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Benefits of the soluble and insoluble fractions of bitter gourd in mice fed a high-fat diet

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ABSTRACT

Background: Bitter gourd (BG) fruit powder was previously showed to prevent high-fat diet (HFD)-induced metabolic disorders in mice. In current study, we investigated the beneficial difference of the water soluble (S-BG) and insoluble fractions (IS-BG) of bitter gourd.

Results: Compared to normal chow diet, the HFD induced greater body weight gain and increased fat mass accompanied by impaired insulin sensitivity, elevated serum lipids and inflammation. Supplementation of BG, S-BG, and IS-BG showed similar beneficial effects and restored the metabolic changes in mice. Interestingly, BG showed no effect on fat mass, which was decreased by both S-BG and IS-BG. Additionally, S-BG and IS-BG inhibited the SREBP-1/FAS pathway, thereby decreasing liver cholesterol accumulation, while only BG showed improvement on mitochondrial activity.

Conclusion: These results further support the position that bitter gourd has multiple active ingredients and that both fractions have beneficial effects on metabolic disorders.

1. Introduction

Metabolic syndrome (MS) is growing into a major public health burden, leading to enormous losses of life quality in both developed and developing nations (Ruiz-Nunez, Dijck-Brouwer, & Muskiet, 2016). MS is characterized by the clustering of risk factors, including insulin resistance, obesity and dyslipidemia (Grundy et al., 2004; O'Neill and O'Driscoll, 2015). As these conditions are among the leading causes of deaths worldwide, preventing metabolic syndrome development is of critical importance (Grundy et al., 2005). Since the development of MS has been largely attributed to a suboptimal lifestyle, including excessive caloric intake, unbalanced diet, chronic stress, and physical inactivity (Danaei et al., 2009; Egger & Dixon, 2011; Ruiz-Nunez, Pruimboom, Dijck-Brouwer, & Muskiet, 2013), nutritional and physical interventions are still considered to be effective strategies to improve metabolic health.

Dietary recommendations have been proposed to prevent or reduce the development of MS in the general population. *Momordica charantia* L., known as bitter gourd (BG), is a common edible vegetable in Asia. Its anti-diabetic, anti-bacterial, antiviral and anticancer activities have been scientifically demonstrated over previous decades (Grover & Yadav, 2004; Klomann, Mueller, Pallauf, & Krawinkel, 2010; Krawinkel & Keding, 2006). In addition, animal studies have also indicated the effects of BG supplementation in regulating weight gain and lipid metabolism (Gadang et al., 2010). Some pharmacological and safety studies of this herb have been carried out (Fernandes, Lagishetty, Panda, & Naik, 2007). Many studies have reported the effects of bitter gourd extracts on insulin resistance (Shih, Lin, Lin, & Wu, 2009; Wang et al., 2011). Aqueous, chloroform and methanol extracts of BG treatment decreased blood glucose levels in type 1 diabetic and normal rats (Virdi et al., 2003). Aqueous extracts of BG fruit have been demonstrated to reduce VLDL levels and decrease blood glucose levels in normal rats (Uebanso et al., 2007). Previous studies have reported that BG inhibits the development of obesity-associated fatty liver (Xu et al., 2014); however, currently, little is known about the soluble and insoluble components of bitter gourd. Given the diversity of bitter gourd consumption, of which juice is the primary one, we intend to provide more support regarding the benefits of soluble and insoluble bitter gourd, to improve the efficiency of bitter gourd consumption and expand options of bitter gourd related product. Therefore, in the present study, we compared the effects of different parts of bitter gourd extracts on metabolic syndrome and mitochondrial function in HFD induced obese mice.

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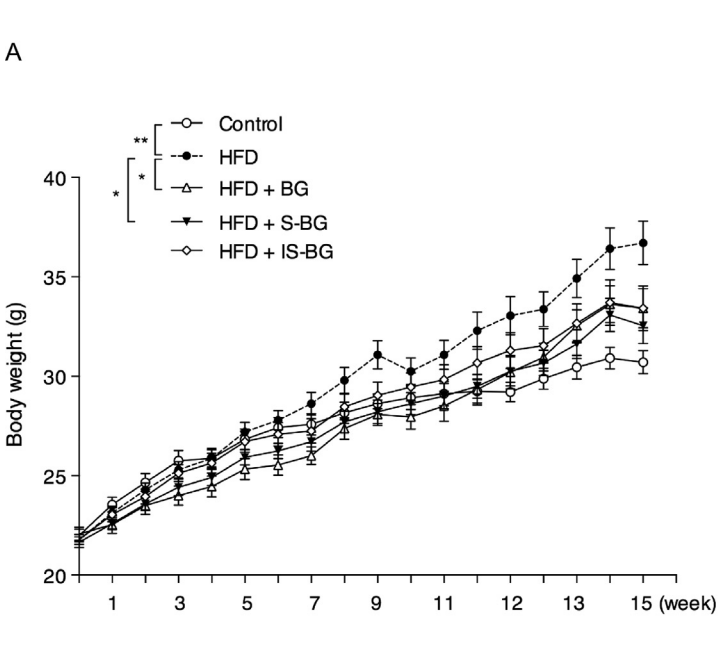

Fig. 1. Effects of BG fractions on body. Body weight curve (A), final body weight (B), and body weight gain (C) in male C57BL/6 mice fed a control diet or a high-fat diet supplemented with BG, S-BG, or IS-BG for 16 wk. The data are the mean ± SEM, $n = 8$. $^{*}P < .05$, $^{**}P < .01$ vs. relative control. BG, bitter gourd; S-BG, soluble fraction of BG; IS-BG, insoluble fraction of BG; HFD, high-fat diet.

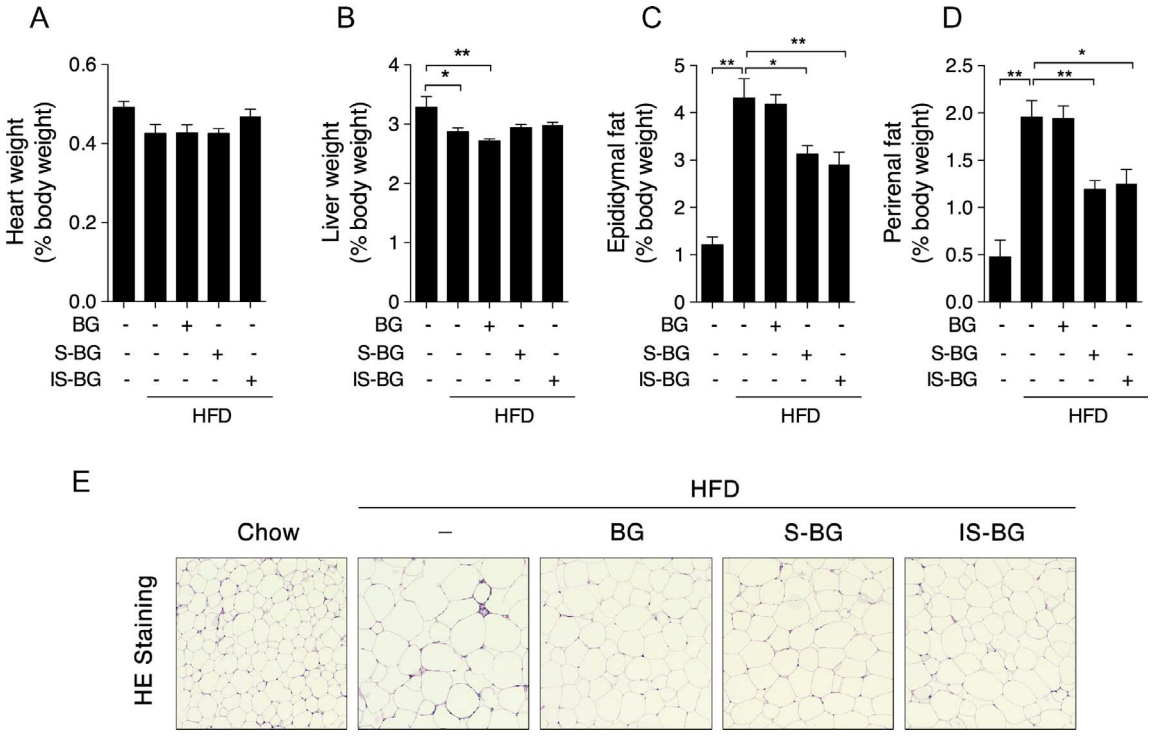

Fig. 2. Effects of BG fractions on tissue weights. The weight ratio of heart (A), liver (B), epididymal fat mass (C), and perirenal fat mass (D), and HE staining of inguinal adipose tissue (E) in male C57BL/6 mice fed a control diet or a high-fat diet supplemented with BG, S-BG, or IS-BG for 16 wk. The data are the mean ± SEM, $n = 8$. $^{*}P < .05$, $^{**}P < .01$ vs. relative control. BG, bitter gourd; S-BG, soluble fraction of BG; IS-BG, insoluble fraction of BG; HFD, high-fat diet.

2. Materials and methods

2.1. Materials

Antibodies against β-actin were purchased from Sigma (St. Louis, MO, USA). Antibody against SREBP-1c was purchased from Santa Cruz Biotechnology (Santa Cruz, CA, USA). Antibodies against GAPDH and fatty acid synthase (FAS) were purchased from Cell Signaling Technology (Danvers, MA, USA). Antibodies against complexes I, II, III, IV and V were purchased from Invitrogen (Carlsbad, CA, USA). Bitter gourd (BG) powder was prepared by Guangxi Zhennong Seed Industry Co., Led. (Guilin, China).

2.2. Animals and treatments

Four-week-old male C57BL/6 mice were purchased from the SLAC laboratory Animal Co. Ltd. (Shanghai, China) and were housed in a temperature (22–28 °C)- and humidity (60%)-controlled animal room on a 12 h light/12 h dark cycle (light from 8:00 to 20:00) with food and water provided during the experiments. After 1 week of acclimatization, mice were randomly divided into five groups (n = 10 in each group): mice fed a normal diet (Control, 12% kcal fat content), mice fed