours, to determine the mineral composition as well as the sensory characteristics of the energy snack bars. The minerals properties evaluated were calcium (Ca), sodium (Na), magnesium (mg) and potassium (K). The sensory parameters studied were taste, crumb appearance, aroma, chewiness, fracturability and general acceptance. Augmented simplex lattice design method of response surface methodology as provided by design Expert statistical software (version 11) was used for the generation of the design matrix. Fourteen formulations were generated. These formulations revealed single, binary and ternary combinations of high quality cassava flour, toasted bambara groundnut flour and roasted cashew kernel flour. The developed "energy" snack bars contain 125.27 mg/100g to 185.58 mg/100g of calcium, 32.27 to 55.58 mg/100g of magnesium, 62.26 mg/100g to 120.25 mg/100g of sodium and 266.66 mg/100g to 374.12 mg/100g of potassium. The "energy" snack bars were acceptable with desirable sensory quality by all consumers. It was observed that while the addition of cassava flour and cashew kernel flour improved ratings for the energy bars, the addition of toasted bambara groundnut flour had the opposite effect.

Keywords: cassava flour, bambara groundnut flour, cashew kernel flour, energy bar, mineral, sensory evaluation

Introduction

Composite flours produced from legumes and tubers will have high protein content and high calorific value (Chinma *et al*., 2007). In selecting the components to use in composite flour blends, the materials should preferably be readily available, culturally acceptable and provide increased nutritional potential (Akobundu *et al.,* 1998). Nigeria is the highest producer of cassava roots, but some of the greatest problems she is facing are the issue of post harvest losses and diversification of the tuber crop. The report from FAO (2008) reveals that the post harvest losses resulting to about 40% of the total harvest products every year. Bambara is grown extensively in Nigeria but it is one of the lesser utilized legumes in Nigeria (Olapade and Adetuyi, 2007). Nigeria produces over 100,000 metric tonnes closely followed by Niger with 30, 000 metric tonnes and Ghana with 20, 000 metric tonnes (Hillocks *et al*., 2012). In 2007, Nigeria produced about 660,000 MT of raw cashew nuts and studies revealed that only about 10% is utilized locally (FAO, 2008). The practical implication of this is that 90% is either wasted or exported unprocessed which attracts very low prices in international trade. In Nigeria, these underutilized crops are in large quantities.

Nutritional benefits attributed to snack bars are elaborate. Their suitability for travel, ease of eating and convenience is of great advantage. However, the growing luxury groups and health-conscious consumers had increased the sales performance of snack bar (Euromonitor International, 2015). The greatest challenge in obtaining a good bar is a combination of many ingredients with main functionality like minerals, vitamins, protein, fibers; binding agents which turn them into a product with good flavour, aroma, texture and decent appearance, while trying to achieve specific goals nutrients (Lima, 2004). Snack bar quality depends on the quality and amounts of ingredients in relation to each other (Mridula, 2013). To satisfy consumers' needs "new" food products should contain nutritional benefits, be convenient, taste good and provide some element of fun (Sloan, 2003). Mahanna *et al*. (2009) evaluated the parameters used by consumers when choosing cereal bars and found that consumers pay special attention to the caloric value and the type of ingredients used in the food.

Mineral are generally very good source of energy for overall health. They generally help in maintenance of muscles functioning, acid base balance and nerve stimulations (Odom *et al.*, 2013).

Mixture Response Surface Methodology (MRSM) is a statistical technique in which the factors are the ingredients or components of a mixture, and the response is a function of the proportions of each ingredient. Measurement of the proportion of each ingredient is by weight, by volume, by mole ratio and so forth (Myers *et al*., 2009).

The objective of the present study was to produce "energy" snack bars from blends of high quality cassava flour, toasted bambara groundnut and roasted cashew kernel flours. In addition, to check the mineral composition and the sensory acceptability of the "energy" bar products.

Materials and Methods

Materials Used for Energy bar Preparation

TMS 30572 variety of cassava was obtained from the National Root Crop Institute (NRCRI) Umudike, Abia state. The bambara groundnut (cream brown eye) seed used was purchased from Ose market, Onitsha Anambra state while the raw cashew nuts were purchased from 'owum' in Enugu state.

Method of Preparation

High quality Cassava flour (HCF)

Cassava tubers were processed using the high grade processing method for cassava flours as described by Oti and Ukpabi (2006).

Toasted bambara groundnut flour (TBF)

Healthy cleaned bambara groundnut seeds (4kg) was soaked in water in the ratio of 1:3 i.e one portion of bambara groundnut seed to three portion of water for 9 h. They were steamed for 20 min, cooled and dehulled. After dehulling, the cotyledons were toasted using Master chef electric toaster oven (120 ^oC for 1h 20 min). The process of toasting was carried out until the toasted colour and flavour was identified. The toasted cotyledons were cooled to ambient temperature. The toasted cotyledons were milled with the milling machine. The milled flour sample was sieved with a sieve of aperture size of 75 µm screen opening to obtain the fine flour sample which was packaged properly in air tight containers.

Roasted Cashew kernel flour (RCF)

Cashew nut flour was processed using the method described by Okafor and Ugwu, (2014).

Date syrup preparation

Date fruits were purchased from a local 'Hausa' market in Asaba, delta state. A 500g of date fruits were soaked in water (3 litres) for 4h. The date fruit was decanted from the water and the seeds where removed manually. The fruit were pureed manually using clean mortar and pestle. The water used in soaking date fruit was added to puree and a clean sieve cloth was used to extract the filtrate which is the date juice (3.5 litres). This juice was concentrated until syrup (1.5 litre) was obtained. The boiling lasted for 3h with gradual heat and stirring to avoid burning.

Energy snack bar preparation

Ingredients for making "energy" snack bar include flour blend (200 g), date syrup (160 mL), soy isolate (100 g), vegetable fats (80 g), baking soda (1.6 g), carboxy methyl cellulose (1.6 g), salt (1.6 g) and chocolate (3.2 g).. All the ingredients used were procured from local market (Ose market in Onitsha). Dry ingredients such as flour blend, soy isolate, carboxyl methyl cellulose, salt and chocolate flavour were mixed together properly in a bowl. The viscous ingredients (margarine and dates syrup) were mixed in another bowl properly using cake mixer (Kenwood). The dry ingredients were added intermittently to the wet ingredients and properly kneaded together to obtain a smooth consistency. After kneading they were placed in mold bar pans (of 5cm diameter) to shape them into bars. The bars were baked at 120^{o}C for 35 min. After kneading they were placed in mold bar pans (of 5cm diameter) to shape them into bars. The bars were baked at 120^{o}C for 35 min. Milk chocolate was purchased from Shoprite supermarket in Onitsha. Some of the chocolate was tempered. The tempered chocolate was poured evenly into the mould (approximately 5 mm thick). The baked bar was then placed onto the chocolate and finally coated with tempered chocolate (approximately 5 mm thick). The products are displayed in plates 101 to 114.

Laboratory Analysis

Mineral Analysis

The method of dry ash digestion and analysis as described by Schachter and Boyer (1980) and modified by IITA (2002) was used to determine the mineral content of the Energy bars. A weighed quantity (0.52g) was put into a clean ceramic crucible. The weight was recorded to the nearest 0.001g. One empty crucible was also included for a blank. This was placed in a cool muffle furnace and estimate temperature to 500^{o}C over a period of 2 hours. It was allowed to remain at 500^{o}Cfor an additional 2 hours before it was cooled down in the oven. The ashed sample was removed from oven, making sure that the environment was free from breeze and then poured first into already labeled 50ml centrifuge tubes. The crucible was rinsed with 5ml of distilled water into the centrifuge tube and rinsed again with 5ml of aqua regia. This process of rinsing was done for three more times to make a total volume of 20ml.The sample was then vortexed for proper mixing, centrifuged for 10min at 3000rpm and the supernatant decanted into clean vials for macronutrient determination using atomic absorption spectrophotometer. This procedure was used for the analysis of potassium, calcium, magnesium and sodium.

Note : Aqua regia solution was prepared as follows: In a 2 litre volumetric flask, about 1.2 litres distilled water was added. 400ml Conc. HCl and 133ml of 70% Nitric acid was carefully added. This was diluted to 2 litres.

Sensory Evaluation

The sensory attributes were evaluated at room temperature (i.e., 25 ± 5◦C) by a panel of forty untrained judges comprising of Athletes and members of the Department of Food Technology, Federal Polytechnic Oko, Anambra State. The panelists were served with the energy bar samples and a questionnaire. The samples were identified with three–digit code numbers and presented in a random sequence to panelists. The panelists were instructed to rinse their mouths with water after every sample and not to make comments during evaluation to prevent influencing other panelists. They were also asked to comment freely on samples on the questionnaires given to them. Sensory acceptability was evaluated based on the description of Aigster *et al.* (2011) for cereal bars using a 9-point Hedonic scale for the following attributes: overall acceptance, colour, form, texture, and chewiness. The Panelists expressed their degree of liking or disliking.

Experimental design

A three-component augmented simplex Lattice design was used as described by Myers *et al.* (2009). The three mixture components evaluated in this study were cassava flour (x_1), toasted bambara groundnut flour (x_2) and roasted cashew kernel flour (x_3). The proportions for each ingredient represents a fraction of the mixture and for each treatment combination, the sum of the component proportions was equal to one. The fact that the proportions must add up to one is the key attribute of mixture designs. Specifically, the settings for various factors must satisfy $x_i \geq 0$, for all i. Thus

$$\sum X_i = X_1 + X_2 + X_3 = 1$$

These designs consist of all combinations of each factor at its high and low levels. In this research, the number of design points in the (3,3) polynomial is

$$(3+3-1)!/3(3-1)!) = 10 \text{ points}$$

This design resulted in 10 flour mixtures. Three additional points were included to provide extra points within the mixture triangle. Four runs were replicated to give an internal estimate of error (Table 1).

Statistical analysis

Statistical analysis was conducted using Statistical Package for the Social Science (SPSS) 23.0 software (SPSS Inc., Chicago, IL, USA). All the results obtained in the present study are represented as mean values of three individual replicate (n=3). A P<0.05 was considered as significant. Means were separated using by Fisher least significant difference (LSD).

Table 1: Experimental design used to produce flour blends

Blends	High quality cassava Flour (HQCF) (%)	Toasted bambara groundnut flour (TBF) (%)	Cashew kernel flour (CKF) (%)
1	0	100	0
2	100	0	0
3	50	0	50
4	0	0	100
5	100	0	0
6	50	50	0
7	50	50	0
8	0	0	100
9	0	50	50
10	0	100	0
11	33.3	33.3	33.3
12	16.7	66.6	16.7
13	66.6	16.7	16.7
14	16.7	16.7	66.6

Mixture design results in blends of pure blends consisting of only one component (single-component blends), binary blends involving a mixture of 2 components and the multi-component mixture involving proportions of all 3 components (assuming equal importance). The three coordinates were (0.5, 0.5, 0), (0, 0.5, 0.5), and (0.5, 0, 0.5).

Results and Discussion

Mineral composition

As shown in Table 2, the elements detected are calcium, magnesium, sodium and potassium. The most abundant of the minerals was potassium followed by calcium then magnesium.

Calcium content of the energy bar snacks ranged from 125.27 mg/kg to 185.58 mg/kg. The highest calcium content was recorded in blend 11 (representing 33.3% cassava flour, 33.3% bambara groundnut flour and 33.3% cashew kernel flour) while the least value was recorded in blend 4 (representing 0 % cassava flour, 0% bambara groundnut flour and 100 % cashew kernel flour) . There were significant differences ($p<0.05$) in the calcium content of the energy bars. Blend 4 and 8 were not significantly different ($p>0.05$). The result of the calcium content is in agreement to the report of Agbaje *et al*. (2014) on the research on the sensory preference and mineral contents of cereal Bars made from glutinous rice flakes and sunnah foods. Calcium is responsible for bone formation in conjunction with phosphorous, magnesium, manganese, vitamin A, C and D; chlorine and protein (Akinhanmi *et al*., 2008).

The magnesium content ranged from 32.27 – 55.58 mg/kg. Energy bars made from blend 1 (0 % cassava flour, 100 % bambara groundnut flour and 0 % cashew kernel flour) had the highest content of magnesium but does not differ significantly ($p>0.05$) from energy bars made from blend 2 and 9. The energy bar made from blend 6 (50 % cassava flour, 50 % bambara groundnut flour and 0 % cashew nut flour) had the least magnesium content but does differ significantly from the energy bars made from blend 7 and 13. The control bar does not differ significantly ($p<0.05$) from energy bars made from blend 4 and 8 (Table 2). The magnesium values were lower than the values reported by Self Nutrition Data (2014) for energy powers (Powerbars and Granlar bars) and Agbaje *et al*. (2014).

The sodium content of the energy bar snacks ranged from 62.26 mg/kg to 120.25 mg/kg. The highest sodium content was recorded in energy bars made from blend 14 (representing 16.7 % cassava flour, 16.7 % bambara groundnut flour and 66.6 % cashew kernel flour) and the energy bar from this blend was significantly different ($p<0.05$) from the energy bars from the other blends. The least value of sodium was recorded in blend 10 (representing 0 % cassava flour, 100 % bambara groundnut flour and 0 % cashew kernel flour). Energy bar made from blend 10 was not significantly different ($p<0.05$) from the energy bars made from blend 1 and 7. According to Self Nutrition data (2014), the Power bar coated with chocolate had a sodium content of 121 mg/100g, while granolar bar had 152 mg/100g. Agbaje *et al*. (2014) obtained a sodium range of 70.54-235.86 mg/kg for cereal bars. These values are higher than the values obtained for the formulated bars. Colbert (2000) advised on the need to decrease sodium intake since there is far too much salt added to most processed food.

Potassium content of the energy bar snacks ranged from 266.66 mg/kg to 374.12 mg/kg. Highest potassium content was energy bars made from blend 12 (representing 16.7 % cassava flour, 66.6 % bambara groundnut flour and 16.7 % cashew kernel flour) while the least value was the energy bars made from blend 9 (representing 0 % cassava flour, 50 % bambara groundnut flour and 50 % cashew kernel flour) respectively. There was no significant difference ($p>0.05$) between the energy bars made from blend 3 and 4. The control bar differed significantly ($p<0.05$) from the other bars. Result from other researchers that developed the conventional energy bars revealed that Power bar snack bar had a potassium content of 362 mg/kg while that of granolar bar was 254 mg/kg. This reveals that the potassium content of the energy bars developed were within the same range with these conventional energy bars. According to Nieman *et al*. (1992), the ratio of sodium to potassium (Na/k) in the body is a great concern for prevention of high blood pressure**,** Na/k ratio <1 is recommended. The Na/k ratio in this study (0.1807 to 0.3578) is an indication that consumption of the energy bars would probably help prevents high blood pressure .

Table 2: Mineral composition of Energy Bars produced from high quality cassava, toasted bambara groundnut and roasted cashew kernel flour blends

Blends	Independent variables			Mineral composition (mg/kg)			
	X_1	X_2	X_3	Calcium	Magnesium	Sodium	Potassium
1	0	100	0	174.45[b]	55.58[a]	66.96[f]	362.26[b]
2	100	0	0	168.59[e]	53.65[ab]	92.36[c]	330.33[f]
3	50	0	50	169.96[d]	50.65[bc]	81.33[d]	298.86[jk]
4	0	0	100	125.27[m]	41.13[e]	90.36[c]	295.58[k]
5	100	0	0	138.56[k]	50.49[bc]	72.44[e]	355.34[c]
6	50	50	0	142.26[j]	32.27[f]	75.98[de]	288.46[l]
7	50	50	0	150.41	33.23[f]	66.25[f]	300.16[j]
8	0	0	100	125.33[m]	40.45[e]	100.27[b]	320.15[g]
9	0	50	50	163.34[g]	53.65[ab]	73.35[e]	266.66[n]
10	0	100	0	172.55[c]	49.58[c]	62.26[f]	344.48[d]
11	33.3	33.3	33.3	185.58[a]	51.47[bc]	77.59[de]	277.46[m]
12	16.7	66.6	16.7	165.36[f]	48.56[cd]	79.36[d]	374.12[a]
13	66.6	16.7	16.7	147.46[i]	35.37[f]	103.26[b]	306.33[i]
14	16.7	16.7	66.6	165.26[f]	45.26[d]	120.25[a]	335.37[e]
control	FIG	BAR		153.25[h]	39.65[e]	98.58[b]	310.45[h]
		LSD[1]		0.7520	3.5252	5.3944	3.3015

X_1 = Cassava flour (%), X_2 = bambara groundnut flour (%), X_3 = cashew kernel flour (%), CHO = Carbohydrate, Values are means of triplicate determinations. Experimental runs were randomized. LSD[1] Least significant difference at p=0.05. Means not followed by the same letter along the column are significantly different @ $p<0.05$.

Sensory Evaluation

Sensory quality evaluation is important for marketing purposes; the results give in-depth insight on the preference and overall acceptance towards product (Parn *et al*., 2015). There was consistency in the overall panel performance when the energy bars were evaluated as demonstrated by the ANOVA result (Table 3). It was observed that while the addition of cassava flour and cashew kernel flour improved ratings for the energy bars, the addition of toasted bambara groundnut flour had the opposite effect (Table 3). Almost all the energy bars containing at least 50 % bambara groundnut flour received low scores for taste, aroma, chewiness, fracturability and general acceptability. Panelists described energy bars containing high levels of bambara groundnut flour as lacking a characteristic flavor associated with baked products. The mean scores for taste ranged from 5.10 – 7.60. The taste of energy bars made from blend 4 had the highest mean score (7.60) and was significantly different ($p<0.05$) from that of blend 1 which had the least mean score (5.10) (Table 3). The taste of the control sample (Fig energy bar) (6.65) was significantly different ($p<0.05$) from the other energy bar samples. The most acceptable taste of the binary combinations was the one produced from (blend 3) (50% cassava flour, 0% bambara groundnut flour, 50 % cashew kernel flour) (7.10). The crumb appearance means score ranged from 5.85 – 8.00. There was a significant difference ($p<0.05$) in the crumb appearance of the control energy bars (8.00) when compared to the other energy bar samples. Among the formulated energy bar samples, the best crumb appearance was the energy bars made from blend 2 (100 % cassava flour, 0 % bambara groundnut flour, 0% cashew kernel flour) (7.72) followed by that from blend 3 (50 % cassava flour, 0 % bambara groundnut flour, 50% cashew kernel flour) (7.40) (Table 3). The "energy" snack bars received score 5.54 to 7.70 for their aroma. Blend 4 and 8 (0 % cassava flour, 0 % bambara groundnut flour, 100% cashew kernel flour) had the highest mean score The desired aroma could be as derived through caramelization, a browning process caused by a reaction of reducing sugars (from date syrup) with primary amine groups under heating condition (Malawat and Hidayah, 2013). The control energy bars had no significant difference ($p>0.05$) in the its aroma when compared with that of energy bars made from blend 2 (100 % cassava flour, 0 % bambara groundnut flour, 0% cashew kernel flour) and blend 13 (66.6 % cassava flour, 16.7 % bambara groundnut flour, 16.7 % cashew kernel flour). In terms of chewiness, the consumer rated the mean score of the products as 5.40-6.90. The products received high scores were attributed to the soft textured of the cashew kernel flour that gave major effects on the overall texture. This property contributed to the product easy to bite and masticate into a state ready for swallowing. Regarding the fractuability of the energy bars, consumers preferred the nature of energy bars from blend 13 and 14 (6.70). There was no significant difference ($p>0.05$) in the fractuarbility of energy snack bars from blends 13 and 14. Some of the panelists commented that the presented product could be improved by decreasing the level of bambara groundnut flour in the product. General acceptance is an attribute determined by a combination of sensory perception components (taste, crumb appearance, aroma, chewiness, fracturability) of the products. The highest mean score for the general acceptance was 6.99 (control bar) and this was closely followed by snack bar produced from blend 4. The results suggested that some of new innovated convenient "energy" snack bars compares favorably to the commercial product.

Table 3: Mean sensory scores observed for energy bars produced from high quality cassava, toasted bambara groundnut and roasted cashew kernel flour blends.

Blends	Textural properties					
	Taste	Crumb Appearance	Aroma	Chewiness	Fracturability	General acceptance
B1	$5.10^{i}\pm0.03$	$5.85^{ef}\pm0.04$	$5.45^{k}\pm0.02$	$5.40^{h}\pm0.02$	$5.50^{h}\pm0.02$	$5.46^{j}\pm0.01$
B2	$6.85^{c}\pm0.03$	$7.72^{a}\pm0.14$	$6.65^{c}\pm0.03$	$5.85^{f}\pm0.03$	$6.25^{d}\pm0.03$	$6.66^{cd}\pm0.05$
B3	$7.10^{b}\pm0.01$	$7.40^{b}\pm0.01$	$6.35^{fg}\pm0.01$	$6.20^{d}\pm0.01$	$6.05^{e}\pm0.01$	$6.62^{d}\pm0.01$
B4	$7.60^{a}\pm0.04$	$6.80^{c}\pm0.10$	$7.70^{a}\pm0.04$	$6.85^{a}\pm0.04$	$5.15^{j}\pm0.04$	$6.82^{b}\pm0.01$
B5	$6.15^{f}\pm0.05$	$7.20^{b}\pm0.05$	$6.30^{g}\pm0.06$	$5.80^{f}\pm0.06$	$6.35^{c}\pm0.06$	$6.36^{e}\pm0.06$
B6	$6.60^{de}\pm0.15$	$6.35^{d}\pm0.00$	$6.45^{e}\pm0.10$	$6.20^{d}\pm0.10$	$5.95^{f}\pm0.10$	$6.31^{ef}\pm0.03$
B7	$6.50^{e}\pm0.00$	$6.60^{cd}\pm0.40$	$6.40^{ef}\pm0.04$	$5.85^{f}\pm0.04$	$5.75^{g}\pm0.04$	$6.22^{g}\pm0.06$
B8	$7.23^{b}\pm0.12$	$6.80^{c}\pm0.10$	$7.70^{a}\pm0.04$	$6.52^{c}\pm0.12$	$5.30^{i}\pm0.04$	$6.71^{c}\pm0.01$
B9	$5.40^{h}\pm0.06$	$5.85^{ef}\pm0.03$	$5.60^{j}\pm0.02$	$5.60^{g}\pm0.02$	$5.55^{h}\pm0.02$	$5.60^{i}\pm0.02$
B10	$5.50^{h}\pm0.09$	$5.00^{g}\pm0.29$	$5.85^{i}\pm0.01$	$5.15^{i}\pm0.01$	$5.25^{i}\pm0.01$	$5.35^{k}\pm0.07$
B11	$6.25^{f}\pm0.20$	$6.00^{e}\pm0.20$	$6.85^{b}\pm0.05$	$5.95^{e}\pm0.05$	$6.25^{d}\pm0.05$	$6.26^{fg}\pm0.05$
B12	$5.80^{g}\pm0.15$	$5.55^{f}\pm0.07$	$6.05^{h}\pm0.02$	$5.95^{e}\pm0.02$	$5.70^{g}\pm0.02$	$5.81^{h}\pm0.06$
B13	$6.65^{de}\pm0.03$	$6.55^{cd}\pm0.03$	$6.55^{d}\pm0.03$	$6.65^{b}\pm0.03$	$6.70^{b}\pm0.03$	$6.62^{d}\pm0.03$
B14	$6.70^{d}\pm0.01$	$6.80^{c}\pm0.07$	$6.55^{d}\pm0.02$	$6.65^{b}\pm0.02$	$6.70^{b}\pm0.02$	$6.68^{c}\pm0.02$
Fig bar	$6.65^{de}\pm0.02$	$8.00^{a}\pm0.43$a	$6.60^{cd}\pm0.07$	$6.90^{a}\pm0.03$	$6.80^{a}\pm0.12$	$6.99^{a}\pm0.05$
LSD	0.1484	0.3116	0.0737	0.0846	0.0848	0.0683

Scores are based on a 9-point hedonic scale with 1 representing dislike extremely; 5: neither like nor dislike; and 9: like extremely; number of panelists: 30. Mean values within a column with the same superscript are not significantly different ($p> 0.05$). B1–B14 refers to blends used in energy bar production.

Conclusion

In conclusion, this study has shown that high quality energy bars can be produced from our locally available raw materials (cassava, bambara groundnut and cashew kernel). Based on the result obtained, these energy bars are good sources of the minerals and has consistent sensory outcome. The result indicates that the addition of cassava flour and cashew kernel flour improved the sensory ratings. Mineral are essential for body maintenance, so feeding on these bars will enhance the mineral level of human. The optimum energy snack bar products when used as snack is convenient, health promoting, and cost effective, hence could be used in various food intervention programmes, such as in disaster situation, famine, war and school feeding systems. Further studies are required to determine the shelf life of this product for better understanding on the food safety purpose.

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