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Original article

Determination of the regulatory properties of *Yucca schidigera* extracts on the biochemical parameters and plasma hormone levels associated with obesity

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ABSTRACT

Yucca schidigera Ortgies, Asparagaceae, is a herbaceous plant. Due to the high saponin content the powdered branches and leaves are used as natural food additive for human and animal. The aim of this study was to investigate the effects of *Y. schidigera* extracts on plasma leptin, ghrelin, adiponectin, insulin, thyroid hormones and some biochemical parameters in mice fed a high-fat diet. Male Swiss Albino mice were divided into seven equal groups. Group I (negative control group) was given standard diet; Group II was given high-fat diet; Group III was given high-fat diet with carboxymethylcellulose; Groups IV–VII were given hexane, petroleum ether, ethyl acetate, and methanol extracts of *Y. schidigera* and high-fat diet via gastric gavage for 60 days. High-fat diet significantly increased plasma leptin, insulin, free T_3 hormone, glucose, cholesterol, low-density lipoprotein, triacylglyceride, aspartate aminotransferase and alanine aminotransferase levels, and significantly decreased plasma ghrelin, adiponectin and free T_4 hormone levels. On the other hand, hormone levels, lipid profile and biochemical parameters were improved by the administration of the PE extract. *Y. schidigera* extracts could be used as preventive medicine in nutritional disorders via regulating energy metabolism and hormonal functions.

Introduction

Yucca schidigera Ortgies is a herbaceous plant from the family Asparagaceae, native to the deserts of the south-western United States and northern Mexico. Due to the antiprotozoal and antifungal properties and hormone-stimulating effects it has been used safely to enhance performance as feed material for livestock as well as food material for humans (Narutoshi, 1992). Moreover, in recent researches, *Y. schidigera* has shown to possess antioxidant, anti-hypercholesterolemic, anticarcinogenic, antiarthritic, anti-inflammatory, antiprotozoal, antifungal and antihypertensive properties. The plant was shown to have secondary metabolites such as eugenol, caffeic acid, rosmarinic acid and α-tocopherol. Moreover, the dried and powdered plant material also contains approximately 10% steroidal saponins and is used commercially as a saponin source (Francis et al., 2002; Piacente et al., 2004; Enginar et al., 2006; Kucukkurt and Dündar, 2013).

Saponins are a class of secondary metabolites found in several plant species. More specifically, they produce soap-like foaming when shaken in aqueous solutions, and, in terms of structure, one or more hydrophilic glycoside moieties combined with a lipophilic triterpene or steroidal aglycone. These compounds are used in phytotherapy and in the cosmetic industry for their cytotoxic, hemolytic, molluscicidal, anti-inflammatory, antifungal, antiyeast, antibacterial and antiviral activities (Leung et al., 1997; Sen et al., 1998; Bachran et al., 2006) as well as in the pharmaceutical industry for the semi-synthesis of steroidal drugs (Chwalek et al., 2006). Moreover, saponins stimulate luteinizing hormone release leading to abortifacient properties (Francis et al., 2002), have immunomodulatory potential (Sun et al., 2009), cytostatic and cytotoxic effects (Bachran et al., 2008) and adjuvant properties for vaccines (Sjolander et al., 1998). Due to their physiological properties, saponins are now expected to serve as functional components in food. They have been reported to decrease plasma cholesterol

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in rats when added to their diets (Oakenfull, 1981; Sidhu and Oakenfull, 1986).

Fatty diet, as well as imbalance between the food intake and energy expenditure are the factors affecting the prevalence of obesity (Altunkaynak, 2005; Milagro et al., 2006). Obesity and overweight pose a major risk for serious diet-related chronic diseases, including type-II diabetes, cardiovascular diseases, hypertension, stroke and certain forms of cancer. Leptin, insulin and T_3 are among the most important hormones to provide this balance (Otukonyong et al., 2005). Leptin, an adipose tissue hormone, regulates body fat mass and body weight by decreasing the appetite and increasing energy expenditure (Zabrocka et al., 2006).

The present study was planned to determine the effects of the extracts obtained from *Y. schidigera*, which was reported to be rich in saponins in the previous studies, on leptin, ghrelin, insulin and thyroid hormones and some biochemical parameters in mice fed a high-fat diet.

Materials and methods

Plant material

Yucca schidigera Ortgies, Asparagaceae, standard powder (Sarsaponin 30® contains more than 8% steroidal saponin) was purchased from Desert King International (San Diego, CA, USA).

Preparation of the extracts

Y. schidigera powder (500 g) was successively extracted with 5 l of hexane (HE), petroleum ether (PE), ethyl acetate (EA) and methanol (ME) by percolation method at room temperature. After completion of extraction the extracts were filtered and the solvent was removed by distillation under reduced pressure and low temperature (40–50 °C) on a rotary evaporator to give crude extracts. Extracts were weighed and yield percentages were calculated as 17.93% for HE, 26.42% for PE, 11.02% for EA and 9.27% for ME.

Animals

Male Swiss Albino mice (25–35 g) were purchased from the animal breeding laboratories of Afyon Kocatepe University Experimental Animal Research and Application Center (Afyon, Turkey). The animals were allowed to acclimatize to the animal facility for at least 7 day before experiment started. The room conditions were maintained in a 12 h light/12 h dark cycle at room temperature (25 ± 3 °C), with rodent standard diet and water provided ad libitum. A minimum of ten animals was used in each group. The study was permitted by the Institutional Animal Ethics Committee (Ankara University Ethical Council Study Number: 2009/34) and was performed according to the international rules considering the animal experiments and biodiversity right.

Experimental protocol

Two different control groups were employed in the study. The negative control group was maintained on standard pellet diet and water ad libitum without administering any plant extract (negative control group). The high-fat diet (HFD) group received special diet containing 40% beef tallow for eight weeks (HFD group-positive control). The vehicle control group received 0.5% CMC suspension in distilled water and was maintained on HFD (CMC group). On the other hand, the experimental group animals received hexane (HE), petroleum ether (PE), ethyl acetate (EA), and methanol (ME) extracts obtained from *Y. schidigera* along with HFD. Extracts were administered orally after suspending in distilled water and 0.5% sodium carboxymethyl cellulose (CMC) by using a gastric gavage at 100 mg/kg doses daily for eight weeks. This dose was determined according to a previous preliminary study (Avci et al., 2006). Blood samples were taken from the heart into tubes with heparin and plasma was obtained at the end of the experimental period, then centrifugation performed at 1500 × *g* (+4 °C) for 10 min and kept at −30 °C in advance of assays.

Biochemical analysis

Plasma leptin (Biovendor, Czech Republic, Cat No. RD291001200R), insulin (Millipore, USA, Cat No. EZRMI-13K), ghrelin (Millipore, USA, Cat No. EZRGRT-91K), total adinopectin (Biovendor, Czech Republic, Cat No. RD293023100R), total tri-iodothyronine (T_3) (DRG International Inc., USA, Cat No. EIA-4569), total tetra-iodothyronine (T_4) (DRG International Inc., USA, Cat No. EIA 4568), free tri-iodothyronine (FT3) (DRG International Inc., USA, Cat No. EIA-2385) and free tetra-iodothyronine (FT4) (DRG. International Inc., USA, Cat No. EIA 2386) were measured using an enzyme-linked immunosorbent assay (ELISA).

Liver damage was assessed by the estimation of serum levels of alanine aminotransferase (ALT), and aspartate aminotransferase (AST) by using commercial kits Teco Diagnostics assay kit (Teco Diagnostics, CA, USA). Serum levels of total protein (Tp), urea, total cholesterol (Tc), glucose, low density lipoprotein-cholesterol (LDL-c), high density lipoprotein-cholesterol (HDL-c) and triacylglyceride (Tg) were determined using COBAS test kits (Roche Diagnostics Systems, Istanbul, Turkey) according to the manufacturers' instructions in Laboratory of Biochemistry, Faculty of Veterinary Medicine, University of Afyon Kocatepe (Turkey).

Statistical analysis of data

The data obtained from the animal experiments was expressed as mean and standard error (±SEM). The statistical differences among the experimental groups were evaluated by one-way ANOVA and Duncan post hoc tests using the SPSS computer software program. A difference of $p < 0.05$ in the mean values was considered significant.

Results

Body weights of the mice are shown in Table 1. Supplementation of HFD to the animals during eight weeks significantly increased the body weight compared to the control group ($p < 0.05$). On the other hand, during the experimental period PE extract prevented the weight gain of mice compared to the other groups.

Plasma glucose, TC, LDL, HDL, TG, AST, and ALP were found to be high in HFD and CMC + HFD groups compared to the control group ($p < 0.05$) as shown in Table 2. On the other hand, administration of 100 mg/kg *Y. schidigera* extracts, especially HE and PE, decreased the levels of these parameters ($p < 0.05$). These results suggest that *Y. schidigera* extracts have capacity to alleviate the biochemical status caused by HFD.

Supplementation of HFD increased leptin, insulin, and FT3 whereas decreased ghrelin, adiponectin, and FT4 ($p < 0.05$). In addition, TT4 and TT3 levels were not changed in all groups (Table 3). On the other hand, administration of 100 mg/kg *Y. schidigera* extracts especially PE resulted in reversal of HFD-induced hormone levels ($p < 0.05$). These results suggest that *Y. schidigera* extracts affected hormone status.

Discussion

Although in some studies it was shown that HFD does not affect weight gain (Gao et al., 2002), in our study it was observed that