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Corn bran dietary fibre modified by xylanase improves the mRNA expression of genes involved in lipids metabolism in rats

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Abstract

The regulation effects of corn bran dietary fibre (CDF) and the xylanase modified form (XMF) in male Sprague Dawley rats on the expression of several genes involved in lipid metabolism were studied. Rats for NF and HF group (8 per group) were fed basic diet (NF) and atherogenic diet (HF), respectively, for six weeks. The rats for CDF or XMF group were fed HF diet, for two weeks first then changed to CDF (10%) or XMF (10%) diet, respectively, for four weeks. XMF ingestion lowered serum total cholesterol (TC), triacylglycerols (TG), low-density lipoprotein cholesterol (LDL-C) and increased high-density lipoprotein cholesterol (HDL-C) significantly ($p < 0.05$) as compared with CDF; The corresponding liver TC, TG and fat in XMF group were also significantly lower ($p < 0.05$). CDF ingestion lowered serum TC, TG, LDL-C, arteriosclerosis index (AI), and liver fat significantly ($p < 0.05$). AI in XMF group was less than 50% of that in CDF group. XMF enhanced the catabolism of lipids by up-regulating the transcription of hepatic cholesterol 7 alpha-hydroxylase (CYP7A1), peroxisome proliferator-activated receptors (PPARα and PPARγ), lipoprotein lipase (Lpl), liver lipase and ileum farnesoid X receptor (FXR), down-regulating the transcription of intestine-bile acid binding protein (I-BABP) and hepatic FXR. While CDF only down-regulated I-BABP transcription, up-regulated ileum FXR, liver PPARα, Lpl and CYP7A1 transcription.

Keywords: Xylanase modification; Corn bran dietary fibre; Hypolipidemic effects; Regulation; mRNA expression; Sprague Dawley rats

1. Introduction

A major cause of cardiovascular turbulence is atherosclerosis, which originates mainly from hyperlipidemia and the turbulent lipids metabolism (Jin, Wen, Tang, & Chen, 1995). The generation and development of atherosclerosis correlate highly with blood total cholesterol (TC) and total triacylglycerol (TG) levels. Among TC, the low-density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL-C) are the most important actors for coronary heart disease. High-density lipoprotein cholesterol (HDL-C) suppresses the ingestion of LDL-C by body cells, transports excessive cholesterol out of cells in the ester form, and thus prevents the accumulation of cholesterol in the cells (Goldstein, Hazzard, Schrott, Bierman, & Motulsky, 1973).

Hyperlipidemia is tightly connected with dietary factors. It is now well established that certain sources of dietary fibre (such as Psyllium and prune among others), independent of the fat or carbohydrate content of the diet, can lower serum cholesterol concentrations (Kritchevsky & Tepper, 2005; Lucas, Juma, Stoecker, & Arjmandi, 2000). A considerable amount of fibre is processed from wheat bran, fruits, pea hulls and bagasse, among others, all these have been incorporated into food products such as bread and fish products (Sanchez-Alonso, Haji-Maleki, & Borderias, 2007; Sudha, Vetrimani, & Leelavathi, 2007).

Corn bran has higher dietary fibre content than both wheat and rice bran (Wang & Liu, 2000), in which about 40% is heteroxylan, followed by cellulose and some phenolic acids (Saulnier, Marot, Chanliaud, & Thibault, 1995). Shane

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and Walker (1995) reported that corn fibre supplementation of low-fat controlled diet in men with hypercholesterolemia resulted in additional lowering of serum TC, TG and VLDL-C, while serum LDL-C and HDL-C concentrations were not significantly altered. Corn bran fibre hydrolysed by α-amylase was also found to lower the plasma and liver cholesterol concentrations significantly in rats (Ebihara & Nakamoto, 2001). Zhang and Wang (2005) prepared a corn dietary fibre from corn residue using α-amylase and alkali proteinase hydrolysis, and fed it to hyperlipidemic mice. The feeding results showed that with the addition of corn dietary fibre up to 8% of total feed, the levels of serum total cholesterol and total triacylglycerols were lowered, and the HDL-C was increased, as compared with the control.

It is known that dietary fibre increases bile acid and cholesterol excretion by decreasing bile acid and cholesterol absorption in the intestinal tract, thus enhancing bile acid synthesis from cholesterol, hence acts as a hypocholesterolemic agent (Marlett, 2001). In a previous study, a new corn bran fibre XMF, which was moderately hydrolysed by xylanase, presented significantly increased bile salts binding capacity than its origin corn bran dietary fibre (CDF) in vitro (Hu, Wang, & Xu, 2008). However, the general mechanisms of hypolipidemic activity of dietary fibre are still uncertain. Lipids (cholesterol and fatty acids) are essential nutriments and have a major impact on gene expression. Cholesterol intracellular concentration is precisely controlled by some complex mechanisms involving transcriptional regulations (Lobaccaro et al., 2001). Soluble phytochemicals have been reported to act as hypocholesterolemic agents through regulating some genes involved in lipids metabolism (Cha et al., 2006; Mezei et al., 2003; Takahashi et al., 2002). The hypocholesterolemic effect of dietary beet fibre is associated with diminished expression of the hepatic apoliprotein A-I gene (Sonoyama, Shuhachi, & Niki, 1995). Corn bran is mainly composed of insoluble fibre (Hu & Wang, 2006). There is no report about whether corn bran dietary fibre improves lipid homeostasis through influencing the transcription of genes involved in lipids metabolism to date. Thus, the purpose of this study was to investigate the influences of corn bran dietary fibre CDF and its xylanase modified form XMF on the regulation of mRNA expression of several genes involved in cholesterol and triacylglycerols catabolism.

2. Methods and materials

2.1. Corn bran dietary fibre (CDF)

Corn bran was provided by Dancheng Caixin Group Co., Ltd. (Henan, PR China) and was milled through a 250 μm screen, then processed as reported previously (Hu et al.).

2.2. Xylanase modified corn bran fibre (XMF)

A 10 L container with a working volume of 8 L of 50 mmol/L phosphate buffer at pH 5.3, containing 0.7 g/100 g CDF of xylanase (NCB 77, 8000 IU/g, from *Bacillus subtilis,* main enzyme activity EC 3.2.1.8), supplied by Hunan New Century Biochemical Co., Ltd., Yueyang, PR China. Eight hundred grams CDF were added to the freshly prepared xylanase enzyme solution. The reaction mixture was incubated in a super water bath thermostatic vibrator (Model 501, Shanghai Experimental instrument Co., Shanghai, PR China) at 50 °C with 145 rpm agitation for 1.75 h, and the reactants handled as in Section 2.1 to obtain the xylanase modified fibre (called XMF).

2.3. Animals and diets

The Jiangnan University Animal Care and Use Committee approved all rat studies. All rats weighing 100 ± 10 g (male Sprague Dawley, from Shanghai Slac Laboratory Animal Co., Ltd., Shanghai, PR China) were placed individually in stainless steel wire mesh cages in a room maintained at 23 °C ± 2.0 °C, with relative humidity of 55 ± 10%, and a daily photo period from 7:00 am to 7:00 pm. Rats consumed food and water ad libitum and were acclimated to the animal facility for one week. All were then randomly assigned to NF (negative control), HF (positive control), CDF or XMF group with eight rats per group. Rats in NF and HF group were fed with basic feed (NF diet) and an atherogenic diet (HF diet), respectively, for six weeks. The rats for CDF or XMF group were fed HF diet, for two weeks first then changed to CDF or XMF diet, respectively, for four weeks. The components of diets were as shown in Table 1. HF diet was an atherogenic diet. Cholesterol, sodium cholate, yolk powder and basic feed were purchased from Shanghai Slac Laboratory Animal Co., Ltd., Shanghai, China). Lard was purchased from a local market in Wuxi, PR China.

Table 1
Components of animal diets

	NF	HF	CDF	XMF
Corn powder	35.5	30	25	25
Soy bean pomace	21.6	20	20	20
Lard	2	15	15	15
Fish powder	2	4	4	4
Cellulose	10	3	–	–
Flour	26	13.8	11.8	11.8
$CaHPO_4$	1	1	1	1
$CaCO_3$	1.3	1.1	1.1	1.1
Lysine	0.12	0.12	0.12	0.12
Methioline	0.13	0.13	0.13	0.13
Choline	0.1	0.1	0.1	0.1
Mineral mixture	0.03	0.03	0.03	0.03
Vitamin mixture	0.02	0.02	0.02	0.02
NaCl	0.2	0.2	0.2	0.2
Cholesterol	–	2	2	2
Sodium cholate	–	0.5	0.5	0.5
Yolk powder	–	9	9	9
CDF	–	–	10	–
XMF	–	–	–	10