# ENERGY BAR FROM A COMPOSITE OF UNRIPE BANANA, SESAME, AND SEMOLINA FLOURS: DEVELOPMENT, SENSORY EVALUATION, PROXIMATE ANALYSIS, AND KEEPING QUALITY EVALUATION

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## ABSTRACT

**Background:** Globally, the popularity and market for energy bars steadily increases, especially with increasing urbanisation. Fresh bananas suffer much postharvest losses mainly due to their short green life. Semolina, a by-product of wheat is usually destined to waste despite its nutritional profile. **Objective:** To developing an energy bar from a composite of unripe banana (*Musa accuminata)*, sesame (*Sesanum indicum)* and semolina flours, assessing the consumer acceptability and determining the nutrient plus keeping quality of the most accepted formulation. **Methodology:** A total of five energy bars from different composite flour formulations namely; A (20:20:60), B (20:10:70), C (10:10:80), D (30:30:40), and E (10:30:60) for unripe banana flour: sesame flour: semolina flour respectively was developed and tested for consumer acceptability using a nine-point hedonic scale. The most accepted energy bar formulation was further profiled for its proximate composition, selected minerals' content, and keeping quality using standard AOAC protocols. **Results:** Formulation D provided the most accepted energy bar regarding the texture, taste, plus overall acceptability, whereas the least accepted sample for most sensory attributes was from formulation A. No significant difference existed in colour for all the formulations. The most accepted energy bar contained 5.72% moisture, 1.02% ash, 5.39% crude protein, 2.94% crude fat, and 4.33% dietary fibre. This energy bar provided a high percentage of carbohydrates and energy value i.e. 72.98% and 1440 KJ/100g (360 calories) respectively. Its mineral analysis revealed 110.51mg/100g of calcium, 38.407 mg/100g of iron, and 399.291 mg/100g of potassium. Indices for the keeping quality of the most accepted energy bar showed a peroxide value of 1.87 and a free fatty acids content of 0.33.

**Conclusion:** This study developed a calories-rich energy bar which can be quickly utilized to fuel plus replenish the body in periods of high energy demand or as an energy-dense snack for people who dont have enough time for meal preparation, manifested in its high carbohydrate content and energy value obtained. Other than increasing the accessibility to cheap high-energy food sources, the present study showed potential of reducing post harvest losses of unripe bananas.

## INTRODUCTION

Energy bars are ready-to eat nutritious foodswith good sensory characteristics,and targeted at people that require quick energy but do not have time for a meal.[1] A typical energy bar usually provides 200-300 calories, a low fat content of about 3-9 g, and is shaped in form of a bar or any other convenient form.[2] Numerous energy bars have been developed and are known by different names such as nutrition bars, sports bars, granola bars, meal replacement bars, protein bars, nutraceutical bars, snack bars, diet bars, cereal bars, among others. [2] Lately, energy bar sales and consumption have increased globally,[2] mainly because modern lifestyles require more time away from home.[3] There is need for a nutritious, pleasing, ready-to-eat, shelf-stable, proportionedyet portable method of food transport and availability; an energy bar can satisfy this demand. [2]

The bars which are well known by most rural households are compressed food bars used in emergency situations. Compressed food bars comprise of soya protein concentrate, baked wheat flour, sugars, vegetable fat, plus malt extract, and are used in relief effort for disasters if local foodis not available or accessible[4] In Uganda, there are few energy bar micro enterprises, for example in Nakasongola district which improves food security and income of farmers.[5] Composite flour is a binary or tertiary mixture of different flours, mostly wheat flour, with flours of differentcrops. Composite flour is found beneficial especially in developing countries becauseit encourages the use of locally available crops as flour. Local raw material replacement instead of wheat flour is rising because of the growing market for confectionaries.[6]

Banana is one of the fifth most crucial food crops across the globe. [1] More than 75% of farmers in Uganda grow bananas, making it the world's second largest producer after India[7]. Banana (*Musa accuminata spp.*)is a staple starchy food for about 80 million people in East Africa and a vital income source.[7] It is a reliable source of starch and energy hence ensuring food security for millions of people.[7] There are more than 120 banana varieties in Uganda, whichhave not yet been identified and/or documented anywhere else in the world. *Musa spp*, consisting of plantain plus dessert bananas,isone of the world's leading food crop as a source of energy in people's diet especially those residing in tropical or humid areas. [1] Although Uganda is regarded as food self-sufficient due to its productive soil and bi-annual rainfall, not all regions of the nation have enough food, and some may experience food insufficiencies for some period in the year[5]. Therefore, the population in some areas of the country suffers from food insecurity and befalls victim of emergency situations[5].Despite the fact that Uganda is the leading producer of plantain plus banana in the sub-Sahara African region, this crop suffers post-harvest losses to a tune of 20-60%.[8]This mainly arises because of bananas' limited green life plus damage from improper produce handling after harvest. [1] A large amount of the produce thus goes to waste, leading to high physical and economic losses. [1] Therefore,using unripe banana in flour form might help in reducing such post-harvest losses. Moreover, the prospects of using banana flour for development of food bars and other snacks have been articulated in several previous studies. [1, 3]

Semolina is the hard part of coarsely-ground durum wheat, high in gluten and protein contents. The high gluten content present helps in binding of the raw materials during cooking of the energy bar. Semolina is also rich in iron; 100 g of semolina provides about 4.36 mg of iron.[9] Since the production of wheat in Uganda is low in addition to by-products of wheat not being well-known by the people,[10] development of energy bars will help increase people's nutritional awareness about semolina and ultimately increase its usage. Uganda being among the highest importers of wheat, encouraging semolina usage can lead to higher rate of wheat production in the country in addition to reducing wheat import costs, which shall eventually boost Uganda's economy.

Sesame (*Sesamun indicum* L.) seeds have for long been used extensively in traditional healing plus cooking purposes due to their nourishing benefits andcurative properties. Sesame is a vital source of phyto-nutrients for example, flavonoids, phenolic compounds, dietary fiber, anti-oxidants, anti-cancer compounds, as well as other health promoting properties. Sesame being a rich source of high quality edible oil and essential amino acids is thus a healthy/nutritious component for the energy bar. Therefore, the present study aimed at (i) development of an energy bar froma composite of unripe banana flour, sesame flour, and semolina flour (ii) carrying out consumer acceptability tests through sensory evaluation of different formulations prepared for the energy bar (iii) carrying out proximate analysis of the most accepted formulation of the energy bar, and (iv) determining the keeping quality of the most accepted energy bar formulation through peroxide value test and test for the free fatty acids content.

## MATERIALS AND METHODS

**Study design:** Experimental study

**Settings:** Food Science Laboratory, Department of Food Science and Nutrition, Faculty of Agribusiness and Natural Resource Sciences, Islamic University in Uganda (IUIU).

**Study duration:** 4 months

**Data collection procedure**

Unripe banana, brown sesame seeds, and wheat grains were purchased from Mbale Central market. After being washed properly, banana fingers were peeled, followed by soaking in water to clean off the sticky sap that appears upon peeling. This was followed by slicing (using a kitchen grater with 3mm thickness) in water that was treated with food-grade citric acid (1 gof citric acid per litre of water) to avoid enzymatic browning. The slices were soaked for 15 min, then spread on a clean sheet of cloth under the sun for 2 days to achieve complete dryness. Dried slices were grinded in an electricstainless steel food grinder, then sieved using a stainless steel sieve, prior to being stored in a polythene bag. Sesame seeds were sorted to get rid of any visible foreign matter. They were washed with clean water to remove dustor any other residual foreign matter, followed by spreading the seeds on a clean sheet of cloth under the sun for 6 hours. Dried sesame seeds were then roasted on a dry pan set on medium heat of the electric coil, for 15 mintilla slightly brown colour and characteristic aroma were evident. Seeds were left to cool prior to being finely ground and sieved. Sesame seeds were then packed in a polythene bag and stored away from light and moisture, awaiting mixing with flour from other raw materials, as shown in Figure 1. After being sorted, wheat grains were conditioned by adding water and keeping them for 24 hours to mellow the inner endosperm. Wheat grains were then dried and grinded into the desired coarse-particle flour. This was followed by sieving and sifting of the wheat particles to allow heavy coarse particles (semolina) remain on the sieve. The composite flour formulations from each raw material, amount of honey, and ghee used in the production of energy bars are presented in Table 1.After cooking, the energy bar matrix was spread into rectangular moulds to be shaped into bars. Bars of 4cm by 12cm were cooled to luke-warm temperature before being cut out using a sharp knife (when the matrix was just warm), then allowed to completely cool to room temperature so they become firm, prior to packaging in air tight polythene packaging material.

**Sensory evaluation Test**

Sensory evaluation for the different energy bar formulations was carried out from the Food science and Nutrition laboratory, employing the nine-point hedonic scale ranging from extremely like to extremely dislike.[11] A total of 50 randomly selected IUIU students with no food allergies were used as panelists in the evaluation that consisted of 5 sensory attributes namely; color, texture, taste, flavour & overall acceptability. Asensory evaluation form and 5 g of the sample from each formulation were served to each panelist, in a random order. Panelists were also provided with drinking water to rinse their mouth before and between successive sample evaluation, to minimise any residual sample effect. After sensory evaluation analysis, all the further tests were conducted on only the most accepted/highly ranked formulation.

**Proximate analysis**

This analysis involved determination of the moisture content, dietary fibre content, total ash, crude fat, carbohydrate content, crude protein, energy value using intenational standard protocols,[12] plus selected minerals (Ca, Fe, and K).

To determine the moisture content, clean crucibles were dried for 30 min in an oven and then cooled from a desiccators before weighing. The crucible weight was taken and 3g of the sample was weighed into a crucible. This was followed by drying the weighed sample(95$^{o}$Covernight) in the oven and cooling in desiccators. Weight of the crucible plus the dried sample was recorded, after which moisture content was calculated as follows;

$$\% \, Moisture = \frac{W2 - W3}{W2 - W1} \times 100$$

Where;

$W_1$ = initial weight of empty crucible (g)

$W_2$ = weight of crucible + sample before drying (g)

$W_3$ = final weight of crucible + sample after drying (g)

$W_2$-$W_3$ = loss in sample weight (g) after drying

To determine ash percentage, the dry ashing method was employed; crucibles were put in a muffle furnace overnight at 550$^{o}$C so as to ensure that any impurities on the surface burn off. The crucibles were cooled in a dessicator for 30min and weighed. A proportion of 5g sample was weighed into the crucible and put in a furnace, then heated at 550$^{o}$C overnight. The crucibles were weighed when the sample turned to grey and ash percentage was calculated as below;

$$\text{Ash (\%)} = \frac{\text{(weight of crucible + sample after drying)- (weight of empty crucible)}}{\text{Weight of sample}} \times 100$$

Determination of the crude protein content was done using the microkjeldahl method.About 4 g of the sample was weighed and placed in the Kjeldahl digestion flask. Sulphuric acid (20mL) and 10g of $Na_2SO_4$catalyst were added and the sample digested in a fume chamber for 60 min at 350 ºC until the digest appeared clear pale green. The digest was left until completely cool, followed by addition of 100mL $H_20$ and mixing. The mixture was then transferred to a distillation flask and 85mL of saturated NaOH solution added from a measuring distillation unit. This was followed by distillation of the mixture into

25mL of 0.1N HCl containing 10mL of boric acid as an indicator. Distillation was continued till the flask contents 'bumped', and excess acid was titrated with 0.1N NaOHsolution.

% Nitrogen in the sample (N) = 14 x (V/1000) x 0.1 x (W/100)

Where; V = volume of 0.1N HCl added – volume of 0.1N NaOH used, W = weight of the sample

Crude protein = N x 6.25

To determine the crude fat percentage, 3g of the sample was accurately weighed into a thimble lined with a circle of filter paper. This was followed by placing both the thimble and content into a 50mL beaker and dried in a mechanical convection oven for 1 hour at 125 ºC. Crude fat was extracted with petroleum ether (40 °C) as a solvent using the soxhlet apparatus semi-continuous method (Soxhlet System HT, 1043 Extraction Unit). After the extraction process was finished, the fat extract was moved from the extraction flask into an evaporating dish that had been previously weighed; the solvent was evaporated till its odor could not be detected. The dish and its contents was dried in an oven for 30 min at 100 ºC, after which cooled in a desiccator. The dish plus content were then weighed.

Crude fat (ether extract) % = W2-W1 x 100/S

Where;

W1 = evaporating dish, W2 = weight of the evaporating dish plus contents after drying

S = weight of sample.

Determination of the dietary fibre content involved addition of 5g sample to 200mL of 1.25% $H_2SO_4$, heating for 30 min and filtering with a Buchner funnel. Distilled water was used to wash the residue until there was no more acid present. For 30 min, the residue was boiled in 200millilitres of 1.25% NaOH. This was filtered and repeatedly rinsed with distilled water till it became alkaline-free. This was followed by rinsing once with 10% HCl, twice with ethanol and thrice with petroleum ether. The residue was placed in a crucible and dried at 105°C in an oven over night. It was cooled in a dessicator before being ignited for 90 min at 550 $^0$C in a muffle furnace, after which allowed to cool, and reweighed.

Total dietary fiber = Weight of ash residue×100

Weight of sample

Determination of the carbohydrate percentage was done by difference method;[13]

% carbohydrates =100 - (% fat + % moisture + % ash + % protein)

Energy value was calculated from the formula;[14]

Energy value (KJ/100g) = 4 (% carbohydrates + % protein) + (9 x % fat)

Determination of the calcium content involved pipetting an aliquot of the test solution into a volumetric flask followed by addition of 1% $LaCl_3$ (w/v) solution to make a final concentration of 0.1% $LaCl_3$

(w/v).This was followed by diluting the solution with 1N $HNO_3$. Calcium determination was done with an atomic absorption spectrophotomer, following the manufacturer's instructions. Absorbance of the prepared standards and test solution was then measured against reagent blank.

$$\text{Ca (mg/100g)} = \frac{\text{Conc.} \times \text{dilution} \times 100}{\text{Weight of sample (g)} \times 1000}$$

Where Conc. = concentration of the sample (mg/L)

To determine the iron content present, the sample was exposed to wet digestion. An aliquot portion of the acidified sample was taken, diluted, and thenread from aninductively coupled plasma-optical emission spectrophotometer,at a wavelength of 248.3.

$$\text{Iron (mg/100g sample)} = \frac{\text{Conc.} \times V \times D \times 100}{W \times P \times 1000}$$

Where; Conc. = concentration of sample in mg/L

V= Total volume in mL

D= Dilution factor

W= Weighed sample in g

P= Sample solution taken, in mL

1000= conversion of mL to L

The results were reported as mg Fe/100g sample and as around number.

Potassium content of the sample was determined using a flame photometer. Standard solutions were prepared by dilution of stock solution of potassium. Volumes of 0.5, 1, 2, 4, 6, and 8 were diluted in 100mL flasks. The photometer was heated for 10 min then distilled water was fed into the instrument. The most concentrated standard solution was aspirated, and the readout was adjusted to 90 using the knobs. Distilled water was aspirated, followed by all the standard solutions. The results were recorded and a calibration curve drawn to calculate the results, using the equation below;

$$y = mx + b$$

Where; y = results from the photometer, x= concentration of the standard solution and M = coefficient

**Keeping quality**

This analysis involved assessment of the peroxide value plus the free fatty acids content. Peroxide value was determined using the AOCS method.[15] About 0.05g of sample was weighed into a 250 mL glass stoppered Erlenmeyer flask. This was followed by addition of 30mL of acetic acid and the flask swirled until complete dissolution of the sample, then addition of 0.5mL of saturated potassium iodide and the flask swirled for 1 min. This was followed by addition of distilled water and vigorous shaking to liberate iodine from the chloroform layer. 0.01N sodium thiosulphate was added plusstarch solution (1 mL) as an indicator. Titration was done until the blue-gray colour disappeared and titre values were recorded.

$$\frac{(S - B) \times \ Nthiosulhate \ \times 1000}{weight\ of\ sample}$$

S= titration of sample

B= titration of blank

To determine the free fatty acid content, 0.2g of sample was weighed in glass vial and mixed with 50 mL of the solvent mixture. This was followed by titration with O.1N KOH solution to the end point of phenolphthalein indicator. The free fatty acid content was calculated from the equation;

Free fatty acid content = 56.1 × N × V/M

Where; N= Exact normality, V= volume of KOH and M= mass of the sample (g)

**Statistical analysis**

Data for the present study was processed using the SAS software, version9.2.Forsensory evaluation results, means were separated by the Duncan's multiple range test (DMRT) with 0.05 as the probability level, using one way analysis of variance.

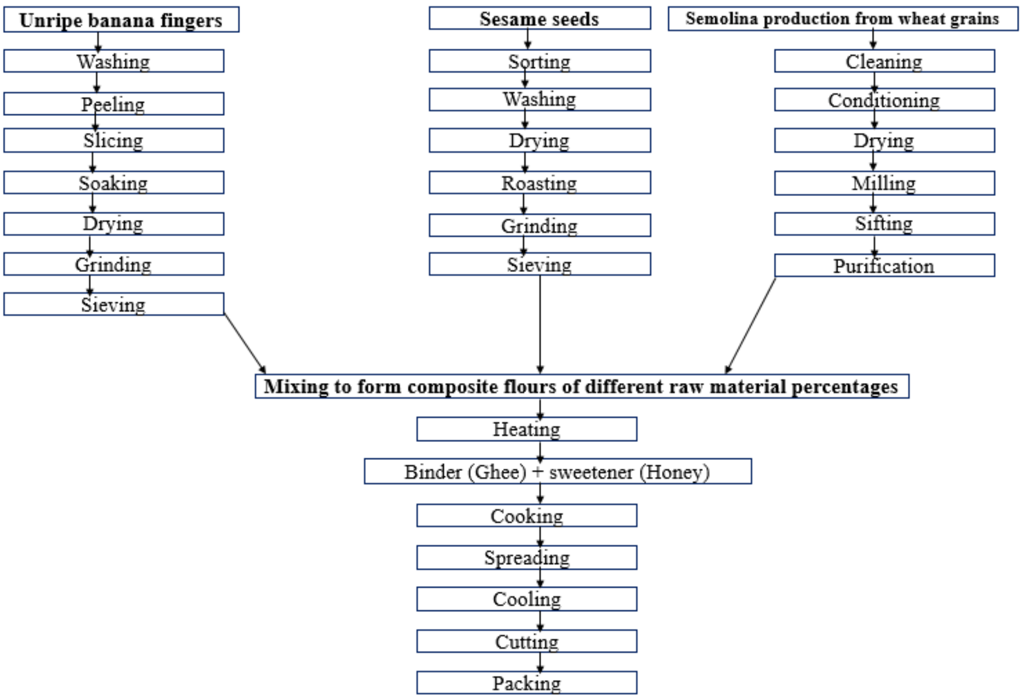


**Figure 1:** Process flow chart for the energy bar production from unripe banana flour, sesame seeds' flour, and semolina flour.

The composite flour formulations from each raw material, amount of honey, and ghee used in the production of energy bars are presented in Table 1. After cooking, the energy bar matrix was spread into rectangular moulds to be shaped into bars. Bars of 4cm by 12cm were cooled to luke-warm temperature before being cut out using a sharp knife (when the matrix was just warm), then allowed to completely cool to room temperature so they become firm, prior to packaging in air tight polythene packaging material.

**Table 1:** Composition of the different formulations of the produced energy bars.

| **Formulation code** | **Unripe banana flour (%)** | **Sesame flour (%)** | **Semolina flour (%)** | **Honey (g)** | **Ghee (g)** |
|---|---|---|---|---|---|
| A | 20 | 20 | 60 | 10 | 10 |
| B | 20 | 10 | 70 | 10 | 10 |
| C | 10 | 10 | 80 | 10 | 10 |
| D | 30 | 30 | 40 | 10 | 10 |
| E | 10 | 30 | 60 | 10 | 10 |

## RESULTS

### Sensory evaluation

Results of sensory evaluation of the energy bars developed from different formulations of unripe banana, semolina and sesame composites are presented in Table 2 below;

The most accepted sample of all was D in terms of texture, taste, and overall acceptability but sample E was preffered most in terms of flavour. Table 2 above shows there was no significant difference in the flavour of the energy bars produced by formulation A, B, C and D but there was a significant difference in the flavour of sample E. Results indicate that there was no significant difference in the colour of all the formulations. Generally, the least accepted sample for most sensory attributes was sample A.

### Proximate composition and keeping quality of the most accepted energy bar formulation

Results of proximate analysis and keeping quality indicators from the most accepted energy bar formulation of unripe banana, semolina and sesame composites are presented in Table 3 below;

The energy bar's most accepted formulation contained 5.72% moisture which is considered a low moisture content. Similarly, this energy bar contained considerably low ash (1.02%) and protein (5.39%).The crude fat content and dietary fiber in the most accepted energy bar was 2.94% and4.33%respectively.This energy bar provided a high percentage of carbohydrates and energy value i.e. 72.98% and 1440 KJ/100g (360 calories) respectively.Mineral analysis revealed 110.51mg/100g of calcium, 38.407 mg/100g of iron, and399.291 mg/100g of potassium. Indices for the keeping quality of the most accepted energy bar showed a peroxide value of 1.87 and a free fatty acids content of 0.33.

**Table 2**: Sensory evaluation results of the energy bars developed from unripe banana, semolina and sesame composites.

| Formulation | Texture | Taste | Colour | Flavour | Overall acceptability |
|---|---|---|---|---|---|
| A | $5.19{\pm}0.69^{c}$ | $5.44{\pm}0.68^{c}$ | $5.94{\pm}0.57^{a}$ | $6.81{\pm}0.19^{b}$ | $5.01{\pm}0.52^{c}$ |
| B | $6.38{\pm}0.66^{b}$ | $6.25{\pm}0.81^{b}$ | $5.57{\pm}0.98^{a}$ | $6.74{\pm}0.31^{b}$ | $5.71{\pm}0.59^{bc}$ |
| C | $5.86{\pm}0.47^{bc}$ | $6.44{\pm}0.03^{b}$ | $5.88{\pm}0.93^{a}$ | $6.86{\pm}0.97^{b}$ | $6.30{\pm}0.93^{b}$ |
| D | $7.50{\pm}0.89^{a}$ | $7.38{\pm}0.50^{a}$ | $5.90{\pm}0.05^{a}$ | $6.69{\pm}0.99^{b}$ | $7.56{\pm}0.55^{a}$ |
| E | $6.98{\pm}0.98^{ab}$ | $6.89{\pm}0.48^{ab}$ | $5.70{\pm}0.99^{a}$ | $7.85{\pm}0.42^{a}$ | $6.13{\pm}0.89^{b}$ |

*Values in the table are Mean±Standard deviation.Values with the same superscript in the same column are not significantly different at $p \leq 0.05$ using the DMRT.*

**Table 3** : Proximate composition and keeping quality results for the most accepted energy bar formulation.

| Nutrients | Most accepted energy bar (Formulation D) |
|---|---|
| Moisture content (%) | 5.72±0.44 |
| Total ash (%) | 1.02±0.03 |
| Crude protein (%) | 5.39±1.2 |
| Crude fat (%) | 2.94±0.01 |
| Dietary fiber content (%) | 4.33±0.26 |
| Carbohydrate content (%) | 72.98±10.63 |
| Energy value (KJ/100g) | 1440 |
| Calcium content(mg/100g sample) | 110.51±82.67 |
| Iron content (mg/100g sample) | 38.407±10.37 |
| Potassium content (mg/100g sample) | 399.291±254.31 |
| Peroxide value | 1.87±0.27 |
| Free fatty acids content | 0.33±0.02 |

*Except the Energy value, all other values in the table are Mean±Standard deviation.*

## DISCUSSION

Texture is a key component which influences a food's sensory quality, in addition toits visual appearance, aroma, plus taste.[16] Texture evaluation is a dynamic intricate process which involves visual perceptions of the product surface, behaviour of the product in reaction to previous handling, and intergration of sensations in the mouth felt during mastication and subsequent swallowing; all these are combined by the human brain and a unique sensation is brought up.[17] From the present study, texture of formulation D was the most preffered. This could be due to the fact that low quantity of semolina was used in formulation D compared to other formulations, as previously shown in Table 1. Semolina has a granular texture and therefore when it was mixed with the smooth unripe banana plus sesame flours, it dissolved into them forming a neither very soft nor very hard, less chewy texture.

Colour is one of the key quality attribute of a food raw material or product, which greatly influences consumer acceptance.[18] It provides information regarding the chemical composition, appropriateness for processing, plus shelf life. Findings of the current study indicated that no significant difference existed in colour of all the samples. The reason could be the presence of honey in an equal quantity throughout all the formulations (Table 1), because honey has an inherent dark-brown rich color which dominated in all the formulations. The other reason stems from accelerated millard reaction between honey and proteins present in all the formulations which led to production of brown melanins in all the energy bar formulations.[19] Other factors that impacted the colour of the developed energy bars include caramelisation and roasting of sesame seeds.

There are four primary categories of tastes that the tongue's receptors (buds) can identify i.e. sweet, sour, bitter and salty.[18] In contrast to the common knowledge that distinct tongue regions correspond to different tastes, some regions are more sensitive than others.[20] In the present study, the taste of formulation D was preffered most, followed by E. This could be due to the presence of higher quantities of roasted sesame flour in both formulations (as presented in Table 1). Several studies indicate that roasted sesame seeds add a unique nutty taste to many food products.[21]

Flavour of a food is greatly influenced by the chemical senses of taste plus smell.[18] These sensations can be changed by adding natural or artificial flavorants. Even with breakthroughs in instrumental analysis, sensory tests are the sole way to measure the flavor impressions which humans experience.[22] The most preffered flavour in the present study was of formulation E, and this could be attributed to the substantial quantity of sesame flour present in this formulation. This tallies with observations in a previous study[5]that sesame seeds not only develop a pleasant flavor during processing but also enhance the taste of food or make it more acceptable for consumption. Sesame contains flavour compounds like 2-acetyl-1-pyrroline (roasty), 2-furfurylthiol (coffee-like), 2-phenylethylthiol (rubbery), 4-hydroxy-2,5-dimethyl-3(2H)-furanone (caramel-like) and 2-furfuryl alcohol which are significant factors influencing the crushed sesame material's overall flavor.[19]

Overall acceptability is based on multiple organoleptic quality parameters and indicates the cumulative perception plus acceptance by panelists or consumers.[18] The overall acceptability of formulation D was preferred most. This could be linked to the composition ratio of unripe banana flour to sesame flour to semolina flour in formulation D which was almost balanced, hence a high mean overall acceptability score of 7.56±0.55and thus contributed to a better taste, texture and overall acceptability.

The energy bar's most accepted formulation contained 5.72% moisture which is considered a low moisture content, and is attributed to loss of moisture during heating and cooking unit operations of the composite processing. Moisture content has an important influence on the shelflife of the product; the lower the moisture content, the better the food's shelf life. Therefore, the low moisture content of the energy bar indicates a good storage stability, as most pathogenic and spoilage bacteria, plus some molds and yeasts, thrive in an atmosphere with high moisture content.[5] The ash content in the most accepted sample was 1.02%. Ash content isindicative of the approximate quantity of minerals in any food sample, [7, 18] and thus, the considerably low ash content in the present study implies that the formulated energy bar was generally not a good source of minerals.However, present results are different from previous findings,[2, 7]which reported that green banana flour plus snack bars made from them had a high ash and mineral concentration. This anomaly from present findings is because the present snack bar was a composite of flour from three different sources i.e. unripe banana, semolina, and sesame. The other reason for the anomaly could be the differences in varieties of green banana and the nutritional profile of the soil in different geographical regions, as observed in a previous study.[7]

The protein content in this energy bar was 5.39%. The reason for this considerably low value could be high heat processing which may have caused protein denaturation or millard reactions may have taken place in which the proteins reacted with carbohydrates and thus a reduction in the former's detectable quantity. In a related study which developed and compared energy bars from maize flour with those from unripe banana flour;[23] the bar with the least amount of protein and lipid contents was the one made with unripe banana flour. Similarly, another study showed a very low protein content from banana flour (2.40%).[2] Therefore, unripe banana flour used in the current study is responsible for the low protein content in the most accepted energy bar formulation.

The crude fat content in the most accepted energy bar was 2.94%, and this was most-likely contributed by the added ghee during cooking, plus some fat naturally inherent in sesame flour. This energy bar had a considerably high amount of dietary fiber (4.33%) and this was because of the high quantity of unripe banana flour in its formulation, which is in congruence with the emphasis of previous authors,[1, 3, 16]that unripe banana is a good source of dietary fibre.

Similarly, this energy bar provided a high quantity of carbohydrates and energy value i.e. 72.98% and 1440 KJ/100g (360 calories) respectively. As expected, carbohydrates are the main component of the energy bar in comparison with other major nutrients present in the energy bar product. This is because the ingredients used in its production contain high amounts of carbohydrates i.e. a generally high amount of unripe banana and semolina flour in the formulation, as these are rich sources of starch[3, 16] In the same vein, the previous work of other authors[2, 23]showed that unripe banana starch if added to different foods results into a product with high carbohydrate and starch content.This implies that the developed energy bar from the present study can be used to quickly fuel or replenish the body with glucose.

Mineral analysis revealed 110.51mg/100g of calcium. This could be attributed to the quantity of sesame added to the formulation (40%), because sesame contains 780 mg of Ca per 100 g whereas unripe banana and semolina provide lesser amounts of Ca. Furthermore, sesame has been reported to be an excellent source of Ca in several previous related studies.[5] The iron content was 38.407 mg per 100g, and thus, the developed energy bar can be used for iron supplementation in individuals that have high iron demands such as pregnant women.

The most accepted formulation contained 399.291 mg/100g of pottasium and this was mainly contributed by the unripe banana flour, as emphasized in similar experiments that green banana flour is a rich potassium source.[3, 7, 16] The potassium content in the most accepted formulation of the present study (399.291 mg/100 g) was close to the potassium content obtained by a previous researcher[7]i.e. 410 mg/100 g was the primary component found in each of the 15 unripe banana varieties under study. The developed energy bar can be used as a snack and is therefore an ideal food product for mantainance of bone integity in the most vulnerable age groups (adolescents, adults and the elderly), particularly among low income earners, if consumed regularly. To this end, some authorsrecommend that potassium supplementation through food ishelpful for people who have excessive potassium excretion through bodily fluids, especially athletes.[24] Potassium, an electrolyte that aids in controlling fluid balance, neuronal transmission, and acid-base balance, is abundant in bananas.[2]

Indices for the keeping quality of the most accepted energy bar showed a peroxide value of 1.87 and a free fatty acids content of 0.33.Peroxide value is assessed in shelf life studies to detect the initiation stage of the autoxidation process;[25] lipid oxidation is a common and an undesired chemical alteration that can affect a products's flavor, aroma, nutritional value and incertain situations, even the texture.[26] Theobserved peroxide value and free fatty acids content in the current study are attributed to the quantity of ghee that was added into the formulation (10g)plus fat naturally present in sesame. The low quantity of free fatty acidsindicates that the energy bar has good keeping quality and can thus be kept for a considerably long period without deterioration (keeping other factors constant). Low fat content arrests rancidity and off-flavour production during storage[18]and thus extended shelf-life of the product.

## CONCLUSION

This study developed a calories-rich energy bar from unripe banana flour, sesame seeds flour, and semolina flour,which can be quickly utilised to fuel plus replenish the body in periods of high energy demandor as an energy-dense snack for people who dont have enough timefor meal preparation. The study revealed that the developed energy bar had a high carbohydrate content and energy value. The study also showed potential of reducing post harvest losses in unripe bananas, by converting them into flour and further product development. Development of such products can increase the availability of cheap high-energy food sources.

**RECOMMENDATIONS:** There is need to further investigate the bioavailability of nutrients in the most accepted formulation of the energy bar. Further studies should be carried out on the storage stability of the energy bar,using preservatives. The most accepted formulation may be used for development of other food products such as cookies or other confections.

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