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Nutritional composition and anti-obesity effects of cereal bar containing *Allium fistulosum* (welsh onion) extract

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ABSTRACT

The nutritional composition and anti-obesity activities of cereal bars containing *Allium fistulosum* extract (AFB) in high-fat diet-induced obese mice was determined. AFB is rich in vitamins C, B_2, and B_3, and B_9 with high protein. Oral treatment of AFB in obese mice reduced body weight, lipid accumulation in liver and adipose tissue as well as adipocyte size, compared to the high fat diet control mice. AFB also decreased serum triacylglycerol, glucose, and insulin concentrations, with increased HDL-cholesterol and adiponectin levels. Furthermore, 5% AFB markedly increased mRNA expression of peroxisome proliferators activated receptor-γ, uncoupling protein-2 as well as β3-adrenoreceptor in the visceral adipose tissue. These results demonstrate that the cereal bar with *A. fistulosum* extract may potentially serve as nutraceutical for improvement of obesity and metabolic disorders.

1. Introduction

Obesity is a major risk factor for dyslipidemia, type 2 diabetes, atherosclerosis and hypertension, cardiovascular disease, and certain type of cancer (Evans, Barish, & Wang, 2004; Lei et al., 2007; Watanabe et al., 2010). With the increasing prevalence of being overweight and obesity in all ages, dietary strategies to achieve weight loss has become a major focus for improving public health in industrialized counties. Weight loss will occur if energy intake is less than energy expenditure, but it appears to be difficult to achieve negative energy balance (i.e. to promote weight loss) and subsequent long-term energy balance (i.e. for weight maintenance) (Zaveri & Drummond, 2009).

Meal replacements, in the form of a powder shake and a snack bar, have been successfully in several weight-loss

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Abbreviations: AF, *Allium fistulosum* extract; AFB, cereal bar containing *Allium fistulosum* extract; ALT, alanine aminotransferase; AST, aspartate aminotransferase; β3-AR, β3-adrenoreceptor; FER, food efficiency ratio; HDL, high-density lipoprotein; HFD, high fat diet; HFD+AFB, High fat diet + cereal bar containing *Allium fistulosum* extract; HFD+B, high fat diet + control bar; HFD+O, high fat diet + orlistat; LDL, low-density lipoprotein; ND, normal diet; PPAR-γ, peroxisome proliferators activated receptor-γ; UCP-2, uncoupling protein-2

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clinical trials (Ditschuneit, Flechtner-Mors, Johnson, & Adler, 1999; Heber, Ashley, Wang, & Elashoff, 1994; Noakes, Foster, Keogh, & Clifton, 2004). Meal replacement do not have documented side effects associated with medications, and may aid weight loss by reducing energy through diminished portion sizes and fat content (LeCheminant, Jacobsen, Hall, & Donnelly, 2005). Meal replacements are easy to prepare, appear to be safe with no adverse effects, and require minimal time for professional intervention (Ditschuneit et al., 1999). In addition, they are relatively inexpensive, convenient, and palatable (Heymsfield et al., 2000). Despite these advantages, it remains the difficulty of weight maintenance due to problem of long-term intake by the excessive calorie restriction. To overcome these limit, alternative strategies using supplementation of functional materials such as herbal products have begun to form a large and growing market.

Allium fistulosum L. (commonly known as welsh onion) is a perennial plant that is a widely cultivated throughout the world, especially in Asia. Member of *Allium* family, *A. fistulosum* is an important flavouring vegetable ingredient in Asian cuisines, especially in China, Japan, and Korea. *A. fistulosum* have been used as traditional medicine for the treatment of common colds, headache, arthritis, and heart diseases (Chen, Chen, Wang, Tsai, & Jen, 2000). *A. fistulosum* has been reported to have antifungal, antioxidative, antiplatelet and antihypertensive activity (Sang et al., 2002; Yamamoto et al., 2005). Recently, anti-obesity activity of *A. fistulosum* in *in vivo* model has been studied (Sung, Yoon, Kim, Yang, & Kim 2011). The treatment of ethanol extract of *A. fistulosum* suppressed effectively the increase of body weight, fat mass, and serum lipid concentrations in high-fat diet-induced obese mice. Thus, the present study produced the cereal bars containing *A. fistulosum* extract as the meal replacement for weight control and subsequently elucidated the effects of these in obesity, body fat deposition, serum glucose, insulin, and lipid profile as well as nutritional composition.

2. Materials and methods

2.1. Preparation of *A. fistulosum* extract and cereal bar containing *A. fistulosum*

The fresh bulbs and roots of *A. fistulosum* (AF) were extracted with 0.5-fold water for 5 h at 90 °C, and the extract was then concentrated under reduced pressure. The concentrate was filtered, lyophilized below 15 brix%, and subsequently stored at 4 °C. Cereal bars for *in vivo* anti-obesity efficiency experiments were prepared by addition of 3% or 5% of AF, respectively. Control bar was added peanut in the place of AF. The material maxing ratio of cereal bar added different amount of AF was shown in Table 1. For the development of cereal bars, the nuts and grains were roasted and blended with AF powder, cranberry, and vitamin-mineral mix. The adhesive agents such as oligosaccharide, sugar, and apple concentrate were mixed, boiled at 100–105 °C, immediately added xanthan gum, and subsequently mixed well with the other materials. The material mixture was poured into a mold, cooled, and trimmed down to size. These cereal bars were kept in a cool place away from direct sunlight and humidity.

2.2. Nutritional content of the extract and cereal bar

A. fistulosum extract and cereal bar containing *A. fistulosum* were analyzed for nutritional components by Jeonnam Biofood Technology Center (Jeonnam, Korea).

2.3. Animals and experimental diets

Male 8-week-old C57BL/6J mice were purchased from The Jackson Laboratory (Bar Harbor, ME, USA). They were housed in an air-conditioned animal room with a 12-h light/12-h dark cycle at a temperature of 21 ± 2 °C and humidity of 50 ± 5%, and were fed a commercial diet (Ralston-Purina, St. Louis, MO, USA) for 1 week. Mice were provided with a laboratory diet and water *ad libitum*. For induction of obesity, the mice were fed a high fat diet (Rodent diet D12492, Research diet, New Brunswick, NJ, USA), providing 60% of energy as fat, 20% as protein and 20% as carbohydrates. Normal mice derived from commercial standard chow diet (Orient Bio Inc., Seongnam, Korea). The sixty mice were randomly divided into five groups ($n = 10$), and respectively fed a normal diet (ND), a high fat diet (HFD), a high fat diet plus orlistat (HFD + O), a high fat diet plus AF-free control bar (HFD + B), a high fat diet plus bar containing 3% AF (HFD + 3% AFB) and a high fat diet plus bar containing 5% AF (HFD + 5% AFB) for 10 weeks. AFB was dissolved in normal saline, and was orally administrated to the mice at a dose of 2 g/kg/day for 10 weeks. Orlistat (Xenical), a positive control, was administered to the mice at a dose of 15.6 mg/kg. The ND and HFD control mice were treated with vehicle (normal saline) only. Body weight and food intake were monitored every 1 weeks. This study adhered to the guide for the care and use of laboratory animals developed by the institute of laboratory animal resources of the national research council, and was approved by the institutional animal care and use committee of Daejeon University in Daejeon, Korea.

2.4. Biochemical assay of serum

At the end of the experiment period, the mice were anesthetized with ether after an overnight fasting. Blood was drawn from the abdominal aorta into a vacuum tube. Biochemical analyses of concentrations of total cholesterol, HDL cholesterol, LDL cholesterol, and triglyceride, glucose, creatinine, AST, ALT were determined using an automatic analyzer (Express Plus, Chiron Diagnostics, East Walpole, MA, USA) with reagents (BioClinical System, Gyeonggi-do, Korea). Serum insulin, leptin, and adiponectin levels were measured through immunoassay (ELISA) using commercially available kits (Linco Research, Charles, MO, USA).

2.5. Weight and histology analysis of adipose tissues and liver

After collecting the blood, the white adipose tissues (subcutaneous and visceral fats) and liver were removed from mice and then weighed immediately. For adipocyte staining, liver and visceral adipose tissue were fixed in 10% neutral formalin solution for 1 day, and embedded in paraffin. All tissues were cut with a thickness of 6 μm, and stained with hematoxylin