

Volume 1, Issue 1

Research Article

Date of Submission: 02 Apr, 2026

Date of Acceptance: 30 Apr, 2026

Date of Publication: 25 May, 2026

Development, Physicochemical and Sensory Characterization of Cereal Bars with Added Local Fruits *Vangueria Infausta* and *Strychnos Spinosa*

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Citation: Domingos, D. A., Chequele, C. C. S., Machalela, A. A., Mutie, E. C., José, A. E., et al. (2026). Development, Physicochemical and Sensory Characterization of Cereal Bars with Added Local Fruits *Vangueria Infausta* and *Strychnos Spinosa*. *J Glob Trad Med Indig Heal Syst* 1(1). 01-13.

Abstract

In Mozambique, a wide variety of edible wild plants with high nutritional and medicinal value are widely available. *Vangueria Infausta* (Maphilua) and *Strychnos Spinosa* (Massala) are sold in informal markets during the harvest season and are consumed in various forms, such as in cereal bars. Cereal bars are food products made by compressing cereal flakes such as corn, rice, or oats, with the addition of honey, sugar, water, and fruit. This study aimed to produce and evaluate the physicochemical, microbiological, and sensory properties of cereal bars with the addition of *Vangueria Infausta* and *Strychnos Spinosa* pulp. 3 formulations were developed: F1: 12% *Vangueria Infausta*, 5.99% *Strychnos Spinosa*; F2: 12.61% *Strychnos Spinosa*, 5.38% *Vangueria Infausta*; and F3: 4.06% *Strychnos Spinosa* and 13.93% *Vangueria Infausta*. The following physicochemical parameters were determined: moisture content by the 105°C drying method, protein by the Kjeldahl method, ash by incineration at 550°C, pH by the potentiometric method, Brix by refraction, fat content by the Bligh and Dyer method, Vitamin A by the chromatographic method, carbohydrate content by the difference method, and caloric value by summing the macronutrients. Sensory analysis was conducted using an affective test with a panel of 50 untrained tasters, who assigned scores for attributes such as: appearance, color, flavor, texture, aroma, and aftertaste. Molds and yeasts were determined using the dilution plating technique (plate count), and microbiological stability was assessed based on initial mold and yeast levels, which were monitored over 30 days of storage. Data were analyzed using the Minitab statistical software package, Version 18.1, at a 5% significance level using Tukey's test. The physicochemical parameters showed moisture (12.2–12.55%), ash (1.56–1.96%), protein (11.0–14.4%), fat (4.24–5.48%), vitamin A (35.6–46.86%), carbohydrates (66.0 to 71.13%), and a caloric value (366.12 to 371.01 kcal). For the microbiological parameters, levels of 0.01 to 0.021 log CFU/100 g were observed. Sensory evaluation showed that the product was accepted, with formulation F2 standing out most, achieving a 78.56% acceptability index. This study concluded that the addition of wild fruits is technically feasible for diversifying their

consumption in cereal bars. Overall, it was found that the second formulation, containing 5.38% *Vangueria Infausta* and 12.59% *Strychnos Spinosa*, yielded better results than the other two in terms of physicochemical quality when used in the production of cereal bars. There is a need to improve the quality management of the bars produced, since the microbiological analysis showed low levels, indicating safety and hygienic sanitary quality.

Keywords: *Strychnos Spinosa*, *Vangueria Infausta*, Wild Berry-Based Cereal Bars

Introduction

The consumption of cereal bars is growing due to their convenience, ease of transport and consumption, and their functional properties [1]. Modern consumers are increasingly aware of the perceived health benefits of food, opting for a more nutritious and balanced diet [2]. These foods offer convenience, nutritional quality, and functional benefits, helping to improve consumer health, particularly in countries like Mozambique that face the challenge of food insecurity [3]. The fight against food insecurity is being addressed through the adoption of food technologies such as the development of fortified bars or those enriched with wild fruits locally available in the country, which can help reduce malnutrition and food insecurity [4].

According to the wild fruits in Mozambique play an important role in reducing food insecurity because they can be used to develop various beverages, baked goods, preserves, and dehydrated flours that can help address the challenge of access to and availability of nutritious foods [5].

Thus, cereal bars may constitute a technological alternative for boosting the production of foods enriched with wild fruits, given that these are rich in various vitamins, phenolic and therapeutic compounds, minerals, proteins, carbohydrates, lipids (mainly in seeds), and calories [6]. The main objective of this research is to develop cereal bars fortified with the local fruits *Vangueria infausta* and *Strychnos spinosa*, evaluating their quality in terms of physicochemical, sensory, and microbiological parameters.

Materials and Methods

The district of Chókwè is located in the province of Gaza, Mozambique. Its area is estimated at approximately 1,864 km², with 222,396 inhabitants according to the 2017 census. It is situated in the south of Gaza Province, along the middle course of the Limpopo River, bordered to the north by the Limpopo River, to the south by the districts of Bilene and Xai-Xai, to the east by the district of Chibuto, and to the west by the districts of Magude and Massingir [7].

Methods

Raw Material Acquisition

2 kg of *Vangueria Infausta* and *Strychnos Spinosa* were purchased at informal buildings in the districts of Bilene and Macia, and their quality, color, characteristics, absence of cracks or cuts, and freshness were assessed using sensory evaluation—through sight, smell, and touch. As for the oat flakes (1 kg), granola flakes (1 kg), and honey (500 mL), these were purchased at the Shoprite supermarket in Macia, and their expiration dates and packaging conditions were verified. These ingredients were then transported to the food processing laboratory at ISPG (Gaza Higher Polytechnic Institute) in high-density polyethylene packaging for the purpose of processing the bars.

Sanitization

Sanitization was performed by immersing the raw materials in a chlorinated water solution containing 10 ppm of active chlorine for 10 minutes.

Peeling and Pulping

Peeling was performed manually using stainless steel knives, removing the *Vangueria Infausta* skin and any defects affecting the pulp. For the *Strychnos Spinosa*, using the same tools, cuts were made on the Massala skin to expose the fruit pulp.

Formulations

Using a BIOBASE analytical balance with a precision of 0.001 g, the cereal bar formulations were prepared based on 200 g of the product, as shown in Table 1 below:

Ingredients (%)	Formulation		
	F1	F2	F3
<i>Strychnos Spinosa</i>	5.99%	12.61%	4.06%
<i>Vangueria Infausta</i>	12%	5.38%	13.93%
Honey	22.03%	22.03%	22.03%
Oat flakes	20.59%	20.59%	20.59%
Granola	39.39%	39.39%	39.39%

Table 1. Cereal Bar Formulations.

Syrup Preparation

Honey and the pulps of *Vangueria infausta* and *Strychnos spinosa* were added to a metal pan and heated on an electric stove at temperatures ranging from 90 to 100°C for 5 to 9 minutes. The mixture was then stirred with a wooden spatula for the duration described, resulting in a syrup.

Mixing

The syrup and dry ingredients (oat flakes and granola) were mixed gradually (1/4, 2/4, 3/4, and 4/4). The dehydrated flakes were added to the still-hot syrup, and a spatula was used to combine them.

Molding

While still hot, the mixture was placed into rectangular metal molds measuring 5 cm wide by 10 cm long. This process took approximately 15 minutes, during which 200 g of the mixture was weighed using an analytical balance and spread onto the metal mold with a spatula until it achieved a rectangular shape and a firm texture.

Cooling

The molds were cooled in a SAMSUNG cooler at a temperature of 5 to 9°C for 15 minutes. This process had a significant impact on the crystallization of the sugars, helping to improve the hard texture of the bars at room temperature.

Packaging

The cereal bars were wrapped in aluminum foil and stored in previously sterilized glass containers under laboratory conditions.

Physical-chemical analyses

Following the standards recommended by the Adolfo Lutz Institute (2008), the soluble solids content (°Brix), moisture, pH, ash content, protein, fat, vitamin A, carbohydrates, and caloric value were determined.

Moisture

Approximately 5g of the cereal bar was weighed into a previously dried and tared Petri dish, then placed in a vacuum oven at 105°C for two hours. Afterward, it was transferred to a metal tray, allowed to cool for 30 minutes, and weighed again. The moisture content was determined using the formula:

$$\% \text{ Moisture} = (\text{end plate} - \text{start plate}) / \text{sample weight} * 100 \quad [1]$$

Determination of ash by incineration

A 5g sample and an empty porcelain crucible were weighed, and their weights were recorded. The sample was then placed in the crucible and incinerated using a Bunsen burner. After the sample had been reduced to a charcoal mass, the contents were transferred to a muffle furnace at 550°C for 6 hours to burn off the organic matter and obtain the ash. Next, the temperature was reduced to 150°C for a period of 1 hour, and the sample was subsequently allowed to cool completely in a desiccator for approximately 25 minutes. The following formula was used to determine ash content:

$$\% \text{ Ash} = (M2 - M) / (M1 - M) * 100 \quad [2]$$

Where:

- M – Weight of the crucible;
- M1 – Weight of the crucible with the sample;
- M2 – Weight of the crucible with ash.

Soluble Solids Content in °Brix

For this purpose, a manual digital refractometer with a scale ranging from 0 to 32 °Brix was used. A 5g sample was diluted in 45 ml of distilled water and stirred manually for 10 minutes until completely homogenized. The sample reading was taken directly from the refractometer's display.

Ph Determination

For this step, the potentiometric method was used. Initially, an extract was prepared by weighing 10 g of sample into 90 ml of distilled water. Next, the cereal bars were ground using a pestle and mortar until the extract was obtained, and the extract was placed in an Erlenmeyer flask. Afterward, the HANNA digital pH meter was turned on and calibrated with buffer solutions of 4.0, 7.0, and 10.0. The reading was taken, and the electrode was inserted into the prepared sample, with the reading displayed on the panel.

Protein Determination

Protein was determined using the Kjeldahl method ($PB = N \times 6.25$), comprising three stages. Stage 1: digestion or

mineralization: during which organic matter is oxidized and nitrogen is converted into ammonium sulfate (NH_4SO_4). 0.2 grams of the sample were weighed on an analytical balance and transferred to digestion tubes, to which a dose of catalytic mixture ($\text{K}_2\text{SO}_4 + \text{CuSO}_4$), 2 mL of concentrated sulfuric acid, and phenolphthalein to proceed with digestion in a digestion block at 375°C until the liquid became clear. After removal from the digestion block, the material was cooled and diluted to 20 mL with distilled water. Phase 2: Distillation: The tube from the digestion block was placed in the distillation apparatus, and 10 mL of 40% sodium hydroxide (NaOH) was added, which reacted with the ammonium sulfate and, under the action of heat, released ammonia. With the tip of the distiller immersed in a 50 mL Erlenmeyer flask containing boric acid solution, ammonium borate (NH_4) was formed, B_3O_3 . 3rd phase: titration: the sample was placed in the distillate for titration with 0.051813471 N sulfuric acid solution, where the ammonium borate formed was proportional to the amount of nitrogen in the sample. The titration ended with the appearance of a violet- e color, indicating the endpoint.

Fat Determination

The fat content was determined using the, in which 2 g of sample was weighed and added to a 70-mL test tube containing 8 mL of chloroform (CHCl_3), 16 mL of methanol (CH_3OH), and 6.4 mL of distilled water, in a 1:2:0.8 ratio, where the three solvents coexist in a homogeneous solution, and the tubes were placed in a rotary shaker for 30 minutes. Next, an additional 8 mL of chloroform and 8 mL of 1.5% sodium sulfate solution were added, and the mixture was agitated for another two minutes. Upon changing the ratio of chloroform, methanol, and water, separation occurred at 1000 rpm for 2 minutes. Thus, all the LIP from the sample was dissolved in 20 mL of chloroform, from which 13 to 15 mL of this layer was withdrawn and transferred to a 30mL test tube containing 0.8 g of sodium amide sulfate, under agitation. This mixture was filtered through filter paper in a small funnel; 5 mL of the clear filtrate was collected, poured into a pre-weighed beaker, and placed in an oven at 105°C until the solvent evaporated. Afterward, the lipid material was cooled, dried, and weighed.

Determination of Vitamin A

Vitamin A extraction was performed on 5.0 g of samples, which were placed in a boiling tube containing 1.69 g of sodium ascorbate. We added 75 mL of ethanol and 7.5 mL of a 50% aqueous potassium hydroxide solution. The mixture was homogenized in a water bath at a temperature between 65 and 85°C for 19 minutes. Next, 75 mL of purified water was added. The extraction was performed in a 250-mL amber-colored separating funnel five times, using 30-mL volumes of hexane. The extract was transferred to another 250mL separating funnel, where it was washed twice with 100 mL of distilled water. The organic phase was dried and filtered through filter paper containing anhydrous sodium sulfate, then transferred to a 250 mL volumetric flask, washing the anhydrous sodium sulfate with the same solution to remove any residues, and making up the volume of the flask with approximately 100 mL of hexane. Subsequently, a 10 mL aliquot was evaporated in a rotary evaporator at a temperature of 45°C for 3 minutes. Finally, it was homogenized and subjected to liquid chromatography.

Determination of carbohydrates

The carbohydrate content was calculated as the difference between 100 and the sum of the percentages (%) of moisture, protein, fat, and ash, as adapted by. To calculate total carbohydrates, the following Equation 1 was applied:

$$\text{alculation of } = (\% \text{ moisture} + \% \text{ protein} + \% \text{ lipid} + \% \text{ ash}) \quad [3]$$

Calculation of caloric value

The caloric value was calculated using the known percentages of protein, carbohydrates, and lipids. Each value was multiplied by its respective caloric value per gram, and the results were then summed according to Equation 2 shown below:

$$\text{Kcal} = (\text{Lipid} * 9 + \text{carbohydrate} * 4 + \text{protein} * 4) \quad [4]$$

Sensory analysis

The sensory evaluation of cereal bars followed the methodology described by in which a panel of 50 untrained tasters was assembled, comprising faculty, students, and staff from the Higher Polytechnic Institute of Gaza of both genders and ages ranging from 18 to 45 years. These participants provided their assessments of the sensory attributes of appearance, aroma, flavor, aftertaste, texture, color, and overall evaluation, using a 9-point rating scale ranging from 1 – Disliked extremely to 9 – Liked extremely. The acceptability index was determined by the average score obtained from the sample relative to the maximum score assigned to the cereal bar formulation with added maphilua and massala by the sensory panel, using the equation below.

$$I(\%) = A * 100 / B \quad [5]$$

Where:

AI Acceptability Index;

B: Represents the maximum score assigned;

Purchase Intention

Purchase intention was assessed according to the methodology described by the where it was obtained by dividing the total number of purchase preferences from a given sample by the total number of panel tasters in the analysis, and the results were calculated using the equation below.

$$IC \% = \frac{(A*100)}{B} \quad [6]$$

Where:

IC – Purchase intention;

B – Total preference regarding the samples;

A – Total number of tasters;

Microbiological Analysis

The microbiological quality of the cereal bars was analyzed by determining the presence of molds and yeasts.

Determination Of Molds and Yeasts

5 g of the sample was weighed, and an initial suspension was prepared, followed by two decimal dilutions as needed. 0.1 mL of the sample was spread over the surface of the agar in the pre-labeled Petri dishes. The inoculum was spread using a Drigalski loop. The Petri dishes were then incubated without inversion at 25±1°C for 48 hours. Finally, an I count of colonies present on the plates containing up to 150 colonies was performed. Molds and yeasts were counted separately. The results were expressed in CFU/g.

Statistical Analysis

This study was based on a completely randomized design (CRD) with (3) formulation and (3) replicates, totaling 9 experimental units. The data were analyzed using the R Studio statistical package, version 4.3.3, via the 5% ANOVA method with Tukey's test. Microsoft Excel 2013 was used to create tables and graphs illustrating the results.

Results and Discussion

These chapters present the results of the physicochemical (i), sensory (ii), and microbiological (iii) analyses of the cereal bars with added wild berries.

The following presents the results of the analysis of variance for the physicochemical parameters of the produced cereal bars.

Parâmetros	Formulations		
	F1	F2	F3
Moisture	12,2±0,72 ^a	12,55±1,03 ^a	12,46±0,50 ^a
Ash	1,56±0,25 ^a	1,96±0,25 ^a	1,7±0,25 ^a
Protein	11±0,32 ^b	14,4±0,27 ^a	12,3±0,45 ^b
Fat	4,24±0,27 ^b	5,48±0,32 ^a	4,76±0,27 ^{ab}
Vitamin A	35,6±0,70 ^b	46,86±0,48 ^a	39,86±1,30 ^b
Carbohydrates (%)	71,13±1,11 ^a	66±1,07 ^b	68,52±1,10 ^{ab}
Caloric Value (Kcal)	366,68±0,05 ^b	371,01±1,05 ^a	366,12±0,03 ^b

Table 2. Analysis of variance for the physicochemical parameters of cereal bars.

Mean ± Standard Deviation; identical letters in the same row indicate no statistically significant difference. F1 – First formulation containing 12% Vangueria Infausta and 5.99% Strychnos Spinosa; F2 – Second formulation with 5.38% Vangueria Infausta and 12.61% Strychnos Spinosa; F3 – Third formulation with 13.93% Vangueria Infausta and 4.06% Strychnos Spinosa.

Vitamin A

Regarding Vitamin A content, formulations 1 and 2 did not differ from each other ($p > 0.05$). Formulation 2 again stood out in terms of levels, with the nutritional quality of Massala once again playing an important role in maintaining the high levels observed.

According to who studied the quality of cereal bars, they found values similar to those reported in this study, with vitamin A levels ranging from 35.0% to 40.43% [2].

These similar results are supported by showing that the addition of fruit to cereal bars influences the increase in fat-soluble vitamins. However, lower results than those of this study were reported by in his study of a savory cereal bar enriched with passion fruit albedo flour, observing averages in the range of 14–19 µg/kJ for vitamin A, respectively, and these low levels may be linked to the nutritional quality of the raw materials used for production and the effect of temperature during the homogenization process.

According to in their study on the development and analysis of cereal bars with added fruit, there is an increase in vitamins, particularly vitamins C and A, which, according to serves as a strategy for adding value to cereal bars, especially in rural areas, helping to reduce symptoms of vision-related diseases (night blindness) [8,9].

Caloric value

No statistical differences ($p > 0.05$) were observed between formulations 1 and 3, with means ranging from 366.68 to 371.01 kcal; this variation was due to differences in the macronutrients of the produced formulations.

The values reported by and in their study of cereal bars with varying concentrations of dried murici and dried banana—both rich in dietary fiber—ranged from 349.61 to 358.77 kcal, which is lower than the results reported in this study; these levels are linked to the concentrations of macronutrients that influenced the final calorie calculation [10,11].

observed higher levels (386.35 kcal/100g and 415.11 kcal/100g) in cereal bars supplemented with oilseeds, pumpkin, watermelon, cantaloupe, okra, and sesame. These higher levels may be linked to the high fat content of the seeds used, which increased the fat content of the cereal bars. In contrast, when developing a cereal bar using green banana biomass (*Musa sapientum* L.), observed reduced energy levels ranging from 192.5 to 210.24 kcal/100g, due to differences in raw materials, the nutritional quality of the ingredients, and the properties of the binders used in the development of the bars. Results observed by showed low levels (328.70 to 354.53 kcal) when studying the improvement of cereal bars with the addition of seed and almond flours from local fruits, which demonstrated the influence of the flour production processes on the final quality [12]. Lower results than those of the present study (291.24 to 364.36 kcal) were reported by in a study on the quality of high-fiber cereal bars, and according to these high values observed in the study may be associated with the type of raw material used and the interaction between the thermal process, which promotes a reduction in energy content by increasing the availability of fiber in the bars[11,13].

Carbohydrates

This parameter showed statistically significant differences ($p < 0.05$) for formulations 1 and 2, with their means ranging from 66 to 71.13%. The levels of moisture, minerals, protein, and fat may have influenced carbohydrate availability.

According to similar results (68–74%) were found when they assessed the nutritional and sensory quality of cereal bars made with locally available fruits [13]. Relatively low results (60–66%) were observed by Micelle et al. (2025) in a study on the acceptability of cereal bars with added ata pulp; the type of ingredient may have influenced the availability of sugars in the final product. According to similar results (66.2–78.4%) were observed when they evaluated the nutritional composition of sugar-free cereal bars with added chestnuts, pumpkin seeds, and oat flakes [14]. when evaluating the quality of cereal bars supplemented with fiber and protein extract, obtained levels between 60 and 66%, and the addition of dehydrated kiwicha fruit, quinoa, shredded coconut, and roasted peanuts may have influenced the reduction in soluble fiber levels; this finding is supported by when they evaluated the physicochemical quality of cereal bars with added local dried fruits [15,16].

Fat

Formulation 2 showed statistically significant differences compared to formulation 1 ($p < 0.05$), with mean values ranging from 4.24% to 5.48%. The formulations developed influenced the variation in fat concentrations.

Higher values (8.45–10.1%) were reported by in their study on the nutritional quality of cereal bars supplemented with sesame seeds; these high levels are attributed to the high lipid concentration in the seed structure, unlike the pulp of massala and maphilua [17]. obtained results $>6\%$ regarding fat content for granolabased cereal bars, and these high levels were driven by the addition of omega- 3 fats to add value to the produced bar [18]. Results slightly lower than those observed in this study (0.73– 2.83%) were reported by when assessing the quality of cereal bars with added fruit, and possibly the type of raw material (*Araucaria angustifolia*) influenced these results because, according to it contains approximately 0.59% essential oil in its composition, a finding supported by regarding the low fat content when analyzing the quality of cereal bars enriched with passion fruit pulp, which may be related to the pulps of Massala and Maphilua. Lower results ($>4\%$) were observed by when developing cereal bars with baru almonds and pineapple peel, with nutritional quality (fat content) being a key factor in these findings [13,19-21].

Proteins

For protein, the means ranged from 11% to 14%, with no statistically significant differences among them ($p > 0.05$). Formulation 2 had higher protein levels due to the concentrations of Massala, and it is possible that this fruit is richer in this macronutrient.

Results consistent (11–12%) with those found in this study were reported by Esther et al. (2024) in their investigation of the nutritional, antioxidant, and sensory quality of fortified cereal bars, even though a variety of ingredients were used. Lower results (5.5–8%) were reported by when developing and characterizing the sensory aspects of cereal bars supplemented with the local fruit licuri; the lipid oxidation process may have influenced the reduction in protein content due to the formation of free radicals [22]. this phenomenon is also supported by who studied the nutritional composition, lipid profile, and sensory characteristics of cereal bars produced with local fruits, finding variations in protein concentration due to the oxidation reaction of the pulp after interaction with oxygen; according to it can be assumed that the processing techniques allowed for enzymatic inactivation, preventing this type of reaction and preserving the protein content of the cereal bar. observed protein levels between 3–16.7% in cereal bars, which are consistent with the results of this study; these levels of 16.7% found can be explained by the addition of milk to the cereal bar formulation in the authors' study. studying the quality of cereal bars supplemented with flour and peel from the *Araucaria angustifolia* fruit, obtained levels ranging from 6.66% to 8.43%, indicating that the low protein content in the composition, compared to the present study, and the addition of low concentrations of oats and flour likely influenced these low levels [13,23-25].

Ash

Regarding ash content, no statistically significant differences were observed ($p > 0.05$), ranging from 1.56% to 1.96%. The variations among the formulations may be linked to the concentration of soluble solids, which influence the mineral concentrations in the sample.

According to similar levels were observed in their study on ways to improve the composition of cereal bar formulations, with a focus on the minerals sodium, magnesium, and potassium [26]. In agreement with these results, highlighted the effect of adding fresh or dried fruits on increasing mineral content in cereal bars, and noted that the addition of fruits to cereal bars helps improve the mineral content of this product, as observed in the study and reported by who found levels close to 2%/100g, aligning with the results of the present study, which ranged from 1.56% to 1.96%[27-29]. According to Michelle et al. (2025), who developed and studied the acceptance of cereal bars with added *Atta*, levels close to those found in this study (1.23–1.86%) were obtained and results lower than those obtained in this study (1– 150%) were reported by who developed and evaluated cereal bars with added cricket flour; the origin of the flour (animal) may have influenced the low mineral levels observed[30].

Moisture

No statistically significant differences ($p > 0.05$) were observed among the formulations, with their means ranging from 12.2% to 12.55%. The variations were slight, indicating the influence of variations in binder concentration on the composition of the bars.

Relatively low values (9.30 to 9.50) were reported by when evaluating the chemical quality of gluten-free cereal bars; the moisture content of the *Vangueria infausta* and *Strychnos spinosa* pulps influenced the final composition of the cereal bars produced in the study [31]. Analyzing the nutritional quality of children’s cereal bars, observed moisture concentrations between 8% and 9%, which were below the levels observed in this study; the starch molasses (54%) used as a binder and high fiber levels may have contributed to greater water evaporation during product dehydration [32]. Low moisture content (8–10%) was also observed by in a study of cereal bars with added gluten-free puffed grains, and the influence of the low moisture content of the grains compared *Vangueria infausta* pulp, and dough on the final moisture content was evident [33]. According to low moisture levels were observed, ranging from 7.3 to 7.9%/100g, and the replacement of honey with xanthan gum/erythritol as a binder led to a reduction in moisture content because, according to this polysaccharide is generally used in powder form [34,35]. Argue that the high moisture levels observed in this study may be associated with the moisture content of the ingredients (*Vangueria infausta*, *Strychnos spinosa*, and honey), which hindered the dissociation of H₂O molecules in the produced bars due to the dehydration time. However, the values found in this study were within the limit established by CNNPA Resolution No. 12 of 2008, which stipulates that the maximum moisture content for cereal-based products should be 15% [14,36].

Microbiological analyses of wild fruit cereal bars

The table below illustrates the microbiological results of cereal bars regarding molds and yeasts.

Microbiological parameters	Formulations		
	F1	F2	F3
Molds and yeasts (log cfu/g)	$2.1 \times 10^{-2} \pm 0.01$	$1 \times 10^{-2} \pm 0.09$	$2 \times 10^{-2} \pm 0.01$

Table 3 - Microbiological parameters of *Vangueria infausta* and *Strychnos spinosa* cereal bars

Legend: Mean ± Standard Deviation. Mean ± Standard Deviation; identical letters in the same row indicate no statistically significant difference between them. F1 – First formulation containing 12% *Vangueria Infausta* and 5.99% *Strychnos Spinosa*; F2 – Second formulation with 5.38% *Vangueria Infausta* and 12.61% *Strychnos Spinosa*; F3 – Third formulation with 13.93% *Vangueria Infausta* and 4.06% *Strychnos Spinosa*.

The mold and yeast counts showed that all cereal bar samples contained mold and yeast, with values ranging from 1×10^{-2} to 2.1×10^{-2} CFU/g of product. However, no regulatory parameters regarding cereal bars were identified. In a study by Strebernich et al. (2011), a lower incidence (1×10^{-5} CFU/g) of the samples showed the presence of molds and yeasts, which was higher than the results found in this study. This is consistent with who found mold and yeast contamination at 1×10^{-1} CFU/g of cereal bar samples, which were similar to the results obtained in this study, ranging from 1×10^{-2} to 2.1×10^{-2} CFU/g of molds and yeasts. The growth of molds and yeasts was associated with the product's storage conditions, and according to levels ranging from 1×10^{-2} to 2.1×10^{-2} CFU/g indicate the need to apply preservation techniques to reduce the probability of proliferation of these pathogens. Studying the quality of cereal bars fortified with locally available fruits (passion fruit), observed consistent levels (<10 CFU/g), indicating a need to improve good manufacturing practices to prevent contamination by these organisms [37,38,8]. Similar results were observed by in a study on the production and sensory analysis of cereal bars made with passion fruit peel flour, demonstrating that adherence to good manufacturing practices is indispensable for the food production chain, ensuring the availability of safe food for communities [39].

Sensory Analysis

The graph below illustrates the results of the sensory attributes in the context of the production of cereal bars enriched with *Vangueria infausta* and *Strychnos spinosa*.

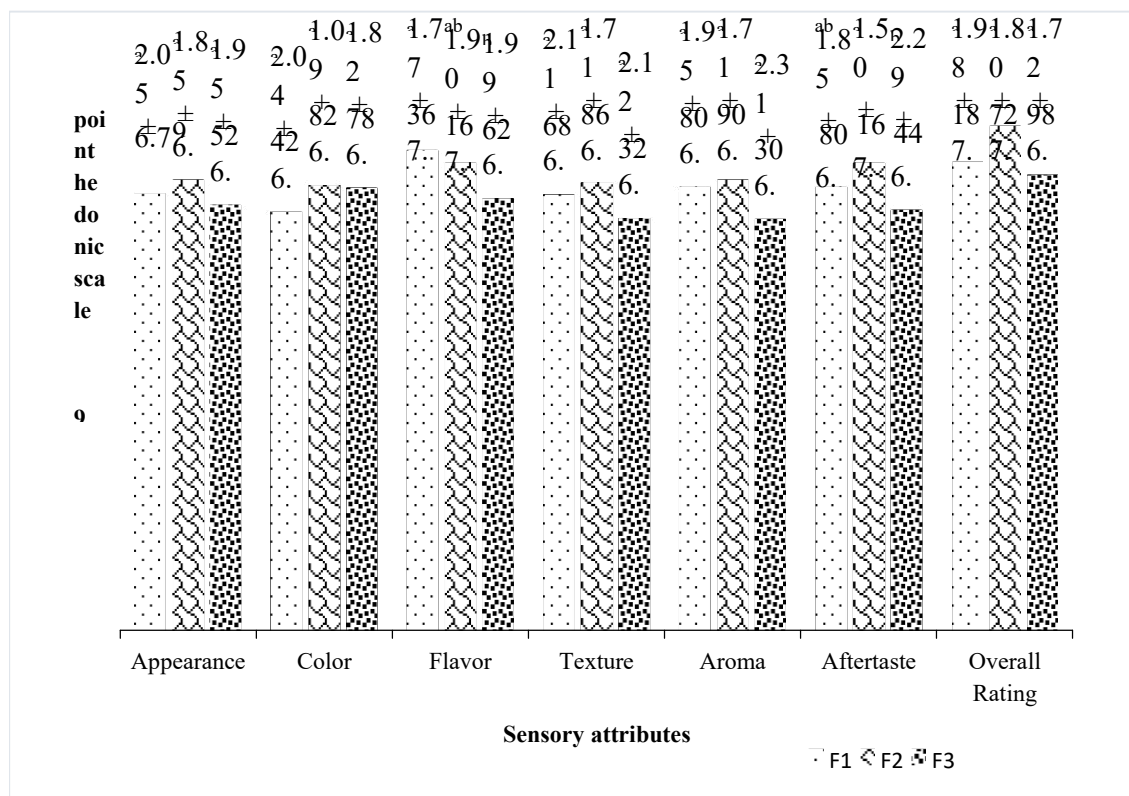


Figure: 1

Graph 1. Analysis of variance of sensory attributes. Legend: Mean ± Standard Deviation; Different letters in the same row indicate statistically significant differences at the 5% level (Tukey's test). Mean ± Standard Deviation; identical letters in the same row indicate no statistically significant difference between them. F1 – First formulation with 12% *Vangueria Infausta* and 5.99% *Strychnos Spinosa*; F2 – Second formulation with 5.38% *Vangueria Infausta* and 12.61% *Strychnos Spinosa*; F3 – Third formulation with 13.93% *Vangueria Infausta* and 4.06% *Strychnos Spinosa*.

Regarding appearance, the graph above shows that the *Vangueria Infausta* (Maphilua) and *Strychnos Spinosa* (Massala) cereal bar formulations did not exhibit statistically significant differences ($p < 0.05$). In turn, formulation F2 showed a higher acceptance rate, and F3 a lower one, with all receiving satisfactory scores in the "moderately liked" range. Since the higher acceptance may be due to the higher concentration of massala, this was the reason for its greater acceptance compared to the others; cultural factors among the tasters may have caused the lower acceptance. However, lower results than those of this study were found by in cereal bars formulated with genipap, with a score of 6.14, whereas

this study obtained an average of 6.52; higher results were obtained by who developed two formulations of cereal bars based on babassu almond flour and found an average value of 7.70, respectively; the difference in the raw material used in this study may have influenced these results[40,41]. in their study on the production of oat and dietary fiber cereal bars, obtained results similar to those of the present study; and who evaluated different cocoa contents in cocoa-enriched cereal bars and observed that the highest levels of acceptance for the appearance attribute were found in the formulation with the highest cocoa concentration [42,43].

For the color attribute, sample F3 had the highest acceptance, followed by the cereal bar with 5.38% *Vangueria Infausta* and 12.59% (F2), while those with 12% *Vangueria Infausta* (F1) were the least accepted, showing no difference among themselves but a significant difference compared to the others. in a study on the applicability of guava residue in cereal bars (with additions of 15%, 30%, and 50%), found overall color ratings between 5 and 6 (representing "neither liked nor disliked" and "slightly liked," respectively) and Muniz (2017), studying the production of cereal bars with guava residue (35% addition), found color averages of 7.05, results similar to those of this study [44].

Regarding flavor, there was no significant difference ($p < 0.05$) among the samples, although the highest score was obtained for the formulation containing 12% Massala and Maphilua. The average score for the samples was 7.36, which is higher than the 6.14 score reported by for bars formulated with genipap. There was also no significant difference in texture (6.68), indicating that the concentration of Massala and Maphilua did not alter their technological properties[40]. The texture results were similar to those found by who developed two formulations of cereal bars based on babassu almond flour and found a mean value of 7.70. Freitas and Moretti (2006) found a mean of 4.57 in the evaluation of banana-flavored cereal bars, a value lower than that of the present study, demonstrating that the bar containing Massala and Maphilua had a texture acceptable to consumers[41].

In terms of texture, the samples did not differ significantly from one another, suggesting that the percentage of *Vangueria infausta* and *Strychnos spinosa* did not influence the results, since the sample with the highest concentration received the highest score. The means obtained for F1 (6.68), F2 (6.68), and F3 (6.32) were higher than those described by for bars formulated with genipap (5.88) and lower than those found by Pinedo et al. (2013) in bars with babassu almond (8.1) [40].

Regarding aroma, however, no significant perceptible difference was observed with the addition of *Vangueria infausta* and *Strychnos spinosa*, since the samples did not show a significant difference ($p > 0.05$) among themselves. According to consumers tend to relate the product's aroma directly to the raw material used in its production. In comparison, found that banana peel cereal bars had averages of 7.01 and 7.10 for the aroma attribute—results higher than those found in the present study [45,46].

Regarding aftertaste, values ranging from 7.16 to 6.43 were obtained for this cereal bar formulated with *Vangueria infausta* and *Strychnos spinosa*, which were lower than those found by who reported 7.8 across all formulations for the cereal bar made with soursop residues. on the other hand, obtained higher values for his cereal bar, with an average of 7.4 to 7.6 for texture [47,48]. Regarding the study by values ranging from 5 to 7 were achieved for flavor in the cereal bar made from ora-pro-nóbis flour and pineapple agro-industrial residue [49].

The results for overall evaluation and purchase intention assessed by the tasters range from 7.72 to 6.69, differing statistically. For the overall evaluation attribute obtained scores of 6 to 7 for the cereal bar made from ora-pro-nóbis flour and pineapple agro-industrial waste, and found overall evaluation scores ranging from 6.44 to 7.84 for the use of banana peels in the preparation of mariolastyle jam; these values are close to those found in the sensory evaluation of the cereal bar in this study, which ranged from 6.13 to 6.36 [49,50].

Acceptability Index

The acceptability index for the four cereal bar formulations analyzed is presented in the graph below. When developing a new product, one of the key points is to assess its acceptability in order to predict its performance in the consumer market [51].

Based on the acceptability scores and the IA calculation, it can be seen that all formulations showed good acceptability, as the evaluated formulations had an IA greater than 70% for all assessed attributes, with F2 having an index of 78.56%, followed by F1 and F3, respectively. The cereal bars with added *Vangueria infausta* and *Strychnos spinosa* have great market potential, as they achieved satisfactory results in terms of sensory acceptance and purchase intention; similar results were found by in their study on the sensory acceptance of iron-fortified cereal bars, where 77.7% had an acceptability index greater than 80%, indicating excellent acceptance of the cereal bars [52]. This is also consistent with in his study on cereal bar development, which showed acceptability scores equal to or higher than the minimum required for two attributes: appearance (70%) and flavor (72%) [53]. It can be concluded that, for these attributes—considered important factors for consumers when choosing a product.

Results below these were found by in his study on the development and acceptability of recipes with quinoa; formulation 1 did not present an acceptability index higher than the minimum required for acceptance [54].

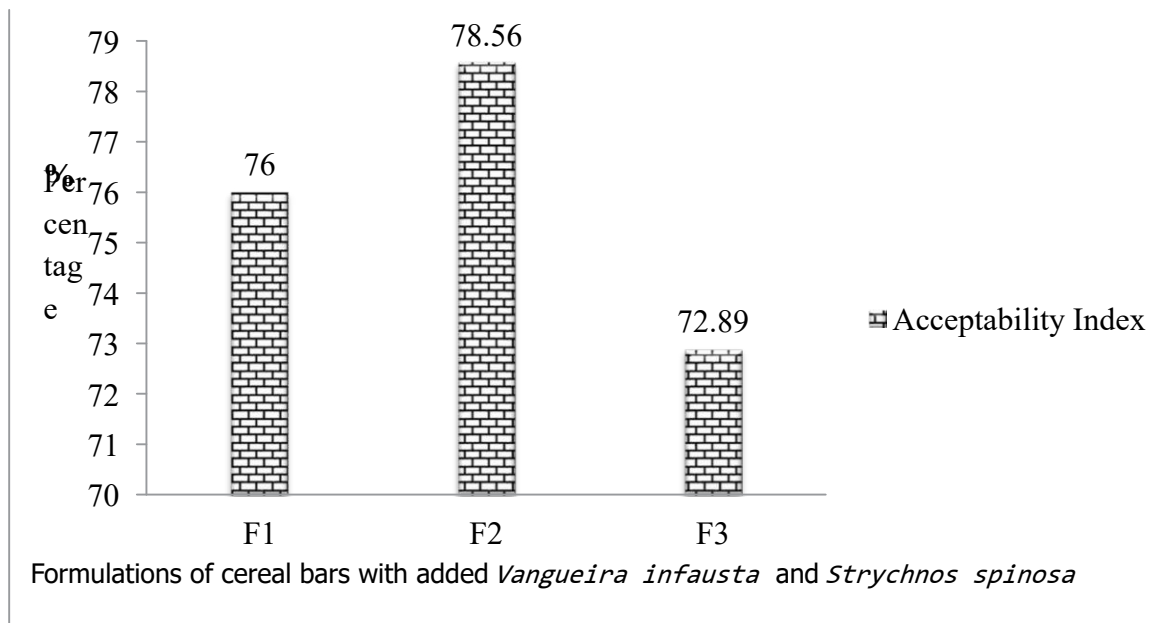


Figure: 2

(*Vangueria infausta* and *Strychnos spinosa*). Legend: Mean \pm Standard deviation; identical letters on the same line indicate no statistically significant difference between them. F1 – First formulation with 12% *Vangueria Infausta* and 5.99% *Strychnos Spinosa* F2 – Second formulation with 5.38% *Vangueria Infausta* and 12.61% *Strychnos Spinosa* F3 – Third formulation containing 13.93% *Vangueria Infausta* and 4.06% *Strychnos Spinosa*.

Purchase Intention Index

Regarding purchase intention, it was evident that there was a statistically significant difference when comparing the attributes that may influence this purchasing preference; thus, formulation F2 had the highest purchase intention (49.5) when compared to the others, while the lowest was F1 with (20.7). This difference can be explained by the concentration of ingredients and associated with the tasters' eating habits, leading to lower acceptance of that formulation. Different results were reported in the study by Brizola and Bampi (2015), 56% responded that they would certainly purchase the cereal bar with 15% green banana flour added, and 42% would possibly purchase it. Comparing this with the study by RIGO (2017), which sought a physicochemical and sensory evaluation of cereal bars with added plum flour (*Prunus saliciana*), 47.14% of participants stated that they "Certainly Would Buy" and 31.43% stated that they "Possibly Would Buy" this product.

In their study of cereal bars made with alternative and regional ingredients from western Paraná, reported a high intention to consume, with 27 of the 37 tasters indicating they would frequently consume the evaluated products [55].

However, factors such as educational level and product knowledge directly influence purchasing decisions, which can lead to reduced consumption of cereal bars, according to and Their study demonstrated that the greater the knowledge of the product and its benefits, the higher the intention to purchase it [56,57].

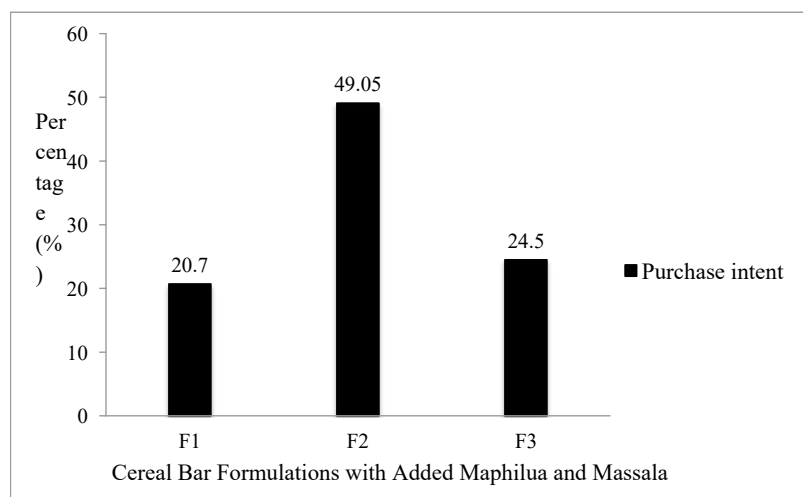


Figure: 3

(Vangueria infausta and Strychnos spinosa). Mean \pm Standard deviation; identical letters on the same row indicate no statistically significant difference between them. F1 – First formulation with 12% Vangueria Infausta and 5.99% Strychnos Spinosa; F2 – Second formulation with 5.38% Vangueria Infausta and 12.61% Strychnos Spinosa; F3 – Third formulation with 13.93% Vangueria Infausta and 4.06% Strychnos Spinosa.

Conclusion

This study concluded that the addition of wild fruits is technically feasible for diversifying their consumption in cereal bars. Overall, it was found that the second formulation, containing 5.38% Vangueria Infausta and 12.59% Strychnos Spinosa yielded better results than the other two in terms of the physicochemical and sensory quality of the cereal bars produced. There is a need to improve the quality and safety management of the bars produced, since the microbiological analysis showed low levels, indicating safety and hygienic-sanitary quality.

References

1. Chemane, S. S. I. (2022). Nutritional Characterization of the fruit Strychnos Madagascariensis and their products: flour and oil, Publisher: University of Porto, Portugal.
2. Sajdakowska, M., Tekień, A. (2019). To raise or not to raise the level of ingredients in yogurts: Polish consumer preferences regarding dairy products. *Nutrients*, vol. 11, no. 10, pp. 1–16.
3. Yami, M., Abioye, O., Sore, S. Z., Mugisho, A., & Abdoulaye, T. (2024). Factors influencing gender and youth integration in agricultural research and innovation in Africa. *CABI Agriculture and Bioscience*, 5(1), 1–12.
4. Kuzma, S, Bierkens, M. F. P, Lakshman, S, Luo, T, Saccoccia, L, Sutanudjaja, E. H, and Beek, R. V. (2023). Aqueduct 4.0: Updated Decision-Relevant Global Water Risk Indicators.
5. FAO. In Brief: The State of Food Security and Nutrition in the World (2023). Urbanization, agrifood systems transformation, and healthy diets across the rural-urban continuum. Rome, FAO, 2023. Available at:. Accessed April 3, 2023
6. Bourekoua, H, Djeghim F, Ayad, R, Benadbelkader A, Bouakkaz, A, Dziki, D, Rozylo, R. (2023). Development of Energy-Rich and Fiber-Rich Bars based on Puffed and NonPuffed Cereals, Edited by: MDPI, Algeria.
7. Bento, S. D., António, E. J., Eugénio, da P. E. S., Bento, F. F. (2023). Sustainability and food and nutritional security: an approach to food availability and access in the municipality of Chókwè-Gaza Province, Mozambique, *Revista Verde* 18:2, pp. 62–71. 18, vol. 2, April–June, pp. 62–71.
8. Isaú, de S. S., Vinicius, C. B., Virilane, K. L. H., Leonardo, H. dos S. (2022). Development and Analysis of Cereal Bars Based on Passion Fruit Shell Flour. *Research Square*. DOI:
9. Medina, V. B. et al. (2014). Determination of Vitamin C and Sensory Analysis of Cereal Bars with Added Dried Fruit. *Food Hygiene*, pp. 145–150.
10. Guimarães, M. M., Silva, M. S. (2009). Nutritional quality and acceptability of cereal bars with added murici-passa fruit. *Rev. Inst. Adolfo Lutz*.
11. Krashina, I., Kurakina, A., Krasina, E. (2021). Development of grain energy bars with high dietary fiber content, *E3S Web of Conferences* 285, Russia.
12. Reznichenko, I.Y., Ruban, N.Y. (2020). Technology and commodity science of innovative food products. 5 (64), 57–61. *Food Processing Techniques and Technology* 50(4):576–587. DOI:
13. 13.%09Rafaela, G. C. C. M. Fabiane, O. F. Cristiane, V. H. Alvaro, L. M. (2024). Enhancement of oat cereal bars with added Araucaria angustifolia flour: seed, almond, or bark. *Ciência Rural*, Santa Maria, v.54:11, e20230509.
14. Yang, X, Li, A, Li, X. 0, Sun, L, Guo, Y. (2020). An overview of classifications, properties of food polysaccharides and their links to applications in improving food textures. *Trends in Food Science & Technology* 102: 1-15.
15. Márquez-Villacorta, L., & Pretell-Vásquez, C. (2018). Evaluation of quality characteristics in high-fiber, high-protein cereal bars. *Biotechnology in the Agricultural and Agroindustrial Sector*; 16(2): 67–78. DOI:
16. Bchir, B., Jean-François, T., & Rabetafika, H. N. (2018). Effect of pear, apple, and date fiber incorporation on the physicochemical, sensory, and nutritional characteristics and the acceptability of cereal bars. *Food Sci. Technol. Int.* 24(3): 198–208.
17. Ramos, E. W. V. B, Souza, L. F. A, Lima, A. V. S. C, Santos, M. R. L. (2015). Physicochemical and microbiological quality of baru cereal bars purchased in Pirenópolis, Goiás. *IV State Congress on Scientific Initiation of the IF Goiano*, pp. 1–2, 21–24.
18. Sarika, K., Jayathilakan, K., Lekshmi, R. G. K., Greeshma, S. S., and Rajkumar, A. (2019). Omega-3-enriched Granola Bar: Formulation and Evaluation under Different Storage Conditions, Edition: *Fishery Technology*, India.
19. Ângela, G.B, Regina, I. N, Luzimar, S. M, Rossana, C. B. D, Suely, P. F. (2016). Influence of the skin on pine nuts (*Araucaria angustifolia*) on their nutritional quality . *XXV Brazilian Congress of Food Science and Technology*. Available
20. Santos, I. S., Barros, V. C., Hunaldo, V. K. L., Santos, L. H., Freitas, A. C. (2022). Development and Analysis of Cereal Bars Based on Passion Fruit Shell Flour, *Research Square*, Maranhão, Brazil.
21. Arruda, L. C., Faria, W. C. S., Siqueira, N. F. M. P., Campos, M. F. S. E., and Barros, W. M. (2021). Development of a cereal bar with baru almonds and pineapple peel, **Research, Society and Development**, vol. 10, Mato Grosso, Brazil.
22. Maximiliano, S., Lorena, A. de A., António, R., Ariana, S., Edite, T. L., Cláudia, C., Bernardo, R. (2024).
23. Eke-Ejifor, J.; Okoye, C. (2019). Nutrient Composition, Lipid Profile and Sensory Properties of Cereal Bars Made from Locally Available Cereals and Nuts. *Int. J. Biotechnol. Food Sci*, 6, 1–8.

24. Camargo, E., Botelho, R. B. A., Zandonadi, R. P. (2023). *Dietetic Techniques, Food PrePreparation and Preparation—Laboratory Manual*, 3rd ed.; Camargo, E., Ed.; Atheneu: São Paulo, Brazil; Volume 1, ISBN 9786555866766. Cereal Bars Made with Brazilian Licuri Nut (*Syagrus coronata*). *Foods*, 13, 502.
25. Thomas, M. S., Wolever, B. J.-W. K., Nicolas, B., Melissa, K., Alexandra, L. J., YiFang, C., Laura, H. (2016). Reformulating cereal bars: high resistant starch reduces in vitro digestibility but not in vivo glucose or insulin response; whey protein reduces glucose but disproportionately increases insulin. *Am J Clin Nutr*;104:995–1003. Printed in the USA.
26. Tarasyuk, G. M., Chahida, A. O. (2024). Prospects for improving the composition of snacks based on consumer behavior analysis. Zhytomyr State Polytechnic University. DOI:
27. Development and Rapid Sensory Descriptive Characterization of Mead, L. C., Hill, A. M., Carter, S., Coates, A. M. (2021). Effect of Walnut Consumption on Diet Quality, Cardiometabolic, and Gastrointestinal Health in Children: A Systematic Review of Randomized Clinical Trials. *International Journal of Environmental Research and Public Health*. Vol. 18, Issue 2. DOI:
28. Morgillo, S., Hill, A. M., & Coates, A. M. (2019). The effects of dried fruit consumption on vascular function. *Nutrients*, Vol. 11, Issue 1. Doi:
29. Fatima, T, Showkat, U, Hussain, S. Z. (2018). Nutritional and health benefits of walnuts. *Journal of Pharmacognosy and Phytochemistry*, vol. 7, Issue 2, pp. 1269-1271.
30. Álvarez, M. A. (2019). Development and evaluation of high-protein bars incorporating cricket flour. Polytechnic University of Valencia; 2019.
31. Budova, A. V., Urubka, S. A., Simrnov, S. O. (2024). Study of the chemical comparison of gluten-free cereal bars and application of a calculated method to estimate the glycemic index and glycemic load. *Agrarnaya nauka Euro-Nordeste*. 25(6):1050-1058. DOI:
32. Honnard, C., Rytz, A., Tudorica, C. M., Fiore, G. L., Do, T. A. L., Bhaskaran, K., Macé, K., and Shahkhalili, Y. (2022). Nutritional composition of infant cereal prototypes can precisely predict their glycemic index. *Nutrients*. 14(18):3702. DOI:
33. Urukov, S. A., Smirnov, S. O., Budova, A., Sokolova, V. S., Yuraskina, E. N., & T. V. (2024). Nutritional composition of puffed grains from gluten-free crops: issues in pediatric dietetics. *Pediatric Nutrition*. 22(2):96-101. Available at:
34. Antonio, O., Adelia, P., Annachiara, O., Mauro, R. (2021). Formulation of a Sugar-Free Cereal-Based Bar with Improved Nutritional Value: Biological and Sensory Analysis. *Bulletin of the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Food Science and Technology*. 67| volume 78 issue 2 | November. DOI:
35. Tian X, Liang T, Liu Y, Ding G, Zhang F, Ma, Z. (2019). Extraction, Structural Characterization, and Biological Functions of *Lycium Barbarum* Polysaccharides: A Review. *Biomolecules* 9: 389
36. Marília, M. G, Maria, S. S. (2008). Nutritional value and chemical and physical characteristics of murici-passa fruits (*Byrsonima verbascifolia*). *Food Science and Technology*. DOI:
37. Chulz, J. G., Freitas, R. S., & Fugmann, H. J. (2013). *Raw Material Procurement and Handling: Simplified Technology for the Production of Food Flakes*, Pearson Education, Spain.
38. Bastos, G. A., Paulo, E. M., Chiaradia, A. C. N. (2015). Stability of potentially prebiotic microorganisms in cereal bars – effect of the incorporation technique. Publisher: *Journal of Pharmaceutical Sciences*.
39. Coelho, A. F. S., DA Silva, K. S., Targino, B. N., Costa, E. B., et al. (2016). Preparation and sensory analysis of cereal bars made with passion fruit peel flour. *Brazilian Journal of Agroindustrial Products*, vol. 18, no. 3, pp. 243–254, 2016.
40. Torres, E. R. (2009). Development of cereal bars formulated with regional ingredients. 2009. 78 p. Thesis (Graduate Program in Process Engineering) – Tiradentes University, Aracaju.
41. Pinedo, R. A. (2013). Development of a cereal bar based on babassu almond flour (*Orbygnia speciosa*). *Revista Brasileira de Produtos Agroindustriais*, vol. 15, no. 4, pp. 405–411.
42. Freitas, D. G. C, Moretti, R. H. (2006). Characterization and Sensory Evaluation of a High-Protein and High-Vitamin Functional Cereal Bar. *Food Science and Technology*, v. 26, n. 2, p. 318-324.
43. Barros, H. E. A., Natarelli, C. V. L., Carvalho, T. I. M. De, et al. (2020). Nutritional Clustering of Cookies Developed with Cocoa Shell, Soy, and Green Banana Flours Using Exploratory Methods. *Food and Bioprocess Technology* 2020 13:9, vol. 13, no. 9, pp. 1566–1578.
44. Roberto, B. S. (2012). Guava residue: metabolism in rats and applicability in cereal bars. Santa Maria. Master's thesis. Federal University of Santa Maria, Rio Grande do Sul.
45. Neres, J. P. G., Souza R. L. A., Bezerra, C. F. (2016). Yogurt with pineapple pulp and peel flour. *Rev. Inst. Laticínios Cândido Tostes*; vol. 70: no. 5
46. Feitosa, B.F, et al. (2018). Development and characterization of cereal bars with added banana peel flour. CONADIS, National Congress on Semi-Arid Diversity.
47. Silva, A. M. (2019). Technological utilization of solid soursop (*Annona muricata* L.) residue in the production of cereal bars and evaluation of their antioxidant potential. 2019. Thesis (Bachelor's Degree in Nutrition) – Center for Education and Health, Federal University of Campina Grande, Cuité.
48. SILVA, S. R., Pinto, E. G., & Soares, D. (2018). Pequi almond flour cookies: physical and chemical evaluation, *Revista Enciclopédia Biosfera*. Goiânia, I (15), 1401.
49. Matiello, E. R, Savoldi, A. L. L, Faion, A. M. (2021). Production of cereal bars from orapro-nobis flour and pineapple agroindustrial waste. *e-TECH Journal: Technologies for Industrial Competitiveness - ISSN - 1983-1838, [S. I.]*, vol. 14, no. 1. DOI:
50. Oliveira, J. O. et al. (2018). Utilization of banana peels in the production of mariola-style jam. *Científica, Jaboticabal*,

v.46, n.3, p.199–206.

51. Moscatto, J. A., Prudêncio-Ferreira, S. H., Haully, M. C. O. (2004). Yacon flour and inulin as ingredients in the formulation of chocolate cake. *Food Science and Technology, Campinas*, vol. 24, no. 4, pp. 634–640. Available at:
52. Paiva, A. P., et al. (2012). Characterization of food bars manufactured with agroindustrial byproducts and waste. *Ciência e agrotecnologia, Lavras*, v.36, n.3, p. 333–340, May/Jun.
53. Skliutas, A. R. (2002). Study on the development of a cereal and dehydrated guava diet bar using the vacuum osmosis process with fructooligosaccharide. Thesis (Master's in Food Technology), State University of Campinas, Campinas.
54. Scheffer, A. S. (2010). Development and Acceptability of Quinoa Recipes. 67 p. Final Course Project (Bachelor's Degree in Nutrition) – University of the Far South of Santa Catarina, Criciúma.
55. Becker, T. S., Krüger, R. L. (2010). Development of cereal bars using alternative and regional ingredients from Western Paraná. *Archives of Health Sciences - UNIPAR*, vol. 14, no. 3, pp. 217–224.
56. Bezerra, I. N., et al. (2017). Out-of-home food consumption in Brazil by place of purchase. *Revista de Saúde Pública, São Paulo*, vol. 51, pp. 1–8.
57. Gonçalves, A. C. A. (2009). Development of a coffee-based beverage fortified with whey protein concentrate: from market research to sensory evaluation. 133 p. Thesis (Ph.D. in Food Science and Technology) - Graduate Program in Food Science and Technology, Federal University of Viçosa, Viçosa.