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Full Length Research Paper

Application of Xylo-oligosaccharide in modifying human intestinal function

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The influence of Xylo-oligosaccharide (XOs) to human intestinal flora, feces shape and properties was observed. The most tolerance administration dose (MTD) was determined, which provided guidance to the XOs oral dosage. Different doses of XOs were given to a designated group of healthy volunteers. According to the change of intestinal flora, feces shape and properties, the probiotics function of XOs was illustrated. Furthermore, the XOs MTD to human beings were set. XOs benefited to the bowel function and the MTD to human being was 12 g per day.

Key words: Xylo-oligosaccharide, gastrointestinal microflora, the most tolerance dose.

INTRODUCTION

Xylo-oligosaccharides (XOs), an emerging food additive and functional polysaccharide, iTs constituted by 2 to 7 xylose molecules that connected by β-1, 4 glycoside bonds (Fukuda et al., 2010; Sinitsyna et al., 2003). Comparing with the other polysaccharide, XOs has prominent stability to acid and heat. With these properties, XOs can benefit to the human health in a great of many aspects, for instance, it can reduce toxic fermented products and harmful bacteria enzymes, restrain diarrhea led from pathogenic bacteria and prevent constipation, reduce cholesterol in serum, strengthen immune system, etc. (Xu et al., 2001).

XOs contribute to the *Bifidobacteria* proliferative activity selectively in gastrointestinal (GI), which is 10 to 20 folds as much as that of other polysaccharide (Okazaki et al., 1990a). Definitely, XOs has positive influence to bowel function, but it is not easy to ferment, that is, it is not easy to be digested by digestive enzymes. So taking an overdose of XOs would lead to diarrhea caused by a massive retention of moisture. This type of gastrointestinal discomfort is a common phenomenon associated with high intake of dietary fiber and that have no toxicological relevance to humans.

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In this paper, we sought to assess the effect of xylo-oligosaccharides on the gastrointestinal microflora and determine the MTD through investigating the correlation between intake of XOs and diarrhea.

MATERIALS AND METHODS

Samples

95% Xylo-oligosaccharide, manufactured by Longlive Biotechnology Limited Company in Shandong, China. Food grade malt dextrin (MD), manufactured by Xiwang Sugar Holdings Limited Company in Shandong, China.

Subjects

The experiments were performed on 120 healthy volunteers between 25 to 50 years old, whose mean age was 32.3 years. The ratio of man to woman was 1:1.

Detection of human gastrointestinal microflora

Fresh faecal samples collected were analyzed by classical bacteriological analysis; each test was contrasted by itself.

The effect of XOs was investigated by measuring Aerobic Mesophilic Bacteria (AMB) and Anaerobic Sulfite-Reducing (ASR) bacterial counts (Waché et al., 2009; Lesniewska et al., 2006; Elli et al., 2006) representing the dominant cultivable bacterial population. The mediums and culture conditions

Table 1. Medium types and culture conditions.

Bacteria	Medium Type	Culture conditions
Enterobacteria	EMB	37°C, 24 h
Enterococcus	PSE	37°C, 24 h
Bacteroides	Modified GAM	37°C, 48 h, anaerobic
C. perfringens	TSC	37°C, 24 h
Bifidobacteria	BBL	37°C, 72 h, anaerobic
Lactobacilli	MRS	37°C, 48 h, anaerobic

Table 2. Experimental design, g/day.

Groups	First week	Second week	Third week
A	15 MD	15 MD	15 MD
B	Blank*	Blank*	Blank*
C	3 XO	5XO	8XO
D	3 XO	5 XO	10 XO
E	3 XO	5XO	12 XO

*without MD or XO.

were list in Table 1.

Xylo-oligosaccharide dose tolerance test

The test included 30 male and 30 female healthy subjects, who were divided into five groups (Group A, B, C, D and E) of 12 subjects, and were investigated to determine the fecal status after administration of XOs. Double blind test was processed and MD was used as placebo tablets.The subjects were fed with different amounts of substances in different periods as presented in Table 2.

Diagnostic criteria of feces

The feces aspects were characterized upon Bristol Feces Aspects Table (Jewis and Heaton, 1997). The Bristol type 1 and 2 were defined as constipation, type 6 and 7 as diarrhea.

Statistical analyses

Bacteriological count data are expressed as the mean of log (CFU/g) ±Standard Error (SE). Statistical analyses were performed with the linear mixed model.

RESULTS

Effect of XOs on gastrointestinal microflora

Fresh faecal samples collected on 10th day from 60 subjects receiving the XOs 1.4 g per day (Okazaki et al., 1990b) were analyzed by classical bacteriological analysis; each test was contrasted by itself. The numbers of viable *Enterobacteria*, *Enterococcus*, *Bacteroides*, *C. perfringens*, *Bifidobacteria* and *Lactobacilli* in fecal samples were shown in Table 3.

Table 3. Evolution of bacteria number in volunteers (log CFU/g, $\bar{X}$ ±SD).

Bacteria	Contrast	XOs group	P value
Enterobacteria	7.74±1.04	7.83±0.84	0.583
Enterococcus	6.36±1.53	6.24±1.39	0.731
Bacteroides	7.15±0.64	7.31±0.46	0.228
C. perfringens	1.73±1.39	1.61±1.42	0.668
Bifidobacteria	7.66±1.65	8.60±1.13	0.004**
Lactobacilli	6.74±1.82	7.47±1.36	0.048*

Compared with before administration: *$p < 0.05$;** $p < 0.01$.

It was indicated that the amount of *Bifidobacteria* and *Lactobacilli* in feces of subjects who administrated XOs were significantly increased ($p<0.05$) compared with that of in controls. Whereas the number of aerobic bacteria and other enterobacteria tested, had no obviously changes ($p>0.05$). So, the ratio of *Lactobacilli* and *Bifidobacteria* in GI was much higher than that of in control group.

The ratio of *Bifidobacteria* and *Lactobacilli* was considered as signal of intestinal health. High ratio of lactic acid bacteria signifies good flora structure. XOs evidently brought about beneficial effects to intestinal of subjects.

Tolerant dose of XOs

As can be observed, XOs was evidently beneficial to the improvement of GI flora. However, it is not easy to be digested by human intestine and man couldn't tolerate high dose of XOs. So, the XOs tolerant dose was investigated.

After three weeks test, the average levels of diarrhea and constipation ratio in every 7 days of various groups were summarized (Figure 1).

The diarrhea ratio decreased to 2.40% after administrated of 3 g XOs per day. This number reached to 6.0% when the dosage was 8 g per day and to 8.34% when the dosage was 10 g per day, compared with 8.40% before test. The diarrhea ratio kept going up in accordance with the increase of XOs dosage. When the dose increased to 10 to 12 g per day, the diarrhea ratio almost backed to the initial state.

In fact, human GI had an adaptive process while XOs was taken in. The diarrhea occurrence of those people who applied XOs on the first day was illustrated in Figure 2. No diarrhea case occurred if subjects took 3 to 5 gXOs, but the rate surged up to 18% if 10 g XOs was taken.

It was showed that XOs could modify intestinal

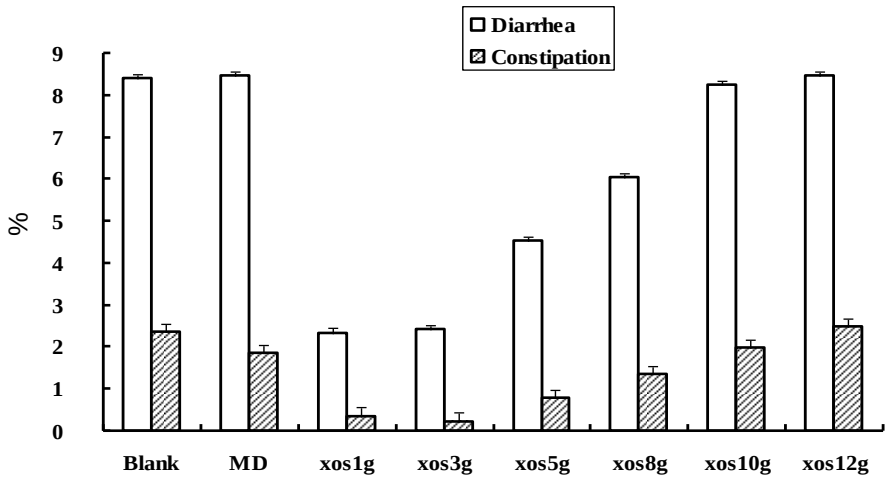

Figure 1. Changes of diarrhea and constipation rate after administration of XOs. Sixty volunteers were investigated to determine the fecal status after administration of XOs. Double blind test was processed and MD was used as placebo tablets. The diarrhea and constipation ratio of the subjects were recorded. The "Blank" represented subjects who toke neither XOs nor MD.

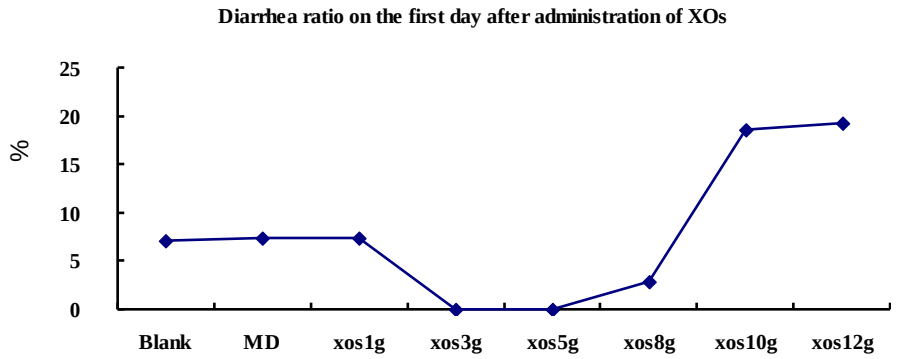

Figure 2. Occurrence of diarrhea at the first day after administration of XOs. Occurrence of diarrhea at the first day after administration of XOs was measured. MD was used as placebo tablets.

functions by increasing LAB number if the dosage ranged from 1 to 12 g, which gave endue it with broad intake functional dose.

The safety of XOs

Although there were not enough efficient data, XOs seemed to be relatively safe and have minimal side effects.

DISSCUSSION

The intestinal flora balance is strongly relevant with human being's physical condition. Microecologics, such as probiotics, prebiotics, synbiotics, can sustain and regulate the balance of gastrointestinal microflora that made microecologics being in the extensive attention (Alvarez and Oberhelman, 2001).

The XOs adopted in this study, which belongs to prebiotics could effectively improve GI function by promoting proliferation of *Bifidobacteria* and *Lactobacilli*. As the study showed, a normal healthy adult's MTD to *LongLive* XOs is 12 g per day. Meanwhile, this product charactered a broad region of effective amount and the intake dose of 1 to 12 g per day helped to modify intestinal disorder.

XOs is produced by xylan, a major component of hemicellulose in plant cell walls that is the second most abundant polysaccharide, next to cellulose on earth (Whistler and Richard, 1970). The knowledge of the

effects of XOs is primarily empiric, but there is a growing body of scientific literature. Ingestion of appropriate, stable, high-quality XOs in adequate amounts can modulate the endogenous flora of the gastrointestinal tract, with positive outcomes. The results thus far have been encouraging. Although promising, many of the claims for therapeutic efficacy have not been well substantiated. The indications, delivery systems, costs, and long-term effects need to be clearly defined.

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