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Active Food Scientific Monitor

Interview with Dr. Gary S. Frost

In this issue we present an interview with Dr. Gary S. Frost, Reader in Nutrition from the Imperial College and Hammersmith Hospitals in London, UK.

Dr. Gary Steven Frost studied dietetics at Leeds Polytechnic School and got a PhD in Nutrition at Kings College University of London.

He is currently head of Therapy Services at Hammersmith Hospitals NHS Trust and responsible for the Nutrition and Dietetic Service, Physiotherapy, Occupational Therapy, Speech and Language Therapy. He is also Honorary Reader in Nutrition and Head of the Nutrition and Dietetic Research Group, Metabolic Medicine in the Division of Investigative Science of the Faculty of Medicine at the Imperial College at Hammersmith Campus in London, and External Lecturer for the Roehampton Institute. He is British Dietetic Association advisor to NICE on Diabetes, member of the Diabetes National Service Framework, member of the Cardiac HIMP and was a member of the NICE type-1 diabetes panel 2001-2003 and of the Recommendations Panel for type-2 diabetes from 1996 to 2002. He is also a member of the British Dietetic Association, the Health Professionals Council, the Nutrition Society, the Endocrine Society, the British Diabetic Association, the British Nutrition Society and serves as a referee for several renowned international scientific journals.

In his spare free time, Dr. Frost does some running for pleasure, plays badminton and basketball. And he is a very keen gardener who grows for instance his own vegetables.

It has been shown that the intake of dietary fibres has an impact on several intermediate markers of disease and health, and contributes to the modulation of blood cholesterol and triglyceride concentrations, glycaemia and insulinaemia, appetite and food intake, etc. In this respect dietary fibres such as inulin-type fructans can help reduce the risk of developing type-2 diabetes, heart disease and obesity in a number of people. Scientific evidence also shows that glycaemic response is strongly involved in the aetiology of these diseases.

Glycaemic response and the prevention of heart disease and type-2 diabetes

What is the role of dietary fibres, and of inulin-type fructans in particular, on the modulation of blood lipids, glycaemia and insulin resistance ?

The role of dietary fibres as a group and its relationship to blood lipids, glucose and insulin concentrations, is very complicated because it is a big and heterogeneous group of compounds. Prospective epidemio-

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P R E F A C E

by Dr. Anne Franck

Obesity is increasing worldwide with about 300 million people believed to be obese and a further 750 million overweight. Obesity is associated with an elevated risk of life-threatening conditions such as type-2 diabetes and cardiovascular disease.

Recent studies have shown that a diet comprised mainly of low-glycaemic foods can improve body's sensitivity to insulin, limit hunger feeling and over-eating, lower blood lipids, and reduce the risk of developing diabetes and heart disease.

A low-glycaemic diet may thus contribute to the prevention of obesity and related diseases. As a result consumers are more and more looking for better-balanced foods and drinks, and the food industry is reformulating products to improve their glycaemic profile. Low-glycaemic foods are usually digested slowly and release energy gradually in the body.

Inulin and oligofructose are non-digestible ingredients with only a minimal impact, if any, on blood glucose and insulin levels. So, they do not contribute to the Glycaemic Index or Glycaemic Load of a meal and, as such, they can replace high-glycaemic carbohydrates in food and improve the nutritional profile of our daily diet. In this issue, we highlight the role inulin and oligofructose can play in a low-glycaemic diet, thereby contributing to weight and health management.

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Glycaemic response and

logical studies support the hypothesis that high-carbohydrate diets that are high in fibre and complex carbohydrates are protective against coronary heart disease (CHD) and type-2 diabetes.

Regarding non-digestible oligosaccharides such as inulin and oligofructose it appears that they have positive effects on blood lipids, glucose and insulin. They may for instance make people more insulin sensitive, with relating benefits for health in the long-term. One issue today is how to get the actual amount of inulin and oligofructose into the human food chain. It is therefore very important for companies such as Orafti and their partners to produce food products which are attractive to people to eat.

What are the possible nutritional and health effects of inulin and oligofructose in this respect ?

Until now it has been proven that inulin and oligofructose have an effect on certain intermediate markers of disease risk and health, such

the prevention of heart disease and type-2 diabetes

as blood and liver triglyceride concentrations, glycaemia and insulinaemia, etc. The extent to which dietary modification can improve insulin sensitivity and lipoprotein profiles in the long-term is, however, unknown. But one may expect that when you modulate someone's blood glucose and influence his/her insulin resistance and lipid metabolism, you may also reduce the risk of developing type-2 diabetes and prevent the onset of heart disease.

A major focus of your work is the role of carbohydrates on insulin resistance and lipid metabolism, and in particular the glycaemic response (glycaemic index and glycaemic load) as a model of the physiological effects of carbohydrates.

Yes, indeed. Low-glycaemic diets induce attenuated and prolonged postprandial insulin release with lower absolute insulin concentrations. Such release patterns are effective in suppressing lipolysis and subsequent visceral release of non-esterified fatty acids in people with abdominal obesity. Elevated free fatty acids (FFA) decrease hepatic insulin clearance inducing insulin resistance. We have shown for instance that the glycaemic index (GI) of the diet is a stronger predictor than dietary fat intake for serum HDL-cholesterol concentration. High levels of HDL decrease CHD risk. Application of the GI has proved beneficial in the dietary management of diabetes, and a recent review of clinical studies has shown that low-GI carbohydrates improve glycaemic control and lipid profiles in type-2 diabetes, as well as in those at risk of CHD.

The improvement in insulin sensitivity seen in patients with CHD, type-2 diabetes or obesity on low-glycaemic diets has been attributed to lower levels of circulating FFAs. High-glycaemic carbohydrates not only produce greater fluctuations in postprandial plasma glucose and insulin concentrations, but also stimulate production of several counter-regulatory hormones such as epinephrine and norepinephrine that may acutely lower insulin sensitivity. We are currently conducting a large research project looking at the long-term health benefits of low-glycaemic diets.

The issue however is how inulin and oligofructose can be integrated properly into the glycaemic index model. So, we need to do more research on these new compounds to determine their beneficial effects which they certainly have.

You are also involved in studies on the effects of certain hormones and nutrients on appetite. Do inulin and oligofructose have such an effect ?

That is a hundred dollar question: we are puzzling, but do not know all the answers for the moment. Animal data have shown that inulin-type fructans modulate hormones involved in appetite regulation such as GLP-1 and ghrelin, and impact food intake. There are some short-term small human studies that suggest that inulin has a modulating effect on appetite. It seems plausible, but it has still to be proven in humans on the long-term.

So, we need more long-term studies ?

Yes, indeed. We now have a lot of animal studies and some short-term human studies with inulin and oligofructose, which point to the same direction. But a lot of small studies cannot give you the ultimate answer on the health benefits of inulin and oligofructose in humans on the long-term. We urgently need long-term studies in humans to demonstrate that inulin and oligofructose not only affect the intermediate metabolites, but also have an effect on the end disease and may actually reduce cardiac risk factors and mortality in the general population. Such studies are expensive and they take a lot of time, but I think we need to do them. We now have started in Britain a large study on the glycaemic index with Orafti as one of our partners.

The role of inulin and oligofructose in a low-glycaemic diet

Food consumption is recognised as a pleasant event during the day, meanwhile our food delivers all necessary nutrients to be able to perform our daily living. With the huge amount of food products that are offered to consumers nowadays, the pleasure of consuming a meal is often mitigated by frustration and health problems. More and more people are suffering from typical illnesses of our wealthy societies, such as obesity, diabetes, and cardiovascular diseases. The over-consumption of foods, and subsequently calories, continues to be one of the driving forces in the development of these Western diseases. One new potential tool to combat this growing epidemic is the control of the glycaemic and insulinaemic responses. In that respect, the Glycaemic Index (GI) and the Glycaemic Load (GL) serve as indicators for the effects of foods on blood glucose levels after a meal. Low-glycaemic foods are usually digested and absorbed more slowly, giving a slower and more sustained release of energy, as well as exerting satiating effects. Foods with a high GI are digested and metabolised more rapidly, giving rise to large fluctuations in blood glucose level and insulin secretion, and will leave you sooner hungry again, looking for a snack. The continue intake of high-glycaemic meals is considered, among other factors such as high-fat diets, to be associated with an increased risk of obesity and chronic diseases. In the context of a low-glycaemic diet, non-digestible food ingredients such as inulin and oligofructose do not contribute to the GI and/or GL of a meal and may exert beneficial effects on postprandial glycaemia and insulinaemia.

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Carbohydrates as part of our everyday diet

Our daily diet contains three major groups of food constituents: proteins, fats and carbohydrates which fulfil the energy demands to our body. Important differences exist in the amounts of calories they actually deliver. Dietary fat delivers almost twice the amount of calories (9 kcal/g) compared with the same amount of carbohydrate (4 kcal/g). In other words, to ingest the same amount of calories from high-fat food you can almost double your carbohydrate intake. Current dietary guidelines advise to get less than 30% of your daily calorie intake from fats, about 10% from proteins, and the remainder (50-60%) provided by carbohydrates. Different carbohydrate fractions exert, however, very distinct physical and physiological properties in the gastro-intestinal tract, which is a major cause of misunderstanding of their physiological and metabolic properties nowadays.

Not all carbohydrates are the same

Probably the easiest way to distinct carbohydrates is by chain length: mono-, di- , oligo-, and polysaccharides. Inulin and oligofructose are medium-chain carbohydrates which are naturally occurring e.g. in leek, onion, garlic, asparagus, Jerusalem artichoke and chicory. A more physiological way of distinguishing them is according to their digestibility in the gastro-intestinal tract.
Carbohydrates such as glucose, sucrose, lactose and starch are easily digested in the gastro-intestinal tract. Other carbohydrates such as cellulose cannot be hydrolysed by the human digestive enzymes. This has led to the dietary fibre concept. Chicory inulin and oligofructose are non-digestible carbohydrates that are classified as soluble dietary fibres. Their non-digestibility has been demonstrated in-vivo with ileostomised volunteers (Andersson et al., 1999). Carbohydrate behaviour in a particular food is not only dependent on its digestibility but also on its rate of digestion and energy release, which in turn are dependent on its chemical and physical structure, the way of food preparation, and the proportional amount of one carbohydrate to another.

The Glycaemic Index and the Glycaemic Load

The glycaemic index (GI) was developed to provide a numeric classification of the quality of available carbohydrates in foods based on their rate of absorption into the bloodstream (Jenkins et al., 1981). It is defined as the ratio of the integrated increase in blood glucose level in a 2-h period after ingestion of 50 g of available carbohydrates from a test food relative to the integrated blood glucose increase after ingestion of 50 g available carbohydrates coming from the reference food (either glucose or white bread), multiplied by 100 (Wolever et al., 1991). Standard cut-off points are: very low GI: GI of 39 or less, low GI: 40-55, moderate GI: 56-69, and high GI: 70 and above. Only few foods have a GI below 40, which is one of the challenges faced by individuals who want to moderate their blood glucose level after a meal.

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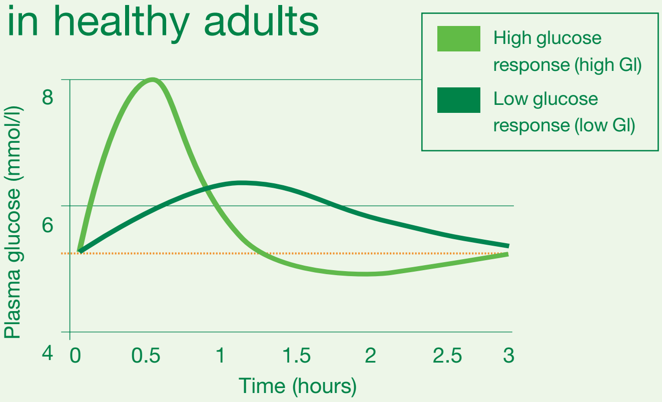
Glycaemic response in healthy adults



Plasma glucose response (mmol/l) from a high versus a low GI food. The change in blood glucose concentration over time is expressed and calculated as the area under the curve (AUC) (Wolever et al., 1991).

GI is expressed as:

$$GI = \frac{\text{AUC of the test food (50 g)}}{\text{AUC of the reference food (50 g)}} \times 100$$

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Quantity matters as well …

Not only carbohydrate quality but also quantity affects glucose response after food intake. The glycaemic load (GL) of a food is calculated by multiplication of its GI by its available carbohydrate content. Providing GL values of foods allows the consumer to estimate the effect a particular food 'serving' has on his/her glycaemic response. Most carbohydrate-containing foods with high GIs also have high GLs if they are consumed in the standard serving size, but some exceptions do exist. A carrot has a high GI but a low GL, in contrast to a potato in which both are high. Even a food with a moderate GI can generate a large GL, if it is dense in carbohydrates or if it is consumed in excess. From a consumer point of view solely applying the GI may be just not helpful enough such as when comparisons have to be made between foods with different carbohydrate contents or when additional quantities of some foods are consumed (consumption of 3 muesli bars versus 1 has the same GI but generates a GL multiplied by three).

Al dente or fully cooked

The GI of a food is dependent on several factors. Food structure slows down digestion for mechanical reasons. Therefore, any process disrupting tissue or cellular structure of food increases its glycaemic response. In starchy foods, gelatinisation of the starch molecules during cooking increases their availability to amylase and therefore the GI. The chemical structure of food is another determining factor. High amylose to amylopectin ratios are considered to be accompanied with lower glycaemic responses. The presence of viscous dietary fibres delays gastric emptying and absorption, because of their thickening or gel-forming properties. They act as a physical barrier to glucose diffusion in the small intestine. Other dietary factors affecting food digestibility are the presence of antinutrients or the co-ingestion of lipids and proteins (Björk et al., 1994).

Good for you carbs

Foods should not be considered as "good" or "bad" simply on the basis of their GI or GL. The GI can be useful for various clinical conditions (obesity, diabetes, hyperlipidemia) and it can also be applied in sport performance. Several lists of the GI or GL of single food items have been published (Foster-Powell et al., 2002). Table 1 gives some GI and GL values. Glucose has the highest GI (100), whereas fructose has a low GI (19) because it requires metabolic transformation in the liver which is a slow process. The GI of table sugar (sucrose) is somewhat intermediate at 68. Interesting is the observation that no direct relation exists between the sucrose content of foods and their individual GI values (Jenkins et al., 1985; Brand-Miller, 1994). Refined grain products and potato have a high GI, almost similar to the one of table sugar or even exceeding it. On the contrary, non-starchy vegetables (such as fruits, legumes) have low GI values, as well as whole grains. Inulin and oligofructose are dietary fibres that are not digested in the upper gastro-intestinal tract, but rather reach the colon intact where they are completely fermented by beneficial bacteria such as bifidobacteria and lactobacilli. As they are neither hydrolysed by human digestive enzymes, nor absorbed as such in the blood circulation, their ingestion does not influence glycaemia. Consequently, their GI value is virtually zero or non-existent. Since the GI of inulin and oligofructose is negligible those ingredients do not contribute to the glycaemic load of a food portion.

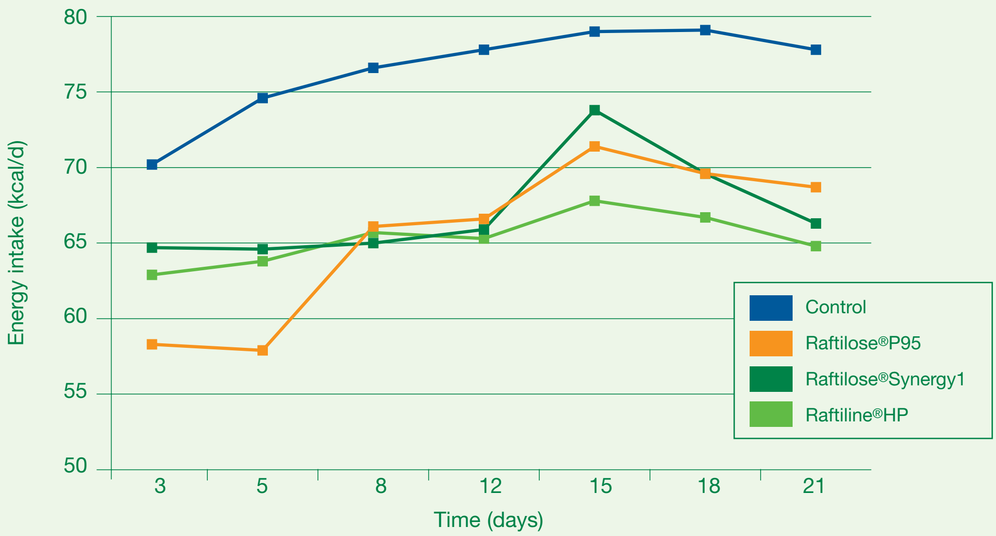
FOOD ITEM	GI (GLUCOSE=100)	FOOD PORTION (G)	CARBOHYDRATES (G) / PORTION	GL / PORTION
SUGARS				
Fructose	19 ± 2	10	10	2
Sucrose	68 ± 5	10	10	7
BREADS				
French baguette	95 ± 15	30	15	15
Bread (white)	63 ± 10	60	32	20
Bread (rye, whole grain)	58 ± 6	30	14	8
ROOT VEGETABLES				
Potato (baked)	85 ± 12	150	30	26
Potato (cooked)	50 ± 9	150	28	14
PASTA				
Spaghetti (boiled)	58 ± 7	150	36	21
BREAKFAST CEREALS				
Corn flakes	81 ± 3	30	26	21
CEREAL GRAINS				
Rice (white, parboiled)	88 ± 3	150	36	32
Rice (brown, parboiled)	64 ± 7	150	36	23
FRUITS				
Apple	38 ± 2	120	15	6
Pear	38 ± 2	120	11	4
VEGETABLES				
Carrots, cooked	71	55	4	3

Adapted from Foster-Powell et al. (2002); Nutrinews (2003), 1: 14-19.

GL is calculated as:

$$GL = \frac{\text{GI of a food x Carbohydrates (g) in that food}}{100}$$

Fructans decrease energy intake



Dietary energy intake (kcal/d) of rats fed a control diet, or a diet supplemented with oligofructose (Raftilose®P95), inulin (Raftiline®HP), or a mixture of both (Raftilose®Synergy1). Mean values are given (six rats per group). Mean values in the supplemented groups are significantly different from those of the control rats (Cani et al., 2004).

The glycaemic response from a meal

Most of the time we do not eat single foods but rather combine them into mixed meals. The predictability of the glycaemic response from a meal by pooling individual GI values of its component foods is supported in studies. For example, Jenkins and co-authors already demonstrated in 1984, that mixing equal proportions of two carbohydrate foods of different GI together into one meal, results in a blood glucose response in diabetics somewhere midway between those of each food alone. Despite the overall effects of carbohydrates on GI, of course also other macronutrients in a meal influence GI. Dietary fat slows down gastric emptying and glucose absorption. Apart from this, ingestion of high fat or high protein meals gives rise to a fast clearance of blood glucose. Both mechanisms lower the GI of a meal (Flint et al., 2004).

Considering all those influences, it still appears that neither fat nor protein do obscure the cumulative effect of the component carbohydrates in assessing GI by the incremental blood glucose response areas (Wolever & Jenkins, 1986).

High glycaemic versus low glycaemic foods: glucose as the ultimate fuel

All available carbohydrates in foods are ultimately digested and absorbed as glucose. Eating foods with different GI changes temporally blood glucose levels inducing a sequence of hormonal changes. Blood glucose level is maintained in the body within a tight range and after a meal insulin is immediately released by the pancreas to normalise it. 2 to 4 hours after the ingestion of a meal, nutrients are almost completely absorbed and normal insulin levels are maintained. After 4 to 6 hours, low circulating levels of glucose and free fatty acids stimulate the release of counter regulatory hormones (glucagon, cortisol, epinephrine, growth hormone) in an attempt to restore levels in the post-absorptive phase. Liver glycogen is released into the blood as glucose, and stored fat as free fatty acids, serving as metabolic fuels. High GI or GL meals trigger the release of huge amounts of insulin to bring down high blood glucose levels, which suddenly drop often to the hypoglycaemic range. These very low circulating concentrations of metabolic fuels (glucose and free fatty acids) provoke a counter regulatory hormone response to restore levels. This resembles a state of fasting normally reached only after many hours without food. The individual falls again in a state of hunger after a short time and can only be satisfied by the over-consumption of calories in the next meal or snack. Such dramatic hormonal shifts do not occur following meals with low GI or GL values. They take longer to digest and absorb, consequently hyperinsulinaemia and reactive hypoglycaemia do not occur. Satiety is prolonged, appetite and food intake are more controlled with low glycaemic meals (Ludwig et al., 1999a; Agus et al., 2000; Warren et al., 2003).

Dietary fibres are proposed as key nutrients in increasing satiety and reducing energy intakes. Besides soluble fibres that increase viscosity of the food bolus with corresponding beneficial effects, recent studies also indicate an important role for inulin and oligofructose in controlling food intake. Consumption of inulin and oligofructose enhanced satiety and reduced energy intake in normal and obese rats (Daubioul et al., 2002; Cani et al., 2004). It appears that the mechanisms responsible for these effects include the release of satiety-inducing hormones such as GLP-1 amide and the precursor proglucagon mRNA in the colon (Kok

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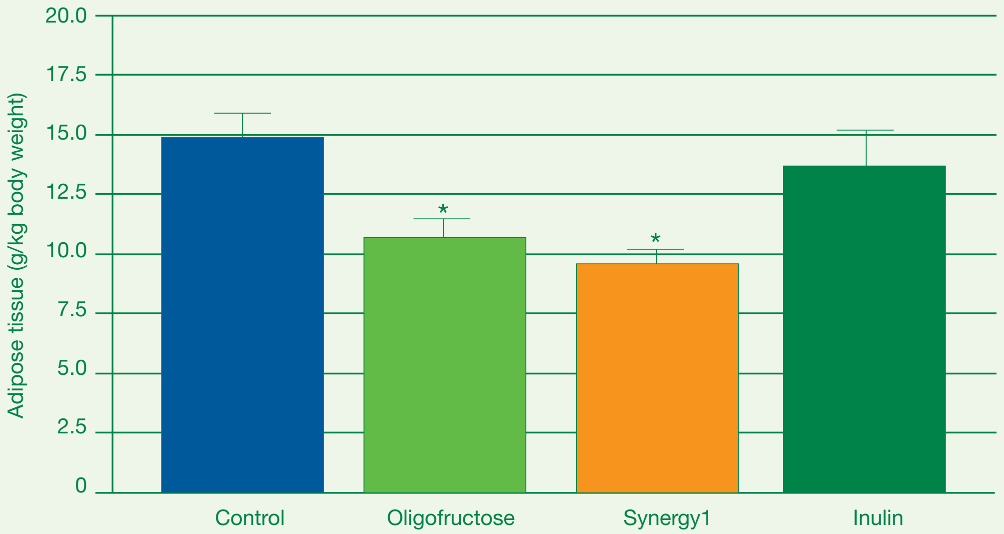
et al., 1998). These hormones could constitute a link between the outcome of fermentation in the lower part of the gut and the systemic consequences from the intake of inulin-type fructans. Similar satiating effects are seen in humans.

A recent study performed by Delzenne and co-authors demonstrated that healthy men and women who received oligofructose-enriched meals twice a day, felt better satiated after their breakfast and dinner, were less hungry and had a lower prospective food intake (personal communication). Overall they had lower energy intake which indicates an important role of inulin-type fructans in modulating energy balance in humans consuming a diet ad libitum.

All calories are not alike

Obesity is the largest global chronic health problem in adults and will be the leading cause of death and disability of this century. Nowadays, almost one third of people living in European Union are overweight and more that one in ten is clinically obese. Numbers in US are even more dramatic. At this point, there remains no general consensus over what specific dietary factors, if any, have been primarily responsible for this condition. The concept a "calorie is a calorie" that underlies most conventional weight loss strategies advising strict calorie-restriction shows poor effectiveness in the outpatient setting. Looking from a hormonal point of view we should start recognising that all calories are not the same. The carbohydrates that typically replace fat in those low fat-low calorie diets are merely high in GI (such as starchy foods). High glycaemic response to meals induces a sequence of hormonal changes that promote anabolic processes, promoting over-eating (Bell & Sears, 2003). This higher voluntary energy intake, if maintained over several months, produces substantial increases in body weight. A recently published study shows beneficial effects by the use of low GI meals on long-term weight loss by altering resting metabolic rate, reducing hunger and increasing satiety, while increasing fat oxidation (Pereira et al., 2004). Similarly, overweight men put on isocaloric high versus low GI meals showed lower body fat mass on the low GI diet (Bouche et al., 2002). In a study performed in 107 obese children, weight loss was significantly improved after 4 months following a low GI pediatric diet plan compared to a traditional energy-restricted diet (Spieht et al., 2000). These observations indicate that low glycaemic diets help to loose body weight and to combat obesity. Also inulin and oligofructose have the potential of being helpful in controlling the plurimetabolic syndrome associated with obesity. Inulin-type fructans have clear systemic consequences, for example on body fat mass development. Studies in animals demonstrated that supplementation of their diets with oligofructose or inulin significantly ($P < 0.05$) decreased the weight of adipose tissue by 30% after a short period of 3 weeks, as compared with the controls (Cani et al., 2004).

Fructans decrease body fat mass



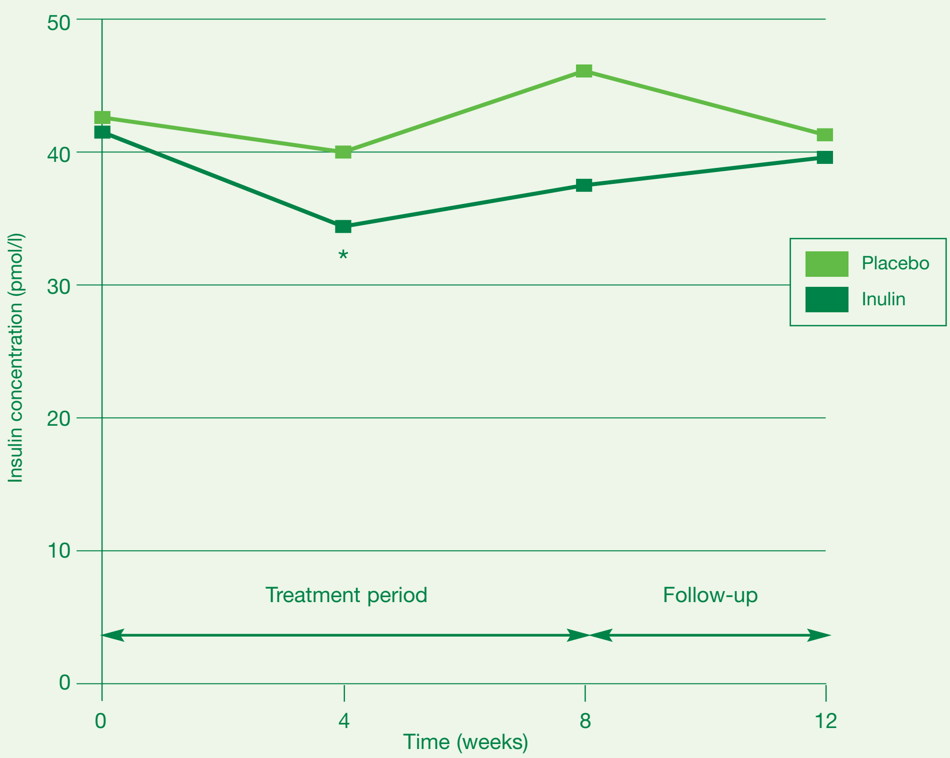
Weight of the epididymal adipose tissue in rats fed a control diet, or a diet supplemented with oligofructose (Raftilose®P95), inulin (Raftiline®HP), or a combination of both (Raftilose®Synergy1). Values are means with their standard errors shown by vertical bars (six rats per group). *: Mean values are significantly different from controls for rats fed diets supplemented with oligofructose or Synergy1 ($P < 0.05$) (Cani et al., 2004).

Low glycaemic diets, diabetes and cardiovascular disease

Having too much body fat increases the risk for type-2 diabetes and coronary heart disease. Obese people have high levels of blood fats since their storage cells are overwhelmed, leading to faulty fat storage in liver and muscle. When fatty acids or breakdown products accumulate, they trigger insulin resistance, blocking the insulin signal, which explains the high risk of obese people for developing sec-

ondary diseases. Besides this, continuous exposure to high GI meals causes functional hyperinsulinaemia on the long-term, leading to insulin resistance, pancreatic exhaustion and finally damage to the ß-cell function with development of type-2 diabetes. High insulin levels inhibit counter regulatory actions that would normally be initiated as response to low levels of circulation fuels. Decreased secretion of glucagon suppresses glycolysis, whereas the diminished lipase activity lowers lipolysis, limiting access to metabolic fuels. In subjects with impaired glucose tolerance, lower plasma glucose and free fatty acid concentrations were observed with a high-carbohydrate, low-GI diet than with a high-carbohydrate, high-GI diet (Wolever et al., 2003). In another study, women who consumed a diet with a high GL showed a 40% greater risk for diabetes than those who consumed a diet with a low GL (Salmeron et al., 1997a). Similar results were obtained in men (Willett et al., 2002; Salmeron, 1997b). These findings are consistent with others that showed a strong inverse relationship between the intake of dietary fibres and the risk of diabetes. Especially cereal fibres were strongly associated (Schulze et al., 2004). Intake of white bread and starch, on the other hand, are known to be associated with increased risk, while the risk decreased with sugars (from fruit) and high intake of total carbohydrates (Hodge et al., 2004). Thus the

Inulin decreases fasting insulin levels



Fasting plasma insulin concentration in adult volunteers receiving either inulin (10 g/d Raftiline®HP) or placebo for 8 weeks. Samples were taken at baseline (week 0), week 4 and week 8 of the supplemental period, and a follow-up sample was taken at week 12. Blood samples were collected following a 12h overnight fast. Values are means for 27 volunteers in each group. *: Mean value is significantly different from that at baseline ($P < 0.01$) (Jackson et al., 1999).

consumption of low GI diets appears to be beneficial in the prevention of diabetes (Hodge et al., 2004).

Inulin and oligofructose are dietary fibres that exert important health benefits and help reducing glycaemic and insulinaemic responses. Studies have demonstrated significantly lower blood glucose and insulin concentrations in rats fed oligofructose (as Raftilose®P95) (Kok et al., 1998). Also in humans, test meals containing oligofructose showed a trend for lower glycaemic responses and peak insulin levels (Rumessen et al., 1990). It also appears that moderately dyslipidemic men and women may benefit from fructan supplementation. In 54 middle-aged subjects, a 4-week daily inulin supplementation (10 g Raftiline®HP) was shown to significantly ($P < 0.001$) improve their fasting insulin concentrations (Jackson et al., 1999). Fasting triacylglycerol levels were also significant ($P < 0.05$) lower in the inulin group compared with the placebo group. These data are supported by findings from animal studies showing that fructans influence the formation/degradation of triacylglycerol-rich particles, and attenuate post-prandial insulin levels.

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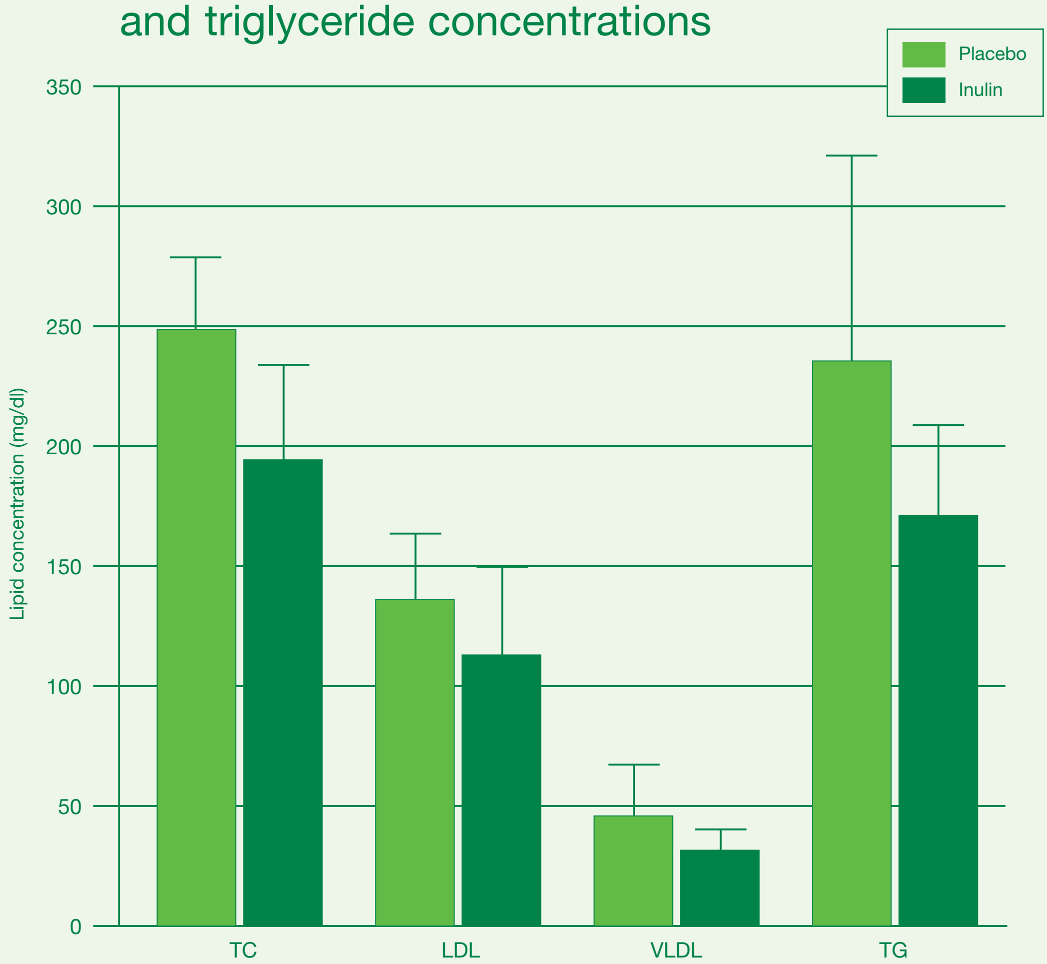
Besides the effect that adiposity has on the etiology of diabetes, it is also recognised as a major risk factor for coronary heart disease (CHD). Evidence is accumulating about the role of insulin resistance in the etiology of CHD (Frost et al., 1996; 1998) and the effect of postprandial glycaemia on oxidative stress and cardiovascular disease (CVD) risk (Cerriello et al., 1999). Increasing emphasis is also being placed on the control of triacylglycerol concentrations in order to reduce the risk of cardiovascular disease. Follow-up of 280 healthy post-menopausal women showed a clear positive association between GI (and also GL) and fasting triacylglycerol levels (Liu et al., 2001).

In the Coronary Artery Risk Development in Young Adults (CARDIA) study, the role of dietary fibre on CHD risk factors was investigated in 2909 healthy subjects. Fibre consumption was considered to protect against cardiovascular disease, because of its beneficial effects on various cardiovascular risk factors, such as levels of insulin, triglyceride and LDL cholesterol, among others (Ludwig et al., 1999b).

The effects of inulin and oligofructose in dyslipidemic and obese subjects have been demonstrated in clinical trials. Increasing evidence supports the use of these fructans for reducing risk factors associated with atherosclerosis and coronary heart disease. A double-blind and placebo-controlled clinical trial in obese, hypertriglyceridemic and hypercholesterolemic young adults administered 7g of inulin per day showed significant ($P < 0.05$) reduced total cholesterol, LDL, VLDL, and triglyceride concentrations after 4 weeks (Balcazar-Munoz et al., 2003). Similarly, the addition of 10g/d inulin (Raftiline®HP) to a moderately high-carbohydrate, low-fat diet beneficially affected plasma lipids, by decreasing hepatic lipogenesis and plasma triacylglycerol concentrations, in relation to placebo in adult volunteers (Letexier et al., 2003).

Inulin lowers total cholesterol, LDL, VLDL and triglyceride concentrations



Lipid profiles in obese, hypertriglyceridemic and hypercholesterolemic young adults (n=12), receiving either a placebo or 7g/d of inulin. Values are given as means ± SD. Differences were significant between both groups for all parameters ($P < 0.05$). TC: total cholesterol, LDL: low density lipoproteins, VLDL: very low density lipoproteins, TG: triglycerides (Balcazar-Munoz et al., 2003).

Dietary fibre as the most important player

Focusing diets on ‘low carb’ or 'low fat' is just too simplistic from the perspective of obesity prevention or reduced risk for its related diseases. Glycaemic response, insulin sensitivity and lipid metabolism are intimately related and the whole diet exerts a major impact. A growing body of theoretical and experimental work, as well as long-tem observations, suggest that diets designed to lower the insulin response to ingested carbohydrates (low GI and/or GL diets) may improve access to stored

metabolic fuels, decrease hunger, and promote weight loss. Such a diet contains abundant quantities of vegetables and fruits, moderate amounts of proteins and healthful fats, and a low intake of refined grain products, potatoes and refined sugars (Ludwig, 2000). It also appears that more benefits can be obtained by increasing the amount of dietary fibres in our daily diet rather than pinpointing our mind to the bad guys.

The role of inulin and oligofructose

Food products may benefit from changes in formulation to lower their GI and/or GL values, be it a change in ingredients or a change in the way that the food products are processed. Inulin and oligofructose are currently found as food ingredients in bread and baked goods, breakfast cereals, yoghurts, ice-cream and other dairy products because they improve the mouthfeel and appearance of lower-energy dense products. Oligofructose is also often used as an alternative to high GI sugars, whereas inulin can replace fat (Franck, 2002). They can contribute to both a reduction in energy intake and improved glycaemia and insulinaemia, as demonstrated by animal and human studies. The GI of oligofuctose and inulin being negligible, they do not contribute to the overall GL of a meal. Thus, inulin and oligofructose are soluble dietary fibres and they serve as important ingredients that can be used by the food industry to improve the glycaemic effects of food products.

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What is the difference between fructo-oligosaccharides synthesised from sucrose and inulin-type fructans obtained from chicory ?

Inulin-type fructans (inulin and oligofructose) consist of a family of ß 2→1 fructo-oligomers and polymers varying in degree of polymerisation (DP). They can be obtained from chicory. In the chicory root, the DP of the native fructans ranges widely from 2 to more than 60 with an average DP (DPav) in the order of 10-12. Commercial chicory inulin is obtained by hot-water extraction of the naturally occurring inulin from the roots by a process that is fairly similar to the extraction of sucrose from sugar beets. Chicory-derived oligofructose (e.g. Raftilose®P95) is obtained by partial enzymatic hydrolysis of inulin (using an inulinase) and has a DPav of 4. It contains a mixture of both GFn-type ($2 \le n \le 7$) and Fn-type ($2 \le n \le 8$) molecules, where G is glucose, F is fructose and n is the number of ß 2→1 bound fructose moieties. Chicory inulin and oligofructose selectively modify the composition and metabolic activity of the human gut flora leading to colonic bifidobacteria predominance. From human studies it appears that both GFn and Fn structures exert the same strong bifidogenic properties (Menne et al., 2000; Roberfroid et al., 1998). Synthesised fructo-oligosaccharides are only composed of short-chain molecules (sc-FOS) with DPav of 3.6. They are produced from sucrose by trans-fructosylation using a ß-fructosidase. The main sc-FOS components are 1-kestose (GF1), nystose (GF2) and fructosylnystose (GF3). Thus, chicory oligofructose and its chemically obtained counterpart (sc-FOS) are actually composed of the same building blocks and have about the same DP. They also share similar physiological effects.

Fructans obtained from chicory offer the additional advantage of also comprising long-chain polymers that can be separated from the native inulin. Native chicory inulin (e.g. Raftiline®ST) has a DPav of 10-12 whereas long-chain inulin (e.g. Raftiline®HP) has a DPav of 25. From a nutritional point of view the degree of polymerisation is particularly important since new scientific evidence is showing that fructans with different DP have distinct physiological properties (Van Loo, 2004). Fructans with a low degree of polymerisation (< 10) are intensively and rapidly fermented in the colon and they modulate the intestinal flora (bifidogenic effect) in the proximal part of the large intestine. Longer-chain fructans, on the other hand, are more slowly fermented and thus reach more distal parts of the colon. In this part of the intestine there are much less easily fermented carbohydrates available, so the bacterial catabolism usually shifts towards proteolysis, resulting in the production of toxic putrefactive products. Long-chain inulin is able to revert the proteolytic activity into a beneficial saccharolytic fermentation (Tuohy et al., 2001).

Taking advantage of this, the specific properties of both oligofructose and inulin are uniquely combined in Raftilose®Synergy1 (a specific spray-dried combination of oligofructose and long-chain inulin). The short-chain fraction of this product modifies the bacterial flora in the proximal part of the colon whereas the longer-chain fraction maintains the beneficial metabolic activity into more distal parts of the large intestine. Synergy1 has been scientifically shown to offer superior physiological benefits in comparison with its individual components (inulin and oligofructose) taken separately (Van Loo, 2004).

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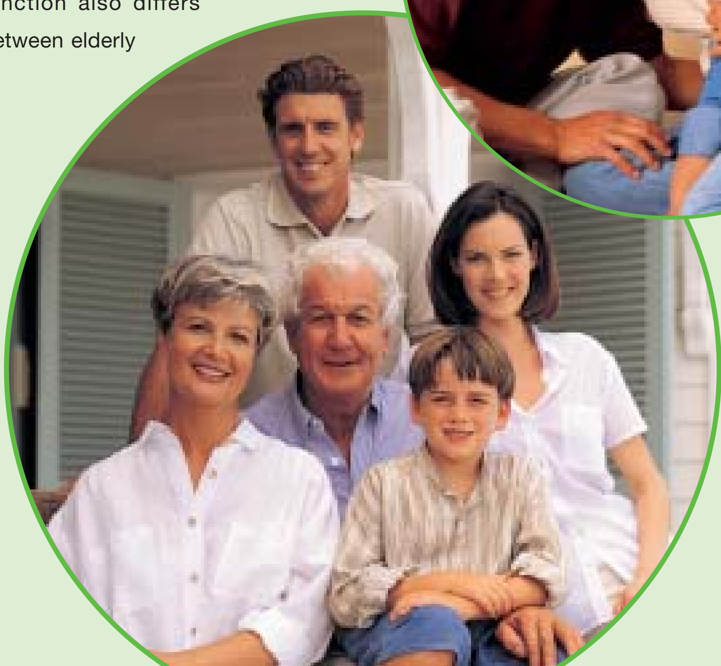
Are the prebiotic effects of inulin and oligofructose influenced by age and regional differences ?

The intestinal microbiota can be considered as a metabolically adaptable and rapidly renewable organ of the body. During early infancy, bifidobacteria are the most prevalent organisms in the large bowel and numbers are much higher in breast-fed than in formula-fed infants. Breast milk creates an environment favouring the development of a simple flora dominated by bifidobacteria. Formula-fed infants have a more complex pattern in which bacteroides, clostridia, and streptococci are prevalent. Prebiotics have been effectively used in infant formulae to increase the numbers of bifidobacteria in the gut of formula-fed infants and to make their microbial ecology more similar to that of breast-fed babies. As solid foods are introduced in the infant's diet, major disturbances in the microbial ecology occur with numbers of enterobacteria and enterococci increasing sharply as well as increased colonisation by bacteroides, clostridia, and streptococci. At weaning, dietary supplementation with oligofructose increases levels of faecal bifidobacteria with subsequent beneficial health effects. During childhood, bacterial populations start to increase in numbers and complexity, resembling more and more the adult-like flora. Day-to-day variations and diet-induced changes in microbial populations are less pronounced in adults. Once the microflora has become established the major bacterial groups in the large intestine remain relatively constant with time. Studies with healthy adult volunteers found however, that supplementation of the diet with inulin and oligofructose can modulate this situation and beneficially alters the composition of the gut flora with increasing numbers of bifidobacteria (Gibson et al., 1995; Rao, 2001). With further ageing structural changes do occur again and protective intestinal micro-organisms such as bifidobacteria decrease in numbers, while putatively detrimental populations such as clostridia and enterobacteria increase. Recent data from the Crownalife EU-project demonstrate that the colonic microbial composition and function also differs between elderly people living in different European countries (France, Germany, Sweden, and Italy). Studies in elderly volunteers revealed that inulin supplementation reverses these detrimental changes (often accompanied by intestinal disease or disorders) and improves gastro-intestinal health (Kleessen et al., 1997).

In conclusion, although the microbial ecology of the large bowel evolves throughout lifespan with inter-regional differences (Europe, Asia, USA…) the prebiotic effects of inulin and oligofructose appear to be rather universal.



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Supplement with synbiotic protects against infections in the elderly

Ageing is associated with alterations in the immune responsiveness that increase susceptibility to infections, reduce the response to immunisation, and increase the incidence of auto-immune diseases. The preservation of an adequate natural killer (NK) cell function is considered part of a successful ageing. The objective of the present study was to assess the effects of a nutritional supplement on the immune function and response to vaccination against influenza and pneumococcus in 60 healthy elderly persons (aged ≥ 70). The supplement contained 480 kcal, 32 g proteins, vitamine E, vitamin B12, folic acid, 10^9 cfu *Lactobacillus paracasei* and 6 g of a mixture of oligofructose (as Raftilose®) and inulin (as Raftiline®) in a 2:1 ratio, and was taken daily in addition to the regular diet. After 4 months of follow-up, NK cell activity increased in the supplemented group, whereas it decreased in controls compared to baseline. Differences between both groups were highly significant at this stage ($P < 0.001$). NK cell activity is one of the first-line defense mechanisms against viral infections. At 4 months all persons were vaccinated. After vaccination, production of IL-2 by peripheral blood mononuclear cells (PBMC) did not change in the supplemented individuals, and decreased significantly in controls ($P < 0.05$). One of the functions of IL-2 is to stimulate NK cell activity. Moreover, most elderly persons had a positive antibody response to the vaccine, but no additional effect of the supplement was observed between groups. During the 1-y follow-up, supplemented subjects reported fewer infections (14.5 %) compared with the controls (24.4 %). The results of this clinical trial show that healthy elderly subjects receiving a nutritional supplement containing a synbiotic improved their immune response as evidenced by an improvement in NK cell activity, a better IL-2 secretion by stimulated PBMC, and a lower incidence of infections.

Bunout, D.; Barrera, G.; Hirsch, S.; Gattas, V.; Pia de la Maza, M.; Haschke, F.; Steenhout, P.; Klassen, P.; Hager, C.; Avendano, M.; Petermann, M.; Munoz, C. (2004) Effects of a nutritonal supplement on the immune response and cytokine production in free-living Chilean elderly. J. Parenteral Enteral Nutr., 28: 348-354.

Scientific evidence for prebiotic nature is strongest for inulin and oligofructose

The present paper updates the criteria a prebiotic should fulfill, gives a conscious overview of the prebiotic nature of well-established prebiotics and evaluates the prebiotic potential of candidate ingredients. Many dietary oligo- and polysaccharides are claimed to be prebiotic, sometimes without due consideration of the criteria required. Briefly, those are: 1) resistance to gastric acidity, no hydrolysis by mammalian enzymes or gastro-intestinal absorption, 2) fermentation by the intestinal microflora and, 3) selective stimulation of the growth and/or activity of intestinal bacteria associated with health and well-being. The third criterion is probably the most contentious and difficult to fulfil. Besides anaerobic sampling, it requires reliable and quantitative microbiological analyses, preferably molecular-based approaches. Today, only three types of carbohydrates, essentially non-digestible oligosaccharides, fulfill the criteria for prebiotic classification. These are inulin and oligofructose, transgalacto-oligosaccharides (GOS), and lactulose (although not a food ingredient). From detailed literature evidence, however, only inulin and oligofructose completely fulfil all three criteria. Evidence on the non-digestibility of GOS and lactulose in vivo is still lacking, although their classification as prebiotics can be generally accepted.

Gibson, G.R.; Probert, H.M.; Van Loo, J.; Rastall, R.A.; Roberfroid, M. (2004) Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. Nutr. Res. Rev., 17: 259-275.

Inulin-type fructans reduce xenobiotic-induced hepatic DNA damage in rats associated with a human flora

Heterocyclic amines (HAs) are carcinogenic substances found in many foods that are primarily formed by heating during food preparation. They are important risk factors in the etiology of human cancers. The aim of this study was to investigate the protective effect of either a fermented milk, oligofructose (Raftilose®P95), oligo-fructose-enriched inulin (Raftilose®Synergy1), or Brassica vegetables towards the 2-amino-3-methylimidazo [4,5-f] quinoline (IQ-) induced genotoxicity in rats associated with a human flora. IQ is a potent carcinogen for liver and colon. Bacterial metabolisation of glucuronic acid-HA conjugates can generate reactive metabolites, which can be transported trough the enterohepatic circulation and cause hepatic DNA damage. Rats

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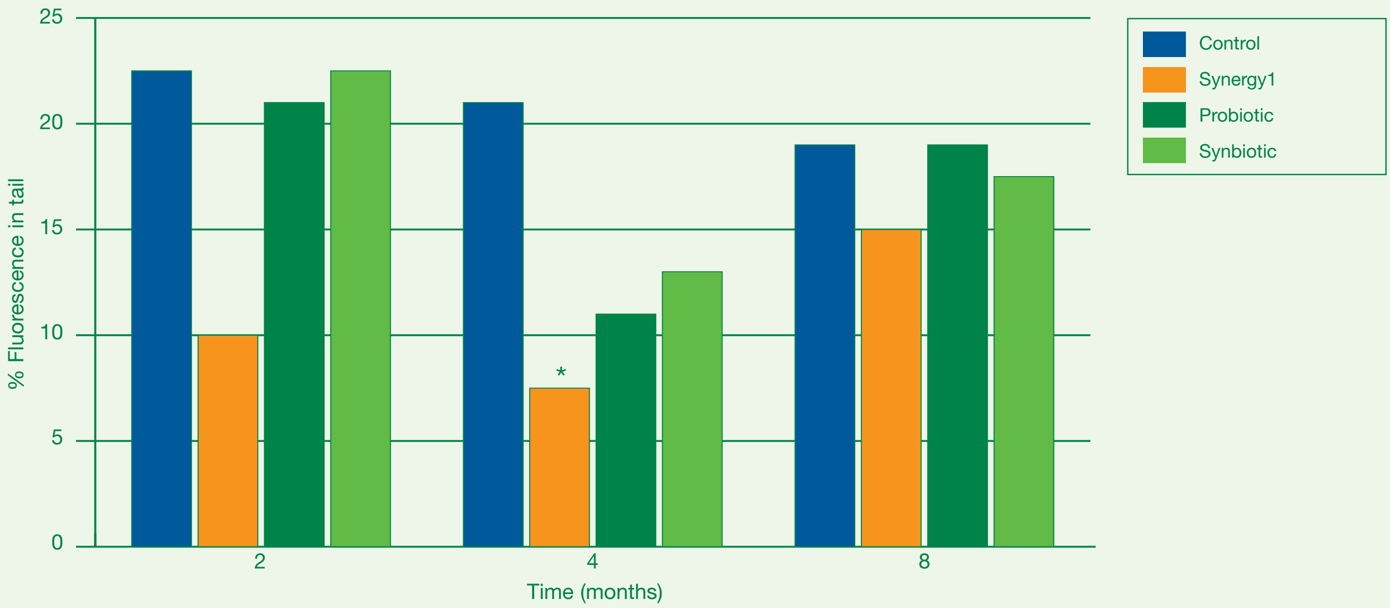
Inulin-type fructans decrease the genotoxicity of faecal water of neoplastic rats

Recent studies found that the combination of inulin and oligofructose (Raftilose®Synergy1) alone or with probiotics protects rats against chemically-induced colon cancer (Femia et al., 2002). The challenges we still need to face are the mechanism through which prebiotics affect pathways of tumour initiation. This study was conducted to elucidate whether the fermentation of inulin-type prebiotics leads to a reduced faecal water genotoxicity in rats with pre-neoplastic lesions or tumours. Animals were supplemented during 8 months with either a combination of inulin and oligofructose (as Raftilose® Synergy1) as a prebiotic, *Lactobacillus rhamnosus* and *Bifidobacterium lactis* as a probiotic, pre- and probiotic together as a synbiotic, or maltodextrins as control. Aqueous faecal extracts of the different groups of rats were taken at 2, 4, and 8 months, and tested for genotoxicity in colonic cell lines (HT29). Human colon cells were used as target because they are considered to be surrogates of the human colonic epithelium in vivo. DNA damage in the human cells was determined by the 'comet assay'. Damaged DNA is visualised as a 'comet' as consequence of the migration of the damaged DNA within an electrical field. Overall, only the prebiotic diet yielded faecal water that was less genotoxic than the one from the control rats, and the difference was significant at 4 months ($P < 0.05$). No differences existed between the probiotic nor the synbiotic group and the controls. Compared with baseline, only both diets containing Synergy1 were effective in reducing the genotoxic potential of the faecal water and this after 4 and 8 months. In the animals receiving Synergy1 alone, the genotoxicity of the faecal water was lower already after 2 months, which reflects a more rapid onset of the anti-genotoxic efficacy. The protective effect of Synergy1 persisted throughout the experiment (up to month 8) in the pre-neoplastic animals. In the tumour-bearing animals, however, this beneficial effect could not be maintained until the end of the experiment, indicating that the onset of pathological lesions is a contributing factor to faecal water genotoxicity (and tumour progression). The results of this study demonstrate that inulin-based diets reduce exposure to genotoxins in the gut, and therefore lead to the prevention of tumourogenesis.

Klinder, A. ; Förster, A. ; Caderni, G. ; Femia A.P.; Pool-Zobel, N.L. (2004) Fecal water genotoxicity is predictice of tumor-preventive activities by inulin-like oligofructoses, probiotics (Lactobacillus rhamnosus and Bifidobacterium lactis), and their synbiotic combination. Nutrition and Cancer, 49: 144-155.

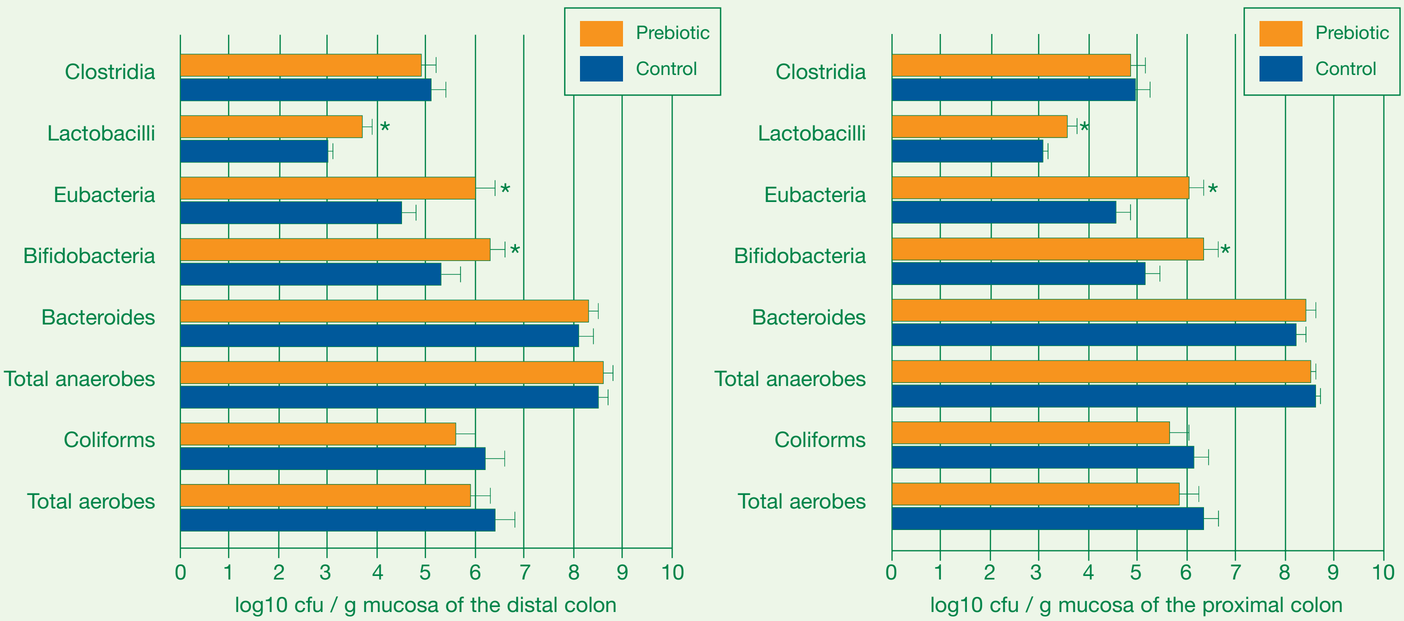


Genetic damage induced in HT29 colonic tumour cells treated with rat faecal waters. Group means are based on the percent fluorescence in tail . * $P < 0.05$ compared to the control rats.

Inulin and oligofructose stimulate mucosa-associated bifidobacteria and lactobacilli in humans

Bacteria that inhabit the large bowel can be distinguished into free living (planktonic flora) or in close association with the mucosa. This mucosa-associated flora (MAF) is critical for epithelial health through its ability to exclude pathogens, stimulate the development of the immune system, and moderate inflammatory responses. Factors that influence MAF are largely unknown, although there exists a clear cross-talk between epithelial cells, bacteria and the gut immune system. Inulin and oligofructose selectively stimulate the growth of bifidobacteria and lactobacilli in the colonic planktonic flora, thereby contributing to barrier function. The purpose of this study was to investigate whether inulin-type fructans exert the same effects in the MAF. An in-vitro chemostat model of surface-associated bacteria was used, followed by an intervention trial in 29 subjects undergoing colonoscopy who supplemented their daily diet for 2 weeks with a mixture of 7.5 g inulin (as Raftiline®HP) and 7.5 g oligofructose (as Raftilose®P95). In-vitro inulin and oligofructose strongly increased (by five-fold) surface counts of bifidobacteria from 6.6 to 7.3 log10 cfu per slide (P < 0.001). Surface lactobacilli doubled in proportions, whereas clostridia counts decreased by two-fold. Concentrations of acetate, butyrate, and lactate increased substantially. Endoscopic biopsies from caecum, transverse and descending colon, and rectum showed a prebiotic effect in humans at all sites. Mucosal bifidobacteria in the proximal as well as the distal colon increased significantly (P < 0.01) by more than 1 order of magnitude (1 log10), the principal species being B. *angulatum*. Also the numbers of lactobacilli increased in the proximal and distal colon after supplementation. Numbers of lactobacilli increased by about 0.5 - 0.7 log10 after prebiotic-feeding compared with controls. There were also more eubacteria in prebiotic-fed subjects (P < 0.01), whereas no changes were observed in total aerobes and anaerobes, bacteroides, clostridia or coliforms. Inulin and oligofructose effectively stimulate surface-associated bifidobacteria and lactobacilli, thereby beneficially affecting the composition of the MAF and possibly contribute to epithelial health.

Langlands, S.J.; Hopkins, M.J.; Coleman, N.; Cummings, J.H. (2004) Prebiotic carbohydrates modify the mucosa associated microflora of the human large bowel. Gut, 53 : 1610-1616.



Effects on the composition of the mucosa-associated flora (MAF) of the proximal and distal colon after supplementing the diet of adult volunteers with 15 g/d of inulin and oligofructose. Values are expressed as means ± SEM (n = 14 in the prebiotic group, n = 15 in the control group) in log10 cfu / g mucosa. * : Indicates a significant difference between control and prebiotic groups (P < 0.05) (Langlands et al., 2004).

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were inoculated with a human flora to reflect the human situation. Brussels sprouts (Brassica vegetables) contain glycosinolates that can be transformed into bioactive compounds (isothiocyanates) which are considered chemopreventive. It was hypothesised that pre- and probiotics may also exert protective capacity through their beneficial effects on the colonic flora and their interplay with various bacterial enzymes. DNA damage was assayed by single cell gel electrophoresis assay (SCGE) and measuring comet tail lengths with fluorescence microscopy. All rats fed the experimental diets exhibited significantly lower DNA damage in their colon and liver cells than rats fed the control diet ($P < 0.05$). The protective effect on DNA liver damage was most pronounced with Synergy1 and lowest with Brassica vegetables, which reduced genotoxicity by 74% and 39%, respectively. In colonocytes again Synergy1, as well as the fermented milk, showed the strongest effects (70 % reduction in comet tail lengths), followed by oligofructose and Brassica vegetables (55% reduction versus controls). The chemopreventive effects of Brassica ingestion correlated with the induction of hepatic UDP-glucuronosyl transferase, which is an HAs-detoxifying enzyme.

Following fructan ingestion, bacterial metabolism in the gut was significantly altered with a lower pH, increased butyric acid production, and decreased activity of the ß-glucuronidase enzyme (by 50%), which may be factors involved in the anti-carcinogenic properties of inulin-type fructans.

Humblot, C.; Lhoste, E.; Knasmüller, S.; Gloux, K.; Bruneau, A.; Bensaada, M.; Durao, J.; Rabot, S.; Andriex, C.; Kassie, F. (2004) Protective effects of Brussels sprouts, oligosaccharides and fermented milk towards 2-amino-3-methylimidazo [4,5-f] quinoline (IQ)-induced genotoxicity in the human flora associated F344 rat : role of xenobiotic metabolising enzymes and intestinal microflora. J. Chromatography B, 803 : 231-237.

A preparation with inulin protects against hepatic encephalo-pathy in cirrhotic patients

Minimal hepatic encephalopathy (MHE) is a cognitive disorder, with psychomotor slowing, as well as deficits in attention, visual perception, and visuo-constructive abilities, that frequently occur in cirrhotic patients (for example alcohol-induced) and may seriously impair the patient's daily functioning. MHE is a predictive factor for the development of overt hepatic encephalopathy (HE). Studying the composition of the gut microflora of cirrhotic patients with MHE reveals that they have significant overgrowth with potentially pathogen Gram-negative (*E.coli*) and Gram-positive (*Staphylococcus spp.*) aerobic gut flora. Supplementation of MHE-patients for 1 month with either a combination of probiotics and fermentable fibres (10 g/d of which 25% inulin) or fibres alone, reversed overgrowth of these harmful bacteria and led to an increase in counts of *Lactobacillus spp.* ($P < 0.05$). Parallel with these changes both treatments reduced circulating blood levels of endotoxin ($P < 0.05$), which is a component of the cell wall of Gram-negative bacteria and indirectly associated with liver injury. Moreover, blood ammonia levels were lowered in both treatment groups ($P < 0.05$), and MHE was reversed in 50% of patients treated with either the synbiotic or fermentable fibres alone. Ammonia is believed to be a key factor in the pathogenesis of MHE. The lower circulating

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Probiotic *Bifidobacterium lactis* has highest substrate specificity towards oligofructose

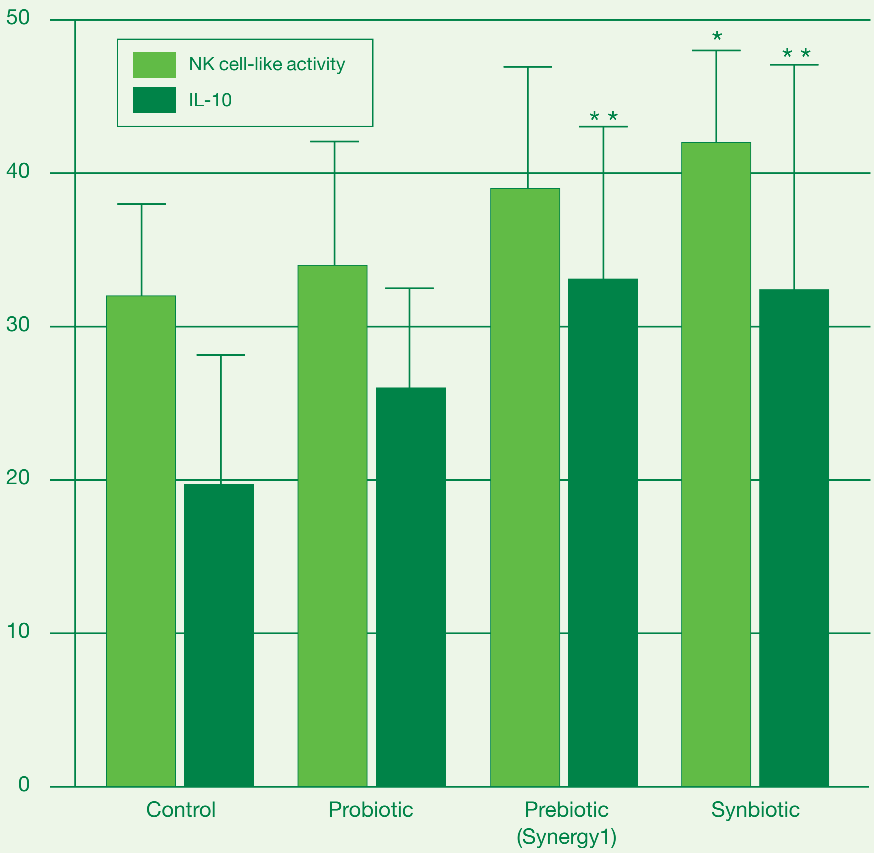
Nutritional interest in inulin and oligofructose lies in the fact that they selectively stimulate the growth of bifidobacteria in the human colon. Bifidobacteria indeed can efficiently utilise these substrates owing to the production of ß-fructofuranosidases (EC 3.2.1.26). Despite the increasing interest in oligosaccharide utilisation by these organisms, limited genetic information regarding their degradation pathway in bifidobacteria is known.

In this study, the ß-fructofuranosidase gene from *Bifidobacterium lactis* was identified and characterised. This ß-fructofuranosidase gene showed high identity with a similar gene (CscA gene) in *Bifidobacterium longum*. The deduced enzyme showed maximum activity towards oligofructose (as Raftilose®P95), to a lesser extent to inulin (as Raftiline®LS) and minimum activity towards long-chain inulin (as Raftiline®HP). From these data it appears that the characterised enzyme is highly selective for oligofructose, has high affinity towards ß (2→1) fructosyl-linkages, and that its specificity decreases as the degree of polymerisation (DP) of the fructan increases. The optimal growth of *B.lactis* on Raftilose®P95 could be explained by the presence of transport systems which are fitted for oligosaccharide uptake when the DP is below 8. The lack of growth of *B.lactis* on Raftiline®HP may indicate the absence of an extracellular inulinase capable of hydrolysing such large substrates.

Janer, C.; Rohr, L.M.; Pelaez, C.; Laloi, M.; Cleusix, V.; Requena, T.; Meile, L. (2004) Hydrolysis of oligofructoses by recombinant ß-fructofuranosidase from *Bifidobacterium lactis*. System. Appl. Microbiol., 27 : 279-285.

Synergy1 alone or as a synbiotic enhances immune functions involved in the prevention of colon cancer in rats

The present study investigated the long-term effects of probiotics, prebiotics and synbiotics on the immune system of rats. It was hypothesised that rats exposed to the colon carcinogen azoxymethane (AOM) and treated with either prebiotics or probiotics alone or both have different immune responses to this carcinogen. A previous study performed in the same rat model found that administering prebiotics alone or in combination with probiotics reduced the number of colonic tumours (Femia et al., 2002). In this study, the probiotic applied contained two strains of lactobacilli and bifidobacteria. The prebiotic used was an oligofructose-enriched inulin which is a 1:1 combination of long-chain inulin and short-chain oligofructose (Raftilose®Synergy1). It appeared that when administrating the carcinogen AOM to the rats their natural killer (NK) cytotoxicity in Peyer's patches (PP) was suppressed. NK cells are involved in both the recognition and subsequent elimination of tumour cells. Suppression of this NK-cell activity may subsequently contribute to tumour growth. Of particular importance was that supplementation with either the prebiotic alone or as a synbiotic prevented this carcinogen-induced NK-cell suppression in PP. After 33 weeks of treatment, immunological investigation of the rat's PP revealed significant higher NK cell-like activity after synbiotic administration as compared with the control or probiotic-fed rats ($P < 0.05$). Additionally, 33 weeks of pre- or synbiotic supplementation also significantly stimulated IL-10 production by PP cells in AOM-treated rats ($P < 0.01$). This increase in IL-10 cytokine production in PP was also found in a previous study after short-term exposure to Synergy1 (Roller et al., 2004). From this study it appeared that the reduced number of AOM-induced colon carcinomas in rats supplemented with Synergy1 alone or as a synbiotic coincided with a marked stimulation of immune functions within the gut-associated lymphoid tissue (GALT) and that PP is the primary lymphoid tissue responsive to this oral intake of prebiotics or synbiotics.



Natural Killer (NK) cell-like activity and IL-10 (ng/l) production (numbers were divided by 10 to allow combination of both parameters on the same Y- axis) of mononuclear cells isolated from Peyer's patches (PP) from rats supplemented for 33 weeks with probiotics, prebiotics, synbiotics.
NK activity is expressed as percentage of lysed target cells from the mouse Moloney leukaemia cell line and measured by flow cytometry (effector/target ratio of 12.5/1.0). Significantly different from control: * $P < 0.05$, ** $P < 0.01$.

Roller, M.; Femia, A.P.; Caderni, G.; Rechkemmer, G.; Watzl, B. (2004) Intestinal immunity functions of rats with colon cancer is modulated by oligofructose enriched inulin combined with *Lactobacillus rhamnosus and Bifidobacterium lactis.* Brit. J. Nutr., 92: 931-938.

continuation of page 17

ammonia levels are presumably a consequence of reduced intestinal production of ammonia due to a shift in proportions of harmful versus beneficial bacteria or as a consequence of lower pH in the colon resulting in reduced ammonia absorption.

Liu, Q.; Duan, Z.P.; Ha, D.K.; Kurtovic, J.; Riordam, S.M. (2004) Synbiotic modulation of gut flora : effect on minimal hepatic encephalopathy in patients with cirrhosis. Hepatology, 39: 1441-1449.

A simple and accurate method to quantify inulin and oligofructose in foods

Nowadays, several methods for the determination of inulin (INU) and oligofructose (OF) are available. These include HPAEC-PAD (HP-Anion Exchange Chromatography with Pulsed Amperometric Detection), High Temperature GC (Gas Chromatography) or LC (Liquid Chromatography) methods. By using these methods, however, other oligo- and polysaccharides can interfere with the inulin peaks and allow only partial quantification. Therefore, techniques that hydrolyse INU and OF prior to analysis of the constituent mono- and di-saccharides before and after hydrolysis by GC, LC, HPAEC-PAD, are most commonly used.

The official AOAC method 997.08 is a reliable enzymatic, chromatographic method for the quantitative inulin and oligofructose determination, but it is very labour intensive, and requires the use of expensive chromatographic equipments. As a fast and easy method, Megazyme commercialises a kit for the enzymatic and spectrophotometric analysis of INU and OF (AOAC Method 999.03). This method can be used for a correct quantitative determination of INU in foods. However, for OF determination this technique causes a considerable underestimation of the result (about 20 %), and therefore cannot be generally applied. The authors (from Orafti) developed a new enzymatic, spectrophotometric method, because of the explicit worldwide need for a simple and accurate method for the determination of INU and OF in foods, using only standard laboratory equipment. The principle is an enzymatic hydrolysis of sucrose by sucrase and a second enzymatic hydrolysis of both INU and OF by a fructanase into glucose and fructose. Sugars are determined in the initial extract and subsequent hydrolysates by spectrophotometric determination.

Calculations of INU and OF are based only on fructose measurement. Extensive validation of the method yielded high recovery 96.0 ± 5.3 %, and good accuracy and precision data (5.9 %). This method is suitable for accurate determination of both INU and OF (GFn and Fn forms) from any origin in any food matrix.

Steegmans, M.; Iliaens, S.; Hoebregs, H. (2004) Enzymatic, spectrophotometric determination of glucose, fructose, sucrose and inulin/oligofructose in foods. J. AOAC Int., 87 : 1200-1207.

Inulin-Type Fructans: Functional Food Ingredients

This book, written by one of the leading researchers in the field of prebiotics, presents a complete review of the latest nutritional research on inulin and oligofructose.

Inulin and oligofructose are naturally occurring non-digestible carbohydrates which are widely used as functional food ingredients. In addition to their role as prebiotics that selectively stimulate the growth of beneficial bacteria in the gut, they act as dietary fibres, offer systemic health benefits, and have applications as low-glycaemic and low-calorie sugar substitute and fat replacer.

The book describes inulin-type fructans and how they can be quantified and used in a wide range of food products, before assessing their nutritional properties with a focus on their behaviour in the digestive system. The author discusses the role of fructans as dietary fibres, their beneficial modulation of the gut microflora or prebiotic effect, as well as their relationship to mineral absorption and bone health, lipid metabolism, carcinogenesis, and the immune system. Marcel Roberfroid then concludes with a discussion on their classification as functional food ingredients.

Each chapter begins with background information on the physiological function covered and the methodology used to assess it, before presenting the scientific results available with inulin and oligofructose, and concludes with future perspectives.

This book thus provides a comprehensive review of the nutritional and health benefits of chicory inulin and oligofructose as feelgood factors.

Marcel Roberfroid is now a retired professor of the Université Catholique de Louvain in Belgium. During his academic career, he investigated the mechanisms of carcinogenesis and their modulation by dietary factors. He was also very active in developing the concept of 'functional food' in Europe and introduced the concept of 'prebiotics' together with his colleague Prof. Glenn Gibson. Prof. Roberfroid was strongly involved in the research on inulin-type fructans and is internationally recognised as a key expert in that field.

Roberfroid, M. B. (2005) Inulin-Type Fructans: Functional Food Ingredients, CRC Series in Modern Nutrition, Edited by Ira Wolinsky and James F. Hickson Jr., CRC Press, Boca Raton - London - New York - Washington D.C.

AGENDA

COLOPHON

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