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Research report

Tragopogon porrifolius improves serum lipid profile and increases short-term satiety in rats ☆

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ABSTRACT

Tragopogon porrifolius (white salsify) is an edible plant commonly used in folk medicine in Lebanon and neighbouring countries. This study investigates the effect of the aqueous extract of the aerial part of *T. porrifolius* on lipemia and appetite regulation using a rat model. Food intake, abdominal fat percentage, blood lipid profile, liver weight and liver enzymes were assessed following 4 weeks of extract intake via drinking water (50, 100, or 250 mg/kg body weight) in standard high-carbohydrate and high-fat dietary conditions. In a separate study, the short term effect of a preload of *T. porrifolius* extract on food intake was evaluated. Results showed that consumption of the plant extract for a period of four weeks resulted in a marked improvement of the lipid profile (triglycerides, total cholesterol, LDL and HDL cholesterol). Body weight, food intake and intra-abdominal fat were also lower in animals given the plant extract (100 and 250 mg/kg). In addition, *T. porrifolius* extract preload produced a dose dependent decrease in food intake observed over 24 h. The intake of *T. porrifolius* aqueous extract therefore improved lipemia and increased satiety in rats with no visible adverse effects.

Introduction

Human obesity is a growing global epidemic. It increases the risk of coronary heart disease, hypertension, stroke, diabetes and certain cancers (Ezzati, Lopez, Rodgers, Murray, et al., 2004; Folsom et al., 1989; Lee and Paffenbarger, 1992; Sellers, Kushi, Potter, et al., 1992; World Health Organization, 2009). According to the World Health Organization (World Health Organization, 2009), the incidence of obesity worldwide has more than doubled in the past 30 years. Global estimates from 2008 revealed that 1.5 billion adults were overweight, of which 500 million were obese. Obesity and its related health problems impose a significant economic burden not only on obese people but also on the rest of society. For example, in the United States alone, about 10% ($147 billion) of the annual US health care budget is spent on obesity due to increased need for medical care and the loss of economic productivity (Finkelstein, Trogdon, Cohen, & Dietz, 2009; Withrow & Alter, 2011). The rise in obesity incidence throughout many countries seems to be driven mainly by changes in the global food system which is producing and effectively marketing more cheap energy-dense processed foods (Hurt, Frazier, McClave, & Kaplan, 2011; Swinburn, Sacks, Hall, et al., 2011). Normally, increases in the consumption of refined fats and carbohydrates are accompanied by a loss of diversity in diet composition leading to the loss of vegetable and herb benefits.

While they are not always parallel, obesity is often accompanied by hyperlipidemia. The metabolic features of obese people include increased serum total cholesterol, triglycerides and LDL cholesterol which are proven risk factors for cardiovascular disease (Di Angelantonio et al., 2009; Harchaoui, Visser, Kastelein, et al., 2009; Kannel & Vasan, 2009). Indeed, treatment of hyperlipidemia is a primary approach in cardiovascular disease prevention (Baigent et al., 2010; Graham, Atar, Borch-Johnsen, et al., 2007). Therefore, it is important to identify and promote natural functional foods that can help manage weight and hyperlipidemia in this obesogenic environment.

Satiety is an internal state that leads to termination of eating under normal physiological conditions. Increased appetite, due to impaired central mechanisms regulating food intake, could cause obesity (Astrup & Raben, 1992; Rosenbaum, Kissileff, Mayer, et al., 2010). Recent efforts have been made to identify various methods that help limit food intake, among which is increasing the satiating power of foods.

Tragopogon porrifolius, family Asteraceae, is an annual or biennial herb indigenous to the Middle East as well as Asia Minor. Its roots, leafy shoots and open flowers are used both cooked and raw (as a salad) (Gupta, Talwar, Jain, et al., 2003). While both roots and shoots are edible, in Lebanon, the shoots are more frequently

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consumed than the roots. *T. porrifolius* is commonly used in folk medicine in Lebanon and neighbouring countries. It has been reported to possess antibilious, diuretic and laxative effects (Formisano et al., 2010; Spina, Cuccioloni, Sparapani, et al., 2007). Phytochemical analysis of *T. porrifolius* revealed the presence of acylated pentacyclic triterpene saponins (Warashina, Miyase, & Ueno, 1991), flavonoids, and different types of bibenzyls and dihydroisocoumarins (Sareedenchai et al., 2009; Zidorn, Lohwasser, Pschorr, et al., 2005). The nutritional value of this plant has been attributed to its monounsaturated and essential fatty acids, vitamins, polyphenols, and fructo-oligosaccharides (FOS) components (Formisano, Rigano, Senatore, et al., 2010; Konopinski, 2009). In fact, the FOS content, which is estimated to be 4–11% (Beirao-da-costa, Januario, Leitao, & Simao, 2005; Konopinski, 2009; Riu-Aumatell, Vargas, Vichi, et al., 2011) was behind its use in a human study to supplement baby food (Flickinger, Hatch, Wofford, et al., 2002).

To the best of our knowledge, no studies were conducted on the effects of *T. porrifolius* on lipemia and food intake. Therefore, the primary objective of this study was to evaluate the effects of *T. porrifolius* water extract intake on blood lipid profile and the eating behavior of rats. We used a 4-week model in which rats were given the extract via drinking water (at doses of 50, 100, or 250 mg/kg body weight) with a standard high-carbohydrate or a high-fat diet. The secondary objective was to assess the short term effects of *T. porrifolius* water extract on food intake.

Materials and methods

Plant collection and extraction

T. porrifolius was collected from Tyre, South Lebanon, during May and June 2011. The plant was initially identified by Dr. Ahmad Houri, a Lebanese plant expert and further confirmed according to descriptions reported by Chevallier (1996). Aerial parts were air-dried in shadow, powdered and soaked in preboiled water with occasional stirring for 30 min. The aqueous extract was then filtered, lyophilized and stored in a well-sealed dry box at 4 °C.

HPLC analysis of the T. porrifolius aqueous extract

The analysis of phenolic acids and flavonoids was performed on a Shimadzo HPLC system (Shimadzu Corp., Kyoto, Japan) consisting of LC 10-ADVP pump, SCL 10A system controller coupled with a photo-diode array detector (SPD-M20A), FCV-10AL Low Pressure Gradient, Rheodyne injector (Model 7125), DGU-20A online degasser, Shim-pack VP-ODS column, 4.6 mm i.d. × 150 mm), Pre-column (10 × 4.6 mm i.d. 5 μm) equipped with LC solution 1.23 SP1 software (Shimadzu, Kyoto, Japan). The column was operated at 25 °C. The mobile phase consisted of 10:2:88-water:acetic acid:methanol v/v (solvent A) and 90:2:8-water:acetic acid: methanol v/v (solvent B) at a flow rate of 1.5 ml/min. The gradient elution program was as follows: 0–15 min solvent A, 15–30 min solvent B followed by washout period for 10 min and the wavelength of detection was set at 280 nm. The phenolic acids and flavonoids were identified by matching the retention time and their spectral characteristics with those of the standard compounds.

All phenolic acids and flavonoid standards (gallic acid, chlorogenic acid, vanillic acid, Syringic acid, caffeic acid, ellagic acid, ferulic acid, myricetin, quercetin, luteolin, kampferol, apigenin) were purchased from Sigma–Aldrich Co. (St. Louis, MO, USA). All HPLC solvents were purchased from Merck (Germany). The standard stock solutions (0.2 mg/ml) were prepared by dissolving each standard in methanol and diluted with the mobile phase in the range 10–60 μg/ml.

Study 1

Animals and diets

Sixty-four adult male Sprague–Dawley rats (Lebanese American University Stock) aged initially 8–10 weeks were housed in a temperature and humidity-controlled room under a 12:12 light/dark cycle (lights on at 0800 h). The rats were allocated into 8 weight-matched groups of 8 rats each. Animals received the aqueous extract via drinking water in one of 3 doses (50, 100, or 250 mg/kg bodyweight) based on the assumption that each rat consumes 10 ml/100 g of body weight (Waynforth & Flecknell, 1992). The control groups were not provided with any extract. Animals were fed either a standard high-carbohydrate (HC) diet or a high-fat diet (HF) (Table 1). The HF diet consists of the HC diet enriched with 10% coconut oil. The diets were given ad libitum for 4 weeks and food intake as well as body weight gain were monitored three times a week during the whole experimental period. Food intake, corrected for spillage, was recorded at 8 am by measuring the difference in food cup weight before and after presentation to the rats. All experimental protocols were approved by the Animal Ethical subcommittee of the Lebanese American University, which complies with Guide for the Care and Use of Laboratory Animals (National Research Council., 2011).

Body composition

At the end of the 4th week, blood samples were collected from the inferior vena cava of anesthetized fasted (overnight) rats. Following sacrifice by exsanguination, the intra-abdominal fat (epididymal, mesenteric and retroperitoneal) and the liver were removed from animals, after which they were cleaned, blotted on a filter paper then weighed.

Blood analysis

Serum was separated by centrifugation at 2000*g* for 15 min and stored at −80 °C for subsequent analysis. Serum lipids (total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides) and liver enzyme activities of aspartate transaminase (AST), alanine transaminase (ALT) and lactate dehydrogenase (LDH) were determined using the relevant Spinreact kits (Spinreact, Spain). All serum samples were run in duplicate and analyzed within the same assay.

Table 1
Nutrient composition of the HC and HF diets.

	High carbohydrate (HC)*	High fat (HF)**
Protein (% wt)	19	17.1
Carbohydrates (% wt)	65.3	58.8
Fat (% wt)	9.6	19.6
Fat breakdown		
Saturated fat	18%	57%
MUFA	29%	16%
PUFA	47%	23%
Fiber (% wt)	4.3	3.9
Metabolizable energy (kJ/g)	17.7	19.9
Energy (protein)	18%	14%
Energy (carbohydrate)	70%	50%
Energy (fat)	20%	36%

MUFA: mono-unsaturated fatty acids
PUFA: poly-unsaturated fatty acids
* Laboratory rodent starter diet No. 1, Hawa Chicken Co., Safra, Lebanon.
** HC diet enriched with 10% coconut oil.