GLUCOMANNAN AND OBESITY: A CRITICAL REVIEW

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Glucomannan (GM) is a soluble, fermentable, and highly viscous dietary fiber derived from the root of the elephant yam or konjac plant, which is native to Asia. Preliminary evidence suggests that GM may promote weight loss. This review summarizes studies using GM for weight loss as well as studies investigating its mechanisms of action. At doses of 2-4 g per day, GM was well-tolerated and resulted in significant weight loss in overweight and obese individuals. There is some evidence that GM exerts its beneficial effects by promoting satiety and fecal energy loss. Additionally, GM has been shown to improve lipid and lipoprotein parameters and glycemic status. Further investigation of safety, efficacy, and mechanisms of action is needed to determine whether GM can help to decrease the high prevalence of overweight and obesity in the United States. (*Altern Ther Health Med.* 2005;11(6):30-34.)

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The prevalence of overweight and obesity has reached alarming levels in the United States. Approximately 65% of US adults are overweight or obese, which translates to nearly 130 million individuals and accounts for as many as 300,000 deaths annually.[1,2] Although many conventional and alternative weight loss options are available, their long-term effectiveness is limited or unknown, and detrimental effects—as in the cases of fenfluramine-phentermine (fen-phen) and ephedra—are not uncommon.[3-5] As a result, increasing numbers of consumers are seeking effective weight-loss strategies that are natural and nontoxic. Preliminary evidence suggests that glucomannan (GM), a dietary fiber, may help to promote weight loss. This review examines the mechanisms of action, safety, and efficacy of glucomannan for reducing weight.

CHARACTERISTICS AND USES

The term *dietary fiber* refers to plant and nonplant (eg, animal, fungal) dietary substances that cannot be digested by human gastrointestinal enzymes. Dietary fibers are classified as either soluble or insoluble depending on their solubility in water. They are classified as fermentable or nonfermentable depending on whether they are fermented by anaerobic bacteria in the colon.[6] Glucomannan is a water-soluble, fermentable dietary fiber extracted from the tuber or root of the elephant yam, also known as konjac (*Amorphophallus konjac* or *Amorphophallus rivieri*). It also can be extracted from certain yeasts. Yeast-derived GM is not marketed as a dietary supplement, however.[7]

Indigenous to Asia, the konjac tuber has been used for centuries as an herbal remedy and to make traditional foods, such as konjac jelly, tofu, and noodles. More recently, purified konjac flour or GM has been used as a food stabilizer, gelling agent, and supplement. It was approved for use as a binder in meat products by the US Department of Agriculture in 1997.[8] Konjac tubers are considered food by the US Food and Drug Administration; however, GM does not have Generally Recognized as Safe status.[9] In addition to weight reduction, GM has been studied for its effects on constipation, serum cholesterol, blood glucose, blood pressure, and insulin-resistance syndrome.

PHARMACOLOGY

Structure

Glucomannan consists of a polysaccharide chain of beta-D-glucose and beta-D-mannose with attached acetyl groups in a molar ratio of 1:1.6 with beta-1,4 linkages.[10,11] Because human salivary and pancreatic amylase cannot split beta-1,4 linkages, GM passes relatively unchanged into the colon, where it is highly fermented by resident bacteria. The molecular weight of GM

ranges from 200,000 to 2,000,000 daltons (average: 1,000,000), varying with processing method and storage time. It can absorb up to 50 times its weight in water, making it one of the most viscous dietary fibers known.[12]

Proposed Mechanisms of Action for Weight Loss

Dilution of Energy Density

Fiber has low energy content. Adding it to the diet, therefore, lowers the energy-to-weight ratio of the food that is consumed.[13] Because studies suggest that eating patterns are consistent with respect to weight of food consumed rather than calories consumed,[14,15] fiber can displace the energy of other nutrients for a given weight of food, yet still induce satiety.[16]

Promotion of Satiety

GM may promote satiety via several mechanisms. The increased mastication effort associated with eating fiber is postulated to induce cephalic- and gastric-phase signals that induce satiety.[13] Other proposed mechanisms include delayed gastric emptying and slowed small-bowel transit time because of the increased viscosity of the GI contents;[13,16] slowed absorption of food in the small intestine leading to attenuated postprandial insulin surges;[17] accelerated delivery of food to the terminal ileum, where satiety signals are transmitted;[18] and elevated levels of plasma cholecystokinin, a hormone believed to mediate fat-induced satiety.[19]

Fecal Energy Loss

Soluble fibers reduce fat and protein absorption,[20] possibly by limiting their physical contact with the intestinal villi. Because this energy loss may be offset by the energy produced through the fermentation of soluble fibers and nutrients trapped in the colon, however, the mechanisms of fecal energy loss remain unclear.[13] Considerable evidence suggests that soluble fiber inhibits carbohydrate absorption[21] and improves glycemic parameters.[22,23]

Safety and Toxicity

Glucomannan is available in capsule form, as a drink mix, and in food products, including flour and pasta. It is no longer available in tablet form, as contact with water can cause the tablets to swell before they reach the stomach. There have been 9 case reports of esophageal obstruction caused by ingestion of GM tablets.[24,25] There have been no reports of esophageal obstruction associated with ingestion of GM capsules, presumably because the outer casing shields the fiber from water before it reaches the stomach.[26] Glucomannan jelly candies have been implicated in several choking deaths around the world and have been banned in the United States, Europe, and Australia.

Few adverse events have been associated with the use of glucomannan capsules. Most events involved minor gastrointestinal complaints, such as bloating, gas, and mild diarrhea.[27] GM has been shown to lower blood glucose levels and should not be taken in association with medications or other dietary supplements that have hypoglycemic effects.[22,28]

GM reduces the absorption of sulfonylurea medications[29] and may reduce the bioavailability of other oral medications that are taken concomitantly. Therefore, oral medications should be taken 1 hour before or 4 hours after ingesting GM capsules.[27]

Dosage

Because of its high viscosity, GM may be effective in smaller doses than those recommended for other fiber supplements, such as guar gum or pectin. For weight loss, a commonly recommended dosage is 1 g 3 times per day, 1 hour before meals. Higher doses, ranging from 3.6 to 13 g per day, have been recommended for managing type 2 diabetes, insulin-resistance syndrome, and dyslipidemia.[27]

CLINICAL TRIALS WITH BODY WEIGHT LOSS AS THE PRIMARY ENDPOINT

Systematic literature searches of electronic databases were conducted to locate all clinical studies related to GM and obesity. Data sources were Medline, PubMed, First Search, Google Scholar, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Library, and the Natural Medicines Comprehensive Database. The reference lists of all studies found were searched for additional articles. A total of 12 human trials were found, and all were included in this review. Seven of the 12 trials identified weight loss as the primary endpoint (Table 1); in the remaining 5 trials, weight loss was a secondary endpoint (Table 2).

The 7 clinical trials with weight loss as the primary endpoints used short-term administration of GM. Four of the 7 trials were published in Italian and, although less than ideal, information about these studies was summarized from an English language abstract. In all 7 trials, GM in doses of 2-4 g per day significantly lowered body weight (-1.4 kg to -5.5 lbs). In one study of obese women without dietary restrictions, participants who received 3 g of GM per day for 8 weeks decreased their mean body weight significantly (5.5 lbs, $P \leq .005$).[30] In a 4-week, single-blind trial of hypertensive outpatients who were randomized to one of 3 groups (placebo, 3 g GM per day, or 3 g GM per day plus calorie restriction), significant weight loss was found in both GM groups. In addition, the GM-plus-calorie-restriction group achieved greater weight loss than the GM-only group (-1.4 kg versus -2.4 kg).[31] A study of patients completing cardiac rehabilitation and consuming normocaloric or hypocaloric diets showed that 3 g of GM per day for 8 weeks significantly decreased body weight (-2.2 kg, $P < .001$).[32]

Two other short-term studies conducted during a 3-4-month period in obese children and adults found that 2-4 g of GM per day in conjunction with balanced or hypocaloric diets resulted in significant weight loss in the GM-treated groups.[33,34] Similarly, substantial weight loss was achieved in 2, 8-week clinical trials in obese children and adults on normocaloric or hypocaloric diets. In one of these studies, significant weight loss occurred in both groups with no significant differences between groups.[35] In the second study, the GM-and-hypocaloric group

TABLE 1 Clinical Trials With Body Weight Loss as the Primary Endpoint

Reference	Participants	Design	Glucomannan/Diet Intervention	Results	Other Findings
Walsh et al, 1983	20 obese women	8-week double-blind trial	Purified GM fiber (from konjac root) 1 g 3 times/day (capsules)	Significant mean BW loss (5.5 lbs, $P<.005$) in GM group	Significant reductions in TC and LDL-C, trend toward significant TG reduction, and some reports of satiety in GM group; no adverse effects
Reffo et al, 1988	31 hypertensive outpatients (3 groups: • placebo • GM • GM plus calorie restriction	4-week single-blind trial	GM 1 g 3 times/day (capsules)/ low-calorie diet (1,000-1,800 kcal) in GM plus calorie restriction group	Significant BW loss in GM (-1.4 kg, $P<.00l$) and GM plus calorie restriction groups (-2.4 kg, $P<.01$)	Significant declines in TC and TG in both GM groups; reports of satiety (n=10), relief of constipation (n=5), and mild bloating/flatulence and diarrhea (n=3) in GM groups
Reffo et al, 1990	28 postinfarcted patients at end of cardiac rehab	8-week double-blind trial	GM 1.5 g 2 times/day (capsules)/ individualized normocaloric or hypocaloric diets (both groups)	Significant BW loss (-2.2 kg, $P<.001$) in GM group	Significant decrease in TC, significant increase in HDL-C in GM group; 2 patients dropped out of GM group due to mild bloating/flatulence
Livieri et al, 1992*	53 obese children (23 in GM group; 30 control group)	4-month trial	Purified GM 2-3 g/day (capsules)/balanced diet (both groups)	Significant reductions in BW and TG in GM group	Trend toward significant decrease in TC in GM group; no major side effects
Vita et al, 1992*	50 severely obese patients	3-month trial	GM-based diet supplement, approx 4 g/day/ hypocaloric diet (both groups)	Significant BW loss in GM group	Improved lipid status and carbohydrate tolerance and greater diet adherence in GM group; no adverse effects
Vido et al, 1993*	60 obese children	8-week double-blind trial	GM 2 g/day (capsules) / normocaloric diet (both groups)	Substantial BW loss in both groups ($P<.01$); no significant difference between groups	Changes in lipid parameters, possibly due to inadequate water intake
Cairella and Marchini, 1995*	30 overweight and obese patients	60-day trial	GM (dose not specified)/1,200 kcal diet (both groups)	GM and low-kcal diet more effective than placebo and low kcal diet for BW, TC, and hunger/satiety variables	

* In Italian; from English abstract
BW=body weight; GM=glucomannan; HDL-C=high-density lipoprotein cholesterol; LDL-C=low-density lipoprotein cholesterol; TC=total cholesterol; TG=triglycerides

was more successful than the placebo-and-hypocaloric group in achieving weight loss.[36]

Besides reducing weight, GM also reduced total cholesterol (TC), LDL-cholesterol (LDL-C), triglycerides (TG), and/or increased HDL-cholesterol (HDL-C) in several of the studies.[30-32] Other beneficial effects reported were increased satiety, relief of constipation, improved diet adherence, and improved glycemic status. Adverse effects were minimal and included a few reports of mild bloating or flatulence and diarrhea, causing 2 participants to drop out of one study.[32]

Clinical Trials With Body Weight Loss as the Secondary Endpoint

Most of the recent research on GM was carried out in patients with type 2 diabetes and/or hypercholesterolemia with body weight loss as a secondary variable of interest (Table 2). Four randomized, placebo-controlled, double-blind, crossover studies and 1 non-placebo controlled study showed no effect on body weight.[22,23,28,37,38] TC, LDL-C, and TC/HDL-C were significantly reduced in 3 of the studies.[23,28,38] Other promising findings were significant reductions in systolic blood pressure (SBP),[22] serum fructosamine,[22,23] and apolipoprotein B,[23,28] and greater

TABLE 2 Clinical Trials With Body Weight Loss as the Secondary Endpoint

Reference	Participants	Design	Glucomannan/Diet Intervention	Results	Other Findings
Arvill et al, 1995	63 healthy males	Double-blind placebo-controlled crossover design with 2 successive 4-week treatment periods separated by a 2-week wash-out period	GM 3.9 g/ day (capsules)	Significant reductions in TC, LDL-C, TG, and SBP; HDL-C and LDL-C:HDL-C ratio did not change significantly; no change in DBP or BW	No adverse effects
Vuksan et al, 1999	11 hyperlipemic, hypertensive type 2 diabetic males	Double-blind placebo-controlled crossover design with 2 successive 3-week treatment periods separated by a 2-week wash-out period	KJM fiber enriched biscuits (~0.7g/412kJ [100 kcal]) or wheat bran fiber control biscuits/NCEP Step II diet	Significant declines in serum fructosamine, TC/HDL-C ratio and SBP; no significant changes in BW, TC, LDL-C, HDL-C, TG, Apo A-1,B, or ratio, glucose, insulin, or DBP	37% of KJM and 34% of wheat biscuits participants reported transient flatulence and soft stools
Vuksan et al, 2000	11 patients with insulin resistance syndrome	Double-blind crossover design with 2 successive 3-week treatment periods separated by a 2-week wash-out period	8-13 g KJM fiber-enriched biscuits/day or wheat bran fiber control biscuits/ NCEP Step II diet	Significant decreases in TC, LDL-C, TC:HDL-C ratio, and LDL-C:HDL-C ratio, Apo A and B, and serum fructosamine; no change in fasting blood glucose, insulin, TG, HDL-C, or BW	3 KJM and 2 wheat biscuit control participants experienced transient flatulence and soft stools
Gallaher et al, 2002	21 overweight, normocholesterolemic subjects	4-week non-placebo-controlled study	2.4 g/day of equal part chitosan/KJM supplement	Significant decreases in TC, HDL-C and LDL-C; no change in TG, BW, or fecal fat; trend toward greater fecal excretion of neutral sterols and bile acids	No adverse effects reported
Chen et al, 2003	22 hypercholesterolemic, type 2 diabetic patients	Double-blind, placebo-controlled crossover study with 2 successive 28-day treatment periods without a wash-out period	KJM 3.6 g/day (progressive dose: 1.2 g for 3 days, 2.6 g for 3 days, and 3.6 g for 22 days)	Significant reductions in TC, LDL-C, TC/HDL-C ratio, Apo B, and fasting glucose; no significant changes in TG, HDL-C, LDL-C/HDL-C, postprandial glucose, or BW; significant increases in fecal neutral sterol and bile acid concentrations	1 subject experienced minor gastric discomfort early in the study, adapted by day 5

Apo=Apolipoprotein; BW=body weight; DBP=diastolic blood pressure; GM=glucomannan; HDL-C=high-density lipoprotein cholesterol; KJM=Konjac-Mannan, LDL-C=low-density lipoprotein cholesterol; NCEP=National Cholesterol Education Program; SBP=systolic blood pressure; TC=total cholesterol; TG=triglycerides;

excretion of fecal neutral sterol and bile acids.[28,38] All of the studies were of short duration (3-4 treatment weeks) and had relatively small sample sizes, however.

Adverse effects were minimal in these studies, which tested GM in doses ranging from 3.6 to 13 g per day in the form of capsules or fiber-enriched biscuits. In the 2 studies that administered GM fiber-enriched biscuits, wheat bran fiber biscuits served as the control.[22,23] Two trials reported no adverse effects;[37,38] the wheat-and-GM-biscuit groups in 2 other trials reported comparable transient flatulence and soft stools.[22,23] One non-placebo-controlled study tested 2.4 g per day of a supplement composed of equal parts chitosan (an indigestible aminopolysaccharide) and GM.[28] In that trial, 1 participant experienced minor abdominal discomfort that subsided after a few days.[28]

CONCLUSIONS AND FUTURE DIRECTIONS

GM may possess properties that promote weight loss when used in conjunction with either a normocaloric or a hypocaloric diet. In controlled trials ranging from 3 weeks to 4 months, doses

of 2-4 g per day resulted in significant weight loss in mostly overweight and obese populations.[30-36] A potential advantage of GM is its relatively good tolerability and low rate (<.05%) of adverse effects. Adverse effects were limited to mild and transient gastrointestinal discomfort, which abated after a few days of use. Another potential advantage is its natural plant source, a feature that many consumers find attractive.

A drawback of the clinical studies with weight loss as the primary endpoint is that all of the studies were conducted 10 or more years ago, and 4 of the studies were published in Italian, limiting the depth and amount of information abstracted. All of these studies were also 4 months or less in duration and had an average sample size of 39 participants.

It is unclear why all of the studies with weight loss as a secondary endpoint showed no reductions in body weight when presumably many of the participants were overweight. One explanation might be that the duration of these studies (3-4 weeks) was inadequate to observe a response to GM. In addition, these studies generally had small sample sizes and may have been underpowered to detect statistically significant weight changes.

Studies have shown that dietary fiber is a safe and effective adjunct to weight-reducing diets. Fiber has been shown to promote and prolong satiety,[39-41] to increase long-term adherence to low-calorie diets,[42,43] and to be inversely associated with weight gain.[44] Commonly used dietary fiber supplements, such as guar gum and psyllium, have not been consistently shown to promote weight loss, however.[45,46] In contrast, limited data suggest that GM is safe and effective in promoting modest weight loss. It may be an acceptable alternative for overweight individuals who are unable or unwilling to increase their fiber intake through food sources. Before GM can be safely recommended for widespread use, however, additional trials of standardized preparations are needed to extend extant data on its safety, efficacy, and weight-reducing mechanisms of action.

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