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Assessment of nutritional status and therapeutic Potential of protein enriched energy dense bars on underweight school going Children

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Under-nutrition is a significant public health issue, especially for school-age children. Underweight, stunting, and wasting can result from poor nutritional consumption and insufficient nutrient intake, which can have long-term health effects. Providing children with nutrient-dense, protein-rich diet is one strategy to combat this problem. The objective of this study is to assess nutritional status and therapeutic potential of protein enriched energy dense bars on underweight school going children. The study involved a sample size of 24 children, who were 6 years old in school but were underweight. Anthropometric measurements and blood samples were taken to analyze the children's serum protein levels and iron content to evaluate their nutritional condition. The children were divided into three groups, with the T_1 received 100g of protein-rich energy bars, the T_2 received 120g for two months, and the T_o receiving no treatment at all. After two months, the nutritional statuses of both groups were evaluated. Results: The findings of this study demonstrated that protein-enriched energy-dense bars significantly improved anthropometric measurements in both groups, including BMI that changed in T_1=0.63 kg/m^2 and T_2=0.88 kg/m^2, WC in T_1=1.1cm and T_2=1.39cm, WHR in T_1 0.04cm and T_2=0.04cm, MAMC in T_1=3.29 and T_2=6.09, MUAC in T_1=0.48cm and T_2=0.76cm, TSF in T_1=0.26mm and T_2=0.36mm, serum protein in T_1=1.23g/dl and T_2=3.06g/dl, iron in T_1=1.64mg and T_2=2.15mg.The study concluded that protein-enriched energy dense bars are beneficial in enhancing children's nutritional status which will help in guiding future interventions to improve the health of the vulnerable population. The 120g protein-enriched energy dense bars showed marginally significant changes than the 100g protein-enriched energy dense bars. Overall, the study contributed to the development of evidence-based interventions to combat under-nutrition among school-going children.

Keywords: underweight, nutritional status, anthropometric measurements, school-going children

INTRODUCTION

The WHO defined child under-nutrition as deficits in weight for age (underweight), height/length for age (stunting), or weight for height/length (wasting) (Hron et al. 2020). Malnutrition has always been attributed to a lack of nourishment. Both anatomical and functional disorders of the brain are linked to malnutrition. (Li et al. 2022). Protein-energy malnutrition (PEM) is an axiom that refers to a collection of related illnesses that includes kwashiorkor, marasmus, and intermediate phases of kwashiorkor-marasmus (Chao et al. 2020). Patients with PEM are more likely to experience complications such as hypoglycemia, hypothermia, severe infection, and electrolyte imbalances. Premature birth, stopped breastfeeding, mental problem, vomiting, contagious tuberculosis, and parasitic infections such as measles, malaria, diarrhoea, and whooping cough are all outcomes of PEM (Awuchi et al. 2020).

Child malnutrition, mostly manifested as stunting, wasting, and underweight, is a severe global public health issue in the underdeveloped nations (Soni et al. 2022). Ignorance, family size, residence, lack of means to buy food, poor maternal education, poverty, food neglect, cultural and religious food customs, lack of quality healthcare, inadequate breast feeding, malformations or congenital defects, chronic infections, child gender, and incomplete immunisation have been identified as major risk factors for under-nutrition (Alou et al. 2021).

Nutritional status is a powerful predictor of school-age children's health and neurocognitive function. The school-age era is nutritionally significant since it is the optimal time for the body to build up nutrient stores in preparation for fast growth during adolescence (Beriso, 2019).Because good nutrition is essential for reducing illnesses and enhancing cognitive development in schoolchildren, it is critical that these children meet their energy and nutrient RDAs. This poor diet has been linked to household food instability, a low educational level, parental nutritional habits, and acquaintance (Bhatti et al. 2021).

During the first six months of an infant's life, breast milk is the only and complete source of nutrition. Breast milk contains all of the nutrients and immune components needed by newborns to maintain optimal health and growth. Breast milk becomes insufficient to support developing infants towards the middle of the first year (Dipasquale et al. 2020).As a result, nutritious complementary foods must be offered. Inadequate supplementary feeding of babies is a major contributor to the high prevalence of child malnutrition. Children with PEM have low total protein levels, which can drop to roughly 50% in extreme cases. Total serum protein and albumin levels were lower in kwashiorkor than in marasmus. Serum insulin levels are low and growth hormone (GH) levels are high in kwashiorkor children during the acute phase of PEM (Farwa et al. 2022).

The stunting prevalence of Chinese children under the age of 5 years was 9.91%, the underweight prevalence was 5.90%, and the wasting prevalence was 2.21%. Every fourth child in the world suffers from protein energy malnutrition; 151 million (26.71%) are underweight, while 182.1 million (32.7%) are stunted. More than 71% of children are born in Asia, 26.1% in Africa, and 4.2% in Latin America and the Caribbean (Ghosh, 2020).The prevalence in Pakistan showed four out of every ten children under the age of five are stunted, and 17.71% are wasting. The double burden of malnutrition is becoming more visible. In the same age range, nearly one in every three children (28.89%) is underweight, with a significant prevalence of overweight (9.48%) (Bhatti et al. 2021).

Till seeds are often referred to as the "*Queen of Oilseeds*" due to their great durability against degradation and oxidation. Because of its large content of significant-quality edible oil and healthy protein, sesame seed has a high food value. Till grains supply 573 kcal and 18g protein, vitamin B1, nutritional fiber, and are abundant in the mineral phosphorus iron, magnesium, calcium, manganese, copper, and zinc. These are high in polyunsaturated fatty acids (PUFA), such as stearic and palmitic acid, as well as natural antioxidants (Petrikova, 2022).

Groundnuts (*Peanuts*) are a popular crop all over the world. Groundnut is used for a variety of applications, including the production of oil. Groundnuts contain phenolic acids, resveratrol, flavonoids and the phytosterols. These chemicals hinder the body from absorbing cholesterol. Groundnut includes a lot of arginine since it contains all the essential amino acids which are 20, and it's also a good source of co-enzyme Q10 (Syed et al. 2021). They will offer the body with abundant nutrients that can promote growth and energy, as well as play an important part in illness prevention. Per 100 g, groundnut contains five hundred seventy kcal. It is particularly high in nutrients and contains 44.0 to 56.5% oil and 22.4 to 30.1% protein on a dry seed basis (Munir et al.2022).

Cereals are a fundamental diet in many regions of the world, with wheat providing greater than 60.0% of people's total daily protein and calorie requirements, particularly in Pakistan (Hussaini et al. 2022). The Bengal gram commonly known as *channa* is a good protein source that contains enough levels of the necessary amino acids (Petrikova, 2022). It is high in proteins that include all of the essential amino acids. Furthermore, it contains a high concentration of docohexanoicacids (DHA) and arachidonic acid (AHA), as well as a low concentration of lipids, the majority of which are polyunsaturated fats. Manganese, zinc, calcium, magnesium, iron and copper are also present as micronutrients (Sirelkhatim et al. 2020).

Dairy products are abundant in protein sources, therefore adequate intake may lower the risk of malnutrition. This included foods high in fibre (whole wheat), protein (green gramme whole and skim milk powder), calcium (the skim milk powder), carotene, millet finger, iron, and Vitamin E (Grenov et al. 2020). Gur that is known as (*Jaggery*) is an organic, conventional sweetener created from the concentration of sugarcane juice that is recognized by several local names around the world. Gur is recognized to generate heat and provide rapid energy to the human body (Jaiswal et al. 2020).

MATERIALS AND METHODS

Procurement of raw material: Wheat flour, milk powder, gingelly and nigar seeds, groundnut, jaggery, roasted bengal gram. All these materials were purchased from the local market of Sialkot with a care that all the materials should be of fine quality. Protein enriched energy dense bars were manufactured and analyzed in the Laboratory of University Institute of Diet and Nutritional Sciences, Faculty of Allied Health Sciences, The University of Lahore, Lahore. The bars were prepared from mixing wheat flour and bengal gram flour. Groundnuts and gingerly seeds were added to increase the protein content. Niger seeds and jiggery syrup were incorporated to enrich the iron content in the product. Grinding of Bengal gram and grinding of ground nuts were done. All the flours and Jaggery syrup mixed thoroughly. Each bar was made of 100g (303kcals) and120g (324 kcals) of mixture.

The sample size was calculated by two independent means and it was 24 then the participants divided into three groups. Each group contained (n= 8) T_0 contained normal diet, T_1 and T_2 were given protein enriched energy dense bars for 2 months. Inclusion Criteria: Children of age 6 years were included. Both Male and Females were included.

Table 1: Preparation of 100g and 120g protein enriched energy dense bars

Ingredients	Composition (100g)	Composition (120g)
Wheat flour	17g	21g
Bengal gram roasted (*channa*)	6.5g	7.8g
Till (white +black)	3.3g and 1.7g	5.4g and 2.3g
Groundnut	6.5g	8.5g
Milk powder	30g	35g
Jaggery	35g	40g

Figure 1: Illustration of Protein enriched energy dense bars

Children with moderate grade of under-nutrition between -3 and -2 z-score were included. Children with BMI below 5thpercentile were included. Exclusion criteria: Any kind of allergies, suffering with any disease like thalassemia, hepatitis, cerebral palsy, asthma, diarrhea, constipation, cold, cough etc other than under-nutrition and under specific treatment or some interventions.

The resulting substance were evaluated using the AOAC method by taking three different readings in order to calculate the proximate analysis parameters (fat, moisture, protein, carbohydrate, fiber and ash) and the results were presented in the mean of the standard deviation (Singh & Dunkwal, 2020). The protein-enriched dense bars were made by combining all of the ingredients and were used to assess sensory qualities. The sensory evaluation of protein-enriched energy dense bars was performed by 8 panel members randomly selected from the department of using the Meilgard approach (Almuziree & Alhomaid, 2023).

RESULTS

The determination of the proximate composition is the most important key feature in order to assess the quality of the material under study. The proximate analysis of the protein enriched energy bars (100g) was carried out and the results discovered the moisture content, crude protein, crude fat, crude fibre, ash, NFE and mineral (Iron content) as expressed in table 2 respectively.

Table 2: Proximate analysis of Protein enriched energy bars

Nutritional components	Proximate Composition (%) (100g)	Proximate Composition (%) (120g)
Moisture	10.22±0.07	10.26±0.08
Crude protein	9.06±0.04	9.10±0.06
Crude fat	20.14±0.60	20.17±0.62
Crude fiber	1.22±0.02	1.25±0.03
Ash	1.39±0.03	1.41±0.04
NFE	60.59±2.6	64.75±2.9
Iron content	6.49±.01	6.84±.03

The data acquired from the panel of 8 members' sensory evaluation of the bars was analyzed using Analysis of Variance (ANOVA), followed by the test of averages (p=0.05).The panel highly valued the sensory evaluation of protein-enriched energy dense bars in terms of appearance, scent, taste, texture, mouth feel, and overall acceptance as shown in table 3.

Table 3: Sensory evaluation of Protein enriched energy dense bars

Sr no	Attributes	Mean ±SD
1	Colour	7.49±0.28
2	Flavor	7.42±0.32
3	Aroma	7.71±0.21
4	Texture	7.51±0.27
5	Taste	7.62±0.37
6	Overall acceptability	7.47±0.07

Table 4: Comparison of parameters inches between Pre and Post tests

Parameters	Groups	Pre	Post	*p*-value
BMI	T_0	12.50±0.53	12.62±0.51	.024^{NS}
	T_1	12.62±0.51	13.99±0.88	.007*
	T_2	12.65±0.51	15.20±2.07	.004**
WC	T_0	20.55±1.79	20.74±1.64	<.001**
	T_1	20.30±1.67	21.93±1.67	.009*
	T_2	20.31±1.38	23.70±2.01	.028^{NS}
TSF	T_0	7.08±0.82	7.15±0.85	<.001**
	T_1	7.35±0.72	7.61±0.67	<.001**
	T_2	7.41±0.44	7.87±0.40	.016^{NS}
MAMC	T_0	106.72±6.86	107.11±6.76	<.001**
	T_1	108.96±7.76	112.25±7.90	.009*
	T_2	111.68±14.50	118.77±10.59	.007*
MUAC	T_0	12.42±0.53	12.58±0.56	.004**
	T_1	12.51±0.53	12.99±0.45	.061*
	T_2	12.17±0.23	12.93±0.37	.018^{NS}
WHR	T_0	0.75±0.02	0.76±0.03	<.001**
	T_1	0.75±0.04	0.72±0.03	.009*
	T_2	0.77±0.04	0.73±0.03	.02^{NS}
Serum protein	T_0	4.52±0.72	4.42±0.58	.005**
	T_1	4.37±0.32	5.60±0.60	.140*
	T_2	4.37±0.51	7.59±0.69	.014^{NS}
Iron Content	T_0	7.47±0.81	7.47±0.76	.081*
	T_1	7.87±0.55	9.41±0.79	.146*
	T_2	8.05±0.77	11.20±0.87	.135*

The mean, standard deviation and *p*-value body mass index, waist circumference, waist to hip ratio, triceps skinfold thickness, mid arm muscle circumference, mid upper arm muscle circumference, serum protein and iron content of underweight children before and after intervention are presented in the Table 4.

DISCUSSION

Protein-enriched energy-dense bars are being investigated as a possible therapeutic solution for underweight school-age children. These bars are intended to give a high concentration of energy and protein in a little amount of space (Sharifi et al. 2023). A study on school-aged children aged between the ages of 4 and 8 was conducted to evaluate the impact of various interventions for improving children's nutritional status. Body weight (8.0-10.1%), mid arm circumference (2.0-3.2%), body height (7.0-9.0%), waist circumference (2.0%), body mass index (5-.7.1%), TSF (5.0%), hemoglobin (6.9-8%), and the hemocrit level (11.2-17.0%) increased as a result of the efficacy research. Thus, high energy cereal-based bars are simple to make, inexpensive, and meet 30% of children's daily caloric needs (Farwa et al. 2022).Similarly our study shows significantly increase in Mean±SD of BMI 15.20±2.07, TSF 7.87±0.40, waist circumference 23.70±2.01 and iron content 9.41±0.79.

A study was conducted on the prevalence of protein energy malnutrition (PEM) in children under the age of five which estimated that 70% of malnourished children were affected and this had a strong emphasis on treating childhood malnutrition. For preventing the malnutrition in children a ladoo was created. It was providing the 1/3rd day of the protein and calories requirements that were essential for children’s growth and development. By monitoring the changes in anthropometric measurements, nutritional intake, the effectiveness of the product in managing malnutrition was evaluated. The reference group's mean weight before and after the intervention was 18.67 0.67 kg and 18.77 0.67 kg, respectively, and the individuals' mean weight gain was 1.5 kg. Before and after the intervention, the control group's MAMC's Mean±SD values were 118.19±1.44 mm and 119.22±1.56 mm, respectively. Before and after the intervention, the control group's arm circumference was 14.27 ±1.42 and 14.43±1.52. For students in grades I, II, and III, the observed increase was 1.072, 1.16, and 0.81 kg, respectively. The supplement contributed around one-third of the daily need, which led to a significant (p=0.05, 0.01) improvement in intake of children (Viswanath et al. 2021). As compared to our study, by giving 100g and 120g of protein enriched energy dense bars in children of 6 years age, the Mean±SD BMI changed to 13.99±0.88 (100g) and 15.20±2.07 (120g), Mean±SD MAMC changed to 118.77±10.59 (100g) and 112.25±7.90 (120g), Mean±SD MUAC changed to 12.99±0.45 (100g) and 12.93±0.37 (120g) and Mean±SD TSF changed to 7.61±0.67 (100g) and 7.87±0.40 (120g).

CONCLUSION

Under-nutrition is a major concern among school-aged children, and delivering nutrient-dense, protein-enriched energy dense bars served as a successful approach to address it. These bars can supply a concentrated amount of micronutrients as well as macronutrients, both of which are necessary for development and growth. The study's findings will provide substantial insight into the curative abilities of protein enriched energy-dense bars that can enhance the nutritional well-being of underweight school-aged children. Overall, the study will help to design evidence-based strategies to reduce under-nutrition in school aged children.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Laiba Khalid designed and also wrote the manuscript. Momina Shahid assembled data. Zarnain Ali Shah and Arooj Attique final approved and guarantor of the article. Fatima Zahra and Smeea Fatima did statistical analysis. Ayesha Shakeel did collection of data. All authors read and approved the final version

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