Journal of Functional Foods 24 (2016) 207–220

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/jff

Soluble dietary fibre partially hydrolysed guar gum markedly impacts on postprandial hyperglycaemia, hyperlipidaemia and incretins metabolic hormones over time in healthy and glucose intolerant subjects

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ARTICLE INFO

Article history:
Received 26 January 2016
Received in revised form 12 April 2016
Accepted 18 April 2016
Available online 25 April 2016

Keywords:
Partially hydrolysed guar gum
Hyperlipidaemia
Postprandial glycaemia
Incretins metabolic hormones

ABSTRACT

Dietary fibre intakes have consistently been associated with reduced risk of diabetes and metabolic syndrome. We investigated in 12 healthy subjects if administration of dietary fibre partially hydrolysed guar gum (PHGG) induces beneficial impact on hyperglycaemia, hyperlipidaemia and incretins metabolic hormones. Administration of 6 g/PHGG with each meal for 12 months significantly lowered the postprandial plasma glucose (PG), reduced both the fasting and postprandial insulin (IRI) and triacylglycerol (TG) levels ($p = 0.05$). Low-density lipoprotein (LDL) was lower, whereas high-density lipoprotein (HDL) level was significantly increased ($p < 0.01$). Plasma leptin, high-sensitive C-reactive protein (hs-CRP) and fasting glucagon like peptide (GLP-1) were also lowered. In fact, 3 out of 6 glucose intolerant subjects turned out to be normal glucose tolerant after only 3 months of PHGG supplementation. Therefore, this preliminary study revealed that inclusion of PHGG in diets potentially impact on metabolic health profiles by affecting circulating metabolites that are responsible for glycaemia, hyperinsulinaemia and hyperlipidaemia factors.

1. Introduction

Postprandial hyperglycaemia has long been associated with increased oxidative stress and the development of heart disease, diabetes and all-cause mortality (Baboota et al., 2013; Gerich, 2003; O'Keefe & Bell, 2007). Many studies have shown that addition of purified dietary fibres results in a smaller postprandial rise of blood glucose levels both in non-diabetic, prediabetic and diabetic subjects, and lowers the risk factor of chronic conditions including glucose intolerance, hyperinsulinaemia, and postprandial hyperlipidaemia (Bays et al., 2013; Chiba, Tsuji,

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Abbreviations: PHGG, partially hydrolysed guar gum; TOT, all subjects; NGT, normal glucose tolerance; IGT, impaired glucose tolerance; PDM, pre-diabetes mellitus; BMI, body mass index; WC, waist circumference; HbAIc, glycated haemoglobin; PG, plasma glucose; IRI, insulin resistance index; TG, triacylglycerols; HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol; APoB48, apolipoprotein-48; RLP-C, remnant-like particles-cholesterol; GLP-1, glucagon-like peptide 1; GIP, gastric inhibitory polypeptide; hs-CRP, high-sensitive C-reactive protein; CRE, creatinine; 8-OHdG, 8-Oxo-2′-deoxyguanosine; LPO, lipids peroxidation; HEL, hexanoyl-lysine adduct; ANOVA, analysis of variance; s.e.m., standard error mean; AUC, Area under curve

http://dx.doi.org/10.1016/j.jff.2016.04.008
1756-4646/

Nakane, & Komatsu, 2015; Kovacs et al., 2002; Morgan, Tredger, Wright, & Marks, 1990; Tucker et al., 2014; Yuan et al., 2014). In light of such potential health benefits, populations have been encouraged to consume more fibre. Recommendations for adult dietary fibre intake fall in the range of 25 to 38 g per day; however, in Japan the dietary fibre consumption continues to be less than recommended, averaging nearly 15 g per day, wherein the soluble fibre intake is far below 5 g per day (Chiba et al., 2015). In recent years, manufacturers have been developing and selling various fibre products. However, inconsistent results have been found for the relationship between fibre and glycaemia. The main reason is that hypothesized mechanisms behind the action of dietary fibre, especially soluble fibre, are still poorly interpreted, because the beneficial effects of fibre on glucose and lipid abnormalities have mostly been attributed to insoluble rather than soluble fibre.

Partially Hydrolysed Guar Gum (PHGG) is a water-soluble dietary fibre with relatively low viscosity (molecular weighs between 1 and 100 kDa, with an average of 20 kDa) derived from guar gum galactomannans produced by *Cyamopsis tetragonolobus* that is widely used in the food industry as a thickener and emulsion stabilizer, using β-endogalactomannase from a strain of *Aspergillus niger* (Kapoor & Juneja, 2009; Slavin & Greenberg, 2003). Its safety is well known and several clinical uses are well established (Finley et al., 2013). Very few studies have investigated the effect of PHGG on postprandial glycaemic responses. Golay (1995) first examined the effect of PHGG in combination with fructose incorporated into a liquid meal on postprandial glucose and insulin concentrations in 6 Type-2 diabetic patients, and results cannot be extrapolated to the general population. Later, Trinidad et al. (2004) reported the randomized cross-over intervention study in 11 healthy subjects and 9 Type-2 diabetic subjects with varied amounts of PHGG. It was revealed that whilst increasing amounts of PHGG significantly decreased the AUC of the plasma glucose curve in a dose-dependent manner in diabetic subjects, it was not reduced significantly in non-diabetic subjects. Hyperlipidaemia refers to elevated low-density lipoprotein (LDL)-cholesterol, elevated total cholesterol (TC) or triacylglycerols (TG), or low levels of high-density lipoprotein (HDL)-cholesterol in the blood to describe the manifestations of different disorders of lipoprotein metabolism. Lowering lipids through dietary therapy has been shown to decrease the incidence of adverse events, and the effectiveness of dietary fibres on hyperlipidaemia has been clearly demonstrated. Takahashi et al. (1993) administrated a comparatively high dose (36 g per day) to 8 healthy volunteers after a control diet for four weeks in a pre-test/post-test intervention to assess the effects of PHGG on fasting serum concentrations of triacylglycerols and total serum cholesterol concentrations. In another study, Yamatoya, Kuwano, and Suzuki (1997) assigned 15 female volunteers to consume either 5 g or 15 g/day of PHGG for two consecutive weeks to evaluate the effect of PHGG on fasting serum TG concentrations and total serum cholesterol concentrations (Yamatoya et al., 1997). However, the effective relationship could not be established between consumption of PHGG and maintenance of normal blood concentration of TG and cholesterol. Since the effective relationship has not yet been fully laid down between the consumption of PHGG and reduction of postprandial glycaemic responses and hyperlipidaemia as beneficial physiological effects, we hypothesized that medium- to long-term intakes of PHGG could be associated with significant reductions in fasting glycaemia and hyperlipidaemia. The positive determinants include composition of meal consumption, fasting (pre-prandial) glycaemic levels, gastric emptying, glucose absorption in small intestinal and overall glucose metabolism, and insulin secretion. Because the relative contribution of aforementioned factors may be altered during the postprandial state, the action of the incretin hormones such as glucagon-like peptide-1 (GLP-1) and gastric inhibitory polypeptide (GIP), also known as glucose-dependent insulinotropic peptides, may exert a major influence on the rate of postprandial glycaemia through their glucagon static and insulin tropic actions, respectively (Chang, Rayner, Jones, & Horowitz, 2010; Marathe, Rayner, Jones, & Horowitz, 2013; Nauck et al., 1993). Therefore, the objective of this preliminary study was to evaluate the effects of PHGG on postprandial glycaemic, hyperlipidaemia, and incretin metabolic hormones GIP and GLP-1 over time in healthy non-diabetic individuals with normal glucose tolerance and glucose intolerant humans.

2. Materials and methods

2.1. *Subjects*

During screening, routine fasting serum chemistry values were applied to determine healthy and glucose intolerant subjects according to the American Diabetes Association (ADA, 2014). Subjects were excluded if they had any active gastrointestinal or metabolic disease or they were positive type-2 diabetes patients with poor glycaemic control (fasting plasma glucose (PG) > 200 mg/dL and haemoglobin HbA1C >9%). A total of 13 healthy, nondiabetic and glucose intolerant subjects were recruited with fasting PG of <6.1 mmol/L (<110 mg/dL), without any first-degree family history of diabetes mellitus or glucose intolerance and were not on any regular medications with normal haemoglobin concentration and blood pressure (≤96 mmHg: diastolic; ≤160 mmHg: systolic). One subject was excluded due to non-Japanese ethnicity to maintain the "self-described as Japanese" ethnic homogeneity of the study. Of 12 subjects, 6 were normal glucose tolerant individuals (NGT: ≤140 mg/dL postprandial PG after 2 h). Another 4 subjects were with normal fasting PG concentration having a tendency of glucose intolerance and were grouped as impaired glucose tolerant subjects (IGT; ≥140 ≤199 mg/dL postprandial PG after 2 h). The remaining 2 subjects with normal fasting PG concentration, but showed somewhat moderate glucose intolerance (≥200 <220 mg/dL postprandial PG after 2 h), were placed in the pre-diabetes mellitus (PDM) group.

Twelve (12) subjects had a mean ± standard error mean (s.e.m.) age of 46.3 ± 2.9 years, weight of 78.9 ± 5.1 kg, height of 170.6 ± 1.9 cm, waist circumference (WC) of 94.1 ± 3.4 cm, and body mass index (BMI) of 27.0 ± 1.5 kg/m^2. Subjects did not use any fibre supplements regularly prior to the study. The nature and possible risk of the experimental procedure were thoroughly explained to the subjects. All subjects gave written informed consent to the protocol which was verified and ap-