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Towards a healthier diet for the colon: the influence of fructooligosaccharides and lactobacilli on intestinal health

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Abstract

The use of probiotics and prebiotics has become firmly established due to their beneficial effects at the nutritional and therapeutic levels. Although their use is not new, the need to identify more effective species of probiotics which meet the criteria of stability, resistance and proliferation has gained considerable importance. Recognised species include *Lactobacillus sporogenes*, a spore-forming fermentative bacterium, that has demonstrated its utility and advantages in various studies and which also exhibits a high degree of safety. At the same time, not all prebiotics respond to the same bifidogenic parameters and they are the source of different nutrients which favour the colonic metabolism. Fructooligosaccharides (FOS) are noted for their considerable bifidogenic power and higher production of butyrate, a short-chain fatty acid which is essential to the colonocyte. The combination of both these effects has been defined as symbiotic and has generated significant interest with regard to their nutritional and therapeutic qualities in intestinal pathologies and in certain disorders of metabolism.

Keywords: Fructooligosaccharides; Lactobacillus sporogenes; Prebiotic; Probiotic; Symbiotic; Butyrate

1. Introduction

The role of lactobacilli in intestinal health and its importance in the generation of immunological defences is well established. The modern diets and lifestyle produce an intestinal imbalance between fermentative and putrefactive flora in the intestine. It has been suggested that lactobacilli may be added to the diet in order to achieve a healthy intestinal

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balance through recuperation of fermentative flora. Soluble fibre is one of the dietary components required for proliferation of lactobacilli and it is therefore associated with the generation of microflora associated with health. This proliferation of the bacteria increases the faecal volume and reduces the transit time, thereby facilitating defecation. Moreover, soluble fibre is the ideal substrate for the generation of certain essential metabolites, for example short-chain fatty acids, for the nutrition of colon cells. The beneficial effects of lactobacilli (a probiotic) and the nutritional contribution of soluble fibre (a prebiotic) have been described exhaustively and are the object of many recent investigations of diet in preventive and therapeutic medicine.

Numerous studies have demonstrated the importance of probiotics but have, however, drawn attention to their short life. There is also a solid body of evidence regarding the bifidogenic and nutritional properties of colon cells influenced by prebiotics. However, it is essential that probiotics be present in sufficient quantity to achieve the entire beneficial potential of both types in a consistent manner. It is this synergetic effect which is being revealed as one of considerable importance for intestinal health and it achieves a symbiotic effect –indicating the conjunction and joint action of prebiotics and probiotics. The particular circumstances of each person, the level of intestinal health, the type of diet, any sub-clinical or clinical condition or deficiency will determine the type of nutrition required at any given time. The diet can be fortified with prebiotics, with probiotics or with both to accomplish the symbiotic effect.

Many diseases are related to an unbalanced diet. These include diseases of the circulatory system, obesity, diabetes and disorders of the intestine, such as colon cancer, Crohn's disease and ulcerative colitis. It has been shown that those who consume a diet high in fat and low in fibre have a reduced number of bifidobacteria in their intestine [1]. More than a decade ago, a theory was put forward that postulated that the beneficial effect of dietary fibre in certain diseases was due to the proliferation of bifidobacteria and the consequent improvement in intestinal microflora [1].

It is now known that intestinal microflora play a role of prime importance for health. For this reason there is a growing interest in manipulating the composition of intestinal flora in order to achieve a more beneficial intestinal bacterial community. Attempts have been made to increase the number of intestinal bifidobacteria and lactobacilli. Thus the microbiological nutritional components – known as probiotics –are used to alter the composition of microflora in the colon (bifidogenic activity). However, these changes can be transitory and the resulting bacterial implantation is very limited. On the other hand, prebiotics are dietary components which are not digested by humans but which have a beneficial effect through the selective stimulation of the growth and/or activity of a single species (or of a limited number) of bacteria which already reside in the colon, thereby improving a person's health.

The consumption of prebiotics can significantly modulate microflora in the colon by increasing the number of certain bacteria and thus altering the microflora composition. In general, non-digestible oligo-saccharides and the fructooligosaccharides in particular, are prebiotic. It has been shown that prebiotics stimulate the growth of endogenous bifidobacteria which, after a short period of time, predominate in human faeces. In addition, prebiotics modulate lipid metabolism probably through fermentation. A combination of the properties of probiotics and prebiotics suggests the concept of symbiotics, and make these compounds suitable candidates for classification as functional dietary components that improve health [2]. Accordingly, some health authorities have accepted the functional relationship between probiotics and prebiotics and recognized that certain fructooligosaccharides are bifidogenic compounds which favour the development of intestinal bacteria [3].

Prebiotics, in the currently accepted view, are relatively short-chain carbohydrates. In order to be effective they must reach the cecum. It has been shown that fructooligosaccharide and inulin resist *in-vivo* digestion by gastric acid and pancreatic enzymes. Apart from their selective effect on bifidobacteria and lactobacilli, prebiotics influence many aspects of the function of the large intestine through fermentation. Short-chain fatty acids are one of the most important by-products of the breakdown of prebiotics. Through their stimulation of bacterial growth and fermentation, prebiotics affect the intestinal motility and are slightly laxative. The fact that one of the prebiotics is an important source of hydrogen in the intestine is of great importance. Prebiotics are similar to the other carbohydrates which reach the cecum –such as the non-starch polysaccharides, sugar alcohols and hard starch, which are substrates for fermentation. However, they differ in their selective effect on the microflora and in their potential to produce flatulence [4].

Based on the effect of fructooligosaccharides on the beneficial genus of bifidobacteria, prophylactic treatment of certain gastrointestinal complications through the selective growth of intestinal bacteria appears possible [5]. Roberfroid [6,7] indicated, however, that simple stimulation of bifidobacteria is insufficient to demonstrate the effect. The composition and activity of colonic microflora must be adjusted in order to optimise the health-inducing activities. Methods are being developed to detect changes in the composition of microflora and to relate these changes to health improvements. Roberfroid has reviewed the criteria used to classify prebiotics, the growth stimulation mechanisms and the physiological effects. [6]

The best recognised effect of the majority of non-digestible oligosaccharides, and in particular the fructooligosaccharides, is the selective stimulation of the growth of bifidobacteria. This effect significantly modifies the composition of colonic organisms. This modification, which has been clearly demonstrated in human volunteers, is considered beneficial, partly because it is accompanied by a significant reduction in the number of potentially pathogenic bacteria. From this point of view, the title of "bifidogenesis" can be justifiably associated with the fructooligosaccharides. Furthermore, improvements in essential minerals and a reduction in serum triglyceridemia following the reduction in hepatic lipogenesis have been described in experimental models. These effects demonstrate the interaction between fructooligosaccharides and the key functions of the organism but their significance in humans remains to be checked. Studies have been carried out using fructooligosaccharides obtained from chicory [7].

2. Probiotics

The role of lactic acid bacteria in intestinal ecology has been widely studied. Clinical preparations based on these bacteria go back to the time of Metchnikoff and his "longevity theory" at the beginning of the last century. This theory suggested that the ageing process is associated with chronic putrefactive intoxication caused by certain intestinal bacteria and that

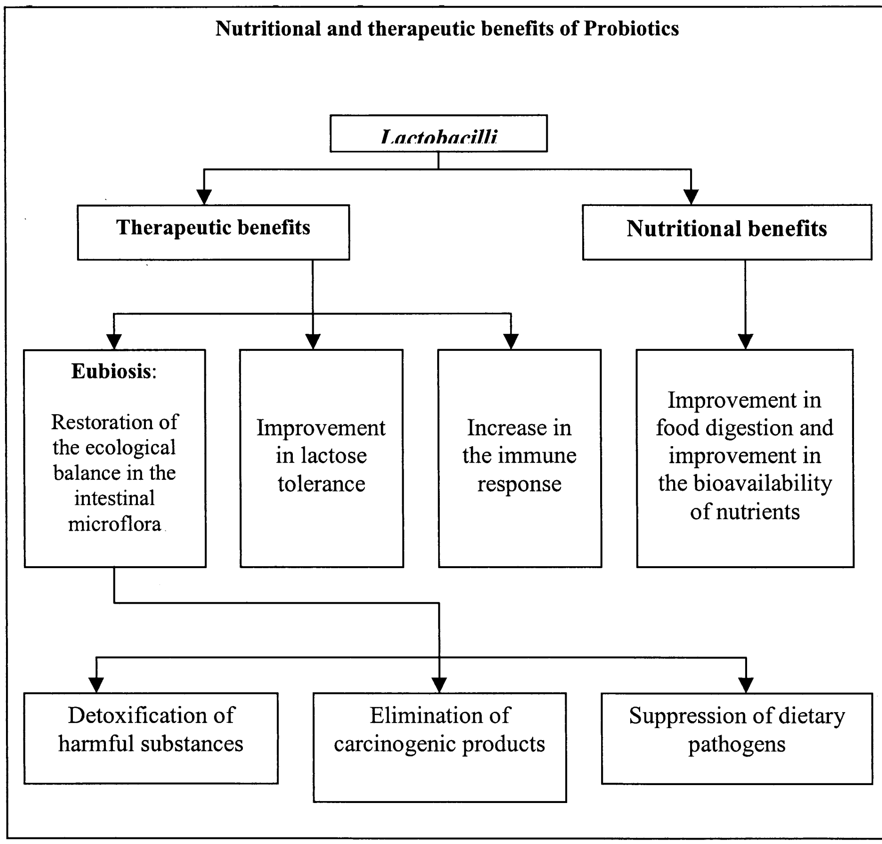

Fig. 1. Nutritional and therapeutic benefits of Lactobacilli.

therapy involving lactobacilli can reduce these effects and can also cure a wide range of pathology [9]. These ideas led to the coining of the term probiotic, or pro-life, which refers to orally ingested microorganisms that can have a beneficial effect on the prevention or treatment of certain diseases.

At the present time it is generally agreed that these bacteria prevent the growth of putrefactive flora through competitive inhibition (acidification of the medium, the production of proteins with antibiotic activity and other hostile substances). From the nutritional point of view, their metabolic activity generates vitamins of the B group, accompanied by proteolytic, lipolytic and beta-galactosidase activity and improvement in digestibility and in the assimilation of different nutrients [10]. At the same time, there are other benefits, such as a tendency to reduce cholesterol and an improvement in tolerance of lactose, improvement in other disorders such as hepatic encephalopathy, stomatitis, vaginitis, intestinal infection, tumorigenesis and an increase in the immune response (Fig. 1).

The ecosystem of the human gastrointestinal tract is highly complex and consists of more than 500 species of bacteria in a constant state of change. This situation is influenced by various factors including diet, stress, age, drugs, etc. Lactic acid bacteria are present in small proportions although their metabolic functions render their presence important. This group

Table 1
Conditions for satisfactory intestinal implantation of probiotics

— Capable of growing in bulk cultures without genetic variation
— Stability: Survival during the manufacturing and storage processes. Mixing with food or excipients must not reduce the probiotic quality
— Resistance to the acid environment of the stomach and the biliary salts, after ingestion
— High capacity of proliferation and affinity for the intestine (adherence to the intestinal wall)
— Ability to survive in the intestine's microbial environment
— Appropriate production of metabolites which are hostile to pathogens (lactic acid, bacteriocins, etc.); preferably dextrorotatory lactic acid L(+), with the object of preventing any metabolic acidosis, especially in children
— Modulation of the metabolic activity (e.g. inactivation of pro-carcinogens)
— Immuno-modulation: the capacity to improve the organism's immunity, to reduce resistance to pathogens and positive contributions to food allergies
— An additional condition is total safety of use. A probiotic must be recognised as safe and must not provoke adverse effects in the patient

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includes the genus *Lactobacillus* containing such common species as *L. bifidus, L. acidophilus, L. casei, L. fermentum, L. salivarius, L. brevis, L. leichmanii, L. plantarum, L. cellobiosus,* etc.

Due to the factors mentioned above, the task of maintaining a correct balance in the intestine (Eubiosis) is not easy. For this reason the use of external supplements with probiotics has emerged as a rapid and efficient formula for re-establishing equilibrium.

Candidate microorganisms for use as probiotics are numerous although the practical results obtained are not satisfactory in all cases. This is mainly due to differences in the viability and activity of the different strains. A series of conditions must be met to achieve satisfactory implantation in the intestines and to guarantee a minimum level of effectiveness (Table 1) [11].

Compliance with these requirements would guarantee re-population starting with a minimum number of viable colonies, to restore the balance of the intestinal flora.

Among the probiotic microorganisms, not all species fulfil the criteria. One such species might be *Lactobacillus sporogenes.*

3. L. sporogenes

L. sporogenes was isolated for the first time in 1933 by Horowitz-Wlassowa and Nowotelnow and was included in *Bergey's Manual of Determinative Bacteriology,* fifth edition. In the sixth edition of the manual, the initial name was changed to *Bacillus coagulans,* due to a restructuring process aimed at simplifying the classification. Furthermore, the presence of characteristics which were common to both genera makes exact taxonomy difficult (Table 2) [12].

According to Bergey's manual, seventh edition, and other sources, *L. sporogenes* responds to the following characteristics: "Gram-positive spore-forming rods 0.9 by 3.0 to 5 micron size, aerobic to microaerophilic, producing L (+)-(dextrorotatory) lactic acid homofermentatively".

Table 2
Differential characteristics of *L. sporogenes*

Characteristic	Bacillup s.p.	*L. sporogenes* Bacillus coagulans	*Lactobacillus s.p.*	Sporolacto bacillus
Catalase	+	+	−	−
Benzidine	+	NA (****)	−	−
Nitrate red.	+	NA (****)	−	−
Gram-reaction	+	+	+	+
Endospores	+	+	−	+
Motility	+	+	− (*)	+
Lactic acid	− (**)	+	+	+
m-A_2PM (***)	+	+	− (*)	+
Fatty acid	Bacillus type	Lactobacillus type	Bacillus type	

(*) Except *L. plantarum*.
(**) Apart from *B. coagulans* other species can produce lactic acid.
(***) Meso-diaminopimelic acid.
(****) No data available.

L. sporogenes grows at a temperature range of 35–50 °C, with an optimum pH of 5.5–6.5. Its capacity to form spores is a differential characteristic compared to other strains of *Lactobacillus*. This is a microencapsulation process in which a covering of calcium-dipicolinic acid-peptidoglycan complex is generated [13]. It is precisely this capacity which confers a high degree of stability in unfavourable conditions such as changes in humidity and temperature during storage or alterations in the micro-ecological environment in the intestine. Its resistance to heat permits it to survive even at 100 °C for 20 minutes on a phosphate pH 7 buffer. The spores are capable of germinating in a malt culture broth in the presence of dilute HCl (pH of 4.6 to 5.6), NaOH solution (pH of 7.6 to 9.6), salt solution (at concentrations of 5%, 10% and 20%), and boric acid (2.5%) and in distilled water. They are also capable of resisting 2–8 times more antibiotic therapy than the vegetative forms [12].

Ingested orally, the spores are capable of resisting gastric acid, which is in turn responsible for their activation in combination with the higher water content. The spore swells and germinates in the duodenum and starts to multiply rapidly. This process usually occurs in a general manner about four hours after ingestion. Metabolic activity commences rapidly with the production of lactic acid and bacteriocins [14].

These characteristics help to give *L. sporogenes* a profile as a highly-efficient probiotic compared to other strains of different species

3.1. Stability

Stability studies have been carried out under the following conditions: The sample used was *L. sporogenes* (6000 million viable spores/g), incubation of a 25 g sample in a brown glass bottle sealed with a polyethylene film at 45 ± 1 °C during 90 days (equivalent to 2 years at room temperature). The glucose yeast extract agar medium was used according to the method of M/s Sami Chemicals Ltd. Bangalore, India. The results demonstrated that during this time the spores maintained their viability and the level of residual activity was close to 100% [12].

Table 3
Summary of the results of different trials carried out with patients with intestinal and allergic disorders using a Japanese product containing *L. sporogenes*. Data from clinical reports by Terumichi Kuniya, Pediatric Clinic of Shinko Hospital, Kobe; Jetsuo Nitta, Medical Clinic of Kugason Hospital; Goro Kaide, Pediatric Clinic of Kanto Teishin Hospital; Michio Ogasawara, Medical Clinical of Kahoku Hospital; Susumu Nakazawa, Pediatric Clinic of Ebara Hospital. (Abstracts of papers on the clinical study of Lacbon (Sporlac) compiled by the Sankyo Co. Ltd. Japan). [12]

Condition	No of subjects	Treatment	Effectiveness rate	Conclusion
Acute and chronic intestinal catarrh.	38	100–600 M spores per day in divided doses, for 2–12 days	86.8	Recovery to regular normal stools; general symptoms including anorexia improved
Diarrhoea	15	75–600 M spores per day in divided doses, for 3–12 days	100	Recovery from diarrhoea to regular normal stools from third to fourth day
Constipation	10	300–750 M spores per day in divided doses, for 2–10 days	70	Recovery to normal stools; and disappearance of abdominal distension
Abnormal intestinal fermentation	9	300–600 M spores per day in divided doses, for 3–14 days	100	Vomiting and nausea disappeared; appetite improved; stool became normal and regular; diarrhoea and stomach ache cured
Dyspepsia infantum	26	100–200 M spores per day in divided doses, for 1–7 days	84.6	General conditions and nature of stools improved frequency of stools decreased to half or less than that before medication.
Allergic skin diseases	5	200–450 M spores per day in divided doses, for 4–12 days	80	Obvious eruptions of strophulus and eczema decreased from the third day (topical therapy employed concomitantly)
Miscellaneous symptoms	10	20–50 M spores per day in divided doses, for 4–20 days	80	Response seen in anorexia of nervous type and malnutrition in infants

3.2. Benefits of L. sporogenes (B. coagulans) *as a probiotic*

Different clinical studies have shown that *L. sporogenes* establishes itself efficiently in the intestine. Apart from the high degree of stability described above, it is also of interest in the formulation of galenical preparations. Lastly, its semi-resident character in the intestine is apparent in the extremely slow elimination from the human intestine, for as long as 7 days after the end of treatment [14].

3.2.1. Intestinal pathology

The use of L. sporogenes as a probiotic has been tested in different countries, mostly Japan and India [12]. Table 3 shows a summary of the results of studies in which a Japanese product containing L. sporogenes was employed.

With regard to infantile diarrhoea, a study was conducted in India on 60 cases of neonatal diarrhoea with more than 6 watery evacuations per day. Treatment consisted of a preparation based on *L. sporogenes* at 5 million spores per kg of weight (approx. 15 m spores/day). Recovery took an average of 1.8 days with a success rate of 81.7% and no collateral side-effect was observed [12]. Similar studies have been carried out in Japan with comparable results (78.4%) [12].

3.2.2. Hypocholesterolemic effects

In a preliminary study [15] the short-term hypocholesterolemic effect was studied in 17 patients (15 men and 2 women, between 32 and 61 years) with hyperlipidemia type II, in an open study with a fixed dosage of 360 M spores/day in tablets. The results showed a significant drop in total cholesterol, LDL cholesterol and the ratios of total cholesterol/HDL-cholesterol and LDL-cholesterol/HDL-cholesterol ($p < 0.001$) after a 3-month period [15]. HDL-cholesterol increased slightly but no changes were observed in the level of triglycerides. The atherogenic lipid ratios were as follows:

Total cholesterol/HDL-cholesterol 24.0% fall, LDL-cholesterol/HDL-cholesterol 33.4% fall. No adverse effect was observed except one case of constipation that was not directly related to the probiotic treatment.

3.2.3. Non-specific vaginitis

Non-specific vaginitis is usually caused by pathogens such as staphylococcus, streptococcus, pneumococcus and E. coli. Other causes include local treatment with certain medicines, foreign bodies, trauma, surgery, etc. Treatment with *L. sporogenes* increases vaginal acidity through the production of lactic acid from the glycogen in the epithelial tissues. A study was carried out on 44 patients, divided into two groups. In the first group the patients had leucorrhea as a result of cervical surgery. The second group consisted of patients suffering from non-specific vaginitis without previous therapy. Of these 26 were of fertile age and 6 were of menopause age. In both groups there was a rapid response and complete improvement in 77.25% of cases. A further 13.6% recovered completely although it took more time and 9.15% exhibited improvement without complete elimination. The authors compared these results with those of a study carried out with the traditional treatment with broxyquinoline and brobenzoxeldine ovules, in which only 26.67% of the cases were satisfactorily resolved [12].

3.2.3. Veterinary medicine

The use of L. sporogenes in the production and growth of various farm animals (chicken, sheep, goats and calves) and dogs and horses has been investigated. The results highlight the effectiveness of a 0.04% addition of *L. sporogenes* to the basic diet, for prevention of weight loss [12].

3.3. Toxicological aspects

Generally speaking, treatment with Lactobacilli has not been associated with toxic effects except for metabolic acidosis attributed to the ingestion of strains which produce the optic D (-) isomer of lactic acid [16]. This does not occur with *L. sporogenes* because it only produces the L(+) isomer of lactic acid.

3.3.1. Acute toxicity

Male rats which were administered 1.3 or 5 g/kg/day of a preparation that contained at least 5 x 10^9 spores of L. sporogenes per gram administered as a 10% suspension directly into the stomach. No harmful effects were observed, not even diarrhoea, in the treated animals. Some animals in the 5 g/kg group exhibited a slight distension of the stomach which reversed within a few hours [17].

3.3.2. Sub-acute toxicity

Male rats were fed 0.3, 3 and 5 g/kg/day of a preparation containing at least 5 x 10^9 spores of *L. sporogenes* per gram over 15 months. No change in body weight or weight of various organs was noted [17]. Similar studies were repeated with dogs, rabbits and guinea pigs, involving a dosage of 10 to 50 g/kg of weight for 7 days. No abnormality was observed during treatment or the subsequent 10 days [17].

4. Prebiotics

4.1. Fructooligosaccharides (FOS)

These natural compounds are found in a wide variety of fruits, vegetables and cereals. They are a mixture of sugar chains formed by a glucose molecule and molecules of fructose joined together. Although they occur in nature (as in the case of saccharose – glucose joined to fructose) they can also be manufactured economically using the beta-D-fructofuranosidase enzyme or with fructosyltransferase which join the additional fructose molecules by means of the transfructosylation mechanisms.

Fructooligosaccharides are not digestible by enzymes such as alpha-amylase, saccharase and maltase, especially in humans. FOS transit through the upper gastrointestinal tract intact without being absorbed. They then enter the intestine where they are available for microbial action. FOS are used selectively by certain types of bacteria which produce acids, such as bifidobacteria and lactobacilli that are habitual inhabitants of the intestine and are considered beneficial. In turn, FOS increase the growth of these beneficial microorganisms [18].

FOS have been extensively examined in studies involving humans and animals, which have established their effectiveness and safety [19]. FOS have no genotoxic, cancerigenous or toxicological effects and are slightly laxative although they produce flatulence when taken in high doses [20].

The flora in the colon contains fermentative bacteria (beneficial) and putrefactive bacteria (harmful). Beneficial bacteria include the bifidobacteria which possess the enzymes needed to metabolise FOS. The use of FOS as a substrate promotes the development of bifidogenic flora [21].

4.1.1. Potential physiological and health effects of FOS

Diverse beneficial physiological effects have been associated with the consumption of FOS. Prebiotics that contain *Lactobacillus acidophillus and Bifidobacterium sp* are available to the consumer; however, such products often have a short shelf life and their potential is less than expected [22].

The FOS represent a selective nutrient for beneficial micro-organisms and they have the potential to increase the effectiveness of current probiotic products [23]. Furthermore, scientific studies carried out in Japan indicate that the consumption of FOS shifts the balance of microflora in the intestine towards greater populations of bifidobacteria and other beneficial micro-organisms—even in the absence of probiotics added to the diet.

The ability of FOS to be digested varies according to the type of microflora which normally inhabits the intestine. As mentioned above, species such as the bifidobacteria and certain lactobacilli including acidophillus and others, can use and grow in FOS. Other species, including *E. Coli*, *Clostridia* and *Salmonella* are not capable. Based on these results which were obtained in the laboratory, the real effects of FOS on microflora populations have been approximately evaluated in humans.

Mitsnoka et al have described the effects on total levels of bifidobacteria and enterobacteria of administering 8 g per day of FOS to adult individuals. The effect on the pH of the stools and their consistency has also been evaluated in the same study [24].

The FOS were removed from the diet of these patients after 14 days to confirm the cause and effect. The general conclusions reached in this work, at least in respect of this group of patients, were as follows:

1) The FOS has effectively promoted the number of bifidobacteria and lactobacilli.
2) The pH of stools fell, probably due to the increase of volatile fatty acids by these micro-organisms.
3) The consistency of the stools of individuals who previously had soft stools, became firmer.

Beneficial effects have also been observed resulting from the increased levels of *Bifidobacteria* and *Lactobacilli* in the large intestine [25]. In the first place, as the number of these bacteria increases and they occupy more of the “microbiological niches” in the intestine, the intestinal bacteria considered as unfavourable, such as *E. Coli*, *Salmonella* and *Clostidium perfringens*, are excluded.

In the second place, the production of putrefactive substances, such as phenol, cresol and indol, reduces and therefore the load on the liver to eliminate these substances also reduces.

Finally, Japanese researchers have clinical data which suggest that, apart from the effects described above, regular additions of FOS to the diet appear to result in a significant reduction in total cholesterol and triglycerides in the blood [26]. These results are consistent with the increased production of volatile fatty acids and their effect on the synthesis of cholesterol in the liver.

As a consequence of the metabolism of the fructooligosaccharides by the fermentative bacteria, short-chain fatty acids and lactic acid are produced. Both of these lead to a drop in the pH of the large intestine. This effect is beneficial for the organism as it constitutes an ideal medium for the development of the bifidogenic flora and, at the same time, it limits the development of bacteria which are considered as pathogens. The contents of the metabolites produced by putrefactive bacteria decrease following the ingestion of fructooligosaccharides.

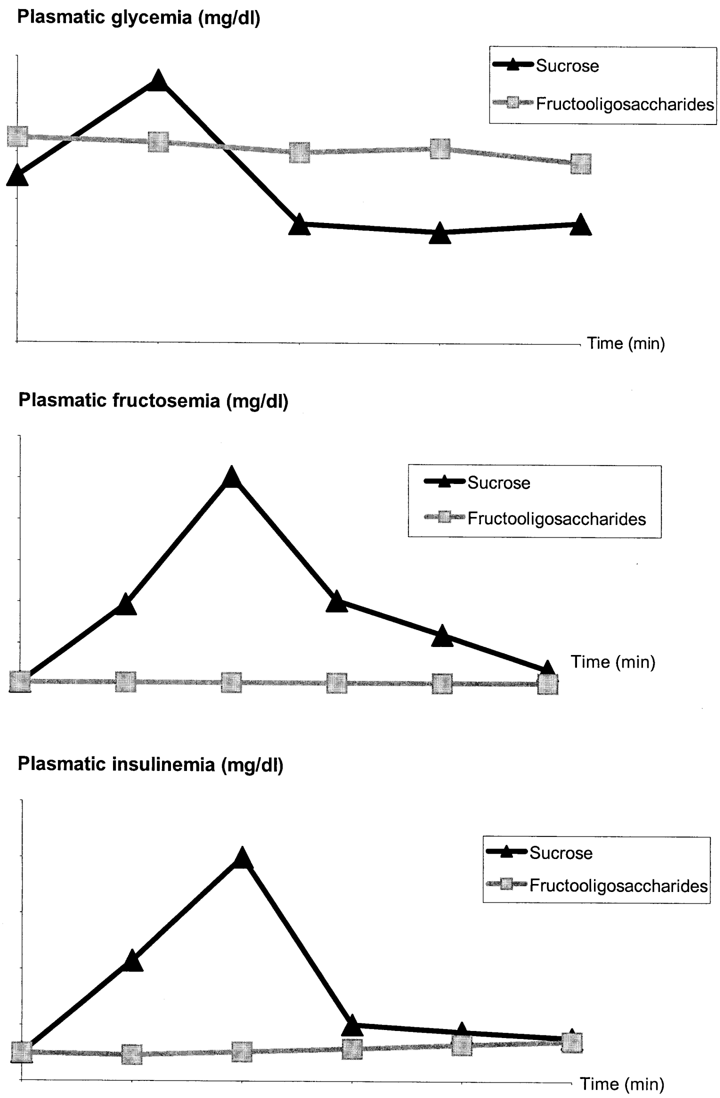

Fig. 2. Levels of glucose, fructose and insulin in plasma as a result of the ingestion of saccharose or fructooligosaccharides (ACTILIGHT 950P), dissolved in 200 ml of water, in 6 healthy subjects.

Microflora in the large intestine play an important role in the maintenance and development of the epithelial tissues of the colon.

Some of the short-chain fatty acid molecules which are created, are used as nutrients by the epithelium of the colon.

The fructooligosaccharides contribute relatively few calories, which are obtained from the metabolites which are formed in the large intestine, generating only 2 kcal/g [8].

Following the ingestion of fructooligosaccharides, no changes occur in the plasmatic levels of glucose, fructose and insulin. Their consumption does not modify glycemia or the insulinemia (Figure 2) [8].

Although the effect of FOS on animals cannot be automatically transferred to humans, large scale tests on diets with FOS involving birds, consistently demonstrate that FOS increase the efficiency and transformation of feed and also reduce mortality. This suggests that an indirect effect of the modification and stabilisation of the intestinal microflora can improve the health of birds, especially in conditions of environmental stress.

In summary, it can be said:

1) That FOS are natural compounds which could be part of a normal diet.
2) There is sufficient data to indicate that FOS are safe at a reasonable level of daily consumption.
3) FOS appear to shift the intestinal microflora in the direction of a greater number of bifidobacteria, lactobacilli and other similar bacteria which produce acids.
4) The evidence suggests that the FOS act as soluble fibre and can be useful in increasing intestinal motility, transport and in the reduction of high levels of cholesterol in the blood.

5. Anti-mutagenic properties of probiotics and prebiotics

Probiotics and prebiotics appear to be anti-mutagenic in different ways. Studies with lactic acid bacteria have demonstrated that they can unite with the mutagenic products of pyrolysis produced during cooking at high temperatures. The bacteria can be alive or dead because the process occurs through absorption by the mutagen of carbohydrate polymers at the cell wall [27]. Lactobacilli also break down carcinogens such as n-nitrosamines, which is important if the process occurs at the surface of the mucosa [28].

A supplement of 4 grams per day of FOSfructooligosaccharides in the form of chewable tablets, in healthy volunteers, increased the number of intestinal bifidobacteria and appreciably reduced the fecal activity of the enzymes involved in the production of phenotoxic metabolites, such as glucuronidase and hydroxylase glycollic acid, indicating the potential of prebiotics and probiotics to reduce or prevent carcinogenesis.

6. Conclusions

The use of probiotics to improve health is not a new concept. It started at the beginning of the last century following Metchnikoff's observations on the regular consumption of fermented milk and the sound health of the consumers. These beneficial properties are due in great part to the ingestion of probiotic bacteria that are traditional inhabitants of our intestines, skin and vaginal mucosa.

Current knowledge shows that the lactobacillus genus is a noteworthy probiotic due to its confirmed effects in a variety of gastrointestinal disorders, vaginal infections, vitamin deficiencies, hypercholesterolemia, etc. The metabolism of this genus plays a limiting role in the growth of pathogens and putrefactive bacteria through competitive inhibition. At the same time it improves the digestibility of nutrients and it also improves immunity.

At the present time, the effectiveness of the traditional species (L. acidophillus, L. bulgaricus, L. brevis, L. casei and L. bifidus) is being questioned due mainly to problems of stability, survival and implantation in the intestine. On the other hand, species such as L. sporogenes, a spore-forming probiotic bacteria, are gaining in importance due to their high resistance to ambient temperatures and adverse physiological conditions and due to their capacity for implantation and proliferation in the intestine. They are widely used in different products and the clinical studies confirm their safety and effectiveness as a probiotic.

It should be pointed out that the effectiveness of probiotics is conditioned by the presence of the necessary fermentation substrate to carry out their metabolic functions. This includes the concept of prebiotics, which refers to substances that are not digested by human enzyme systems, that are fermented by the probiotic flora and that exhibit the ability to stimulate their growth and metabolism.

FOS stand out due to their high bifidogenic capacity at low doses. In addition, they constitute an important source of butyric acid, which is an essential nutrient of the colonocyte.

Various studies have demonstrated the utility of the FOS as an efficient prebiotic, its role in constipation, hypercholesterolemia and the absorption of nutrients, without altering physiological parameters such as insulin and fructose levels, practically without any undesirable effects. The association of a probiotic and a prebiotic has led to the concept of the symbiotic. The symbiotics represent a promising and safe tool against different intestinal and metabolic disorders.

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