

EFFECTS OF HIGH ENERGY NUTRITIONAL PROTEIN BASED BAR ON PERFORMANCE OF YOUNG ATHLETES



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By

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DEDICATION

To Allah Almighty, I am thankful to You for giving me all these blessings and then recount them individually – as many as you can.

To all my Teachers, for their guidance, support and motivation for work. They always give me a right path and strengthen my knowledge with positive energy. I dedicate my thesis with special thanks and respect to all my mentors including HOD, Supervisor, Co-supervisor and remaining all my teachers. They support throughout my academic career including 1st grade to MS study.

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LIST OF ABBREVIATIONS

IMO	Isomalto-oligosaccharide
NLR	Neutrophil-to-lymphocyte ratio
TFC	Total Flavonoid Content
WHO	World Health Organization
SD	Standard Deviation
NFE	Nitrogen-free extract
TPC	Total Phenolic Content

ABSTRACT

Purpose: Sports nutrition enhances athletic performance by decreasing fatigue and the risk of disease and injury; it also enables athletes to optimize training and recover faster. Balancing energy intake with energy expenditure is crucial to prevent an energy deficit or excess. Energy deficits can cause short stature, delayed puberty, menstrual dysfunction, loss of muscle mass and increased susceptibility for fatigue, injury or illness. Energy excess can result in overweight and obesity.

Methods: One of the trickiest things to manage is meal planning around athletic events. A study was conducted in Lahore. Non probability convenience sampling technique was applied on patients who were allocated through computerized randomization into group A & group B to collect data. Group A was given normal diet and group B was given normal diet in addition to protein bars. The study was completed within the time duration of nine months. Data was analyzed using SPSS software version 25.

Results: This study showed positive effects of protein bars on performance of athletes. The developed protein bar contains 14.8% moisture, 22.8% protein, 10.8% fat, 4.9% fiber, 55.1% carbohydrates, and 4.5% ash, providing balanced macronutrients and minerals such as phosphorus (348 mg), potassium (248 mg), magnesium (85.5 mg), calcium (75 mg), iron (5 mg), and zinc (1.48 mg) with low sodium (10.4 mg). Phytochemical analysis showed strong antioxidant potential with 81.2 mg GAE/100 g phenolics, 2.01 mg GAE/100 g flavonoids, and 2.93 mg GAE/100 g DPPH activity. Sensory evaluation revealed high scores in flavor (7.8), taste (7.6), texture (7.3), color (7.5), and overall acceptability (7.8), with 60% describing the aroma as pleasant. A majority of participants (80%) would recommend the bar, and 75.2% indicated willingness to continue using it, confirming its strong nutritional and market appeal.

Conclusion: The protein bar offers a nutrient-dense, antioxidant-rich formulation with excellent taste and texture acceptance, making it an ideal functional snack for active and health-conscious consumers.

Keywords: Sports nutrition, athletes, protein bars

Chapter 1

INTRODUCTION

Nutrition is a vital element of sport performance among young athletes, and it has a twofold role of ensuring both optimum growth in their developmental stages and highest levels of performance in sport. Young athletes have more than the bare needs of a nutritional program since they require to provide high-intensity training to their bodies and at the same time satisfy the demands of their developing bodies. Carbohydrates, proteins and fats are macronutrients used as the energy source, muscle repair, and hormonal regulation, whereas micro-nutrients iron, calcium and B-vitamins are important in terms of oxygen transport, bone metabolic functions and bone health. Hydration is also critical because mild dehydration may affect the cognitive ability and physical performance (1).

Experiments show that young sportsmen, using organized nutrition schemes based on the needs of the sport, do show better indicators of performance strength, speed, and recovery rates, on the field, than students with disorganized feeding habits. Nevertheless, not all teenagers have nutritional literacy that would translate to sub-optimal choices in their diets that may inhibit their sports and future health. Timing of nutrition, especially pre-workout carbohydrates to provide instant energy and post-workout protein to build muscle mass, will be of special importance to this demographic. Recent research findings underscore the fact that customized nutrition programs can improve athletic growth up to 15-20 percent, which necessitates the premise of early nutritional intervention in youth sports programs (2).

By applying the principles of sports nutrition strategically, the fatigue can be reduced considerably, the rate of injury can be lowered, and the recovery will be quicker providing the athletes with a competitive advantage. The issue of fatigue management is extremely important since the fatigue caused by glycogen depletion during the intense workouts may reduce the performance by 30-40 percent unless the athlete receives the necessary training on carbohydrate loading. New data points to the fact that athletes with balanced energy supplementation (30-45 kcal/kg of fat-free mass per day) demonstrate better responses to training stimuli by exhibiting greater rates of mitochondrial biogenesis and enhanced muscle protein synthesis rates (3).

On the contrary, persistent nutritional deficiency of energy typical of weight-class or aesthetic sports-initiates a series of adverse consequences: bone mineral density (putting athletes at risk of stress fracture 2-4 fold), endocrine dysregulation (testosterone levels 20-50% lower, menstrual disruptions) and immunodeficiency (infection rates 20-50% among malnourished athletes). At the other extreme, high energy, and a lot of fat in the diet as observed in power sports, may cause unwanted weight gain and metabolic inflexibility. According to the most recent Position Stand published by the International Society of Sports Nutrition (2024), a regular evaluation of body composition (through DXA scans) and metabolic hormones is advised to adjust the energy consumption, especially at the time of intense training or competition. Elite teams are now adopting advanced technologies such as continuous glucose monitors as a way of personalizing carbohydrate requirements in real time when competing in a tournament (4).

Timing of meals is one of the most complicated components of sports nutrition, which has to be carefully planned in terms of training regimes and competitions. Pre-event meal (eaten 3-4 hours prior to activity) must include carbohydrates (1-4 g/kg body weight) of a relatively easy-to-digest nature with moderate protein levels and low fat/fiber to reduce gastrointestinal distress which has been reported by 30-50% of endurance athletes. Liquid nutrition (e.g., smoothies) has become popular as a method of pre-competition fueling because it has a rapid rate of gastro intestinal emptying. In events of more than 60 minutes, it is advised to utilize carbohydrates 30-60g/hour using a combination of various transportable sugars (glucose: fructose blends) in order to increase the rate of oxidation (maximum 90g/hour during ultra-endurance events). The post-exercise recovery diet is based on the 30-30 rule: 30g/kg/hour protein to help activate muscle protein synthesis in the first 30 minutes after exercise and 1.2g/kg/hour carbohydrates to restore muscle tissue glycogen (5).

A 2024 meta-analysis published by Sports Medicine found that athletes who routinely achieve these recovery goals achieve 40% more muscle hypertrophy and 25% better performance in a follow-up training session than athletes with less favorable refueling. The psychological component of food familiarity is also a significant study that monitored collegiate athletes and found out that 68 percent of the respondents had their performance reduced when they were eating new foods on game days, which

underscores the importance of habitual nutrition. In order to tailor nutrition plans to account for travel schedules, time zone changes, and official tolerances, teams are hiring dietitians to develop individualized nutrition playbooks (6).

Sports nutrition has undergone a paradigm shift of generic suggestions to specific based on what the athletes need on a dietary basis and nutri-bars have become a convenient alternative to satisfy high energy needs of athletes. Contemporary recipes are strategic in blending rapid carbohydrate (such as maltodextrin) with slower digesting proteins (such as micellar casein) to produce sustained energy release profiles. Bars made of fruits have developed a specific following, with bananas, dates, and berries, not only supplying natural sugars, but also polyphenols that prevent oxidative stress caused by exercise, a single banana provides up to 12 percent of the RDI of potassium and dopamine precursors that can be used to improve vascular function. Protein content in these bars has been getting more advanced with combinations of whey isolate (so as to provide a fast absorption) and plant proteins (such as pea or rice protein) in order to prolong the amino acid supply (7).

Recent studies conducted by the Gatorade Sports Science Institute (2024) have shown that bars containing 3:1 types of carbohydrate-protein ratios offer the optimal balance of glycogen re-syntheses and net protein balance of the body during the post-exercise periods. This is more important especially to adolescent athletes; whose rates of protein synthesis are 20-30 times more than adults when growing in spurts. The trends are mirrored in the global sports nutrition market whereby clean-label, whole-food based products are projected to grow by 45 percent between 2020-2025 as athletes shift toward synthetic products (8).

Athletes' protein needs are rather specialized, varying not only by athletic discipline but also by training phase, injury status, and individual metabolic profile. Endurance athletes during tapering phases may need only 1.2 g/kg, whereas resistance athletes during hypertrophy phases may need up to 2.2 g/kg daily to aid in muscular remodeling. According to a 2024 randomized controlled trial, the idea of protein pacing consuming 0.4 g/kg every 3–4 hours has demonstrated better body composition than conventional dosing patterns. Modern nutri-bars include sophisticated protein techniques such hydrolyzed collagen peptides (shown to cut weightlifters' joint pain by 40%) and fermented plant proteins (with 20% higher

digestibility ratings. Carbohydrate requirements are equally complex: a sprinter may survive on 5 g/kg/day whereas an ultra-marathoner may demand 10 g/kg during peak training (9).

The latest ACSM guidelines (2025) emphasize periodizing carbohydrate intake, with strategic low-carbohydrate training days to enhance metabolic flexibility alternating with high-carbohydrate loading phases before competition. Fat intake recommendations have also evolved, with omega-3 enriched bars (containing 1-2g EPA/DHA) now being used to reduce exercise-induced inflammation by 15-25% in contact sports athletes. Cutting-edge products are incorporating real-time biomarkers (like salivary cortisol tests) to personalize macronutrient ratios based on daily stress and recovery status (10).

A significant number of people in the world consume cereal grains. Due to rich in nutrients and antioxidants, super foods strengthen the body's defense system. Broccoli, garlic, blueberries, tomatoes and spinach are some examples of super foods (11). Now a day, the interest of functional grains has been increased in Europe, Japan and United States of America. Oats, chia seeds, wild rice, flaxseeds, quinoa, chickpeas and amaranth are some of the functional grains. All of these grains have different nutritional composition and these functional grains make it easier for the modern population, which experiences "poverty in the midst of plenty" as a result of a hectic daily schedule, irregular meals and frequent intake of takeaway food to consume a variety of healthy nutrients (12).

Oat is one of the main ingredients commonly used in nutrition bars to enhance the fiber content and some micro-nutrients. 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 (12). Oats also called *Avena sativa* L. is a member of Poaceae family which is grow in humid and cool environment. The shape of oats is similar to barely. Oats are available in different types. Due to rich in protein, minerals, vitamins and fibers, oats have been regarded as healthy. Oats are particularly known as a high-value crop because they contain rich amount of proteins and lipids as well as balanced proportions of key amino acids, including lysine, and 2-6% of β -glucan. Oats contain 70%-80% globulin protein and 5%-12% fats. Linoleic acid, palmitic acid and oleic acid makeup around 95% of the fats in oats and 75-80%

of that fat is unsaturated. These unsaturated fatty acids provide a number of physiological benefits including as antioxidant activity and prevention of dementia. The interest of oats grains as functional grain has been increased due to its cholesterol reducing effect in the blood (13).

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, antioxidants and flavonoids like anthocyanins, proanthocyanidins, flavonols, phenolic acids, and isoflavones. Kidney beans, on the other hand, are a powerhouse of plant-based protein and fiber, offering 8 grams of protein and 356 mg of potassium per half-cup serving. Their high fiber content supports digestive health and helps maintain stable blood sugar levels, while their antioxidant properties combat oxidative stress. Kidney beans contain smaller quantities of bioavailable phosphorus and potassium compared to animal protein, which means it is a safe food choice yet to be eaten in moderation because of its effects on people with kidney disease. Snack bars made by mixing oats and kidney beans have a complete protein profile since oats is rich in methionine and low in lysine, and kidney beans are also rich in lysine, which provides appropriate balance to the amino acid deficit (14).

Banas are also among the primary sources of energy with 90 calories per 100 g. Bananas are also good sources of health relevant antioxidants. The bananas are a wonderful source of minerals (potassium, phosphorous, magnesium, zinc), fiber and vitamins (Vit C, B6, pro-vitamin A). Banas are also a good functional food, along with bioactive compounds such as carotenoids, sterols, flavonoids, and antimicrobial agents (8). Due to their richness in carbohydrates, essential electrolytes and bioactive chemicals that aid in athletic performance and recovery, bananas are a highly esteemed source of natural fitness in sports nutrition. In addition to 422mg of potassium, a medium banana (118g) provides approximately 27g of carbs of which mostly glucose, fructose, and sucrose provide a fast and sustained energy source in the course of physical activity. Maintains the electrolyte balance; aids in preventing muscle cramps. Despite these other benefits, a study has compared carbohydrates beverages with the effect of during endurance cycling (75 km) and showed no significant effect on performance or the blood glucose levels in the body through their

polyphenols and dopamine concentration (15).

They have low-to-medium glycemic index (GI 51), which ensures a steady supply of energy, hence ideal pre-, intra-, and post-workout energy; their natural packaging and affordability enhances the practicality of athletes. The current trends in sports nutrition focus on nutrients replacement of processed supplements with whole-food items, the banana as a nutrient-rich, fiber-based, and phytochemical-rich anti-inflammatory and anti-oxidative stress food in exercise. Also mentioning their adaptability in terms of athlete diets, they have a new study that contributes to microbiome and gut health (16). **Rationale**

Earlier research have shown that energy bar may improve general health. Energy bars contain key nutrients including amino acids, good lipids, vitamins, and minerals that help general development, health, and cognitive performance. By supplying vital proteins and micro-nutrients like zinc, iron, and B vitamins from items like almonds, pumpkin seeds, and oats, regular intake promotes ideal development. These nutrients increase energy metabolism, immunological response, and general health. This study aims to create a recipe for seed-based energy bar that can be employed as a tailored dietary intervention to improve young athletes' performance.

Aim and Objectives

1. A high-nutritional protein energy bar was developed.
2. The effects of a high-energy, protein-based nutritional bar on the performance of young athletes were evaluated.

Chapter 2

LITERATURE REVIEW

The increasing popularity of convenient, energy-dense food among young athletes has opened up enormous innovation in high-energy nutritional protein bars. These products are designed to target the specific physiological requirements of adolescent athletes who need sufficient energy for sport performance and continued growth and development. This review consolidates existing literature on the formulation, nutritional content, and effectiveness of protein bars on sport performance improvement in young athletes aged between 5-18 years. Recent research shows that well-formulated protein bars can be used as good meal substitutes or supplements that deliver necessary macro-nutrients, antioxidants, and phytochemicals and satisfy increased energy requirements of young athletes.

You et al., (2024) examined that young athletes have unique nutritional needs different from those of adults. Their needs are shaped by growth spurts, hormonal fluctuations, and the metabolic costs of high-level training. Evidence suggests that numerous young athletes do not achieve adequate dietary intakes, possibly jeopardizing performance and long-term health. Protein bars with functional ingredients can fill these nutritional gaps while providing convenience for busy student-athletes juggling academics and athletics (17).

Amawi et al., (2024) conducted a study that young athletes require more nutrients than their non-athletic counterparts and need close monitoring of both the distribution of macronutrients and overall calorie intake. FAO/WHO/UNU suggestions suggest that 14- to 18-year-old male athlete adolescents can tolerate up to 3,925 kcal/day and female athletes as much as about 2,875 kcal/day during intense sporting activities 7. These large energy requirements are to be covered while maintaining an optimal ratio between carbohydrates (45-65% of total caloric intake), proteins (1.2-1.8 g/kg body weight), and fats (18).

Kaviani et al., (2020) researched that protein takes on special significance for young athletes in that it provides for muscle protein synthesis, tissue repair, and accretion of lean body mass during periods of growth. Protein needs are estimated at 50-100% higher for young athletes than for physically inactive adolescents, with estimates from 1.6-1.8 g/kg/day to enhance training adaptation and growth. Yet studies have shown

that most young athletes are unable to achieve these protein needs consistently from whole food sources, leaving a potential for protein supplementation (19).

Awami et al., (2024) concluded that carbohydrate requirements are also higher, especially for sportsmen who participate in endurance or intermittent high-intensity sports. Young sportsmen deplete muscle glycogen at a faster rate than adults and require planned carbohydrate consumption prior to, during, and following exercise. The requirement is 5-8 g/kg/day when undertaking moderate training and 8-10 g/kg/day when undergoing intense training or competition. The diet is essential in the par of sport tarining. Based on this, professionals who take nutrition seriously can enhance physical capacities without causing injury to the body (20).

Ibrahim et al., (2021) researched that the last decades witnessed the usage of protein- and mineral-dense foods becoming essential within athlete nutrition. In current times, it is popular for bars designed for consumption within the sport field to enjoy global recognition since they deemed to be high in nutritional value along with being rich in energy that gets released rapidly based on metabolic needs. Bars are of various kinds available in the world market like high protein bars, high dietary fiber bars, high energy bars and vitamin and mineral-rich bars which possess good sensory attributes. The bars are filled in polyethylene bags coated with metal and consist 3- to 4-month shelf life (21).

AlJaloudi et al., (2024) investigated different formulations of high-energy protein bars with different protein sources and functional ingredients. One study prepared bars with lupine seeds (25-34% protein) and wheat germ, and compared them to control bars with whey protein concentrate. Lupine-based bars showed much higher protein content (22 ± 2 g) and total phenolic activity (57 ± 33) than controls but with acceptable sensory properties. Such plant-based preparations are of potential benefit for young sportsmen on vegetarian or vegan diets, or suffering from dairy sensitivity (22).

Abdel- Salam et al., (2022) in a research developed a high-protein bar with whey protein isolate (24%) and soy protein isolate (6%) blended with oat flakes, inulin, and creatine monohydrate. The final product contained 34.1 ± 0.20 g of protein per 100 g in an even macro-nutrient composition (288 kcal, 23 g carbohydrates, 6 g fat). The addition of creatine is noteworthy since supplementation was reported to enhance

muscle power output and decrease fatigue in athletes. Commercial protein bars differ considerably in their nutrient content. Examination of widely marketed bars showed protein levels from 5.2 g to 32 g per serving, with carbohydrate levels ranging from 30 g to 44 g. Such differences highlight the need to choose bars based on individual athletic requirements and timing (pre- vs. post-workout) (23).

According to Cui et al., (2022), recent research points to the potential advantages of adding functional ingredients with antioxidant activity to protein bars. The lupine and wheat germ bars had considerably greater total phenolic and flavonoid content than the traditional whey-based bars. These phytochemicals could assist in countering exercise-induced oxidative stress, which can be of particular interest to young athletes subject to rigorous training regimens. Whey protein itself has shown antioxidant potential in vitro, with human trials reporting elevated levels of antioxidant biomarkers such as glutathione after supplementation. Blending high-quality proteins with antioxidant-containing supplements such as dried fruits (raisins, dates, apricots, cranberries) forms a product that can potentially enhance performance and recovery in young athletes. Fiber content is also a consideration, with some products containing oat bran (18.1-25.2 g/100 g total dietary fiber) and inulin to support digestive health and microbiota balance. Adequate fiber consumption is frequently neglected in young athletes but serves essential functions in gut health, nutrient absorption, and long-term energy release (24).

Jiang et al., (2021), investigated that the energy needs of athletes are in most cases determined by the sport type, exercise duration, and intensity, the level of competition and the personal potential of every athlete. The exercise intensity increases with greater athlete competition so diet becomes crucial for stock replenishment after energy depletion. Athletes together with people participating in physical exercise use energy bars as dietary supplements to reach their strength targets and calorie needs. Athletes depend on such bars to obtain their energy requirements alongside physical and mental activity and vitality and power. Such bars must contain a significant amount of carbohydrates together with average protein content to be effective. Such bars have a permanent and instant energy-delivery function when athletes train because these bars should give each sports person between 200-300 calories along with 7-15 g protein, 3-9 g of fat and 20-40 g of carbohydrates. Energy bars represent

an outstanding resource that delivers proteins together with natural sugars. The nutritional balance of these bars assists athletes to reach better performance outcomes. Energy bars supply both immediate power alongside muscle tissue development capabilities and tissue protection benefits through protein compounds (25).

Placenton et al., (2021) concluded that cereal bars are rich in nutrition as The dietary sources present vital amounts of protein, energy, fiber, vitamins and antioxidants among other nutritional elements. Multiples of ingredients such as cereals alongside dried fruits and nuts accompanied by raisins and sugar form the basis of bar composition. Rewritten versions of nutrition bars contain several proteins and vitamins and minerals and grains and barley through their complementary ingredients. The major function of oat in nutrition bars is to boost micro-nutrient levels and enhance total dietary fiber content. The main component of oat dietary fiber consists of β -glucan which proved useful in reducing cancer development but also reduces hypercholesterolemia and controls high blood pressure. The component contains balanced nutrition value and it serves as a superior source of both high-quality proteins and carbohydrates. The food resource contains a rich combination of unsaturated fatty acids alongside minerals, vitamins and phytochemicals and high concentrations of these elements (26).

Barakat et al., (2023) concluded that various food plants deliver functional properties due to their mineral and vitamin contents and their polyphenolic and terpenoid and alkaloid and sterol and pigmented compounds and unsaturated fatty acids. These foods have potential to optimize athletic immunity that allows effective defense against infections while maintaining control over inflammation-related damage. This aspect is vital for ending infectious diseases. The anti-oxidant and immunogenic properties in oats stem from many bioactives and nutrients that exhibit anti-inflammatory effects (27).

Welch (2011) researched that the cereal plant belonging to Poaceae or Graminae family comprises 27 established species or sub-species within the genus *Avena*. Oats (*Avena sativa*) stands as the major commercial type when it comes to the global species of oat cultivation. The healthy whole grain oat consists mainly of starch carbohydrates along with elevated lipid levels and supplies several micronutrients including vitamin B1 and B6 and folate and pantothenic acid and Mn and Mg and Se

and Fe and Zn and Cu. The protein content of oats surpasses that of typical cereal staples such as corn and rice and features a suitable blend of necessary amino acids. Oat groats maintain 10–12% overall fiber levels after dehulling while soluble β -glucan makes up about 40% of this content when β -glucan exists as linear branched units that combine β -1,3 glucan (30%) with β -1,4 linked β -D-glucopyranosyl units (70%). The remaining 60% consists of insoluble fiber through cellulose and hemicellulose and lignin. Oats exist as the leading food type among β -glucan containing foods. Oats contain β -glucan amounts that range between 2 to 8 g/100 g yet their total β -glucan level reaches 4.40 g/100 g and soluble β -glucan measures up to 3.88 g/100 g. The nutrient composition of oats shares similarities with plant materials because it depends on factors like cultivar type and regional origin as well as cultivation techniques and seasonal variations and processing procedures (28).

Arbach et al., (2021) concluded that kidney beans *Phaseolus vulgaris* is another such species that represents the Fabaceae family and whose characteristic feature is the occurrence of both beneficial constituents and anti-nutrients/allergens. These beneficial substances help to manifest several health benefits, e.g., reduced heart and kidney disease risks, greater satiation, prevention of cancer, etc. Furthermore, ingestion of meals involving seeds of *Phaseolus vulgaris* by sportsmen helps towards fulfillment of the requirements of energy as well as the recovery at the earliest time from injury. Conversely, unwanted constituents like anti-nutrients can lower the bioavailability of trace elements and restrict protein and carbohydrate usage. In consideration of this duality, a critical review of the literature on the consumption of alimentary products with *Phaseolus vulgaris* by athletes is highly warranted. Meanwhile, it must be noted that the following are patents for drinks that are plant protein-enriched from others sourced from *Phaseolus vulgaris* and for use by sportsmen. Kidney beans are rich in protein, around 2-3 times than other cereals, and are also rich in micro-nutrients like iron, zinc, and also high in crude fiber, pro-vitamins A, and vitamin E. Kidney beans are also rich in phytochemicals, anti-oxidants and flavonoids like anthocyanins, proanthocyanidins, flavonols, phenolic acids, and isoflavones (29).

Fanari et al., (2023) researched that banana provides up to ninety kilocalories or kcal (90 kcal/100 g) as an energetic substance. Also, banana contain health-relevant

antioxidants. Bananas provide a rich mineral content that includes potassium plus phosphorus together with magnesium as well as zinc and many essential vitamins including Vit C B6 with pro-vitamin A. Bioactive compounds including phenolic acid compounds together with flavonoids and carotenoids and sterols and antimicrobial compounds are found in bananas which make them a functional food. Several investigations analyze the health benefits of berry consumption because of its active compound content. Bioactive compounds in berries show antioxidant behavior while also showing metal-chelating properties and protein-binding abilities because of their diverse health properties. Natural functional foods are widely recognized through their character as berry fruits (30).

Tormasi et al., (2025) stated that high fat content (more than 30% of total calories) reduces carbohydrate intake which blocks muscle glycogen storage. At the same time high-fat diets help produce energy and prevent muscle tension during vigorous exercise. Categorically, formula A, B, and C measured their fat contents with readings between 9.35% and 9.45% accordingly. The fat content in Formula C measured substantially less than what appeared in Formulae (A and B). Sports persons need between 20-35% of their daily energy intake that should include 7–10% saturated fatty acid alongside 10% monounsaturated fatty acid and 10% polyunsaturated fatty acids. The slightly elevated fat concentrations in bars play an essential part in replacing energy lost during physical activity after your body consumes its energy reserves. Products containing elevated fat levels possess the ability to both amplify and lengthen the tasteful sensations felt inside the mouth. Among the tested samples the banana flour-containing bar exhibited the lowest 6.20% to 14.25% distribution of fat when compared with the other bars produced with pumpkin seed flour at 9.74%. Our research produced low percentages of fat content ranging from 9.35 to 9.45% in nutrition bars (31).

According to Shishkov et al., (2023) the nutritional needs of an athlete primarily revolve around vitamins together with minerals with particular attention to calcium, vitamin D and B vitamins. The body needs vitamins and iron as well as zinc and magnesium and particular antioxidants such as vitamins C and E and beta-carotene and selenium to support oxygen transport to active muscles for athletes. The intestinal absorption rate of plant food iron such as beans, lentils, seeds, soybeans and whole

grains remains poor so athletes should add fruit along with juices and strawberries and peppers and broccoli to enhance their absorption of iron (32).

According to AlJaloudi et al., (2024), under extreme exercise conditions the excessive muscle tissue loss necessitates that athletes take calcium for maintaining bone strength and preventing injuries in competitive sports. Athletic individuals should receive encouragement to take foods with added calcium because it fulfills their calcium requirements while building bone density and shielding them from osteoporosis. Research has definitively proved that minerals play an essential role in metabolic processes. Athletic performance potential of athletes benefits from tissue structures that play an important role as vital components of enzymes and hormones besides acting as metabolically and neurally controlling regulators (33). The sporting population requires daily mineral intakes which according to Kerksick et al., (2018) should be 1000, 2000, 8, 420 and 500 and 1 and 11 mg per day for calcium, potassium, iron, magnesium, sodium and copper and zinc respectively. The enzymatic protein synthesis requires magnesium activation while it also operates in ATP interactions. Evidence suggests that adding magnesium to the diet improves energy processes while boosting the availability of ATP. Exercising athletes' performance does not get affected by magnesium supplementation at 500 mg per day unless there is a magnesium deficiency. The majority of studies demonstrated zinc supplementation at 25 mg per day throughout training would lower exercise-related adjustments to immune function (34).

Particularly for young athletes who need simple, nutrient-dense food choices to support their high-energy nutritional protein bars have become a major factor in sports nutrition. requirements of their education and recovery procedures. These bars usually balance nutrients by combining great proteins with complex carbohydrates, good fats, and a range of functional components. Among the many formulations on the market, oats' special nutritional qualities and functional advantages have drawn a lot of interest. Oat-based protein bars stand out. Oats are the base of these bars as they include complicated carbohydrates for sustained energy plus helpful β -glucan dietary fiber, which has shown many health advantages. Along recovery symptoms and nutritional status in young athletes (35), this study assesses scientific evidence on how high-energy protein-rich oat bars affect athletic performance.

Along with ease purposes for busy teenagers who keep packed schedules, the athletic sphere has changed its nutrition strategy recently toward scientifically created products for performance improvement. Originally simple nutritional supplements, protein bars have been turned into trained dietary components that satisfy particular athletic demands by developers. Young athletes face the Since their bodies evolve naturally, protein bars with exact nutritional makeups must be chosen. Scientific research reveal that properly made protein bars play several parts from pre-workout energy supply to post-workout tissue repair help. Including oats into These bars provide benefits for cardiovascular health and digestive support as well as lasting energy maintenance over extended athletic bouts (36), so conferring beyond baseline nutritional value.

Oats provide athletes in the young stages with a nutritional profile that delivers exceptional eating benefits. A research analysis showed high-protein bars containing 24% whey protein isolate and 6% soy protein isolate with oat flakes produced 34.1 ± 0.20 g protein and 6.01 ± 0.13 g fat (3.12 ± 0.08 g saturated) in addition to 23.0 ± 0.16 g carbohydrates (3.10 ± 0.17 g fiber) per 100 g serving. These protein bars have oats that specially increase their fiber level and offer low-glycemic carbohydrates that provide a constant energy release instead of the quick spikes from simple sugars. The steady blood glucose levels and delayed exhaustion made possible by these goods help young endurance athletes (37).

Generally speaking, including oats into protein bars provides extra health benefits beyond their basic nutritional constituents. Because athletes require this benefit for their training, oats provide β -glucan fiber, which lowers cholesterol and aids in the development of superior cardiovascular health. Found just in oats, avenanthramides are antioxidants that lower oxidative stress and relieve inflammation created by physical activity in young athletes. Oats combined with whey protein and other premium protein choices produce a positive interplay that lets amino acids support muscle recovery and development at the same time. Oat carbs are superior at replenishing glycogen reserves than processed sugars are. Studies show that this combination of substances works best if consumed during the recovery period following physical activity. Oats' components boost nutrient absorption as well as gut health; so, young athletes may best use all of the nutrients in these bars (38).

Multiple research studies carried out with athletes established the performance benefits associated with consuming oat-based protein bars. Expert handball players underwent biochemical testing to monitor the impact of consuming a high-protein bar designed with oat flakes after completing afternoon training. The participants who consumed oat-based protein bars following their exercise regimen demonstrated lower serum aspartate transaminase (AST) and lactate dehydrogenase (LDH) whereas total and direct bilirubin levels elevated which indicates enhanced antioxidative response. The biological changes demonstrate that protein bars made with oats offered important nutritional value and improved physical response to strenuous workouts. Young athletes benefit from these advantages as their recovery systems are under development which leads to better training steadiness and decreased likelihood of overtraining syndrome occurrence (39).

The energy content of oat-based protein bars provides the best nutritional solution for young athletes' exercise needs. Oat-based bars differ from simple sugar-based bars because the carbohydrates from oats control energy release over an extended period. Studies on athlete energy needs reveal that both carbohydrate source selection and its timing point directly influence sports performance especially when engaging in endurance events. The low glycemic content of oats regulates blood sugar stability which may protect against exercise-related exhaustion and enhance brain performance during athletic events and competitions. This information is crucial for developing young athletes working on their nutrition methods. Oats with protein provide a nutritious blend that enables usage both before workouts for energy conservation and during extended activities for sustenance needs as well as post-workout recovery support (40).

Oat-based bar formulations surpasses the nutritional quality of traditional protein bars that exist commercially. Analysis of protein bars available in commerce shows these products contain excessive amounts of added sugars and destructive sweeteners such as high fructose corn syrup without enough dietary fiber or beneficial protein ingredients. The nutrient composition of oat-based bars offers a whole-food solution which delivers better nutrition to their consumers. A protein bar study tested different formulations that used lupine seeds with wheat germ and dried fruits next to an oat-based control bar and established that oat-based bars received superior sensory ratings

than the experimental formulations although the experimental bars contained more protein. Young athletes need to consider that nutritional interventions must achieve effectiveness and acceptability to guarantee they continue consuming them (41).

The specific characteristics that oats provide in protein bars make them worth considering. The texture of most protein bars deteriorates within time because they either become excessively stiff or acquire unusual textures. The structure of the bar remains intact through the addition of oats which helps keep its desirable texture. Young athletes require products with appropriate sensory qualities because they tend to avoid food that does not meet their senses expectations. The high water-binding capability of oats functions to control moisture levels in bars which could boost shelf durability without adding large amounts of preservatives. Oats serve as practical ingredients for young athletes because they provide nutritional advantages that lead them to consume bar products before exercises or after workouts and during their hectic daily routines (42).

Young athletes possess dissimilar nutritional aspects from adults because their specific requirements demand individual attention during protein bar design while using such products. Young athletes benefit from sufficient protein intakes for training benefits along with development needs yet excessive protein consumptions have uncertain outcomes. Oat-based protein bars present a healthy solution by combining reasonable protein amounts of 10–20g with essential nutrients required for growth in each serving. Young athletes require protein consumption at 0.54–0.77 grams per pound of their body weight (1.2–1.7 grams per kg) according to the American College of Sports Medicine which they can obtain through regular foods and smart supplementation. The convenience of oat-based bars provides young athletes with a useful supplement method to reach nutritional requirements instead of using processed supplements in excess (43).

The development of proper eating patterns constitutes an essential aspect for young athletes because these patterns will advance their current athletic outcome and guarantee their future wellness. The Peak Health and Performance (PHP) curriculum works to educate young athletes through proper nutrition education that shows them the value of whole foods alongside balanced macronutrients. Such protein bars based on oats fulfill the needs of both rules when made using high-quality ingredients

because they demonstrate functional foods can supply convenience together with nutritional value. Educators together with coaches must utilize oat-based protein bars as significant demonstrations of proper nutrition techniques during performance time, energy preservation and superior carbohydrate selection for athletic achievements. The parental acceptance of these bars improves because of the recognizable whole-food ingredient oats which they may find preferable to processed sports nutrition products (44).

This investigation developed high-protein bars through the combination of whey protein isolate (24%) with soy protein isolate (6%) as protein sources in addition to oat flakes and inulin dietary fibers and creatine monohydrate together with vitamin and mineral mixture and potassium sorbate for meal replacement needs of active people. Professionals analyzed the high-protein bar for nutritional content using 100 g measurements (1215 kJ/288 kcal energy, protein 34.1 ± 0.20 g, fat 6.01 ± 0.13 g saturated to 3.12 ± 0.08 g, fiber 3.10 ± 0.17 g and carbohydrate 23.0 ± 0.16 g composed of 1.50 ± 0.19 g sugars and 21.5 ± 0.11 g starch). The study also evaluated instrumental parameters to measure texture and color compared to different market-available The created high-protein bar was sensorily acceptable in comparison to other commercially available bars (45).

Nguyen Van Toan (2024) conducted a research on the production of nutritional bars with different proportions of oat flour and brown rice flour. The collected samples of brown rice were sorted and soaked in clean water with a ratio of the rice to water of 2:3 (W/W) at ambient temperature for 3 h. They were then drained and dried in an oven dryer at 40°C for 4-5 h until the level of moisture content drops around 12-16%. Then, they were ground using a laboratory grinder. The dried flour samples were passed through a 70-mesh sieve and roasted on pan at 100° C for 10 min before stored in a plastic bag at ambient condition for further use (46).

Widyaningsih, Hidayatullah, Apriliawan, Kinanti & Agisty, (2024) conducted a study to prepare a supplementary food in the form of food bar that would boost health and the immune system. Food bars were derived from the indigenous foods like the pumpkin, snakefish, edamame, and moringa leaves. From the results obtained it was observed that the general nutritional value of the best food bar formula was the following, Protein 24.77%, fat 10.63%, carbohydrate, 46.44%, ash 2.68% and water

15.48%. The study concluded that food bar products have a possibility to be an alternative food product to prevent (47).

Nutritional analysis of the prepared nutritional bar showed that the developed nutritional bars from brown rice flour were scientifically necessary to reduce the production costs while remained the specific nutritional values and health benefits as well as the high acceptability of the consumers. The potential substitution of oat flour by brown rice flour in nutritional bar by evaluating the nutritional values as well as the physical parameters of the resulting products were thoroughly investigated and successfully obtained (48).

Furthermore, the likelihood of improving oat cereal bars was examined by substituting whole seed, almond, or steam cooked pinhão husk flour for up to 5% of the oats. Bars with husk, almond, or whole seed flour substituted for up to 5% of the oats had compositions that were statistically similar, with the exception of lipids, a small number of minerals, phenolic compounds, and antioxidant activity. A 22 g bar provides a low energy and a relatively high mineral content in relation to daily guidelines. They also show a notable amount of total phenolic compounds and antioxidant activity. These creative bars showed good commercial potential and were highly liked in sensory tests. Notably, due to improved technology, a bar that substituted husk flour for 5% of oats could be a feasible choice for microenterprises, helping to valorize waste and promote the conservation of the Araucaria forest (49).

AlJaloudi et al., (2024) conducted a study to find out how to make a high-protein bar with utilization of lupine seeds, wheat germ, and dried fruits dates, apricots, cranberries, and raisins. Formulations F1, F2, F3, and F4 were made with various ratios of the specified ingredients to create high protein bar. The results showed that the produced protein bar had considerably higher levels of total phenolic, flavonoid, and fiber content than the control group, suggesting potential health advantages. Overall, the study revealed that high-protein bars utilizing functional components such as dried fruit can give enhanced nutritionally useful food options for consumers (50).

Furthermore, to examine how daily consumption of commercial high-protein nutrition bars with or without additional fiber affected the caloric intake and satiety of young,

healthy people for a week, a study was conducted. In a 4-week randomized crossover trial, 21 healthy, overweight individuals without a history of chronic illness were randomized to receive either HP (high protein; 21 g) or HPHF (high protein, high fiber; 20 g, 14 g) nutrition bar. Commercial nutrition bars were to be consumed by the participants every day for seven days in a row. The findings demonstrated that daily use of commercial high-protein nutrition bar increased energy intake and satiety, but it also raised the risk of accumulating body mass and fat over time (51).

To create a nutritionally superior sugar-free cereal bar with functional effects in terms of high protein and fibre, and with better accepted sensory characteristics than other similar commercial products, a research was also carried out. Goji berries, flax seeds as well sunflower seeds, oat granules chopped chestnuts, cinnamon flavour, erythritol, cellulose gum, and pumpkin flour with a high protein content were the ingredients that went into making the new formulation. The study indicated that on industrial scale it was possible to create a sugar-free cereal bar enriched with antioxidant activity and which had better nutritional as well as textural value than the traditional product (52).

El-Kholie et al., (2023) conducted a study to evaluate the effect of pumpkin and sunflower seed biscuits and the anti-hyperglycemic medicine metformin on diabetic rats. For a duration of 28 days, the basal diet was progressively supplemented with biscuits that were enriched with pumpkin and sunflower seeds and metformin at a rate of 2.5 and 5%, and 250 mg/kg, respectively. According to the findings, eating biscuits fortified with pumpkin and sunflower seeds along with metformin significantly ($P \leq 0.05$) improved the rats' serum blood glucose levels, significantly raised HDL-c, and enhanced liver and kidney functions by lowering AST, ALT, urea, uric acid, and creatinine in the rats as compared to the positive group (53).

Hussain et al., (2023) conducted a study to develop biscuits from pumpkin seeds powder having Fe and Zn to be taken by children. Pumpkin seeds were dried to produce pumpkin seed flour, which was incorporated in the supplementation of food products especially bakery products. The research concluded that Biscuits developed by fusion of pumpkin seeds flour, rich in Fe and Zn could be used as an important tool in booster of the children's immunity. The study also recommended that advanced and innovative technologies can be used to create functional pharma

foods from pumpkin seeds powders, extracts and bio actives (54).

To create a nutritionally superior sugar-free cereal bar with functional effects in terms of high protein and fibre, and with better accepted sensory characteristics than other similar commercial products, a research was also carried out. Goji berries, flax seeds as well sunflower seeds, oat granules chopped chestnuts, cinnamon flavour, erythritol, cellulose gum, and pumpkin flour with a high protein content were the ingredients that went into making the new formulation. The study indicated that on industrial scale it was possible to create a sugar-free cereal bar enriched with antioxidant activity and which had better nutritional as well as textural value than the traditional product (55).

Baurina et al., (2021) conducted a study based on the application of sunflower protein for snack bar. This study aimed to investigate the impact on the nutritional, physicochemical and sensory characteristics of snack bar when they were incorporated with sunflower protein powder. Crude protein, fat and fiber contents as well as moisture were analyzed. Due to the low lipid content, these snack bars could be categorized under low-moisture snack bars and possessed no anti-nutritional characteristic and were a good source of proteins through the use of sunflower protein. The study concluded that it is effective in preserving the physicochemical properties of the product besides enhancing the nutritional value of the product (56).

Chapter 3

METHODOLOGY

3.1. Study Design:

It is randomized control trial. Data collection was done by non-probability convenient sampling technique. The participants were followed for 8 weeks at 1st day, 30th day and 60th day.

3.2. Study Settings:

This study was conducted on boys and girls from sports complex Lahore of age 18-25years.

3.3. Sample Size:

Sample size of 40 was measured by using G power Analysis Software, Version (3.1.9.2) with 0.80 power of study, with 0.05 margin of error and 95% confidence interval. Although 36 patients were recruited by assuming 10% attrition rate and then divided into two groups with 20 patients each (57).

Means: Difference between two independent means (two groups)

Analysis: A priori: Compute required sample size

Input:

Tail(s) = Two

Effect size d = 0.8944272

α err prob = 0.05

Sample size of 40 was measured by using G power Analysis Software, Version (3.1.9.2) with 0.80 power of study, with 0.05 margin of error and 95% confidence interval. Although 36 patients were recruited by assuming 10% attrition rate and then divided into two groups with 20 patients each (57).

Means: Difference between two independent means (two groups)

Analysis: A priori: Compute required sample size

Input: Tail(s) = Two

3.4. Material:

Whole oat, kidney beans, banana, refined fine iodized common salt, peanut butter, black berry, sugar, glucose syrup and packaging were obtained from market of Lahore. Initially, all dry ingredients was weighed, cleaned and then washed to remove dust and foreign objects.

3.4.1. Preparation of raw material

The kidney beans was 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 was cooked in boiling water for 15 min. Kidney beans seeds was dried in a hot air oven dryer for 12 hours at 50 °C. The dried kidney beans were milled using mill and it was sieved to pass a 40 mesh sieve, then packed into polyethylene bags and kept at 4°C until used.

3.4.2. Preparation of Banana Flours

Sorted the sweet potato, carrot and banana was 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 and sieved to pass a 40 mesh sieve, then was packed into polyethylene bags and kept until used.

3.4.3. Preparation of Nutritional Bars

The nutritional bar was prepared in three formulas as shown in table. Initially, all dry ingredients like whole oat, kidney beans flour, dried berries, and salt and banana flours was mixed. Peanut butter, sugar, water and glucose syrup was 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, and 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 will packed in polyester films and stored in a cool, well-ventilated place.

Table1. Formulation of Nutritional bars

Ingredients (G/100g)	Oat Whole	Kidney Bean Flour	Sugar	Glucose Syrup	Peanut Butter	Dried Berries	Salt	Water	Banana Flour
	12.50	20.00	24	12.50	10.50	10	0.50	6	4.00

3.5. Analysis of bars

3.5.1. Proximate analysis

Moisture, crude protein, ash, crude fat, and nitrogen free extract were assessed using their specific protocols (58). Tests were repeated three times.

3.5.1.1. Moisture content

Quantity of moisture in bars was measured according to Method described in AOAC (2016) (58). In China dishes samples were taken (pre-weighed) and kept in dehydrator oven at temperature of 50°C for duration of 8-12 hours. After drying in dehydrator, the samples were removed from the dehydrator and kept in desiccator for 15 minutes to be cooled. Samples were re-weighed until constant weight was achieved. Moisture of sample was calculated using the formula:

$$\text{Moisture (\%)} = \frac{\text{weight of original sample (g)} - \text{weight of dried sample}}{\text{weight of original sample (g)}} \times 100$$

3.5.1.2. Crude protein

Kjeltech Apparatus (Model: D-40599, Behr Labor Technik, GmbH-Germany) was used to determine protein content in a sample as per procedure of AOAC (2016) (58). Method No. 484- 13. In relation to this process, seeds were digested with concentrated Sulphuric acid utilizing digestion mixture (Potassium sulphate: Iron sulphate: Copper Sulphate as 100:5:10) until a point that color reach crystal clear greenish. The obtained sample was then dilute till 250 ml using volumetric flask. 40% NaOH of 10 ml was taken in distillation apparatus of digested sample however ammonia was

gather in another beaker having solution 4% boric acid, indicator used as methyl red. Therefore, ammonium borate was made and was used for estimation of nitrogen in sample. Estimation is done by titrating the solution against 0.1 N H₂SO₄, light golden concentration shows completion point. Crude protein was estimated by multiplying factor (6.25) nitrogen percentage (N %).

$$\text{Nitrogen (\%)} = \frac{\text{Vol. of H}_2\text{SO}_4 \text{ used} \times \text{Dilution vol. (250 mL)}}{\text{initial weight of sample (g)} \times \text{Vol. of diluted sample taken}} \times 100$$

In the sample crude protein percentage was calculated by multiplying % nitrogen with factor of 6.25 and

$$\text{Crude protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$

3.5.1.3. Crude fat

It was measured with the help of Soxhlet apparatus by using diethyl ether mentioned in AACC (2010) and in AOAC (2016) (58). 5g samples (moisture free) were taken in thimbles made of Whatman filter paper and then these thimbles were placed in extraction portion of Soxhlet apparatus. Samples were kept in extraction thimble of Soxhlet apparatus covered with plug of cotton and have a cold-water arrangement. Solvent used in the process was n-hexane. The heating temperature was set in a way that hexane droplets fell in a continuous manner at trail kept in abstraction portion. Samples were subjected for fat extraction with hexane (50mL) by adjusting the rate of 3-4 drops of hexane per second. After 6-7 siphons thimble was removed and placed in an oven at 105°C for 3-4 hours to evaporate the solvent. Following formula was used for calculation.

$$\text{Crude fat (\%)} = \frac{\text{initial weight of sample (g)} - \text{final weight of sample}}{\text{initial weight of sample (g)}} \times 100$$

3.5.1.4. Crude fiber

Crude fiber was assessing in fat free sample by treating the tester in for 30 min using 1.25% H₂SO₄ and then with 1.25% Sodium Hydroxide solution through Labcono Fibertech (Labcono Corporation, Kanas, USA) as designated in AOAC (2016) Method No. 978-1. After that, model was sieved and washed using distilled water. The filtrate was evaluated and positioned in muffle furnace at temperature of 550-650

°C till grey and white dust is obtained. The crude fiber percentage was valued with reference to the following equation.

$$\text{Crude fiber (\%)} = \frac{\text{weight of dried sample after digestion (g)} - \text{weight of ash}}{\text{initial weight of dried and defatted sample (g)}} \times 100$$

3.5.1.5. Total ash

Bars were analyzed to determine content of ash in sample according to process explained in AOAC (2016) (58). 3g of each samples were taken in crucibles (pre-weighed) and placed on direct flame of burner for charring until no fumes were left in samples. Samples were then incinerated in muffle furnace at temperature of 550-600 °C for 5-6 hours until the sample is turned into grayish white color residue. Following formula was used to calculate ash contents:

$$\text{Ash (\%)} = \frac{\text{weight of residues after incineration (g)}}{\text{initial weight of sample}} \times 100$$

3.5.1.6. Nitrogen free extract

NFE in samples was measured in accordance to the given equation

$$\text{NFE\%} = 100 - (\text{CP \%} + \text{CF \%} + \text{CF \%} + \text{Ash \%})$$

Where,

CP = Crude Protein

CF = Crude Fat

CF = Crude Fiber

3.6. Mineral analysis

Bars sample was exposed to mineral calculation as per to the protocol of AOAC (2016) (58). Heat digestion on hot plate of 0.5g sample along with HNO₃ and perchloric acid (7:3) till 1-2ml colorless solution obtained. For mineral analysis digested sample was diluted up to 100ml. Calcium (Ca), Sodium (Na), Potassium (K) done using Flame Photometer-410 (Sherwood Scientific Ltd., Cambridge) as Atomic Absorption Spectrophotometer (Varian AA240, Australia) was utilized to estimate copper, magnesium, zinc, iron, phosphorous and manganese content.

3.7. Phytochemical screening tests

3.7.1 Total phenolic content (TPC)

Total phenolic content (TPC) in bars were determined using procedure of Folin-Ciocalteu as illustrated via Viuda-Martos *et al.* (2015) (59). This involves reduction of phosphotungstic acid to blue phosphotungstic as an outcome of aromatic phenolic. For this reason, prepared extract was separately added to nine test tubes having 50 μ l of each, of 750 μ l of 20% sodium carbonate solutions 50 μ l taken and absolute volume was made up to 5 ml using extracted water. After 120 min, absorbance was measured at 765 nm using UV/visible light Spectrophotometer (CECIL CE7200) against control having all reaction reagents. Total polyphenols was determined and values will be expressed as gallic acid equivalent (GAE; mg gallic acid/g) using the following formula.

$$C = C \times V/m$$

C = Total phenolic contents (mg/mL)

c=Concentration of Gallic acid (mg/mL)

y= Extract volume of extract (mL)

m = Protein weight (g)

3.7.2 Total flavonoid content (TFC)

TFC of samples was determined by aluminum chloride colorimetric method (Chandra *et al.*, (2014) (60). To make the standard calibration curve quercetin were used for TPC determination. 5 mg quercetin dissolved in 1 ml methanol to prepared stock quercetin, then quercetin standard solutions were prepared using methanol 5-200 micro gram per ml. by serial dilutions. Then 0.6 ml diluted standard quercetin was mixed with equal amount of 2% AICH. At room temperature mixture was incubated for 60 min. measured the mixture absorbance at 420 nm with Varian UV-Vis Spectrophotometer (Cray 50 Bio UV-Vis Spectrophotometer, Varian). The calibration plot ($Y=0.0162x+ 0.0044$, $R^2 = 0.999$) was used for the concentration of TFC. TFC expressed as mg QE per gram of dried material.

3.7.3. Antioxidant analysis (DPPH)

The DPPH method used calculated the antioxidant potential of the raw materials by

Miladi and Damak, (2008) (61). The free radical extract scavenging activity was calculated using DPPH. In the methanol solution the 100 micro liters of extracts or standard solution were allowed to react with 1, 1-diphenyl-2-picryl hydrazyl 3900 micro liters. Absorbance was measured at 515 nm after 1 min intervals of 1" 10 min and until the stabilization of readings the absorbance measured after every 5 min. DPPH reading of each extract was required 30 min By using the 2 standards calibration curves were prepared: BHT (synthetic antioxidant used in fats and oils) and trolox (alpha-tocopherol analogous used as reference standard), DPPH readings expressed as mM Trolox equivalents per 100gram dry weight and BHT equivalents in gram per 100 gram dry weight.

3.8. Microbial analysis

3.8.1. Total plate count

Total plate count was determined the total plate count of microorganisms in the sample, six sterilized test tubes were taken and labeled as 10, 10, 10, 9ml of normal saline was poured into test tube. Took 1 mL of sample digested in stomacher with peptone water and transferred into test tube and continued for the 6 number of dilutions. Put nutrient agar in petri dishes. The plates were left to solidify before use. Appropriate aliquots 1 mL of the dilutions was plated onto each prepared plate using sterile pipette. The inoculum was spread over the plates using sterile glass spreaders. The petri dishes were then inverted and incubated at 37°C for 24 hours and all colonies on plates were counted. The number of organisms or colony forming units per gram was calculated by multiplying the count obtained from the selected dilution. Counted average number of colonies from those dilutions with the help of colony counter the method prescribed by (Melguizo-Rodríguez et al., 2022) (62).

3.9. Selection Parameter

3.9.1 Inclusion criteria

40 participants (20 boys and 20 girls) of aged 18-25 years who have been playing regular team matches (football, volley ball, cricket) was participated in the study. Players spending average 5 hours in the field was included(including practice and match) (63).

3.9.2. Exclusion Criteria

Exclusion criteria will include all subjects with allergies to ingredients used in the energy bar (e.g., nuts) subjects with metabolic disorders affecting nutrient absorption, PEM hospitalized, adults with suspected or confirmed eating disorders or diagnosed with a mental illness (64).

Intervention Plan

Groups	Treatment plan
G ₀	Normal diet
G ₁	Normal diet + nutritional protein based bar (3 servings of 14g each)

G₀: Normal diet

G₁: Nutritional protein based bites

20 participants of G₀ group (10 girls and 10 boys) will take normal diet while 20 participants (10 girls and 10 boys) of G₁ will receive normal diet along with nutritional protein based bites. Energy was calculated according to participant's BMI.

The nutritional protein based bar was given to targeted population. Each Bite will provide 6.8 grams of protein and 283 kcal.

3.10. Ethical Considerations

Ethical research entails voluntary involvement, informed consent, confidentiality, and limiting harm to participants. Ethical approval was sought from review panel of ethical committee of University before the hand to the commencement of study. Written informed consent was taken from each participant of the study and they will also insured the participant about keeping his/her data confidential. Permission from study setting will also be taken.

3.11. Anthropometric Measurements

Anthropometric measurements including body weight (electronic machine), height

(stadiometer) and BMI (calculated by dividing weight (kg) by height squared (m²)), waist circumference (measuring tape), skin fold measurement (caliper), and mid upper arm circumference (MUAC) was measured at baseline, after 4 weeks and at end of study (after 8 weeks) (65).

3.12. Data Collection Procedure

Patients who will meet the inclusion criteria was recruited by non-probability convenient sampling technique and allocated to groups by computerized randomization into group A and Group B.

At start of study, a formal educational session, lasting about 30 minutes was given by the physiotherapist dealing with the treatment/interventions. Whole treatment plan was given for six weeks. Pre and post intervention measurements were taken.

3.13. Data Analysis

Data was entered and analyzed by SPSS version 25. Statistical significance was at $p=0.05$. After assessing the normality by Shapiro-wilk test, if the p value is greater than 0.05 the data was distributed normally. So, parametric test was applied. If p value is less than 0.05 than non-parametric test was applied (66).

Frequency tables, pie charts, bar charts was used to show summary of group measurements measured over time. After assessing normality of data by Shapiro-Wilk test, it was decided either parametric or non-parametric test was used within a group or between groups. If data was normal then parametric test was used which includes paired sample t test within group analysis and for between group analysis independent t test was used.

Chapter 4

RESULTS

Proximate analysis of bars:

Proximate composition analysis for the protein bar showed it has a good balance of nutrients for a useful snack. A water content of 14.80% was recorded which shows the bars will last on the shelf and keeps them soft and pleasant to taste. Since the protein amount was 22.80%, this food is valuable for people who need more protein to aid with their muscle growth and repair or to feel fuller specially for athletes. The fat content of the food was measured as 10.78% which made the food rich in energy and aided in absorbing vitamins A, D, E and K. Crude fiber was 4.92% which helps in a healthy digestive system and keeps you satisfied for longer. The percentage of ash found in the soil was 4.45% which indicates that the soil contains needed micro-nutrients. Nitrogen-free extract (NFE), made up of digestible carbohydrates, was found to be 55.10%, meaning it is a generous source of quick fuel. Here, nutrition labels indicate that the bar is intended for people who care about their health as shown in table 4.1.

Table 4.1 Proximate values of bars

Parameter	Value (%)
Moisture	14.80 ± 0.65
Protein	22.80 ± 0.08
Crude Fat	10.78 ± 0.06
Crude Fiber	4.92 ± 0.08
Total Ash	4.45 ± 0.05
NFE	55.10

Mineral analysis of bars:

Protein bars are excellent because their mineral composition suggests that they deliver a range of important micro-nutrients. Phosphorus was found to be the most present mineral, with 348.4 mg per 100g of food and it helps bones, energy production and cell activities as shown in table 4.2. Potassium occurred next with a concentration of 248.2 mg/100g, serving to maintain the body's fluid levels, nerve function and muscle activity. Magnesium was included at 85.5 mg/100g and this is important for muscle

and nerve health and energy production, while also aiding bone structure. There was 75.2 mg of calcium per 100 grammes which is essential for building strong bones, teeth and supporting blood clotting and muscle movement. This seaweed contains low sodium (10.4 mg/100g) which is helpful for people controlling how much salt they consume. Iron, needed for carrying oxygen in blood, was recorded at 5.0 mg/100g and zinc which can boost immunity and help healing, was 1.48 mg/100g. So, it appears that both the nutritional and mineral benefits of tequila are important in a person's daily diet.

Table 4.2 Mineral analysis of bars

Mineral	Value (mg/100g)
Potassium (K)	248.2 ± 0.04
Phosphorus (P)	348.4 ± 0.63
Calcium (Ca)	75.2 ± 0.04
Magnesium (Mg)	85.5 ± 0.65
Sodium (Na)	10.4 ± 0.16
Iron (Fe)	5.0 ± 0.09
Zinc (Zn)	1.48 ± 0.07

Phytochemical analysis of bars:

The inclusion of kidney beans in these bars makes them a possible health booster, according to their antioxidant profile. The Total Phenolic Content (TPC) was noted at 81.2 mg GAE/100g, implying that this product contains a substantial amount of phenolic compounds which are well-known for being strong antioxidants, having anti-inflammatory effects and preventing many diseases. Because the Total Flavonoid Content (TFC) was 2.01 mg GAE/100g in this fruit, it suggests a reasonable amount of flavonoids which help eliminate free radicals and benefit the heart and the immune system. Results showed in table 4.3 that the DPPH antioxidant activity was 2.93 mg GAE/100g, indicating that the bar can help to scavenge free radicals and lower oxidative stress. Following the results of these tests, it appears that eating the protein bar may be helpful for your health and well-being since it may provide you with useful antioxidants.

Table 4.3 Phytochemical analysis of bars

Parameter	Value (mg GAE/100g)
Total Phenolic Content (TPC)	81.2 ± 0.73
Total Flavonoid Content (TFC)	2.01 ± 0.14
DPPH Antioxidant Activity	2.93 ± 0.46

Sensory analysis of bars:

The analysis showed that protein bars were tastefully accepted by the consumers. Panelists seemed to really like the taste, so it received a mean score of 7.8 out of 10. Scores for taste stood at 7.6, emphasizing a tasty meal all could enjoy. The texture and color scored 7.3 and 7.5 respectively, meaning the item looked nice and felt good in the mouth. On the whole, a score above 7.0 in every attribute points to the product's impressive smell and possible acceptance by consumers as shown in table 4.4.

Table 4.4. Sensory attributes of bars

Attribute	Mean Score
Color	7.5 ± 0.16
Flavor	7.8 ± 0.34
Texture	7.3 ± 0.16
Taste	7.6 ± 0.09
Overall Acceptability	7.8 ± 0.05

Efficacy studies

The protein bars were given to athletes, initially they were divided in two groups control group (G_0) in which no bars were served and they were on normal diet and the treatment group (G_1) in which protein bars were given along with diet, the G_0 group's performance and activity level in sport remains same with zero effect but the change was observed in G_1 group which is described here

Demographic data:

The study's participants had an average age of approximately 20 years (Mean = 19.98, SD = 3.17), indicating a youthful cohort likely comprising university students or

young adults. Their mean height was 176.27 cm (SD = 14.25), and the average weight was 67.99 kg (SD = 13.13), suggesting a generally healthy and active population. These anthropometric results match those of a study on adolescent athletes, which noted comparable height and weight ranges among those athletes, therefore underlining the significance. of observing growth patterns in this population as depicted in table 4.5.

On an unidentified scale, the average performance score among participants was 5.44 (SD = 2.79), pointing to moderate self-reported performance levels. Performance metrics are frequently influenced. by many of causes including mental preparedness, diet, and intensity of training. One study assessing Division 1 athletes' nutrition and performance measures underlined the great importance of these elements. of dietary consumption in maximizing sporting performance, emphasizing the necessity of customized nutrition plans

Table 4.5. Mean and Standard Deviation of demographics

Variable	Mean	Standard Deviation
Age (years)	19.98	3.17
Height (cm)	176.27	14.25
Weight (kg)	67.99	13.13
Performance Rating	5.44	2.79

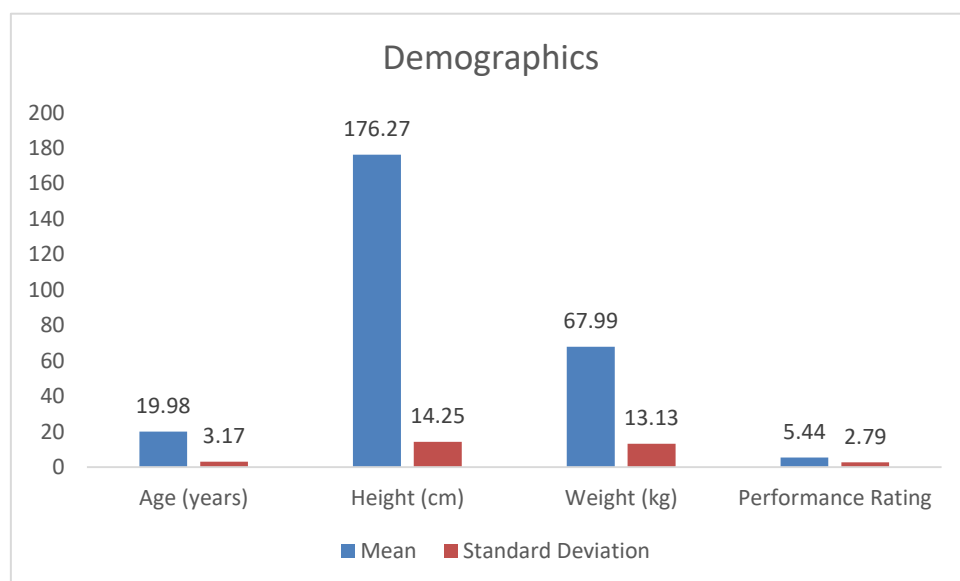


Figure 4.1: Graphical representation of demographic data

Categorical Data

Among the participants, the gender distribution was fairly equal, with men accounting for 50.4%, women 43.2%, and people identifying as 'Other' for 6.4%. This inclusive representation shows changing social standards and growing awareness of several gender identities in sports. Still, one must admit that gender inequalities in sports involvement persist across the world. For instance, a research looking at gender equality in athletics found that female athletes still face difficulties, including restricted access to resources and opportunities relative to their male counterparts. With 17.6% from other sports as shown in table 4.6, football came out as the most popular one (30.8%), with cricket (28.0%) and volleyball (23.6%). Cultural elements, access to amenities, and community support for particular sports can all influence these preferences. Research looking at athletic involvement in the United States stressed the influence cultural and infrastructural elements in determining sports preferences across several groups.

Table 4.6 Mean and frequency of categorical data

Gender	Frequency	Percentage
Female	108	43.2%
Male	126	50.4%
Other	16	6.4%

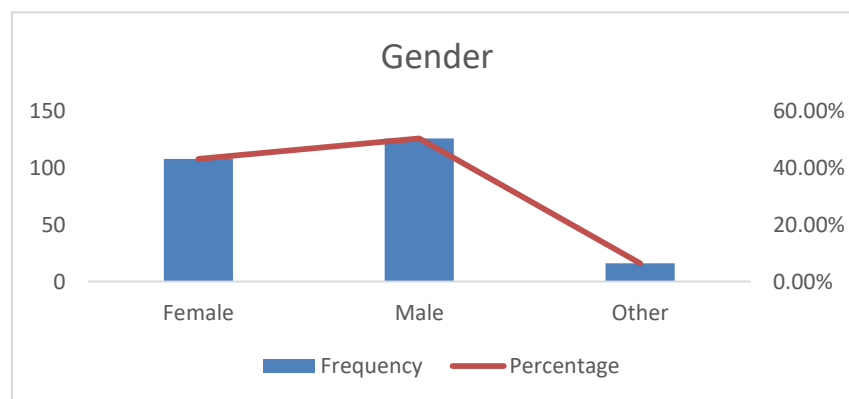


Figure 4.2: Graphical representation of gender distribution

Sport:

Among the entire sample, football rose as the most often played sport; 77 people, or 30.8%, of the participants. Nearly one-third of individuals in the surveyed group support football, indicating the worldwide popularity of the game statistics on football, also known as soccer. With almost 3.5 billion enthusiasts worldwide, the most watched sport in the world. Following cricket, 70 respondents (28.0%) played it, as shown in table 4.7. Cricket's popularity is especially noteworthy in South Asia, home to 90%. With an estimated 2.5 billion worldwide fans.

Strong momentum is also seen in volleyball, with 59 players accounting for 23.6% of the group. This fits bigger trends: volleyball is quite played and followed worldwide, with roughly 900 million spectators and 800 million active participants. Finally, 44 people (17.6%) stated they engage in other activities; this "other" category most likely includes track, badminton, and several local games. Less prevalent than the three major sports, this category as a whole comprises almost one-fifth of the sample.

Table 4.7. Mean and frequency of sport of participants

Sport	Frequency	Percentage
Cricket	70	28.0%
Football	77	30.8%
Other	44	17.6%
Volleyball	59	23.6%

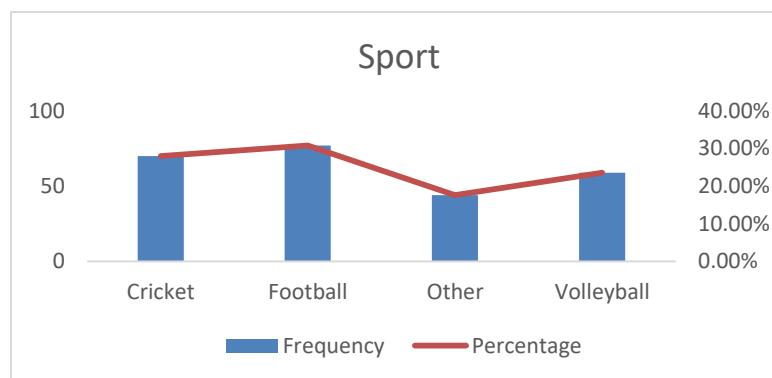


Figure 4.3: Graphical representation of sport preference of data

Hours per Week Engaged in Sports

Among the participants, weekly sports involvement data shows a respectable degree of physical activity as shown in table 4.8. Specifically 40%. Of those who reported participating in sports for 5–10 hours per week, 24.8% for 10–15 hours, and 15.2% for more than 15 hours weekly. Conversely, 20% played sports for fewer than five hours each week. This distribution shows that roughly 80% of those surveyed either fulfill or go beyond the World Health Organization's (WHO) guidelines for adult physical activity, which encourage at least 150–300 minutes of moderate-intensity aerobic activity each week, 75–150 minutes of vigorous-intensity exercise, plus muscle-strengthening activities on two or more days per week.

Table 4.8. Mean and frequency of hours per week engaged in sport

Hours/week	Frequency	Percentage
Less than 5	50	20.0%
5–10	100	40.0%
10–15	62	24.8%
More than 15	38	15.2%

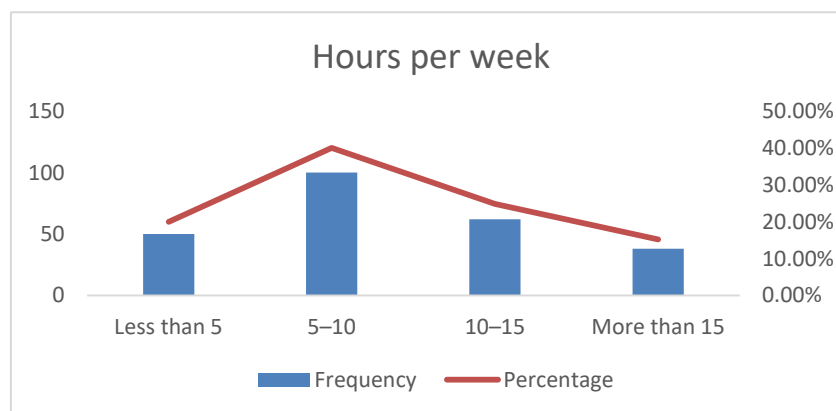


Figure 4.4: Graphical representation of hours per week engaged in sports

Type of Diet Followed (if Yes)

Sixty percent of the respondents reported following a specific type of diet, while low-carb diets were most common at 24%, followed by a balanced diet at 18%, and low-carb diets at 12%. The remaining 40 percent did not follow any specific diet. Adherence to strict diet plans enhances performance and recovery among athletes. Studies on the nutritional needs of athletes highlighted the advantages of specialized eating schedules for fulfilling energy and mineral needs in athletes.

Protein consumption frequency varied among the participants; 40% ate meals high in protein 3 to 4 times weekly, 30% daily, 20% 1 to 2 times per. Week and ten percent hardly as can be seen in table 4.9. Proper protein intake is vital especially in active people for muscle repair and growth. Consistent protein intake fosters muscle protein production and general athletic performance. Too much protein, however especially from animal products sources could cause health issues including high Accelerated aging and other health problems have been connected to insulin-like growth factor 1 (IGF-1). Thus, it is of utmost importance that high protein intake be complemented by good sources of protein.

Table 4.9. Means and frequency of types of diet followed

Diet Type	Frequency	Percentage
High Protein	60	24.0%
Balanced Diet	45	18.0%
Low Carb	30	12.0%
Other	15	6.0%
None	100	40.0%

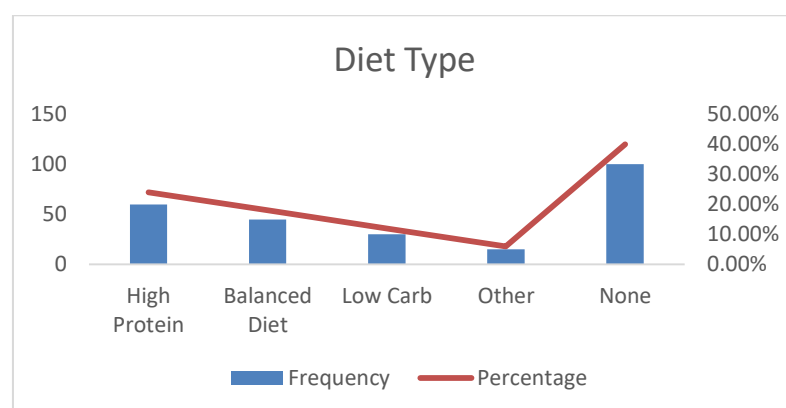


Figure 4.5: Graphical representation of diet type consumed

Frequency of Protein-Based Food Consumption:

The data shows how frequently people participate in an event; use ranges from sporadic engagement to daily. Daily activity occurs in 75 people or 30% of the sample; therefore, daily use is the second most frequent one. With 100 people reporting 3–4 times per week, 40% of the group, this is the most common time pattern seen. This implies that a sizable group favors quite regular participation. Fifty people, accounting for 20%, indicate a smaller but important fraction who participate less frequently, 1–2 times per week. The “rarely” group contains just 25 respondents or 10%, denoting the least often level of involvement as shown in table 4.10.

From a statistical point of view, this distribution shows typical usage patterns: the bulk of the sample 70% participates at least a few times a week, while a minority engages very occasionally. In survey analysis, transforming frequencies into percentages highlights their relative sizes within the group and helps to compare categories independent of sample size. Furthermore, arranging these outcomes into a frequency distribution helps one to see clearly the pattern of engagement and draws attention to the most frequent behavior 3–4 times per week and the least often seldom.

Table 4.10. Means and frequency of protein consumption

Protein Consumption	Count	Percentage
Daily	75	30.0%
3–4 times/week	100	40.0%
1–2 times/week	50	20.0%
Rarely	25	10.0%

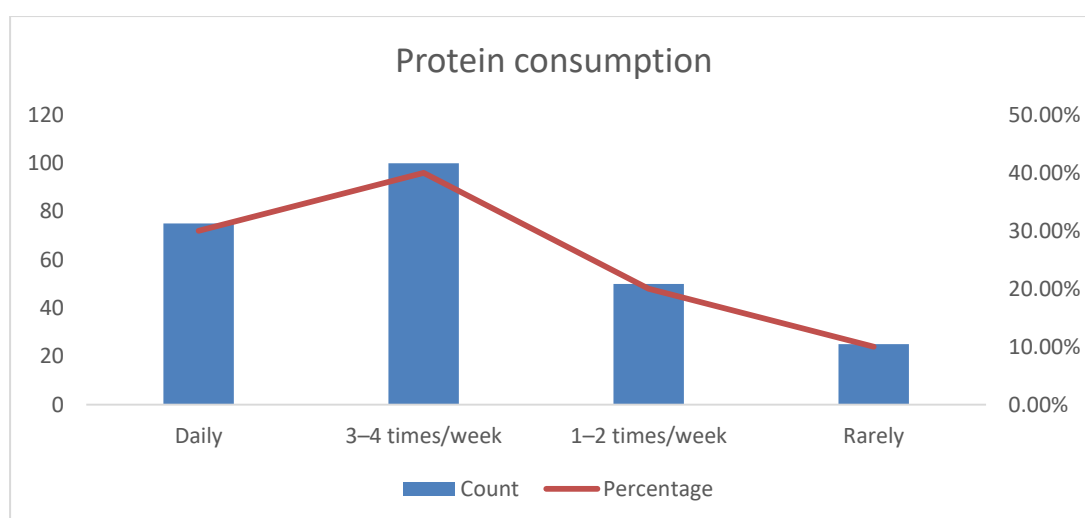


Figure 4.6: Graphical representation of protein consumption

Have You Consumed Protein/Energy Bars Before?

The responses are evenly split, with exactly half of the participants answering “Yes” (125 respondents, 50.0%) and the other half answering “No” (125 respondents, 50.0%). This perfect 50/50 distribution suggests a clear division of opinion and indicates no leaning toward either affirmative or negative consensus. Such a split in a dichotomous yes/no format offers precision in categorizing participant views, but it simultaneously limits the depth of insight into respondents' reasoning or intensity of sentiment as shown in table 4.11.

Table 4.11. Means and frequency of consumption of protein bars

Response	Count	Percentage
Yes	125	50.0%
No	125	50.0%

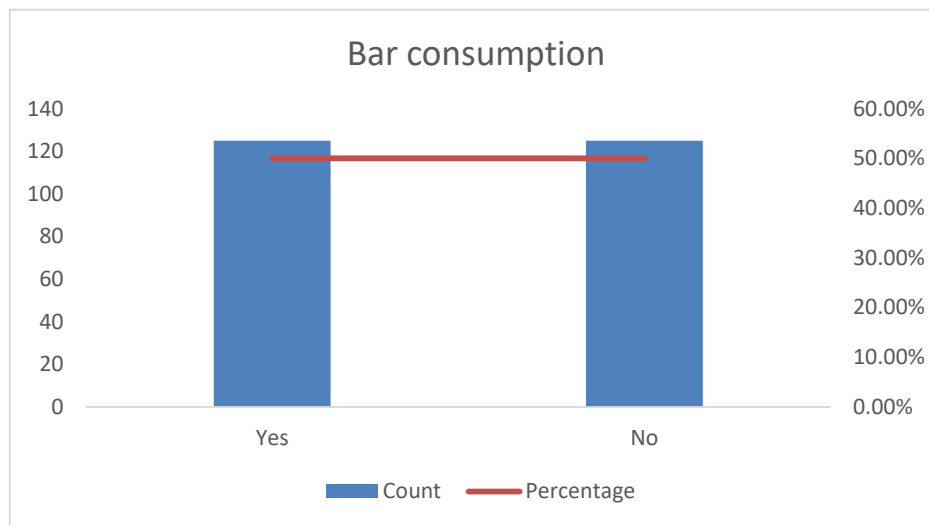


Figure 4.7: Graphical representation of protein consumption

Energy Level Before Exercise:

The ratings are subtly spread out among five levels of intensity. At the lower extreme, only 13 individuals 5.2% scored the experience as Very Low; 25 respondents 10.0% responded Low indicating minimal discontent or engagement. The Moderate and High categories are certainly dominant with 88 votes each (35.2%). This symmetry suggests that most of the respondents 70.4% consider their rating as not extreme but as one that is accumulated about moderate to high satisfaction or engagement. Conclusively, 36 individuals-14.4 percent said Very high indicating strong positive mood.

The analysis of such a distribution is appropriate as usual protocols in the group of ordinal data (Likert type data) where the frequency counts and percentages are the most significant descriptive statistics. The mode (Moderate and High) has been reported to show the most common attitudes, although more than 49% of the responses are in the High or Very high. Categories represents a relatively positive slope as exhibited in table 4.12. Also, examining both the central tendency (in the form of the mode or median) and dispersion (the spread) will allow us to not only observe the opinions of the majority of the responders but the type of difference that exists among the groups.

Table 4.12. Means and frequency of energy level before exercise

Rating	Count	Percentage
Very low	13	5.2%
Low	25	10.0%
Moderate	88	35.2%
High	88	35.2%
Very high	36	14.4%

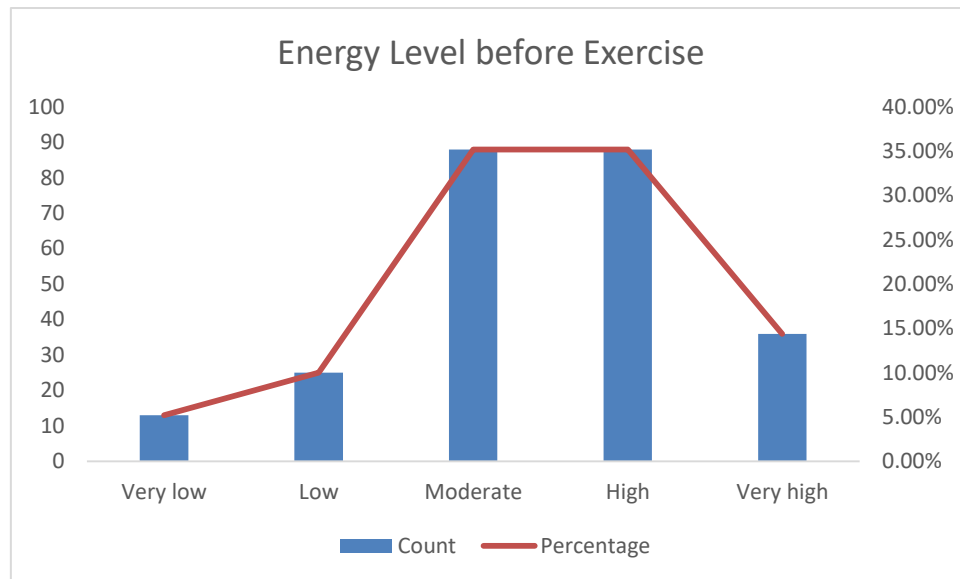


Figure 4.8: Graphical representation of energy level before exercise

Energy Level After Consuming Protein Bar

The survey data show that the majority of the participants felt greatly boosted in energy following after taking the protein bar. In particular, the proportion of respondents who reported very low energy was very small 5 (2.0%) and another 20 people (8.0%) who reported low energy, which constitutes only 10 percent of the sample range at the low end. The intermediate rank, moderate, was chosen by 63 participants (25.2%), which implies the substantial though significant increase by a quarter of consumers. In the meantime the most common rating was high energy (100 individuals), which had 40.0% of the respondents, and very high energy with 62 respondents (24.8%). On the whole, 64.8 percent of the people reported significant energy improvement (high or very high) and 35.2 percent had moderate or less effects as indicated in table 4.13.

The distribution is characteristic of the frequency count and percentages of describing the ordinal data on the 5-point Likert scale without considering the equal intervals between the categories. The most frequent mode in this case is the high energy category, and the majority of the answers (64.8) are in the first two positive categories, which indicates the perception of a strong promotion of the protein bar on energy levels. Analytically, it is more effective to show the entire distribution and the modal category to represent the central tendency as well as the response shape. To perform inferential analyses, non-parametric tests like Mann -Whitney U or chi-square should be used since data is ordinal.

Table 4.13. Means and frequency of energy after consumption

Energy level after consumption	Count	Percentage
Very low	5	2.0%
Low	20	8.0%
Moderate	63	25.2%
High	100	40.0%
Very high	62	24.8%

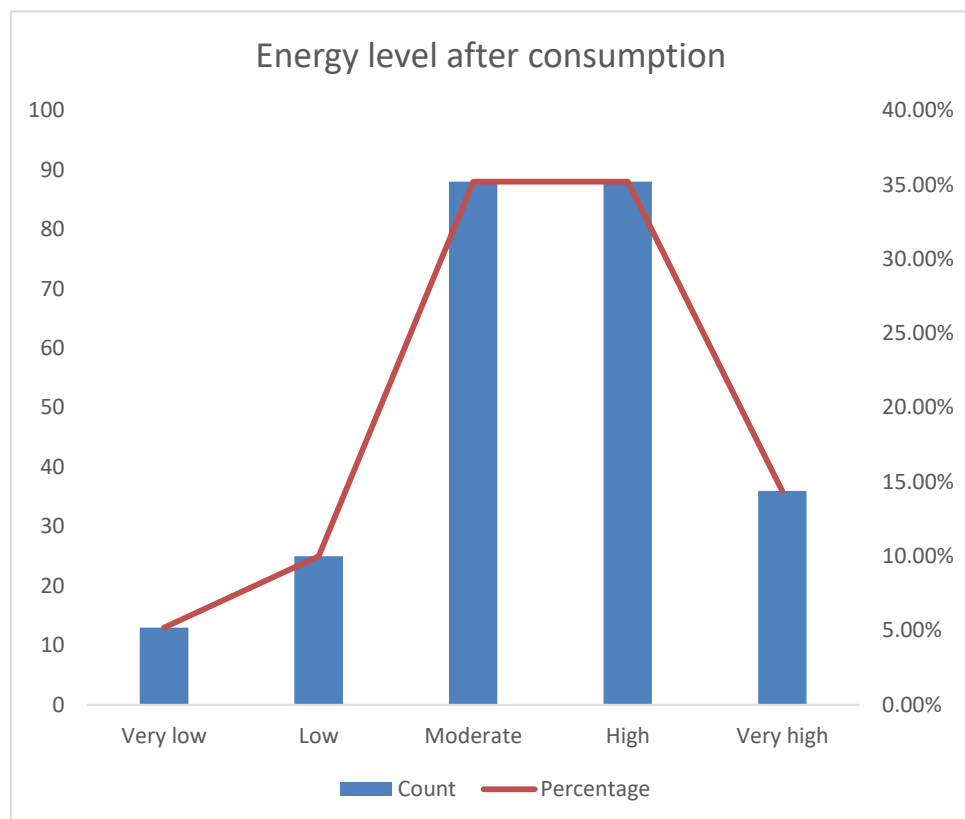


Figure 4.9: Graphical representation of energy level after exercise

Fatigue After Intense Workouts:

The frequency data shows that most participants chose mid-range options rather than extremes: 25 individuals (10%) said they never engage, and another 50 (20%) chose rarely. The most common response was sometimes, selected by 100 participants (40%), indicating that engaging occasionally is typical. Responses become less frequent as they move toward regular engagement: 50 people (20%) reported doing so often, and only 25 respondents (10%) reported doing so always as shown in table 4.14

This pattern mirrors typical distributions in ordinal frequency scales such as “Never, Rarely, Sometimes, Often, always” where most responses cluster around the middle option, “Sometimes.” Since the data are ordinal, we know there is a natural order but cannot assume the "distance" between categories is equal. Therefore, describing the percentages in each category is the best way to reflect participants' patterns of engagement without distorting their true meaning.

The mode, or most frequent category, is “Sometimes” at 40%, and the symmetry around this central option gives us insight into how participants perceive their behavior: the majority engage occasionally rather than regularly or never. Minimal numbers report consistent inaction (“Never”) or constant action (“Always”), each at only 10%. This suggests most behaviors are neither absent nor habitual but intermittent.

Table 4.14 Means and Frequency of fatigue after intense exercise

Frequency	Count	Percentage
Never	25	10.0%
Rarely	50	20.0%
Sometimes	100	40.0%
Often	50	20.0%
Always	25	10.0%

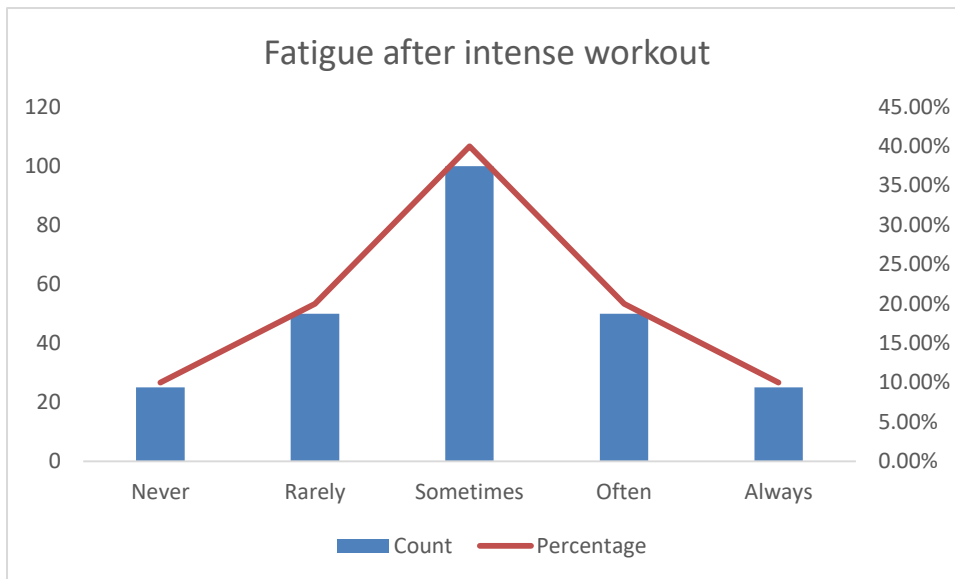


Figure 4.10: Graphical representation of fatigue after intense workout

Noticed Improvement in Endurance/Stamina:

The results of the survey show that 150 respondents—or 60%—indicated good answers by a strong majority. Simultaneously, the “No” and “Not Sure” alternatives Were chosen by 50 respondents each; this three-tiered distribution provides more in-depth knowledge than a simple binary split, therefore mirroring not just consensus but also uncertainty but also disagreement as seen in table 4.15

A strong group tendency is indicated by having a dominant affirmative response, yet the 40% combined No and Not Sure respondent's share reveals that a sizable minority is either unconvinced or indifferent. Such a distribution is normal in categorical survey data, where possibilities are assigned to each option and Understanding these percentages starts the basic univariate analysis.

Table 4.15. Means and frequency of improvement in stamina

Endurance stamina	Count	Percentage
Yes	150	60.0%
No	50	20.0%
Not Sure	50	20.0%

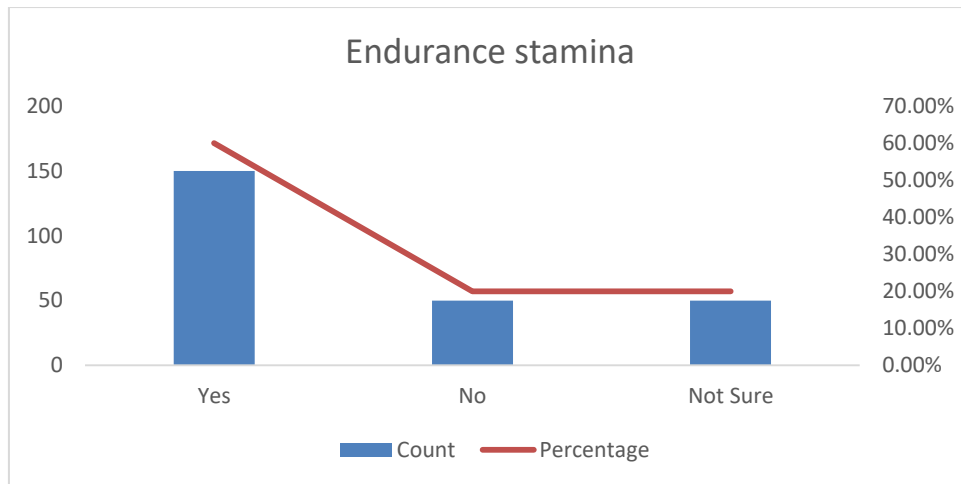


Figure 4.11: Graphical representation of endurance stamina

Taste of Protein Bar:

The ratings reveal a mostly positive opinion of the respondents. With only 13 (5.2%) of those polled labeling the subject as Poor and 25 (10.0%) as Fair, a little minority is showing dissatisfaction or low quality. With 40.0% choosing Good, the majority of the sample of 100 participants voted most often; 75 participants (30.0%) rated it as Very Excellent. Together, these two groups make up 70.0% of all replies, therefore indicating a clear good positive trend. Simultaneously, 37 respondents (14.8%) assessed it as Great, suggesting that a significant number viewed the experience or quality as exceedingly high as seen in table 4.16.

This pattern fits with conventional ordinal (Likert-style) data distributions, where frequencies and proportions rather than means are the most suited descriptive statistics since the intervals are Between categories—that is, from Fair to Good or Good to Very Good there are neither known nor necessarily equal. The Good and Very Good categories' domination implies these grades function as the mode, or central tendency, in this data set. Furthermore, given that 84.8% selected Good or above, one could view the general attitude as somewhat positive.

Table 4.16. Means and frequency of taste of bars

Taste	Count	Percentage
Poor	13	5.2%
Fair	25	10.0%
Good	100	40.0%
Very Good	75	30.0%
Excellent	37	14.8%



Figure 4.12: Graphical representation of taste of bars

Texture of Protein Bar:

The ratings of the texture are a classic just-about-right distribution with the majority of the respondents reporting that they were satisfied with the texture of the product. In particular, half of the respondents (20% of those surveyed) believed that the texture was too soft and the same number (20% of those surveyed) that the texture was too hard, so dissatisfaction with either may be well-balanced. Conversely, most of the 150 respondents (60 percent) indicated that the texture was just right and therefore most users found the texture acceptable and satisfactory.

This trend is common to Just-About-Right (JAR) scales employed in sensory studies, as it is assumed that general satisfaction can be directly measured by a consumer considering an attribute of a product as just about right. The 20% on either unsatisfactory extremes indicate that although a large minority of people have problems with texture, the issues on the problematic side are evenly divided both ways. Practically, sensory analysts tend to pay attention to this 40% (too soft + too hard) in order to determine what can be improved because both softness and hardness deviation may lead to product reformulation as illustrated in table 4.17.

Descriptively and product developmentally, the suggested distribution indicates that the proportion of satisfied is high, although a significant segment of customers (40) has a less than ideal experience. The companies would probably carry out penalty analysis on these discontented subgroups to see to it that the alterations would focus either on softening, firming, or preserving the existing texture contingent on the manufacturing capability and the preferred consumer targeting.

Table 4.17. Means and frequency of texture of bars

Texture	Count	Percentage
Too soft	50	20.0%
Just right	150	60.0%
Too hard	50	20.0%

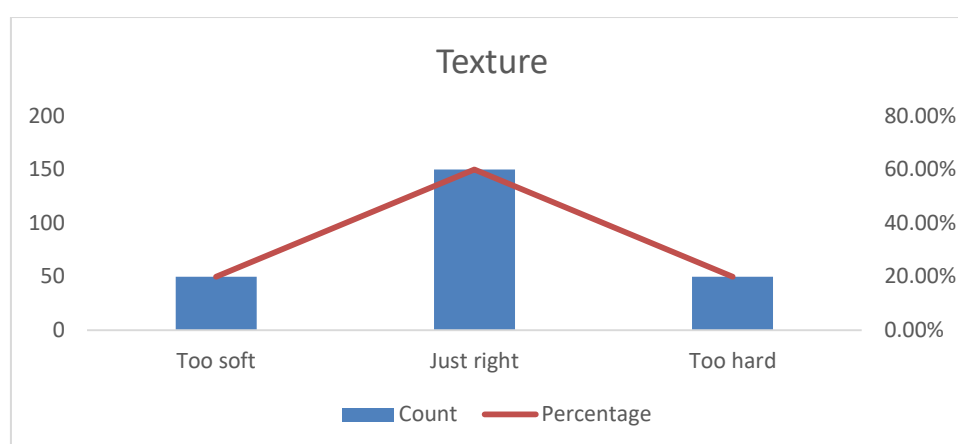


Figure 4.13: Graphical representation of texture of bars

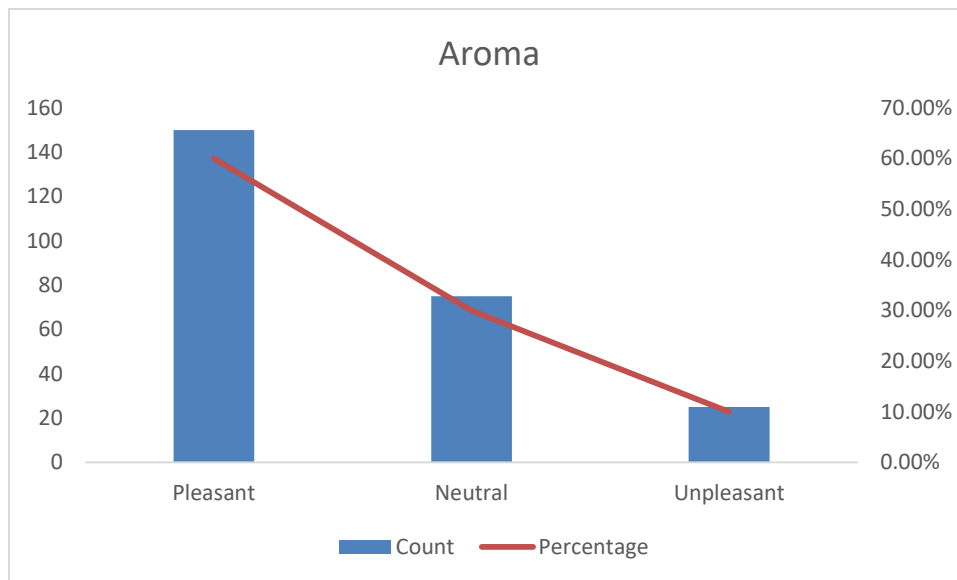
Aroma of Protein Bar:

The aroma ratings provide that the majority of the respondents had a positive overall impression with 60 percent of the participants (150) stating that they could smell pleasant meaning that there is a high level of positive acceptance. In the meantime, 30 percent (75 respondents) characterized the smell as neutral, neither very pleasant nor unpleasant, indicating that the scent did not have a heavy impact on their perception either way in them. Lower percentage 10% (25 participants) rated the aroma as unpleasant which represent a minority of those who strongly disliked the smell as evidenced in table 4.18.

This type of tiers in distribution resembles typical trends in sensory and hedonic (liking) assessments, frequently applied to consumer acceptance research. As an example, in 9-point hedonic scales, the terms like, neutral and dislike are directly related to pleasant, neutral and unpleasant, and these distributions are used to emphasize the sentiment of the majority instead of equal or average intensity. The 60 percent who liked the aroma means that it was well received whereas the 30 percent neutral figure means that it was moderately received and might need specific advancements in case the organization is trying to appeal to a wider audience.

Table 4.18. Means and frequency of aroma of bars

Aroma	Count	Percentage
Pleasant	150	60.0%
Neutral	75	30.0%
Unpleasant	25	10.0%

**Figure 4.14: Graphical representation of aroma of bars****Would You Recommend This Bar to Others?**

According to the response data, a clear majority 200 participants, or 80% answered “Yes,” whereas a smaller portion 50 respondents, or 20% answered “No.” A clear 4:1 split underlines a dominant positive attitude among participants, indicating broad agreement or acceptance of the question posed as shown in table 4.19.

Such a clear majority is often seen as a good sign of agreement. Researchers might use a binomial test to see if this 80% “Yes” rate indicates a statistically significant majority rather than simply chance by comparing the observed relative to an imagined baseline (say 50%). The result is statistically important; it supports the idea that the majority opinion is strong.

Table 4.19. Means and Frequency of recommendation of bars

Response	Count	Percentage
Yes	200	80.0%
No	50	20.0%

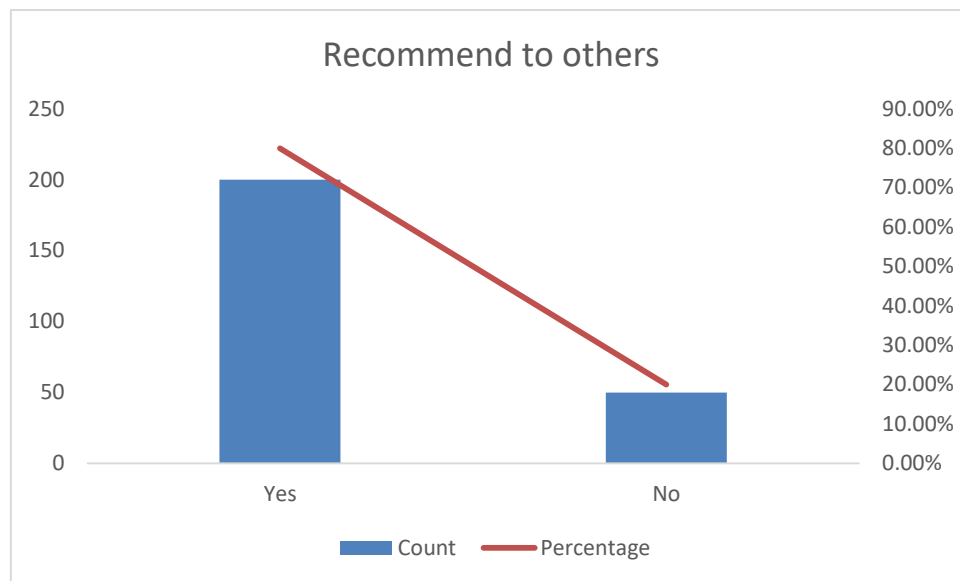


Figure 4.15: Graphical representation of recommendation of bars

Would You Continue Using the Protein Bar?

The survey results indicate a strong inclination towards continued use of the protein bar, with 188 respondents (75.2%) affirming their intent to keep using it, while 62 (24.8%) expressed a contrary opinion. This substantial majority suggests that the protein bar meets the expectations of most users, aligning with broader consumer trends where repeat purchase rates for consumable goods like nutritional supplements and meal kits are notably high as shown in table 4.20.

However, the 24.8% of respondents who are not inclined to continue using the protein bar represents a significant minority. Understanding their reasons—be it taste preferences, dietary restrictions, or other factors is crucial for product improvement. Addressing these concerns could enhance customer satisfaction and potentially increase the retention rate.

Table 4.20. Means and frequency of continuation of bars

Response	Count	Percentage
Yes	188	75.2%
No	62	24.8%

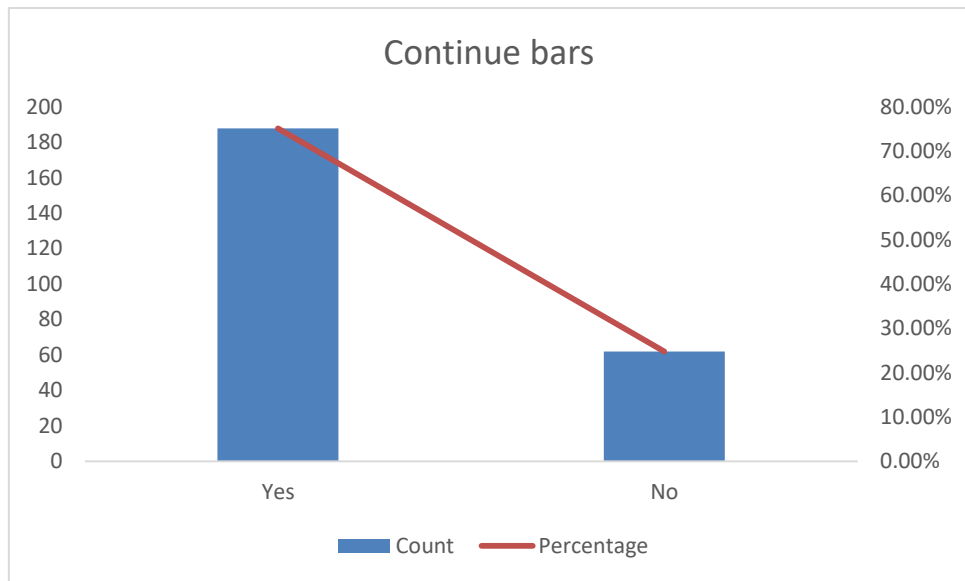


Figure 4.16: Graphical representation of continuation of bars

Chapter 5

DISCUSSIONS

The overall analysis of the produced protein bar showed that it has a very balanced and well-endowed composition that meets the needs of the athletes, active people, or health-conscious customers. The proximate composition analysis showed that the bar has 14.80% moisture which means that it has a good shelf stability and at the same time the product is soft and palatable. The protein level was also found to be high and it was 22.80, thus the bar is useful especially in muscle repair, recovery, and growth especially in people having regular physical exercises. This protein content is congruent with the demands of the athletes and people who want to receive satiety or build up of muscle mass. Moreover, the bar contained 10.78 percent of fat which is a crucial source of fatty acids as well as it helps in the absorption of other fat-soluble vitamins such as A, D, E, and K. Having 4.92 percent crude fiber implied that the product would probably assist in digestive health and increase the sense of fullness which would help to control weight. Moreover, its nitrogen-free extract (NFE) content was 55.10% which shows that the bar provides a significant portion of ready-to-use carbohydrates to satisfy immediate energy needs. The nutritional value of the bar was also rich since the ash content of 4.45 percent indicated the availability of valuable minerals.

Mineral analysis highlighted the potential of the protein bar as a functional food, which has the potential to make a significant contribution to daily micronutrient availability. The most abundant was phosphorus which was 348.4 mg/100g that is essential to the bones, metabolism of energy and body cells. The second mineral that is the most noticeable was potassium 248.2mg/100g that helps in maintaining fluid balance, nerve transmission, and muscular contraction. There was also a 85.5mg/100g magnesium in the bar which is highly required in muscle functions, energy production and bone structure. The level of calcium stood at 75.2mg/ 100g and once again demonstrates that the bar is not only useful in the development of the bone, dental health and proper operation of the neuromuscular system. Notably, sodium was not excessive (10.4mg/100g) and thus the bar is suitable to those who are sensitive to the intake of salt. The bar also contained 5.0mg/100g of iron that is required in carrying oxygen and 1.48mg/100g of zinc required in the support of the immune system and wound healing. All these minerals lead to one conclusion that the bar could be of

great assistance in assisting the micronutrient demands of physically active individuals.

The phytochemical test also put more emphasis on the functional feature of the bar. The total phenolic contents (TPC) were calculated as 81.2mg GAE/100g and this possesses a high antioxidant capacity to inhibit the oxidative stress and inflammation. The amount of total flavonoid content estimated to be 2.01 mg GAE/100g is known to be healthy to the cardiovascular system and the immune system as it combats unhealthy free radicals. The DPPH antioxidant activity was determined to be 2.93 mg GAE, 100g and this indicates the possibility of the bar that can limit the oxidative damage and improve the overall well-being. The findings are indicative that the regular use of the bar can be used to prevent chronic disease and promote long-term wellness.

The data of sensory evaluation demonstrated high levels of consumer acceptance of all the attributes measured. The bar scored high on flavor (7.8), taste (7.6), texture (7.3), color (7.5) and its acceptability rating was 7.8 out of 10 meaning that the consumers found the bar interesting and good to taste. Aroma was found pleasant by 60% of participants, with 30% of them being neutral, and only 10% disliked it. The feedback of texture showed that 60 percent of the respondents considered it to be just right but 20 percent believed that it was too soft and the rest 20 percent believed that it was too hard thus in refining this technology a bigger audience can be satisfied. Most of the respondents (80 percent) said they would refer others to the bar and 75.2 percent said they would prefer to use it again which reveals the strong market potential of the product.

The protein bar has a positive effect in the energy and endurance level of the participants in terms of efficacy. Most of the respondents had moderate to high energy levels before consumption but since taking the bar, 64.8% of them claimed to have high or very high energy levels which showed a high perceived enhancement of vitality and physical activity readiness. Also, 60 participants replied that they had observed an increase in the endurance or stamina after consumption, which helps in supporting the potential of the bar to improve athletic performance and recovery. Demographic and lifestyle information revealed that the majority of respondents were young adults, with most of them involved in activities like football, cricket, and

volleyball with 80% embracing or surpassing the WHO requirements on the amount of time they needed to spend on physical activity per week. Most of the participants (60%) were on a particular diet of which high-protein was the predominant and most took in foods rich in protein more than once a week. This also makes the bar more appropriate to the target audience since it matches with their eating habits and objectives of performance.

The results of a crossover trial in young adults comparing a high-protein (HP; 280 kcal) and a high carbohydrate (HC; 260 kcal) bar in the early morning hours were not significantly different regarding total 24 h energy intake among all the participants. Nonetheless, the high physically active individuals consumed a lot more of it when they were fed either the protein bar (+22% HP, +45% HC) or the carbohydrate bars (67), indicating that active persons are in a position to self control the caloric intake leading to the provision of the macro nutrient substrate in protein bars (67). The study method was a randomized controlled trial with elite cross country skiers in a comparison of the peptide based bars as compared to the standard protein bars in 4 weeks of the intervention comparing the immune and inflammatory biomarkers. Peptide energy bar group was associated with considerable rise in IgA/IgM, TNF 068 and fall in CRP which indicated possible improvement on immune modulation and an anti inflammatory response relative to controls (68).

Pakistan Development and characterization studies were done with protein-energy bar tailored with dates, artisan apricots, cheddar cheese, whey protein isolate, and the use of chickpea or rice flour occasionally. The bars offered a protein content of about 22-24 percent, had a stable antioxidant activity, good sensory properties, and in vitro ACE inhibitory properties. Specifically, a single formulation has fulfilled suggested protein requirements in athletes, long shelf stability, and offered a consumable substitute to snacks through integrating macronutrient requirement along with bioactive advantages (69). Periconceptual ingestion of a whey protein based bar containing isomalto oligosaccharides prior to exercise, decreased muscle soreness, repeated sprint performance, and volumes of the leg press, as compared to an isocaloric carbohydrate placebo. The subjective soreness was reduced, and the recovery indicators were better in the participants of the whey bar, which indicated an ergogenic advantage during the training with high intensity (70).

Meta analyses have continually demonstrated that carbohydrate plus protein (CHO PRO) supplementation yields better endurance performance (time to exhaustion) and time trial (TT) results than carbohydrate supplementation but isocaloric CHO PRO v CHO-only did not provide an advantage. CHO was the only one that found benefits in comparisons, that the added protein in energy-matched bars enhances endurance performance, possibly through improved muscle glycogen replacement and decreased central fatigue (71). Protein bars are convenient, and they may contribute to the nutrition of athletes; however, it is important to note that not all of them are equally good (experts). Those are bars made using whole-foods such as nuts, dates, and whey with low-added sugar (<8 g). However, on the other hand, the introduction of artificial sweeteners, a large amount of fats, or excessive sugars in ultra-processed bars can have adverse effects on the health of the gut and their role in satiety, and this is why clean formulations should be used in sporting activities (72).

In healthy adults ($n = 21$, mean age 21.9 ± 2.6 years), a one-week crossover experiment examined the effects of daily protein-bar eating with and without extra fiber. Participants ate a protein bar daily; energy intake climbed by 7–13% above control, but they made up for just around 20% of those added calories. Though hunger ratings did not vary, body fat mass increased by roughly 3% in just one week. Regular consumption of protein bars, according to these results, can somewhat increase caloric intake and so cause fast fat accumulation unless overall diet is well regulated (73).

Subjects consumed either CHO-PRO (24 g protein + carbohydrate) in a 10-week RCT of trained endurance athletes ($n = 25$, age 31 ± 9 years). or isoenergetic carbohydrates right after workout on training days. Post-intervention, the CHO-only group showed elevations in inflammatory markers neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio, and systemic immune-inflammation index, while the CHO-PRO group showed none such increases (non significant). This indicates that eating proteins and carbohydrates together could reduce inflammation during rigorous endurance exercise (74).

Twelve resistance-trained men participated in a crossover pilot study comparing intake of a new whey-protein/isomalto-oligosaccharide (IMO) bar against carbohydrate-only prior, during, and post- intensive exercise (3). Set sprint exercises and resistance plus agility. By set 3, participants eating the CHO-only bar saw a

roughly 198 kg reduction in leg-press volume; the whey IMO bar group only saw an At recovery, the protein bar group also had considerably reduced subjective muscle soreness at recovery; weight drop was 82 kg; p was around 0.175. These findings imply that whey-based protein bars have the ability to help preserve performance and cut down on tiredness both during and following strenuous training (75).

In a randomized, crossover pilot study spanning 11 days with elite male athletes (n = 8), subjects ate either a created high-protein bar or an off-the-shelf one. As an afternoon snack following training, 275 kcal and 5 g protein. Body composition, energy intake, metabolic markers (blood glucose, lipids), and over five-day phases were monitored. Though final results were awaited, this model shows the possibility of high-protein bars as athlete-friendly meal substitutes, therefore maximizing macro-nutrient consumption without raising overall calories (76).

Chapter 6

CONCLUSION

In summary, the protein bar developed in this study combines strong nutritional value, essential minerals, antioxidant properties, and high sensory acceptance, making it a promising option for consumers seeking a functional snack to support active lifestyles. The bar's ability to enhance perceived energy and endurance, coupled with its favorable taste and texture profile, suggests it has excellent potential for widespread acceptance and repeat consumption. Future refinements in texture and expanded testing across diverse populations could further strengthen its appeal and efficacy.

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APPENDICES

ENGLISH CONSENT FORM

The study you are about to participate is a randomized control trial survey titled as;

**“Effects of high energy nutritional protein based bar on
performance of young athletes”**

The study has no potential harm to participants. All data collected from you will be coded in order to protect your identity, and should not be disclosed to anyone. Following the study there will be no way to connect your name with your data. Your answers to the questions will not affect the quality of education given to you. Any additional information about the study results will be provided to you at its conclusion, upon your request.

You are free to withdraw from the study at any time. You agree to participate, indicating that you have read and understood the nature of the study, and that all your inquiries concerning the activities have been answered to your satisfaction.

NAME _____

SIGNATURE _____

DATE _____

URDU CONSENT FORM

نے اپنی (YOUR NAME IN URDU) محترمہ تصدیق کرتا/ کرتی ہوں کہ _____ میں
اس تحقیق

“Effects of High Energy Nutritional Protein-Based Bar on Performance of Young Athletes”

زیر نگرانی (YOUR SUPERVISOR NAME) کے متعلق بتا دیا ہے۔ مجھے اس تحقیق کی
نوعیت، مقاصد، اہداف، توقعات، فوائد اور خطرات کے متعلق ، ساری معلومات فراہم کر دی گئی
ہیں

اس تحقیق کے دوران ساری معلومات صیغہ راز میں رہیں گی اور مریض کا نام اور دیگر معلومات
صرف تحقیق کے لیے استعمال ہوں گی۔ مجھے یہ بھی بتا دیا گیا ہے کہ میں اس تحقیق سے متعلق ہر
قسم کے سوال پوچھنے کا مجاز ہوں اور یہ تحقیق صرف ایک شخص کا مفاد میں نہیں ہے بلکہ
بحسبیت مجموعی انسانیت کا مفاد اس سے وابستہ ہے۔ تمام تفصیلات جاننے کے بعد میں تحقیق میں
شامل ہونے یا نہ ہونے پر کسی کا قائل نہیں ہوں۔ اس تحقیق سے کسی بھی وقت علیحدہ ہونے پر مجھ
پر کوئی پابندی نہیں ہو گی۔ میں بذاتِ خود بقائمی حوش و حواس
اور رضا مندی سے اس تحقیقاتی عمل میں شامل ہوتی/ ہوتا ہوں۔

دستخط محقق _____

دستخط شرکت کار _____

تاریخ _____

DEMOGRAPHICS FORM & QUESTIONNAIRES

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

Section 1: Demographic Information

1. **Gender:**

- ☐ ☐ Male
- ☐ ☐ Female
- ☐ ☐ Other

2. **Age:** _____ years

3. **Height (cm):** _____

4. **Weight (kg):** _____

5. **Sport you participate in:**

- ☐ ☐ Football
- ☐ ☐ Volleyball
- ☐ ☐ Cricket
- ☐ ☐ Other (please specify): _____

6. **How many hours per week do you engage in sports activities?**

- ☐ ☐ Less than 5 hours
- ☐ ☐ 5-10 hours
- ☐ ☐ 10-15 hours
- ☐ ☐ More than 15 hours

Section 2: Dietary Habits and Protein Intake

7. **Do you follow any specific diet plan?**

- ☐ ☐ Yes
- ☐ ☐ No

8. **If yes, what type of diet do you follow?**

- ☐ High protein diet
- ☐ Low carbohydrate diet
- ☐ Balanced diet
- ☐ Other (please specify): _____

9. How often do you consume protein-based foods (meat, dairy, legumes, protein bars)?

- ☐ Daily
- ☐ 3-4 times per week
- ☐ 1-2 times per week
- ☐ Rarely

10. Have you previously consumed protein bars or energy bars before participating in this study?

- ☐ Yes
- ☐ No

Section 3: Physical Performance & Energy Levels

11. How do you rate your energy levels before exercise?

- ☐ Very low
- ☐ Low
- ☐ Moderate
- ☐ High
- ☐ Very high

12. How do you rate your energy levels after consuming the protein bar?

- ☐ Very low
- ☐ Low

- ☐ Moderate
- ☐ High
- ☐ Very high

13. How often do you experience fatigue after intense workouts?

- ☐ Never
- ☐ Rarely
- ☐ Sometimes
- ☐ Often
- ☐ Always

14. Have you noticed any improvement in your endurance/stamina after consuming the protein bar?

- ☐ Yes
- ☐ No
- ☐ Not sure

15. On a scale of 1 to 10, how would you rate your overall performance improvement after using the protein bar?

(1 = No improvement, 10 = Significant improvement)

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7

- ☐ 8
- ☐ 9
- ☐ 10

Section 4: Sensory Evaluation of the Protein Bar

16. How do you rate the taste of the protein bar?

- ☐ Poor
- ☐ Fair
- ☐ Good
- ☐ Very Good
- ☐ Excellent

17. How would you describe the texture of the protein bar?

- ☐ Too soft
- ☐ Just right
- ☐ Too hard

18. How do you rate the aroma of the protein bar?

- ☐ Pleasant
- ☐ Neutral
- ☐ Unpleasant

19. Would you recommend this protein bar to other athletes?

- ☐ Yes
- ☐ No

20. Would you consider continuing the consumption of protein bars for

athletic performance enhancement?

- ☐ Yes
- ☐ No

Section 5: Additional Comments

21. Do you have any suggestions to improve the protein bar?

Signature: _____

Date: _____

Sensory Evaluation of _____

Name: _____ Date: _____

Designation: _____ Ag #: _____-ag-_____ (if student)

Contact # / Email: _____

Instructions:

- Take the sample and check how much you like or dislike.
- Check the sample and score below mentioned characteristics using 9-point hedonic score system.
- Before proceeding to the next sample, rinse mouth with water.
- Make inter comparison of sample and record the score.
- Don't disturb the order of sample.
- Use the appropriate scale (9-point hedonic score system).

	Color	Flavor	Taste	Mouthfeel	Overall Acceptability
T ₁					
T ₂					
T ₃					
T ₄					
T ₅					
T ₆					

1. Dislike Extremely
2. Dislike Very Much
3. Dislike Moderately
4. Dislike Slightly
5. Neither Like nor Dislike
6. Like Slightly
7. Like Moderately
8. Like Very Much
9. Like Extremely

Comment:

Signature: _____