Effect of β-glucan from oats and barley on weight loss and adiposity

Obesity is a growing public health concern, but studies suggest that soluble fibre from certain cereal whole grains can help weight management. Specifically, the cell wall carbohydrate β-glucan found in oats and barley may impact body weight, body mass index (BMI), and adipose tissue. Rebecca Mathews and her collaborators in the US conducted a thorough review of key studies demonstrating the efficacy and mechanisms behind oat and barley β-glucan on weight loss. β-glucan has been shown to enhance the feeling of satiety, slow gastric emptying, increase appetite-suppressing gut hormones, and promote the growth of specific gut bacteria that metabolise β-glucan to short-chain fatty acids that may further impact energy and appetite regulation. These findings confirm the importance of whole grains in combating obesity.

Obesity is an ongoing public health concern. The combination of abundant high-calorie foods with a lack of physical activity has gradually expanded our waistlines. The increased prevalence also leads to a rise in obesity-related illnesses such as type 2 diabetes and cardiovascular disease, and certain cancers are also on the rise. Engaging in more physical activity and replacing high-calorie, low-nutrient foods with healthy whole foods is the simplest weight-loss strategy. Recent evidence has suggested whole grains and dietary fibre impact weight, with many observational studies suggesting a link between cereal fibre, whole grain, and lower Body Mass Index (BMI). This link was clearly evident in meta-analyses of randomised controlled studies in which subjects did not change their usual diet: here, isolated soluble fibre and/or viscous fibre in whole foods was shown to reduce body weight and BMI (Thompson et al, 2017; Jovanovski et al, 2020). Soluble or viscous fibre was also shown to induce an even more significant reduction in body weight when combined with a calorie-restricted diet (Jovanovski et al, 2021). The effect of individual fibres was not assessed in these meta-analyses, but soluble fibre as a whole, which included psyllium, guar gum, konjac, and β-glucan, demonstrated a beneficial effect.

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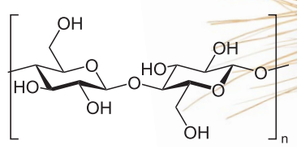
β-glucan, an indigestible carbohydrate found in the cell walls of oats and barley, is concentrated in the bran layer. Rebecca Mathews and her collaborators wanted to determine if there was reliable, consistent evidence supporting a relationship between β-glucan, weight loss, and body fat and whether there were plausible physiological mechanisms that would explain the effect. Oats and barley are the richest sources of β-glucan (Wood, 2011), and both are wholegrain foods that can readily be incorporated into the diet. Other cereal grains such as wheat, rice, and corn do not contain β-glucan.



In 2009, the European Food Safety Authority (EFSA) offered their scientific opinion on the ability of β-glucan to maintain or achieve normal body weight based on a health claim petition submitted to them. The agency concluded that a cause-and-effect relationship could not be established based on the evidence provided. Although a few studies reported on the effect of β-glucan on satiety, none of the studies specifically addressed the impact of β-glucan on body weight. Another review summarising clinical studies on β-glucan showed a correlation between reduced body weight and BMI, but found no impact on the circumference of the study subjects' waistlines (Rahmani et al, 2019). Furthermore, this review did not consider every study that evaluated the effect of β-glucan on body weight, nor did they assess the quality of the studies. Due to these uncertainties, Mathews and colleagues aimed to conduct a more comprehensive overview of β-glucan, body weight, and adipose (fat) tissue. The aim was to examine the totality and quality of the evidence in a process similar to what regulatory agencies such as the US FDA and EFSA use to verify health claims.

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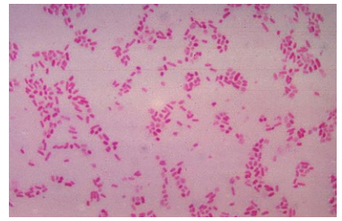
THE PROCESS

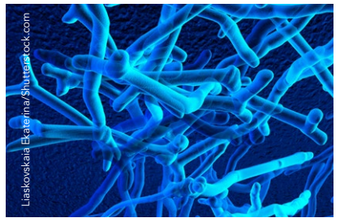
Multiple searches were conducted using large scientific databases of peer-reviewed papers published in English across the globe to identify all human observational and clinical studies that evaluated the effect of β-glucan on body weight or body-fat parameters. A total of four observational studies and 72 intervention studies were identified. Even though body-weight changes were measured in these studies, the majority were not specifically designed to examine the role of β-glucan on body weight. Most were designed to study the effects of β-glucan on lowering blood cholesterol or blood glucose levels, and participants were told to maintain their body weight for the duration of the study. Since inclusion of these types of studies would significantly bias the evidence, they were excluded from the review. All remaining studies were evaluated for quality. Several factors were considered when assessing the quality of a study, such as if they were randomised, double blind, controlled for bias, used a calorie-matched placebo food in place of the β-glucan containing food, had an appropriate sample size with a low dropout rate and good compliance to the study protocol. Studies that did not meet these criteria were considered low quality and excluded from the analysis.

THE RESULTS

Data collected between 2001 and 2010 from about 14,700 children (O'Neal et al, 2015) and 22,800 adults (Fulgoni et al, 2015) by the National Health and Nutrition Examination Survey (NHANES) in the US showed that those who consume cooked oatmeal had a lower risk of being overweight after adjusting for potential confounders such as gender, age, race, ethnicity, physical activity, poverty income ratio, and smoking status. Another observational study of 713 school children aged 8–11 years conducted in Denmark reported that the higher the intake of whole grain oats, the lower the fat mass measured after adjustment of confounders (Damsgaard et al, 2017). A fourth NHANES data evaluation of children and adults between 2009 and 2012 also revealed that underweight, normal weight and overweight individuals ate more cooked oatmeal than obese individuals (Musa-Veloso et al, 2016). However, this last study was not given much weight because the analysis did not consider potential confounders that could have biased the outcome. Observational studies tell us whether there is a potential relationship between a food ingredient and a specific health effect. While the three observational studies suggest an association between oat (ie, β-glucan) intake and body weight and body fat, cause and effect cannot be established.



Bacteroides.



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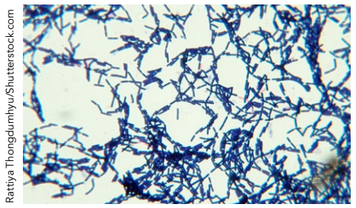
Bifidobacteria.



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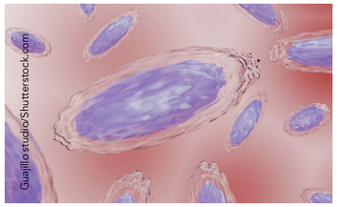
Firmicutes.



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Akkermansia.

Well-designed randomised controlled clinical studies that investigate changes in body weight and body fat after subjects consume foods containing β-glucan compared to a placebo allow the determination of a true causal effect.

Oats and barley as sources of β-glucan can be consumed in a variety of foods.

After low-quality studies were eliminated, conclusions were drawn from six high- or moderate-quality studies that were conducted in adult overweight subjects living in Japan, Taiwan, Brazil, Venezuela, and the United States (Aoe et al, 2017; Chang et al, 2013; Raimondi de Souza et al, 2016; Reyna-Villasmil et al, 2008; Smith et al, 2008; Shinzu et al, 2008). About 75–80% of the studies that measured body weight, BMI, or body fat-related measures observed a significant reduction when subjects were consuming their usual diet (undefined) or healthy diets. However, only 33% of the studies that measured waist circumference reported a decrease. The β-glucan dose that was consumed ranged from 3–7g a day for 6–12 weeks. Oats and barley as sources of β-glucan can be consumed in a variety of foods. About 1.5 cups of cooked oatmeal provides 3g of β-glucan and 1 cup of pearled barley provides 2.5g of β-glucan.

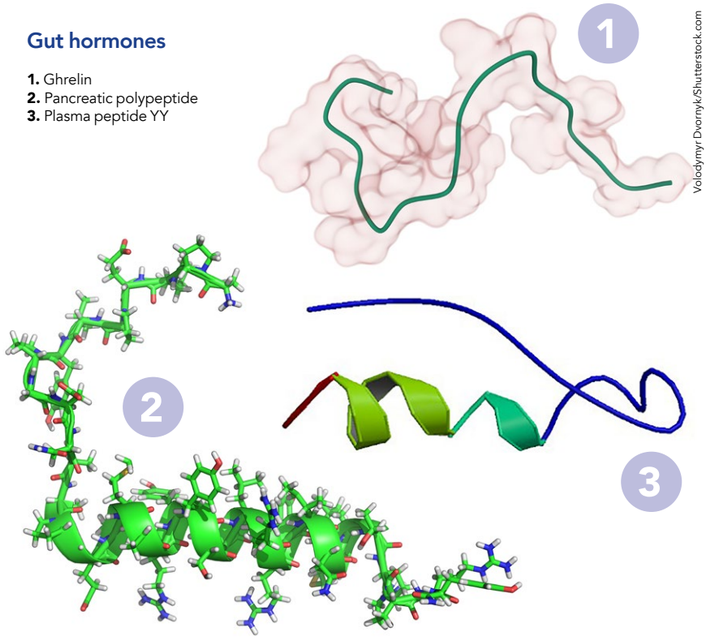
MODE OF ACTION

Satiety

Several potential mechanisms underlying the effect of β-glucan on weight loss have been proposed. One possibility is its effect on satiety, or the feeling of fullness, which inhibits further eating. When subjects were asked to rate their feelings of satiety after consuming β-glucan foods, some studies did not see an effect, but several did (Rebello et al, 2016).

Gastric emptying

Another mode of action could be delayed gastric emptying caused by β-glucan's ability to absorb water and form a viscous mass. Geliebter et al (2015) found that cornflakes passed through the digestive tract faster than an energy-equivalent amount of oatmeal. This was attributed to the fibre content, as the cornflakes had no dietary fibre. The molecular weight of β-glucan was found to be a significant factor in delaying gastric emptying, with higher-



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Gut hormones

1. Ghrelin
2. Pancreatic polypeptide
3. Plasma peptide YY

molecular-weight β-glucan passing through the gastrointestinal tract at a much slower rate than lower-molecular-weight β-glucan. Processing can affect the molecular weight of β-glucan. In one study, test subjects were given a high-viscosity oat bran beverage and a low-viscosity oat bran beverage (Juvonen et al, 2009). The researchers were surprised to find that participants drinking the low-viscosity oat bran beverage reported feeling significantly more satiated three hours later. However, when they measured the energy intake of participants for the rest of the day, the total energy intake of those who consumed the high-viscosity drink was significantly lower than those who consumed the low-viscosity drink.

Overall, the totality of the observational and clinical evidence suggests that oat and barley β-glucan aids in preventing weight gain.

Gut hormones

Viscous fibers have been shown to delay the intestinal absorption of nutrients, which stimulates the production of appetite-regulating gut hormones (Rebello et al, 2016). When 3g of extracted barley β-glucan was consumed in a drink at breakfast, the appetite-stimulating hormone ghrelin was decreased and pancreatic polypeptide, a hormone that reduces appetite, was significantly increased (Barone Lumaga et al, 2012). Additionally, it was observed that eating increasing amounts of β-glucan was associated with rising concentrations of plasma peptide YY, a hormone known to reduce intestinal motility and food intake (Beck et al, 2009a).

Gut microbiota

The influence of β-glucan on gut microbiota is a developing area of study and another potential mechanism through which β-glucan may impact body weight and body fat. Previous research has shown that transplanting the gut microbiome from obese mice into lean mice caused the lean mice to develop a higher fat mass. This suggests that gut microbiota play an important role in energy regulation. Although there are studies that show β-glucan consumption enhances the growth of specific gut bacteria, very few have examined the possible association with body weight or body fat. In one study, β-glucan increased Bacteroidetes and decreased Firmicutes, and this shift was correlated with a lowered BMI and waist circumference (Wang et al, 2016). On the other hand, changes in *Bifidobacteria* and *Akkermansia* were not significantly impacted, whereas another study reported an increase in *Bifidobacteria* after the consumption of oat β-glucan (Connolly et al, 2016). The risk of obesity has been linked to a decrease in *Bifidobacteria* and *Akkermansia*. Several factors, such as the subjects' original microbiome, usual diet, and the dosage of experimental preparations, would impact which gut bacterial species are enhanced by β-glucan.

Short-chain fatty acids

In addition to its potential impact on microflora communities, β-glucan has been shown to have a profound effect on short-chain fatty acids. These are produced when gut bacteria digest dietary fibre, such as β-glucan, and serve as an energy source for colon cells. Short-chain fatty acids have been shown to have direct effects on fat cells and thereby regulate metabolism by participating in the body's appetite and energy-management signals, such as hormone expression. A study with mice demonstrated decreased gene expression involved in fat metabolism in liver and fat tissue and a correlation with increased short-chain fatty acids following the intake of β-glucan (Mio et al, 2020). More research is needed to confirm the potential anti-obesity effect that may be induced through changes in gut microbiota and short-chain fatty acid production following the consumption of β-glucan.

CONCLUSIONS

Overall, the totality of the observational and clinical evidence suggests that oat and barley β-glucan aids in preventing weight gain and adiposity, and there are multiple plausible mechanisms that underlie this effect. Additional studies are required to further the understanding of this phenomenon.

Behind the Research

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Research Objectives

Mathews examines the relationship between oat and barley β-glucan and obesity.

Detail

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Bio
Rebecca Mathews has been working as an independent consultant to food companies for the last 30 years and is the principal of R Mathews and Associates. She has an academic background in life sciences, nutrition, and epidemiology from the University of Toronto. Before starting her company, she worked as a nutrition scientist at Quaker Oats Co.
The main focus of her company is to review the scientific literature to evaluate the totality and quality of the evidence for food ingredients in assessing health effects for potential health claims, research publications, or for identifying gaps in the research. She has authored several health claim petitions for food companies that have been approved by regulatory agencies in the US, Malaysia, and Australia. She was also a co-author of the first health claim petition approved by the US FDA (oat beta-glucan and the reduced risk of coronary heart disease).

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Collaborators
Varsha Shete and YiFang Chu, Health & Nutrition Sciences, Global R&D, PepsiCo, Inc.

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References

Mathews, R, Shete, V, Chu, Y, (2021) The effect of cereal β-glucan on body weight and adiposity: A review of efficacy and mechanism of action. *Critical Reviews in Food Science and Nutrition*, 1–13. doi.org/10.1080/10408398.2021.1994523

Personal Response

If β-glucan significantly or reliably causes weight loss, would we not expect to see study participants lose weight even in the studies that instructed them to maintain weight, assuming they made no change to their diet?

No, because in these studies the subjects are carefully monitored by nutritionists on a weekly or biweekly basis who measure their body weight and advise them to adjust their caloric intake so that body weight does not significantly change. If the objective of the study was to investigate whether β-glucan lowers blood cholesterol or blood glucose, it is important that body weight stays constant, otherwise you would not know if the decrease observed was due to β-glucan or a decrease in body weight. The design and quality of a study in minimising bias are paramount in determining if the conclusions of the study are valid.

What inspired you to conduct this review?

Most of the reviews I conduct are due to requests from food manufacturers who want an independent evaluation of whether a food ingredient demonstrates a specific health effect for a potential health claim and/or for marketing purposes. PepsiCo Inc. asked me to do this particular review. Several of the reviews are not published but are used for regulatory purposes. In this instance, we chose to publish this work because of its possible public health impact as well as to encourage researchers to continue delineating some of the mechanisms by which β-glucan impacts body weight and adiposity. The link with gut microbiota that are enhanced with β-glucan intake is especially intriguing and warrants additional research.