

The effect of cereal by-product dietary fibre on the serum lipid profile and short-chain fatty acid concentration in caecal digesta of rats

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ABSTRACT

The hypolipaeamic effect of different dietary fibres (cellulose, oat bran, wheat bran) added to diets for rats was evaluated on 36 animals. The best results in lowering total serum cholesterol and low-density lipoprotein cholesterol (2.08 and 0.88 mmol/l, respectively) were obtained in the group with oat bran. The highest total caecal and caecal tissue weights (1.36 and 0.43 g/100 g BW, respectively) as well as butyric acid production (13.23 μ mol/g of caecal content) were observed in this group as compared with the cellulose and wheat bran groups.

KEY WORDS: rats, oat bran, wheat bran, serum cholesterol, caecum, short-chain fatty acids

INTRODUCTION

Fibrous feeds traditionally have not been used for nonruminants due to their documented reduction of diet digestibility, especially in young, growing animals (LeGoff and Noblet, 2001). Nonetheless, some types of fibre and fibre sources do not exert such negative effects on nutrient digestibility but can have protective effects on gut health (Montagne et al., 2003) and reduce cardiovascular disease risk (Keogh et al., 2003). These protective and physiological effects are dependent on a complex mixture of structural, chemical and physical properties of dietary fibre (water-holding capacity, viscosity, gel formation and bile acid binding). Oat bran, an important source of water-soluble fibre, has been shown to reduce serum cholesterol (Levrat et al., 2000) in comparison with insoluble, nonviscous fibres such as cellulose (Romero et al., 2002).

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Moreover, in comparison with cellulose, soluble fibres are easily fermented in the large intestine to short-chain fatty acids (SCFA). It was found by Demigné et al. (1995) that propionic acid may lower hepatic cholesterol synthesis. SCFA, butyrate in particular, stimulate the development and growth of the large and small intestines and play a role in cancer prevention (Hass et al., 1997).

The aim of this study was to evaluate the influence of different dietary fibres on serum lipids and production of SCFA in the caecum of rats.

MATERIAL AND METHODS

Thirty-six male Wistar rats with an initial weight of about 130 g were divided into 6 groups of 6 animals each. The animals were housed individually in steel cages, food and water were provided *ad libitum*. Three groups were fed with mixtures supplemented with 1% cholesterol (Sigma) and contained one of three kinds of fibre, %: cellulose 2.5, oat bran 13, or wheat bran 5. The other three groups contained the same fibres but without the cholesterol supplement. All diets were isofibrous (2.5% dietary fibre; AOAC, 1990), and contained, %: sunflower oil 6, sucrose 20, minerals 4, vitamins 2, casein 20, and were supplemented with maize starch to 100%. The experiment lasted 6 weeks. Body weights and feed intake were recorded weekly. At the end of the experiment the animals were anaesthetized. Blood was withdrawn by cardiac puncture and serum was isolated by centrifuging (1500 g for 15 min). Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and triacylglycerols (TAG) were determined enzymatically in serum. The cholesterol in the low-density lipoprotein fraction (LDL-C) was calculated as $LDL-C = TC - HDL-C$. The caecum was removed and weighed. The caecal content was preserved (25% metaphosphoric acid) and frozen (-20°C). The concentrations of SCFA (acetic, propionic, butyric) in caecum digesta were measured using a gas chromatograph (CP-WAX 58 column, 0.53 mm×25 m). Data were analysed using two-way analysis of variance (SAS, 1992).

RESULTS

The influence of the diets on serum total cholesterol and cholesterol fractions and on short-chain fatty acid concentrations in the caecum is shown in Table 1. Total serum cholesterol concentrations and low-density cholesterol were the lowest in rats from the oat bran group when compared with other groups. The highest ratio of high-density lipoprotein cholesterol to total cholesterol (0.59) was also found in this group. In groups fed diets supplemented with 1% cholesterol, negative effects

Table 1. Effect of dietary fibre on serum lipids, short-chain fatty acid concentrations, and pH of caecal digesta

Item	Dietary fibre			Cholesterol		SEM	DF × Ch
	cellulose	wheat bran	oat bran	with	without		
Total cholesterol, mmol/l	2.40 ^a	2.29 ^{ab}	2.08 ^b	2.54 ^a	1.98 ^b	0.04	ns
High-density lipoprotein cholesterol, mmol/l	1.22	1.24	1.20	1.02 ^b	1.41 ^a	0.03	ns
Low-density lipoprotein cholesterol, mmol/l	1.18 ^a	1.05 ^{ab}	0.88 ^b	1.52 ^a	0.57 ^b	0.04	ns
High-density lipoprotein cholesterol: total cholesterol ratio	0.53 ^b	0.56 ^{ab}	0.59 ^a	0.41 ^b	0.71 ^a	0.01	ns
Triacylglycerols, mmol/l	1.29 ^b	1.61 ^a	1.26 ^b	1.38	1.39	0.05	ns
Short-chain fatty acid, μmol/ g caecum content							
acetic	43.16 ^b	48.43 ^b	60.22 ^a	42.62 ^b	58.59 ^a	1.49	*
propionic	13.60 ^c	23.40 ^a	18.46 ^b	16.40 ^b	20.58 ^a	0.80	ns
butyric	6.81 ^c	10.83 ^b	13.23 ^a	10.55	10.03	0.46	ns
total SCFA	63.58 ^b	82.66 ^a	91.91 ^a	69.57 ^b	89.19 ^a	2.33	ns
Caecum							
pH of digesta	7.40 ^a	7.15 ^{ab}	6.94 ^b	7.32	7.01	0.01	ns
total weight, g/100 g BW	1.15 ^b	1.26 ^{ab}	1.36 ^a	1.28	1.23	0.04	ns
tissue weight, g/100 g BW	0.29	0.37	0.43	0.35	0.38	0.03	ns

^{a,b} - values in rows with different letters differ significantly ($P \leq 0.05$); * - $P < 0.05$; ns - $P \geq 0.05$

on the lipid profile and elevation of total serum cholesterol were found. The total SCFA concentrations were significantly higher ($P \leq 0.05$) in the oat-bran and wheat-bran groups when compared with the cellulose group. The highest concentrations of butyric acid were observed in the oat-bran group, that of propionic acid, in the wheat-bran group. In groups fed diets supplemented with 1% dietary cholesterol, the concentrations of acetic and propionic acids and total SCFA were significantly lower ($P \leq 0.05$) than in groups without cholesterol. An increase in total caecum weight with the oat-bran and wheat-bran diets was noted compared with cellulose, but in caecal tissues the weight differences were not significant. The caecal digesta of rats in the oat-bran group had a lower pH (6.94) compared with the other diets.

DISCUSSION

In the present study, the favourable effects of oat bran on serum total cholesterol and lipoprotein profile were comparable to the data obtained by Kerckhoffs et al.

(2003). The results suggest that feeding dietary fibres rich in soluble fibre resulted in lower serum lipid concentrations than feeding water-insoluble fibre such as cellulose or wheat bran, which differ greatly in structure and chemical properties. The elevation in caecal total and tissue weight on the oat and wheat bran diets may result from SCFAs normalizing cell proliferation. Sakata et al. (2001) observed that butyrate influences the development and growth of the large and small intestine by stimulating epithelial cell proliferation and crypt depth in the large intestine.

CONCLUSIONS

The oat bran in diets for rats decreased total serum cholesterol and improved the lipoprotein profile. Oat bran also produced the highest amount of butyric acid and may have greater trophic effects in the caecum of rats than cellulose and wheat bran.

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