

## CHAPTER 1

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### INTRODUCTION

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***“Exercise is King, Nutrition is Queen. Put them together and you've got a Kingdom”.***

**-Jack Lalanne - 'The Godfather of Fitness', Hunnicutt (2006)**

Throughout human history, sports have occupied a significant role in our cultural organization, surpassing limitations of geography and tradition to bring people together through the common bonds of competition and physical achievement. Originating from the ancient Olympic Games in Greece and continuing to today's worldwide sporting extravaganzas, sports have transformed into a vibrant and complex arena that encompasses not just physical skills, but also mental resilience, collaborative spirit and a mirror of cultural principles.

The importance of sports nutrition cannot be overstated in terms of enhancing athletes' and active people's general health and performance. It entails a carefully planned approach to providing the body with certain nutrients that support recovery, energy, strength and endurance. There is a strong link between athletic performance and nutrition because the right combination of nutrients may make the difference between reaching one's greatest potential and falling short of it. In this field, dietary decisions go beyond simple nourishment to become a field of exact science, where understanding the body's nutritional needs may release the full potential of its physical capabilities (Potgieter, 2013).

A solid nutritional foundation is essential for achieving optimal physical performance. It serves as both the source of energy for biological processes and the providers of the necessary compounds to extract and utilize the potential energy stored within this fuel. Beyond their role as sources of energy, energy substrates like carbohydrates, fats and proteins also contribute significantly to maintaining the overall structure and functional well-being of the organism. Furthermore, water and electrolytes (such as sodium, potassium, calcium, magnesium, chlorides and phosphates) are crucial for the efficient operation of all bodily systems. The influence of macronutrients and their significance

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in the context of exercise has been extensively researched. The requirements for macronutrients, potential dietary adjustments, or supplementation have been widely observed and studied, with established guidelines to achieve optimal performance. Athletes should choose conditioning and training methods that align with their energy systems. The primary dietary objective for athletes revolves around obtaining sufficient nutrition to enhance health and fitness, ultimately leading to improved performance (Kelkar, 2007).

Athletes globally increasingly rely on nutritional supplements to enhance training and performance (Garthe and Maughan, 2018). These supplements aid in injury recovery, training adaptation, competition performance and provide essential nutrients (Knapik et al., 2016). The growing supplement market offers a variety of options, including bars, gels, liquid meals and sports beverages, gaining acceptance within athletic communities (McDowall, 2007; IOC, Legg et al., 2015). Supplement usage among athletes ranges from 13% to 50%, with common choices including whey and soy protein, carbohydrates, energy drinks, vitamins, minerals, fish oils and creatine. Many athletes use multiple supplements simultaneously, often exceeding three types (Nabuco et al., 2017; Graham-Paulson et al., 2015; Aljaloud and Ibrahim, 2013; Muwonge et al., 2017).

According to the International Society for Sports Nutrition (ISSN) and the American Council of Sports Medicine (ACSM), most people can get enough micronutrients via a regular, nutrient-rich diet that includes a variety of food categories (Potgieter, 2013). But for a variety of reasons, such as a lack of awareness about appropriate foods, out-of-date information on sports nutrition, restricted access to sports professionals, financial limitations, time constraints that make it difficult to obtain or consume appropriate foods, a lack of availability of healthy food options, frequent travel and the selection of inappropriate supplements, many athletes fall short of their nutrition goals (Maughan and Burke, 2012).

The evolution of sports nutrition has been characterized by breakthroughs in comprehending nutrient timing, the makeup of macronutrients and the distinct requirements across various sports. Starting with the initial focus on carbohydrate loading and culminating in the contemporary acknowledgment of protein's significance, sports nutrition has evolved into a scientific field that customizes dietary approaches to

align with the distinct prerequisites of diverse physical endeavours. Athletes have long recognized the significance of proper nutrition in enhancing physical performance and recovery. From endurance athletes to bodybuilders, the need for targeted nutritional strategies to support the body's demands during training and competition is paramount. Protein, as one of the fundamental macronutrients, plays a crucial role in muscle repair, growth and overall tissue maintenance.

Sports enthusiasts commonly acknowledge the importance of protein, particularly in terms of muscle growth and often harbour concerns about meeting their protein intake requirements due to training and competition. However, protein stands as a vital nutrient not solely confined to muscle development; its significance extends to numerous other functions, rendering it essential for both seasoned athletes and individuals with less physical activity. Within the body, proteins are in a perpetual state of synthesis and breakdown. This constant cycle facilitates the mending of potentially damaged or malfunctioning proteins. Moreover, proteins can also serve as an energy source, a particularly critical aspect for athletes engaged in demanding endurance sports. As any excess protein that the body cannot utilize is excreted, it becomes imperative to consistently replenish macronutrients like proteins through a well-balanced diet (Fink and Mikesky, 2011).

Protein bars have gained significant traction in the global market, driven by growing consumer awareness of health, fitness and convenience. In the current economy, the demand for protein bars is fueled by the increasing number of health-conscious individuals, athletes and busy professionals seeking quick, nutritious snack options. The market has diversified, offering bars catering to various dietary preferences such as vegan, gluten-free and low-sugar alternatives. Economically, the protein bar market is expected to witness steady growth, driven by rising disposable incomes, urbanization and a shift towards on-the-go nutrition. Major players in the food industry are investing heavily in product innovation to meet the demand for high-protein, functional foods. This has resulted in increased competition, leading to the availability of affordable and premium products, which appeal to a broad consumer base (Rajabi, 2017).

Cereals have become an essential component of modern lifestyles due to their versatility in the form of ready-to-eat products, instant foods, cereal bars and energy bars. Once limited to breakfast, cereal consumption has expanded to various times of

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the day, making these products a regular part of many consumers' diets. The growing demand for processed and convenience foods is largely driven by increased health awareness, evolving socio-economic factors and the lack of time to prepare meals that provide balanced nutrition. One example of such a nutritionally balanced convenience food is energy bars, which have gained significant popularity in the global market since the 1980s (Jetavat et al., 2020).

Millets have long been a staple in traditional Indian diets, but in recent years, a shift toward cereal consumption has occurred for various reasons. However, there is a renewed interest in millets due to their notable nutritional and functional properties. Although millets are generally low in high-quality protein, combining them with soy, pulses, or milk proteins can enhance both the quantity and quality of the protein content in millet-based products. Utilizing extrusion technology to develop such products can result in extrudates that are low in fat, high in protein and fiber and rich in other functional nutrients. These extrudates, when powdered and combined with malted cereals, can be formulated into suitable weaning mixes for infants. (Sumathi et al., 2007).

Protein is available in a variety of dietary sources. These include foods of animal and plant origins as well as the highly marketed sport supplement industry. The components comprising whey protein are abundant in essential amino acids and branched-chain amino acids, offering substantial nutritional value. These proteins exhibit a range of advantageous properties that contribute to overall well-being. Moreover, whey is a notable source of various vitamins and minerals. While its prominent role lies in sports nutrition, whey protein also finds application in diverse areas such as baked goods, salad dressings, emulsifiers, infant formulas and medical nutritional products (Małecki, et al., 2020).

Isolates stand out as the most refined iteration of soy protein products, boasting the highest protein content. Unlike flour and concentrates, isolates lack dietary fiber. This variant of soy protein emerged in the 1950s within the United States. Renowned for their exceptional digestibility, isolates seamlessly integrate into various food products, including sports drinks, health beverages and even infant formulas (Hoffman and Falvo, 2004). The inclusion of groundnuts in protein bars adds a valuable nutritional component, contributing to the bars' protein content, amino acid profile, healthy fats

and overall taste and texture. This makes groundnuts a popular choice among manufacturers aiming to create nutritious and delicious protein bars for consumers seeking convenient and protein-rich snack options.

Protein is widely regarded as one of the most vital macronutrients for humans due to its multifaceted functions within the body. Various demographic groups, including athletes and those engaged in physical activities, have been subject to comparisons of their protein requirements. The impact of consuming protein from animal and plant sources on sports performance have been examined. In recent times, combinations of dairy and soy protein have emerged in the market as ingredients for sports nutrition products, including nutrition bars and convenient ready-to-consume or powdered beverages (Paul, 2009).

During both training and competitive phases, inadequate protein consumption has been documented among various groups of Indian athletes, including competitive runners, boxers and weightlifters, as well as female collegiate hockey players from North India, sportspersons from the Coimbatore district and both volleyball players and runners. This suboptimal intake stands in contrast to the recommended dietary allowances for protein (Malla et al., 2017).

Dietary protein is acknowledged as a pivotal nutrient in facilitating optimal training adaptation and refining body composition among endurance athletes (Stokes et al., 2018). Athletes' protein intake contributes to the augmentation of muscle mass, strength, immune function, recovery and the process of Muscle Protein Synthesis (MPS). The act of endurance exercise elevates the breakdown of amino acids, particularly branched-chain amino acids, which supply energy to active muscles (Beck et al., 2015).

For athletes, the recommended daily protein intake generally ranges from 1.2 to 2.9 grams (g) per kilogram (kg) of body mass, contingent upon factors like age, sport type, body composition and engagement in resistance training (Thomas, et al., 2016). Research advocates the consumption of combined carbohydrates and protein (specifically essential amino acids). When taken as a pre-exercise meal, protein aids in achieving optimal protein synthesis, escalating energy substrate availability, prolonging exhaustion time, minimizing muscle damage and soreness. As a post-exercise meal, protein facilitates recovery, expedites MPS and replenishes depleted muscle glycogen stores (Jäger et al., 2017).

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Acknowledging the significance of protein represents only the preliminary stage and there exist several complexities linked to offering this vital nutrient in a form that is both convenient and pleasing to the palate. Protein bars have arisen as a prevalent and practical option, furnishing a mobile source of crucial nutrients. The expression "Sports Foods (SF)" typically denotes distinct food items intentionally crafted to satisfy the dietary necessities of athletes. These items encompass a variety of classifications, each custom-tailored to achieve distinct objectives that harmonize with the fundamental nutritional aspirations of enhancing training adaptation, facilitating recovery and optimizing performance during competitive occasions (Peeling et al., 2019). Food or nutrition bars are commonly characterized as "bar-shaped foods designed to enhance physical energy, typically composed of a blend of fats, carbohydrates and proteins, often supplemented with vitamins and minerals" (Anon, 2017).

Athletes frequently use convenience supplements like energy bars, meal replacement powders and ready-to-drink options to meet calorie needs and manage weight or performance goals. Protein bars, specifically designed for athletes and bodybuilders, provide 20 to 35 grams of protein per bar to support energy during intense exercise. These bars combine protein, carbohydrates, fats and additional nutrients such as fiber, vitamins and minerals. Ingredients include grains, protein sources like whey, soy and pea, sweeteners, nuts, seeds, dried fruits, flavors and preservatives, all aimed at improving taste, acceptance and shelf life.

In the field of sports nutrition, the quest for optimal performance and enhanced recovery has led to continuous innovation in the development of specialized dietary products. Athletes and fitness enthusiasts alike seek nutritional solutions that are not only effective but also convenient to incorporate into their demanding routines. One intriguing avenue within this landscape is the utilization of extruded products as raw materials for sports foods. Extrusion technology, characterized by the application of heat, pressure and mechanical forces to transform raw ingredients into a range of textured and structured forms, has gained significant attention in the food industry. While initially employed for the production of breakfast cereals and snack items, extrusion has now transcended its traditional applications to potentially revolutionize the sports food sector (Twombly, 2020).

Beyond nutritional content, taste and aroma are fundamental factors that influence consumers' choice of food products. These edibles are expected to offer a gratifying

sensory experience, stemming from the intricate interplay of various sensory quality attributes (Sampaio et al., 2010). Consequently, the creation of novel food items holds significant significance for the sustenance of most businesses and intricately aligns with evolving consumer preferences and trends. As consumers become increasingly discerning, their brand selection process becomes more meticulous, underscoring the need for companies to adapt and innovate.

The development of protein bars necessitates a delicate balance between achieving desirable taste, texture and nutritional characteristics. The conventional trial-and-error approach to formulate these bars can be time-consuming, resource-intensive and often leads to suboptimal outcomes. In this context, the implementation of advanced statistical methods, such as Response Surface Methodology (RSM), has emerged as a valuable tool to streamline the product development process and optimize protein bar formulations (Nadeem et al. 2012).

RSM shows up as a potent technique for the creation and improvement of protein-energy bars in this situation. It is a statistical method that helps with experiment design, multivariate analysis of effects and response optimisation. It offers a methodical framework for investigating the intricate interactions between different processing parameters, formulation elements and how they affect the sensory, nutritional and physical qualities of the finished product. Researchers and food technologists can determine the ideal formulation conditions that result in enhanced product attributes by methodically changing these elements and tracking their impacts RSM (Riswanto et al. 2019). It is recognized as a valuable approach for enhancing process efficiency, particularly when the factors affecting the process, such as protein sources in this case, are believed to exert either individual or combined influences on the targeted outcomes (Martinez et al., 2004).

When it comes to sports nutrition, coaches are extremely important in directing the eating habits of young athletes. The perspectives of coaches about sustenance, hunger and nutrition among young Indian athletes are examined in a qualitative study conducted by Cherian et al. (2020). This study provides insight into the difficulties coaches encounter in keeping an eye on and optimising young athletes' nutritional choices during a crucial developmental period. The study reveals the opinions of

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coaches on the relationship between nutrition and performance, challenges they have in comprehending nutrient intake and variables influencing players' food choices through in-depth interviews held at a state-sponsored residential sports centre. It emphasises how crucial it is to comprehend the viewpoints of coaches in order to customise efficient dietary plans for young athletes.

In the quest for optimal athletic performance and muscle recovery, the role of sports nutrition has become increasingly prominent. Central to this pursuit is the recognition of protein as a fundamental component in supporting muscle repair, growth and overall athletic function. During physical exertion, muscles undergo stress and damage, making protein essential for their repair and regeneration, ultimately enhancing recovery and performance. However, acknowledging the importance of protein is merely the initial step; the challenge lies in delivering this vital nutrient in a manner that is both convenient and palatable. This is where protein bars step into the spotlight, offering a convenient and palatable solution. With their portable nature and nutrient-rich composition, protein bars have emerged as a favoured choice among athletes and fitness enthusiasts alike. Providing a blend of proteins, carbohydrates and fats, these bars prioritize delivering a substantial amount of protein, making them an accessible option for individuals with hectic schedules and high nutritional demands.

The development of cost-effective protein bars for Indian athletes requires a holistic approach that balances nutrition, affordability, cultural sensitivity and regulatory compliance. As more individuals in India embrace sports and fitness activities, investing in accessible and tailored nutritional options is crucial for nurturing a healthier and more active nation.

### **Research Rationale:**

The recommended nutritional regimen can have a better compliance when studies on development of sports specific convenience and cost-effective foods with good visual appeal, taste, textures, shelf life and high acceptability are carried out. Athletes are more likely to adhere to their nutritional plans if they enjoy the taste and texture of the food products. The formulation of protein bars must involve intricate interplay among various ingredients to achieve both nutritional excellence and sensory appeal. Conventional methods may not fully capture the complexities of these interactions.

Hence, there arises a need for innovative approaches that can systematically optimize protein bar formulations. RSM offers a structured framework to explore the synergistic effects of ingredients, concentrations and processing parameters on the final product. By employing RSM, this study aims to streamline the protein bar development process, effectively balancing nutritional content and consumer acceptability. Thus, the study intends to optimize protein in Protein- Energy Bar (P-E Bars) that fulfil not only nutritional criteria, but also customer expectations in terms of sensory appeal, cost effectiveness and shelf life.

### **Broad Objective:**

To develop a Protein-Energy Bar using Response Surface Methodology in order to replenish and bridge the gap in the macronutrient consumption as per the dietary requirement of physically active individuals.

### **Specific Objectives:**

1. To conduct an online market survey on food bars for various purpose (viz., athletes, fitness trainers, yoga bars, schoolchildren, astronauts and for general purpose).
2. To set the levels of cereal and pulses ingredients ratio in the *crispies*.
3. To standardize the bar formula.
4. To optimize the levels of crispies, whey and pulse protein for the protein bars using RSM.
5. To develop a nourishing Protein-Energy Bar with a good sensory score and commercial value.
6. To conduct sensory analysis of the developed food product by semi trained panel
7. To study the chemical analysis of proximate principles of the developed food product.
8. To study the textural attributes of the developed food product.
9. To evaluate the shelf life of the standardized product.
10. To conduct a cost analysis of the final product.
11. To conduct an acceptability study on athletes and trainers.