Evaluation of commercial microbial hydrocolloids concerning their effects on plasma lipids and caecal formation of SCFA in mice

Lindström, Cecilia; Holst, Olle; Hellstrand, Per; Öste, Rickard; Andersson, Kristina E

Published in:
Food Hydrocolloids

DOI:
10.1016/j.foodhyd.2012.01.019

2012

Link to publication

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Evaluation of commercial microbial hydrocolloids concerning their effects on plasma lipids and caecal formation of SCFA in mice

Cecilia Lindström a,b,*, Olle Holst a, Per Hellstrand c, Rickard Öste b,d, Kristina E. Andersson c

aDivision of Biotechnology, Department of Chemistry, Lund University, Box 124, SE-221 00 Lund, Sweden
bDepartment of Applied Nutrition and Food Chemistry, Department of Food Technology, Engineering and Nutrition, Lund University, Box 124, SE-221 00 Lund, Sweden
cAventure AB, Scheelevägen 22, Box 719, SE-220 07 Lund, Sweden
dDivision of Biotechnology, Department of Chemistry, Lund University, Box 124, SE-221 00 Lund, Sweden

ARTICLE INFO

Article history:
Received 31 October 2011
Accepted 31 January 2012

Keywords:
Exopolysaccharides
Hydrocolloids
Cholesterol
SCFA

ABSTRACT

Exopolysaccharides (EPS) are excreted by microorganisms into the surrounding environment and have been shown to have various physiological effects and are commonly used as food additives due to their rheological properties. Four commercially available microbial EPS with different polymeric structures and composition were tested in LDL receptor knock-out mice to investigate their effect on blood cholesterol, lipoproteins and caecal formation of SCFA. After four weeks on a Western diet supplemented with 4% EPS there were significant increases in caecal content and caecal tissue weight for the EPS groups compared to the control. The total pool of caecal short chain fatty acids was increased when mice were fed scleroglucan, xanthan and dextran. There were no differences in plasma cholesterol levels on the experimental diets compared to the control. Plasma triglycerides did not differ between groups. The results indicate that EPS supplementation to a Western diet may help in maintaining a healthy intestinal environment.

1. Introduction

Various microorganisms produce polysaccharide structures as capsular or extracellular slime (Sutherland, 1998). Exopolysaccharides (EPS) have different structural and chemical composition and may be homo- or heteropolysaccharides (Sutherland, 1982). These hydrocolloids are invaluable in food formulations due to their rheological properties and are used as gelling and viscosifying agents (Sutherland, 1994). They may be produced in situ thus providing functional properties without the use of additives (De Vuyst & Degeest, 1999; Ruas-Madiedo, Hugenholtz, & Zoon, 2002). EPS have similar structures to dietary fibres originating from plant material. Dietary fibres have on many occasions been shown to regulate body weight, glucose homeostasis, insulin sensitivity and other risk factors of cardiovascular disease like the plasma lipid profile (Galisteo, Duarte, & Zarzuelo, 2008). Elevated levels of serum cholesterol are associated with atherosclerosis and coronary heart disease (CHD) (Karnik, 2001). Four hydrocolloids that have a well documented hypocholesterolemic effect in humans (Theuwissen & Mensink, 2008) and animals (Anderson, Jones, & Riddell-Mason, 1994) are psyllium, pectin, guar gum and beta-glucans, all from different origin and of dissimilar composition structurally and chemically (Theuwissen & Mensink, 2008). A cholesterol lowering effect is also found with fungal beta-glucans (Nicolosi et al., 1999), seaweed (Jiménez-Escrig & Sánchez-Muniz, 2000) and various EPS (Levrat-Verny & Behr, 2000; Maeda, Zhu, Suzuki, Suzuki, & Kitamura, 2004; Zou, Guo, & Sun, 2009).

There are several different mechanisms proposed to explain the beneficial effects of soluble fibres on physiological functions. Firstly, the presence of soluble fibres in the intestine leads to absorption of fluid and an increase in viscosity of intestinal contents (Mäkeläinen et al., 2007). This increase may make the unstirred layer adjacent to the mucosa thicker, leading to impaired absorption of 1) bile acids (Kerckhoffs, Bouw, & Hornstra, 2002) and possibly dietary cholesterol and 2) glucose, causing the blood sugar to rise slowly giving a low insulin response (Mäkeläinen et al., 2007). This leads to decreased insulin-stimulated hepatic HMG-CoA reductase activity and consequently cholesterol synthesis (Theuwissen & Mensink, 2008). The binding of bile acids by soluble fibres leads to increased faecal bile acid excretion which is followed by a stimulation of hepatic bile acid
synthesis from circulating cholesterol thereby lowering blood cholesterol levels (Beylot, 2005). Further the increased production of SCFA in the large intestine due to fermentation of non-digestible carbohydrates may alter hepatic lipogenesis. Acetate stimulates lipogenesis and propionate is an inhibitory molecule that might compete with acetate for the transporter of acetate into hepatocytes. Propionate has also been suggested to directly inhibit hepatic cholesterol synthesis (Beylot, 2005). Other beneficial effects of SCFA are that butyrate affects absorptive and metabolic functions of enterocytes thus slowing down intestinal fat transport (Marcil, Delvin, Garofalo, & Levy, 2003). In addition SCFA dose dependently stimulate mucin production by intestinal epithelial cells. Since the mucus layer protects the mucosa from chemical, mechanical and microbial challenges a high concentration of SCFA plays a mucoprotective role (Willemsen, Koetsier, & Van Deventer, 2003). The total SCFA content and regional differences in the intestinal tract consequently affect the health state of the colon and are important factors in cancer development and gastrointestinal disorders, which often occurs distally where SCFA concentrations are low. Increased SCFA production and delivery of especially butyrate may help preventing these colonic diseases (Wong, de Souza, Kendall, Enam, & Jenkins, 2006). SCFA also control intraluminal homeostasis by affecting water and electrolyte absorption and maintaining colonic osmolarity. Hence is useful in the treatment of different types of diarrhoea (Vernia, 2007).

Although most Western people ingest EPS on a daily basis as food additives, these substances are scarcely studied concerning their physiological effects. If these functional ingredients were shown to be beneficial to health, food products with added value could be developed. The growing demand of healthy foods motivates the investigation of new and old substances to test their potential as health promoting ingredients. Clinical trials are costly and time-consuming to perform. Animal models are a cost-efficient alternative for the screening of candidate food components, and also enable mechanistic studies. Health beneficial effects of dietary fibres have been studied in both wild type and genetically modified mice, such as the LDL-receptor deficient mice (LDLr−/−) (Andersson, Immerstrand et al., 2010; Andersson, Svedberg, Lindholm, Oste, & Hellstrand, 2010; Choi, Kim, Jung, Hong, & Song, 2010; Dupasquier et al., 2007; Immerstrand et al., 2010). In this study four commercially available EPS i.e. scleroglucan, xanthan, gellan and dextran were tested in mice to evaluate their effect on plasma cholesterol, lipoproteins, SCFA production in caecum and faecal bile acid excretion.

2. Experimental methods

2.1. Exopolysaccharides

Four commercially available microbial hydrocolloids were used for the experiment: scleroglucan (Actigum CS 11 GR, Cargill), xanthan (Keltrol T, C P Kelco), gellan (Kelcogel LT100, C P Kelco) and native dextran (GE Healthcare BioSciences AB). The EPS were analysed by the accredited laboratory Eurofins concerning their protein, fat and mineral content. Due to their low content of contaminants they were regarded as pure EPS when added to the diets.

2.2. Diets

The EPS were dissolved in water together with maltodextrin (C Dry MD 01910, Cerestar) to aid solubilisation. Dissolved EPSs were frozen at −20 °C and sequentially freeze dried for 72 h. The freeze drier was programmed to start at −20 °C and increase the temperature by 10 °C per hour up to 20 °C. The dry EPS/maltodextrin mix was mortared and blended with a diet premix (Research Diets Inc., New Brunswick, NJ, USA) to an EPS concentration of 4% (w/w). Anhydrous butter (Arla, Sweden) was melted and heated to 50 °C before addition and final mixing of the diet. The diet was stored at 4 °C until use and was administered as powder. As negative control 4% (w/w) microcrystalline cellulose (Avicel PH 101, FMC Biopolymer) was used. The EPS and cellulose diets were all based on the same premix and all diets contained equal amounts of maltodextrin (Table 1 and Table 2).

2.3. Animals

The reduction of plasma cholesterol by dietary fibres has been relatively larger in LDLr−/− than in wild type mice (Andersson, Immerstrand et al., 2010; Andersson, Svedberg et al., 2010), possibly due to the higher magnitude of hypercholesterolaemia in the genetically modified mice. To be able to observe small changes in the plasma cholesterol level the LDLr−/− model was chosen for this experiment. At arrival female, homozygous, LDL-receptor deficient mice (B6.129s/Ldlr<sup>−/−</sup>HiHer/J, Charles River Laboratories, Sulzfeld, Germany) were acclimated to their new environment for two weeks while fed a commercial normal chow (R34 rodent chow, Lactamin, Vadstena, Sweden). At the age of 10 weeks the mice (n = 49, body weight 18.6 ± 1.5 g) were randomly divided into five groups, and fed a Western type diet, containing 4% dietary fibres, for four weeks. The mice were housed in plastic cages with housing material and free access to water and food (22 °C, relative air humidity 60% with a 12 h light/dark cycle). At baseline and after two and four weeks on the experimental diet blood was collected from the saphenous vein into EDTA-coated microvette tubes after 4 h fasting. The tubes were centrifuged at 5000×g for 10 min at 4 °C to yield plasma. In samples for analysis of lipoprotein patterns sucrose was added to a final concentration of 10%. The plasma was stored at −80 °C.

After four weeks the mice were killed by cervical dislocation under isoflurana anaesthesia. Caeicum contents were collected and immediately frozen in liquid nitrogen before storage at −80 °C. Caeicum tissue was rinsed in PBS, blotted between filter papers and weighed. All experiments followed national guidelines for the care and use of animals and were approved by the Malmö/Lund regional ethical committee for laboratory animals. The animals tolerated the study well.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation of the diets (g/kg diet).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Control</th>
<th>EPS diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casein, 80 mesh&lt;sup&gt;a&lt;/sup&gt;</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>α-methionine</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Corn starch</td>
<td>281</td>
<td>281</td>
</tr>
<tr>
<td>Maltodextrin 10</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Sucrose</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>EPS</td>
<td>0</td>
<td>44</td>
</tr>
<tr>
<td>Cellulose</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>Butter, anhydrous&lt;sup&gt;b&lt;/sup&gt;</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Corn oil</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Mineral mix S10026</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Potassium citrate H2O</td>
<td>16.5</td>
<td>16.5</td>
</tr>
<tr>
<td>Vitamin mix V10001</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Choline bitartrate</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

EPS, exopolysaccharide.

<sup>a</sup> Casein is 88% protein.

<sup>b</sup> Anhydrous butter contains 230 mg cholesterol per 100 g. The amount of cholesterol in all diets was 0.46 g/kg diet.
2.4. Plasma cholesterol and triglycerides

Plasma concentrations of cholesterol and triglycerides were determined enzymatically in duplicates (Infinity Cholesterol/Triglyceride Liquid Stable Reagent, Thermo Scientific, Melbourne, Australia) according to the manufacturer’s manual.

2.5. Lipoprotein

The lipid distribution between HDL and LDL + VLDL was calculated by separating plasma lipoproteins on agarose gels with barbital buffer as described by Andersson, Immerstrand et al. (2010). Duplicate samples were run.

2.6. Analysis of short chain fatty acids

The SCFA analysis was performed by gas chromatography according to Zhao, Nyman, and Ake (2006) with some modifications. Acetic acid, propionic acid, iso-butyric acid, butyric acid, isovaleric acid and valeric acid were used as standards; 2-ethylbutyric acid was used as internal standard. Duplicate samples were run.

The chromatographic analysis was performed using an Agilent 6890N system equipped with a flame ionization detector and an N10149 automatic liquid sampler (Agilent Technologies Inc., USA). A fused-silica capillary column with a free fatty acid phase (DB-FFAP 125–3237, J&W Scientific, Agilent Technologies Inc., USA) of 30 m * 0.53 mm (inner diameter) coated with 0.50 µm film thickness was used. The SCFAs were identified on chromatograms by their specific retention times. Calibration curves for each SCFA were made using the standard SCFA mixture.

2.7. Bile acids in faeces

At baseline and at week 4 faeces were collected cage-wise after the animals had been on grills for 24 h. The faeces collected from each cage were freeze-dried, mortared and weighed. Three samples from each cage were run in duplicates for total bile acid measurements. Bile acids were extracted in 75% ethanol at 50 °C for 2 h (Yu et al., 2000). The solids were discarded after centrifugation and the supernatants were analysed according to the manufacturer’s description using the Colorimetric Total Bile Acids Assay Kit (Diazyme Laboratories, CA, USA) modified to suit a 96-well plate assay.

2.8. Statistics

Data analysis was performed using SigmaPlot 11.0 (Systat Software Inc.) using one-way ANOVA for multiple comparisons followed by Tukey’s test to determine significance of differences between groups. Results are expressed as mean values and their standard error. Values with a P < 0.05 were considered statistically significant. Data failing the normality test were analysed by the Kruskal–Wallis one-way analysis followed by Dunn’s method for pairwise multiple comparisons between groups. Data are expressed as median values and the 25th and 75th percentiles.

3. Results

3.1. Body weight, feed intake and faecal excretion

The weight of the mice was recorded throughout the study. There was no significant difference in feed intake or the mean body weight gain. Mice fed dextran seemed to have less faecal output, but this could not be verified statistically since faeces were collected as a pooled sample from each cage (Table 3). Remarkably, gellan faeces contained 25% water while the other groups contained approximately 10%.

3.2. Plasma cholesterol and triglycerides

There were significant differences between the EPS-groups concerning plasma cholesterol levels after 4 weeks on the diets (Table 4). Both scleroglucan and gellan gave significantly lower plasma cholesterol concentrations than the xanthan. However none of the EPS were significantly different from the negative control. Feeding the mice EPS did not alter plasma triglyceride levels.

3.3. Lipoprotein

At the start of the study the LDL + VLDL fraction was high as expected for the LDLr−/− mice, the HDL fraction being about 34% in all groups. After 4 weeks on the experimental high fat diets the HDL fraction was further decreased in all groups to constitute less than 27% of the lipoproteins. Xanthan gave the lowest level (18%) which was significantly lower than the control (Table 4).

3.4. Caecum content, caecal tissue weight and SCFA formation

The EPS-containing diets induced a significant increase in caecum content and caecal tissue weight compared to the negative control (Table 5). The caecum contents were visibly different concerning the colour and viscosity between groups. Gellan ingestion resulted in a caecum content with a cuttable gel like consistency. Scleroglucan, xanthan and dextran induced an increase in the total...
amount of caecal SCFA where acetic acid constituted the major part (Table 5). The butyric acid level was increased by scleroglucon and propionic acid levels were increased upon consumption of xanthan and dextran. Increased SCFA production may lower the intestinal pH leading to increased mineral solubility and reduced formation of secondary bile acids (Wong et al., 2006). Unfortunately the pH was not measured in the present study due to small samples of caecal content.

3.5. Bile acids

Although the scleroglucon, xanthan and gellan groups showed increased bile acid excretion compared to the control, none of them were statistically significant (Table 4). Dextran induced lower bile acid excretion than the other EPS-groups, but this was significant only relative to gellan.

4. Discussion

Hydrocolloids are used in food design due to their rheological properties. There is a difference between viscous and gelling fibres in that a gel does not flow but elastically stretches when deformed. The properties of viscous fibres are well known whereas the role of gelation in relation to physiological effects is unknown (Wood, 2007). Gellan is an anionic, multifunctional gelling agent produced by the genus Sphingomonas. It has a linear structure based on a tetrasaccharide repeating unit composed of two D-glucose, one L-rhamnose and one D-glucoronic acid. It is approved for use in the food and medical sector in the US and the EU (Fialho et al., 2008). In the present study xanthan was shown to induce growth of caecum tissue in mice and rats leading to enlargement of the organ (Forsythe, Chenoweth, & Bennink, 1978; Immerstrand et al., 2010). The present results indicate that this phenomenon occurs also for EPS in mice.

Xanthan is produced by Xanthomonas campestris and is approved as a food additive without any quantity limitation. It exhibits pseudoplastic behaviour and is extensively used as stabilizer in sauces and dressings (Palaniraj & Jayaraman, 2011). Xanthan was shown to induce growth of caecum tissue in mice and rats leading to enlargement of the organ (Forsythe, Chenoweth, & Bennink, 1978; Immerstrand et al., 2010). The present results indicate that this phenomenon occurs also for EPS in mice.

<table>
<thead>
<tr>
<th>Plasma cholesterol levels (mmol/L)</th>
<th>Plasma triglycerides (mmol/L)</th>
<th>Plasma HDL (%)</th>
<th>Bile acids in faeces* (µmol/mouse and 24 h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SEM</td>
<td>n</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>Negative control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.65</td>
<td>10</td>
<td>5.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Scleroglucon</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.85</td>
<td>10</td>
<td>6.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Xanthan</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.57</td>
<td>10</td>
<td>6.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Gellan</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.58</td>
<td>10</td>
<td>5.3&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Dextran</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.63</td>
<td>9</td>
<td>5.0&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Table 4

Plasma lipid profile and bile acid excretion in faeces.

Table 5

Caecal content, caecal tissue weight and caecal SCFA in mice fed experimental diets.

<table>
<thead>
<tr>
<th>Acetic acid&lt;sup&gt;d&lt;/sup&gt; (µmol)</th>
<th>Propionic acid&lt;sup&gt;d&lt;/sup&gt; (µmol)</th>
<th>Butyric acid&lt;sup&gt;d&lt;/sup&gt; (µmol)</th>
<th>Total SCFA&lt;sup&gt;d&lt;/sup&gt; (µmol)</th>
<th>Caecum content (mg)</th>
<th>Caecal tissue weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>25–75%</td>
<td>n</td>
<td>Median</td>
<td>25–75%</td>
<td>n</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.3–5.6</td>
<td>10</td>
<td>0.83&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.60–0.93</td>
<td>10</td>
</tr>
<tr>
<td><strong>Scleroglucon</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.5–13.5</td>
<td>10</td>
<td>1.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.1–1.4</td>
<td>10</td>
</tr>
<tr>
<td><strong>Xanthan</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>9.6–13.8</td>
<td>10</td>
<td>1.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.2–1.6</td>
<td>10</td>
</tr>
<tr>
<td><strong>Gellan</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.9–6.7</td>
<td>9</td>
<td>0.88&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.71–1.1</td>
<td>9</td>
</tr>
<tr>
<td><strong>Dextran</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.9–14.6</td>
<td>9</td>
<td>1.9&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.4–2.8</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 5

Caecal content, caecal tissue weight and caecal SCFA in mice fed experimental diets.

n, number of observations.

<sup>a</sup> The concentration of SCFA (µmol/g caecal content) multiplied with the caecal content (g). Since these data failed the normality test a Kruskal–Wallis one-way analysis of variance on the ranks was run followed by Dunn’s method for pairwise multiple comparisons. Data are expressed as median and 25th and 75th percentiles. Groups with unlike superscript letters were significantly different (P < 0.05).
glycosidic linkages like cellulose. The branches consist of mannose and glucoroniacid. Cellulose is not fermented (Barry et al., 1995) which would suggest that the microbial action is performed on the side chains of xanthan. In the present study fermentation of xanthan than the greatest proportion and level of acetate. This may be the result of polysaccharide deacetylation since the EPS is partially acetylated (Bourquin, Tigtemeyer, & Fahey, 1996). In agreement with Bourquin et al. butyric acid was produced at around 6% of the total SCFA concentration.

Dextran is an α-(1,6) linked glucan that is branched mainly at the α-(1,3) position. It is produced by several bacterial genera but for commercial production Leuconostoc mesenteroides is the most commonly used species. Dextran is used as a blood plasma substitute and is present in many food systems through in situ production (Naessens, Cerdobbel, Soetaert, & Vandamme, 2005). No reports have been found on cholesterol levels in relation to ingestion of dextran. In this report native dextran did not have any effect on plasma cholesterol or triglyceride levels. However dextran was significantly increasing the total pool of SCFA including butyric and propionic acid levels. High levels of SCFA and butyric acid in particular may have a mucoprotective role in the gut (Willemse et al., 2003).

The basidiomycete Sclerotium rolfsii produces scleroglucan composed of a β-(1,3) linked glucopyranosyl backbone with single β-(1,6) linked glucopyranosyl branches on every third subunit. Scleroglucan is not approved for food use in the US and EU but it is extensively used in Japanese food products (Schmid, Meyer, & Sieber, 2011). No reports on physiological effects of scleroglucan have been found in the literature. In this study scleroglucan at a concentration of 4% had a positive effect on the mice gut since it is known for its gel-forming ability; two mechanisms behind the cholesterol lowering effect of oat and barley β-glucans (Andersson, Elleögård, & Andersson, 2002; Andersson, Immerstrand et al., 2010; Zhang et al., 1992). Bile acid excretion in faeces was measured in the present study but there was no difference between the control and experimental groups concerning either plasma cholesterol or bile acid levels indicating no binding of bile acids by the EPS.

In conclusion the tested food hydrocolloids do not impart any negative effects on the investigated parameters in mice. All EPS showed an increased bulking effect leading to an increase in caecal tissue weight comparable to what is known for plant dietary fibre. That together with the increased SCFA production may help in the maintenance of a healthy gastrointestinal tract.

Acknowledgements

The study was supported by the Lund University Antidiabetic Food Centre, which is a VINNOVA VINN Excellence Centre, and Aventure AB. The authors declare no conflict of interest. Pontus Perstrand is greatly thanked for making the graphical abstract.

References
