Galactomannans - a Natural Soluble Dietary Fiber

In their capacity as water-soluble dietary fibres, galactomannans bring positive influence to bear on the metabolism. They regulate the digestive process and the resorption of nutrients, as well as supporting the prevention or treatment of the complaints of modern civilisation. The action potential of these natural polysaccharides has been confirmed by numerous scientific tests, which will be summarised in the following report.

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1 Introduction

About a quarter of the inhabitants of Western Europe suffers from digestive problems. In most cases constipation is the main problem. Various factors can cause a delayed evacuation of the bowels.

Possible Causes of Constipation: [1]

- Wrong diet
- Not drinking enough water/insufficient fluid intake
- Lack of exercise
- Stress and anxiety
- Suppression of the urge to open the bowels
- Hormonal influences
- Illness / drugs

One result of this is a general feeling of being unwell, but it can also be the cause of modern civilisation complaints such as haemorrhoids, diverticulitis, etc.

Moreover, the long period of time that the food mass remains in the digestive tract has a negative influence on the intestinal flora. Toxic metabolic products are subsequently formed which can be absorbed by the bowel walls. This so-called "autoxication" phenomenon is the cause of a wide range of medical complaints.

A balanced diet rich in dietary fibres combined with sufficient intake of fluids can to a great extent reduce the danger of constipation and its negative consequences. At the same time, further positive influences on the organism are to be observed.

2 Dietary Fibre

Trowell et al [2] designate plant polysaccharides and lignin as dietary fibre which is resistent to the hydrolysis of human digestive enzymes.
This indispensable dietary fibre can be divided into water-soluble and water-insoluble roughage.

Examples of water-soluble dietary fibre:

- Cereal slime substances
- Pectins from fruit and vegetables
- Polysaccarides from brown algae and red algae
- Reserve polysaccharides from legume seeds
- Reserve polysaccharides from tubers
- Reserve saccharides of plant exudates
- Microbially produced polysaccharides

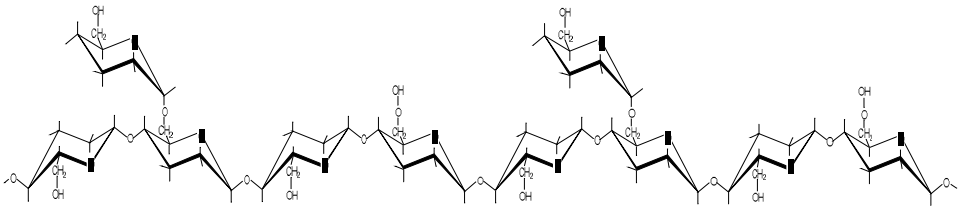
Examples of water-insoluble dietary fibre

- Cellulose, hemicellulose
- Lignin
- Cutin
- Suberin

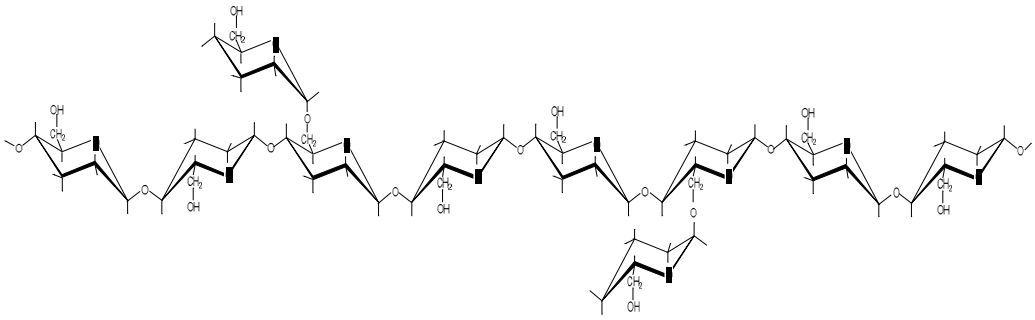
Besides these indispensable dietary fibres, these days we are gaining more and more new knowledge of potential dietary fibre suppliers [3]. Prototypes of potential dietary fibres are lactose and starch. Today these are known as resistent starches. On the other hand, recognition is growing of the significance of lactose in baby-food, in which lactose incorporates the most important dietary fibre.

3 Galactomannans

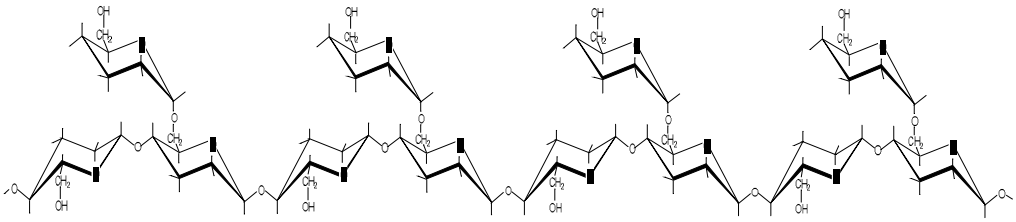
Guar gum, Tara gum and Locust bean gum composed of the aldoses mannose and galactose are the best-known galactomannans today. These three galactomannan molecules have a linear main chain made up with mannoses. The many side chains consist of a single galactose molecule. The only differences between the three galactomannans are the number (the ratio) of mannose to galactose units and the distribution.



Locust Bean Gum (Carubin) Ratio Mannose to Galactose 4 : 1



Tara Gum (Tara-Galactomannan) Ratio Mannose to Galaktose 3 : 1



Guar Gum (Guaran) Ratio Mannose to Galactose 2 : 1

Galactomannans have been researched very thoroughly up until now as dietary fibre because of their interesting physical-chemical properties.

3.1 Physical-Chemical Characterisation of Galactomannans as Dietary Fibre

The physical-chemical properties of dietary fibres [4] which have a bearing on their physiological effects, are primarily influenced by the chemical composition. the molecular and supermolecular structure, as well as by the chemically functioning groups.

A high molecular weight and the multiplicity of free hydroxyl groups are characteristics of galactomannans. The following characteristics should be mentioned:

3.1.1 Interaction with water

The strong swelling capacity of galactomannans in water and their consequent water-binding and water-holding ability represents an important property for the food technology field. It has a major influence on the flow behaviour and the consistency of aqueous systems.

This swelling ability is put to good use in the development and production of foodstuffs and pharmaceutical as well as cosmetic products.

We can also establish the same advantageous swelling properties in their action as dietary fibre. The food mass gains more volume and becomes softer and from this result various advantages for the whole digestive system.

3.1.2 Solubility

The solubility of dietary fibres is decisively influenced by the structural branches of the macromolecules. Linear and poorly branched molecules are barely soluble in water. Strongly branched molecules, on the other hand, generally dissolve well in water.

For this reason Guar gum dissolves better in water than Tara gum and even more so than Locust bean gum.
The solubility also depends largely on the manufacturing process and the milling grade of the gums. Finely milled gums clearly dissolve much quicker because of their extended surface. Or with certain

manufacturing processes the swelling behavour can be improved so that even cold-soluble Locust bean gum can be manufactured, which is normally hot-soluble due to its structure.

3.1.3 Bioadhesion

Bioadhesion describes the adhesion of materials to biological tissues. The adhesion of galactomannans potentially increases with the concentration and describes their pronounced ability to raise the unstirred water layer as resorption barrier [5].

3.1.4 Binding of organic substances

With their wide range of binding mechanisms, galactomannans are in a position to adsorb many organic substances [6] [7]. The binding of sugar molecules, aminoacids, bileacids, steroids, mutagenes and also drugs is of direct diet-physiological use.

3.1.5 Cation-Binding

The absence of carboxyl groups and sulfatester groups in galactomannan molecules prevents the direct binding of cations [8]. A reduction of the bio-availability of minerals and trace elements is consequently not to be expected. In spite of this, the influence of galactomannans on ionically dissolved substances, based on their interaction with water (water-binding ability), cannot be excluded.

3.1.6 Interactions

The conformatively arranged domains of Tara gum and in particular Locust bean gum can become interactive with selected polysaccharides such as Carragheenan, Agar Agar, Xanthan, etc. In the process three-dimensional networks (gels) are formed by reason of the double helix-, helix-band and band associations. These networks, which occur in food as gel particles, possess a strengthened affinity to water and dispose of interesting, mechanical-physical characteristics.

Interactions of galactomannans with other water-soluble, water-insoluble as well as between other macromolecules, can influence the internal structure of the food mass. These can be consistency, slippery and wrapping actions, diffusion properties and further sensory characteristics.

4 Diet-Physiological Actions of Galactomannans

The above-listed properties of galactomannans and the diet-physiological characteristics resulting the refrom can be utilised successfully in the treatment of metabolic disturbances and illnesses connected with diet.
Much of the scientific research carried out to date was made with Guar gum. However, these findings could also be carried over to be valid for Locust bean gum and Tara gum.

4.1 Sensory Influences

The most important purpose for using galactomannans in the food industry to date has been to improve the texture and consistency of our foodstuffs. The importance of the sensory aspect of foodstuffs for the maintenance or promotion of health has not been subject of much research. Attractive and appealing food, however, does exercise a great influence on health and well-being.

One important characteristic of galactomannans in food intake paraphrases an earlier frequently u-

sed designation "slimy substance". Galactomannans as slimy substances facilitate swallowing and food transport through the gullet and are therefore used in food for the sick, small babies and the elderly.

4.2 Emptying of the Stomach/Transit time

The high water-binding property of galactomannans, combined with a more or less high rise in viscosity delays emptying of the stomach [9]. Studies with 16g of Guar gum, combined with 10g of Pectin, tried out on four test persons, have shown a rise in the half-life time from 23 +/-6 minutes to 50 +/- 15 minutes. Other fibres like wheat bran accelerates the transit time of the food mass from the mouth to the Zökum.

The longer transit time of food in the stomach prolongs the feeling of being full. For this reason the voracious appetite often occurring in overweight people can be reduced.

4.3 Digestion and Resorption of Food

The positive influence of galactomannans on the consistency of food, combined with the slowed-down transit from stomach to intestine, facilitates the chemical and enzymatic digestion of food. At the same time, the unstirred water layer is thickened on the mucous cells of the small intestine [10]. Through this the contact between the food and the mucous cells is made difficult. Digestive substrates are therefore slower in reaching their specific enzymes or carrier bonds [11].

All these actions together delay the resorption of foodstuffs and thus regulate the whole metabolism in that the high readings registered after the meal are levelled off.

4.3.1 Influence on the carbohydrate metabolism

The various carbohydrates provide the organism with a source of energy after the decomposition of the monosaccharides. The energy resorbed as glucose can then be transported with the blood to the consumers such as muscle cells.
The insulin lowers the glucose resorption through raised substrate pressure. A frequently excessive intake of easily digested carbohydrate sources is a source of stress for the insulin-forming gland. The result of this can be diabetes mellitus or diabetes of the elderly.

Galactomannans slow down the resorption of glucose [12] and thereby reduce the risk of becoming ill with diabetes or can support the medicinal treatment of diabetics [13].

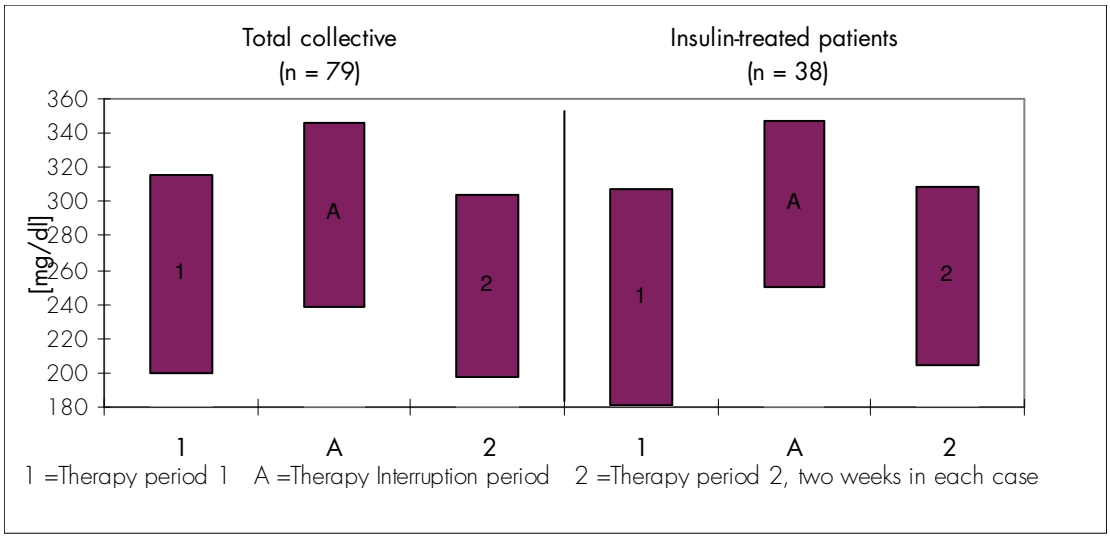


Figure 1: Behaviour of the 1h pp blood glucose levels in a multi-centre study of the action of guar on the carbohydrate and lipid metabolism of out-patient type II diabetics
H.Laube, K. Federlin, B. Knick, K. Irsigler, C. Najemnik, P. Wahl, H.-D. Klimm, J. Vollmar, Ch. Bräuning [13].

Likewise significantly lowered values can be found in the measurement of glucose shed in 24-hour urine.

4.3.2 Influence on the Fat Metabolism

Already in 1965 in vivo-trials pointed to a lipid-lowering action of Guar. More detailed studies proved the action of Guar on the cholesterin- and triglycerid levels.

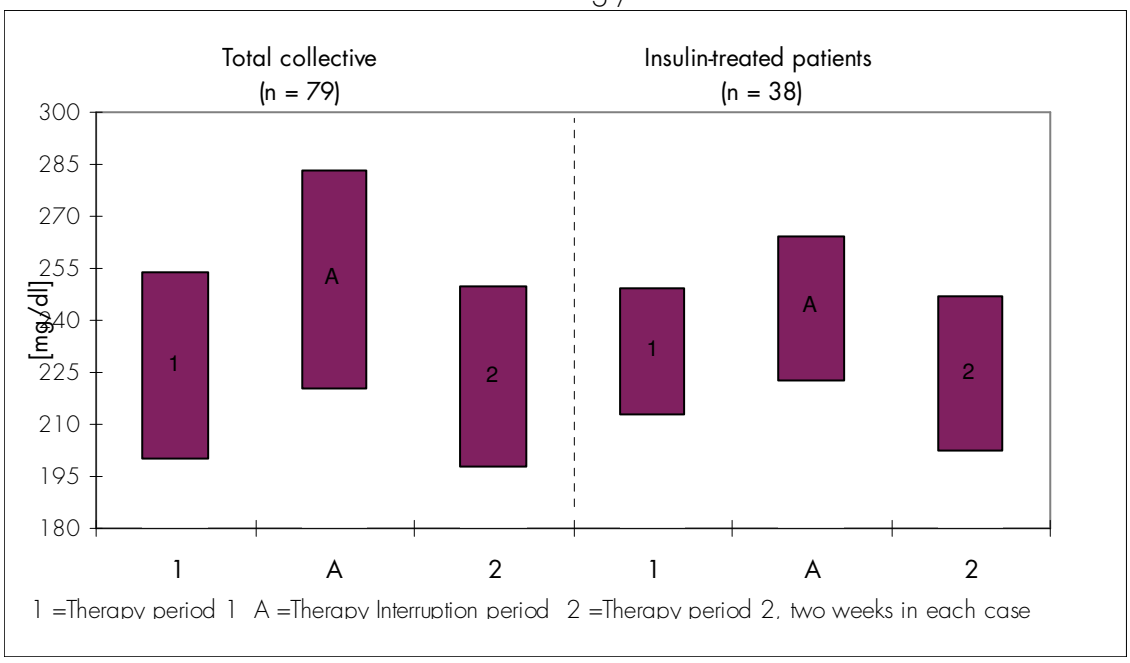


Figure 2 : Behaviour of l h pp cholesterin levels in a multi-centre study of the action of guar on the carbohydrat•e and lipid metabolism of out-patient type II diabetics.
H.Laube, K. Federlin, B. Knick, K. Irsigler, C. Najemnik, P. Wahl, H.-D. Klimm, J. Vollmar, Ch. Bräuning. [16].

A mechanism which causes Guar to lower the serum cholesterin is the adsorption of cholesterin by the Guar molecules. These are extracted from the cholesterin cycle and expelled with the faeces.

4.3.3 Influence on the Protein Metabolism

The digestion of Guar has very little or no influence on the utilisation of dietary proteins. The results of an in-vivo trial of the nitrogen balance of young rats led to this statement [17]. But a displacement of the N-expulsion from the urine to the faeces occurs under the influence of Guar [18].

This effect on the N-expulsion prompted the Faculty of Medicine in Athens to treat patients suffering from chronic kidney insufficiency with Locust bean gum.

Several patients with kidney disease were treated with 50g per day of Locust bean gum over a period of 5 to 26 months and the following results were obtained[19] :

The galactomannan was generally well assimilated. All the patients treated showed 15-20% lower levels of urea, creatinine and phosphate in the serum. Interestingly enough, a lowering of the blood pressure (systolic and diastolic) was also achieved which previously had been too high.
Without doubt these positive results can be attributed to the Locust bean gum. The statistical evaluations certainly showed a significant difference of $p < 0,005$.

Through the administering of Locust bean gum in the treatment of kidney insufficiency the haemodialysis treatments were able to be shortened or the time between treatments lengthened.

4.3.4 Influence on Vitamin and Mineral Absorption

Animal experiments on rats led to the recognition that the absorption of the minerals zinc, chrome, copper and cobalt is not influenced by a 10% portion of guar in their food. On the other hand, a negative influence on the absorption of iron was described [20].

The absorption of fat-soluble vitamins should also not be influenced by water-soluble galactomannans. At any rate in trials with rats no reduction in the concentration of vitamins A and E was detected, either in the serum or in the liver.

4.4 Influence on the Large Intestine (Colon)

Subject of many scientific studies is the in-depth examination of intestinal flora. These have shown that in particular water-soluble polysaccharides are thoroughly fermented.

Under the anaerobic conditions the bacteria can cover their energy needs from the non-oxidative degradation of monosaccharides and aminoacids. Galactomannans are monomerised with intra- and extra-cellular bacterial enzymes and so form an important energy source for various bacteria

such as the bacteroids, ruminococces and others [21]. The hydrolysis does not always occur as far as the monomers so that further bacteria participate in the degradation of the oligomers [22].

How important the microbial digestion is for the monogastrides as well was only revealed with the knowledge of the importance of dietary fibres for human health. Today we know that intestinal bacteria, which constitute 40-50% of the faeces [23], improve the consistency of the faeces mass and raise the volume of the stool.
On the other hand, the metabolic products deliver to our intestinal inhabitants valuable nutrients for the whole organism. We know today that effects emanating from the short-chained carbonic acids influence the mucous cells and further processes in the macroorganism.
n-butyrate serves the colon-enterocyten as energy substrate[24] extends the cellular doubling time of human colo-rectal cancer cell lines [25] and influences the activity of numerous enzymes [26].

Galactomannans as soluble dietary fibre constitute an important source of energy for many intestinal bacteria.

4.5 Effects of the galactomannans

Scientific data shows the enormous potential of galactomannans in the prevention of degenerative illnesses.

Physiological-dietary effects:

- Nitrogen flux changed
- Intra-abdominal pressure reduced
- Serum cholesterol content lowered
- Emptying of stomach slowed down
- Unstirred water layer strengthened
- Nutrient absorption slowed down
- Bacterial proliferation raised
- Fermentation strengthened
- Decomposition reduced
- Short-chained carbonic acids increased
- pH-level lowered
- N-fixation in chymus strengthened
- Neoplastic incidence lowered
- Gas formation raised
- Bowel motility raised
- Transit time shortened
- Stool volume slightly raised

5 Desirable Consumption of Dietary Fibres

In 1985 the German Society of Nutrition recommended the ideal intake of 30-40g of dietary fibres per day. Kritchevsky [28] talks of 10-13g/1000 kcal as daily energy intake. Dietary fibres can be taken in the form of dietary fibre preparations. They should, however, be taken as part of a balanced mixed diet [29]. The intake of 2/3 insoluble and 1/3 soluble dietary fibres is regarded as ideal [30].

Galactomannans form one group amongst many diverse water-soluble dietary fibres. By virtue of the exhibited properties and actions on the organism they are indeed very important and should therefore be included in our basic foodstuffs.

If galactomannans are contained in the basic foodstuffs, they will be consumed regularly every day and in this way can reveal their true physiological-dietary advantages.

Examples of Basic Foodstuffs containing Galactomannans:

- Milk products — Joghurt, Desserts, Milk drinks, Fresh and Processed cheese.
- Bakery products — Bread and Biscuits
- Nutrition — Soups, Sauces, Ketchup
- Desserts — Ice cream, Pudding, Fruit preparations, etc
- Drinks — Soft drinks, Sport drinks

The food of today is extremely lacking in dietary fibres and other nutrients - but still very rich in energy. By means of diverse products and preparations food producers are trying to compensate for this deficiency.
We move in waves from low-fat diets to cholesterin-free foodstuffs, diet-products, vitamin capsules and others. The latest trend lies in the realisation of bacterial concentrates, enriched with different kinds of sugar.
However, none of these products can hold out on the market for long - not even the most up-to-date new developments.
But the result of these diet trends is an uncertain public who change from diet to diet and more likely bring about negative consequences for their health through an irregular diet. Here I am also thinking about extreme follow-on illnesses such as bulimia and anorexia.
The food industry is called upon here to make use of scientific knowledge, above all in the development of basic foodstuffs.

For it is a fact that all scientific research to date shows the enormous potential of dietary fibres, and in particular the galactomannans, in the prevention of degenerative illnesses.

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