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Recent Advances in Possible Effects of Bread Types and Enrichments on Appetite during Ramadan Fasting

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A B S T R A C T

Introduction: Bread is the staple food of most Muslims and can be considered to be a component with a remarkable effect on satiety and appetite during Ramadan fasting. This study aimed to present the recent advances in investigating the effect of different types of bread and enrichments on satiety and appetite.
Methods: In this paper, articles focusing on the effect of various bread types (including enriched bread) on satiety and appetite, particularly during fasting were reviewed. Articles were found in databases such as ISI, PubMed and Google Scholar.
Results: Different bread types with lower glycemic index are recommended for Ramadan fasting, especially for the Sahur meal, due to better satiety and sglycemic control. In addition, fermentable dietary fibers, such as arabinoxylans, β-glucan, fructans, and resistant starch, can influence appetite through fermentation in the colon by saccharolytic bacteria and gastrointestinal tract releasing hormones changes. Consumption of wholemeal bread results in the moderation of satiety and starvation. Barely, oat and rye breads demonstrate the better improvement of satiety compared to white wheat bread due to their higher fiber content, probiotic ingredients and steadier glycemia. On the other hand, use of protein-rich breads can result in delayed gastric emptying, steadier insulin levels and higher satiety. Beta-glucan enrichment shows similar significant results in terms of reducing hunger and increasing satiety by influencing the appetite and satiety and regulating hormones such as insulin, ghrelin and PYY. Fiber enrichment and probiotics (Fructo-oligosaccharides/Inulin) could also be considered in this regard.
Conclusion: During Ramadan fasting, barley bread, oat bread and wholegrain wheat bread could be suggested as the preferred bread types to be incorporated into the main meals to improve satiety and decrease hunger feeling.

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Introduction

Different types of bread, such as white, whole wheat buttermilk, wholegrain, rye, barley, chickpea, Burgen wholemeal and Lupin bread are consumed as the staple food by most people in their daily meals (1-5). Wholegrains are composed of endosperm, germ and bran (6). Wholemeal wheat products contain a high amount of non-viscous dietary fibers, which are associated with many health benefits (7).

Fasting is a religious practice among Muslims, which prohibits eating, drinking and smoking from dawn till dusk (7). When Ramadan and summer coincide, fasting may take as long as 17 hours a day.

The main complaint of individuals while fasting is the feeling of thirst and hunger. Apparently, diet, particularly the consumption of bread as the staple food of most Muslims, influences the appetite and satiety of fasting individuals. This article aimed to review the

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recent advances regarding the effects of consuming different types of bread and enrichments on satiety and appetite for recommendation in Ramadan fasting.

Material and methods

As the number of related articles on association between different types of breads, enrichments and appetite and satiety during fasting in research database was few, this review article investigated this association using related keywords such as the "glycemic", "insulinemic", "ghrelin", "leptin" and "PYY" in research databases including ISI, PubMed and Google Scholar.

Results

Satiety is defined as the feeling of fullness and is basically induced by neural and hormonal signaling throughout the gastrointestinal tract, with the purpose of regulating further intake and optimizing digestion and nutrient absorption (8). Multiple factors affect satiety and appetite, including environmental (such as culture, social conditions, availability of food), personal (physical and psychological factors) and food-related factors (high protein, high fiber, low GI carbohydrates, highly viscous beverages, unchangeable diet and excessive food portion sizes) (9).

Satiety is commonly measured within 0.5-3 hours, and the associated long-term effects are rarely explored (10). Appetite and satiety are mostly assessed by subjective tools, such as the visual analogue scale (VAS), the scale proposed by Haber et al., SI (recording and weighing food portions) and measuring the level of related hormones (leptin, ghrelin and PYY), which might help in the assessment of appetite changes (11).

Ghrelin and leptin are two appetite-regulating gastric hormones with counteractive functions. Ghrelin is an orexigenic hormone, whereas leptin is involved in the long-term balance of caloric intake, fat deposition and energy balance (12, 13). Competitive action of ghrelin and leptin in the regulation of food intake has been demonstrated in several studies (14, 15). Serum leptin follows a circadian rhythm, which reaches its peak during 22:00-3:00. After the first meal in the morning, the plasma levels diminish drastically and reach the lowest level before 17:00. It is also notable that changing the meal time shifts the diurnal rhythm of leptin (16, 17).

Some animal studies have claimed that food intake and fasting can affect the serum levels of ghrelin and leptin (18). On the other hand, in humans, the plasma level of ghrelin rises before a meal and reduces after ingestion (19). The circadian rhythm of these hormones is influenced by Ramadan fasting. Short-term fasting may result in the reduction of serum leptin levels by 30-66% (20). Moreover, a study on plasma ghrelin changes and elongated fasting in rats and mice demonstrated an increase in the plasma ghrelin levels (21). In another study, leptin and ghrelin plasma levels before and during Ramadan were determined. Nocturnal decrease of leptin was observed, and the circadian rhythm of leptin and ghrelin plasma levels remained unchanged (22); leptin level changes have been attributed to mealtime changes.

Mechanisms other than meals might control the secretion of ghrelin. Natalucci et al. (2005) have suggested that ghrelin secretion may be regulated more by neuronal signals than the gastrointestinal signals (23). Although fasting did not alter ghrelin levels as investigated in the study by Alzoghaibi et al. (2014) (22), intake of non-caloric fiber led to the reduction of ghrelin levels in a research conducted by Nedvidkova et al. (2003) (24).

As discussed earlier, dietary fiber can stimulate hormonal responses and exert intrinsic effects, thereby resulting in the regulation of body weight. High-fiber foods might improve satiety through bulking and low energy density, while also causing the secretion of appetite-regulating hormones for a longer duration from the gastrointestinal tract. Furthermore, they delay gastric emptying by increasing the viscosity of the intestinal content, which leads to lower postprandial glycemia (6).

Insulin, ghrelin and leptin in gastric and adipose tissue affect satiation. As insulin is associated with leptin and ghrelin levels, it might be involved in the short-term and midterm appetite as well (25). Possible mechanisms in this regard include potentiation by leptin of cholecystokinin-mediated satiation, inhibition of insulin secretion, modulation of peripheral tissue, and brain sensitivity to insulin action (26).

Appetite during Ramadan Fasting

During the holy month of Ramadan, frequency of meal and sleep habits changes, without any variations in their biochemical characteristics (27, 28). Results of a study performed by McNeil et al. (2014) showed that appetite ratings and metabolic factors (cholesterol, triglyceride, LDL, and glucose) did not change over time during Ramadan fasting (29). Nevertheless, Finch et al. (1998) (30) reported that as the holy month of Ramadan proceeds, the sense of hunger declines during the day.

Gastric index is an important factor that influences the appetite and nutritional intake (31, 32). Carbohydrates with higher GI content further stimulate food intake (33, 34). GI is affected by type and amount of dietary macronutrients especially carbohydrates and fibers (32).

In a collaboration with the Diabetes and Ramadan (DAR) International Alliance, the International Diabetes Federation (IDF) has accentuated the following consultation with dieticians for proper dietary planning and use of a balanced diet by fasting individuals, which contains 45-50% carbohydrates, 20-30% protein and less than 35% fat (preferably mono- and polyunsaturated fats). Moreover, consumption of fiber-rich and low-GI foods (e.g., rice, granary breads and beans instead of sugary dishes) are recommended. This diet has been shown to result in a slower release of energy while fasting (35-37).

A randomized crossover study by Png et al. (2014) compared low-GI carbohydrate foods and normal mixed meal (CON) for the Sahur meal in 12 male runners (38). Both groups showed increased blood glucose level at 45 minutes after the meal, and the peak was reported to be significantly higher in the CON meal group ($P<0.01$). On the other hand, by the time, the blood glucose level showed a slower reduction in the low-GI meal group. At 360 minutes postprandial, the blood glucose level in the low-GI group was significantly higher compared to the CON group ($P<0.05$). However, the sensation of hunger, fullness, satiety and satisfaction were not significantly different between the two study groups ($P>0.05$).

The Effect of Different Types of Bread on Appetite and Satiety

According to Breen et al. (2013), commonly consumed breads are whole wheat buttermilk bread (whole wheat flour and buttermilk), wheaten white (wheaten yeast bread) and wholemeal bread, whole grain bread (wholemeal flour and cracked wheat) and granary/multigrain bread (1).

Appetite and food intake decrease following the use of dietary fibers at high concentrations (39). Weight loss following the regular consumption of high fiber contents might occur through decreased gastric emptying rates, PYY and ghrelin modulation and colonic fermentation mechanisms (40).

Fermentable dietary fibers (e.g., arabinoxylans, β-glucan, fructans, and resistant starch) (41, 42) can influence the appetite by becoming fermented in the colon by saccharolytic bacteria (43). Wholegrain rye is a considerable source of fermentable dietary fibers, which is found in whole and cracked kernels (44). In a study by Ibrugger et al. (2014), rye kernel bread and boiled rye kernel, consumed as late mixed evening meals, were observed to increase breath hydrogen excretion, which is an indicator of fermentation and decreased ad libitum energy intake at lunch on the following day. However, differences in the subjective appetite sensation between breakfast and lunch did not reach significance in the mentioned research (45).

In a study by Isaksson et al. (2011), breakfasts containing boiled rye kernel and rye kernel bread were found to reduce hunger and increase satiety for the following lunch, respectively (42). In another research, feelings of hunger and desire to eat reduced in the afternoon following the consumption of different rye bread breakfasts, which contained rye bran (an intermediate rye fraction) or sifted rye flour (46). Consumption of both rye breads increased satiety compared to the reference white wheat bread (WWB), while no difference was observed in any of the appetite measures between the two types of rye bread (45).

Effect of the cereal grain structure on satiety has been investigated by many researchers. As concluded by Hlebowicz et al. (2008), whole kernel breads improve satiety more than whole grain breads within 90 minutes after consumption (47). Najjar et al. (2009) evaluated four different types of bread, including white wheat bread, whole wheat bread, sourdough bread and whole wheat barley bread. In the mentioned study, glucose, GLP-1 responses and GI after the ingestion of sourdough bread were reported to be significantly lower compared to white bread, whole wheat bread and even whole wheat barley bread (48).

According to the literature, foods that contain barley have lower GI compared to white wheat bread and may exert more significant satiety effects (49, 50). In this regard, Johansson et al. (2013) suggested that an evening meal containing barley kernel can facilitate the regulation of glucose, amplify GLP-1 release, decrease the subsequent energy intake and reduce hunger over two consecutive meals, as well as fasting plasma free fatty acids in the next morning. These outcomes were associated with the fermentation of indigestible carbohydrates by the gut microbiota (50). In their research, Nilsson et al. (2015) compared barley kernel bread with WWB on three consecutive days. The barley bread intake group showed increased levels of PYY, GLP-1, and GLP-2, while the ghrelin levels, colonic fermentation and insulin response were not influenced significantly (51).

In a research conducted by Berti et al. (2005) (52), three different experiments were conducted to investigate the effect of varied crop formulations and their complements on specific and general satiety. Effect of consuming white bread (regular bread) and oat bread (40% toasted oats) immediately before and two hours before a meal as a snack was studied as well. The findings showed no significant differences between the two bread types in terms of the energy intake and weight intake of water and breads regarding specific satiety.

Health advantages of oat bran or oat fiber intake have attracted the attention of consumers. Some of the important benefits in this regard are prolonged postprandial satiety, reduction of blood cholesterol level, and glycemic response. According to the results of the present study, oat bread exerts more satiating effects compared to white bread (53). Therefore, higher oat bread intake can result in a lower energy intake.

Comparison of the SI of white bread with grain bread and whole meal bread showed that white bread was least satisfying. From this point of view, the intake of oat bread with lower GI (54) and higher fiber content may be advisable in order to modulate energy intake (52). Moreover, addition of alternative crops can affect the satiating efficiency of the product. However, consumption of cereal-based foods (e.g., bread) as a snack did not reduced energy intake at the subsequent meal (52).

In some eastern countries, chickpea (*Cicer arietinum L.*) is a part of the daily diet, which contains a high proportion of carbohydrates and proteins (55). Compared to white bread, chickpea bread causes a lower GI (54), and compared to WWB, chickpea bread shows no differences in terms of the GI, satiety response, food intake and some hypoglycemic effects due to higher insulin levels (3). Combination of chickpea with wheat or other types of bread might minimize hypoglycemia.

Figure 1 shows suggested mechanisms of the effects of bread fiber on satiety.

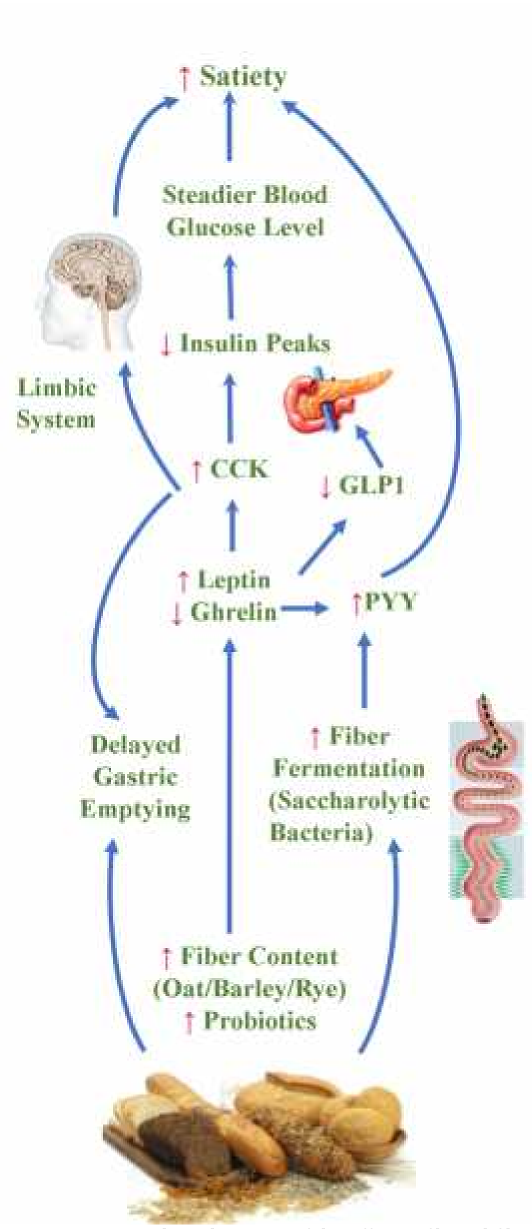

Figure 1. Suggested mechanisms of the effects of bread fiber on satiety

Different Types of Enrichment

Nowadays, there is growing interest in the role of certain extracts as the potential functional additives of plant foods in satiety and lower levels of subsequent glycemia. In order to regulate energy intake and glycemic control, addition of certain ingredients to bread as part of the daily meal is advisable.

Gonzalez-Anton et al. (2015) have reported that the enrichment of cereal-based bread with certain dried fruits, proteins and fibers can improve the glycemic response, increase satiety, reduce the sensation of hunger, and enhance appetite control in healthy adults (56). In this regard, Lee et al. (2006) noted that consumption of the bread enriched with lupin kernel flour, which is high in fiber and protein content, influences the sensation of satiety and energy intake levels in human (5).

In another study, Vitaglione et al. (2009) evaluated short-term appetite and satiety-related hormone including insulin, ghrelin and PYY and also blood glucose were measured after the consumption of a meal enriched by barley beta-glucans. According to the findings, sensation of satiety and fullness increased, and starvation reduced significantly. In addition, ghrelin level decreased by 23%, and PYY level increased by 16% independent of the insulin level. Also, glycemic changes were blunted after bread ingestion. Therefore, it was concluded that in a short period of time, appetite could be alleviated by the consumption of barley beta-glucans mediated by ghrelin and PYY (57).

Several studies have been performed to evaluate the effects of enriched meals with prebiotics (FOS/Inulin) on weight management and satiety. Depending on the type of probiotics, dose and duration of consumption, contradictory effects have been observed. Effects of FOS or Inulin supplementation on weight management and satiety have indicated that these prebiotics may play a greater role than merely the substitution of energy-dense foods and their traditional prebiotic effects. Furthermore, they may help a certain category of people to actively manage their weight; however the exact target population and the optimum dosages remain unknown (58).

There are different factors other than food fiber content that affect satiety, such as particle size, energy density, volume, palatability, and botanical structure (59). Early satiety might be due to the weight and volume of foods, which cause the extension of the antrum, whereas high fiber content may lead to late satiety (6). In a study conducted by Hlebowicz et al. (2008), effects of different weight breads on satiety were investigated, and increased satiety was reported after the ingestion of wheat bread made from intact kernels followed by wholemeal and RWB (47). To investigate the effect of particle size in satiety, four different wheat breads with varying particle sizes including whole grains, cracked grains, coarse and fine wholemeal flour were studied. The fine flour meal followed by the coarse flour and cracked grain meals and at last the whole grain meal had the higher AUC for plasma glucose and insulin response. The results were reverse for satiety. The WWB had the highest palatability and satiety (60).

In another study, the satiety effects of WWB and RWB were compared, and WWB showed higher satiety compared to RWB. It also resulted in decreased hunger and prospective food intake. Therefore, it could be suggested that due to the type of dietary fiber content in wheat and increased bulk (not the viscosity), fiber content had no effect on glycemia compared to the two types of bread (6). Similar findings indicated no difference between the glycemic response of wholemeal and white wheat breads (61).

In Holt et al. study, seven types of bread were evaluated in terms of their SI (range: 100-561%), including coarse white bread, wholemeal fruit bread, low-fat high-moisture bread, protein and fiber-rich bread, high-fiber bread, high-protein bread and low-fat high-fiber bread with the same energy content. According to the findings, regular white bread had the minimum SI score, and mean SI scores were negatively correlated with energy intake (62). In addition, GI and the satiating properties of a meal were observed to be inversely correlated (63).

Occasionally, foodstuffs are added to bread in order to improve its quality, one of which is *Ascophyllum nodosum* (a type of seaweed) that when used at the concentrations of up to 4% per 400 gram of wholemeal bread, causes a 16.4% decrease in the energy intake after four hours of a test meal (64). Coe and Ryan (2016) prepared four types of white bread by the addition of polyphenol-rich extracts (baobab fruit extract, green tea extract, grape seed extract, and resveratrol) in a crossover trial. The enriched types of white bread had no effects on glycemic response or satiety, yet the baobab fruit was shown to increase insulin control (65).

A summary of the studies about possible effects and mechanisms of different types of bread and enrichments on satiety and appetite are brought in Table 1.

Table 1. Summary of the studies about possible effects and mechanisms of different types of bread and enrichments on satiety and appetite

Study Authors	Bread Type	Bread Enrichment	Participants	Outcomes	Suggested mechanism
Breen et al. 2013	White wheat Whole wheat buttermilk Whole grain Pumpernickel rye	-	n=100 Adults with T2DM (66 males and 44 females; mean age, 65.5 ± 12.4 years; mean body mass index, 31.4 ± 5.4 kg/m^2)	No difference in appetite ratings among the 4 breads.	A high glycemic and insulinemic response was promoted by type of wheaten whole grain bread.
Isaksson et al. 2009	Rye bran bread (20% of total bread) Intermediated rye fraction bread Sifted rye flour bread (80% of total grain) WWB	-	n=35 (29 females and 6 males)	Decreased hunger feelings both before and after lunch when included in a breakfast meal compared to WWB.	Not mentioned
Johnson et al. 2005	White bread	Chickpea flour or extruded chickpea flour	n=11 (9 males and2 females; age: 32+/-2 y; BMI: 24.7+/-0.8 kg/m^2)	No effects on satiety or food intake or product palatability.	Not mentioned
Keogh et al. 2011	White bread BürgenWholemeal Seeds bread Lupin bread	-	n=20 (Males and femalesaged 20.1-44.8 y, BMI: 18.4-24.8 kg/m^2)	Higher fullness responses and lower postprandial glucose responses for the Lupin bread (P<0.01), and the Bürgenbread (P<0.05) compared with the white bread.	Not mentioned
Lee et al. 2006	White bread Lupin kernel flour enriched	Lupin kernel flour	n=16 Nonsmoking healthy males and females	Higher self-reported post meal satiety and lower energy intake (P< 0.001) in enriched bread.	Gut fermentation and plant protein
Kristensen et al. 2010	Refined wheat bread (RWB) Wholegrain wheat bread	-	n=16 (10 females and 6 males)	Wholemeal breads increased satiety measures compared to their refined counterparts; No significant modification on subsequent EI was observed.	Factors such as fiber content, energy density, volume, botanical structure and particle size as well as palatability
Issakson et al. 2011	Whole rye kernel bread Milled rye kernel bread Sifted wheat bread	-	n=24 (Aged 20-60 y; BMI: 18-27 kg/m^2)	All rye breakfasts resulted in higher satiety ratings in the morning and afternoon compared with the iso-caloric reference breakfast with sifted wheat bread.	Stimulated release of satiety hormones (GLP-1, PYY) by L-cells in the colon and an increased fermentation correlated with increased satiety.
Ibrugger et al. 2014	Wholegrain rye bread	-	n=12 Healthy 18–65-year-old males with normal BMI (18–25 kg/ m^2)	Consumption of wholegrain rye products reduced subsequentad libitum energy intake.	Colonic fermentation and enhancement of the production of satiety-inducing hormones such as GLP-1 and PYY.

Continuous of Table 1.

Hlebowicz et al. 2008	- Whole-kernel wheat bread - Wholemeal wheat bread - White wheat bread	White wine vinegar	n= 13 (6 males and 7 femalesaged 25±4 y [range 22–35 y]; BMI 22.8±3.07 kg/m^2 [range 17.7–29.7kg/m^2)	The post-prandial ratings of satiety were higher after whole-kernel wheat bread meal served with vinegar.	Increased antral distension after ingestion of intact cereal kernel.
Najjar et al. 2009	- Whole wheat bread - White wheat bread - Sourdough - Whole wheat barley	-	n=11 Overweight or obese males	Ingestion of white bread did not result in postprandialglycemicor insulinemicresponses that were greater than those of ultra-fine grind whole wheat breads. The consumption of sourdough bread resulted in lower overallglucose and GLP-1 responses compared to those of thesewhole wheat and whole wheat barley breads.	Due to an increased level of organic acids (based on reduction of the pH in the dough).
Granfeldt et al. 1994	- Boiled intact kernels from all genotypes or - Boiled flour from milled normal and - High amylase (covered) barley kernels - WWB	-	n=10 Healthy subjects (5 males,5 femalesaged 34±8 years)	All barley products elicited lower metabolic responses and higher satiety scores when compared with white wheat bread.	Due to the viscous properties of the β-glucans.
Johansson et al. 2013	- Boiled barley kernels (BK) - White wheat bread (WWB)	-	n= 19 (6 males and 13 females aged 24.2±1.9 y, with normal BMI: 22.3 ± 2.0 kg/m^2)	BK evening meal, facilitate glucose regulation, increase the release of GLP-1, reduce subsequent energy intake while at the same time decreasing hunger over 2 subsequent meals, and reduce fasting FFA the subsequent morning.	Mediated through gut microbial fermentation of the indigestible carbohydrates
Nilsson et al. 2015	- Barley kernel based bread (BB) - White wheat bread (WWB)	-	n=20 3 males, 17 females aged 64.1±5.9y, normal BMI: 23.6±2·3 kg/m^2	Metabolic benefits of ingestion of barley kernel-based bread for 3 days	Gut fermentation of BB.Increased concentrations of GLP-1, PYY and GLP-2,facilitated glucose regulation and improved insulin sensitivity. Positive relationships were observed between total SCFA and gut hormones PYY and GLP-2, indicatinga causal relationship between SCFA production andguthormone secretion.

Continuous of Table 1.

Berti et al. 2005	- Oat bread (40% toasted oats) - White wheat bread (WWB)	-	n=15 Healthy male volunteersaged 22.8±2.2 y; BMI: 23.1±3.2 kg/m^2	Both the different time of preload consumption and the bread formulation did not affect weight and energy intake. the large white bread preload induced a significant decrease of desire to eat and a significant increase of satiety and fullness sensations, compared with the small one.	Sensory and physical factors and food preparation methods can changethe feeling offullness responses.
Gonzalez-Anton et al. 2015	- Cereal based bread - WWB	Cereal bread enriched with fiber (10.1%) and wheat protein (10%)	n=30 Healthy adults (17 males and 13 femalesaged: 19 - 32 y (mean age25.61), BMI: 19.2- 28.5kg/m^2)	Appetite control by enriched bread by reducing hunger and enhancing satiety	Improved glycemic, insulinemic, and gastrointestinal hormone responses such as orexigenic ghrelin and anorexigenicGLP1, PYY, and cholecystokinin.
Vitaglione et al. 2009	- Wheat bread	β-glucan-enrichment	n=14 (7 males and 7 females aged: 23.9±3 y, range 20–29y BMI 22.9±2.8 kg/m^2)	Bread formulatedwith barley β-glucans is able to modulate appetite ratings bydecreasing hunger and increasing fullness and satiety and toreduce by 19% energy intake on the subsequent meal.	Satiety effect of b-glucans ismediated by ghrelin and PYY.
Behall et al. 1999	- Whole-grain wheat bread (WW) - Ultrafine ground wholegrain wheat bread (UFWW) - WWB	-	n=26 Males and females	The particle size of whole grain wheat flour did not substantially affect glycemic responses.	Similar glucose and insulin responses, as well as areas under the curve.
Holt et al. 2001	- Coarse white bread - Wholemeal fruit bread - Low-fat high moisture bread - Protein and fiber-rich bread - High fiber bread - High protein bread - Low-fat high fiber bread	-	n=10	The breads' glycemic responses were not significantly associated with fullness responses.	The strongest predictor of the breads' SI scores was their portion size and thus energy density.
Hall et al. 2012	- Wholemeal bread	Seaweed (Ascophyllum nodosum)	n=12 (over weight males age 40.1±12.5 years BMI≥25 kg/m^2)	Significant reduction (16.4%) in energy intake at a test meal 4 hour after breakfast	The seaweed acted as a bulking agent, increasing gastric stretch to a greater extent than standard wholemeal bread. Altered gut peptide response mediated enhanced satiety or brought about premature satiations at the subsequent test meal.

Continuous of Table 1.

Coe et al. 2016	White bread	Polyphenol extracts: White bread with green tea extract (0.4%), white bread with baobab fruit extract (1.88%)	n=13 (9 females and 4 males)	Enriched breads did not reduce glycemic response or hunger. But baobab fruit extract added into white bread improved insulin economy.	Not mentioned

Main Results

There were only a few articles discussing the effects of different types of bread and their enrichment on satiety and appetite during Ramadan fasting. Since metabolism changes during fasting, especially in the holy month of Ramadan, specific studies should be designed in order to clarify the role of bread in satiety and appetite control while fasting. However, review of the studies investigating the effects of different types of bread and their enrichments indicated that white wheat bread has is associated with minimum satiety effects compared to barley, rye or oat breads. In this regard, whole kernel breads have a stronger effect compared to WWB or whole grain breads on satiety, as well as the steady glucose and insulin levels. Additionally, as the fiber proportion increases, satiety is prolonged; therefore, enrichment with fermentable dietary fibers (e.g., β-glucan, fructans, fructo-oligosaccharides/Inulin, resistant starch or other prebiotics) can improve the satiety effect of breads and ad libitum energy intake.

Sourdough breads could be recommended owing to their lower glucose, GLP-1 responses and GI after ingestion. Moreover, breads with higher protein content can yield better results as well. Adding foodstuff, such as dried fruits, might also influence satiety, but further investigations should be performed in this regard.

Conclusion

As bread is the most common part of meals during Ramadan, consumption of barley bread, oat bread and wheat bread with higher fiber content is recommended as the preferred bread in the main meals, especially for the Sahur meal, in order to improve satiety and delay hunger.

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