American Journal of Food Science and Technology, 2022, Vol. 10, No. 1, 53-65
Available online at http://pubs.sciepub.com/ajfst/10/1/8
Published by Science and Education Publishing
DOI:10.12691/ajfst-10-1-8

Formulation and Evaluation of High Energy-protein Bars as a Nutritional Supplement for Sports Athletics

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Received March 08, 2022; Revised April 11, 2022; Accepted April 18, 2022

Abstract The objective of this study was to formulate and evaluate high energy-protein bars as a nutritional supplement for sports athletics. The nutritional bars (formulas A, B, and C) were prepared using the same ratios of whole oat, kidney beans flour, peanut butter, dried berries, sugar, and glucose, in addition to sweet potato (with formula A), carrot flour (with formula B) and banana flour (with formula C). The chemical composition, texture profile analysis, Total phenolic content (TPC), Total flavonoids (TF), DPPH radical scavenging activity, and Ferric reducing antioxidant power (FRAP), energy content and sensory evaluation of bars were determined. Formula A was the highest bar in terms of protein, fat, minerals, and energy content, while, formula C was the highest in carbohydrate and ash values. The highest crude fiber was observed with formula B. Also, formula B exhibited the highest antioxidant activity compared to all other formulas. No significant differences could be traced among bars in the sensory properties. Moreover, the bar with banana flour (formula C) was significantly higher in hardness, adhesiveness, resilience, and springiness compared with the other bars formulas. This study recommends the use of formula A as a source of protein, fat, minerals, and energy in the nutrition of athletes, and formula B which has a higher antioxidant capacity to improve the health of the athletes.

Keywords: *bars, athletes, nutritional supplement, antioxidant activity, texture profile analysis*

Cite This Article: Faten Farouk Abdel-salam, Rehab Mohamed Ibrahim, and Maha IK Ali, “Formulation and Evaluation of High Energy-protein Bars as a Nutritional Supplement for Sports Athletics.” *American Journal of Food Science and Technology*, vol. 10, no. 1 (2022): 53-65. doi: 10.12691/ajfst-10-1-8.

1. Introduction

The choice of diet is a necessary part of sports training. Accordingly, athletes who care about their nutrition are able to improve their physical performance without harming the body. In recent decades, the use of foods rich in proteins and minerals has become an important part of the nutrition of athletes [1]. Nowadays, nutritional bars have gained international fame because they are considered high in nutritional content in addition to being rich in energy that is quickly released on the basis of metabolic demand. There are different types of bars in the world market such as high protein bars, high dietary fiber bars, high energy bars and bars rich in vitamins and minerals which have good sensory properties. These bars are packed in polyethylene bags lined with metal and have a shelf life ranges from 3 to 4 months [2,3,4].

Athletes’ energy requirements depend largely on the type of sport, duration, and intensity of exercise, competitive level and the individual capabilities of each athlete. Moreover, the higher the level of competition between athletes the greater the intensity of exercise, and therefore this is accompanied by a significant decrease in energy reserves that must be replaced by an appropriate diet. Therefore, athletes and people who engage in physical activity resort to energy bars, which are an important dietary supplement to maintain their strength and caloric needs. These bars provide athletes with power, vitality and physical, and mental activity. Therefore, these bars must contain a high percentage of carbohydrates and moderate content of protein. Additionally, the purpose of these bars provide energy permanently and quickly during the training of the athlete and it is expected that these bars provide the athlete from 200-300 calories, 7-15 g protein, 3-9 g of fat and 20-40 g of carbohydrates [3]. Moreover, Energy bars are considered one of the most excellent sources of proteins and natural sugars. Also, it nutritionally balanced to enhance performance. In addition to energy provision, the protein content in energy bars also helps to build muscle mass and protects tissues [5].

Cereal bars have high nutritional value because they are a good source of protein, energy, fiber, vitamins, antioxidants, etc. They are usually prepared from many ingredients such as cereals, dried fruits, nuts, raisins, sugar, etc. In addition, they are fortified by the use of a wide range of proteins such as soybeans, whey protein, grains, barley, vitamins and minerals [2,6].

Oat is one of the main ingredients commonly used in nutrition bars to enhance the fiber content and some micronutrients. Moreover, it is an important source of soluble dietary fiber, mainly β-glucan which have been reported as anti-cancer, anti-hypercholesterolemia, and hyper blood pressure [7]. It is also a balanced food component and is an excellent source of high-quality protein and carbohydrates. Moreover, it contains a high percentage of unsaturated fatty acids, vitamins, minerals and phytochemicals [8].

Kidney beans are a good source of protein, about 2-3 times compared to other grains, and they also contain micronutrients such as iron, zinc, and also rich in crude fiber, pro-vitamins A, and vitamin E. Kidney beans also contain phytochemicals, anti-oxidants and flavonoids like anthocyanins, proanthocyanidins, flavonols, phenolic acids, and isoflavones [9,10].

Carrots are one of the most important root vegetables, they contain biologically active compounds such as carotenoids and phenolic compounds and have strong antioxidant activity due to anthocyanin content (17.4 to 45.4 g/kg on dry weight). Moreover, carrot has important biological activities such as anti-diabetes, anti-carcinogenic, and cholesterol-lowering, and has a role in reducing cardiovascular disease [11,12].

Sweet potato has important health benefits, because of its content of β-carotene compounds, dietary phenols, fiber, carbohydrates, and B vitamins group like B_1, B_2, B_3, B_5, and B_6, and minerals like iron, manganese, calcium, potassium, and magnesium [13]. Furthermore, recently, sweet potatoes were used in the diet of athletes, because they are rich in carbohydrates that are slow to digest, and help in strengthening muscles, improving the physical performance of the athlete, and recovery from fatigue [14].

Bananas are one of the most important sources of energy (90 kcal/100 g) [15]. Also, banana contain antioxidants that are important for health. Bananas are a good source of fibers, vitamins (Vit C, B_6, pro-vitamin A), minerals (potassium, phosphorus, magnesium, and zinc). As well as contains bioactive compounds like phenolic acid compounds, flavonoids, carotenoids, sterols, and antimicrobial compounds. which make bananas an ideal functional food [16].

Many studies have been published in relation to the health benefits of berry consumption due to its content of active compounds [17,18,19]. Thanks to the rich and diverse composition of bioactive compounds and their health-promoting properties which result in their antioxidant activity, their metal chelating capacity, and their affinity for proteins. So, berry fruits are widely recognized as natural functional products [20,21].

The aim of the present study is to prepare and evaluate high energy–protein bars as a nutritional supplement for sports athletics.

2. Materials and Methods

2.1. Materials

Whole oat, kidney beans, carrot, sweet potato, banana, refined fine iodized common salt, peanut butter, black berry, sugar, glucose syrup and packaging were obtained from local market of Alexandria, Egypt. All chemicals and reagents used in this study were of analytical grade except Folin-Ciocalteu's phenol reagent of Sigma-Aldrich Company (St. Louis, Missouri, USA).

2.2. Preparation of Kidney Beans Flour

The kidney beans were sorted to remove small stones, lumps of dirt and defective seeds then washed using tap water. Kidney beans were soaked in water for 12h. Discard soaking water and the soaked kidney bean seeds were cooked in boiling water for 15 min. Kidney beans seeds were dried in a hot air oven dryer for 12 hours at 50 °C. The dried kidney beans were milled using mill (Moulinex AR1044) and it was sieved to pass a 40 mesh sieve, then packed into polyethylene bags and kept at 4°C until used [22].

2.3. Preparation of Sweet Potato, Carrot and Banana Flours

Sorted the sweet potato, carrot and banana were washed with running tap water to remove any soil, dirt and dust and then peeled and sliced (5 mm thickness). Thereafter, dipped in citric acid (0.5%) solution for 30 minutes, then drained again and dried in hot air oven dryer for 12 hours at 50°C. The dried samples were milled using a mill (Moulinex AR1044) and sieved to pass a 40 mesh sieve, then packed into polyethylene bags and kept until used [23,24,25].

2.4. Preparation of Dried Berries

After sorting of defected fruits berries were washed with running tap water to remove any soil, dirt were sorted and dust. After that, it was dipped in Na_2CO_3 solution (3%) for 4 min at 50°C .Then drained and dipped in 0.1 % sodium metabisulphite solution for 2 min, and dried in hot air oven dryer at 65°C until the moisture content of berries reached 10:12 %. Finally, it was packed in polyethylene bags and kept at 4°C until used [26].

Table 1. Formulation of nutritional bars

Ingredients (g/100 g)	Formula A (Bar with sweet potato flour)	Formula B (Bar with carrot flour)	Formula C (Bar with banana flour)
Oat whole	12.50	12.50	12.50
Kidney Beans flour	20.00	20.00	20.00
Sugar	24	24	24
Glucose Syrup	12.50	12.50	12.50
Peanut butter	10.50	10.50	10.50
Dried berries	10	10	10
Salt	0.50	0.50	0.50
Water	6	6	6
Sweet potato flour	4.00	-	-
Carrot flour	-	4.00	-
Banana flour	-	-	4.00

2.5. Preparation of Nutritional Bars

The nutritional bars were prepared in three formulas as shown in Table 1. Initially, all dry ingredients like whole oat, kidney beans flour, dried berries, and salt, and/or sweet potato, carrot and banana flours were mixed. Peanut butter, sugar, water and glucose syrup were heated at 70 °C for 3 min, and then mixed with the mixture of dry ingredients until getting a uniform mixture. The final uniform mixture was put in a stainless-steel tray and spread, then cooled to 28°C. Thereafter, the mixture was cut into rectangular bars (10 cm x 3.3 cm) where each one weighs approximately 40 g. Finally, it was packed in polyester films and stored in a cool, well-ventilated place.

2.6. Gross Chemical Composition and Total Caloric Values

Chemical constituents of ingredients and samples of final products (moisture, protein, fat, ash, crude fiber and dietary fiber) were determined according to the AOAC [27]. Carbohydrates (NFE) were calculated by difference. Total caloric values (K.cal) of ingredients and samples of final products were calculated as mentioned by AOAC [27]. according to following equation

$$Energy\ (K.cal) = [Protein\ (g) \times 4] + [Carbohydrate(g) \times 4] + [Fat\ (g) \times 9].$$

2.7. Preparation of Ethanolic Extracts from Ingredients and Bar Samples

Five grams of each ingredient and bar samples were mixed with 30 mL ethanol (75%), stirring for 2 hours at room temperature. Finally, the mixtures were filtered using Whatman filter paper No.1 and the extracts were stored at -20 °C until analysis [28].

2.8. Antioxidant Activity of Ingredients and Samples of Final Products

2.8.1. Determination of Total Phenolic Contents of Extracts

Total phenolic contents of extracts were determined using the method developed by Abirami *et al.* [29]. One and half milliliters of Folin–Ciocalteu's reagent (diluted 10 times) and 1.2 ml of Na_2CO_3 (7.5% w/v) were added to 300 µl of extract. Mixtures were shaken and kept at room temperature for 30 min before measuring absorbance at 765 nm using a spectrophotometer (Pg T80+, England), tests were carried out in triplicate. Total phenol content (TPC) was expressed as Gallic acid equivalent in mg/g plant material or extract.

2.8.2. Determination of Total Flavonoids

Total flavonoids content of extracts were determined according to Barros *et al.* [30]. Shortly, 0.5 ml of extract was mixed with 2 ml of distilled water followed by addition of 150 µl of $NaNO_2$ (5%) solution. After 6 min, 150 µl of $AlCl_3$ (10% w/v) was added and allowed to stand for another 6 min before 2 ml of NaOH (4% w/v) was added. The mixture was brought to 5 ml with distilled water. Then the mixture was allowed to stand for 15 min at room temperature. The absorbance was measured at 510 nm using a spectrophotometer (Pg T80+, England). Rutin was used as standard to determine the total flavonoids content.

2.8.3. DPPH Scavenging Activity

Scavenging activity of 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical was determined according to the method of Brandwilliams *et al.* [31]. Two milliliters of 0.15 mM DPPH was added to 1 ml of extracts in different dilutions. A control was prepared by adding 2 ml of DPPH to 1 ml of methanol. The contents of the tubes were mixed and allowed to stand for 30 min, and absorbance was measured at 517 nm using a spectrophotometer (Pg T80+, England). Triplicate tubes were prepared for each extract. The results were expressed as % radical scavenging activity.

$$\text{Radical scavenging activity\%} = \frac{(\text{Acontrol} - \text{Asample})}{\text{Acontrol}} x100.$$

2.8.4. Ferric Reducing Antioxidant Power (FRAP)

Ferric reducing antioxidant power was determined according to Oyaizu [32]. One milliliter of each extract was added to 0.1 M, pH 6.6 phosphate buffer (2.5 mL) and 1% (w/v) potassium ferricyanide (2.5 mL). The mixture was then incubated in a water bath at 50ºC/ 20 min followed by 2.5 mL trichloroacetic acid (10% w/v) solution. The contents of the tubes were mixed well and 2.5 ml of solution was removed from each tube. To this, 2.5 ml solution, 2.5 ml water and 0.5 ml ferric chloride solution (0.1% w/v) were added. The mixtures were allowed to stand for 30 min before absorbance measurements were taken at 700 nm using a spectrophotometer (Pg T80+, England). Triplicate tubes were prepared for each extract. The FRAP values, expressed in mg GAE/g, were derived from a standard curve.

2.9. Titratable Acidity (TA) and pH Values of Bar Samples

Titratable acidity (TA) as citric acid (%) was determined by titration with 0.1 M NaOH to an end point of pH 8.2. The pH values were measured using a digital Metler Toledo Mp 230 pH meter.

2.10. Determination of Minerals

Minerals including calcium (Ca), iron (Fe), potassium (K), sodium (Na), zinc (Zn), magnesium (Mg) and copper (Cu) were measured in ash solution using ICP-OES Agilent 5100 VDV according to AOAC [27].

2.11. Color Measurement

Color values like the L*(lightness), a*(red intensity), and b*(yellow intensity) of the samples were measured using a Hunter Lab Ultra Scan, VIS model, colorimeter (USA). The instrument was standardized during each sample measurement with a black and white tail (L*= 94.1, a*= 1.12, b* =1.26). Mean of five readings of each color index of Hunter scale (L*, a*, b*) were recorded [33].

2.12. Texture Profile Analysis (TPA)

Texture profile analysis of nutritional bar samples were performed using TA-XT 2 Texture meter (Texture Pro CT3 V1.2, Brookfield, Middleboro, USA) as described by Yuan and Chang [34]. Force time deformation curves were obtained during applying a 5 kg load cell, at a 1mm/s cross head speed. The following texture attributes were calculated, hardness cycle 1 (g), adhesive force (g), resilience, fracturability (g), hardness cycle 2 (g) and springiness (mm).

2.13. Sensory Evaluation

The three bar samples (formula A, B, and C) were served to fourteen staff members of Food Technology Research Institute Alexandria, Egypt. The panelists were asked to judge for color, taste, odor, texture, and overall acceptability of samples using standard hedonic rating scale from 9 (like extremely) to 1 (dislike extremely) according to Banach *et al.* [35].

2.14. Statistical Analysis

The statistical analysis was performed using one-way analysis of variance (ANOVA) using SAS statistical analysis software [36]. Means were compared by Duncan's test at the significance level of $P < 0.05$.

3. Results and Discussion

3.1. Gross Chemical Composition and Energy Content of Raw Ingredients

The data given in Table 2 show moisture (%), protein (%), fat (%), ash (%) and NFE (%) and energy content (k.cal/100 g) of raw ingredients (Kidney beans flour, whole oat, sweet potato flour, carrot flour, banana flour and dried berries). The results showed that the highest moisture content was found for banana flour (12.81%), while the lowest moisture content was observed for whole oat (10.80%). Kidney beans flour was the highest in protein content (22.82%) among all other ingredients followed by whole oat (12.10 %), and the lowest protein content was found for banana flour (2.40%). Fat (%) showed the highest value for whole oat followed by sweet potato, while carrot flour was the lowest. Also, the highest ash content was observed for kidney beans flour and whole oat. While, the lowest ash value was found in sweet potato flour. On the other hand, banana flour was the highest in carbohydrate content (81.58 %), while the lowest carbohydrate content (58.96 %) was found with kidney beans flour. The common bean such as kidney bean, soybeans etc is rich and inexpensive source of proteins, carbohydrates, dietary fiber to millions of people [37]. Flour obtained from oat grains, which are typically high in protein content [38]. The legumes can be used to enhance the protein content in the diet of low and medium-income earners [39]. Legumes like kidney beans as known a good source of minerals such as K, P, Ca, Mg and trace element [40]. The results given here are in agreement with Yasmin et al. [41] who reported that kidney beans contains 22 % protein.

The results in Table 2 illustrate that the higher energy value was obtained from whole oat (373.53 K.cal/100 g) followed by sweet potato flour (369.99 k.cal/100 g), and the lowest energy value was obtained from Kidney beans flour (342.42 k.cal/100 g).

3.2. Antioxidant Activity of Raw Ingredients

3.2.1. Total Phenolic and Total Flavonoids

The total phenolic (TP) and total flavonoids (TF) of raw ingredients are shown in Figure 1. The results revealed that the carrot flour was the highest in TP (7.57 mg GAE/g) followed by dried berries (7.35 mg GAE/g), while kidney beans flour was the lowest (4.68 mg GAE/g), compared to all other ingredients. Concerning of TF content, carrot flour was found to contain the highest value of TF (198.58 µg/ml extract) followed by dried berries (100.48 µg/ml extract) compared to other ingredients, and the lowest value of TF was found for whole oat (42.42 µg/ml extract).

3.2.2. DPPH Scavenging Activity (%) and FRAP Values

The highest DPPH scavenging activity was observed with Kidney beans flour (83. 92%) and sweet potato flour (83. 83%), while, the lowest scavenging activity was found with carrot flour (53.68%). The results in Figure 1 revealed also the FRAP values of raw ingredients. Dried berries observed the highest FRAP value followed by sweet potato flour and then carrot flour, while, the lowest FRAP value was found for oat flour.

Table 2. Chemical analysis and energy content of raw ingredients

Component	Kidney Beans flour	Whole Oat	Sweet potato flour	Carrot flour	Banana flour	Dried berries
Moisture (%)	12.75±0.84	10.80±0.20	11.08±1.01	11.39±0.53	12.81±0.52	10.90±1.31
Protein (%)	22.82±1.20	12.10±0.22	9.26±0.87	5.74±0.62	2.40±0.27	6.44±0.52
Fat (%)	1.70±0.40	5.29±0.10	3.99±0.20	0.098±0.006	1.34±0.10	3.23±0.23
Ash (%)	3.76±0.27	2.11±0.038	1.42±0.095	1.52±0.68	1.87±0.34	2.11±0.34
NFE (%)	58.96±0.52	69.38±0.34	74.26±1.86	80.96±0.36	81.58±0.53	77.32±0.87
Energy content (Kcal/100 g)	342.42±2.65	373.53±2.07	369.99±3.81	347.68±1.01	347.98±2.16	364.11±5.11

Results are reported as mean ±SD of triplicate analysis.

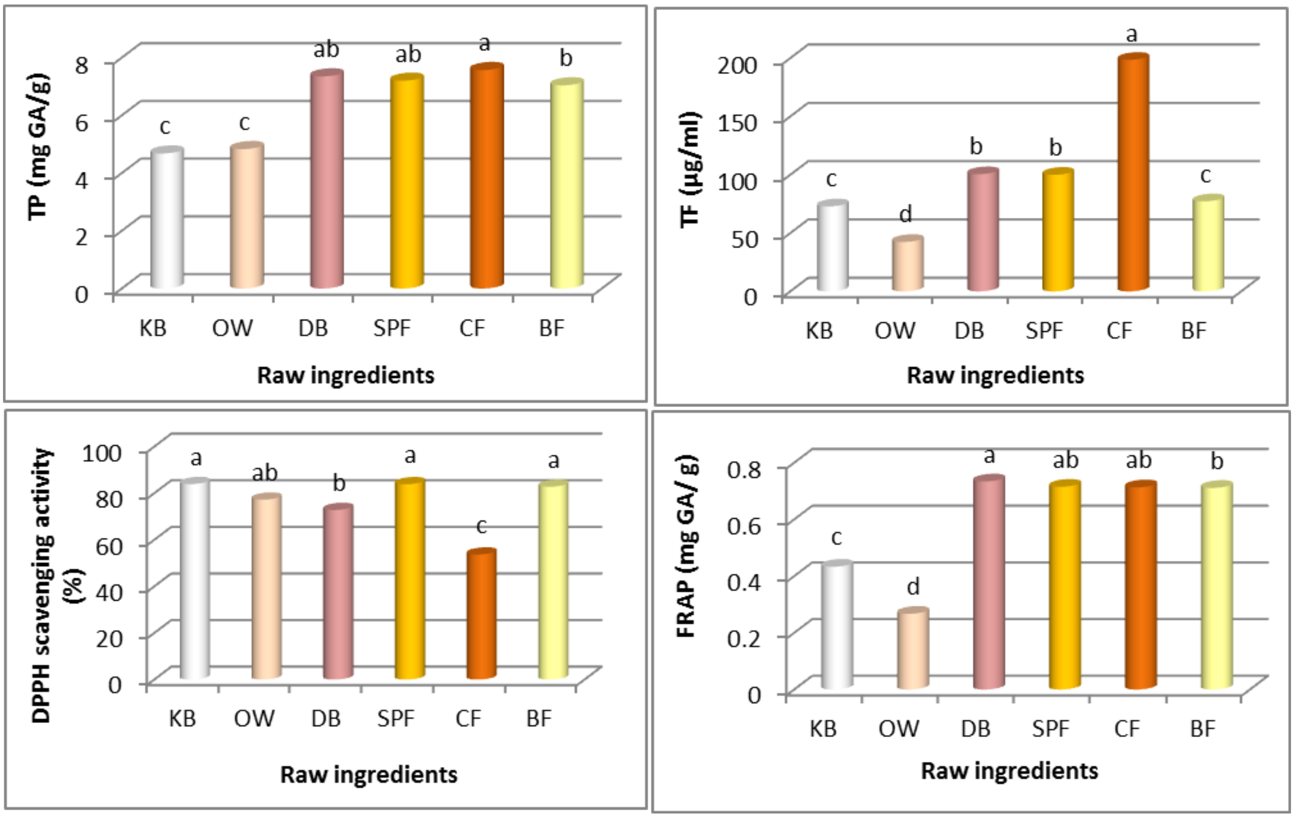


Figure 1. Antioxidant activity of raw ingredients (KB: Kidney Beans flour, OW: Oat whole, DB: Dried berries, SPF: Sweet potato flour, CF: Carrot flour and BF: Banana flour)

Phenolic compounds are recognized as the major antioxidants in plants. Phenolic compounds are produced as secondary metabolites in plants and have various protective impacts. They are also potent antioxidants and can exert anti-microbial, anti-inflammatory, anti-carcinogenic, anti-allergic, anti-platelet, vasodilatory, and neuroprotective effects [42]. The higher antioxidant activity was due to the higher TP in the extract [43]. Berries contain high levels of flavonoids (anthocyanins, flavonols and flavanols such as condensed tannins or proanthocyanidins), phenolic acids (hydroxybenzoic, chlorogenic acid and hydroxycinnamic acids), hydrolysable tannins (gallotannins andellagitannins), stilbenoids and lignans [44,45]. The consumption of carrot and its products is increasing steadily due to its recognition as an important source of natural antioxidants having anticancer activity [46].

3.3. Physicochemical of Bar Samples

The physicochemical properties of bar samples are presented in Table 3. Results indicate that the moisture content ranged between 9.47 % to 9.81% and the highest ($P<0.05$) moisture content was found with formula B while the lowest ($P<0.05$) moisture content was observed with formula A. Many studies reported that the sweet potato and carrot have a short shelf life due to their high moisture content, and therefore these foods must be treated with other dry composite flour in order to increase the shelf life, so they were used in some products such as bread, pasta, biscuits, etc [47]. The moistures values in formula A, B and C were lower than the values (11.67%) which found by Obi [48]. Generally, many studies stated that the maximum moisture content in cereal products should not exceed 15%, which is the limit established by Resolution CNNP A No. 12 of 1978 for products based on cereals and derivatives, as increasing the shelf life of the product can be extended through low moisture content [49]. Therefore, nutrition bars with low moisture content can be stored for a long time without damage [50,51].

The adequate consumption of high-quality protein is essential for optimal growth, which is essential to support bone growth in infants and children and to sustain the mass and health of the skeleton in adult development, and health in humans. Protein is one of the most important vital nutrients for humans because of its functional properties, which including improving the healthy growth of muscle mass [52,53]. The protein requirement of athletes ranged from 1.2 to 2 g/ kg body weight per day. Therefore, if the protein exceeds this rate, the athlete is more at risk of damage to muscle tissue, especially in the case of strenuous exercise [54]. The results in Table 3 show that the protein content in nutrition bars (A, B and C) ranged from 12. 36% to 13.73%, and the highest value was found with formula A, whereas, the lowest value was found with formula B. These findings may be due to the high protein content in the formulas ingredients (whole oat, and kidney bean flour). These results are in agreement with those obtained by de Arruda et al. [47], who reported that the protein content of the cereal bar supplemented with baru almonds was 12.24%, where baru almonds contain 23 to 30% protein. Habiba *et al*. [55] found that the protein content of nutrition bars made with banana and pumpkin seed flour was in a range from 5.5 to 14.25 according the percentage of each ingredient. On the other hand, Van Toan, and Vinh [4] found that the protein contents in nutritional bars contacting whey protein powder (WPP) ranged from 18.23% to 20.13%. This may be due to whey protein powder being the main ingredient in the formulas, as it represents 40%.

Table 3. Physico-chemical properties of bar samples

Component	Formula A	Formula B	Formula C
Moisture (%)	9.47±0.05^{b}	9.81±0.05^{a}	9.49±0.21^{b}
Protein (%)	13.73±0.26^{a}	12.36±0.24^{b}	12.70±0.65^{b}
Fat (%)	9.45±0.18^{a}	9.39±0.11^{a}	9.35±0.42^{a}
Ash (%)	1.59±0.18^{b}	1.81±0.06^{ab}	1.99±0.05^{a}
NFE (%)	62.37±0.18^{a}	62.29±0.32^{a}	63.13±0.91^{a}
Crude Fiber (%)	3.39±0.24^{b}	4.34±0.02^{a}	3.34±0.28^{b}
Dietary Fiber (%)	1.65±0.15^{b}	2.16±0.16^{a}	1.84±0.16^{b}
Acidity (%)	0.47±0.02^{a}	0.37±0.01^{c}	0.42±0.02^{b}
pH	5.22±0.006^{c}	5.83±0.00^{a}	5.31±0.00^{b}
Energy content (Kcal/100 g)	389.45±1.52^{a}	383.12±0.70^{b}	387.47±2.46^{a}

Formula A: Bar with sweet potato flour, Formula B: Bar with carrot flour and Formula C: Bar with banana flour. Results are reported as mean ±SD of triplicate analysis. Means in a row not sharing the same superscript are significantly ($P \leq 0.05$) different.

Burke *et al*. [56] reported that the fats are an important source of energy and prevent muscle tension during intense exercise, and consuming a high percentage of fat (> 30% of total calories) can reduce carbohydrate intake, so it is not possible to maintain muscle glycogen. The fat content in formulas A, B and C ranged from 9.35% to 9.45%. Formula C was significantly the lowest in fat content compared with other formulas (A and B). The daily recommendation for athletes is 20-35% of total energy which includes 7–10% saturated fatty acid, 10% monounsaturated fatty acid and 10% polyunsaturated fatty acids. The slightly higher fat content in bars plays an important role in order to replace it energy used during physical activities as a result of exhaustion of energy during exercise. Moreover, products with the high fat contents enhance and retain the feeling of the mouth product flavors [57,58]. Habiba *et al*. [55] found that the bar with banana flour had the lowest fat (6.20%) content compared to pumpkin seed flour (9.74%) and mixed bars samples (14.25%). In our study, the obtained in the fat content of nutrition bars (9.35-9.45%) was lower than that obtained by Van Toan, and Vinh [4].

Ash is an important indicator that expresses the content of mineral elements in food products. The ash contents in bar formulas ranged from 1.59% to 1.99% and the significantly highest value was found in formula C compared with formulas A and B. Van Toan, and Vinh [4] reported that the nutrition bars enriched with oats and brown rice showed a significant increase in ash content which contributed to the good supply of minerals in bars . Also, Moreira-Araújo *et al*. [49] found that the ash content in cereal bar enriched with cowpea bean whole flour ranged from 1.19% to 1.43%.

Several studies have indicated that the recommended dietary requirements of carbohydrates for athletes vary depending on the type, duration and intensity of exercise [55]. The total carbohydrate values in nutrition bars are given in Table 3, the results showed that the significantly highest carbohydrate content was observed with formula C (63.13%), while, the significantly lowest carbohydrate value was found in formula B (62.29%). According to Moreira-Araújo *et al*. [49] the carbohydrate content (69.53%) in nutrition bars supplemented with cowpea bean (7.5%) was lower than in the control (73.94%) containing cornstarch. Several studies indicated that the cereal bars made with rice, grains and dried fruits are high in total carbohydrate content. In addition, the use of sugar and honey in cereal bars as a binding agent contributes significantly to the high carbohydrate content [60]. Sweet potatoes contain carbohydrates, which serve as the main energy source for the athlete. It is also an easily digestible nutrient that prevents fatigue after exercise. Also, it contains a low percentage of sugar, and is considered very low in the glycemic index, and therefore does not raise sugar significantly [61]. The consumption of carbohydrates before and during exercise is an external fuel source for the muscles and central nervous system. The metabolism is primarily dependent on the oxidation of carbohydrates and fats and is vital for the proper functioning of cells and tissues. Furthermore, energy balance is an important aspect of an athlete's performance during both high and low-intensity activities. An athlete's nutritional requirements depend on the intensity of the exercise or exercise so there must be a balance in the total energy production to compensate for the energy expended [56].

The results in Table 3 revealed that the crude fiber and dietary fiber in formula B (4.34 and 2.16% respectively) were significantly higher than formula A (3.39 and 1.65, respectively), and formula C (3.34 and 1.84%, respectively). Van Toan, and Vinh [4] found that the highest crude fiber content was obtained with nutrition bar containing 100% oat flour, while the nutrition bar containing brown rice flour was the lowest. It is worth noting that oat flour is higher in fiber content compared to brown rice flour, and this has led to a decrease in crude fiber in nutrition bars. Also, Banana is a functional food due to its high level of fiber, phytochemicals, minerals, vitamins, etc [62]. There are no studies showing general recommendations for fiber in athletes but, dietary fiber is very important for maintaining a healthy gut and microbiome important for athletic performance [63]. Dietary fiber has important physiological effects, including lowering the level of cholesterol in the blood, and/or lowering the level of glucose in the blood. Perhaps the most dynamic function of dietary fiber is fermentation, which causes many biochemical, physiological and microbiological changes in the large intestine [64].

Also, as shown in Table 3, the titratable acidity (TA) of bar samples ranged from 0.37 to 0.47%. There were significant differences among all bar samples. The sample formula A showed a significant higher ($P \leq 0.05$) in TA than other formulas. The pH value in formula B (carrot bar) was 5.83 being higher that for than formula A and C (5.31 and 5.22, respectively).

Regarding to the energy values of nutrition bars, the lowest energy values was found with formula B (383.12 kcal/100 g), while the significantly highest value was obtained with formula A (389.45 kcal/100 g). Calorie values express the energy consumed from macro nutrients such as carbohydrates, proteins, and fats. This value is nearly to the reported value of 300 - 424 kcal/100 g [4,51]. Also, Habiba *et al*. [55] found that energy values of bars containing banana flour and mixed flour (pumpkin seed flour and banana flour) were 398.60 and 424.94 kcal/100 g, respectively. It is worth noting that the daily nutritional energy requirements for athletes range between 40-70 kcals/kg/day (2000-7000 kcals/ day for a 50-100 kg athlete).

3.4. Mineral Content of Bar Samples

Several studies have indicated that vitamins and minerals are among the most worrisome elements in an athlete's diet, including calcium, vitamin D, and B vitamins. Vitamins, iron, zinc, magnesium, also some antioxidants like vitamins C and E, beta-carotene, and selenium, iron are important elements for athletes because they helps the body to use and carry oxygen for active muscles. The iron from plant sources like beans, lentils, seeds, soybeans, whole grains or ground grains, bread, and pasta is not well absorbed, so it should be fruit, juices, strawberries, peppers, or broccoli included in the diet to help iron absorption [65,66]. The data in Table 4 show the mineral content of bar samples. It can be noted that the sample containing sweet potato flour (formula A) is superior to sample with carrot flour (formula B) and banana flour (formula C) in terms of calcium, iron , potassium , sodium, zinc and copper contents (82.86, 4.22, 497.76, 370.23, 1.82 and 0.373 mg /100 g, respectively). On the other hand, formula B was found to be the significantly highest in magnesium content (3.76 mg /100 g) compared to other formulas. Brazil [67] reported that the cereal bars are a good source of iron, phosphorous and zinc, along with their high content of copper and manganese. Oat grains are also rich in macroelements, like K, Ca, Mg as well as in microelements like Cu, Zn, Fe, Mn, Bo, Mo, Co and Se [68]. Also, Moreira-Araújo et al. [49] found that the sample enriched with cowpea bean whole flour 7.5% had significantly higher content of copper, phosphorus, magnesium and zinc. Habiba *et al.* [55] found that the banana flour contains 22.96 mg Ca, 1491.88 mg K, Fe 1.22 mg, Mg 108.05 mg and P 74.54 mg. It is known that bananas are rich in potassium, which is an electrolyte that helps in regulating fluid balance, nerve transmission, and acid base balance. Some research suggest that excessive increases or decreases in potassium may cause athletes to cramp. During intense exercise, potassium loss occurs and this is associated with muscle spasms, so the use of potassium supplements by athletes reduces the occurrence of muscle cramps [69,70].

Table 4. Mineral content of bar samples

Minerals (mg/100g)	Formula A	Formula B	Formula C
Ca	82.86±0.040[a]	72.56±0.276[b]	55.22±0.191[c]
Fe	4.22±0.034[a]	2.78±0.043[c]	3.33±0.146[b]
K	497.76±0.026[a]	439.06±0.235[b]	303.30±0.167[c]
Na	370.23±0.028[a]	224.71±0.471[b]	164.66±0.233[c]
Zn	1.82±0.110[a]	1.45±0.023[b]	1.58±0.059[b]
Mg	2.86±0.025[b]	3.76±0.131[a]	2.87±0.024[b]
Cu	0.373±0.031[a]	0.335±0.030[ab]	0.293±0.022[b]

Formula A: Bar with sweet potato flour, Formula B: Bar with carrot flour and Formula C: Bar with banana flour. Results are reported as mean±SD of triplicate analysis. Means in a row not sharing the same superscript are significantly ($P \leq 0.05$) different.

Intense exercise causes a significant decrease in muscle mass, so calcium plays a key role in bone health in athletes, as its consumption helps maintain bone density and also reduce the risk of bone injury during competition. So, athletes should be encouraged to consume calcium-fortified foods to meet their calcium needs and improve bone density and prevention of osteoporosis in athletes [71]. Many studies have confirmed that minerals are essential for metabolic processes. It represents a structure for tissues and important components of enzymes and hormones, and regulators of metabolic and neural control also improve the athletic performance ability of athletes. The recommended nutritional needs of minerals for athletes such as calcium, potassium, iron, magnesium, sodium, copper and zinc are (1000, 2000, 8, 420, 500, 1 and 11 mg /d for male, respectively) [72].

Magnesium activates enzymes involved in protein synthesis and participates in ATP interactions. Some suggests report that magnesium supplementation improves energy metabolism and ATP availability. Studies indicates that magnesium supplementation (500 mg/d) does not affect exercise performance in athletes unless there is A deficiency [73]. Many studies suggested that zinc supplementation (25 mg/d) during training diminishes exercise-induced changes in immune function [74].

3.5. Antioxidant Activity of Nutritional Bars Samples

Figure 2 shows the antioxidant activity of nutritional bars samples. The nutrition bar sample containing carrot flour was significantly the highest in TP (4.68 mg GAE/g), TF (46.4 µg/ mL) contents, and DPPH scavenging activity (85.25 %) compared to other bar samples. On the other hand, the significantly lowest values of TP and TF was observed with bar sample containing banana flour. The significantly lowest DPPH scavenging activity was found with the sample containing sweet potato flour (75.53%). Concerning the FRAP values, there were insignificant ($P>0.05$) differences among all formulas investigated here.

The nutrition bars in the present study showed higher antioxidant activity due to the antioxidant activity of raw materials used in preparation of these bars. The impact of antioxidants on DPPH radical scavenging it is due to their ability of hydrogen-donating [43]. According to Chaiklahan *et al.* [75], the DPPH radical scavenging activity of the nutrition bars depended on the amount of phenolics in banana flour, pumpkin seed flour, chickpea, and raisins. So, it can be suggested the increase in DPPH scavenging activity of formula B is due to the higher content of TP. Health beneficiary effect of banana pulp is due to bioactive compounds such as phenolic acids, flavonoids, carotenoids, sterols, and antimicrobial compounds, the compounds that make banana a perfect functional food [76]. Additionally, consumption of products containing oat flour has hypocholesterolemic and elimination of free radicals [77,78].

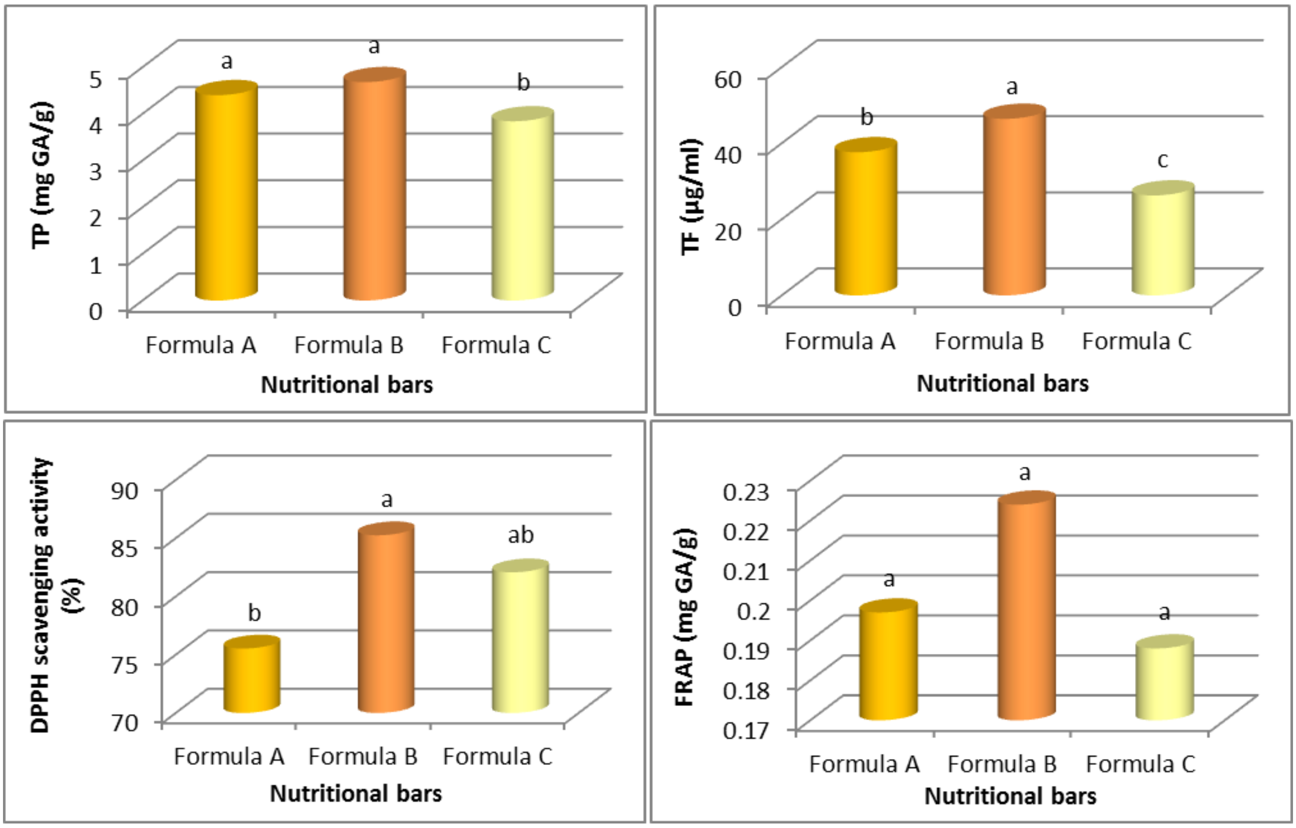


Figure 2. Antioxidant activity of nutritional bars samples (Formula A. bars with sweet potato flour, Formula B. bars with carrot flour and Formula C. bars with banana flour)

3.6. Color Measurement

The color of cereal bars is one of the most important parameters for determining consumer acceptance. The color values (lightness, redness, and yellowness) of the bar samples are given in Table 5. Color parameters showed that the significantly highest value of lightness was found with formula C (57.78) followed by formula A (53.16), meanwhile, the lowest lightness value was obtained with formula B (49.98). The decrease in lightness in formula B could be attributed to the natural pigments in carrot such as carotenoids. Otherwise, the redness in formula B (17.93) was significantly higher than formula A (8.16) and formula C (5.40). This could be due to the combination of cereals, fruits, and sweeteners leading to an increase in lightness and the redness decreased in bar samples containing bananas (formula C). Finally, the yellowness value was significantly higher with formula B (31.47) compared with other treatments. In general, the high redness and yellowness in formula B may be due to the presence of carotenoids. Korese *et al*. [79] revealed that, cookies fortified with sweet potato flour showed higher redness and yellowness and this may be due to the high carotenoids and some pigments in sweet potatoes flour, in addition to Maillard and caramelization reactions during baking. Furthermore, the presence of high sugars in sweet potato flour contributed to the increase in the redness of the cookies. Bchir *et al*. [80] reported that cereal bars prepared from pear and wheat bran had higher L*values, while, a* and b* were positive among all cereal bar formulations. This may be due to the original color of the fibers, in addition to the reaction of Millard and caramel reaction during the preparation of the cereal bars. The significant difference ($P < 0.05$) in L* values between all bar samples might be due to the differences in polyphenols concentration in bar formulas [55].

Table 5. Color values of bar samples

Physical properties	Formula A (Bar with sweet potato powder)	Formula B (Bar with carrot powder)	Formula C (Bar with banana powder)
L^*	53.16 ± 3.16^{ab}	49.98 ± 2.43^{b}	57.78 ± 2.22^{a}
a^*	8.16 ± 0.84^{b}	17.93 ± 0.94^{a}	5.40 ± 0.21^{c}
b^*	25.06 ± 2.06^{b}	31.47 ± 2.43^{a}	28.15 ± 1.75^{ab}

Formula A. bar with sweet potato flour, Formula B. bar with carrot flour and Formula C. bar with banana flour. Results are reported as mean ±SD of triplicate analysis. Means in a row not sharing the same superscript are significantly ($P \leq 0.05$) different.

3.7. Texture Profile Analysis

Texture is one of the most important parameters that determine product quality. The instrumental determinations of texture profile analysis of nutritional bar samples are shown in Table 6. It could be noted that the hardness values (g) of the bar samples which recorded the significantly highest hardness in cycle 1 were formula B then formula C, while formula A was significantly the lowest one. Otherwise, the hardness in cycle 2 showed that formula C was significantly ($P \leq 0.05$) highest than other formulas. Samakradhamrongthai *et al*. [81] reported that high-energy cereal bars had highest hardness and stickiness, and this could be related to the migration of moisture among the carbohydrates (like starches, pectin, sugars, and maltodextrin) and the proteins. Adhesive force and resilience were found to be significantly highest ($P \leq 0.05$) in formula C and (11.00 and 0.080, respectively), than formula B (8.03 and 0.050) and formula A (2.03 and 0.030, respectively). The fracturability showed the significantly highest value with formula B value (6.84 g) compared to formula C and A (599 and 442 g, respectively). Concerning the springiness values, formula C was significantly (P≤0.05) highest than other formulas, while formula A was significantly the lowest in springiness. Also, Habiba *et al.* [55] found that the fracturability value of mix bars (containing pumpkin seed and banana flour) was highest than bars containing pumpkin seed flour or banana flour, and this may be due to the formulas being close to each other in textural properties.

Table 6. Texture profile analysis of nutritional bar samples

Texture profile	Formula A	Formula B	Formula C
Hardness Cycle 1(g)	442±7.05[c]	684±3.95[a]	599±3.95[b]
Adhesive Force (g)	2.03±0.15[c]	8.03±0.35[b]	11.00±1.01[a]
Resilience	0.030±0.002[c]	0.050±0.004[b]	0.080±0.003[a]
Fracturability (g)	442±7.51[c]	684±3.050[a]	599±4.51[b]
Hardness Cycle 2 (g)	205±4.95[c]	365±3.00[b]	600±4.10[a]
Springiness (mm)	1.31±0.10[c]	1.57±0.11[b]	1.90±0.11[a]

Formula A: Bar with sweet potato flour, Formula B: Bar with carrot flour and Formula C: Bar with banana flour. Results are reported as mean ±SD of triplicate analysis. Means in a row not sharing the same superscript are significantly (P≤ 0.05) different.

3.8. Sensory Evaluation

Sensory evaluation such as color, taste, odor, texture, overall acceptability of nutrition bars are presented in Figure 3. It could be observed that the sample containing banana flour (formula C) had significantly the lowest scores in color, taste, texture and overall acceptability compared to other formulas. On the other hand, the sample containing sweet potato flour (formula A) had significantly the highest taste, odor and texture scores. Although all samples had a high acceptance, the sample containing sweet potato was the most preferred by the panelist in terms of taste, odor and texture. The degree of sensory acceptance of nutrition bars is related to different components like rice flakes, oats, and dried fruit) and binders (like glucose syrup and honey). Although the sensory evaluation of all samples ranked as moderately like to extremely like acceptance according to 9-point. Hedonic scale, no significant differences could be traced in all sensory characteristics among the three formulas.

3.9. Nutrition Facts

The data in Table 7 show the nutrition facts of bar samples under study. Based on the daily value of 4500 calories diet it was found that 40 grams of formula A, B, and C can cover 3.41- 3.46 % from daily provides of calories. Also, the results in Table 7 reveal that 40 grams of formulas A, B, and C can meet 2.52, 2.50 and 2.49%, respectively, from daily provides of fat, 4.58, 4.12 and 4.23%, respectively, from protein, 4.44, 4.43 and 4.49 % respectively, from carbohydrate and 4.52, 5.79 and 6.07% respectively, from the crude fiber. Therefore, the nutrition bars can be used as an important nutritional supplement. Hence, it will be a highly sought-after functional food for athletes whose want to enhance their physical and healthy abilities and athletic performance.

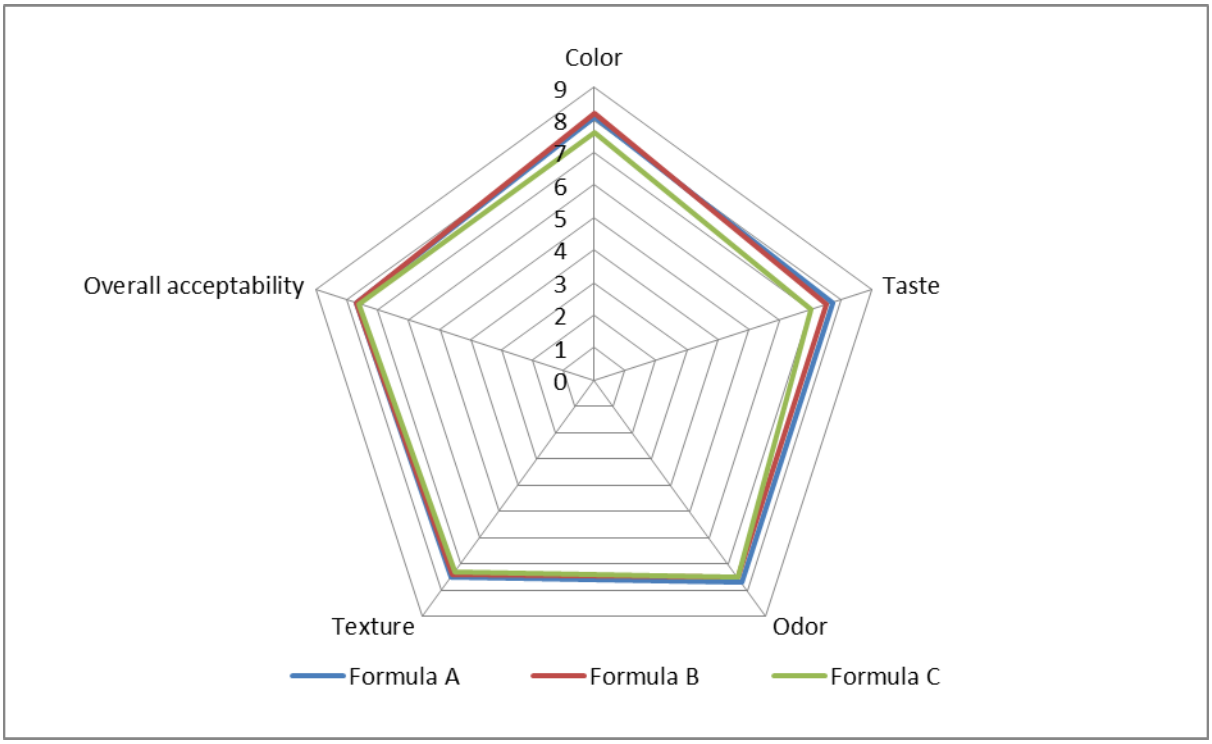
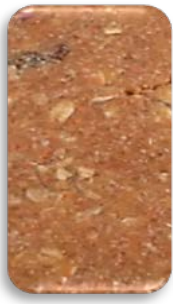
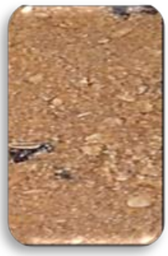


Figure 3. Sensory evaluation of bar samples. Formula A: Bars with sweet potato flour, Formula B: Bars with carrot flour and Formula C: Bars with banana flour.

Table 7. Nutrition Facts of bar samples

Nutrition Facts (1 Serving per container, Serving Size 40 g)				
Sample		**Nutrition Facts**		**% Daily Value**
Formula A (Bar with sweet potato flour)		Calories (Kcal)	155.78	3.46
		Total fat (g)	3.78	2.52
		Protein(g)	5.492	4.58
		Carbohydrate(g)	24.948	4.44
		Crude fiber(g)	1.356	4.52
		Dietary fiber(g)	0.66	2.2
		Ca(mg)	33.144	3.314
		Fe(mg)	1.688	21.1
		K(mg)	199.104	9.96
		Na(mg)	148.092	29.62
		Zn(mg)	0.728	6.62
		Mg(mg)	1.144	0.272
		Cu(mg)	0.1492	14.92
Formula B (Bar with carrot flour)		Calories (Kcal	153.248	3.41
		Total fat (g)	3.756	2.50
		Protein(g)	4.944	4.12
		Carbohydrate(g)	24.916	4.43
		Crude fiber(g)	1.736	5.79
		Dietary fiber(g)	0.864	2.88
		Ca(mg)	29.024	2.90
		Fe(mg)	1.112	13.9
		K(mg)	175.624	8.78
		Na(mg)	89.884	17.98
		Zn(mg)	0.58	5.27
		Mg(mg)	1.504	0.358
		Cu(mg)	0.134	13.4
Formula C (Bar with banana flour)		Calories (Kcal	154.988	3.44
		Total fat (g)	3.74	2.49
		Protein(g)	5.08	4.23
		Carbohydrate(g)	25.252	4.49
		Crude fiber(g)	1.336	6.07
		Dietary fiber(g)	0.736	3.35
		Ca(mg)	22.088	2.21
		Fe(mg)	1.332	16.65
		K(mg)	121.32	6.07
		Na(mg)	65.864	13.17
		Zn(mg)	0.632	5.75
		Mg(mg)	1.148	0.273
		Cu(mg)	0.1172	11.72

Percent Daily value are based on 4500 calories diet and Fiber 30g (Loucks, 2004; Barrero et al., 2014).

4. Conclusion

In this study, three bar formulations (formula A, formula B and formula C) were prepared using the same ratios of whole oat, kidney beans flour, peanut butter, dried berries, sugar, and glucose, in addition to sweet potato (with formula A), carrot flour (with formula B) and banana flour (with formula C). The highest protein, fat, minerals values, and energy content was found with formula A, while, the highest carbohydrate and ash values were observed with formula C. Formula B was found to be the highest in crude fiber and antioxidant activity compared to all other formulas. There were no significant differences among the bars in the sensory evaluation.

Formula C was significantly the highest in hardness, adhesiveness, resilience, and springiness compared with the other bars. From the obtained results it could be concluded that formula A and B are potential nutritional of athletes.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgements

The authors are thankful to Prof. Dr. Mohammed Mohamoud Youssef, Professor of Food Science and Technology, Department of Food Science and Technology, Faculty of Agriculture (El-Shatby), Alexandria University, Egypt, for his support and valuable advice during carrying out the work.

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