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Short-term effects of a fiber–protein functional product on subjective appetite and calorie intake

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ABSTRACT

Overweight and obesity are rising global health concerns, contributing to increased metabolic and cardiovascular diseases. Among the multiple factors influencing body weight, dietary intake plays a critical role. This study aimed to develop and optimize a snack enriched with protein and fiber to evaluate its effects on appetite and subsequent food intake. Whey protein, casein, and egg albumin were combined with fibers such as inulin, oligofructose, glucomannan, and apple fiber to formulate different samples. Sensory evaluation by ten semi-trained panelists assessed taste, texture, color, and overall acceptability, and the optimal formulation contained 30.3% protein and 11.6% fiber. A randomized, controlled, single-blind clinical trial was conducted on 40 healthy adults (BMI 19–25 kg/m²), divided into intervention product and control (placebo) groups. Appetite was measured using a 100-mm visual analogue scale, and food intake was recorded during an ad libitum lunch 3.5 h after snack consumption. Results demonstrated that the optimized product significantly influenced hunger, fullness, desire to eat, and overall appetite score ($p<0.05$). Effect size analysis indicated moderate effects on hunger and fullness and a large effect on desire to eat, while actual food intake was minimally affected (small effect size: $d<20$). In vitro evaluation suggested that fiber–protein interactions increased viscosity and gastric retention, delaying digestion and which may enhance satiety signaling. In conclusion, the optimized high-protein, high-fiber snack improved appetite regulation mainly by enhancing satiety, although its effect on immediate food intake was limited, supporting its potential as a functional food for weight management

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1. Introduction

In recent decades, overweight and obesity have emerged as escalating global health concerns, significantly contributing to the rising incidence of metabolic and cardiovascular diseases.

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The World Health Organization (WHO) reported that, in 2016, approximately 1.9 billion adults worldwide were classified as overweight, of whom nearly 30% were obese. This alarming trend highlights that excess body weight has become a widespread issue influenced by numerous factors such as insufficient physical activity, genetic predisposition, socio-economic

background, and unhealthy dietary behaviors. Among these determinants, dietary intake plays a particularly critical role in the development and persistence of obesity (1, 2).

In response, the food industry has attempted to reformulate its products to lower their energy density. Nonetheless, the growing prevalence of obesity indicates that modifying eating habits and reducing calorie consumption remain challenging for many individuals. As a result, designing food products capable of promoting satiety and curbing appetite is considered a promising approach to assist in weight management and decrease overall food intake, especially among overweight and obese populations (3).

The regulation of appetite is a multifaceted physiological process involving complex signaling pathways between the hypothalamus and various organs such as the stomach, pancreas, intestines, and adipose tissue. The sensation of fullness begins when the stomach expands, triggering neural signals to the brain. Additionally, several gut hormones—such as cholecystokinin (CCK), glucagon-like peptide 1 (GLP-1), peptide YY (PYY), and ghrelin—are released during food digestion and absorption, playing a key role in regulating satiety (4). A variety of dietary components, including proteins, fibers, short- and medium-chain fatty acids, and indigestible carbohydrates, can enhance satiety through hormonal and physiological pathways. Numerous studies have focused on the satiating effects of various types of dietary fiber and carbohydrate compounds, such as pectin, alginate, guar gum, β-glucan, glucomannan, inulin, oligofructose, and fibers naturally present in cereals and fruits like wheat, barley, and apple (5). Satiety develops in three main stages: it begins with sensory and chewing cues before swallowing, continues as the stomach expands and digestion slows, and is reinforced once nutrients are absorbed and hormones signaling fullness are released into the bloodstream. Protein enhances satiety mainly by stimulating appetite-regulating hormones (CCK, GLP-1, and PYY), increasing energy expenditure, raising amino acid levels that signal fullness, and promoting gluconeogenesis, which helps sustain the feeling of satiety (6).

To develop a functional food capable of suppressing appetite effectively, several mechanisms must be considered, particularly textural and sensory attributes, the ability to expand in the stomach and delay gastric emptying, and the stimulation of satiety hormones in the gastrointestinal tract. In the current research, these aspects were incorporated into the formulation strategy. Proteins and fibers were selected as the principal active ingredients due to their well-documented influence on appetite control. Specifically, whey protein, casein, and albumin were combined with fibers such as inulin, oligofructose, glucomannan, and apple fiber to create and optimize the formulation. The study hypothesized that a product containing both fiber and protein synergy would elicit stronger satiation responses than products high in either component alone. Although the majority of research has experimented with these nutrients individually or in liquid meals, and no research exists on solid, palatable foods that include a particular combination of these proteins and fibers to maximize sensory acceptability and satiety.

2. Material and methods

2.1. Product formulation

The ingredients used in the product formulation included whey protein concentrate (80% WPC, Hilmar Company, USA), casein (85% calcium caseinate, Agro Company, Poland), egg albumin (Ovopol, Poland), glucomannan fiber (Trades S.A., Spain), apple fiber (NutriCargo, USA), inulin (Frutafit TEX, SENSUS, Netherlands), oligofructose (Frutafit TEX, SENSUS, Netherlands), aspartame (NovoSweet, China), acesulfame potassium (NovoSweet, China), cocoa powder (Indcresa, Spain), margarine (Behshahr Company, Iran), fructose syrup (Zar Fructose Company, Iran), flavoring essence (Magnolia Company, Iran), and lecithin (Azarnoosh Shokoofeh Company, Iran). In this study, the ratio of the three types of proteins and the four types of fibers was kept constant across all formulations, while the total percentage of protein and fiber varied among treatments. The remaining mixture, comprising fructose syrup, margarine, aspartame, acesulfame potassium, cocoa powder, and lecithin, was adjusted accordingly to balance the formula as the protein and fiber levels increased or decreased. Efforts were also made to maintain a nearly constant dough moisture content across all formulations, which averaged 31±1%. To prepare the samples, water and fructose syrup were first mixed in a food processor for 2 min. All powdered ingredients were then added and blended for another 2 min. Finally, margarine and lecithin were incorporated, and the mixture was thoroughly blended for an additional 2 min, resulting in a uniform dough. The final dough was molded and baked in an oven at 180°C for 18 min. After baking, the samples were cooled, packaged, and stored under refrigerated conditions until further analyses were performed.

2.2. Sensory evaluation

For the sensory evaluation of the samples, ten semi-trained panelists were recruited from among the students and staff of the Faculty of Nutrition and Food Technology, Shahid Beheshti University of Medical Sciences. The participants received preliminary training on how to assess the samples in terms of texture, chewability, flavor, color, and overall acceptability. The evaluation sessions were conducted in the faculty's pilot laboratory. At the beginning of the session, the purpose of the study was briefly explained to the assessors without disclosing specific details such as the product formulation. A commercial product from Nestlé (Optifast bar) designed for weight management and containing various fibers, proteins, oils, carbohydrates, minerals, vitamins, flavorings, and sweeteners was used as the control sample. This product was chosen because its texture closely resembled that of the test samples. The panelists were instructed that the objective was to develop a product with textural properties similar to the control, and therefore, the control sample served as the reference point for scoring the sensory and textural characteristics of the developed samples. A 9-point hedonic scale was used for the evaluation, where a score of 1 indicated "dislike extremely" and 9 indicated "like extremely". Each panelist was asked to taste 10 grams of each of the 17 samples, rinse their mouth with water between samples, and take short breaks before testing the next one. It should be noted that the

assessors were not informed about the composition or formulation of any of the samples.

2.3. Clinical phase

The objective of this phase was to evaluate the effect of the optimized product on appetite and food intake in comparison with a placebo product. This phase was designed as a randomized, controlled, single-blind clinical trial, conducted as follows: The study population consisted of students and staff members of the National Nutrition and Food Technology Research Institute (NNFTRI), aged between 18 and 50 years, with a Body Mass Index (BMI) ranging from 19 to 25. Sampling was carried out according to specific inclusion criteria. Among these individuals, those who met the eligibility criteria and expressed willingness to participate were selected for the study. The sample size was determined based on the findings of Hassanzadeh-Rostami et al. (2020), using the mean and standard deviation of appetite scores, with a 95% confidence level and 80% statistical power, as calculated by the following formula. The minimum sample size required for each group was 17 participants. However, considering a possible 15% dropout rate, the final sample size was set at 20 participants per group.

2.3.1 Participants

Participants were recruited through phone calls or in-person invitations from among the students and staff of the National Nutrition and Food Technology Research Institute. The objectives, details, and significance of the study were clearly explained to all potential participants, who were not informed about the product composition. Individuals willing to take part completed an eligibility screening form, and those meeting the inclusion criteria were asked to sign an informed consent form before enrollment. Eligible participants were then randomly assigned to one of two groups: the intervention group, which received the product containing fiber and protein, and the control group, which received the product without fiber and protein. Randomization was performed using coded cards labeled "A" and "B." The study was conducted over two days with a minimum three-day interval between sessions at the NNFTRI facilities and the Shahid Rahimi male dormitory.

Participants included men and women aged 18 to 50 years with BMI between 19 and 25 kg/m². Additional inclusion criteria were regular breakfast consumption, absence of medications affecting the gastrointestinal system or appetite, non-smoking and non-alcohol use, not following a specific diet, no weight loss of 3 kg or more in the past three months, no recent changes in diet or physical activity, not being pregnant or lactating, having a regular menstrual cycle (for women), no known allergies to any product components, and willingness to participate in the study. Exclusion criteria included developing any acute illness during the study, non-compliance with the intervention protocol, or voluntary withdrawal from participation.

2.3.2. Study Design and Implementation

This study was conducted following the experimental protocol described by Chungchunlam et al. (7, 8). The experiment was performed over two separate days, with a minimum three-day interval between sessions. Participants were instructed not to consume any alcoholic beverages for at least one day before each test day. All subjects arrived at the Faculty of Nutrition and Food Technology at 8:00 a.m. after an overnight fast of 8–12 h and were served a standardized breakfast

identical in both composition and energy content. Each participant received 200 mL of sterilized milk (109 kcal) and a 60 g cake (275 kcal).

Two h after breakfast, participants were provided with either the optimized product (containing 30% protein and 10% fiber) or a placebo product, which was visually identical but contained no protein or fiber. During the interval between breakfast and snack consumption, participants were allowed to drink only water. The placebo product was formulated to resemble the optimized product in appearance and texture; however, maltodextrin replaced protein and fiber. The caloric content of the placebo was balanced to match that of the optimized product by adjusting the proportions of other components such as water, oil, and fructose syrup.

At 10:00 a.m., both groups received 60 g of their assigned product as a mid-morning snack. After 210 min, all participants were served a fixed lunch meal with a known weight and caloric value. Participants were allowed to eat ad libitum, and additional servings were provided upon request. To determine food intake, each meal was weighed before and after consumption, and the difference was recorded as the amount of food eaten. The energy intake during lunch was then estimated using the weight and energy density of the meal components. The caloric content per gram of the meal was calculated, and the energy of the uneaten portion was subtracted from the initial total energy to obtain the total caloric intake. The lunch meal consisted of rice with grilled chicken (chelo joojeh kebab), including 340 g of rice, 180 g of chicken, 15 g of vegetable butter, 70 g of grilled tomato, one lemon or sour orange, 40 g of onion, 100 g of yogurt with shallot, and a 500 mL bottle of water.

2.3.3. Appetite assessment

Appetite was evaluated using a 100-mm Visual Analogue Scale (VAS) for satiety. The questionnaire included four questions assessing: (1) How hungry do you feel? (2) How full do you feel? (3) How much food do you think you could eat? and (4) How strong is your desire to eat?

Before breakfast, all participants completed the VAS questionnaire. Breakfast was served at 8:00 a.m., and the designated mid-morning snacks were provided to both the control and intervention groups at 10:00 a.m. Before consuming the snacks, participants again completed the self-administered satiety questionnaire. Following snack consumption, the VAS questionnaire was completed at 0, 15, 30, 45, 60, 90, 120, 150, 180, and 210 min. At the end of the study, participants also rated the palatability of the lunch meal using a questionnaire to examine the possible relationship between food intake and meal palatability. The Composite Appetite Score (CAS) was calculated using the following equation (9):

$$\text{CAS} = \frac{\text{Hunger} + (100 - \text{Fullness}) + \text{Desire to Eat} + \text{Prospective Food Consumption}}{4}$$

Additionally, the Satiety Index (SI) of the optimized product was determined using the following formula:

$$\text{Satiety Index} = \frac{(\text{Appetite before eating} - \text{Appetite after eating at various time points})}{\text{Energy or weight of food consumed}} \times 100$$

2.4. Statistical analysis

For statistical analysis of appetite parameters and food intake, an independent t-test was applied, considering a 95% confidence level for significance. To evaluate the

magnitude of the product's effect on appetite, the standardized mean difference (SMD) was calculated as the effect size. Interpretation of the effect size was based on Cohen's d classification (10), in which values between –0.19 and +0.19 indicate a negligible effect, 0.20–0.49 a small effect, 0.50–0.79 a moderate effect, 0.80–1.19 a large effect, and values above 1.20 represent a very large effect. Effect size calculations were performed using STATA software (version 14). Additionally, the area under the curve (AUC) for appetite-related parameters was computed using Microsoft Excel 2019.

3. Results

3.1. Optimal formulation

To obtain optimal formulation, the optimization process was carried out based on sensory evaluation of the product. Among the evaluated sensory attributes, taste, texture, color, and overall acceptability were selected as the key determinants of final product quality. The objective of the optimization was to achieve the highest possible scores for these responses while maintaining desirable nutritional properties. Accordingly, reducing the caloric content of the product and increasing protein and fiber levels were defined as nutritional goals within the optimization model. The results showed that, under these conditions, the formulation containing 30.3% protein, 11.6% fiber, and a 58% mixture ratio exhibited the highest desirability value. Based on sensory evaluation, this sample achieved the greatest overall acceptability score and was therefore selected as the final optimal formulation.

3.2. Appetite measurement

After optimization and product development, the optimized product and the placebo were used in two groups, control and intervention to evaluate the effects of consumption on appetite and food intake. The nutritional characteristics of both products are presented in Table 1, and the demographic and anthropometric characteristics of the study participants are shown in Table 2.

The analysis of the appetite-related parameters is presented in Table 3. The results indicated that the mean values between the intervention and control groups were statistically significant ($p<0.05$) for all parameters except for the expected amount of food to be consumed. According to the interpretive ranges defined by Cohen for effect size based on the standardized mean difference, it can be concluded that, compared with the placebo group, the optimized product had a moderate effect on hunger sensation, feeling of fullness, and overall appetite score. Moreover, the parameter desire to eat was more strongly influenced than the others, showing a large effect size. However, the effect size for the expected amount of food to be consumed indicated that the optimized product had a negligible effect on this parameter compared with the placebo.

In addition, the parameter food intake, which represented the amount of food consumed during lunch 3.5 h after consuming the snack, suggested that the optimized product had a small effect on actual food intake. Fig. 1 shows the satiety index values for the optimized and placebo products at different time intervals after snack consumption. The results demonstrate consistently higher satiety index values for the optimized product compared to the placebo at all time points. Fig. 2 illustrates the temporal changes in satiety-related parameters following snack consumption.

Table 1. Nutritional characteristics of the snack in the control and intervention groups

Items	High-fiber and high-protein snack	Placebo*
Weight (g)	60	60
Energy (kcal)	229	225
Carbohydrates (g)	15	37**
Fiber (g)	6	-
Protein (g)	18	-
Fat (g)	10	13

* The placebo product was formulated without fiber and protein, and maltodextrin was used as a substitute for these components. ** This amount of carbohydrates was provided by maltodextrin and fructose syrup.

Table 2. Demographic and anthropometric characteristics of participants in the clinical trial

Parameters	Intervention group	Control group
Sex	Male (11)	Male (10)
	Female (6)	Female (5)
Age	34±8	33±7
BMI (Kg/m^2)	23.3±0.6	24.4±0.5

Table 3. Comparison of appetite parameters between the intervention and control groups

Parameters	Intervention (AUC±SE)	Control (AUC±SE)	P-value	Effect size (CI 95%)
Hunger sensation	162.8±2.5	214.7±4.5	0.003	-0.78(-0.45 to -1.11)
Feeling of fullness	197.5±5.2	135.4±3.4	0.008	0.63(0.25 to 1.02)
Desire to eat	157.7±4.2	217.2±4.8	0.002	-0.85(-0.45 to -1.25)
Expected amount of food to be consumed	187.5±4.9	217.3±6.6	0.615	-0.08(0.11 to -0.22)
Overall appetite score	302.6±3.8	353.3±4.5	0.003	-0.74 (-0.35 to -1.13)
Food intake (Mean ± Standard Error, g)	820±22	870±22	0.023	-0.23 (-0.11 to -0.35)

The results were analyzed using an independent t-test, and a p-value < 0.05 was considered statistically significant. The effect size was expressed as the Standardized Mean Difference (SMD). AUC refers to the Area Under the Curve of the plotted graph.

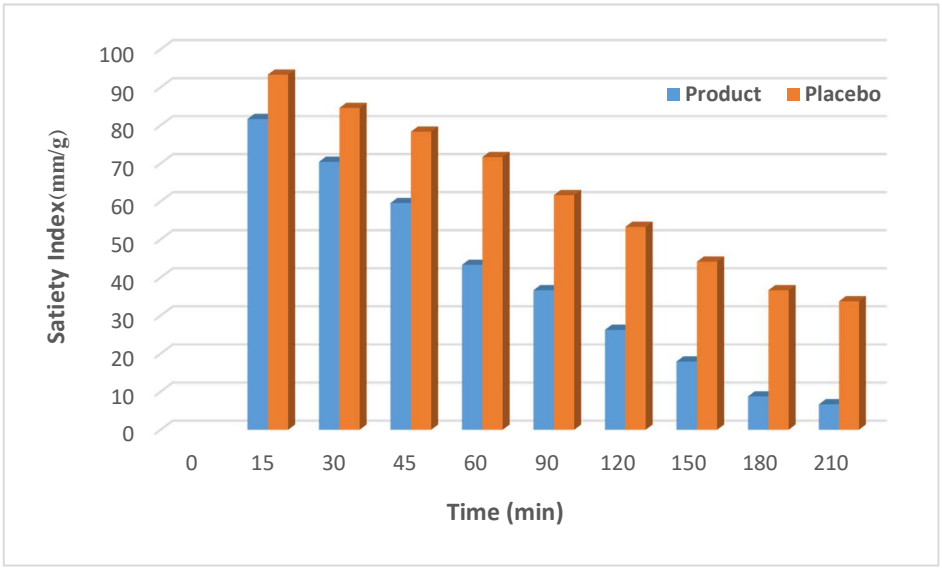

Figure 1. Satiety index values for the product and placebo at different time intervals after consumption

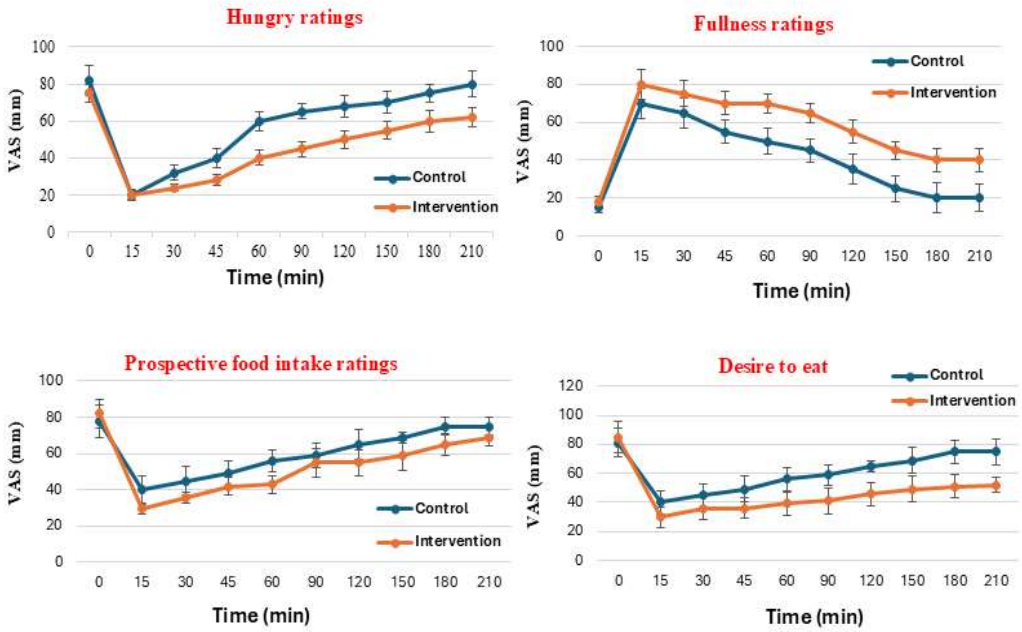

Figure 2. Appetite-related parameters.

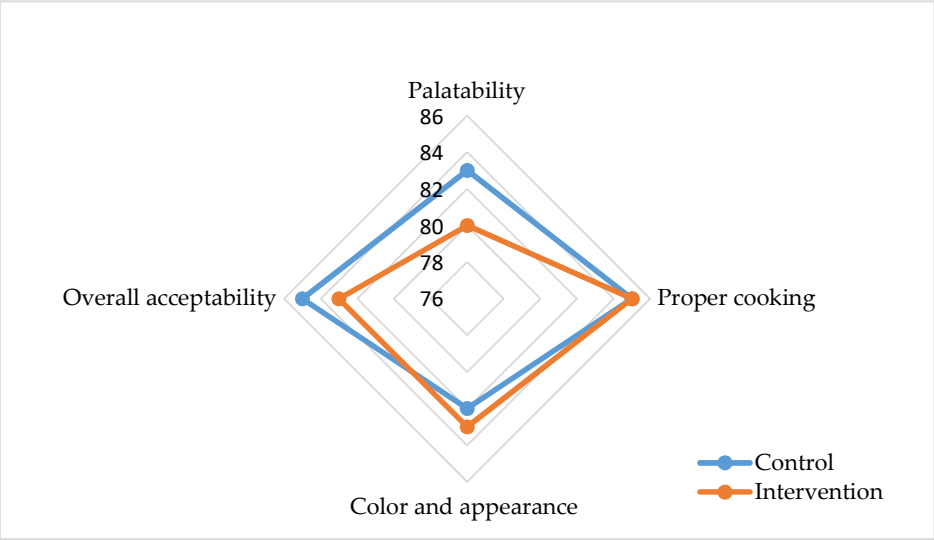

Figure 3. Comparison of the palatability parameters of the consumed meal between the control and intervention groups using the independent t-test.

To assess whether the palatability of the lunch meal influenced food intake, a VAS questionnaire was used to evaluate four parameters taste, color and appearance, degree of doneness, and overall desirability in both the control and intervention groups. The results, shown in Fig. 3, indicate that there were no significant differences between the two groups for any of these four parameters ($p>0.05$).

4. Discussion

In this study, by selecting different types of fibers and proteins, we primarily aimed to design a product with desired textural characteristics. As the percentage of fiber and protein in the samples increased, hardness, cohesiveness, elasticity, and chewiness of the product also increased. This occurred due to the high water-binding capacity of the fibers, which increased the viscosity and firmness of the texture. Additionally, the high gelling ability of albumin, casein, and whey proteins contributed to higher elasticity and cohesiveness in samples with elevated protein content. The increase in these parameters in the developed product leads to longer chewing time and a greater number of chewing cycles in the mouth. Indeed, increased chewing time enhances motor responses to food texture in the brain, allowing food particles to be more exposed to oral sensory receptors for taste and flavor perception. Rapidly consumed foods and beverages, with minimal retention time in the mouth, can promote overeating. This is associated with insufficient generation or reduced levels of sensory signaling during eating, ultimately limiting cephalic phase responses and delaying satiety onset (11).

During food consumption, from the mouth until the beginning of digestion, it is hypothesized that satiety perception can be influenced through five mechanisms: 1) the type of macro- and micro-molecules in the food;

2) food texture and its transport during oral processing; 3) physiological activities in the mouth required for bolus formation; 4) oral processing time; and 5) a combination of these factors. Therefore, in the present study, optimization was performed based on textural parameters and sensory evaluation, aiming to develop a product with maximal cohesiveness, hardness, elasticity, and chewiness (12). The proteins used contributed to a structure with high chewiness and elasticity, while the fibers in the formulation enhanced water absorption, increasing viscosity, cohesiveness, and hardness of the final product. These factors require greater engagement of the jaw muscles during chewing, resulting in longer mastication time and, consequently, more time for physiological and psychological signaling to the brain. Ultimately, this promotes satiety and prevents overeating (13).

The results of this study showed a significant difference ($p<0.05$) between the mean values of appetite parameters, including hunger, feelings of fullness, desire to eat, and overall appetite score. This significant difference was also observed for food intake. However, when calculating the effect size using Cohen's d, it was found that the effect of the optimized product, compared to the placebo, on hunger and feelings of fullness falls within the moderate effect interpretation range, while the product had a strong effect on the desire to eat. Moreover, the effect size for the parameter "expected food intake" was within the negligible or small effect interpretation range. Examination of the confidence intervals for the effect sizes of satiety parameters indicated that almost all of them spanned at least three interpretive regions, including weak, moderate, strong, and very strong effects.

Food intake results in the control and intervention groups also showed a significant difference between the two groups, with lower food intake observed in the intervention group. Despite the statistical significance of this difference ($p<0.05$), the calculated effect size indicated that the optimized product in the intervention group had a weak effect on food intake compared to the control group. The confidence interval for this effect size also covered two interpretive regions: trivial or minor effect and weak effect.

Based on the clinical findings described above, it can be concluded that the optimized product in this study has a moderate effect on overall appetite compared to placebo and a weak effect on food intake. However, considering the confidence intervals of appetite parameters, which span three interpretive regions, it suggests that if this study were to be repeated, there is a 95% probability that the results would fall within one of these interpretive regions. The inclusion of multiple interpretive regions may be due to variability related to the age and gender of the study participants. Additionally, this variability may be inherent to appetite as a parameter, which is a cognitive and psychological measure influenced by various factors, making it difficult to achieve reliable results within a single interpretive region.

Several studies have investigated the effects of combining fiber and protein on appetite and food intake. For instance, Bonnema et al. examined the effect of a breakfast containing 30 g of egg protein and 7 g of fiber compared to a control breakfast (10 g of protein and 1 g of fiber) on appetite and food intake. The results showed that the total appetite score in the intervention group was significantly different from that of the

control group ($p<0.05$) (14). Additionally, food intake during the 3 h following breakfast was significantly lower in the intervention group compared to the control group ($p<0.05$). In this study, Cohen's d effect size was calculated only for food intake and was 0.23, indicating a weak effect of this type of breakfast on food intake compared to the control group. Our study results were consistent with these findings.

In another study, Mollard et al. conducted a clinical trial to evaluate the effect of combining pea protein (18 g) and fiber from pea hulls (10 g) in a single meal in men with a BMI of 18–25. The results showed that total appetite score and food intake did not differ significantly compared to the control group, which contained 10 g of protein and 2 g of fiber (15). Similarly, Sayer et al. investigated the effect of a breakfast containing fiber (psyllium) and protein (egg) on appetite and lunch intake in overweight individuals. In this study, four types of breakfast were tested among 15 overweight men and women: normal protein (12 g) + normal fiber (2 g), normal protein (12 g) + high fiber (8 g), high protein (25 g) + normal fiber (2 g), and high protein (25 g) + high fiber (8 g). The results indicated that all appetite parameters showed significant differences up to 180 min compared to 15 min before the start of the test, but these differences were no longer significant at 240 min. Moreover, lunch intake did not differ significantly among the four groups (16).

Differences in study results can arise from several factors, including the nature of appetite as a cognitive and psychological parameter, which is influenced by multiple factors. Additionally, methods for assessing appetite vary greatly across studies, contributing to inconsistent results. For example, the timing of appetite assessments using questionnaires ranges from 60 to 240 min in different studies. The caloric content of the products used to evaluate appetite also varies widely across studies. Furthermore, control samples used as placebos must be free of active ingredients present in the intervention and have caloric content approximately equal to that of the intervention product, but this requirement is often not met. Other factors include the type of fiber and protein used; as mentioned earlier, soluble fibers with high water-binding capacity and viscosity can be more effective in reducing appetite. Among proteins, casein, whey, egg, and soy proteins are more effective than others in suppressing appetite. Considering the significant differences ($p<0.05$) between the control and intervention groups, the above hypothesis is partially confirmed. However, based on the calculated effect size, the part of the hypothesis related to food intake is not fully supported, as the developed product had a weak effect on food intake compared to the control group.

Among the limitations of this study was its short duration. Although a brief intervention can capture early shifts in appetite, it is not sufficient to assess the sustainability of these changes or longer-term patterns of appetite regulation and dietary intake. Future studies with extended follow-up periods could provide a clearer picture of the true effectiveness of this product in eating behavior. Additionally, it was not possible to measure key appetite-related hormones, including CCK, leptin, GLP-1, Ghrelin, and PYY. The absence of hormonal data prevented us from determining the physiological pathway underlying the observed effects namely, whether the product acted through

modulation of appetite hormones or through other mechanisms such as gastric mechanical effects, delayed gastric emptying, or sensory–cognitive influences.

5. Conclusion

This study successfully developed an optimized fiber–protein snack by systematically adjusting protein and fiber levels while maintaining desirable sensory and textural properties. The final formulation, containing approximately 30% protein and 12% fiber, achieved the highest sensory acceptability and exhibited the most favorable textural profile, characterized by greater hardness, cohesiveness, elasticity, and chewiness. These attributes are likely to prolong oral processing and enhance early satiety signaling. Findings from the clinical trial showed that consumption of the optimized product produced moderate improvements in subjective appetite parameters, including hunger, fullness, and overall appetite score and a strong effect on desire to eat when compared with the placebo. However, the influence on actual food intake at the subsequent meal was small, indicating that changes in subjective appetite did not fully translate into reductions in energy intake. These observations are consistent with previous research on fiber–protein combinations, highlighting variability in appetite responses and modest effects on food intake. Although the optimized product demonstrated favorable sensory qualities and short-term satiety effects, its impact on actual eating behavior was limited. Longer-term studies that include hormonal measurements are needed to clarify the physiological mechanisms underlying these effects and to determine whether sustained consumption of this product can meaningfully influence appetite regulation and dietary intake.

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Authorship contribution

The author solely performed all tasks related to this study, including study design, data collection, analysis, interpretation, manuscript writing, revision, and final approval.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data for the study is available upon request.

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