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Nutritional Composition of Developed Bars and Their Impact on Work Performance of Adolescent Swimmers' Girls

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

With the growing interest in sports nutrition and its impact on athletic performance, understanding the specific needs of adolescent athletes, particularly females, is crucial for optimizing their training and performance outcomes. The three variants of the Protein-rich bar (PB1, PB2, PB3) with the CB were developed by using different ingredients. The research employs a mixed-methods approach, combining nutritional analysis of developed bars with performance assessments among adolescent swimmers' girls. Firstly, organoleptic evaluation (9-point hedonic scale) was performed on the variants of Protein-rich bar with the CB. Then nutritional analysis involves proximate (moisture, ash, protein, crude fat, crude fiber, CHO), mineral (calcium, iron), as well as antioxidant analysis (DPPH,

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TPC, vitamin C) assessed on selected variants of Protein-rich bar with the CB. Pre- and post-intervention were done on two groups for 3 months and performance assessments included anthropometric measurement, sit and reach test, hand grip strength test, Nelson hand reaction time test, and Tuttle pulse ratio test. Preliminary findings suggested that the developed bars (PB1) provide a more balanced nutritional profile than the CB. Moisture 10.2±0.66%, ash 3.7±0.27%, protein 22.3±0.74 g, crude fat 13.1±0.41 g, crude fiber 11.5±0.02 g, CHO 39.4±0.19 g, iron 4.4±0.15 mg, calcium 82.4±0.21 mg, DPPH 47.6±0.31%, TPC 53.1±0.11 mg GAE, and vitamin C 11.2±0.19 mg in 100 g respectively in PB1 and significantly difference at ($p<0.05$). Additionally, the consumption of PB1 bar appears to positively impact higher work performance among adolescent swimmers girls. Overall, this study contributes to the growing body of research on sports nutrition tailored to adolescent athletes, particularly focusing on the nutritional needs of swimmers girls.

Keywords: Adolescent; athlete; nutrition; supplemented; work performance.

1. INTRODUCTION

Adolescence is marked by fast physical development, changes in body composition, physiology, and endocrine system, as well as significant biological, emotional, social, and cognitive changes. It is one of the most important life transitions. Nutritional and energy requirements rise throughout adolescence as a result of puberty-related changes in body composition and faster growth rate [1].

Sports and physical activity are becoming steadily more a part of the modern way of life to promote health. After engaging in physical activity or exercise, the body has to be protected against mechanical stress and the potentially harmful effects of free radicals, whose production is boosted and can cause oxidative damage to macromolecules [2,3]. Protein may help athletes grow muscle, reduce weariness from activity, boost their immune systems, and more, so ensure their diet has enough of these items [4]. In addition to ensuring peak performance, a healthy diet helps avoid the “female athlete triad,” which consists of restricted food intake, irregular menstruation, and weak bones. Particularly young adolescent athletes have unique nutritional demands and requirements that need to be well watched. Therefore, for female adolescent athletes, replacing all or part of the cereal with nutritionally superior millets and other functional foods can provide all the necessary nutrients, including fiber, antioxidants, protein, carbohydrates, and vitamins, as well as micronutrients like calcium and iron [5].

High-protein bars are one of the product categories that is expanding the quickest on the market. These products are low in sodium and carbohydrates, high in fiber and protein (>20 g per serving), and rich in vitamins, minerals, and antioxidants. People who are actively engaged in physical activity and concerned about their health are particularly drawn to high-protein bars [6]. Nonetheless, an increasing number of purchasers indicate a desire to increase their intake of protein. A few of them believe that having a bar rather than a meal would help them control their weight since they are overweight and do not have enough time to make a traditional meal. Others just want a fast snack to keep them from becoming hungry [7].

The goal of this study was to develop bars that are protein-rich bar (PB). To assess the organoleptic evaluation, fortified bars were first examined. Then, proximate, mineral, and antioxidant analyses were performed on a chosen variant of the protein-rich bar in comparison to the Control bar (CB). We were following a three-month period of bar supplementation to evaluate the work performance of adolescent swimmers girls.

2. MATERIALS AND METHODS

2.1 Procurement of Raw Materials

The raw materials like chickpea, soy protein, proso millet, foxtail millet, oat flakes, rolled oats, rice flakes, figs, almonds, dried apricot, watermelon seeds, pumpkin seeds, jaggery, honey, and ghee were procured from the market of Banasthali, Rajasthan.

2.2 Developed Bars

The three variants of Protein-rich bars (PB1, PB2, PB3) with CB were developed by using various ingredients at different amounts as shown in Table 1. These were prepared in the Cooking Laboratory of Banasthali Vidyapith, Rajasthan. The different Protein-rich bars and a CB were evaluated for their organoleptic evaluation.

Table 1. Ingredients of Protein-Rich Bars with Control Bar

Ingredients (100 g)	CB	PB1	PB2	PB3
Chickpea (g)	-	5	-	10
Soy Protein (g)	-	5	10	-
Proso Millet (g)	-	5	-	10
Foxtail Millet (g)	-	5	10	-
Oat Flakes (g)	-	10	10	10
Rolled Oats (g)	20	-	-	-
Rice Flakes (g)	20	10	10	10
Figs (g)	10	10	10	10
Almonds (g)	5	5	5	5
Dried Apricot (g)	10	10	10	10
Watermelon Seeds (g)	5	5	5	5
Pumpkin Seeds (g)	5	5	5	5
Jaggery (g)	10	10	10	10
Honey (ml)	10	10	10	10
Ghee (g)	5	5	5	5

CB = Rolled oats – 20 g, Rice flakes – 20 g;
PB1 = Chickpea – 5 g, Soy protein – 5 g, Proso millet – 5 g, Foxtail millet – 5 g, Oat flakes – 10 g, Rice flakes – 10 g;
PB2 = Soy protein – 10 g, Foxtail millet – 10 g, Oat flakes – 10 g, Rice flakes – 10 g; and
PB3 = Chickpea – 10 g, Proso millet – 10 g, Oat flakes – 10 g, Rice flakes – 10 g

2.3 Organoleptic Evaluation

A panel of experts rates the quality of the bars as part of the organoleptic evaluation. The evaluation process includes measuring, analyzing, and evaluating the properties of bars as perceived by the senses of taste, smell, touch, and hearing. The panel involves 30 members who were selected based on the triangle difference test. The bar's acceptance is decided using the 9-point hedonic scale performa. To evaluate several protein-rich bars with a CB created by incorporating different components at varied amounts, a panel of 25 semi-trained individuals was chosen [8].

The proximate, mineral, and antioxidant activity was done on a selected variant of a Protein-rich bar (PB1) by organoleptic evaluation and a CB.

2.4 Proximate and Mineral Analysis

The moisture content of the bars was determined using a moisture analyzer (Air oven). Ash level of the bars after 6 hours at 550° C in the muffle furnace. The total protein content of the bars was measured using the Kjeldahl technique. The Soxhlet equipment was used to calculate the crude fat. By using an acid and alkali treatment procedure, the crude fiber was calculated. To compare the approximate composition of the bars, the total contents of moisture, ash, protein, crude fat, and crude fiber were subtracted from 100 to find the number of carbohydrates (CHO). The bars' mineral content was evaluated using Wong's method for iron and the titrimetric method for calcium [9,10].

2.5 Antioxidant Activity

The DPPH (1, 1-diphenyl-2-picryl hydrazyl) technique and TPC (total phenolic content) technique, as reported by AlJaloudi [11], and the titrimetric method were used to analyze the antioxidant activity of the bar using vitamin C [10].

2.6 Work Performance Evaluation

2.6.1 Selection of subject

As Banasthali Vidyapith is a fully residential educational university for girls, 100 adolescent swimmers' girls between the ages of 17-19 who were beginner swimmers who had just recently started swimming within a month or two months were included in the study. A total of 100 adolescent swimmers girls were divided into two groups: the control group and the experimental group.

2.6.2 Inclusion and exclusion criteria

The following requirements were met to include research participants: (i) They had to follow a vegetarian diet; (ii) They couldn't be fasting; (iii)

They couldn't be on any special diets; (iv) Respondents were willing to take part in the research; and (v) Individuals who exclusively swim for an hour.

The following requirements were met to exclude research participants: (i) They did not include in any other physical activity; (ii) They skipped any meal.

2.7 Pre- and Post-Intervention of Supplementation of Developed Bars

The groups were made aware of the study beforehand, and their participation was guaranteed by obtaining an "Informed Consent Form" from each of them. There has been a pre- and post-intervention were done on both groups for 3 months. The Control group (n=50) supplemented the CB, and the Experiment group (n=50) supplemented the selected variant of the Protein-rich bar (PB1). Every participant in both groups was administered one bar of 50 g each day. The effects of supplementation were investigated by evaluating the pre-and post-intervention of the subjects.

2.7.1 Anthropometry test

A height rod was used to measure height without a bare foot, to the closest 0.1 cm. The participants' body weights were measured using an electronic scale with a sensitivity of 0.1 kg. The competitors were simply wearing shorts and a T-shirt, and they had no shoes on. The body weight in kilograms (kg) divided by the square of the participants' height in meters (kg/m^2) yielded the body mass index (BMI) [12].

2.7.2 Sit and reach test

The participants' knees were stretched, their legs were seated together, and their soles were pressed up to the box's edge. Next, the participants raised their arms and stacked one hand on top of the other. They extended their hands, palms down, as far as they could without bending their knees along the measuring scale. The first test administrator made sure to check that the knees were completely extended and that the heel stayed at the 35 cm mark for the whole test. Using the scale located on the left side of the reach indicator, scores were recorded in centimeters to the closest 0.5 cm [13].

2.7.3 Hand grip strength test

An adjustable-grip hand dynamometer was employed. Using the ideal grasp span, the subject does the test with both hands in turn, slowly and persistently pressing for at least two seconds. We used an algorithm we devised especially for adolescents to adapt the handgrip span based on hand size. Both the hand's individual highest score, expressed in kilograms, was noted. The study made use of the mean of the results obtained from each of the handgrip tests [14].

2.7.4 Nelson hand reaction time test

For the Nelson Hand Reaction Test, each participant was seated in a chair with their hands and forearms comfortably positioned on the Table 1. The thumb and index fingers of the hand were positioned with their upper halves parallel to the Table 1, 8-10 cm above the surface. The test supervisor positioned and held a ruler between each participant's thumb and index finger. The supervisor gave the participants instructions to stare at the ruler's center point directly and to grab it when it was released. At the moment the participant caught the value shown on the upper portion of the ruler, it was recorded. After taking five measurements and removing the best and worst values, the average of the remaining three readings was determined. This resulted in the measurement of the distance the ruler dropped. The values on the ruler were computed for each measurement using the formula below, and the participants' response times were also computed. The formula: [15]

$$\text{R.T.} = \sqrt{\frac{2 * \text{ Distance the stick (timer) falls (in ft.)}}{32 \text{ (Acceleration gravitational constant)}}}$$

where, R.T. = Reaction Time (sec.)

2.7.5 Tuttle pulse ratio test

The participant's resting heart rate was measured while seated for one minute. It is guaranteed that the individual did not exercise for at least an hour prior to the count. Following the measurement of their resting pulse, the participant was instructed to move up and down a 13-inch-high stool at a pace of 30 steps per minute. Four counts to one full step up and down are spoken, which helps the subject maintain the appropriate tempo. To help the participant, the test should be administered using either a metronome set at a cadence of 30*4=120 per minute or a tape recorder counting 1-2-3-4 for each step at a rate of 30 step-ups for one minute. After doing 30 step-ups in a minute, the participant requested a seat. For two minutes, the pulse rate is promptly and constantly counted. The two-minute pulse count after exercise is divided by the one-minute resting pulse count to get the pulse ratio. The Tuttle Pulse Ratio score is the name given to this ratio [16].

2.8 Statistical Analysis

The IBM SPSS Statistics software was used to statistically process the data. The triplicate determinations' mean±standard deviation (SD) was used to express the results. The One-Way Analysis of Variance (ANOVA) test is used to compare means and examine differences in the sensory evaluation of developed bars in order to assess the significance level at 5%. Findings on proximate, mineral, and antioxidant activity were compared at the significant level at 5% probability level ($p<0.05$), as well as pre-and post-intervention within each group using an Unpaired T-Test.

3. RESULTS AND DISCUSSION

3.1 Organoleptic Evaluation

Table 2 illustrates the organoleptic evaluation of the developed bars. Along with a CB, three distinct Protein-rich bar variants (PB1, PB2, and PB3) were examined for color, appearance, texture, taste, aroma, and overall acceptability. In color attribute, CB and PB2; in appearance PB1; in texture PB3; in taste and aroma PB1 indicates the highest score. The overall acceptability was noted for PB1, which was followed by PB2, PB3, and the CB in that order. The mean of the standard deviation of each attribute in different formulated bars used in the sensory evaluation showed a significant difference ($p<0.05$).

Abdel-Salam's study developed high-energy protein bars whose organoleptic evaluation revealed that bars containing sweet potato flour have the highest score of odor, texture, and taste. The degree of sensory acceptability of bars is associated with various ingredients (such as oats, rice flakes, and dried fruit) and binders (such as honey and glucose syrup) [17]. Mathur and Kumari's study prepared multigrain fibre and protein-enriched composite bars. They found that incorporating puffed amaranth and oats in the bar has the highest overall acceptability [18]. Mukherjee's study developed protein-rich flavored bar with dates, oats, flaxseeds, sesame seeds, pumpkin seeds, peanut powder, and honey in three different treatments of cocoa powder, guava flavor, and orange flavor. Its study revealed that bar formulated with dates, oats, flaxseeds, sesame seeds, pumpkin seeds, peanut powder, and honey with cocoa powder have scored the highest attributes in terms of color, appearance, body, texture, flavor, taste, and overall acceptability [19].

3.2 Proximate and Mineral Analysis

Table 3 and Fig. 1 illustrates the proximate and mineral analysis of the developed bars. CB and PB1 were examined for moisture, ash, protein, crude fat, crude fiber, CHO, iron, and calcium. PB1 had a better amount of nutrient composition than CB. The mean of the standard deviation of each proximate and mineral analysis in different developed bars showed a significant difference ($p<0.05$).

3.2.1 Moisture content

The low moisture content suggests a longer shelf life and ease of storage. Almost all meals contain water, therefore it is crucial for several microbiological and chemical processes. It also significantly affects food quality, freshness, and microbiological resistance [20]. The moisture content (100 g) of developed bars in our study was found to be good in CB (8.9%) than in PB1 (10.2%). This outcome is quite similar to the 8.53% value from cereal bars including quinoa, flaxseed, and fruits that Kaur's study got [21]. In another study, developed a high-energy protein date-based bar, the moisture content was 11.22% [22].

3.2.2 Ash content

Food products' ash content, an inorganic element, is a crucial component of their quality and indicates the presence of minerals [23]. In our study, the crude ash content (100 g) was found to be higher in PB1 (3.7%) than in CB (1.4%). The study conducted by Jabeen developed energy-rich protein bars with dates, dried apricot, chickpea gram, and rice flour. The ash ranged from 2.12%-2.44% [24]. Zahra's study found that when the apricot content (12 g) increased, so did the ash content of nutri-bars, rising to 3.50% [25]. Allai's study showed the lowest ash content which is 1.67%-1.72% in protein-rich pregelatinized whole grain cereal bar [26].

Table 2. Sensory Evaluation of Developed Bars

Attributes	Products			
	CB	PB1	PB2	PB3
Color	8.1±0.03*	8.0±0.12*	8.1±0.05*	7.9±0.01*
Appearance	8.0±0.02*	8.6±0.24*	8.4±0.01*	8.5±0.13*
Texture	7.5±0.11*	8.5±0.16*	8.5±0.04*	8.6±0.02*
Taste	7.1±0.13*	9.0±0.15*	8.7±0.21*	8.6±0.06*
Aroma	7.5±0.21*	8.5±0.12*	8.3±0.25*	8.4±0.32*
Overall Acceptability	7.5±0.32*	9.2±0.19*	8.5±0.07*	8.4±0.21*

*Values are expressed as mean±SD, n=3. Values followed by * are significant difference ($p<0.05$)*

Table 3. Proximate and Mineral Analysis of Developed Bars

Proximate and Mineral Analysis (100 g)	Products	
	CB	PB1
Moisture (%)	8.9±0.03*	10.2±0.66*
Ash (%)	1.4±0.01*	3.7±0.27*
Protein (g)	8.3±0.35*	22.3±0.74*
Crude Fat (g)	11.3±0.13*	13.1±0.41*
Crude Fiber (g)	9.3±0.56*	11.5±0.02*
CHO (g)	61.0±0.21*	39.4±0.19*
Iron (mg)	3.6±0.01*	4.4±0.15*
Calcium (mg)	54.2±0.04*	82.4±0.21*

*Values are expressed as mean±SD, n=3. Values followed by * are significant difference ($p<0.05$)*

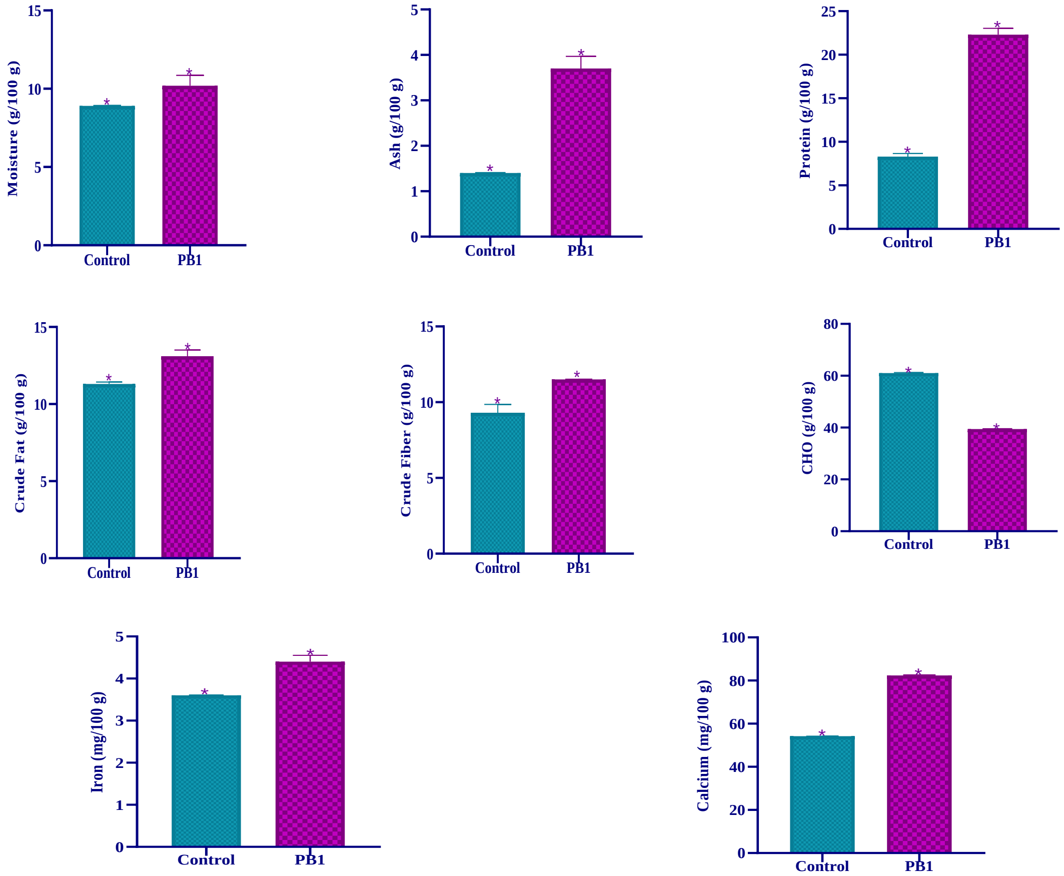

Fig. 1. Proximate and Mineral Analysis of Developed Bars

3.2.3 Protein content

The highest protein content (100 g) in the present study in PB1 (22.3 g) due to the addition of different pulses, millets, and cereals and lowest in the CB (8.3 g). When compared to the findings of earlier research on millet bars, the PB1 variants had a larger protein content. Samuel and Peerkhan's study found 15.74-18.32 g of protein in the developed pearl millet protein bar [27]; Vahini's study found 11.1 g of protein in the developed millet bar [5]; Sobana's study found 13.7 g of protein content in the developed composite sport bar (made from different millets, pulses, cereal, seeds, nuts, and sweeteners) [28]. Similar findings were found to be in the study of Chaudhary's study, they formulated a granola bar, and the protein content ranged from 21.0-23.0 g in 100 g [29].

3.2.4 Crude fat content

The crude fat content (100 g) was higher in PB1 (13.1 g) than in the CB (11.3). Szydłowska's study reported fat content of 19.1-23.0 g in different musli bars, pumpkin bars, and coconut bars [6]. Rafiu's study prepared high fibre cereal bar. The fat content was 7.31%-10.72%, they did not include any type of seeds. Incorporating different ingredients in bars decides the fat content and it increases by adding seeds and nuts [30].

3.2.5 Crude fiber content

The crude fiber content (100 g) of our study was found good in PB1 (11.5 g) and low in CB (9.3 g). Similar findings were found in the study, that prepared snack bars from African breadfruit, maize, and coconut blends [31]. As discussed in Ojha and Meethal's study, found lower crude fiber content in the developed gluten-free cereal bar with the utilization of buckwheat, proso millet, and amaranth and snack bars by using jackfruit seed flour and ragi flour than our study. The ranges between 3.92-7.11 g in gluten-free cereal bars and 7.56-9.66% in the snack bars [32,33].

3.2.6 CHO content

A good amount of CHO content (100 g) was found in PB1 (39.4 g) and higher in CB (61.0 g) in our study. The lower CHO content in food may lower the risk of diseases like diabetes, and heart disease. The higher CHO content range between 57.67-66.41 g in nutrition bar enriched with spirulina, bengal gram, peanuts, corn flakes, puffed rice, jaggery, liquid glucose, ghee, and coconut flakes, and in the Control bar the range 71.78 g in this all ingredients were same but spirulina powder were not incorporated [34]. The lower CHO content was found that similar to our study. The range is 29% on the nutri-composite bar made by using foxtail millet [35].

3.2.7 Iron content

An important dietary mineral called iron (Fe) is needed to sustain several critical human processes, including erythropoiesis, the metabolism of cellular energy, and the growth and operation of the immune system [36]. The iron content (100 g) was present in (4.4 mg) in PB1 and (3.6 mg) in CB which means PB1 found a good result in our study. Zainal's study prepared *Canavalia ensiformis* tempeh energy bar. In this iron was present in the range of 1.00-2.82 mg/kg [37]. Samuel and Peerkhan's found 4.36-6.36 mg/kg of iron content in the developed pearl millet protein bar [22].

3.2.8 Calcium content

Calcium is necessary for maintaining strong teeth and bones as well as for nerve function, muscular contraction and relaxation, and immune system function [38]. The calcium content (100 g) was present in (82.4 mg) in PB1 and (54.2 mg) in CB which means PB1 found a good result in our study. Similar findings were found in another study. The range of calcium was 51.88-86.92 mg in sesame seed-enriched bars [39]. Eke-Ejiofor and Okoye's study found very low calcium content in the prepared cereal bars ranged from 38.47-59.93 mg/kg [40].

3.3 Antioxidant Activity

Table 4 and Fig. 2 illustrates the antioxidant activity of the developed bars. CB and PB1 variants of the developed bar were examined for DPPH, TPC, and vitamin C analysis. As according to the analysis PB1 had good antioxidant activity as compared to the CB. The mean of the standard deviation of each antioxidant activity in different developed bars showed a significant difference ($p<0.05$).

3.3.1 DPPH

The DPPH inhibition (%) of the highest antioxidant activity was found in PB1 (47.6%), whereas the CB had the lowest DPPH inhibition

(18.9%). The highest DPPH inhibition (%) in the developed bar between the range of (32.28%-50.47%) while (9.21%) in the control sample [11]. A study developed different oat bars by using oat flakes, sunflower seeds, chickpea seeds, sesame seeds, pumpkin seeds, flaxseeds, dried apricot, dried plum, raisins, cinnamon, sucrose, glucose syrup, and water. They found the DPPH inhibition (%) in the range of 17.33%-23.02% in the developed bars [41].

3.3.2 TPC

The TPC (mg GAE/100 g) of the highest antioxidant activity was found in PB1 (53.1), whereas the CB had the lowest TPC (mg GAE/100 g) (15.3). The highest TPC (mg GAE/100 g) in the developed bar between the range of (46.56-56.56) while (13.59) in the control sample [11]. Strong antioxidant activity found in phenolic compounds helps to prevent degenerative illnesses and slow down the aging process. In one study, developed eight different variants of protein-polyphenol-fibre bars from protein powders, vegetable oil (rapeseed oil, sunflower oil), coconut powder, Dutch cocoa powder, cookies, vanilla powder, maltodextrin, soy lecithin, freeze-dried strawberries, and bananas. The TPC (mg GAE/100 g) of these eight variants between the range (66.89-103.04) [42]. Rajagukguk's study developed a pulse-based snack bar enriched with *Lactiplantibacillus plantarum*. They found the TPC (mg GAE/100 g) (293.16) in a chickpea-based snack bar and (305.90) in a lentil-based snack bar [43]. According to Meng's study, there was a range of phenolic content of 193.3-678.4 mg GAE/100 g in the various varieties of raisins and 839-890 mg GAE/100 g in dried apricots [44].

3.3.3 Vitamin C

The vitamin C (mg/100 g) of the highest antioxidant activity was found in PB1 (11.2), whereas the CB had the lowest (7.7). Antioxidant vitamin C is important for the body's biochemical and molecular processes. The vitamin helps in its absorption via interacting with other nutrients like iron and copper. In one study, vitamin C (g/100 g) content ranged between (8.76-21.16) in baobab based ready-to-eat sorghum and cowpea blend snack bars [45]. Silva's study developed snack bars added of jerivá flour. The vitamin C (mg/g) content of this bar was (35.31-40.81) and 34.36 in the control bar. Concerning the amount of jerivá flour added, there was a consistent rise in the vitamin C content as the flour concentration increased [46].

Table 4. Antioxidant Activity of Developed Bars

Antioxidant Activity	Products	
	CB	**PB1**
DPPH Inhibition (%)	18.9±0.05*	47.6±0.31*
TPC (mg GAE/100 g)	15.3±0.15*	53.1±0.11*
Vitamin C (mg/100 g)	7.7±0.00*	11.2±0.19*

*Values are expressed as mean±SD, n=3. Values followed by * are significant difference (p<0.05)*

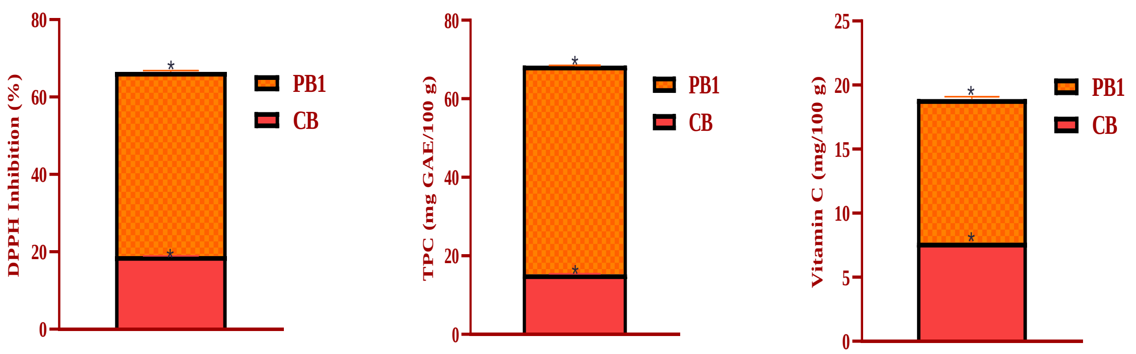

Fig. 2. Antioxidant Analysis of Developed Bars

Table 5. Pre-and Post-Intervention of Developed Bars in Different Groups

Test	Control Group		Experiment Group	
	Pre	Post	Pre	Post
Height (m)	1.61±1.24 [ns]	1.64±0.09[ns]	1.56±0.08 [ns]	1.58±1.01 [ns]
Weight (kg)	55.2±4.89*	57.8±5.21*	56.2±5.03*	61.9±6.16*
BMI (kg/m^2)	22.2±1.63*	24.1±2.24*	21.7±1.60*	24.9±3.31*
Sit and Reach Test (cm)	26.9±1.89*	29.2±3.34*	27.1±2.29*	32.3±1.19*
Right-Hand Grip Strength Test (kg)	29.5±3.52*	32.1±2.45*	26.1±2.16*	33.4±1.09*
Left-Hand Grip Strength Test (kg)	22.2±1.00*	23.4±0.08*	25.6±1.19*	28.9±2.16*
Nelson Hand Reaction Time Test (sec)	2.5±0.08*	3.0±1.01*	2.4±0.03*	3.3±0.16*
Tuttle Pulse Ratio Test	1.9±0.01*	2.3±0.92*	2.0±0.03*	3.0±1.06*

*Values are expressed as mean±SD, n=50. Values followed by * are significant difference (p<0.05) and [ns] are not significant difference (p<0.05)*

3.4 Pre- and Post-Intervention of Supplementation of Developed Bars

Table 5 illustrates the means for the control and experimental groups of height, weight, and BMI, both before and following the study's assessment of supplemented developed bars for 3 months. Based on the pre-and post-intervention of the control group, the average height was 1.61±1.24 and 1.64±0.09 m and the experiment group was 1.56±0.08 and 1.58±1.01 m respectively. The control group's mean weight for pre-intervention (55.2±4.89 kg) and post-intervention (57.8±5.21 kg) and the experiment group's mean weight for pre-intervention (56.2±5.03 kg) and post-intervention (61.9±6.16 kg) respectively. In terms of pre-and post-intervention, the control group's mean BMI was 22.2±1.63 and 24.1±2.24 kg/m^2, and the experiment group's mean BMI was 21.7±1.60 and 24.9±3.31 kg/m^2 respectively. A statistical study of the pre-and post-intervention of the control and experiment group revealed that the findings were significant difference (p<0.05) except for height and the results depicted that after the supplementation of the developed bars the BMI was more increased in the experiment group than the control group.

Similarly, Table 5 illustrates the means for the control and experimental groups of the sit-and-reach test, right- and left-hand grip strength test, Nelson hand reaction time test, and Tuttle pulse ratio test both before and following the study's assessment of supplemented developed bars for 3 months. The pre-and post-intervention of the control group's mean of sit and reach test was 26.9±1.89 and 29.2±3.34 cm, the right-hand grip strength test was 29.5±3.52 and 32.1±2.45 kg, the left-hand grip strength test was 22.2±1.00 and 23.4±0.08 kg, Nelson hand reaction time test was 2.5±0.08 and 3.0±1.01 sec, and Tuttle pulse ratio test was 1.9±0.01 and 2.3±0.92 respectively. Based on the pre-and post-intervention of the experiment group's mean of sit and reach test was 27.1±2.29 and 32.3±1.19 cm, the right-hand grip strength test was 26.1±2.16 and 33.4±1.09 kg, the left-hand grip strength test was 25.6±1.19 and 28.9±2.16 kg, Nelson hand reaction time test was 2.4±0.03 and 3.3±0.16 sec, and Tuttle pulse ratio test was 2.0±0.03 and 3.0±1.06 respectively. A statistical study of the pre-and post-intervention of the control and experiment group revealed that the findings were significant difference (p<0.05) and the results depicted that after the supplementation of the developed bars, the physical performance of adolescent girls was more increased in the experiment group than the control group.

Akınoğlu's study reported BMI ranged from 20.69±2.41 kg/m^2 and sit and reach test 18.50±7.02 cm of 15 years adolescent female athletes [47]. The right-hand grip strength test ranged was 28.00±3.817 kg and the left-hand grip strength test ranged was 26.00±2.976 kg of adolescent swimmer's females [48]. Konai's study reported reaction time test ranged was 0.163±0.015 for football players and 0.176±0.014 for cricket players between 14-16 years of female [49]. Elbel's study reported Tuttle pulse-ratio test in men was 2.66±0.26 [50].

4. CONCLUSION

In conclusion, this study investigated the developed bars were found to contain a balanced combination of nutrients, and antioxidant activity which are essential for sustained energy release and muscle recovery. This suggests that these bars can serve as a convenient and effective nutritional supplement for adolescent swimmers, providing the necessary fuel for their rigorous training regimes. Secondly, the consumption of the developed bars was associated with improved work performance among adolescent swimmers' girls. Participants who consumed PB1 bar demonstrated improved higher overall performance compared to those who consumed the CB bar. This indicates that the nutritional content of the developed bars played a significant role in enhancing the girls' work capacity and athletic performance. Overall, this study provides valuable insights into the role of nutritional supplementation in optimizing the work performance of adolescent swimmers' girls, highlighting the importance of balanced nutrition in supporting athletic endeavors during adolescence.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

CONSENT

As per international standards or university standards, Participants' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Jodhun BM, Pem D, Jeewon R. A systematic review of factors affecting energy intake of adolescent girls. African Health Sciences. 2016;16(4):910-922.
2. Chauhan ES, Chaudhary M, Singh R. Effects of ergogenic supplements and dietary supplements on young athletes' performance: A review. Scientific Journal of Sport and Performance. 2022;1(2):71-82.
3. Jovanov P, Sakač M, Jurdana M, Pražnikar ZJ, Kenig S, Hadnađev M, Marić A. High-protein bar as a meal replacement in elite sports nutrition: a pilot study. Foods. 2021;10(11):2628.
4. Liu S, Wen N, Su H. Influence of high-protein food on physical function of athletes. Journal of Food Quality. 2022;2022:4447061.
5. Vahini V. Nutritional and microbiological assessment of nutrient enriched millet bar for adolescent female athletes. International Journal of Engineering and Scientific Research. 2018;8(1):204-208.
6. Szydłowska A, Zielińska D, Łepecka A, Trząskowska M, Neffe-Skocińska K, Kołożyn-Krajewska D. Development of functional high-protein organic bars with the addition of whey protein concentrate and bioactive ingredients. Agriculture. 2020;10(9):390.
7. Harwood WS, Drake M. Understanding implicit and explicit consumer desires for protein bars, powders, and beverages. Journal of Sensory Studies. 2019;34(3):e12493.
8. Chaudhary M, Singh R, Chauhan ES, Sharma M. Evaluation of nutraceutical of enriched Bread. International Journal of Agriculture, Environment and Biotechnology. 2023;16(4):231-239.
9. Sharma S. Experiments and techniques in biochemistry. New Delhi, Galgotia Publications; 2007.
10. Raghuramulu N, Madhavan Nair K, Kalyanasundaram S. A manual of laboratory techniques (2nd eds.). National Institute of Nutrition, Hyderabad (India); 2003.
11. AlJaloudi R, Al-Dabbas MM, Hamad HJ, Amara RA, Al-Bashabsheh Z, Abughoush M, Choudhury IH, Al-Nawasrah BA, Iqbal S. Development and characterization of high-energy protein bars with enhanced antioxidant, chemical, nutritional, physical, and sensory properties. Foods. 2024;13(2):259.
12. Şebnem CŞ, İsmail G, Yakup A. The effects of a 12-week-swimming training on

some anthropometric parameters and hand grip strength of female elementary school students. The Annals of the "Ştefan Cel Mare" University. 2013;6(1):12-16.

13. Ayala F, de Baranda PS, Croix MDS, Santonja F. Reproducibility and criterion-related validity of the sit and reach test and toe touch test for estimating hamstring flexibility in recreationally active young adults. Physical Therapy in Sport. 2012;13(4):219-226.
14. Ortega FB, Artero EG, Ruiz JR, Vicente-Rodriguez G, Bergman P, Hagströmer M, Castillo MJ. Reliability of health-related physical fitness tests in European adolescents. The Helena Study. International Journal of Obesity. 2008;32(5):S49-S57.
15. Kanlı K, Yerlikaya T, Angın S. The relationship between grip strength and reaction time in different age groups. Cyprus Journal of Medical Sciences. 2023;8(5):360-364.
16. Renjith TA, Kumar KBS. Dissect the acute effect of aerobic dance on cardiovascular endurance among young women. International Journal of Physiology, Nutrition and Physical Education. 2018;3(2):736-738.
17. Abdel-Salam FF, Ibrahim RM, Ali MI. Formulation and evaluation of high energy-protein bars as a nutritional supplement for sports athletics. American Journal of Food and Technology. 2022;10(1):53-65.
18. Mathur M, Kumari A. Development and evaluation of multigrain fibre and protein enriched composite bars. The Pharma Innovation Journal. 2022;11(4):30-41.
19. Mukherjee K, Anisha V, Barla N. Development of protein rich flavored bar. International Journal for Research in Applied Science & Engineering Technology. 2021;9(12):104-107.
20. Zambrano MV, Dutta B, Mercer DG, MacLean HL, Touchie MF. Assessment of moisture content measurement methods of dried food products in small-scale operations in developing countries: A review. Trends in Food Science and Technology. 2019;88:T484-496.
21. Kaur R, Ahluwalia P, Sachdev PA, Kaur A. Development of gluten-free cereal bar for gluten intolerant population by using quinoa as major ingredient. Journal of Food Science and Technology. 2018;55:3584-3591.
22. Alfheeaid HA, Barakat H, Althwab SA, Musa KH, Malkova D. Nutritional and physicochemical characteristics of innovative high energy and protein fruit-and date-based bars. Foods. 2023;12(14):2777.
23. Ismail BP. Ash Content Determination. Food Analysis Laboratory Manual. 2017;117-119.
24. Jabeen S, Javed F, Hettiarachchy NS, Sahar A, Sameen A, Khan MR, Siddeeg A, Riaz A, Aadil RM. Development of energy-rich protein bars and in vitro determination of angiotensin I-converting enzyme inhibitory antihypertensive activities. Food Science and Nutrition. 2022;10(4):1239-1247.
25. Zahra SM, Nadeem M, Hussain S, Qureshi TM, Din A, Rashid F. Development and evaluation of nutri-bars for internally displaced people in humanitarian emergencies. Journal of Agricultural Research. 2014;52(2):217-226.
26. Allai FM, Dar BN, Gul K, Adnan M, Ashraf SA, Hassan MI, Pasupuleti VR, Azad ZRAA. Development of protein rich pregelatinized whole grain cereal bar enriched with nontraditional ingredient: nutritional, phytochemical, textural, and sensory characterization. Frontiers in Nutrition. 2022;9:870819.
27. Samuel KS, Peerkhan N. Pearl millet protein bar: nutritional, organoleptic, textural characterization, and *In vitro* protein and starch digestibility. Journal of Food Science and Technology. 2020;57(9):3467-3473.
28. Sobana RM. Quality evaluation of millet based composite sports bar. International Journal of Food Science and Nutrition. 2017;2(4):65-68.
29. Chaudhary M, Singh R, Chauhan ES. Nutritional properties and organoleptic evaluation of formulated granola bar. International Journal of Food and Fermentation Technology. 2022;12(1):41-45.
30. Rafiu A, Hassan CZ, Arifin N, Asma AR. Physico-chemical analysis of high fibre cereal bar formulated with glutinous rice flakes and sunnah foods. Journal of

Advances in Food Science and Technology. 2015;2(2):47-58.

31. Edima-Nyah AP, Nwabueze TU, Ojimelukwe PC. Development and quality evaluation of snack bars from African breadfruit (*Treculia africana*), maize (*Zea mays*) and coconut (*Cocos nucifera*) blends. Journal of Scientific and Engineering Research. 2019;6(5):74-83.
32. Ojha P, Adhikari A, Manandhar U, Maharjan S, Maharjan S. Utilization of buckwheat, proso millet, and amaranth for a gluten-free cereal bar. Indonesian Food Science and Technology Journal. 2022;5(2):57-62.
33. Meethal SM, Kaur N, Singh J, Gat Y. Effect of addition of jackfruit seed flour on nutrimental, phytochemical and sensory properties of snack bar. Current Research in Nutrition and Food Science Journal. 2017;5(2):154-158.
34. Kumar A, Mohanty V, Yashaswini P. Development of high protein nutrition bar enriched with *Spirulina plantensis* for undernourished children. Current Research in Nutrition and Food Science Journal. 2018;6(3):835-844.
35. Bukya A, Ankush SA, Nagesh GD. Development, characterization and optimization of cereal, legume and millet incorporated nutri-bar and its storage studies. International Journal of Scientific Research. 2018;7(3):81-83.
36. Weyh C, Krüger K, Peeling P, Castell L. The role of minerals in the optimal functioning of the immune system. Nutrients. 2022;14(3):644.
37. Zainal ANA, Mohd ZZ, Abdullah MAA, Rusli ND, Zainol MK. Physicochemical properties and sensory acceptance of *Canavalia ensiformis* tempeh energy bar. Food Research. 2020;4(5):1637-1645.
38. Orngu OA, Mbaeyi-Nwaoha IE. Development and quality evaluation of a cereal-based breakfast product from yellow maize (*Zea mays*), sesame (*Sesamum indicum*) and mushroom (*Pleurotus ostreatus*) flour blends. International Journal of Food Science & Technology. 2022;57(6):3750-3759.
39. Irshad Z, Aamir M, Akram N, Asghar A, Saeed F, Ahmed A, Teferi Asres D. Nutritional profiling and sensory attributes of sesame seed-enriched bars. International Journal of Food Properties. 2023;26(2):2978-2994.
40. Eke-Ejiofor J, Okoye C. Nutrient composition, lipid profile and sensory properties of cereal bar made from locally available cereals and nuts. International Journal of Biotechnology and Food Science. 2018;6(1):1-8.
41. Omran AA. Enhancing the nutritional value of oat bars. American Journal of Food Science and Technology. 2018;6(4):151-160.
42. Jolji M, Pecsenye B, Mposula Z, Aleya A, Kiss T, Mathé E. Development and comparative analysis of protein-polyphenol-fibre bars as nutritional supplements suitable for healthy senior consumers. Acta Universitatis Sapientiae, Alimentaria. 2023;16(1):103-125.
43. Rajagukguk YV, Arnold M, Sidor A, Kulczyński B, Brzozowska A, Schmidt M, Gramza-Michałowska A. Antioxidant activity, probiotic survivability, and sensory properties of a phenolic-rich pulse snack bar enriched with *Lactiplantibacillus plantarum*. Foods. 2022;11(3):309.
44. Meng J, Fang Y, Zhang A, Chen S, Xu T, Ren Z, Han G, Liu H, Zhang Z, Wang H. Phenolic content and antioxidant capacity of Chinese raisins produced in Xinjiang Province. Food Research International. 2011;44(9):2830-2836.
45. Momanyi D, Owino W, Makokha A. Formulation, nutritional and sensory evaluation of baobab based ready-to-eat sorghum and cowpea blend snack bars. Scientific African. 2020;7:e00215.
46. Silva EPD, Siqueira HH, Damiani C, Vilas Boas EVDB. Physicochemical and sensory characteristics of snack bars added of jerivá flour (*Syagrus romanzoffiana*). Food Science and Technology. 2016;36(3):421-425.
47. Akınoğlu B, Paköz B, Hasanoğlu A, Kocahan T. Investigation of the relationship between sit-and-reach flexibility and the height, the leg length and the trunk length in adolescent athletes. Baltic Journal of Health and Physical Activity. 2021;13(4):29-37.
48. Neogi A, Bandyopadhyay A, Dey SK. Anthropometric and physiological characteristics in young

Indian elite swimmers: A comparative study. Sports Medicine Journal/Medicina Sportivâ. 2016;12(2): 2762-2771.

49. Konai S, Barman T, Das M. Comparative study on kinesthetic perception and reaction time of 14-16 years football and cricket players. International Journal of Advanced Research. 2024;12(1):556-559.
50. Elbel ER, Reid KM, Ormond DE. Comparison of certain tests of physical fitness and certain bodily measurements. Journal of Applied Physiology. 1958;12(1): 37-41.

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