Orginal Article Open Access
Iranian Journal of Diabetes and Obesity (IJDO)

The Cumin Bread Satiety Index: A Randomized Controlled Cross-over Study

Seyed-Ali Khodaie[1], Roghaye Razavi[2], Ali Akbar Safari[3], Nasim Namiranian[4], Hassan Mozaffari-Khosravi[5,6], Haniyeh Nikkhah[7], Mohammad Kamalinejad[*8,9]

[1]MD-PhD of Persian medicine, Diabetes Research Center, Non-Communicable Disease Research Institute, Shahid Sadoughi University of Medical Sciences,Yazd, Iran.
[2]Master of Nutrition, Diabetes Research Center, Non- Communicable Disease Research Institute, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[3]Pharm D, PhD of Traditional pharmacy Evidence-based Phytotherapy and Complementary Medicine Research Center, Alborz University of Medical Sciences, Karaj, Iran.
[4]MD, Associate Professor of Community & preventive medicine, Diabetes Research Center, Non- Communicable Disease Research Institute, Shahid Sadoughi university of medical sciences, Yazd, Iran.
[5]Department of Nutrition, School of Public Health, Shahid Sadoughi University of Medical Sciences,Yazd, Iran.
[6]Diabetes Research Center, Non- Communicable Disease Research Institute, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[7]PhD student of Genetic, Diabetes Research Center, Non- Communicable Disease Research Institute, Shahid Sadoughi university of medical sciences, Yazd, Iran.
[8]DSc, School of Pharmacy, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[9]Research & Development Manager, Sepid Gohar Qeshm Company. Tehran, Iran.

Abstract

Objective: The aim of present study was to compare the effect of cumin bread (designed on a mixture of wheat flour and cumin powder 2%) and white bread on the satiety index of healthy adults.

Materials and Methods: This randomized controlled cross-over clinical trial was conducted on 15 healthy participants. Volunteers were randomly allocated into 2 groups to consume either cumin bread or the white bread. The satiety index was measured over a period of 120 minutes.

Results: 12 out of 15 participants completed the study and were included in the final analysis. The results showed that the consumption of cumin bread compared to white bread significantly increased the satiety index (P= 0.0001). Additionally, the participants did not report any complaints when consuming cumin bread or white bread.

Conclusion: The present study suggests that cumin bread has a greater potential to enhance satiety compared to white bread. This result highlight cumin bread may be an effective strategy for improving satiety in healthy individuals. Further studies are needed to validate these preliminary results and to further elucidate the underlying mechanisms.

Keywords: Cumin, Bread, Satiety index, Persian medicine

QR Code:

Citation: Khodaie S, Razavi R, Safari A A, Namiranian N, Mozaffari-Khosravi H, Nikkhah H et al. The cumin bread satiety index: A Randomized controlled Cross-over Study. IJDO 2025; 17 (4) :229-237

URL: http://ijdo.ssu.ac.ir/article-1-990-en.html

10.18502/ijdo.v17i4.20037

Article info:

Received: 12 December 2024

Accepted: 20 May 2025

Published in October 2025

Corresponding Author:

Mohammad Kamalinejad, DSc, School of Pharmacy, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
Tel: (98) 35 372 0215
Email: mkamalinejad@SBMU.AC.IR
Orcid ID: 0000-0002-2011-334X

[DOI: 10.18502/ijdo.v17i4.20037]

Introduction

The satiety index (SI) expresses the extent to which a food increases the feeling of fullness over a two-hour period after eating (1). A higher SI for a food means that a person will be hungry later after eating the food (2). Postprandial blood glucose levels, via glucoreceptors, and insulin response (IR) are stated to be highly correlated with satiety (3,4).

It is possible that energy-rich foods are consumed excessively by reducing the feeling of satiety per calorie, which is due to the easy consumption and rapid digestion of the foods (5). The lifestyle interventions, such as the use of dietary fiber, protein and highly satiating foods eliciting a positive effects on glycemic and insulinemic response, can be useful in the treatment and prevention of overweight, obesity and, chronic metabolic diseases [type 2 diabetes mellitus (T2DM), and cardiovascular disease] (6-10). Meta-analysis studies showed the strong association between vegetable consumption and lower incidence of T2DM and high blood pressure (11,12).

From previous research, high fiber consumption improves satiety, reduces body mass index (BMI) and thus decreases related chronic diseases (8,9). Recently, the addition of extracts from some plants to high glycemic index foods such as bread has been found to enhance the satiety index of these products by slowing gastric emptying (5,13).

A number of studies have confirmed that whole grain rye flour, Sweet corn flour, Salba seeds, hazelnuts, chickpea flour, and brown sorghum to some products can enhance the feeling of satiety and reduce hunger in the short term; It also makes it a useful product for the prevention and control of chronic metabolic diseases (5,6).

Globally, due to the highest consumption of wheat bread in the diet and the fattening effects of bread, the type of bread consumed may effect on satiety and overall energy intake (1). It has been reported that the SI for bread, as a staple food of diet and a primary source of carbohydrate and energy consumption, varies from 100% to 561% (1,13). It seems that the processing and preparation of bread is effective in the feeling of satiety after eating bread (7). In Iran, the industrial production of bread is gradually increasing. To date, due to the effect of the quality and quantity of food such as bread, as a factor diet-related to non-communicable diseases including T2DM, as well as the high glycemic response of many breads on the market, conscious consumers are looking for breads with higher fiber content and lower glycemic index (GI), which has a favorable effect on the satiety response (1,14). On the other hand, according to scholars of Persian medicine, adding some medicinal plants such as cumin to the dough improves the quality of bread (15).

Cumin (*Cuminum cyminum* L.) belongs to the Apiaceae family, which has relatively high fiber content (90% dietary fiber) (16). Antioxidant effects and improvements in the metabolic profile of cumin extract have been reported in the control of diabetes, weight, and blood pressure (16,17). Although, one study has shown that adding cumin to bread significantly reduces its glycemic index and glycemic load (18), the effect of using cumin in bread formulation on appetite control is not known.

To our knowledge, no study has investigated the effect of adding cumin into bread on the appetite sensations in healthy people. This has generated much interest into the role of cumin extracts as potential functional food ingredients for improving satiety index. In this regard, we hypothesized that cumin bread enhances satiety responses over a 120-minute period in healthy humans. The aim of this investigation was to evaluate the areas- under the curve (AUCs) of changes in satiety after the consuming cumin bread and white bread in healthy adults.

[DOI: 10.18502/ijdo.v17i4.20037]

Materials and methods

Breads preparation and their nutritional characteristics

Cumin was purchased from a local market in Tehran, Iran and was identified in the herbarium center of Shahid Beheshti University of Medical Sciences in Tehran with the code (BMU-8035). The cumin bread was produced in the laboratory and then adapted for production in a commercial bakery. Cumin bread was containing 2% cumin powder, 98% wheat flour (locally named Setareh), and permitted bread additives (salt and standard ingredients to improve the quality of bread). Both breads were manufactured by "Padena Asia (Nan Avaran) "factory in Eshtehard industrial town, Alborz province, Iran. Meanwhile, the bread preparation formulation is standardized based on the measurement of total phenol. All bread samples were baked and packaged in transparent packs the day before, kept at room temperature and tested the next morning.

Nutritional compounds in the cumin bread were determined at Behesht Aein, an internationally accredited Tehran, Iran laboratory using AOAC and Pearson chemical analysis methods (18).

Subjects

This experiment was a double-blind, single-center, randomized crossover controlled clinical trial that was carried out in May 2023 at Yazd Diabetes Research Center, Iran. In this study, new ready-to-eat cumin bread was compared with the white bread. Fifteen healthy volunteers (self-reported) were recruited through personal communication and from employees. The People were eligible to enroll the study if they were aged between 20 and 50 years, with 18.5 ≤BMI ≤25 kg/m2, normal fasting plasma glucose (< 105 mg/ dL), relatively sedentary, regular consumption of bread (at least three times per week), no history of gastrointestinal disease or gastric surgery, and usual diet. Individuals with cumin allergy, history of dieting three months prior to screening, weight changes ≥5% for 6 months before the study, a history of genetic or metabolic diseases, regular and high intensity activity, smoking, opioid addiction, taking of supplements or medications influencing appetite or gastrointestinal function, breast feeding, and pregnancy were excluded. Sample size was estimated by the formula represented for crossover clinical trials, considering type 1 error (α) 0.05, type 2 errors (β) (power 90%) of 0.1 and d:0.5. With consideration for 15 % attrition rate, the final sample size was determined to be of 30 participants in the current study.

The allocation diagram of the participants who were involved in the study is shown in Figure 1.

Study design

The Subjects were asked to maintain their regular physical activity level, diet and refrain

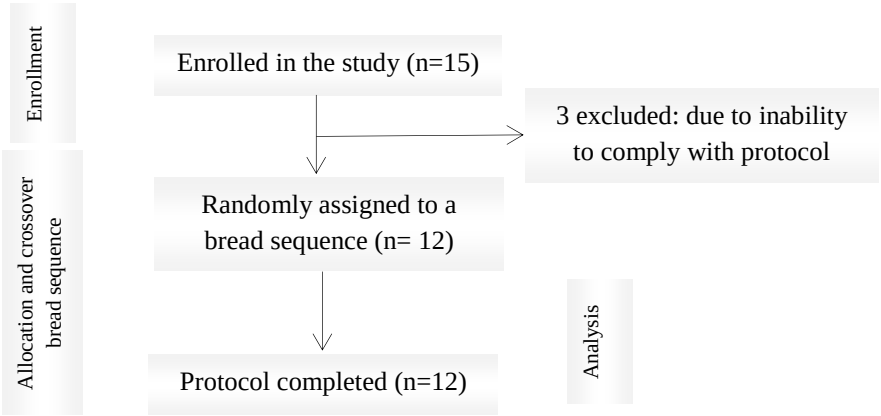

Figure 1. Participant recruitment, allocation, and random assignment processes flow diagram.

[DOI: 10.18502/ijdo.v17i4.20037]

from taking any supplements or medication that may interfere with the results of the study during the trial period. On the morning of the test, the participants completed a physical activity questionnaire [Physical Activity Questionnaire is a standardized tool designed to assess the amount and pattern of individuals' physical activity by evaluating the intensity, type, and duration of activities. The collected data are usually reported in minutes per week or metabolic equivalent units (MET-min/week) and are used to examine physical activity levels and their association with health indicators (19)] and a 24-hour dietary recall [the 24-hour dietary recall is a widely used method in nutritional assessment, in which individuals are asked to report all foods and beverages consumed during the previous 24 hours. Owing to its simplicity, low cost, and applicability in large-scale studies, it is frequently employed in nutritional research, although its accuracy may be limited by reliance on memory and its inability to fully reflect usual dietary patterns (20)], including their food intake the day previous of the intervention. Both studied breads were prepared in the same size, shape, color, smell, and packaging (by the same factory). The breads were not labeled to decrease the risk of biases. On each day of the study, participants, investigators and analysts were blinded and did not know about the type of bread allocated. Each bread was cut with the equal shape and weighing 90 grams and only the slice was given to the participants.

Intervention

The subjects were instructed to abstain from consuming unusual large meals, nicotine, caffeine, or any other drugs and heavy exercise the day prior to each experiment. Each participant randomly consumed one of the two investigated breads (white bread or cumin bread) on two separate days. On each study day, fasting blood sugar (FBS) was taken from each volunteer; and 90 grams of bread was distributed to each participant. Then, they were asked to consume the bread between 8 .00 am and 9.00 am after a 10-h overnight fast. Bread was consumed in a sitting position within 10 to 15 minutes; also, participants were allowed to drink only water and tea without sugar along with bread during the study. The Participants were not permitted to drink or eat anything else during the 2-hour of the test. Each participant served as their own control and bread was tested before breakfast in simple random order on different days, with at least one- week wash- out period between each experiment. The random sequence was generated using a simple randomization procedure with equal probability of being assigned to each sequence of the two types of breads for each volunteer. Each study was completed on a separate morning and the study days were considered one week- interval apart from each other to eliminate carryover effects. In the throughout the procedure and in the interval between the test days, the subjects continued their ordinary diet and daily activities.

Measurement of variables

On each day of the study, FBS were measured before consuming the breads (0 minute) using a calibrated finger-stick blood glucose meter (GLUCOCARD™ 01-mini, ARKRY, Japan).

On each day of the intervention, height (HEIGHT 200 CM, NO 26 SM) and body weight (OMRON HEALTHCARE CO, Ltd, JAPAN) of each participant were measured before the intervention while wearing light clothing and unshod by a trained researcher to the nearest 0.1 kg and 0.1 cm, respectively. BMI was calculated as weight (kg) divided by height (m^2).

Satiety assessment

For all cases, subjective satiety sensations were assessed using a 10 cm -long continuous line visual analogue scale (VAS) (10). The VAS anchored on a standard seven-point Likert scale with the following categories: 3-

[DOI: 10.18502/ijdo.v17i4.20037]

("very hungry"); 2- ("Hungry"); 1- ("a little hungry"); 0 ("no special feeling"); +1("a little full"); +2("full"); +3 ("very full"). The participants were asked, immediately before bread consumption (0 min) and at 15, 30, 45, 60, 75, 90, 105, and 120 min after the bread consumption, to rate their true sensation of fullness or hunger by marking a line on a VAS. Subjects could not refer to previous times when ratings the VAS. Also, they did not consult their hunger levels with each other. The participants provided VAS data, and the Satiety area under the curve (AUC) was evaluated after the consumption of cumin-enriched bread using the trapezoidal formula, relative to white bread, which was considered as the reference with an index of 100. SI was obtained using the following formula.

$$SI = \frac{\text{AUC of cumin- enriched bread}}{\text{AUC of white bread}} * 100$$

Statistical analysis

The normality for data (due to the small sample size) was assessed using the Shapiro-Wilk test. The total incremental area under the curve (iAUC) was calculated for satiety response following consumption of cumin bread and white bread. The data are expressed as mean± SD. Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software version 24 (SPSS Inc., Chicago, IL, USA). $P< 0.05$ was regarded statistically significant. The SI was compared between two types of bread using paired t-test. The graph was drawn using Graph pad prism 8.

Ethical considerations

At the beginning, after explaining of the purpose and nature of the study to the volunteers, written informed consent was obtained from them. This trial was approved by the University Research Ethics Committee at Shahid Sadougi University of Medical Sciences (IR.SSU.REC.1402.035) and was registered in the Iranian registry of clinical trials (http://www.irct.ir: IRCT20160221026684N5). All the procedures were also carried out according to the recommendation of the CONSORT statement and the guidelines of the Helsinki Declaration.

Results

A total of twelve healthy adults (9 females and 3 males; mean age 34.25±5.13 years; mean body mass index 22.13±2.49 kg/m2) Table 1, completed the study (Figure 1 shows the flowchart of the participants). Also, two participants were excluded due to not strictly following the study protocol.

Satiety index of cumin bread and white bread

As shown in Table 2, the total satiety AUC values after consuming cumin bread were significantly higher than white bread (P= 0.0001). A significant difference was observed between the SI of the examined breads (P= 0.0001). The SI of cumin bread was significantly higher than white bread (Figure 2). The SI values of all 2 types of bread are exhibited in the Table 2.

Table 1. Basic characteristic of participants

Variables	Value
Sex (M/F)	3 (25) M/9 (75) F
Age (years)	34.25 (±5.13)
Weight (kg)	64.12 (±11.49)
Height (cm)	169.83 (±10.13)
BMI (kg/m2)	22.13 (±2.49)
FBS (mmol/L)	97.83 (±9.42)
PA (MET-min/day)	955 (±305.95)
Calorie (kcal)	1978.54 (±582.17)

Data are presented as number (percentage) or mean± SD.
Abbreviations: BMI: Body mass index; FBS: Fasting blood sugar; PA: physical activity.

[DOI: 10.18502/ijdo.v17i4.20037]

Side effects

During the study, the participants did not report any adverse effects.

Discussion

The findings of the present study support the hypothesis that the intake of cumin bread significantly increased the SI in healthy participants. Therefore, we could not exclude that the difference in carbohydrate, energy, protein, and dietary fiber contents of the two breads could have justified at least partially our results (7).

Different factors may influence SI. It seems that the addition of cumin to bread has increased the SI of the bread due to the high fiber content and polyphenol in cumin (21,22). These effects primarily can be explained not only by the higher fiber and protein content in cumin bread but also by reducing rate of gastric emptying (8).

Indeed, the higher fiber and protein content in cumin bread compared to white bread may account for the increased satiety potentially by delaying gastric emptying (1,5,23,24). Another plausible explanation for the difference in satiety measures between breads could be due to differences in glycemic response and attenuation the secretion of insulin (insulin is correlated to short-term satiety regulation) (4,20); However, insulin has a controversial role (25).

Previous studies have found that polyphenols inhibit the action of carbohydrate-digesting enzymes (22,26); Therefore, it is thought that there is a significant inverse association between the content of polyphenol and the rate of starch digestibility (27).

On the other hand, several mechanisms have been suggested for how fiber in cumin bread aids in satiety greater: 1- Increasing chew ability (28,29), 2- Increasing the bulk and emptying time in the gastrointestinal tract (30). Increasing the emptying time and the volume of the digestive tract, which is related to the fermentable and viscous properties of dietary fibers, leads to stimulating the release of satiety hormones by intestinal cells (cholecystokinin (CCK), PYY, pancreatic polypeptide (PP), and GLP-1) which play a major role in regulating food consumption; these hormones cross the blood-brain barrier,

Table2. The AUC and the SI of white bread and cumin bread

Variables	**White bread** (N= 12)	**Cumin bread** (N=12)	***P*-value**
AUC (mm/min)	151.9 (±30.10)	233.2 (±27.92)	0.0001
SI	100	152.86 (±61.1)	0.0001

Data are presented as number (percentage) or mean± SD. *P*-value was obtained from paired t- test (2-tailed).
Abbreviations: AUC: Area Under the Curve; SI: Satiety Index.

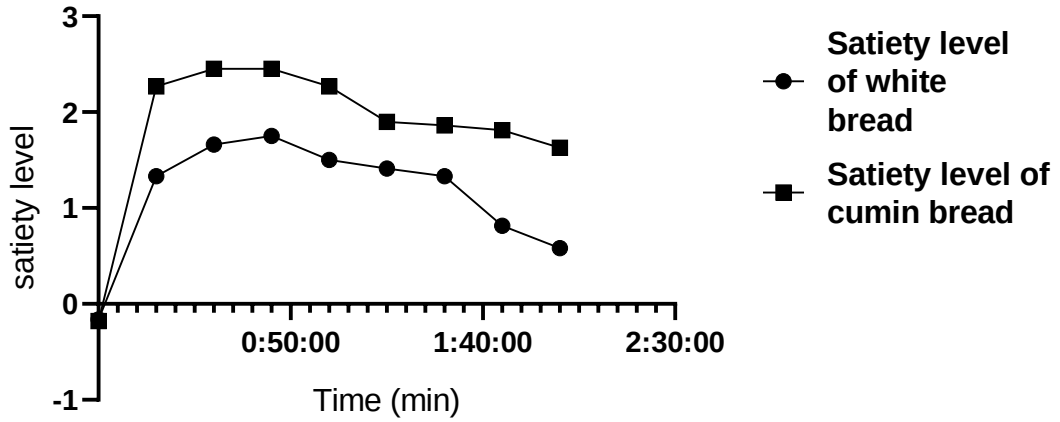

Figure 2. Changes in satiety after eating white bread and cumin bread

[DOI: 10.18502/ijdo.v17i4.20037]

bind to their receptors, which are the satiety centers of the hypothalamus in the brain, and suppress sensations of appetite (22,31-36); Furthermore, Another possible explanation might be that reducing gastric emptying rate increases the time that macronutrients are in contact with the absorptive surfaces and potentially affects satiety (35).

These results are in line with findings from previous studies. Isaac Amoah et al. investigated how the consumption of vegetable-enriched bread (VB) in comparison to commercial white bread (WB) and wheat meal bread (WMB) impact on appetite and suppress food intake. This experimental study randomized crossover design where 10 participants took a 75 g serve of WB, WMB, or VB. The authors reported that the consumption of the vegetable-enriched bread resulted in increased fullness sensation compared with commercial breads (22). Keogh et al (2011) found that a laboratory based test meal following the Bürgen® Bread breakfast reduced energy intake relative to a breakfast with white bread (1).

In another study, the effect of rye bread breakfast on subjective appetite during 8 hours was investigated; Researchers found that consumption of rye bread compared with wheat bread has significant satiety effects (5).
Other authors did not find different satiety responses. For example, a study by Clegg et al showed that berries had no effect on satiety when consumed with starch-rich pancakes (30).
Shelly Coe and colleagues reported, addition of polyphenol- rich extracts [green tea extract (GTE) and baobab fruit extract (BAO)] into white bread had no effect on satiety in healthy participants (17). Different forms and doses, and differences in dietary fiber content might justify these divergent results.

The strength of the current research is the use of a randomized, controlled crossover design. Limitations of current study are (1) the lack of polyphenols analysis after baking the cumin bread, 2) Ethnicity of participants, 3) Not measuring hormonal responses, 4) The impossibility of distinguishing soluble and insoluble dietary fiber in our breads (determining the total dietary fiber content only).

Conclusions

In conclusion, the addition of cumin to bread favorably affected appetite sensations. Cumin bread is not consumed widely in Iran, but it should certainly be included as an alternative to ordinary bread in the diet, to help individuals reduce their daily calorie intake due to its satiety properties. Hence, according to the results obtained from this study, cumin bread has a greater potential to enhance satiety compared to white bread.

This result highlight cumin bread may be an effective strategy for improving satiety in healthy individuals. Further exploration of these results will be useful in improving our knowledge of how cumin bread may influence the secretion of gastrointestinal hormones.

Acknowledgments

The authors would like to sincerely thank the staff of Yazd Diabetes Research Center. They are also grateful to all participants for their cooperation. In addition, we would like to thank the management of the Nan Avaran factory in Karaj, Iran, for providing the bread used in this study.

Funding

This research was supported by Behdane Baran Salem Abi Company.

Conflict of Interest

None.

Author contributions

N.N generated the random allocation sequence. H.N, R.R and SA.Kh enrolled participants, and assigned participants to interventions. Study design was conducted by M.K, AA.S and H.M-Kh. Writing article by H.N, R.R and SA.K. All the authors critically revised the manuscript, agree to be fully

[DOI: 10.18502/ijdo.v17i4.20037]

accountable for the integrity and accuracy of the study, read and approved the final manuscript.

References

1. Keogh J, Atkinson F, Eisenhauer B, Inamdar A, Brand-Miller J. Food intake, postprandial glucose, insulin and subjective satiety responses to three different bread-based test meals. Appetite. 2011;57(3):707-10.
2. Rolls BJ. Carbohydrates, fats, and satiety. The American journal of clinical nutrition. 1995;61(4):960S-7S.
3. Mayer J. Glucostatic mechanism of regulation of food intake. New England Journal of Medicine. 1953;249(1):13-6.
4. Flint A, Gregersen NT, Gluud LL, Møller BK, Raben A, Tetens I, et al. Associations between postprandial insulin and blood glucose responses, appetite sensations and energy intake in normal weight and overweight individuals: a meta-analysis of test meal studies. British Journal of Nutrition. 2007;98(1):17-25.
5. Isaksson H, Fredriksson H, Andersson R, Olsson J, Åman P. Effect of rye bread breakfasts on subjective hunger and satiety: a randomized controlled trial. Nutrition Journal. 2009;8(1):39.
6. Kehlet U, Kofod J, Holst JJ, Ritz C, Aaslyng MD, Raben A. Addition of rye bran and pea fiber to pork meatballs enhances subjective satiety in healthy men, but does not change glycemic or hormonal responses: A randomized crossover meal test study. The Journal of nutrition. 2017;147(9):1700-8.
7. Bo S, Seletto M, Choc A, Ponzo V, Lezo A, Demagistris A, et al. The acute impact of the intake of four types of bread on satiety and blood concentrations of glucose, insulin, free fatty acids, triglyceride and acylated ghrelin. A randomized controlled cross-over trial. Food research international. 2017;92:40-7.
8. Gonzalez-Anton C, Lopez-Millan B, Rico MC, Sanchez-Rodriguez E, Ruiz-Lopez MD, Gil A, et al. An enriched, cereal-based bread affects appetite ratings and glycemic, insulinemic, and gastrointestinal hormone responses in healthy adults in a randomized, controlled trial. The Journal of nutrition. 2015;145(2):231-8.
9. Yuan JY, Smeele RJ, Harington KD, van Loon FM, Wanders AJ, Venn BJ. The effects of functional fiber on postprandial glycemia, energy intake, satiety, palatability and gastrointestinal wellbeing: a randomized crossover trial. Nutrition journal. 2014;13(1):76.
10. Shishehbor F, Salimi Z, Veissi M, Malehi AS, Shiri-Nasab M, Helli B. Effect of oak flour on glycemic index and satiety index of white bread. Iranian Red Crescent Medical Journal. 2020;22(1):e95552.
11. Wang PY, Fang JC, Gao ZH, Zhang C, Xie SY. Higher intake of fruits, vegetables or their fiber reduces the risk of type 2 diabetes: A meta-analysis. Journal of diabetes investigation. 2016;7(1):56-69.
12. Zurbau A, Au-Yeung F, Blanco Mejia S, Khan TA, Vuksan V, Jovanovski E, et al. Relation of different fruit and vegetable sources with incident cardiovascular outcomes: a systematic review and meta-analysis of prospective cohort studies. Journal of the American Heart Association. 2020;9(19):e017728.
13. Breen C, Ryan M, Gibney MJ, Corrigan M, O'Shea D. Glycemic, insulinemic, and appetite responses of patients with type 2 diabetes to commonly consumed breads. The Diabetes Educator. 2013;39(3):376-86.
14. Gonzalez-Anton C, Artacho R, Ruiz-Lopez MD, Gil A, Mesa MD. Modification of appetite by bread consumption: a systematic review of randomized controlled trials. Critical reviews in food science and nutrition. 2017;57(14):3035-50.
15. Emami SA, Sobhani Z. Characteristics of different ethnic and traditional bread from the perspective of Islamic traditional medicine. Journal of Ethnic Foods. 2020;7(1):13.
16. Morovati A, Pourghassem Gargari B, Sarbakhsh P. Effects of cumin (Cuminum cyminum L.) essential oil supplementation on metabolic syndrome components: A randomized, triple-blind, placebo-controlled clinical trial. Phytotherapy research. 2019;33(12):3261-9.
17. Taghizadeh M, Memarzadeh MR, Asemi Z, Esmaillzadeh A. Effect of the Cumin cyminum L. intake on weight loss, metabolic profiles and biomarkers of oxidative stress in overweight subjects: a randomized double-blind placebo-controlled clinical trial. Annals of Nutrition and Metabolism. 2015;66(2-3):117-24.
18. Khodaie S-A, Nikkhah H, Safari AA, Namiranian N, Mozaffari-Khosravi H, Razavi R, et al. T The Effect of Bread with and without Cumin on Glycemic Index, Glycemic Load and Glycemic Response in Healthy People: A Randomized Clinical Trial. Journal of Nutrition and Food Security.2025;10(4):1-11.
19. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and

[DOI: 10.18502/ijdo.v17i4.20037]

MET intensities. Medicine and science in sports and exercise. 2000;32(9; SUPP/1):S498-504.
20. Castell GS, Serra-Majem L, Ribas-Barba L. What and how much do we eat? 24-hour dietary recall method. Nutricion hospitalaria. 2015;31(3):46-8.
21. Coe S, Ryan L. White bread enriched with polyphenol extracts shows no effect on glycemic response or satiety, yet may increase postprandial insulin economy in healthy participants. Nutrition Research. 2016;36(2):193-200.
22. Amoah I, Cairncross C, Merien F, Rush E. Glycaemic and appetite suppression effect of a vegetable-enriched bread. Nutrients. 2021;13(12):4277.
23. Russo A, Stevens JE, Wilson T, Wells F, Tonkin A, Horowitz M, et al. Guar attenuates fall in postprandial blood pressure and slows gastric emptying of oral glucose in type 2 diabetes. Digestive diseases and sciences. 2003;48(7):1221-9.
24. Lee YP, Mori TA, Sipsas S, Barden A, Puddey IB, Burke V, et al. Lupin-enriched bread increases satiety and reduces energy intake acutely. The American journal of clinical nutrition. 2006;84(5):975-80.
25. Wolever TM, Leung J, Vuksan V, Jenkins AL. Day-to-day variation in glycemic response elicited by white bread is not related to variation in satiety in humans. Appetite. 2009;52(3):654-8.
26. Guzar I. Effect of starch-polyphenol interactions on starch hydrolysis: University of Guelph; 2012.
27. Englyst KN, Englyst HN, Hudson GJ, Cole TJ, Cummings JH. Rapidly available glucose in foods: an in vitro measurement that reflects the glycemic response. The American journal of clinical nutrition. 1999;69(3):448-54.
28. Martins ZE, Pinho O, Ferreira IM, Jekle M, Becker T. Development of fibre-enriched wheat breads: impact of recovered agroindustrial by-products on physicochemical properties of dough and bread characteristics. European Food Research and Technology. 2017;243(11):1973-88.
29. Chambers L, McCrickerd K, Yeomans MR. Optimising foods for satiety. Trends in Food Science & Technology. 2015;41(2):149-60.
30. Williams BA, Mikkelsen D, Flanagan BM, Gidley MJ. "Dietary fibre": moving beyond the "soluble/insoluble" classification for monogastric nutrition, with an emphasis on humans and pigs. Journal of Animal Science and Biotechnology. 2019;10(1): 1-12.
31. Perry B, Wang Y. Appetite regulation and weight control: the role of gut hormones. Nutrition & diabetes. 2012;2(1):e26.
32. Steinert RE, Feinle-Bisset C, Asarian L, Horowitz M, Beglinger C, Geary N. Ghrelin, CCK, GLP-1, and PYY (3–36): secretory controls and physiological roles in eating and glycemia in health, obesity, and after RYGB. Physiological reviews. 2017;97(1):411-63.
33. Wanders AJ, van den Borne JJ, de Graaf C, Hulshof T, Jonathan MC, Kristensen M, et al. Effects of dietary fibre on subjective appetite, energy intake and body weight: a systematic review of randomized controlled trials. Obesity reviews. 2011;12(9):724-39.
34. Kristensen M, Jensen MG. Dietary fibres in the regulation of appetite and food intake. Importance of viscosity. Appetite. 2011;56(1):65-70.
35. Peters HP, Mela DJ. The role of the gastrointestinal tract in satiation, satiety, and, food intake: evidence from research in humans. Appetite and Food Intake: Behavioral and Physiological Considerations. CRC Press, Taylor & Francis Group: Boca Raton, FL. 2008:187-211.
36. Blundell J, De Graaf C, Hulshof T, Jebb S, Livingstone B, Lluch A, et al. Appetite control: methodological aspects of the evaluation of foods. Obesity reviews. 2010;11(3):251-70.

[DOI: 10.18502/ijdo.v17i4.20037]