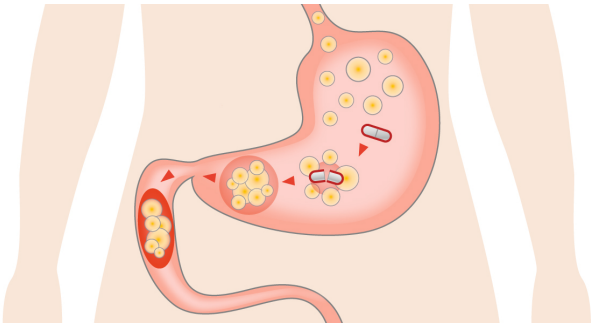
The Value of Chitosan as a Dietary Fiber

PRIMEX offers natural, effective and convenient solutions for weight management



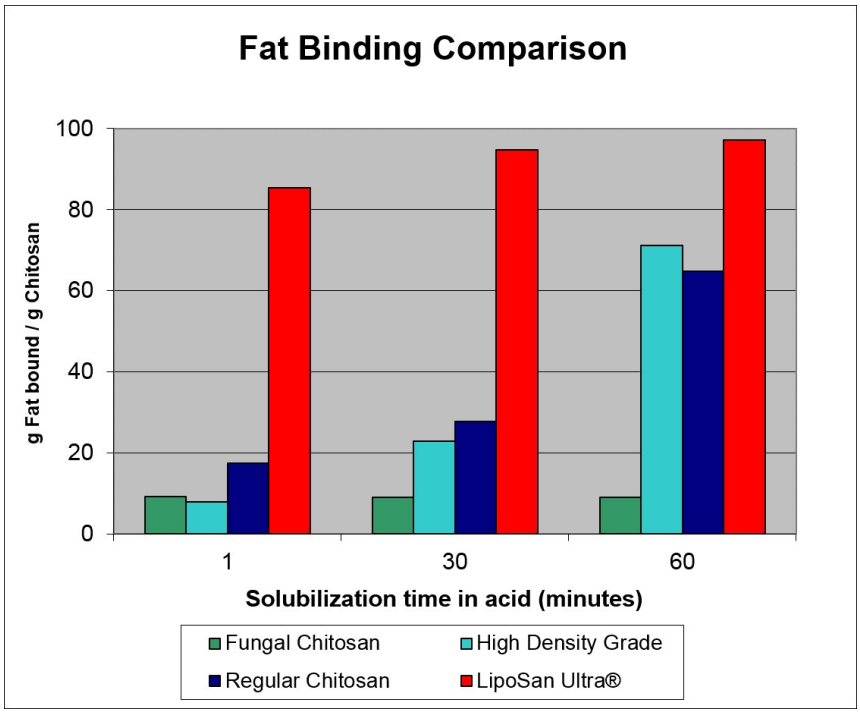
Obesity has become a worldwide problem and the health burden of obesity-related complications is growing. This is because overweight and obesity lead to adverse metabolic effects on blood pressure, cholesterol, triglycerides and insulin resistance. If there was a simple explanation to this epidemic problem, there would be a simple solution. We all know though that obesity results from energy imbalance—too many calories in, too few calories burned.

The healthy keys to weight management include: monitoring calorie and fat intake, being active and following a healthy lifestyle. But why does this not work for everybody? Modernization, globalization and current life-style conditions contribute to the obesity problem. People eat differently nowadays and spend less energy. They become tempted by short-term weight loss solutions instead of following a long-term weight management program and choose a suitable lifestyle. A slow and steady weight loss plan is emphasized, being well supported by delicious, nutritive and well balanced food choices. Improved eating habits, appropriate portion sizes and physical activity are important for a successful weight management plan which must be tailored to individuals' needs. Nevertheless, the most effective way to achieve weight loss is to reduce calories in our meal. This can be accomplished by the selection of appropriate food products, especially those that minimize hunger, fill the stomach and contribute to low caloric intake, such as dietary fiber.

A dietary fiber is a carbohydrate not digested in the small intestine, but that can be fermented by commensal bacteria once in the colon, resulting in the production of short chain fatty acids (SCFAs) and gases. In the human gut, SCFAs are an important source of energy for the gut and some are transported to other sites around the body for use. The gut microbiota interacts with the host through its metabolites. Some metabolites can damage the gut mucosa, such as indoles, ammonia and amines, while others are beneficial, such as SCFAs [1]. Lin *et al.* [2] examined the effects of SCFAs on body weight, glucose metabolism, and gut hormones in mice and demonstrated that butyrate, propionate, and acetate all protected against diet-induced obesity and insulin resistance. Interestingly, butyrate and propionate, but not acetate, induced gut hormones and reduced food intake. Dietary fibers can therefore be used as prebiotics, i.e. nondigestible food ingredients selectively stimulating the growth and activity of bacterial species in the colon. Accumulating evidences indicate that prebiotics have a diverse range of health benefits, particularly by influencing microbial gut ecology, mineral absorption, laxation, potential anticancer properties, and lipid metabolism, together with anti-inflammatory and other immune effects, including atopic disease. Fermentation processes and SCFA production in the large intestine are believed to contribute to several of these phenomena [3].

The physico-chemical properties of dietary fibers play other important roles in human physiology. Dietary fibers are differentiated based on their water solubility which is related to their structure. The soluble and insoluble nature of dietary fibers contributes to their different technological functionality and physiological effects. Technological properties in foods include water-holding capacity, swelling, oil-holding capacity, viscosity, texturizing, stabilizing, gel-forming and antioxidant; all greatly relevant to the food industry to improve texture, sensory characteristics and shelf-life. In the human body, soluble fibers increase viscosity and reduce the glycemic response and plasma cholesterol, while insoluble fibers are porous, contributing to fecal bulk and decreased intestinal transit time [4]. Recently, Kristensen and Jensen [5] reviewed several studies where the majority of them indicated that viscous dietary fiber enriched beverages increased the sensation of satiety or fullness. Indeed, dietary fibers have three primary mechanisms in the human digestive tract: bulking, viscosity and fermentation.

Chitosan is a natural dietary fiber and the most abundant natural amino polysaccharide. It is obtained by deacetylation of chitin processed mainly from animal (crustacean shell) or fungal (mushrooms and related microorganisms) source. Chitosan, a copolymer of glucosamine and N-acetyl-glucosamine, is soluble in acidic environment following its protonation, resulting in its unique cationic and bioactive nature. This characteristic offers a great potential as a dietary fiber since chitosan will first dissolve in stomach acid and become soluble and viscous, behaving like a soluble fiber. Once transiting to the intestine the higher pH will cause it to gel and become less soluble, contributing to faster transit time and reduced putrefactive activity. This is advantageous because rapid intestinal transit is linked to higher energy recoveries by the host due to increased bacterial metabolite production in the colon [3]. Chitosan has been demonstrated to possess several biological properties, among which antioxidative, emulsifying, flocculating, fat-binding and antimicrobial, are important ones for the food industry [6]. Indeed, chitosan can chelate fat and reduce cholesterol [7-8] and do not influence calcium, magnesium and iron status (8-week elderly study) [9]. According to EFSA, a daily consumption of 3-g chitosan will contribute to the maintenance of normal blood LDL cholesterol concentrations [10].



Primex ehf, an Icelandic marine biotech company, is a global leader in the manufacture and supply of pure chitin and chitosan products. The combination of high quality marine raw materials and a unique processing technology allows **Primex** to produce the purest and most effective chitosan on the market today. **Primex** products are certified as natural, and include **ChitoClear®** chitosan of different grades and viscosities for various applications, and **LipoSan Ultra®**

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chitosan**,** which is a safe and effective weight loss and cholesterol lowering supplement. **LipoSan Ultra®** is a unique, patented product (US Patent No. 6,130,321) that contains succinic acid, a GRAS food additive. The **LipoSan Ultra®** patented process results in a more granular product with high tap density and much better flow properties than regular chitosan, allowing easier and faster capsule filling as well as higher fill weights, resulting in fewer capsules at meal time. **LipoSan Ultra®** rapidly dissolves in the stomach, complexes and traps fats and oils consumed, and reduces the digestion of dietary fat hence limiting the calorie intake. This superior efficacy of **LipoSan Ultra®** implies that it can be taken just before a meal as a convenient weight management product.

Clinical studies have already demonstrated the advantages of Primex products to human health. LipoSan Ultra® (3 g daily for 8 weeks) has been shown to be efficacious in facilitating weight loss and reducing body fat and LDL-cholesterol in overweight and mildy obese individuals (BMI 31-32) despite simple routines and minimal changes of lifestyle [11]. Similarly, **ChitoClear®** chitosan (4.5 g daily for 6 months) supplemented to a low calorie diet (1000 kcal/day) contributed to significantly higher body weight loss and decrease of systolic and diastolic blood pressure in fifty obese women [12]. Another study revealed that daily consumption of **ChitoClear®** chitosan (4.5 and 6.75 g) for 8 weeks did not affect serum-fat soluble vitamins or other safety parameters in 56 mildy hypercholesterolemic Finnish subjects (BMI ≤ 26) eating a typical diet. A modest reduction in plasma cholesterol concentrations was observed [13]. In a guinea pig study, **ChitoClear®** chitosan was also shown to selectively reduce fat absorption and have higher affinity to bind fatty acids with higher polarity. **ChitoClear®** chitosan significantly increases the excretion of highly atherogenic saturated fatty acids (lauric and myristic) compared to other fibres. Intestinal bioconversion of cholesterol and bile acids is therefore inhibited by **ChitoClear®** chitosan. Furthermore, the ratio of *n*–6/*n*–3 fatty acids in feces is significantly increased by **ChitoClear®** chitosan [14], which could be tactically used to balance this fatty acid ratio in our diet, hence reducing the risk of many chronic diseases [15].

Furthermore chitosan, being a source of dietary fiber, is also a valuable prebiotic which can promote optimal colonic conditions. Back in 1995, Terada and coworkers [16] showed that a 2-week intake of chitosan (3 g daily for 7 days and then 6 g) led to reduced occurrence of lecithinase-negative clostridia and fecal concentrations of putrefactive products (ammonia, phenol, p-cresol and indole) which resulted in less offensive fecal odours. After 14-day intake, SCFA levels had significant increased, especially propionic acid formation. Unfortunately, few studies have considered these beneficial effects of chitosan on human health but recent publications indicate its potential to modulate the colonic microbiota [17-18]. Mrazek *et al.* [19] observed changes in overall bacterial composition and *bifidobacteria* subpopulation in response to chitosan intake (3 g daily) after only 2-3 days. This was reflected by raised levels of fecal *Bacteroides*, slightly increased or unchanged levels of *Bifidobacterium* and a little increase in butyrate-producing bacteria. After termination of the 4-week chitosan treatment, it took only 2 days to reestablish the initial microbiota. Similarly to the work of Lee *et al*. [20], the findings point to a prebiotic effect of chitosan on *Bifidobacterium*, beneficial for human health. This stimulating effect is meaningful for the use of chitosan to encapsulate probiotic cultures. The design of functional foods that would generate specific SCFA patterns at controlled sites in the large intestine is an interesting challenge aiming for positive health consequences, e.g. in the prevention and treatment of colonic diseases. **ChitoClear®** chitosan is obviously a good candidate, just as **LipoSan Ultra®**.

More information on Primex chitin and chitosan products are available at www.primex.is. Information on Primex revolutionary **LipoSan Ultra®** natural weight control supplement can be found at www.liposan.com.

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