Fructo-oligosaccharide effects on blood glucose. An overview[1]

Efeitos dos fruto-oligossacarídeos no controle glicêmico. Revisão

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ABSTRACT

PURPOSE: To identify the current status of scientific knowledge in fructo-oligosaccharides (FOS), non-conventional sugars that play an important role in glycemia control.

METHODS: We performed a search for scientific articles in MEDLINE and LILACS databases, from January 1962 to December 2011, using English/Portuguese key words: “blood glucose/glicemia”, “prebiotics/prebióticos” and “dietary fiber/fibras na dieta”. From an initial number of 434 references, some repeated, 43 references published from 1962 to 2011 were included in this study. The selected texts were distributed in three topics: (1) metabolism of FOS, (2) FOS and experimental studies involving glucose and (3) human studies involving glucose and FOS.

RESULTS: Five studies have shown that the use of FOS reduces the fecal content and increases intestinal transit time. Experimental studies have shown that dietary supplementation with high doses (60 g/Kg) of propionate, a short-chain fatty acid decreased glycemia. The use of lower doses (3 g/kg) did not produce the same results. Study in subjects with diabetes type II showed that the addition of 8 grams of FOS in the diet for 14 days, caused a reduction in serum glucose. In another study with healthy subjects, there were no changes in glycemic control.

CONCLUSIONS: This review demonstrates that consumption of FOS has a beneficial influence on glucose metabolism. The controversies appear to be due to inadequate methodological designs and/or the small number of individuals included in some studies.

Key words: Review. Blood Glucose. Oligosaccharides. Prebiotics. Dietary Fiber.

RESUMO

OBJETIVO: Conhecer o estado atual do conhecimento científico em fructooligossacarídeos (FOS), açúcares não-convencionais que desempenham um papel importante no controle da glicemia.

MÉTODOS: Realizamos uma busca de artigos científicos nas bases de dados MEDLINE e Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS), a partir de janeiro 1962 a dezembro de 2011, usando como descritores termos Português/Inglês: “glicemia/blood glucose, “prebióticos/prebiotics” e “fibras na dieta/dietary fiber. A partir de um número inicial de 434 referências, algumas repetidas, 43 referências foram consideradas adequadas para a finalidade deste estudo e foram, portanto, selecionadas para análise. Os textos selecionados foram distribuídos em três tópicos: (1) metabolismo de FOS (2), FOS e estudos experimentais envolvendo glicose e (3) estudos em humanos envolvendo glicose e FOS.

RESULTADOS: Cinco trabalhos mostraram que o uso de FOS diminui o conteúdo fecal e aumenta o tempo do transito intestinal. Estudos experimentais demonstraram que a suplementação dietética com altas doses (60 g/Kg) de propionato, um ácido graxo de cadeia curta, diminuiu a glicemia. A utilização de doses menores (3 g/Kg) não produziu os mesmos resultados. Em indivíduos diabéticos tipo II a adição de 8 g de FOS na dieta, durante 14 dias, induziu uma redução da glicemia. Em indivíduos sadios, não ocorreram alterações da glicemia.

CONCLUSÕES: Essa revisão mostra que o consumo de FOS exerce influência benéfica no metabolismo glicêmico. As controvérsias evidenciadas parecem estar mais ligadas a desenhos metodológicos inadequados e/ou ao número reduzido de indivíduos incluídos em alguns estudos.

Descritores: Revisão. Glicemia. Oligossacarídeos. Prebióticos. Fibras na Dieta.

Introduction

Different from the majority of simple sugars and oligosaccharides, fructo-oligosaccharide (FOS), a naturally occurring oligosaccharide, passes intact through the upper digestive tract without being digested but is degraded in the colon by indigenous bacteria[1]. FOS are mainly known for its ability to improve host health as it stimulates the growth of some beneficial bacteria, such as the bifidobacteria.FOS may be found in many plant foods such as bananas, onions, garlic, asparagus, wheat, rye, Jerusalem artichoke. Besides, it may be produced enzymatically[6]. It is possible to find industrial products containing FOS, alone or with other ingredients in Brazil. Recent use of FOS as a food ingredient has stimulated much research to know its functionality and its effects on human health, especially in relation to its bifidogenic character[7]. Thus, its potentially beneficial effects in preventing and controlling some diseases have been extensively discussed, particularly in those conditions associated with the increase of peripheral insulin resistance, eg, diabetes mellitus and metabolic syndrome.Recent studies suggest that butyrate and other short-chain fatty acids (SCFA) may mediate the effects of diet and gut microbiota on host appetite, metabolism, adiposity, and immunity[8-11].

Considering that non digestible oligosaccharides are often cited as being important dietary fibers in nutritional advice concerning specific disorders associated with the metabolic syndrome[12], the aim of this review was to know the current status of FOS specific role in blood glucose control.

Methods

We conducted a search for scientific articles in MEDLINE and Latin American Literature and Caribbean in Health Sciences (LILACS) databases, from January 1962 to December 2011, using English/Portuguese keywords: "blood glucose/glicemia", "prebiotics/prebióticos" and "dietary fiber/fibras na dieta". From an initial number of 434 references, some repeated, 43 references published from January1962 to December 2011 were included in this study. The selected texts were distributed in three topics: (1) metabolism of FOS, (2) FOS and experimental studies involving glucose and (3) human studies involving glucose and FOS.

Results

Metabolism of FOS

FOS are not hydrolyzed by endogenous enzymes in the small intestine of humans and following ingestion reach the cecum and colon in intact form, where they are metabolized completely by the colonic microflora, through fermentation, producing gases (carbon dioxide, hydrogen, methane) and reducing the colon pH by lactate and SCFA production, such as acetate, propionate and butyrate, which are quickly absorbed by the colonic mucosa[13-17]. The solubility of these oligosaccharides in water decreases fecal content and increases intestinal transit time Butyrate, together with acetate and propionate, are major SCFA, also known as volatile fatty acids, produced by microbial fermentation in the gastrointestinal tract[18].

Digestive tolerance to FOS depends on the amount ingested, the presence of factors that reduce their osmotic load in the small intestine and the degree of adaptation of the colonic microflora in the fermentation of these sugars. The osmotic effect of these sugars is determined by the concentration of sugar that leaves the stomach and this obviously depends on the amount ingested, but also on factors that slow gastric emptying, the type of meal and its solid content and viscosity[16]. The fraction fermented in the large intestine provides 8.4 kJ / g (2 kcal) and energy loss when a sugar is fermented is approximately 50%[16].

Experimental studies

Boillot *et al.*[19] showed that long-term dietary supplementation with propionate lowers blood glucose, suggesting that the improvement in glucose tolerance and insulin sensitivity may be due to propionate effects on carbohydrate metabolism. A study using Sprague-Dawley rats showed that these concentrations were not affected by supplemental propionate, a short-chain fatty acid. However, it should be noted that the amount of propionate in this study was small (3g / kg), compared with the previous study, where twenty-fold larger doses were used[20]. Although it is known that high levels of free fatty acids (FFA) are associated with insensitivity to insulin and inhibition of glucose uptake by muscle[21], some studies have found that lower FFA levels were not associated with a reduction in blood glucose, although in fasting, such levels have shown a tendency to lower values in the group fed with propionate but no significant difference between groups[19].

Propionate has some hypoglycemic effect under certain circumstances[22]. The mechanism of action of propionate at cellular level in isolated rat hepatocytes[23] is related to a decrease in gluconeogenesis[24], inhibition of pyruvate carboxylase, which in turn is inhibited by metabolic products of propionate, the methylmalonyl-CoA and succinyl CoA[25]. In addition, propionate stimulates glycolysis in isolated rat hepatocytes[24] although shown to be gluconeogenic in vitro[23].

Clinical studies

Yamashita *et al*.[26] studied the systemic effects of adding FOS (8g daily) for 14 days to the diet of patients with type 2 diabetes mellitus whose serum glucose concentration was uncontrolled. Fasting blood test showed an 8% reduction in serum glucose levels[26]. Alles *et al.*[6] used 15g for 20 days in patients with type 2 diabetes and found no significant changes in glucose levels. In another study, Luo *et al*.[27] showed that chronic consumption of 20 g FOS / day in healthy individuals decreased the hepatic glucose production but had no effect on glucose metabolism stimulated by insulin. Similar results were found by other researchers[28,29].Parnell and Reimer[30] studied the effects of oligofructose supplementation on body weight and satiety hormone concentrations in adults and concluded that oligofructose supplementation has the potential to promote weight loss and improve glucose regulation in overweight adults. Published studies have demonstrated that consumption of foods containing the soluble fiber, b-glucan from oats and barley, have beneficial effects on glucose metabolism, lipids and blood pressure in overweight and/or mildly hypercholesterolemic persons[31]. De Mello and Laaksonen studied the effects of dietary fiber in the treatment of metabolic syndrome and type 2 diabetes mellitus. After an extensive literature review the authors concluded that, despite the paucity of data on longer-term studies that focus specifically on dietary fiber, the recommended use of 25g of fiber per day from a diet rich in whole grains, fruits and vegetables, is likely to decrease the risk for obesity, metabolic syndrome and type 2 diabetes mellitus[32].

Acetate can reduce plasma free fatty acids (FFA)[33] and this could benefit the blood glucose and insulin sensitivity in the long term because high concentrations of fatty acids decrease tissue glucose utilization and increase tissue insulin resistance[21].Unlike sucrose, 25g of FOS did not increase serum levels of postprandial glucose and fructose[16]. The improvement in carbohydrate metabolism could be justified by the SCFA, since propionate and / or acetate administered intravenously, orally or by rectal infusion reduces plasma FFA concentrations[34,35]. For Cummings[36], SCFA absorbed in the colon can improve carbohydrate metabolism, considering that a high concentration of sodium propionate in the diet is associated with a noticeable improvement in carbohydrate tolerance due to inhibition of salivary amylase. Other studies where viscous fiber meals and low glycemic index foods[37,38] replaced the normal diet in healthy volunteers[39] and in patients with diabetes[40,41]also indicated a subsequent reduction in the concentrations of blood glucose and insulin. However, Giacco *et al*.[42], using FOS 10.6 g /day of did not detect effects on blood glucose, either in fasting or in the postprandial period.Studies with infants indicate that consumption of prebiotic mixtures galactooligosaccharide / fructooligosaccharide and inulin/ galactooligosaccharide reduce the incidence of infections[43]. These results are important, especially in the preparation of infant formula, although these studies are not conclusive with respect to diarrhea, especially in patients with chronic intestinal inflammation and those in treatment with antibiotics. In general, dietary fiber and FOS appear to have similar effects in children and adults.

Conclusions

This review demonstrates that consumption of FOS has a beneficial influence on glucose metabolism. The controversies verified here seem to be linked to inadequate methodological designs and/or the small number of individuals included in some studies. The use of FOS supplementation in the diet may therefore be a strategy for reducing blood glucose. The duration of the treatment and dose to be administered are still questions to be answered. Further studies may clarify these questionings.

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