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The Effect of Dietary Protein Quality on Short-Term Satiety and Daily Energy Intake

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Introduction: Some protein structures in the structure of foods are known to provide long-lasting satiety. Depending on the food source, this period of satiety can be shortened or lengthened. It has been reported that in diets for treating obesity in which long-term satiety is a goal, animal-derived proteins can help people feel fuller for longer. This study aimed to examine the effects on satiety markers after breakfast of consuming breakfast foods prepared with different protein sources.
Materials and Methods: The study included 40 participants but concluded with 39 participants. Sixteen males and 23 females participated in the research. The participants in the study were randomly assigned to begin the investigation. After 12 hours of fasting, the study participants were offered two separate breakfasts on separate days. Two distinct breakfasts consisting of foods of animal origin and foods of vegetable origin were served.
Results: The breakfasts had similar calories, protein, fat, carbohydrates, and fiber. Before and after breakfast, a VAS scale with seven satiety markers was created and applied. The scale was applied 0 minutes before breakfast, 30 minutes, 60 minutes, 120 minutes, and 180 minutes after breakfast. After breakfast, it was observed that the satiety markers of animal origin had a longer duration and higher scores than those of plant origin.
Conclusion: In cases where energy restriction is necessary, it has been determined that increasing the protein quality in the foods consumed can provide long-term satiety regardless of the amount consumed.
Keywords: dietary protein, satiety, hunger, energy intake

Introduction

According to the World Health Organization (WHO) (1), more than 300 million people worldwide are obese. Obesity, typically caused by an imbalance between energy intake and expenditure, is a consequence of modern lifestyle factors such as a sedentary lifestyle, lack of physical activity, and poor diet (2). The treatment of obesity, a significant public health issue, is constantly evolving and changing (2, 3).

Protein quality attracts as much attention as the amount of protein a person consumes in his daily diet, and it is reported that it is an issue that should be emphasized (4-6). Recent studies on treating obesity have highlighted the importance of increasing dietary protein intake. However, increasing dietary protein can be associated with numerous health issues (7-10). Therefore, it can be observed that the focus of research is shifting toward dietary protein

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quality. As sources of dietary protein, there are both vegetable and animal proteins (11). Studies have demonstrated that as the protein quality of a food's composition increases, so does the sensation of pleasure and satiety, and it has also been observed that it provides the balance of negative energy intake (8, 11). Egg, a protein of animal origin, has been shown in studies to increase the resting metabolic rate. When a plant-based protein source was added to the same diet, identical outcomes were not observed (2). A study conducted on experimental animals found that the same amount of soy protein and egg protein had different effects on thermogenesis in adipose tissue, with the addition of egg protein increasing thermogenesis more. It has been emphasized for a long time that an increase in dietary protein increases the resting metabolic rate. However, it has been observed in recent studies (4,8,9) that increasing the quality of dietary protein while maintaining the quantity of dietary protein positively affects the resting metabolic rate. Thus, it is believed that more effective and favorable results can be obtained in the treatment of obesity by altering the protein quality of the diet without the negative effects of a high-protein diet (1, 12).

The present study aimed to examine the effects on satiety markers after breakfast by consuming foods prepared from different protein sources at breakfast meals.

Materials ve Methods

Study Design

The study was conducted with the assistance of volunteer faculty and students from the University. It was conducted between 01.04.2018 and 15.05.05.

Ethical Statement

Mardin Artuklu University, the Non-Invasive Research Ethics Committee approved the study (Date: 12.03.2018; No: 2018/1-5). The calculation of the study's sample was done by taking into account the outcomes of earlier studies that applied to the current study's objectives and produced findings (11).

Determination of participants

After conducting the required medical and physical exams on each participant, the individuals who expressed an interest in participating in the study were subsequently included. Forty individuals gave their time voluntarily to take part in the study. Following the Principles of the Declaration of Helsinki, prior to the study's beginning, the participants were provided with information regarding the purpose of the study, and informed consent was obtained from those individuals who agreed to take part in the study. During the research, one of the participants announced that he did not wish to proceed with the work, and as a result, he was removed from the investigation. Also, 39 participants were required to finish the study.

Inclusion criteria

Persons aged between 18-45 years, without communication problems, with a body mass index (BMI) between 18.5 kg/m^2 and 30 kg/m^2, and without any acute or chronic disease were included in the study. The individuals included in the study were included in the study after the specialist physician examined them and a report was obtained that they were eligible to participate.

Exclusion criteria

People who have used vitamin-mineral and nutritional support products in the last month, people who follow a unique nutrition program (weight loss diets, etc.), people who are allergic to any food, people who are addicted to drugs or alcohol, pregnant or breastfeeding women, and people with allergies have been left out.

Form for the collection of information

We used the form that contained demographic information about the individuals, including ages, genders, marital statuses, employment statuses, monthly incomes, levels of physical activity, and meal preferences for each day.

During the first interview, both the text and the signed consent form were completed. The text contains information regarding the participant's general health status, and the signed consent form indicates that the participant wanted to participate in this study of their own free will and was not pressured to do so.

Anthropometric measurements

During the initial interview, the researcher took anthropometric measurements of the people who were going to be included in the scope of the study and recorded those measurements. The Tanita BC 545N brand portable Bioelectrical impedance (BIA) device was used to measure each individual's body weight, body fat mass, muscle mass, fat rate, and basal metabolic rate. The participants' feet were measured barefoot, without their shoes or socks on.

Study protocol

The study was conducted in a fully randomized crossover. Random numbers table was used for randomization. While making this calculation, the site https://www.randomizer.org/ was used. The participants in the study groups were split into two different groups and assigned to them at random. In the first group, 20 individuals were chosen randomly; in the second group, 20 were chosen randomly. Five individuals from each group participated in the crossovers. On the first day that they were invited for the interview, five people from the first group were

Table 1. Energy and macronutrients of breakfasts served in the study

Breakfast	Energy(kcal)	Protein (g)	CHO(g)	Fat (g)	Fiber(g)
Animal-based breakfast	308	15,5	24,5	16,5	4,2
Plant-based breakfast	305	14,5	27	15,5	5.1

*** CHO: Carbohydrate*

Table 2. Demographic characteristics and eating habits of individuals

Variables	Female (23)		Male (16)		p
Age, years	24.04±6.56		23.93±4.29		
▪ Marrial status	n	%	n	%	
▪ Married	3	13	1	6.3	0.631
▪ Single	20	87	15	93.8	
Educational status					
▪ University	19	82.6	14	87.5	0.522
▪ Master	4	17.4	2	12.5	
Daily Meal Habit					
▪ 2 meals	3	15	4	25	0.356
▪ 3 meals	9	45	9	56.3	
▪ 3 or more	8	40	3	18.75	
The Habit of Skipping Meals					
▪ Yes	8	40	8	50	0.821
▪ No	4	20	3	18.8	
▪ Sometimes	8	40	5	31.3	
Most Skipped Meal					
▪ Morning	7	38.9	10	66.7	0.106
▪ Lunch	11	61.1	4	66.7	
▪ Evening	-	-	1	6.7	
Regular Breakfast Habit					
▪ Yes	10	50	9	56.3	0.709
▪ No	10	50	7	43.8	

*** Pearson X^2 test, $p<0.05$*

given a breakfast that was prepared using foods derived from animals as their breakfast. On the other hand, on the day that they were called for the interview, five people from the second group were provided with a breakfast that had been prepared using foods derived from plants.

The individuals in question were contacted once more one week later. During the second interview, the groups were switched, and individuals from the first group were given a breakfast that was prepared using foods derived from plants, while individuals from the second group were given a breakfast that was prepared using foods derived from animals. The individuals were not provided with any information regarding the components that made up the breakfast. It was decided that a week should pass between each breakfast, and this rule was implemented (Figure-1).

Where the study was carried out, time and presentation for breakfast

The area designated for breakfast was constructed in such a way as to allow natural light to illuminate the space. It is furnished with enough tables, chairs, and space for 15 people to consume breakfast simultaneously.

Table 3. Anthropometric measurements of individuals by gender

Anthropometric measurements	Female	Male	P value **
Body weight (kg)	58.65±7.84	68.79±9.18	0.001
Height (cm)	159±8.46	172.69±5.72	0.034
Waist circumference (cm)	76.75±7.3	82.75±6.29	0.002
Hip circumference (cm)	95.25±5.73	94.56±5.98	0.004
BMI (kg/cm^2)	21.98±2.45	23.14±2.85	0.041
Body fat percentage (%)	26.41±7.19	16.93±6.89	0.051
Body muscle weight (kg)	40.72±4.81	53.97±6.36	0.001
Bone mineral amount (kg)	2.2±0.27	2.85±0.31	0.004
Basal metabolic rate (kcal)	1322.8±131.18	1685.25±190.76	0.008
Waist/hip ratio	0.81±0.06	0.88±0.05	0.007

*** Independent t-test; p<0.05*

Table 4. The p-values of the total scale scores of the individuals after breakfast

Time	Breakfast	Mean	SD	P value **
30. min	Animal-based breakfast	448.81	113.84	0.001
	Plant-based breakfast	523.19	121.93	
60. min	Animal-based breakfast	529.86	114.82	0.001
	Plant-based breakfast	479.58	129	
120. min	Animal-based breakfast	464.75	128.38	0.001
	Plant-based breakfast	406.94	130.73	
180.Min	Animal-based breakfast	363.28	137.04	0.03
	Plant-based breakfast	316.44	125.78	

*** Paired student t-test; p<0.05*

Table 5. Energy and macronutrient intakes and p-values of the individuals on the day of the experimental breakfast

Variables	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrate (g)
Animal-based breakfast	927.24±448.68	32.29±17.69	40.35±25.58	103.97±53.9
Plant-based breakfast	1215.12±562.99	46.67±23.64	44.81±26.37	150.93±80.99
P value **	0.014	0.008	0.466	0.004

*** Paired student t-test; p<0.05*

The nutritional value of various breakfast foods

The individuals shared a similar breakfast in terms of total amount of calories, total amount of protein, total amount of fat, the total amount of carbohydrates, and total amount of fiber. If the majority of the breakfast consists of foods derived from animals, then it is referred to as an "animal" breakfast; if the majority of breakfast consists of foods derived from plants, then referred as "Plant-based" breakfast (Table-1).

Research morning meals and the components that make them up

The experimental breakfast method prepared an omelet to be eaten first thing in the morning. *Content of the omelet derived from animals:* The omelet was prepared using a Teflon pan coated with a non-stick coating by adding fifty milliliters of cow's milk, fifteen grams of curd cheese, one whole egg, ten grams of whole wheat flour, and two milliliters of sunflower oil. Food consisted of strawberry jam weighing 15 grams, cucumbers weighing 75 grams, and tomatoes weighing 75 grams. This was done so that the macronutrient content of each breakfast would be consistent.

The content of the omelet is derived from vegetables: chickpea flour (40 grams), soy milk (60 milliliters), curd cheese (3 grams), wheat flour (10 grams), and sunflower oil (15 milliliters). The ingredients were combined in a large bowl before being cooked in a frying pan made of Teflon, which does not stick.

Developed VAS scale for study

The development and implementation of a visual analog scale, also known as a VAS scale, for indicating levels of hunger and fullness

In this study, the participants' hunger, satiety, and satisfaction levels were evaluated using the visual analog scale (VAS) (13), and before and after the subjects had breakfast, each completed a separate scale to measure their progress. The newly developed pre-breakfast scale included six questions with subheadings. Seven subheadings are included in the scale that was developed after breakfast. On a scale that ranged from 0 to 100 points, the participants were asked questions about how much they enjoyed and were satisfied with their breakfast, how hungry they felt after eating breakfast, how full their stomach felt, how much food they desired to consume, how much food they felt they could consume, how full felt, how satisfied felt, and how much they desired sugary foods. On the scale, a score of '0' indicates 'not at all,' a score of '50' indicates 'I do not feel anything,' and a score of '100' is the highest possible score, with options including 'extreme' and 'too much' depending on the question. At 0 minutes before breakfast, individuals were asked to complete the VAS scale, which included markers for hunger and satiety. The same individuals completed the scale 30, 60, 120, and 180 minutes after breakfast.

Food consumption form

On the morning of the study's breakfast, participants were also asked to record all the foods they consumed throughout the day on the food consumption record form. Individuals were invited to an interview with their completed forms the following day. Together with the individuals participating in the study, the researcher recorded the forms by correcting any deficiencies. The Nutrition Information Systems (BeBiS) calculated the daily energy and nutrient intake and the amount of food group consumption.

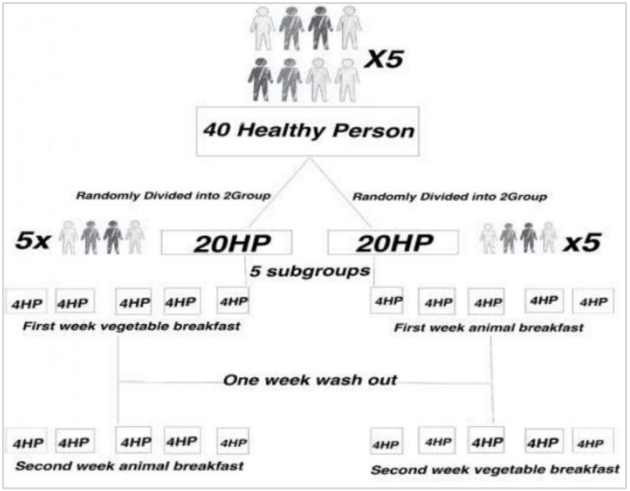


Figure 1. Randomization of study

Statistical analysis

SPSS version 23 and Microsoft Excel were used to generate analyses and graphs for the study. The mean, standard deviation, frequency, and percentage were utilized in the descriptive statistics of the study's variables. The paired parametric t-test was used to compare variables with normal distribution. All tests of variables were conducted at a significance level of 5%. After breakfast, the VAS scores of each participant were compared for each question. Finally, the total scale score was computed by adding the scale scores for every six questions on the 6-item scale. BEBIS was used to calculate the energy, macro, and micronutrient content of all foods consumed by the individuals on the day of breakfast. As a result of the calculation, the food consumption, energy, and nutrient intake of the days when the two breakfasts were prepared were compared. Using the paired t-test, normally distributed numerical data were evaluated at a significance level of 5%.

Results

Table-2 lists the demographic characteristics and dietary habits of individuals. According to gender, 16 men and 23 women participated in the study. The average age of women was 24.04±6.56 years, and the average age of men was 23.93±4.29 years. In the study, individuals' eating habits were examined, and it was determined that fifty percent skipped meals. Table-3 provides anthropometric measurement of individuals based on their gender. Men had a BMI of 23.14±2.85 kg/m^2, while women had a BMI of 21.98±2.45 kg/m^2. The total score of the six-question VAS scale administered after breakfast was used for evaluation. Table 4 provides the p-values of the individuals' total scale scores after breakfast. At the 30th, 60th, 120th, and 180th minutes after breakfast, the maximum score on a 6-question scale was 600, and the minimum score was 0. Breakfasts of animal origin were associated with a lower total score at 30 minutes ($p<0.05$). At the 60th, 120th,

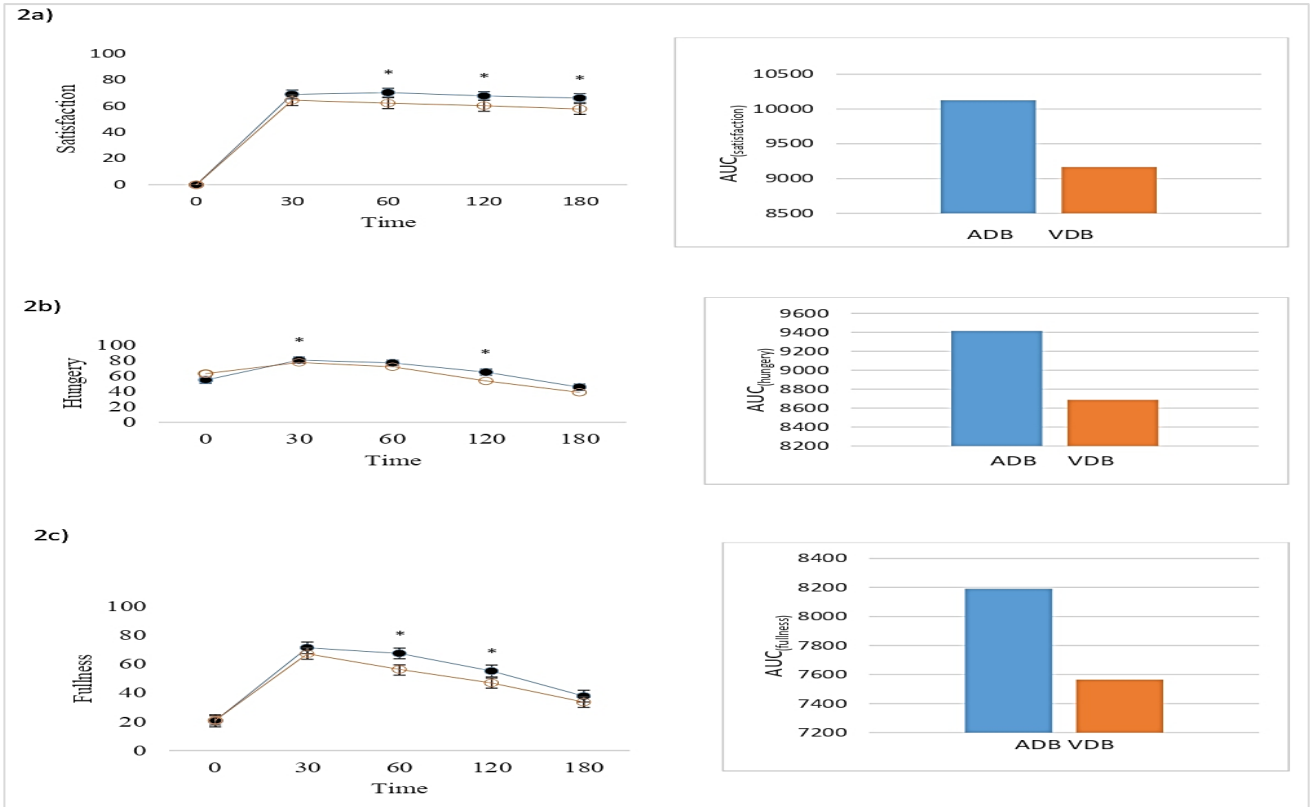


Figure-2.1. Before and after breakfast line charts (animal-derived breakfast: ADB); black circles: (●); vegetable derived breakfast (VDB); white circles (O). [2a] Satisfaction - [2b] Hungary - [2c] Fullness *(Paired student t-test; * $p<0.05$).*

180th, and 180th minutes, the total scale score for the breakfast of animal origin were consistently more significant than those for the breakfast of vegetable origin ($p<0.05$).

Table-5 displays the individuals' energy and macronutrient intakes and p-value on breakfast day. The energy and macronutrient intakes of the individuals who consumed an animal-derived breakfast on the day of fed were lower than on the day they consumed a plant-based breakfast ($p<0.05$).

The individuals consumed less energy, carbohydrates, fat, and protein on the animal-derived breakfast day. 30th, 60th, 120th, and 180th minutes after an animal and vegetable breakfast, the sensation of satisfaction-pleasure, the sensation of hunger, the sensation of satiety, the desire to consume food, the amount of food that can be consumed, the sensation of stomach fullness, and the desire to consume sugary food were measured. 0- Utilizing a 100-point visual analog scale, it was evaluated.

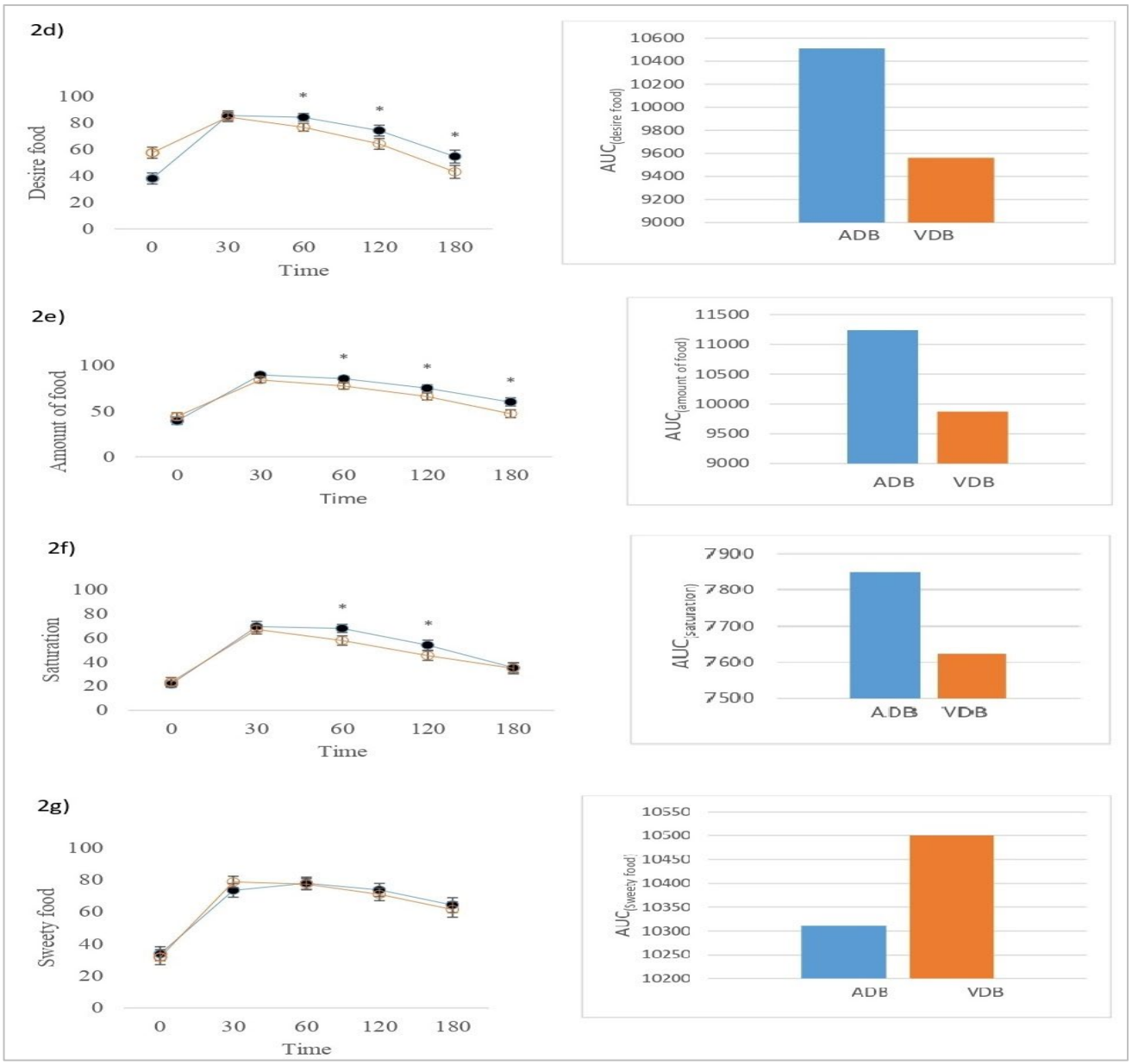


Figure-2.2. Before and after breakfast line charts (animal-derived breakfast: ADB); black circles: (●); vegetable derived breakfast (VDB); white circles (O). [2d] Desire food - [2e] Amount of food - [2f] Saturation - [2g] Sweety food *(Paired student t-test; * $p<0.05$).*

The scores for hunger, the desire to consume food, the amount consumed, and the desire to consume sugary foods were reversed. Points for hunger, the desire to consume food, and the amount of food that can be consumed were higher for the animal-based breakfast than the vegetable-based breakfast ($p<0.05$). After consuming a plant-based breakfast, the desire to consume sugary foods decreased ($p<0.05$). Positive ratings were given to the sensations of pleasure satisfaction, satiety, and stomach fullness following breakfast. Individuals' satisfaction, satiety, and stomach fullness scores after a breakfast of animal origin were higher than those after a breakfast of vegetable origin ($p<0.05$) (Figure 2).

Discussion

Obesity is a worldwide public health problem. One of the treatment approaches to a health problem reached epidemic proportions in this way is calorie restriction (14). Maintaining a negative energy balance in treating obesity prevents weight gain and also plays an essential role in reducing weight. However, compliance with restricted calorie becomes problematic over time, and individuals have difficulty maintaining such a lifestyle. Therefore, foods reducing the feeling of hunger and make the feeling of fullness feel longer may be more appropriate in treating obesity and may reduce weight loss (11). Previous studies have shown that breakfast with eggs increases satiety and reduces energy intake at lunch (15). Individuals who regularly eat breakfast with foods of animal origin have more weight loss than individuals who have breakfast with foods of plant origin. The fact that these studies looked at the protein content of breakfasts rather than the macro-nutrient content raises the question of whether eggs are effective.

The present study aimed to determine the effects of consuming breakfast made from various protein sources on post-breakfast satiety markers and daily food intake in healthy individuals after a 10–12 hour fast. The people were given a choice between two different breakfasts that were both vegetable and animal-based. The VAS scale was used to question and evaluate each person's satiety markers, pleasure-satisfaction with breakfast, hunger after breakfast, the feeling of fullness in the stomach, desire to consume food, amount of food that can be consumed, the feeling of satiety, and desire for sugary food.

According to studies, eating eggs for breakfast is more filling than eating cereal in normal-weight and overweight people (15-17) and those who are not overweight (16). Consuming an egg-based breakfast as opposed to a cereal-based breakfast had a short-term effect on stomach fullness and significantly reduced energy intake. However, it did not affect long-term energy intake despite having a similar energy density and macronutrient composition (17). Animal origin was found to have significantly higher levels of feeling full in the stomach after breakfast than plant origin. An egg-based breakfast increased feelings of fullness and decreased food intake in a study of kids (18). According to this study, people who consumed breakfast made from animal products felt less hungry at the 30th and 120th minutes, and their VAS scores were higher.

A study on proteins and the amino acids they contain found that eggs and cheese have a similar saturation power despite the significant differences in protein kinetics and their effects on hormone secretion. However, this similarity is impossible for proteins of vegetable origin (19). Another study found that when mixtures with varying amounts of fiber and the same protein content were compared, there was no difference between the areas under the curve for hunger or fullness. Since this situation was reflected in the scale with higher scores, individuals fed with breakfast of animal origin had higher scores, and this situation was found to be statistically significant; it was discovered

that after 120 minutes, the desire to consume food after breakfast was significantly lower in the breakfast of animal origin compared to the vegetable origin.

Numerous studies have examined how a protein source affects appetite (20). The effects of eating a mixed meal and a meal with a 22% protein content on appetite were equivalent. Additionally, dietary fiber has impact appetite (21-24). Evidence suggests that the amount of fiber may have little impact on satiety in a high-protein diet, even though a plant-based breakfast has a marginally higher fiber content (1 g) than an animal-based breakfast. However, more research is needed to compare the effects of high protein/high fiber diets on appetite (10, 24). The scores of individuals decrease as their food intake increases. Following this evaluation method, it was discovered that individuals consumed less food in the 120^{th} and 180^{th} minutes after the 60^{th} minute, which was reflected in the scores as higher scores and was found to be statistically significant.

Protein content was positively correlated with the food's saturation score compared to various test foods. The saturation score of a food is positively impacted by both the protein quality and the protein content of the food (25). Losing body weight was positively correlated with an increase in the food saturation score (26, 27).

The 10% protein breakfast contains casein, soy, and whey protein. Whey protein breakfasts induced a more significant satiety response. However, when the protein content was increased to 25% of the protein in breakfast, this difference was lessened. Within seven hours, a different study that looked at soy and soy milk in a mixed meal found no difference in the responses to hunger or fullness (21). According to some reports, a high-protein diet's effect on appetite can be attributed to an overall increase in the intake of amino acids (23, 28). A food high in protein is an egg. The fact that eggs have high concentrations of the branched-chain amino acid leucine significantly impacts satiety. By decreasing mTOR signaling in the hypothalamus, the amino acid leucine can decrease food intake and body weight (29). Leucine also contributes to insulin signaling and glucose metabolism (30). The results showed that the satiety of breakfast increased along with the participants' scores. After breakfast, it was discovered that breakfasts of animal origin had higher satiety scores than breakfasts of vegetable origin. At the 60th and 120th minutes, this situation was discovered to be significant. However, they reported that the protein source might regulate postprandial blood glucose levels by reducing postprandial blood glucose level in blood glucose levels (11, 17, 20). The study examining the protein source did not show any difference in appetite response or total food intake. Animal breakfasts were also less satisfying than plant-based breakfasts when people's post-breakfast sugary food cravings were assessed right after breakfast. However, compared to breakfasts of vegetable origin, the desire for sugary foods has grown future for breakfasts of animal origin. A lower overall score at 30 minutes resulted from feeding an animal-derived breakfast ($p< 0.05$). Additionally, the breakfast of animal origin consistently received higher overall scale scores at the 180^{th} minute than the breakfast of vegetable origin.

Studies have shown that an egg-containing breakfast increases satiety and reduces energy intake at lunch. When a low-energy diet was applied to individuals who regularly ate breakfast with eggs, more significant body weight loss was observed compared to individuals fed a higher-energy diet (11, 31, 32). The energy and macronutrient intake of the individuals with the animal-derived breakfast during the day they were fed was found to be lower than the day that was fed with the plant-based breakfast. Individuals took in less energy, carbohydrates, fat, and protein.

In the study, both types of breakfast were given to the same people. This is one of the study's strengths. In studies done on humans, the study's most vital points are eating foods that people eat every day and measuring how whole people feel. As the study's biggest flaw, it did not look at the hormones that affect satiety because it did not have enough money to do so.

Conclusion

In this study, the people were given two different breakfasts with different kinds of food. As a result of the study, a visual analog scale was used to figure out how whole the people were. As a result of the study, it was found that eating an animal-based breakfast made people feel fuller for longer, and their daily energy intake was less. When the goal is to feel full for a long time, it has been decided that foods with protein from animals are better.

Conflict of Interest

The authors declare no conflict of interest for the present study.

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No financial support was provided from any institution or organization within the scope of the research.

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