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Cereal β -glucan Fibre Drink as a Part of Nutritionally Balanced Diet Alters Lipid Profile: An Intervention Study

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Abstract: Cereals, like oat and barley are a natural source of β -glucans with very important physiological properties. Cereal β -glucans, as a part of natural fibre, are capable of lowering the blood glucose and the total cholesterol level, may enhance the immunity and help to reduce the body weight and the total body fat amount. The aim of this study was to assess a cholesterol lowering potential of an 8-week long consumption of a cereal β -glucan fibre drink (Actiglucane) in a group of the 25 young (19-34 years), healthy, non-smoking women with an elevated body fat percentage (>29%). Actiglucane was implemented into nutritionally balanced diet and was consumed in a mid-morning and an afternoon snack time (2×45 g of drink concentrate diluted in 250 mL of water, what includes 3 g of β -glucan day⁻¹). Compared to the control group, the significant decrease in LDL cholesterol ($\Delta = 0.55 \pm 0.08$ mmol L⁻¹; p<0.02) and the atherogenic index ($\Delta = 0.62 \pm 0.10$; p<0.004) was found at the end of the intervention. Owing to these beneficial properties, the β -glucan fibre drink may be used in cardiovascular and obesity disease prevention programs at a large population scale.

Key words: β -glucan fibre drink, cholesterol, atherogenic index, weight management

INTRODUCTION

β -glucans, as a component of dietary fibre are known to possess various potential health benefits, including a bowel transit time reduction, a prevention of constipation and colorectal cancer, as well as a glucose and/or cholesterol lowering effect (Mikusova *et al.*, 2011; Brennan and Cleary, 2005). More than one meta-analysis and many reviews have been focused on the evaluation of the dose-response effect of β -glucans` various sources (Tiwari and Cummins, 2011; Ames and Rhymmer, 2008; Aman, 2006; Brown *et al.*, 1999; Ripsin *et al.*, 1992) differing in molecular weight, the viscosity and their physiological effects (Wood, 2007; Poppit, 2007), concluding that cereal β -glucans, especially those originated from oat and barley, positively influence levels of total, high density (HDL) and low density (LDL) cholesterol in humans. The mechanism of action is mainly due to the increased intestinal content viscosity; the affection of gut physiology as a prebiotic ingredient

causing an elevation of short chain fatty acids level as well as an increased bile acids excretion. However, not all of these studies showed an effect of cereal β -glucans on the lipid profile in humans (Havrlentova *et al.*, 2011; Smith *et al.*, 2008; Brennan and Cleary, 2005; Lovegrove *et al.*, 2000). The question is, if β -glucan extracts can contribute to the improvement of the atherogenic lipid parameters comparable to the whole grains (Poppit, 2007).

The aim of the current study was therefore to assess the cholesterol lowering potential of the 8-week long consumption of the cereal β -glucan fibre drink (flavoured β -glucan extract named Actiglucane, 3 g of β -glucan day⁻¹) added to the nutritionally balanced diet of the healthy, overweight women.

MATERIALS AND METHODS

Study design and participants: Potential participants were recruited via flyers and oral presentations. Inclusion

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criteria of the study were: age of 19-34 years, non-smoker, healthy, intake of no medication that could influence the outcomes of the study. Finally, 25 subjects met the criteria and were assigned into the treatment (nutritionally balanced diet and drink-DD) or the control (C) group. Intervention group comprised of 15 women (age: 27.7±1.1 years, body weight: 77.0±2.5 kg, fat percentage: 37.8±1.5%, body mass index: 27.4±1.1 kg m⁻², waist circumference: 88.6±1.8 cm). Ten women in the same age group with healthy lifestyle (adherence to nutritionally balanced diet, no intervention) were recruited as the control group. All volunteers were fully informed of the nature and purpose of the study and a written informed consent was obtained. The experimental protocol was approved by a local ethic committee.

Subjects were asked to restrain from food and use of intense physical activity for 12 h prior to the examination. Upon the arrival to the Slovak Medical University (Bratislava) in the morning, blood samples were drawn from antecubital vein and an analysis of body composition using In Body Analyser 720 (direct segmental multi-frequency bioelectrical impedance method, Biospace Ltd., USA) was done.

Biochemical analyses such as glucose, triglycerides (TAG), Total Cholesterol (TC) and high density lipoprotein cholesterol (HDL-C) content in the blood were performed using standard laboratory methods on an automatic analyser Vitros 250 (Johnson and Johnson, USA). Low density lipoprotein cholesterol (LDL-C) was calculated according to the Friedewald formula (Friedewald *et al.*, 1972). Atherogenic Index (AI) was calculated as a ratio of TC and HDL-C (Krajcovicova-Kudlackova *et al.*, 2004). Very low density lipoprotein cholesterol (VLDL-C) content was calculated as an amount of TAG in mmol L⁻¹ divided by 2.2. The body composition analyses and the blood drawn were taken twice, at the beginning and at the end of the intervention (8 weeks).

Diet protocol and fibre drink: All subjects in the intervention group (DD) underwent dietary counselling (initial phase, 2 months prior to the study). They were instructed and encouraged to lower consumption of the high energy and the high saturated fat food, to enhance consumption of fruit and vegetables, to include whole grain cereal products instead of white flour products, as well as to control their daily portions (size and frequency), to achieve a nutritionally balanced diet. Group meeting sessions took place every two weeks. Food records were collected weekly in electronic form. Diet analyses were completed using the nutrition software Alimenta (Institute for Food Research, Bratislava, Slovak Republic).

After the first two months (initial phase), the cereal β -glucan fibre drink called Actiglucane (prepared in two flavours by Essentia Ltd. Company, Slovak Republic) was implemented into the participants' nutritionally balanced diet.

The daily dose (2×45 g of concentrate diluted in 250 mL of water) consisted of 3 g of β -glucan which is a minimal effective dose for cardiovascular disease prevention according to the Food and Drug Administration (FDA, 1997). The content of the total β -glucan in the Actiglucane concentrate was measured on an Infrared Spectrophotometer with Fourier Transformation at peak wavelength 895 cm⁻¹. To calculate the amount of β -glucan a lichenan standard (1,3/1,4 β -glucan) calibration curve was used. Nutritional composition of the Actiglucane concentrate such as dry mass, ash, proteins, fat, dietary fibre including a soluble and an insoluble form and the total monosaccharide content were determined according to the Slovak STN and international ISO norms (STN ISO 2171:2008/Z1, STN 56 0031, STN 56 0146). Free sugars were analysed by a standard HPLC method with refractometric detection. The chromatographic separation was performed on the ZORBAX Carbohydrate C18 analytical column (250 mm×4.6 mm, 5 μ m) using the ZORBAX 12.5×4.6 mm pre-column, with column temperature set at 30°C, by isocratic elution with acetonitril and water (75:25) at a flow rate of 1 mL min⁻¹. The injection volume was 20 μ L and the analysis lasted 30 min. The energy value of the Actiglucane concentrate was calculated according to the formula: the protein content×4+the available carbohydrates content×4+the fat content×9. The available carbohydrates were calculated by the difference of all other basic nutritional components (dry mass minus the sum of protein, fat, ash and the total dietary fibre content). The nutritional composition of the Actiglucane concentrate is summarized in the Table 1.

Table 1: Nutritional composition of the actiglucane

Component	Apple flavour	Pineapple flavour
Dry mass (g kg ⁻¹ FW)	344.3±0.1	368.9±0.1
Ash (g kg ⁻¹ FW)	14.9±0.1	14.8±0.1
Proteins (g kg ⁻¹ FW)	6.5±0.1	6.4±0.1
Fat (g kg ⁻¹ FW)	1.0±0.1	1.7±0.1
Monosaccharides (g kg ⁻¹ FW)	225.8±0.4	241.5±0.3
Sucrose (g kg ⁻¹ FW)*	<5.0	<5.0
Glucose (g kg ⁻¹ FW)*	107.0	94.0
Fructose (g kg ⁻¹ FW)*	125.0	115.0
Maltose (g kg ⁻¹ FW)*	39.0	36.0
Total dietary fibre (g kg ⁻¹ FW)	38.5±0.5	33.7±0.1
Soluble fibre (g kg ⁻¹ FW)	9.6±0.2	8.5±0.1
Insoluble fibre (g kg ⁻¹ FW)	28.6±0.5	25.3±0.4
Total β -glucan (g kg ⁻¹ FW)	31.0±0.2	29.0±0.2
Energy - calculated (kcal kg ⁻¹)	1170±5	1300±5

FW: Fresh weight, *Relative standard error of the HPLC measurements was below 5%, Results are expressed as Means±SD

Statistical analyses: Analyses were performed using the Statgraphics software for Windows 3.0. Normality of data was tested using Kolmogorov-Smirnov test as a goodness of fit test. Paired student's t-test was used to compare significance of the change during intervention vs. baseline for each parameter in both groups. One-way ANOVA was used for each parameter to test the specific differences between the groups.

RESULTS

The cholesterol lowering potential of the 8-week long Actiglucane (cereal β -glucan fibre drink) consumption added to the nutritionally balanced diet was assessed in the current study.

In the initial phase, all participants of the intervention group (DD) were educated about the nutritionally balanced diet in order to achieve stabilized dietary habits throughout the experiment. Unity in the eating habits during the intervention part of the study prevented the interference of results which could be caused by possible change of subjects' diet other than addition of the tested drink.

The implementation of the Actiglucane fibre drink into the nutritionally balanced diet (consumed in the mid-morning and the afternoon snack time) caused significant changes in a fat and energy intake of all volunteers. Satiating effect and a low caloric value (111 kcal/daily dose) of Actiglucane resulted in a decreased fat intake (53%, $p < 0.016$) as well as the daily 24 h energy intake (17%, $p < 0.034$). The changes which were observed in the lipid profile after two month long intervention are presented in the Fig. 1.

Variability of the measured parameters in the control group was significantly higher in comparison to the DD group because the dietary habits in C group were uncontrolled. Statistically significant improvements (at the 95% confidence level) of the most measured parameters (TC, LDL and HDL cholesterol content) as well as the Atherogenic Index (AI) were achieved at the end of the intervention. The decrease of the total cholesterol ($\Delta = -0.43 \pm 0.10 \text{ mmol L}^{-1}$, $p < 0.0009$) and the increase of HDL cholesterol ($\Delta = 0.13 \pm 0.05 \text{ mmol L}^{-1}$; $p < 0.033$) in the DD group at the end of the intervention were significant. No significant change in the above mentioned parameters was observed in the DD compared to the C group, as well as in the C groups itself. Notable LDL cholesterol decline of $\Delta = -0.55 \pm 0.08 \text{ mmol L}^{-1}$ ($p < 0.020$) and atherogenic index drop of $\Delta = -0.62 \pm 0.10$ ($p < 0.004$) compared to the controls were achieved throughout the study. No statistically significant changes have been found in the TAG and the VLDL-C levels.

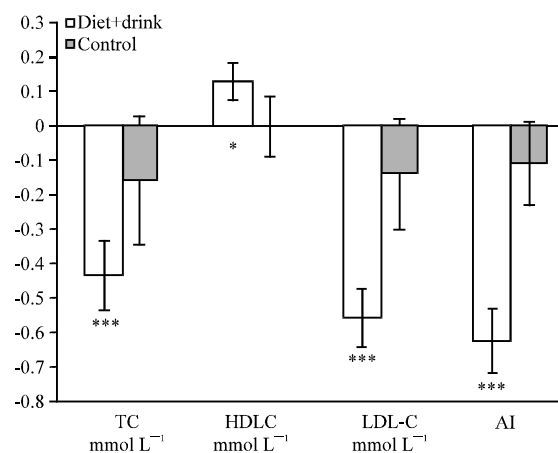


Fig. 1: Lipid profile changes after the 8-week long consumption of the actiglucane fibre drink (comprising of 3 g of β -glucan day⁻¹) added to the nutritionally balanced diet (diet+drink) compared to the control group with no intervention, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ significant changes baseline vs. end of the intervention

DISCUSSION

The present study was focused on the improvement of lipid parameters of the overweight women subjects. Our results are in a good agreement with literature, proving the hypothesis that the cereal β -glucan extract may improve cardiovascular disease risk markers (such as the LDL and the total cholesterol content) similarly to cereals itself. In the current study the LDL cholesterol level drop by 17% has been seen in an 8-week long period. Similar results were observed by Keenan *et al.* (2007), where the LDL cholesterol level fell by 13% in a group consuming a concentrated barley β -glucan extract (3 g of β -glucan day⁻¹) during a 6-week study. Comparable results were found by the total cholesterol content, while the HDL cholesterol level remained unchanged. Compared to the aforementioned study, our data showed an elevation of the HDL cholesterol by 9% and a decrease of the total cholesterol by 8%. Moreover, the atherogenic index dropped from the initial value of 3.61 which was above critical limit for women, to 2.99 (within the reference range), what is of major relevance for the cardiovascular risk prevention. On the other hand, some studies failed to show any significant results (Poppit, 2007). No significant difference in the total plasma and LDL cholesterol level was observed by Lovegrove *et al.* (2000) in the 8-week double blind randomized controlled study using oat bran concentrate (3 g of β -glucan day⁻¹). Some of the possible

reasons for these confusing results may be the treatment such as cooking, freezing or storage of studied cereals which can diminish their physiological activity (Poppit, 2007). To conclude the available results in this area, Tiwari and Cummins (2011) conducted a meta-analysis including 126 clinical studies evaluating the effect of various amounts of β -glucans. The dose-response model showed that 3 g day⁻¹ of oat or barley β -glucan is sufficient to decrease the total blood cholesterol (Δ TC = 0.60 mmol L⁻¹) and the low-density lipoprotein cholesterol (Δ LDL-C = 0.66 mmol L⁻¹). Results of our study are in accordance with the above mentioned meta-analysis, indicating that not only cereals itself but also cereal β -glucan extract can be effective in the atherogenic risk parameters reduction. Owing to these beneficial properties, the β -glucan fibre drink (Actiglucane) may be used in cardiovascular and obesity disease prevention programs at a large population scale.

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