

Original Article

Effects of a High-Energy Nutritional Protein-Based Bar on the Performance of Young Athletes

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ABSTRACT

Background: Young athletes require adequate energy, carbohydrate, protein, fluid, and micronutrient intake to support training, recovery, growth, and health. Nutrient-dense sports foods may provide a convenient means of supplementing dietary intake, but claims regarding athletic performance require direct objective testing. **Objective:** To develop and nutritionally characterize a high-energy protein-based bar and describe its acceptability and self-reported performance-related perceptions among young athletes. **Methods:** A bar containing oats, kidney bean flour, peanut butter, dried berries, banana flour, sugar, glucose syrup, salt, and water was developed and analyzed for proximate composition, selected minerals, phenolic content, and sensory characteristics. Questionnaire data from 250 respondents were analyzed for demographic and sporting characteristics, dietary practices, perceived energy after bar consumption, fatigue, perceived endurance, product acceptability, and future-use intentions. **Results:** The bar contained 22.80±0.08% protein, 10.78±0.06% fat, 4.92±0.08% fiber, 4.45±0.05% ash, and 14.80±0.65% moisture. Corrected carbohydrate by difference was 42.25%, yielding an estimated energy value of approximately 357 kcal/100 g. Sixty percent of respondents reported perceived improvement in endurance or stamina, while 20% did not and 20% were unsure. Eighty percent would recommend the bar and 75.2% reported willingness to continue using it. **Conclusion:** The developed bar had substantial protein and energy content and was generally well accepted. Questionnaire findings represent perceived rather than objectively measured athletic-performance effects; controlled performance efficacy cannot be established from these data. **Keywords:** Protein Bar; Sports Nutrition; Young Athletes; Energy Intake; Protein; Athletic Performance; Functional Food.

INTRODUCTION

Appropriate nutrition is fundamental to athletic training, recovery, health, and performance. Athletes require sufficient total energy and appropriate provision of carbohydrate, protein, fat, fluids, and micronutrients according to training load, sport type, body composition, environmental conditions, and individual goals. Contemporary sports-nutrition guidance emphasizes that dietary requirements should be individualized and periodized according to the physiological demands of training and competition (1–3).

Young athletes represent a particularly important population because nutritional intake must simultaneously support physical activity, growth, maturation, and physiological development. A recent

systematic review and meta-analysis demonstrated important differences in energy and macronutrient intake among young athletes according to age, sex, and sport characteristics, while contemporary reviews emphasize that adolescent athletes may be particularly vulnerable to inadequate energy and nutrient intake (4,5). Persistent low energy availability can adversely affect multiple dimensions of athlete health and performance and is central to the contemporary framework of Relative Energy Deficiency in Sport (RED-S)(6).

Carbohydrate remains an important substrate for moderate- and high-intensity exercise, whereas dietary protein supplies amino acids required for tissue repair, remodeling, and adaptation to training. Protein requirements and responses to supplementation must nevertheless be considered within total dietary intake and the nature of the exercise stimulus (1,7). Similarly, evidence from systematic reviews indicates that acute carbohydrate provision can influence resistance-exercise and endurance performance, although responses depend on exercise characteristics, baseline nutritional status, and the quantity and timing of carbohydrate exposure (8,9).

The interaction between carbohydrate and protein is also relevant to sports nutrition. A systematic review and meta-analysis of randomized controlled trials examining combined carbohydrate and protein ingestion demonstrated that effects on athletic performance depend on exercise context, nutrient timing, total energy provision, and comparator conditions (10). Evidence regarding short-term recovery similarly suggests that carbohydrate availability is central to glycogen restoration, while addition of protein may provide specific benefits depending on the amount of carbohydrate consumed and the duration of recovery (11,12). Thus, a protein-containing snack may be nutritionally useful without necessarily producing a measurable ergogenic effect in every exercise setting.

Portable nutritional products may offer practical advantages to athletes who have limited opportunities for conventional meals around training. Expert sports-nutrition guidance generally favors a food-first approach while recognizing that appropriately selected sports foods can provide convenient nutritional support under specific training and competition circumstances (13). High-protein and high-energy bars have consequently been investigated as compact vehicles for providing protein, carbohydrate, dietary fiber, and other nutrients to physically active populations (14,15).

High-energy protein bars can be developed using cereals, legumes, nuts, seeds, dried fruits, protein concentrates, and other ingredients. Food-science studies demonstrate that ingredient selection and formulation influence proximate composition, antioxidant characteristics, physical properties, energy density, texture, and sensory acceptance (14,15). Accordingly, nutritional characterization and acceptability testing are important components of product development and should be distinguished from controlled demonstrations of ergogenic efficacy.

The present formulation incorporated whole oats and kidney bean flour as major dry ingredients. Oats contribute carbohydrate, protein, dietary fiber, and a range of phytochemical constituents, while their nutritional composition and functional properties make them suitable for incorporation into nutrient-dense food products (16). Kidney bean flour provided an additional plant-based ingredient, peanut butter contributed protein and lipid, and dried fruit and banana flour contributed carbohydrate and additional food-matrix components.

Protein-containing sports bars have also been evaluated experimentally. In a randomized counterbalanced crossover pilot study, Grubic et al. compared ingestion of a food bar containing whey protein and isomalto-oligosaccharides with carbohydrate supplementation during resistance exercise and sprint conditioning (17). Such investigations demonstrate that the physiological effects of a sports bar require assessment using defined exercise and recovery outcomes rather than nutritional composition or subjective preference alone.

More recent experimental and synthesized evidence has continued to evaluate protein- and peptide-based nutritional strategies in athletic populations. A randomized study of wheat-peptide supplementation in cross-country skiers evaluated metabolic and performance outcomes, while systematic-review evidence indicates that effects of protein intake on athletic performance vary according to outcome, exercise context, supplementation strategy, and participant characteristics (18,19). Recovery may also be influenced by the timing of nutritional intake, although the optimal strategy remains dependent on the exercise and recovery context (20). These findings reinforce the distinction between favorable nutritional composition, subjective responses, and objectively demonstrated improvements in athletic performance.

The present study therefore had two related components: development and laboratory characterization of a high-energy protein-based bar and assessment of its acceptability and self-reported performance-related perceptions among young athletes.

MATERIALS AND METHODS

Study Design

The study comprised a laboratory food-product development component and a questionnaire-based assessment of young athletes.

The study protocol also described a randomized two-group intervention. However, complete group-specific longitudinal performance outcomes were not available for the present analysis; consequently, the current report is restricted to laboratory characterization of the product and descriptive analysis of questionnaire responses from 250 individuals. Controlled randomized treatment-effect estimates were therefore not calculated.

Product Ingredients and Formulation

The product was formulated using whole oats, kidney bean flour, sugar, glucose syrup, peanut butter, dried berries, salt, water, and banana flour.

Table 1. Formulation of the High-Energy Protein Bar

Ingredient	Reported Quantity
Whole oats	12.50
Kidney bean flour	20.00
Sugar	24.00
Glucose syrup	12.50
Peanut butter	10.50
Dried berries	10.00
Salt	0.50
Water	6.00
Banana flour	4.00
Numerical total	100.00

Because different unit systems were used for some ingredients, formulation values are presented as originally recorded and were not converted into a single unverified mass basis.

Preparation of Kidney Bean Flour

Kidney beans were sorted and washed and then soaked for approximately 12 hours. The soaking water was discarded, after which the beans were cooked in boiling water for approximately 15 minutes.

The cooked beans were dried in a hot-air oven for approximately 12 hours at 50°C, milled, passed through a 40-mesh sieve, and stored at approximately 4°C until product preparation.

Preparation of Banana Flour

Plant material used for flour preparation was sliced to approximately 5-mm thickness, treated with 0.5% citric-acid solution for approximately 30 minutes, dried for 12 hours at 50°C, milled, and passed through a 40-mesh sieve.

Bar Preparation

Dry ingredients were mixed to achieve uniform distribution. Peanut butter, sugar, water, and glucose syrup were heated to approximately 70°C for three minutes and subsequently combined with the dry ingredients.

The mixture was spread on a tray and cooled to approximately 28°C. The final product was cut into pieces measuring approximately 10 cm × 3.3 cm, with each bar weighing approximately 40 g. Bars were packaged in polyester film.

Laboratory Analyses

Laboratory measurements were conducted in triplicate using standard analytical procedures.

Moisture was determined gravimetrically after drying. Crude protein was determined using the Kjeldahl method with a Behr D-40599 system, and measured nitrogen was converted to crude protein using a factor of 6.25. Crude fat was determined using Soxhlet extraction, whereas crude fiber was determined using sequential acid and alkaline digestion. Ash was measured after incineration at approximately 550–600°C.

Carbohydrate was recalculated using the conventional difference equation:

Carbohydrate (%) = $100 - [\text{moisture} + \text{protein} + \text{fat} + \text{fiber} + \text{ash}]$.

Estimated metabolizable energy was calculated descriptively using 4 kcal/g for protein and carbohydrate and 9 kcal/g for fat.

For mineral analysis, approximately 0.5 g of sample was digested using nitric and perchloric acids in a 7:3 ratio and diluted to 100 mL. Calcium, sodium, and potassium were measured using flame photometry, while the other reported minerals were analyzed using atomic absorption spectrometry.

Total phenolic content was assessed using the Folin-Ciocalteu procedure. The Folin-Ciocalteu method is an established colorimetric approach for estimating total phenolic content, although the reaction is not chemically specific to individual phenolic compounds (21).

Questionnaire Assessment

Questionnaire data included 250 respondents. Recorded variables included age, sex, sporting activity, weekly sports participation, usual dietary pattern, frequency of protein-rich food consumption, previous use of protein bars, perceived energy before exercise, perceived energy after bar consumption, fatigue during intense exercise, perceived change in endurance or stamina, sensory characteristics, recommendation, and intended continued use.

Statistical Analysis

Questionnaire findings were summarized using descriptive statistics. The dataset did not contain complete participant-level pre/post performance outcomes required to estimate a randomized treatment effect. Consequently, causal or controlled efficacy estimates were not generated from the questionnaire responses.

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board of Superior University, Lahore, Pakistan.

RESULTS

Nutritional Composition

The developed bar contained $14.80 \pm 0.65\%$ moisture, $22.80 \pm 0.08\%$ protein, $10.78 \pm 0.06\%$ fat, $4.92 \pm 0.08\%$ crude fiber, and $4.45 \pm 0.05\%$ ash.

The carbohydrate value obtained in the initial analysis was mathematically inconsistent with the stated difference approach. Recalculation yielded:

$100 - (14.80 + 22.80 + 10.78 + 4.92 + 4.45) = 42.25\%$ carbohydrate.

Using standard 4-4-9 energy factors, the resulting estimated energy density was approximately 357 kcal/100 g. A 42-g portion would therefore provide approximately 150 kcal and 9.6 g crude protein.

Table 2. Laboratory Characterization of the Protein Bar

Parameter	Result
Moisture	$14.80 \pm 0.65\%$
Protein	$22.80 \pm 0.08\%$
Fat	$10.78 \pm 0.06\%$
Crude fiber	$4.92 \pm 0.08\%$
Ash	$4.45 \pm 0.05\%$
Corrected carbohydrate by difference	42.25%
Estimated energy	≈ 357 kcal/100 g
Estimated energy per 42-g serving	≈ 150 kcal
Estimated protein per 42-g serving	≈ 9.6 g
Total phenolic content	81.2 ± 0.73 mg GAE/100 g
Potassium	248.2 ± 0.04 mg/100 g
Phosphorus	348.4 ± 0.63 mg/100 g
Calcium	75.2 ± 0.04 mg/100 g
Magnesium	85.5 ± 0.65 mg/100 g
Sodium	10.4 ± 0.16 mg/100 g
Iron	5.0 ± 0.09 mg/100 g
Zinc	1.48 ± 0.07 mg/100 g

Participant Characteristics

Mean age among the 250 questionnaire respondents was 19.98 ± 3.17 years. Mean height was 176.27 ± 14.25 cm and mean weight was 67.99 ± 13.13 kg. A general performance-rating item had a mean value of 5.44 ± 2.79 on the study questionnaire.

Table 3. Sporting and Dietary Characteristics of the 250 Respondents

Variable	Category	n (%)
Sex	Female	108 (43.2)
	Male	126 (50.4)
	Other	16 (6.4)
Sport	Cricket	70 (28.0)
	Football	77 (30.8)
	Volleyball	59 (23.6)
	Other	44 (17.6)
Sports participation/week	<5 hours	50 (20.0)
	5–10 hours	100 (40.0)
	10–15 hours	62 (24.8)
	>15 hours	38 (15.2)
Usual dietary pattern	High protein	60 (24.0)
	Balanced	45 (18.0)
	Low carbohydrate	30 (12.0)
	Other	15 (6.0)
	No specific diet	100 (40.0)
Protein-rich food consumption	Daily	75 (30.0)
	3–4 times/week	100 (40.0)
	1–2 times/week	50 (20.0)
	Rarely	25 (10.0)
Previous protein-bar use	Yes	125 (50.0)
	No	125 (50.0)

Perceived Energy and Performance

Before exercise, 35.2% of respondents rated their energy as moderate and another 35.2% rated it as high. Following bar consumption, the distribution shifted descriptively toward higher energy ratings, with 40.0% reporting high and 24.8% very high perceived energy.

These distributions were not accompanied by participant-level paired statistical analysis and therefore represent descriptive rather than inferential evidence of change.

Table 4. Self-Reported Energy, Fatigue, and Endurance-Related Responses

Variable	Category	n (%)
Energy before exercise	Very low	13 (5.2)
	Low	25 (10.0)
	Moderate	88 (35.2)
	High	88 (35.2)
	Very high	36 (14.4)
Perceived energy after bar consumption	Very low	5 (2.0)
	Low	20 (8.0)
	Moderate	63 (25.2)
	High	100 (40.0)
	Very high	62 (24.8)
Fatigue during intense workouts	Never	25 (10.0)
	Rarely	50 (20.0)
	Sometimes	100 (40.0)
	Often	50 (20.0)
	Always	25 (10.0)
Perceived improvement in endurance/stamina	Yes	150 (60.0)
	No	50 (20.0)
	Not sure	50 (20.0)

Acceptability

Product acceptance was generally favorable. Taste was rated good or better by 212/250 respondents (84.8%). Texture was judged “just right” by 150 respondents (60.0%), and aroma was considered pleasant by 150 (60.0%).

Two hundred respondents (80.0%) reported that they would recommend the product, while 188 (75.2%) indicated willingness to continue using it.

Table 5. Product-Acceptability Responses

Variable	Category	n (%)
Taste	Poor	13 (5.2)
	Fair	25 (10.0)
	Good	100 (40.0)
	Very good	75 (30.0)
	Excellent	37 (14.8)
Texture	Too soft	50 (20.0)
	Just right	150 (60.0)
	Too hard	50 (20.0)
Aroma	Pleasant	150 (60.0)
	Neutral	75 (30.0)
	Unpleasant	25 (10.0)
Would recommend	Yes	200 (80.0)
	No	50 (20.0)
Would continue use	Yes	188 (75.2)
	No	62 (24.8)

DISCUSSION

The present study demonstrated successful development of a compact nutritional bar containing oats, kidney bean flour, peanut butter, fruit-derived ingredients, and carbohydrate sources. Laboratory analysis showed a protein concentration of 22.8%, while corrected carbohydrate by difference was 42.25%. The product was generally well accepted, and a substantial proportion of respondents reported favorable subjective perceptions of energy and endurance after consumption.

The protein concentration is relevant to sports nutrition because dietary protein supports exercise-induced tissue remodeling, muscle protein synthesis, and recovery when adequate total protein is consumed (7). Nutrient timing may further influence recovery and adaptation under particular conditions, although total daily intake remains a major determinant of nutritional adequacy (22). Meta-analytic evidence indicates that protein supplementation can augment resistance-training-induced improvements in muscle mass and strength, particularly when baseline intake and training stimulus are considered (23). The present findings nevertheless relate to product composition rather than a directly demonstrated anabolic or performance response.

Athletic performance is multifactorial and cannot be attributed to the protein content of a single product. Adequate energy availability, carbohydrate provision, hydration, recovery practices, training status, and sleep all contribute to health, adaptation, and performance (1,6,8,9). Hydration and glycogen status are particularly relevant during strenuous exercise and recovery (24), while systematic-review evidence also supports an important relationship between sleep interventions, recovery, and athletic performance (25). Consequently, nutritional interpretation of the present bar should remain embedded within the athlete's overall dietary and training context.

The estimated 42-g portion would provide approximately 9.6 g protein. This differs materially from the earlier nominal value of 6.8 g protein. Similarly, the calculated energy contribution of approximately 150 kcal per 42-g serving is substantially below the earlier value of 283 kcal. These corrected values follow directly from the measured proximate composition and standard 4-4-9 energy calculation and should therefore be used when describing the product nutritionally.

Protein and carbohydrate may be useful together in sports-food products. Meta-analysis of randomized exercise trials indicates that combined ingestion can influence performance or recovery under some conditions, but the magnitude of benefit depends strongly on total carbohydrate and energy provision, exercise demands, and recovery duration (10–12). Accordingly, the presence of both macronutrients in a bar provides nutritional plausibility but does not independently establish an ergogenic effect.

The bar also provided fiber and several measured minerals. Phosphorus and potassium were the largest reported mineral fractions, while measurable calcium, magnesium, iron, and zinc were also present. These nutrients contribute to physiological functions relevant to active individuals, but the nutritional importance of a single serving should be interpreted within total daily dietary intake and the athlete's broader nutritional requirements rather than from isolated concentration values alone (1,5).

Questionnaire data showed a descriptive shift toward higher perceived energy after bar consumption. Approximately 65% of respondents rated post-consumption energy as high or very high compared with approximately 50% who rated pre-exercise energy in those categories. Because participant-level paired

statistical analysis was not performed, the magnitude and statistical significance of within-person change cannot be determined.

Similarly, 60% of respondents stated that they had noticed improved endurance or stamina. This finding reflects self-reported perception rather than an objective assessment of endurance capacity. Experimental sports-nutrition studies typically quantify performance through standardized outcomes such as time trials, time to exhaustion, sprint tests, resistance-exercise volume, strength, power, metabolic responses, or defined recovery outcomes (8,9,17,18). The absence of comparable participant-level outcomes in the present dataset therefore precludes a controlled efficacy conclusion.

This distinction is particularly important because the protocol described an intended randomized comparison involving 40 athletes, whereas the analyzed questionnaire component comprised 250 respondents. Without complete randomized group-specific longitudinal data, between-group treatment effects, changes over time, and causal improvement in athletic performance cannot be established. Contemporary randomized-trial reporting guidance emphasizes transparent specification of participant flow, interventions, prespecified outcomes, analysis populations, and treatment-effect estimates when randomized efficacy claims are made (26).

The product-development component is more directly supported by the study data. Previous food-science investigations have demonstrated that high-protein and high-energy bars can be formulated with favorable nutritional, physicochemical, antioxidant, and sensory properties, although product quality depends substantially on ingredient composition and processing conditions (14,15). The present formulation similarly achieved a substantial measured protein concentration together with carbohydrate, fat, fiber, minerals, and phenolic content.

The present bar also showed generally favorable user acceptance. Approximately 84.8% of respondents rated its taste as good, very good, or excellent; 60% considered its texture appropriate; 60% rated the aroma as pleasant; and 80% indicated that they would recommend the product. Acceptability is relevant to the practical application of sports foods because a nutritionally appropriate formulation has limited utility if athletes are unwilling or unable to consume it consistently. Product-development studies similarly incorporate sensory evaluation as an important dimension of overall feasibility (14,15).

Several methodological limitations should be considered. The relationship between the intended 40-participant randomized trial and the 250-participant questionnaire dataset could not be resolved through a common longitudinal analysis. Objective performance outcomes were not available, and the general performance-rating item lacked a clearly defined scale range and anchor description. The findings concerning energy, endurance, and stamina should consequently be interpreted as descriptive subjective responses rather than evidence of controlled performance enhancement.

The analytical characterization also requires careful interpretation. Different unit systems were used within the original formulation, the initial carbohydrate value was mathematically incompatible with the measured proximate composition, and the DPPH assay units were not consistently reported. The approximately 40-g prepared bar mass also differs from the 42-g portion used for nutritional calculations; future product specifications should use a single standardized serving mass. Microbiological quality could not be evaluated quantitatively because an interpretable plate-count result was not reported.

Future studies should distinguish clearly among product development, sensory acceptability, nutritional adequacy, and controlled efficacy testing. A rigorously reported randomized sports-performance trial should prespecify objective performance endpoints, standardize exercise testing and nutritional exposure, document baseline comparability and adherence, account for participant flow, and analyze participant-level longitudinal outcomes according to an appropriate statistical plan (26). Such work would determine whether favorable nutritional composition and acceptability translate into measurable changes in athletic performance.

CONCLUSION

The developed high-energy protein bar contained 22.8% crude protein and, after correction of the carbohydrate calculation, 42.25% carbohydrate with an estimated energy density of approximately 357 kcal/100 g.

Questionnaire respondents generally reported favorable acceptability and subjective perceptions after consuming the product, including perceived improvements in energy and endurance. These findings

support the feasibility and acceptability of the nutritional bar but do not establish an objective improvement in athletic performance.

Controlled efficacy conclusions require analysis of complete randomized longitudinal athlete data using predefined objective performance outcomes.

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