

Determination of satiety index of low-fat yogurt in healthy normal-weight Isfahanian adults

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ABSTRACT

Measuring the satiety index of food components has not been done in Iran yet. The aim of this study was to determine the satiety index (SI) of low-fat yogurt among healthy normal-weight adults in Isfahan. This semi-experimental study was conducted on 30 healthy normal-weight adults for two consecutive days. In the first day, each participant consumed 90 grams white bread and in the second day 526 grams low-fat yogurt (1.5% fat) within 15 minutes. We evaluated the satiety of low-fat yogurt and white bread based on VAS and LIKERT scales. Anthropometric indices were measured. Food intakes, physical activity in the night before each test, hunger and palatability of each food were evaluated by food record, physical activity record, Three-Factor Eating Questionnaire (TFEQ), respectively. The satiety index of low-fat yogurt was 136.66 ± 1.46 compared to white bread (with SI of 100). The changes of satiety 120 minutes after consumption of white bread and low-fat yogurt were not significant based on the VAS scale, but according to the LIKERT scale low-fat yogurt changes showed a significant increase (mean changes = 1.60 ± 0.43 (SD)) ($P=0.03$). The hunger of people was equal to 1.66 units. The satiety index of low-fat yogurt in normal-weight Isfahanian adults was higher compared to white bread; suggesting higher satiety for low-fat yogurt than white bread. According to the LIKERT scale, 120 minutes after consumption of low-fat yogurt, satiety showed a significant increase. The applied method in this study is suggested to be used for determination of SI of other foods in the Iranian population.

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1. Introduction

Obesity is a major public health problem in the world (1). The prevalence and severity of obesity have increased in recent years, because of complex interactions between genes, dietary intakes, physical activity and the environment (2). Obesity can increase the risk of cardiovascular diseases, type 2 diabetes and some types of cancer (1). Identification of foods with a high satiety index (SI) might help people to prevent obesity. Food satiety (post-ingestive or inter-meal) is defined as the suppression of getting more food after eating (3). The SI-tool ranks different foods on their ability to satisfy hunger and reflects the total amount of full filling that creates by each test food for more than two hours (defined as short time satiety). This index could help people to select slimming food

with filling characteristic instead of fattening ones, while it is not related to nutritional values or calorie content of foods (4). Previous investigations have documented that foods with low glycemic index (LGI), high fiber, high protein, and water content increased satiety (5). Previous studies have also shown that fiber (6), especially insoluble fiber (7), sugar, glucose content of drinks, yogurt, fructose (8) and LGI foods (9) reduced food intake and increased fullness. The satiety response to dietary fat might be dependent on the availability of fat to stimulate cholecystokinin (CCK) release (10). Triacylglycerol with unsaturated fatty acids increased satiety and decreased food intake, whereas triacylglycerol with saturated fatty acids did not (11). Consuming sunola, butter and sunflower oil have not changed SI and food intake in trials (12). Also, high carbohydrate yogurt (81% of energy)

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increased satiety more than high fat yogurt (13). Dairy consumption may decrease the risk of obesity (14) and central obesity in both women and men (15, 16). Several studies have focused on the effect of dairy consumption on satiety and energy intake; however, they have led to inconsistency results. Yogurt was suggested as a food with high SI that could increase satiety (17). The protein content of commercial yogurt is generally higher than that of milk and is more easily digested than protein from milk (18). The energy intake in a lunchtime meal was lower after the intake of yogurt, cheese, and milk, respectively, compared to water (19). Several studies reported a decrease in both subjective appetite and energy intake after dairy consumption (19, 20), while others reported decrease in appetite, but not in energy intake (21, 22). No differences in post-snack hunger or fullness area under curve (AUC) was observed between the normal protein (NP) and high protein (HP) yogurt snacks (23); however, another investigation has reported greater fullness AUC and lower hunger for high protein yogurt AUC vs. low protein and moderate protein yogurt (24). Yogurt and dairy products are available foods for all people. The published data about the effect of yogurt intake on satiety have led to inconsistent results. In addition, most studies in this regard were performed in America and Europe; while the Iranian community with different life styles, dietary habits and food intakes from

western societies is less studied. We aimed to determine the satiety index of low-fat yogurt (1.5%) among healthy normal-weight adults in Isfahan. Low-fat yogurt instead of high-fat yogurt was applied to investigate the effects of the protein content of yogurt on SI rather than the fat.

2. Materials and methods

2.1. Participants

We asked healthy normal-weight adults to participate in the study. Thirty healthy adult volunteers (eight males and twenty-two females) were selected to participate in this study. The participants were eligible for the study if (1) they were between 18 and 65 years old; (2) had a normal body mass index (BMI: 18.5 to 25); (3) did not have any changes in BMI over the past three months; (4) did not report any history of disease (such as stroke, dementia or any condition that prevents a person to be interviewed and also other chronic diseases such as diabetes mellitus, hypertension, chronic liver cirrhosis, renal failure, uncontrolled thyroid disease, inflammatory bowel disease, rheumatoid arthritis, severe heart failure, cachexia and cancer in the last 3 years); and (5) did not use medicine. All participants completed the study. Flow diagram of participants throughout the study is shown in Fig. 1.

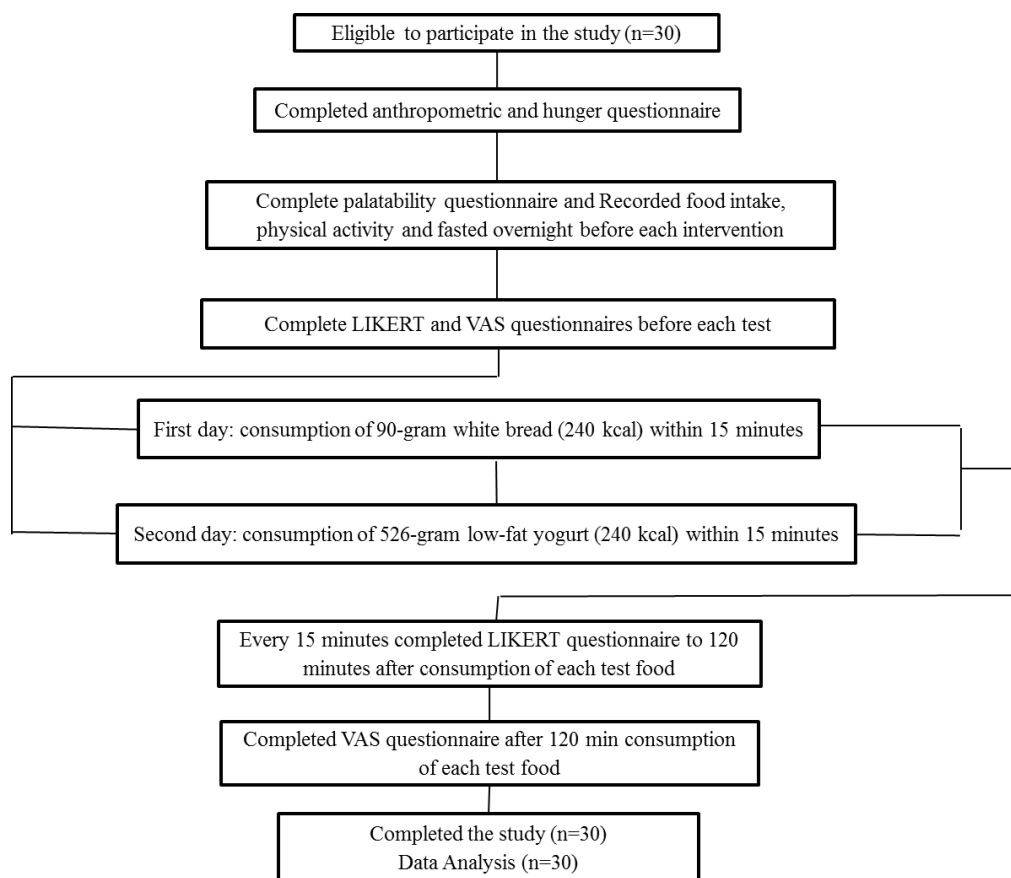


Fig. 1. Flow diagram of participants throughout the study.

2.2. Study design

This study was a semi-experimental study. Satiety index of low-fat yogurt (1.5%) was considered as the main outcome of interest. Satiety index of white bread was also assessed as the reference food in order to compare the resulting values of low-fat yogurt with it. All participants provided signed informed written consent. The study was ethically approved by the Ethics Committee of Food Security Research Center, Isfahan University of Medical Sciences, Isfahan, Iran. The study protocol was also registered in the Iranian Registry of Clinical Trials (IRCT: www.irct.ir) (IRCT2015092323957N3).

2.3. Intervention details

We have determined SI of yogurt in healthy normal-weight adults, used white bread as the reference food and measured SI of test foods with both VAS and LIKERT scales. The intervention was performed in two consecutive days. We asked the participants not to change their food intake and physical activity in the night before each intervention and to record their food intake and physical activity from 6 p.m. to midnight in the nights before interventions. We asked the participants to be presented at 8:00 a.m. at Isfahan University of Medical Sciences. The place of study was quiet in order not to put stress on individuals. Subjects were tested at the same time of days and under a similar condition, as possible. Anthropometric measurements were done following an overnight fast (for 10 hours) by the same person. All participants completed hunger questionnaire, palatability of test foods, and satiety questionnaires based on VAS and LIKERT scales at the start of each test. In the first day of the intervention, each participant consumed 90 grams of white bread (=240 kcal energy) within 15 minutes. The consumed white bread was fresh, was made from wheat flour, bought from one place and served at room temperature. In the second day of the intervention, each participant consumed 526 grams low-fat yogurt (=240 kcal energy) within 15 minutes. Low-fat yogurt used in the present study had 1.5% fat, was bought from one company and served at 5 ° C temperature in dishes with spoon. In each day of the intervention, during 120 minutes after consumption of test food, at an interval of every 15 minutes participants have completed satiety questionnaires based on LIKERT scale. They have also completed satiety questionnaire based on VAS scale, 120 minutes after consumption of test food. During these 2 hours, they seated at tables in a quiet, non-stressful environment, were not permitted to eat or drink until the end of the session (120 minutes). Subjects could read, talk quality and watch film but they were not allowed to compare their individual responses to questionnaires.

2.4. Measurement of satiety index of low-fat yogurt

We calculated the satiety index of low-fat yogurt (1.5%) and white bread separately based on both VAS and LIKERT scales. VAS scale rates between 0 to 100. The rating scale

based on the LIKERT for white bread and low-fat yogurt is as follows: -3 to 3 (-3: I am quite hungry, -2: I am hungry, -1: I am half hungry, 0: It does not matter, 1: I am semi-full, 2: I am full, 3: I am quite full). The area under curve (AUC) for each test food was calculated and the SI percentage of low-fat yogurt compared to white bread were obtained through the following formula:

$$SI\% = \frac{AUC\ 120\ min\ satiety\ to\ 1000\ KJ\ of\ the\ test\ food}{AUC\ 120\ min\ for\ 1000\ KJ\ of\ white\ bread} \times 100$$

2.5. Assessment of hunger and palatability

Hunger was evaluated based on the LIKERT scale by a three-factor eating questionnaire (TFEQ), which contains nine questions (25). Hunger score based on TFEQ ranged from 0 to 3. Before each intervention, food palatability for test foods (white bread and low-fat yogurt) was measured in terms of visual, smell, taste and secondary pleasure by 100 mm, VAS scale (26).

2.6. Anthropometric measurements

Height and weight were measured and recorded by a trained nutritionist. Body weight was measured while individuals were minimally clothed, without shoes, using a digital portable scale (QF-2003D, China) and recorded to the nearest 0.1 kg. Height was measured with an accuracy of 0.5 cm, in a standing position with the head in a horizontal position, without shoes, using a tape meter while the shoulders were in a normal state. Body mass index (BMI) was calculated as weight (in kg) divided by height (in meters squared). Waist circumference, as an indicator of fat distribution, was measured by the non-elastic meter in rib cage area and above the navel. The smallest circumference between the thorax and thighs without pressure on the body with an accuracy of 1 cm was recorded.

Hip circumference was measured at the largest circumference between the waist and knees and waist-to-hip ratio (WHR) was calculated by dividing the waist to hip values. Measurements were performed three times for each person and the value that was shown at least twice for each participant was recorded. Body fat percentage was calculated from triceps skin-fold thickness (TSF) measurement on the right side of the body by a trained nutritionist. The skin-fold with the thumbs and index finger of the left hand about 1-1.5 cm proximal to the skin fold site was firmly grasped and pulled away from the body, respectively. The caliper that was perpendicular to the long axis of the skin fold and with a faced-up dial held in the right hand by the nutritionist. The caliper was read 4 seconds after releasing the pressure of the measurer's hand from the lever. The measures were recorded 3 times with 10 seconds intervals. To avoid subjective errors, all measurements were made by the same nutritionist.

2.7. Assessment of dietary intakes:

Food records of the nights before low-fat yogurt and white

bread tests were received. All dietary assessments were analyzed using Nutritionist IV software (version 3.5.2, Axxya Systems, Redmond, Washington, USA).

2.8. Assessment of physical activity:

We asked the participants not to change their regular physical activity during the nights before low-fat yogurt and white bread tests and to record their physical activity. Data from the physical activity records were converted to metabolic equivalent tasks-hour/day (MET-h/d).

2.9. Assessment of other variables

Additional information regarding age, sex, educational level, marital status, socio-economic status, medical history, medications use, supplements and herbal medicine use was obtained through interview and questionnaire.

2.10. Statistical analysis

Descriptive statistics are presented as Mean \pm Standard deviations (SDs) or standard errors (SEs). Normal distribution of outcome variables was assessed by using Kolmogorov–Smirnov test. Differences in mean energy intakes, physical activity, mean palatability and satiety scores were analyzed using paired sample T test and repeated measures procedure in which test foods and testing occasions were considered as repeated factors. All statistical analyses were performed using IBM SPSS software version 20 (IBM SPSS, Tokyo, Japan). P values less than 0.05 (two tailed) were considered as statistically significant.

3. Results

Participants of the study were 30 adults with an average age (Mean \pm SD) 26.80 \pm 9.40 years (age range 18 to 53 years), and 73.3% (n =22) of them were female. Most of them had family size of 4 or less (83.4%). Most of them were undergraduate students (80%). Anthropometric indices of the study participants are presented in Table 1.

Table 1. Anthropometrics indices of study participants at baseline (n=30) *

Indices	Mean \pm SD	Min-Max
Weight (Kg)	57.97 \pm 7.83	44.00 – 75.40
Height (cm)	163.20 \pm 7.99	151.00 – 181.00
Body mass index (Kg/m ²)	21.77 \pm 2.34	18.52 – 24.76
Waist circumference (cm)	73.67 \pm 9.00	61.00 – 98.00
Waist to hip ratio	0.78 \pm 0.09	0.68 – 1.07
Triceps skin fold (mm)	3.37 \pm 0.67	3.00 – 5.00

*SD: Standard deviation, Kg: kilogram, cm: centimeter, m: meter, mm: millimeter.

Mean weight, body mass index and waist circumference of participants were 57.97 \pm 7.83 kg (Mean \pm SD), 21.77 \pm 2.34

(kg/m²) and 73.67 \pm 9.00 cm, respectively. Energy intake before white bread and low-fat yogurt tests had no significant difference (312.00 \pm 26.42 (SE) vs. 303.73 \pm 17.23 kcal, p=0.78). Also, findings from physical activity records revealed that participants' activity levels at the nights before two tests were not significantly different (p=0.60) (Fig. 2). Based on the three-factor eating questionnaire (TFEQ), the rate of hungry in participants was 1.66 units (minimum: 0.78 and maximum: 2.56 units). Palatability of foods according to the visual, smell, taste, secondary pleasure and palatability based on 100 mm, VAS scale for test foods among the study participants are presented in Table 2. Low-fat yogurt palatability was higher than the white bread among the participants (57.85 vs. 53.11), but the difference was not statistically significant (p=0.32).

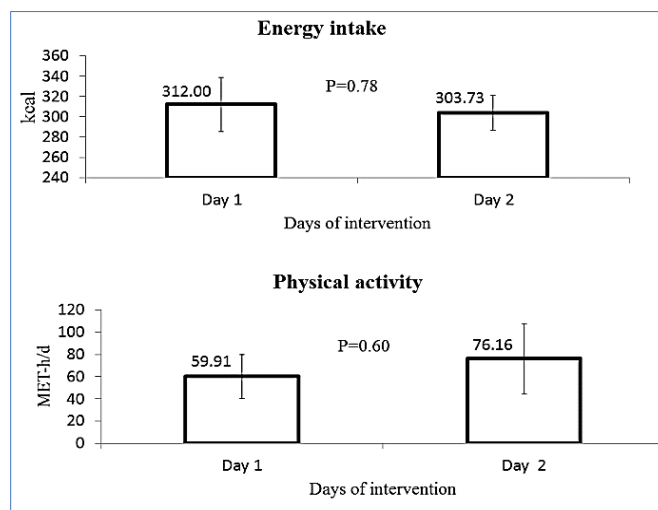


Fig. 2. Energy intake and physical activity of participants the night before the test.

Table 2. The palatability of each test food.

	Mean \pm SE*	Min- Max
White bread	53.11 \pm 3.91	2.60 – 89.60
Low-fat yogurt	57.85 \pm 4.06	18.80 – 97.60

* SE: Standard error

The satiety scores of low-fat yogurt and white bread in participants based on VAS and LIKERT scales before and after consumption of each test food are indicated in Table 3. Changes in satiety 120 minutes after consumption of low-fat yogurt and white bread in comparison to baseline, based on the VAS scale were not significant; but according to the LIKERT scale, 120 minutes after consumption of low-fat yogurt, there was a significant increase in satiety (Mean \pm SD) (changes=1.60 \pm 0.43) (p=0.03). Fig. 3 shows changes in satiety after the consumption of low-fat yogurt and white bread. Satiety from low-fat yogurt and white bread intake in different minutes after consumption of these foods based on LIKERT scale are presented in Table 4. Thirty minutes after the consumption of white bread and low-fat yogurt, most satiety was provided, as shown in Fig. 3. Then, there was a decreasing.

Table 3. The satiety scores of white bread and low-fat yogurt based on VAS and LIKERT scales before and after each test food. *

	Before	After	Change **	P ***
VAS scale				
White bread	56.02 ± 2.05 [55.08(47.29 – 61.92)]****	57.98 ± 2.44 [57.17(48.96 – 69.88)]	1.97 ± 2.00	0.33
Low-fat yogurt	51.09 ± 2.82 [54.33(47.63 – 63.33)]	50.49 ± 2.55 [50.58(44.67 – 62.67)]	-0.60 ± 2.17	0.79
LIKERT scale				
White bread	-1.00 ± 0.30	0.17 ± 0.37	1.17 ± 0.42	0.36
Low-fat yogurt	-1.13 ± 0.26	0.47 ± 0.36	1.60 ± 0.43	0.03

* Values are mean ±SE (Standard error)
 ** Food test satiety difference before and after consumption
 *** To compare between variables (by paired samples T test)
 **** Median values and percentiles 25 and 75 are listed in brackets

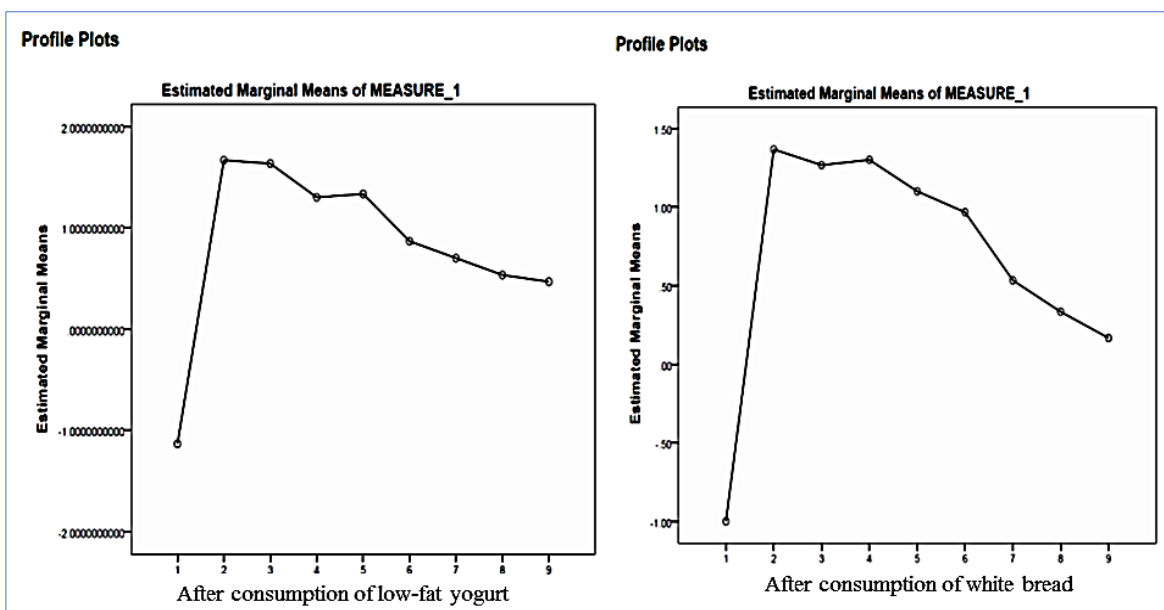


Fig. 3. Changes in satiety after consumption of low-fat yogurt and white bread based on LIKERT scale every 15 minutes for 2 hours after each test food.

trend. The area under the satiety curve that was calculated by the trapezoidal method was 5.89±1.63 for low-fat yogurt and 4.31±1.30 for white bread. Satiety index calculated by the

formula was 136.66±1.46 percent for low-fat yogurt compared to white bread (with satiety index of 100); suggesting higher satiety index for low-fat yogurt compared to white bread.

Table 4. The amount of satiety changes based on LIKERT scale to every 15 minutes for 2 hours after each test food*.

	White bread satiety	P**	changes of white bread satiety compared to 0 min	P***	Low-fat yogurt satiety	P**	changes of low-fat yogurt satiety compared to 0 min	P***
0 min	-1.00 ± 0.30				-1.13 ± 0.26			
15 min	1.37 ± 0.21		-2.37 ± 0.26	<0.001	1.67 ± 0.26		-2.80 ± 0.33	<0.001
30 min	1.27 ± 0.19		-2.27 ± 0.28	<0.001	1.63 ± 0.26		-2.77 ± 0.35	<0.001
45 min	1.30 ± 0.17		-2.30 ± 0.30	<0.001	1.30 ± 0.29		-2.43 ± 0.36	<0.001
60 min	1.10 ± 0.21	<0.001	-2.10 ± 0.34	<0.001	1.33 ± 0.28	<0.001	-2.47 ± 0.36	<0.001
75 min	0.97 ± 0.27		-1.97 ± 0.35	<0.001	0.87 ± 0.33		-2.00 ± 0.40	0.001
90 min	0.53 ± 0.32		-1.53 ± 0.39	0.02	0.70 ± 0.34		-1.83 ± 0.41	0.004
105 min	0.33 ± 0.35		-1.33 ± 0.41	0.09	0.53 ± 0.36		-1.67 ± 0.43	0.02
120 min	0.17 ± 0.37		-1.17 ± 0.42	0.36	0.47 ± 0.36		-1.60 ± 0.43	0.03

* Mean ± SE
 ** To compare variables in different times (paired samples T test)
 *** To compare variable changes every 15 minutes compare to zero time (paired samples T test)

4. Discussion

This semi-experimental study on 30 healthy Isfahanian normal-weight adults (22 women and 8 men) determined satiety index of $136.66 \pm 1.46\%$ for low-fat yogurt as compared to white bread (with satiety index of 100). We found that low-fat yogurt increased satiety more than white bread. The changes of satiety after 120 minutes of white bread and low-fat yogurt consumption based on the VAS scale were not significant; but according to the LIKERT scale, 120 minutes after consumption of test foods, satiety significantly increased for low-fat yogurt. The area under the satiety curve for low-fat yogurt was more than white bread. Energy intake and physical activity of participants before white bread and low-fat yogurt tests were not significantly different; suggesting that calculated satiety index was independent from these two variables. Applied methodology in this study to determine satiety index was used for the first time in an Iranian community. This method is suggested to be used for calculating satiety index of other foods in different populations. Holt et al. have produced satiety index of different food groups in 11-13 healthy normal-weight adults and considered white bread as the reference food (4). They measured the test foods with VAS and LIKERT scales and reported satiety index of 88% for yogurt, but did not determine the fat content of consumed yogurt. They reported a negative correlation between SI scores and palatability ratings ($r = -0.64$, $p < 0.001$). We also found an inverse correlation between palatability of low-fat yogurt and SI among 30 healthy normal-weight adults, but we have determined a high satiety index for low-fat yogurt (136.66%). De Graaf et al. have measured biomarkers of satiety, like CCK and glucagon-like peptide-1 (GLP1) and reported that changes in these markers could show the effects of food satiety. High levels of CCK and GLP1 correlated with lower hunger and food intake (27). Unfortunately, in the present study, we could not measure biomarkers of satiety. Duncan et al. were performed an investigation on obese and non-obese people with low energy density diet (including a lot of fresh fruits, vegetables, whole grains, dried beans and small amount of fat) and high energy density diet (including large amount of fat and refined carbohydrates such as desserts); they reported that the average satiety was directly related to the high energy density diet (28). Belza et al. have conducted an investigation on normal-weight and overweight men, they measured satiety based on VAS scale every 15 minutes to 240 minutes and showed that a high protein diet increased satiety with the release of GLP1, peptide YY (PYY) and glucagon. They also reported that palatability of a normal protein diet was higher than high protein diet (29). Another study on healthy normal-weight women showed that a high protein diet provided lower AUC of hunger and higher AUC of satiety in 24 hours than a normal protein diet (30), while Burton-Freema et al. have documented that fat causes satiety with release of CCK (10). MacIntosh et al. have shown that after taking the oil Sunola (mono-unsaturated fatty acids), sunflower seeds (poly-unsaturated fatty acids) and butter (saturated fatty acids), no difference was observed in satiety

index and food intake after 2 hours in healthy normal-weight men (12). Inconsistency in these findings of investigations might be related to different study designs, body mass index range of participants in different studies, age range of individuals, type of test foods and used scales for determining of satiety index. Several mechanisms are suggested for satiety of different foods. Satiety index has a direct relationship with fiber, water and protein content of foods. Low glycemic index foods, high fiber, and high protein diets increase satiety. High protein diets control the energy intake, reduce food intake, increase satiety and thermogenesis. These diets have positive effects on body composition and glycemic control and increase the satiety more than carbohydrates or fat (5). Sensory specific satiety (SSS) has an important role in food choices. Previous studies have revealed that there is no difference between sensitivity to sensory-specific satiety in obese and normal-weight people and taste of foods had a significantly stronger effect on sensory-specific satiety than fat content (31). Intake of low glycemic index and high fiber foods reduce food intake and increase satiety compared to food with high glycemic index and low fiber (32). Carbohydrates stimulate satiety mechanism and reduce food intake for a short term (8). Intake of high-volume foods helps to suppress hunger and enhance satiety (33). High palatability foods like high fat and sugary foods might also decrease satiety and the release of insulin (4). This study has some strengths. It was conducted in Iranian healthy population for the first time; so, the disease would not affect the results. We used low-fat yogurt as the test food; a high-protein available food for all individuals. However, several limitations need to be considered when interpreting our findings. The number of people in the study was not enough to have decisive result. A larger study sample might result in significance satiety based on VAS scale. The study was conducted on adults; considering the high prevalence of obesity in children and adolescent, further investigations in children are needed. We measured satiety index of low-fat yogurt; determination of satiety index for other foods is suggested. Our study was conducted on normal-weight healthy subjects, we suggest more studies in this regard among obese individuals. Also, we could not measure biomarkers of satiety in participants, because of financial limitation.

5. Conclusion

In total, in normal-weight Isfahanian adults, satiety index of low-fat yogurt was 136.66 percent compared to white bread (with satiety index of 100); suggesting that low-fat yogurt increased satiety more than white bread. According to the LIKERT scale, 120 minutes after consumption of low-fat yogurt, satiety has significantly increased. The applied method in this study is suggested to be used for determination of SI of other foods in different population.

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