JOURNAL OF FOOD AND BIOTECHNOLOGY

Original Research Article | ISSN 3041- 6299 | Open Access

Determination of the Glycemic Indices and Sensory Properties of Snack Bars Produced from the Blends of Acha, Breadfruit and Cocoa Powder

Iwuagwu, C. F., Olawuni, I. A., Uzoukwu, A. E., and Ofoedum, A. F.*

Department of Food Science and Technology, School of Engineering and Engineering Technology, Federal University of Technology, Owerri, PMB 1526, Imo State, Nigeria

Corresponding author: **Ofoedum, Arinze F.** | E-mail: **ofoedum.arizona.edu@gmail.com**

Citation: Iwuagwu, C. F., Olawuni, I. A., Uzoukwu, A. E., and Ofoedum, A. F. (2025). Determination of the Glycemic Indices and Sensory Properties of Snack Bars Produced from the Blends of Acha, Breadfruit and Cocoa Powder. *Journal of Food and Biotechnology.* **38 to 43. DOI: https://doi.org/10.51470/FAB.2025.6.1.38**

28 March 2025: Received | 20 April 2025: Revised | 15 May 2025: Accepted | 06 June 2025: Available Online

Abstract

Background: *This study envisaged the production of snack bars from blends of Acha, breadfruit, and cocoa powder and the determination of the glycemic index and sensory properties of the produced snack bars. A snack bar is defined as "versatile product often developed from fruits, nuts, thus, an ideal food format to provide healthy nutrients, bioactive components, and dietary fibers to the final consumers. Different blends of Acha, breadfruit, and cocoa were produced and subjected to glycemic response testing and sensory evaluation using a 9-point hedonic scale.*

Methods: *The processing of Acha grains involved handling methods such as harvesting, threshing and winnowing, cleaning, washing, drying, dehulling, milling of acha grains into fine flour using an attrition mill and sieving through a 250 µm mesh, and packaging. Breadfruit seeds were thoroughly cleaned in potable water to remove any dirt. They were further soaked in water for 4h to enhance processing. The soaked breadfruit was boiled at 100ºC for 15 min and dried in a cabinet drier at 70 ºC for 1h to enhance the removal of the hulls by winnowing. The dehulled seeds were toasted at 65ºC for 10 min and coarsely milled to obtain granules of breadfruit. Cocoa powder, serving as a flavor enhancer and source of antioxidants, was added during formulation. Different blends of flours were prepared in varying ratios, and the resulting composite flour samples were used to produce snack bars.*

Results: *The produced snack bars underwent various analyses, such as glycemic response and sensory properties. The glycemic response was used to determine the glycemic index of the snack, which showed that the snack bar samples' value ranged from 48.70-68.70 , thus,recorded by sample SAB and control, respectively. The sensory parameters include taste, texture, mouthfeel, appearance, and general acceptance. The taste of the different samples ranged from 6.25(SCS) to 7.60(SAS). The texture of the produced nutrient-dense snack bar samples ranged from 6.20 (SDS) to 6.70(SAB), and the commercial sample SAS had a value of 7.30. The mouthfeel value ranged from 6.25(SDS) to 7.00 (SAB). The appearance values of the samples ranged from 6.00(SES) to 7.60(SAS). The sample SAS had the highest general acceptance with 8.25%. Sample SES had the least acceptance with a mean score of 6.60%. There were no significant differences in each of the sample SABs and others.*

Conclusion: *The most acceptable formulation was found to be the blend containing 80% Acha, 15%breadfruit, and 5% Cocoa powder, offering a balance of nutritional value and sensory appeal.*

Keywords: *Acha, Breadfruit, Coco-powder, Snack bar, Processing, Glycemic Index, Sensory properties.*

INTRODUCTION

The eating habits and lifestyle choices of people worldwide may have an impact on nutrient intake in recent years. In order to satisfy the fundamental requirements of the human body, a nutritious diet is crucial. In order to create foods that are safer and more nutritious while yet meeting consumer demands, experts in the food industry have been constantly modifying recipes and ingredients as well as developing new technology. The snack, cereal, and nutrition bars can be divided into three primary categories: energy and nutrition bars, organic snack bars, and health and wellness snacks, per a survey on snack food consumption in the United States [17].

Snack bar consumption is typically impacted by the consumers' age, gender, and level of nutritional education. The International Markets Bureau market indicator indicates that the following factors also affect snack bar consumption: satiating a sweet tooth, saving time, using as a source of energy, losing weight, and using the protein, fibre, vitamins, and other nutrients. The emphasis has typically been on consumption, therefore it is challenging to acquire a comprehensive classification of functional bars. Thus, snack bars can be eaten as a dessert after lunch or dinner, as a meal replacement for breakfast, lunch, or dinner, or as a component of a meal (as part of breakfast, lunch, or dinner, or as a snack in between meals).

Customers who don't have time for a full meal and need a quick energy source frequently eat snack bars [39]. Other names for them include energy bars, food bars, protein bars, fruit bars, cereal bars, granola bars, nut bars, sports bars, etc., depending on what is used and how it will be utilised. These are readily consumable, portable, and easy-to-eat sources of lipids, proteins, and carbs [4]. Many bars may be used as functional foods since they contain a variety of natural components, and many types of fruits, nuts, and cereals are significant sources of bioactive phytochemicals [35]. Malnutrition and micronutrient deficiencies can be reduced by using bars as a feasible and effective fortification medium [27].

Bars are among the most practical and useful snacks on the market. Customers have a reason for seeking out snack bars. For a substantial breakfast, one could go for a cereal bar. A protein-rich sports bar might be necessary for an athlete before to a workout. A broad range of people, including kids, find protein bars appealing. You can keep vitamin-enriched bars on hand as family-friendly snacks [8].

Energy bars are regarded a practical source of energy for those who need immediate energy but do not have time for a meal. They are supplemental snacks that comprise cereals and other high-calorie meals in bar forms that resemble chocolate bars in size and shape [21].

Typically, an energy bar (45g to 80g) contains 20g to 40g of carbohydrates, 3-9g of fat, 7-15g of protein, and 200-300cal (840-1300KJ). Combined with complex carbohydrate sources like oats and barley, the majority of carbohydrates are different sugars, such as fructose, glucose, maltodextrin, and others, in different ratios, to produce energy rapidly. Since energy bars are made of carbohydrates and don't need low-calorie sweeteners to taste better, they typically don't contain sugar alcohols. Energy bars are kept low in fat and typically contain cocoa butter and dark chocolate as its primary ingredients. Some are baked, while others can be filled and baked or cold-formed [21], [8], and [38]. In order to use raw materials, prevent financial losses, and prevent environmental contamination, by-products have received extra attention in recent years. Energy or nutrition bars are becoming more and more popular among consumers who are concerned about their health, students, and people who are addicted to losing weight [35] because of its convenience and nutritional content. Consumers' growing need for wholesome snacks has fuelled the market for energy bars, which provide convenience and nutrition, and have seen rapid expansion, accounting for over 20% of the market annually [19] [29].

Nutritious foods are preferred over traditional sweets by health-conscious consumers. This trend has prompted the creation of a number of ready-to-eat, nutrient-dense, and energy snacks with various nuts and fruits [38].

In addition to adding value to products, using fruit and vegetable by-products in nutrition bars helps create new food items and reduces raw material waste by using peels, seeds, and other leftovers. [30]

Consumers of today want to give themselves the necessary nutrition in addition to sating their appetite. In light of this, food processors nowadays are working to create snack bar recipes that include a variety of wholesome foods. Protein, lipids, and vitamins are among the vital nutrients that snacks give the body in addition to satisfying hunger and taking the place of meals [16], [3].

The purpose of this study is to create a snack bar using combinations of cocoa powder, breadfruit and acha powder while also analysing the glycaemic index and sensory qualities of each.

MATERIALS AND METHODS

Sources of Materials:

Raw Material Collection

Acha (*Digitariaexilis*) and African breadfruit (*Treculia Africana D.*) were sourced from the Relief Market, Owerri. Cocoa powder, margarine, and other optional ingredients used were purchased at Everyday Supermarket, MCC Road, Owerri, Imo state, Nigeria.

Place and Duration of the Research: The research was carried out at the Laboratory of the Department of Food Science and Technology, Federal University of Technology, Owerri. The period taken for the research was 4 months.

Reagents and Equipment used: Analytical grade chemicals used were sourced from the Department of Food Science and Technology, Owerri.

Methods

Production of Acha flour

Acha grains were sorted and cleaned to remove dust and sand particles. The cleaned acha seeds were steeped in potable water and allowed to sprout for 48h.

The sprouted acha seeds were boiled for 5min before drying in the cabinet dryer (Model No. BOV-T30C, CHINA) at 110°C for 1h as described by [15]. Dried acha grains were milled in Artmash disc attrition mill (Model No.254, CHINA) and re-milled for precise particle size control(250um) [10], [31], [34], [30].

Production of toasted African breadfruit granules

The seeds were cleaned thoroughly in potable water to remove any dirt and rotten flesh, as well as impurities. They were further soaked in water for 4h to enhance processing. The Soaked African breadfruits were boiled at 100^{0}C for a period of 15 minutes and subsequently dried in a cabinet drier at 70^{0}C for 1h to enhance the removal of the hulls. The dehulling was done manually by rubbing off and winnowing. The dehulled seeds were toasted at 65^{0}C for 10 min and coarsely milled using an attrition mill to obtain granules of African breadfruit [1], [33].

Product formulation

Trials on formulation were conducted to get the best sets of formulation for the product. The ratios used below were informed by a combination of nutritional, functional, sensory, and processing considerations. Five samples with the following ratios of formulation were selected.

SAS: 0% Acha. 0% breadfruit, 0% cocoa
SAB:80% Acha,15% bread fruit,5 % cocoa.
SCS: 75% Acha,20% bread fruit,5% cocoa
SDS: 70% Acha, 25% breadfruit,5 % cocoa.
SES: 65% Acha, 30% breadfruit, 5% cocoa.

Fifty grams (50g) of margarine and sugar each were mixed using a tabletop Kenwood mixer (Model no. KBO3001). Measured quantities of processed Acha, African Breadfruit, cocoa powder (see formulation ratio for each sample), and 100gof eggs were added and mixed. The dough was poured onto a stainless-steel table and flattened using a hand sheeter. The sheeted mix using a vernier caliper was cut into 90 x 40 x 10mm with an approximate weight of sixty grams (60g) each and placed on baking trays.

They were baked in an electric oven (with a model No.: DGF4080, CHINA) at 165^{0}C for 30 min. The same treatment was given to all the samples for uniformity. See figure 1 for the process flow:

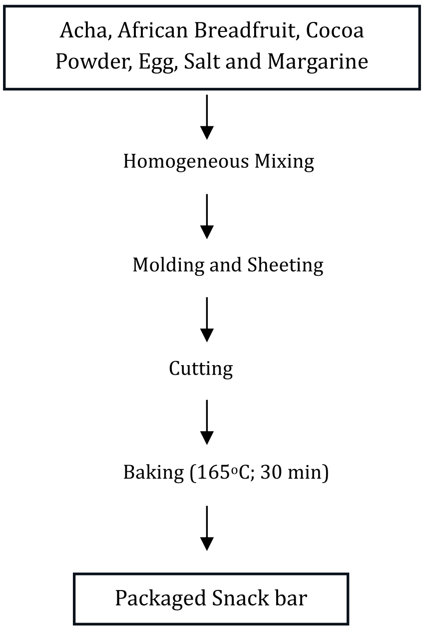

Figure 1. Flow chart for the production of snack bars

Determination of the glycemic indices of the snack bars.

Glycemic response

The use of human subjects for glycemic response in this work was approved by the Health Research Ethical Committee of the Federal Medical Centre, Owerri-Imo State. Glycemic response was carried out as described by [13], using capillary finger sticks and Accu-Answer blood glucose monitoring device from Roche Diagnostics, Indianapolis, USA. Twenty human subjects (students) reported to the 3JC diagnostic laboratory between 0700 and 0800 hours following an 8-hour fast.

After a 5–10minute rest, a capillary finger-stick blood sample was obtained from each subject for the measurement of fasting blood sugar. Due to the collection of the baseline blood samples, subjects were fed the test samples in random order. There was a total of 5 test samples that were fed to the subjects one time each in random order. Each test sample consisted of 8fl. Oz. (240ml) of table water with a 60.0g portion of samples and 60ml sample of glucose as a control. Glucose was used as the positive control and is often used as a reference food in glycemic response studies. Additional blood samples were collected for measurement of glucose concentrations at 15, 30, 45, 60, 90, and 120 minutes following the start of the test meal as described by [12].

Using the Acu-Answer Ultra-Soft Lancing Device (One-Touch®, USA), the subjects were instructed to warm their hands prior to the finger prick in order to increase blood flow; the fingers were not squeezed to extract blood from the fingertips because this could dilute the blood with plasma; an automatic analyser (Acu-Answer Glucometer) was used to measure the blood glucose using a 0.6μL blood sample; and the blood glucose meters were calibrated every day using manufacturer-provided control solutions.

Calculation of Glycemic Index and Glycemic Loads

Geometric calculations were used to determine the incremental area under the blood glucose response curve (iAUC), omitting the region beneath the baseline [11]. As a percentage of the mean IAUC for the standard food consumed by the same subject, the IAUC for each test meal consumed by each participant was calculated as follows:

$$GI = \frac{\text{iAUC for the test food containing 50g of available carbohydrate}}{\text{IAUC of a standard food with an equal carbohydrate portion}} \times 100$$

The GI of each tested food was taken as the mean value from the whole group of subjects [12]

The glycemic load (GL) was calculated according to the formula:

$$GL = \frac{\text{GI of test food} \times \text{amount of carbohydrate in a serving of test food (g)}}{100}$$

Sensory Evaluation [12],[23]

The method described by [18] was adopted for the sensory scoring test with the aid of a 9-point Hedonic scale. It was used to evaluate the sensory characteristics of the test samples and controls, such as taste, texture, mouthfeel, appearance, and general acceptability. Sensory attributes of the energy bars were evaluated in fresh condition at ambient temperature using a 45-member volunteer panel, which was made up of staff and students of the Federal University of Technology, Owerri. Each panelist was told to score each coded sample based on the hedonic scale with 9 = liked extremely and 1= extremely disliked. The data generated from panelists were subjected to statistical analyses.

RESULTS AND DISCUSSION

Table 1: Average glycemic response of human subjects group fed with formulated snack bars.

Time (Minutes)	SAS	SAB	SCB	SDS	SES	LSD
0	5.60^a±0.10	5.40^a±0.07	5.50^a±0.00	5.50^a±0.20	5.60^a±0.07	0.32
15	5.80^a±0.01	5.50^b±0.06	5.70^a±0.07	5.60^b±0.04	5.40^c±0.10	0.18
30	5.80^a±0.09	5.60^b±0.07	5.60^b±0.03	5.00^a±0.01	5.80^a±0.06	0.16
45	5.60^c±0.00	5.80^c±0.03	6.00^b±0.07	7.00^a±0.14	5.80^c±0.09	0.21
60	5.70^b±0.04	5.70^b±0.04	5.80^a±0.04	6.70^a±0.14	5.80^b±0.01	0.19
90	5.80^b±0.01	5.80^b±0.06	5.800^b±0.07	6.20^a±0.09	5.70^b±0.06	0.16
120	5.70^a±0.04	5.70^a±0.07	5.800^a±0.04	5.80^a±0.09	5.70^a±0.00	0.15

Values were means ± SD of triplicate determination. Means not having the same values along therows are significantly different ($p<0.05$)

Key:

A: SAS -0% acha, 0% breadfruit, 0% cocoa (Control)
B: SAB -80% acha ,15% bread fruit,5 % cocoa.
C: SCS: 75% acha,20% bread fruit,5% cocoa
D: SDS: 70% acha, 25% breadfruit,5 % cocoa.
C: SES: 65% acha, 30% breadfruit, 5% cocoa.

Table 2: Glycemic index and Glycemic loads of the snack bars

Samples	Glycemic Index	Glycemic Load	Classification
SAS	100.00^{a}+0.27	50.00^{a}+0.08	High
SAB	48.70^{e}+0.12	24.35^{e}+0.10	Low
SCS	56.70^{d}+0.07	27.80^{d}+0.03	Low
SDS	64.10^{c}+0.04	32.05^{c}+0.11	Moderate
SES	68.70^{b}+0.00	34.35^{b}+0.06	Moderate
LSD	**0.23**	**0.43**	

Values were means ± SD of triplicate determination. Means not having the same values along therows are significantly different (p<0.05)

Key: Glycemic index (G.I.) classification
70 or more –High
56 -69 -Moderate
55 or less - Low
Source: (Lowe et al., 2013).

Table 3: Sensory evaluation of the snack bar samples

Samples	SAS	SAB	SCS	SDS	SES LSD
Taste	7.60^{ab}	7.05^{ab}	6.25^{c}	6.45^{bc}	6.95^{ab}**0.68**
Texture	7.30^{a}	6.70^{ab}	6.65^{ab}	6.20^{b}	6.30^{b} **0.89**
Mouthfeel	6.95^{a}	7·00^{a}	6.35^{b}	6.25^{c}	6.40^{b}**0.46**
Appearance	7.60^{a}	7.30^{a}	6.60^{b}	6.25b	6.00^{b}**0.49**
General Acceptability	8.25^{a}	7.75^{a}	6.85^{b}	6.70^{b}	6.60^{b}**0.83**

Values were means ± SD of triplicate determinations. Means not having the same superscript along the rows is significantly different (p<0.05).

Table 1 shows the average glycemic responses of the student group fed with formulated snack bars. The fasting blood glucose levels of the groups of students fed the snack bars SAS, SAB, SCS, SDS and SES were 5.6, 5.4, 5.5, 5.5, and 5.6 mg/dl, respectively. The glycemic responses of the group on the respective snack bars at 0 min was decreasing for samples SAB, SCS and SDS. With the reference food SAS and SES (5.6) mg/dl having the highest value, which can be attributed to the high glucose level obtained in the reference food and also high ratio of breadfruit in the formulated sample upon intake by the cell after consumption. A sudden rise was observed from the transient point of 15 minutes to 30 minutes on the respective snack bar samples and reaching the peak at 45 minutes for sample SCS and SDS at (6.00) and (7.00), respectively, with an observable further increase in glycemic response at 60 minutes. The glycemic responses in the test group at any of the time intervals were found to different significantly (p>0.05). This agrees with the report of [14] [32]. The test group fed with the snack bar sample SDS had the lowest glycemic responses at the time interval (30min). On the other hand, the snack bar sample SDS had the highest glycemic responses at the time interval (45 and 60 minutes) at (7.0 and 6.7), respectively, as recorded in Table 4.1. The glycemic response in the test group could be as a result of the varying proportions of the Acha and breadfruit which are rich sources of dietary fibre invariably contributing to the glycemic response on the test group fed with the formulated diet as reported by [6]. Dietary fibre is an important bioactive component that plays a significant role in nutrition as well as in treatment and prevention of many diseases [2].

Glycemic index

Table 2 represents the glycemic index, glycemic load, and glycemic classification of the test group fed with formulated snack bar samples. The glycemic index is a number used to gauge how much a particular food may raise blood sugar levels [20]. As a tool, it is often used to promote better blood sugar management. It can be inferred from Table 2 that the glycemic index of the diet ranged from 48.70 to 68.70 in samples SAB and SES, respectively. The low glycemic index recorded in the samples may be as a result of the different ratios of Acha and African breadfruit, which are excellent sources of fibre used in the formulation of the snack bar. Moreover, Acha, which is a major component of the formulated snack bar under study, has been discovered to have a low glycemic index of 66, which is moderate.

Sensory analysis

Taste

The panelists scored the control sample (SAS) highest (7.60) and the sample (SCS) the lowest (6.25). Control sample (SAS) in had scores which were significantly higher than (p<0.05) those of snack bars, with the exception of sample SAB with a score of 7.05. The taste of snack bars was found to slightly decrease with an increase in the ratios of breadfruit and also decrease in the ratio of Acha. Consequently, samples SAB and SES were the most preferred snack bars as the panelists scored them 7.05 and 6.95, respectively. Both sample tastes were significantly higher (p<0.05) than the tastes of the other snack bar samples (SCS and SDS)

Texture

All the formulated snack bars were rated equally in terms of texture as there was no significant difference (p>0.05) between the scores, which ranged from 6.20-6.70. The score of 7.30 for SAS (commercial energy bar sample) was significantly rated higher (P<0.05) than those of the snack bars. The texture of the snack bars may have been affected by their relative hardness, which was contributed to by crude fibres. This observation is in line with the report of [9] on effect of high dietary fibre on the texture of snack bars. Also, in support of the above findings, [15], reported that higher water activity also had an influence on the texture of snack bars, which was evident on the snack bars that affected the panelists' ratings of the samples for texture.

Mouthfeel

In terms of mouthfeel, sample SAB was rated to be the most preferred among the formulated snack bar (7.00). However, there was no significant difference (p>0.05) between the mouthfeel of sample SAB and those of the other snack bars. All the other samples, including the control sample were not significantly different (p>0.05) in terms of mouthfeel. This implies that time duration to masticate the snack bars before the 'ready-to-swallow' state, when a constant rate force is applied, were similar to the control sample (SAS).

Appearance

There was no discernible (p>0.05) difference between the snack bars in terms of appearance. In contrast to the commercial control sample (SAS), which received the highest score of 7.60, they were substantially different (p 0.05) from each other. The sensory scores for appearance were suggestive that varying the ratios of the components for the snack bar did not affect their appearance. However, the preference for the appearance of the control energy bar sample may be linked to the different types of raw materials with different characteristics, which were used in the production of the commercial energy bar (control sample, SAS) and the production technology.

Overall acceptance

For overall acceptance, sample SAS (control) was rated to be most preferred (8.25), its overall acceptance was significantly (p<0.05) higher than that of the snack bars. The overall acceptance of sample SES was lowest (6.60) and that of sample SAB was highest (7.75) among the snack bar samples. However, the overall acceptances of samples SCS, SDS and SES nutrient-dense snack bar samples were similar in their values and were not significantly different (p>0.05) from each other. The panelists overall preference for sample SAS is in line with its high scores for taste (8.25), texture (7.30) mouthfeel (6.95) and appearance (7.60) compared to the scores recorded for the snack bars produced which ranged from 6.25-7.05,6.20-6.70,6.25-7.00 and 6.00-7.30 respectively for taste, texture, mouthfeel and appearance. This finding is also in line with the reports of [25], [22], [24], [37], [7] where they suggested that different types of raw materials with different characteristics which were used in the production of the commercial snack bar (control sample, SAS) and the production technology, had influence on the sensory characteristics of snack bars.

CONCLUSION AND RECOMMENDATION

Snack bars were made using a combination of Digitaria xillis, Artocarpusaltilis, and Theobroma cacao. In comparison to the control sample, which had a higher index of 100, the samples' glycaemic index revealed that they are fairly low, lying between 48.70 and 68.70. The samples' low glycaemic index indicates that the formulation's varying proportions of acha and African breadfruit might have influenced the outcome. Although the control sample had higher overall acceptance values, the snack bar's sensory qualities showed that the SAB product was well-liked. However, additional study is required to optimise snack bar composition, including ingredient selection, ratio, and employing various strategies to commercialise snack bars.

Concurrent Interest: The authors have declared that they have no competing interests, and the article has not been published in any other journal and no external funding source.

Funding Sources: No funding sources for this research work.

Contributions of theAuthors: All the authors worked together to complete this research work.

REFERENCES

1. Akajiaku, L. O., Eze, J. I., and Oti, E. (2024). *Toasted African breadfruit production techniques*. Journal of Food Processing and Preservation, 48(2), 234–240.

2. Anderson, J. W., Baird, P., Davis, R. H., Ferreri, S., Knudtson, M., Koraym, A. and Williams, C. L. (2009). Health benefits of dietary fiber. *Nutrition Reviews*, 67(4), 188–205.

3. Anitha, R., Rajeswari, P., and Senthil, M. (2000). Effect of fruit and vegetable fortification on snack products. *Journal of Food Science and Nutrition*, 23(2), 134–138.

4. Ayad, A., Elkhatib, R. M. and Mohamed, H. H. (2020). Functional snack bars: Formulation and health impact. *International Journal of Food Sciences*, 14(3), 112–119.

5. Ballougou, S., Dansi, A., Loko, Y. L., Ahissou, H. and Vodouhè, R. (2015). Improving Acha flour production using traditional and modern technologies. *African Journal of Food Science*, 9(10), 500–508.

6. Burke, L. M., Collier, G. R. and Hargreaves, M. (1998). Glycemic index–a new tool in sport nutrition? *International Journal of Sports Nutrition*, 8(4), 401–415.

7. Canalis, M. S., Fornari, T. and Arroyo, P. (2017). Sensory evaluation of functional snacks. *Food Quality and Preference*, 22(4), 366–371.

8. Constantin, O. E. and Istrati, D. (2018). Overview of cereal bars as functional foods. *Romanian Biotechnological Letters*, 23(1), 13257–13264.

9. Dutcosky, S. D., Grossmann, M. V. E., Silva, R. S. S. F. and Welsch, A. K. (2006). Combined sensory optimization of a prebiotic cereal product using multivariate analysis. *Food Chemistry*, 98(4), 630–638.

10. Eboagu, O. F., Anyanwu, I. A. and Njoku, N. E. (2020). Acha flour milling and characterization. *Nigerian Journal of Food Science and Technology*, 38(3), 19–24.

11. FAO/WHO. (1998). *Carbohydrates in human nutrition: Report of a joint FAO/WHO expert consultation*. Food and Agriculture Organization.

12. Flint, A., Møller, B. K., Raben, A., Pedersen, D., Tetens, I., and Holst, J. J. (2004). The use of glycemic index and glycemic load in predicting glycemic response. *American Journal of Clinical Nutrition*, 79(3), 538–546.

13. Foster-Powell, K., Holt, S. H., and Brand-Miller, J. C. (2002). International table of glycemic index and glycemic load values. *American Journal of Clinical Nutrition*, 76(1), 5–56.

14. Hertzler, S. R. (2000). Glycemic response of snack bars in human subjects. *Journal of the American Dietetic Association*, 100(9), 1102–1107.

15. Hofsetz, K., and Lopes, M. M. (2005). Influence of water activity on the texture of cereal snack bars. *Food Research International*, 38(5), 501–506.

16. Hogan, S., Zhang, L., Li, J., Sun, S., Canning, C., and Zhou, K. (2012). Antioxidant properties and bioactive compounds of cocoa powder-enriched bars. *Journal of Functional Foods*, 4(4), 901–909.

17. IMBMI. (2013). *Snack bar consumption trends in North America*. International Markets Bureau Market Indicator Series.

18. Iwe, M. O. (2010). Handbook of Sensory Methods and Analysis (2nd ed.). Rejoint Communications.

19. Izzo, A. A. (2001). Trends in functional food consumption. Trends in Food Science & Technology, 12(4–5), 187–193.

20. Jenkins, D. J., Kendall, C. W., Augustin, L. S., Franceschi, S., Hamidi, M., Marchie, A. and Axelsen, M. (2001). Glycemic index: Overview of implications in health and disease. American Journal of Clinical Nutrition, 76(1), 266S–273S.

21. Kabuo, N. O., Onwuka, G. I., and Nwachukwu, I. D. (2017). Nutrient composition of energy bars from local ingredients. Nigerian Food Journal, 35(1), 65–71.

22. Karklioa, S., Cucu, T., and Verhe, R. (2012). Effects of formulation and storage on sensory properties of snack bars. Journal of Food Composition and Analysis, 26(4), 182–188.

23. Kris, K. L., Rosen, K. A., and Ludwig, D. S. (2010). GI and GL measurements: Reproducibility and implications. Journal of Nutrition, 140(5), 885–890.

24. Krystyjan, M., Gumul, D., Ziobro, R., and Sikora, M. (2015). Starch-based bars enriched with fruits and nuts: Sensory and nutritional characteristics. International Journal of Food Properties, 18(1), 133–141.

25. Lourencetti, N. M., Faria, E. V. and Silva, R. (2013). Technological attributes of cereal bars. Brazilian Journal of Food Technology, 16(4), 285–292.

26. Lowe, G., Morgan, H., and Wells, C. (2013). Glycemic classification and energy analysis of food products. European Journal of Clinical Nutrition, 67(2), 117–124.

27. Nadeem, M., Anjum, F. M., and Khan, M. I. (2012). Nutritional profile and storage stability of protein-enriched snack bars. Pakistan Journal of Nutrition, 11(4), 318–322.

28. Naves, A., Silva, P. and Costa, S. (2010). Utilization of fruit by-products in energy bar formulations. Food and Bioproducts Processing, 88(1), 37–42.

29. Olawuni, I.A., Uzoukwu, A.E., Ibeabuchi, J.C., Ofoedum, A.F., Nwakaudu, A.A., Alagbaoso, S.O., Anaeke, E.J. and Ugwoezuonu, J.N. (2023). Proximate, Functional and Sensory Analysis of Quinoa and Wheat Flour Composite Cake. Asian Journal of Dairy and Food Research. DOI: 10.18805/ajdfr.DRF-340

30. Olawuni, I.A., Ofoedum, A.F., Uzoukwu, A.E., Alagbaoso, S.O., Iroagab, L.N., Anaeke, E.J. Ndukua, O.E. and Uyanwa, N.C. (2024). Proximate, Physical and Sensory Properties of Quinoa and Wheat Flour Composite bread. www.twistjournal.ne https://10.d0 i.org/10.5281/zenodo.10049652 //83

31. Ofoedu CE, Iwouno JO, Ofoedu EO, Ogueke CC, Igwe VS, Agunwah IM, Ofoedum AF, Chacha JS, Muobike OP, Agunbiade AO, Njoku NE, Nwakaudu AA, Odimegwu NE, Ndukauba OE, Ogbonna CU, Naibaho J, Korus M, Okpala COR. 2021. Revisitingfood-sourced vitamins for consumer diet and health needs: a perspective review, from vitamin classification, metabolic functions, absorption, utilization, to balancing nutritional requirements. PeerJ 9:e11940 DOI 10.7717/peerj.11940.

32. Odimegwu, E.N., Ofoedum, A.F., Olawuni, I.A., Uzoukwu, A.E., Akajiaku, L.O., Eluchie, C.N., Alagbaoso, S.O., Uyanwa, N.C. andOkezie, F.P. (2024). Nutrients and Sensory Qualities of MoiMoi Developed from Flours of Broad Bean (Viciafaba) Seeds Grown in South Eastern Nigeria as Affected by Different Processing Treatments. Asian Journal of Dairy and Food Research. 1-11. doi: 10.18805/ajdfr.DRF-434.

33. Olawuni, I.A. Alagbaoso, S.O, Ofoedum, A.F and Uzoukwu, A.E (2019). "Incorporation of Peanut Butter as Substitute for Shortening in Biscuit Production.." IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) 13.10(2019): 62-69. DOI: 10.9790/2402-1310016269 www.iosrjournals.org

34. Alagbaoso, S.O., Olawuni, I.A., Ibeabuchi, J.C., Ofoedum, A.F. and Onyeneke, E.N. (2019). "Functional And Sensory Properties Of Biscuit Produced From Peanut Butter Substituted With Shortening.." IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 13, Issue 10 Ser. II (October. 2019), PP 34-43 www.iosrjournals.org

35. Rawat, D. and Darappa, I. (2015). Nutraceutical potential of cereal-based snack bars. Journal of Food Science and Technology, 52(5), 2761–2769.

36. Rawat, D., Saxena, J. and Yadav, D. (2015). Consumer perception of nutritional bars. Indian Journal of Nutrition and Dietetics, 52(3), 209–218.

37. Sharoba, A. M., El-Desouky, A. I., Mahmoud, M. H. and Youssef, K. M. (2014). Nutritional evaluation of energy bars. Annals of Agricultural Sciences, 59(1), 27–35.

38. Silva, M. R., Costa, A. I. and Albuquerque, T. G. (2014). Snack bar development using functional ingredients. Food Science and Human Wellness, 3(4), 208–214.Sun-Waterson, A., Feng, J. and Kwok, S. (2010). Inclusion of fruit fibers in energy bar formulation. Journal of Food Processing and Preservation, 34(5), 911–920.

39. Yadav, R. B. (2020). A review on functional and energy bars. International Journal of Current Microbiology and Applied Sciences, 9(10), 3487–3501.