



Fennel (*Foeniculum vulgare*) and Fenugreek (*Trigonella foenum-graecum*) Tea Drinking Suppresses Subjective Short-term Appetite in Overweight Women

JiYoung Bae¹, JiEun Kim¹, Ryowon Choue^{1,2†}, Hyunjung Lim^{1,2*}

¹Department of Medical Nutrition, Graduate School of East-West Medical Science, Kyung Hee University, Yongin 446-701, Korea

²Research Institute of Medical Nutrition, Kyung Hee University, Seoul 130-701, Korea

Appetite controlling has been an main strategy for regulating food intake and energy balance in obesity treatment. The aim of this study was to examine the effects of drinking tea of the medicinal herbs, fennel and fenugreek, on the subjective appetite in overweight Korean women. The study was conducted using a placebo-controlled, single-blinded, randomized, and 3-way crossover design. Nine healthy women were given fennel tea (FT), fenugreek tea (FGT), or placebo tea (PT). After drinking a given tea, a lunch buffet was provided and then food consumption of subjects was analyzed. Subjective appetite, hunger, fullness, desire to eat, and prospective food consumption were measured at seven independent time point using a visual analog scale (VAS). Mean age of 9 subjects were 49.7 ± 4.5 years and their mean body mass index were 24.6 ± 0.6 kg/m². There was no significant difference in food consumption in the lunch buffet after drinking each tea; however, with respect to the subjective appetite scale, FGT decreased hunger, led to less prospective food consumption, and increased feelings of fullness compared with the PT ($p < 0.05$). Similarly, the consumption of FT resulted in decreased hunger, less prospective food consumption, and increased feelings of fullness compared with the PT ($p < 0.05$). The area under the curve of VAS graph indicated that FGT resulted in a higher feeling of fullness than the PT ($p < 0.05$). In conclusion, drinking the FT and FGT were significantly effective aid to suppress subjective appetite among overweight women in South Korea.

Key Words: Fennel (*Foeniculum vulgare*), Fenugreek (*Trigonella foenum-graecum*), Visual analog scale, Appetite

*Corresponding author Hyunjung Lim

Address Department of Medical Nutrition, Graduate School of East-West Medical Science, Kyung Hee University, 1732 Deogyongdaero, Giheung-gu, Yongin 446-701, Korea
Tel +82-31-201-2343 **Fax** +82-2-969-7717
E-mail hjlim@khu.ac.kr

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†Corresponding author Ryowon Choue

Address Department of Medical Nutrition, Graduate School of East-West Medical Science, Kyung Hee University, 1732 Deogyongdaero, Giheung-gu, Yongin 446-701, Korea
Tel +82-2-961-0769 **Fax** +82-2-969-7717
E-mail rwcho@khu.ac.kr

Introduction

Human body has a powerful physiological function for balancing energy input and output. Appetite control is one of such physiological functions. Appetite is a complicated action occurring in the interaction between end-organs and central nervous system. Nowadays, people easily over-eat but the appetite control becomes more difficult by breaking down homeostatic system and this, in turn, cause overeating again.

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Previous studies have been reported that such a negative cycle contributes to exacerbate obese conditions [1].

Foeniculum vulgare (Fennel) and *Trigonella foenum-graecum* (Fenugreek) have long been used to control appetite. Fennel fruit, a type of herb belonging to the *Apiaceae* family has been widely used for medicine and clinical studies with female obese patients show that its seed has significant efficacy on appetite control [2], prevents weight gain and reduces the efficiency of dietary intake due to appetite control [3]. Fenugreek is a herb of the soy family, originated from India and the North Africa. Its seeds are used for medicine and have shown positive effects on lowering blood sugar [4,5] and on anti-diabetes [6,7] in many clinical and animal studies. About 50% of its seeds, in particular, are mainly fiber, which help increase the feeling of fullness and reduce food intake [8,9]. However, previous studies on fennel and fenugreek and their effects on appetite control have primarily used fennel essential oil or fenugreek fiber extracts only. Fennel essential oil is not easy to use for ordinary people, and products of fenugreek fiber extract can be hardly seen in commercial markets of South Korea. Despite their demonstrated effectiveness, ordinary people cannot easily access these products. Considering the shifted atmosphere of modern society towards increased tea consumption [10], people may benefit from enhanced access to fennel and fenugreek by serving these as a tea.

Therefore, we aimed to examine the effects of fennel and fenugreek in the form of tea on food consumption and subjective appetite using a visual analog scale (VAS) in Korean overweight women.

Materials and Methods

Study design

A placebo-controlled, single-blind, and randomized 3-way crossover design was used to examine the effect of the fennel tea (FT) and fenugreek tea (FGT) on appetite control of overweight Korean women who were enrolled in this study. By using computer-generated randomization schedule, the participants were randomly assigned to the order of placebo tea (PT) for control, FT and FGT for experiments. To minimize the carry-over effects on the experiment, we placed one-week wash-out period between experiment days, making two times of suspension period in the middle. Each of participants drank all of three different teas at least once (Figure 1). The subjects were advised to have dinner at the same time, in a day before each experiment.

On experiment days, after a rest of 10-minute, a researcher asked them to complete a subjective appetite assessment survey using a VAS [11] (-15 min). Simultaneously, the subjects were provided with the experimental teas to drink within 5 minutes. Fifteen minutes after drinking of the tea, subjects were provided breakfast (0 minute), which was to be finished within 20 minutes. The VAS was again completed by the subjects at 15, 30, 60, 90, and 120 minutes after the start of breakfast. During written completion of the VAS, the subjects sat down quietly to read, meditate, or pursue other activities within the allowed range of minimal activities. Drinking of water was not allowed. The participants were then moved to a restaurant at 12 o'clock and again completed the VAS (210 minute) while drinking the same experimental tea which they had in the morning followed by a lunch buffet, and then they returned home. Before the study subjects left, we asked them

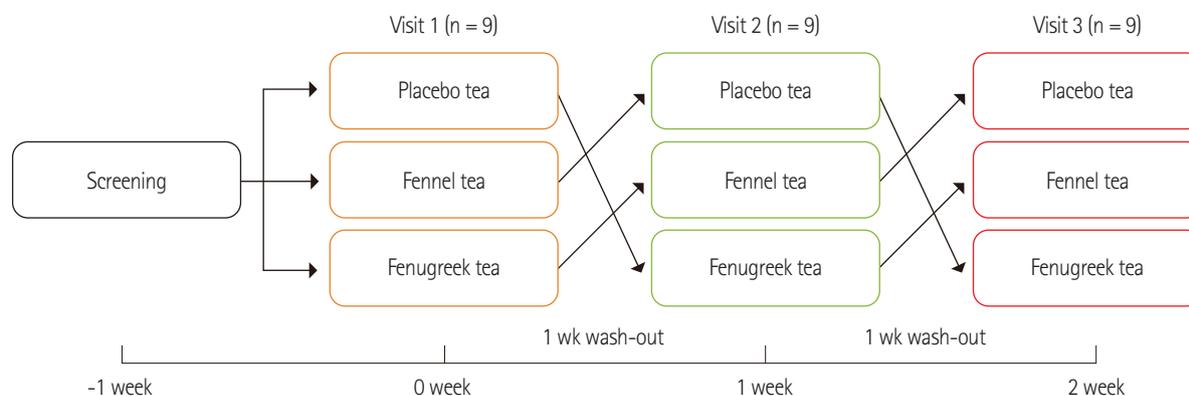


Figure 1. Study design. A placebo-controlled single-blinded randomized 3-way crossover design. Subjects: 9 healthy overweight women ($23.0 \text{ kg/m}^2 \leq \text{body mass index} < 25.0 \text{ kg/m}^2$).

to fill out a food record for the meals consumed during the rest of the day and bring the completed document back to the next visit.

This study was conducted with approval of the institutional review board (IRB) of Kyung Hee University (KHSIRB-13-039[RA]).

Subjects

The study subjects consisted of healthy women living in a metropolitan area with no change in weight during 3 months before the study began and who had a body mass index (BMI) between 23.0 kg/m² and 25.0 kg/m². To remove all other factors contributing to appetite control caused by menostasia or stress, study subjects consisted of individuals with a regular menstrual cycle and no known overeating symptoms due to premenstrual syndrome (PMS). Written consent form was obtained individually from who wants to participate in the study after further explanation of the study protocol. General information, such as age, current and past medical history, drug administration status, family medical history, cohabiting family members, place of residence, educational level, and employment status, and health-related behaviors activity was collected using a constructive questionnaire. Exclusion criteria were as follows: 1) those who smoked or had gastrointestinal surgery, ongoing gastrointestinal disease, or were under treatment for gastrointestinal disorders, 2) suffered from a disease within recent 3 months or were allergic to any foods, 3) scored at least 2.5 points in the restrained eating scale of the Dutch Eating Behavior Questionnaire (DEBQ) [12], 4) required special meals or were currently prescribed medication, 5) pregnant women, and 6) those who the present research operators have met were not appropriate for participation as human subjects in the study. Then finally total of nine women participated in the study.

Fennel tea and Fenugreek tea

We purchased fennel seeds (*Foeniculum vulgare*) and fenugreek seeds (*Trigonella foenum-graecum*) directly from the Medical Herbs Institute of New Zealand (MHINZ), in dried condition. In the previous study [3], 2-4 drops of fennel oil on dried cloth or cotton ball was inhaled through the nose as a dry inhale method for appetite controlling. Here, 2-4 drops of oil corresponds to the volume of 0.1-0.2 mL and the oil content in dried fennel is about 5-6%, which weighs about 2-4 g. Thus we decided to use 2 g of dried fennel and ignored the specific gravity gap between oil and dried fennel.

Fenugreek contains approximately 50% of fiber and 20%, out of 50% is fat-soluble fiber and the remaining 30% is water-soluble fiber. Taking 8 g of fenugreek-extracted fiber had a significant effect on enhanced feeling of fullness and the decrease of energy intake in obese people in the West [9]. In that 8 g of fenugreek extracts total amount of fiber is 7.2 g and approximately 4.3 g out of the 7.2 g total fiber is water-soluble. In this study we used 24 g of dried fenugreek equivalent to the 7.2 g of water soluble fiber. All dosage of fennel and fenugreek was determined within safety range [13,14].

Fennel tea was prepared [15] by pouring 250 mL of distilled water at 100 °C onto 2 g of dried fennel seeds and placing a lid on the container to brew for 20 minutes. And then the tea was filtered and cooled down to 30-40 °C until reaching an appropriate temperature for consumption. For fenugreek tea, we poured 400 mL of cold water onto 24 g of dried fenugreek seeds, placed a lid on the container and brought it to a boil, after which it was filtered and cooled down to 30-40 °C. For placebo tea, 2 g of harmless natural food color (natural additive; NO. 4; gamboges coloring, maltodextrin, Naturals Korea Co., Ltd.) were added to the same amount of boiling water.

Breakfast menu

When the intake ratio of carbohydrate : protein : fat was 60:20:20, glucagon-like peptide-1 and peptide tyrosine tyrosine (PYY) reached their top level in blood at 30 minutes after starting a meal [16]. In accordance with a previous research, we adjusted the ratio of carbohydrate: protein: fat in 500 kcal (KDRIs, The Korean Nutrition Society. Dietary Reference intakes for Koreans, 2010) of breakfast to 60:20:20 as well. As the effect of fenugreek on appetite control was due to high contents of fibers [8,9], we planned our menu containing less than 1 g of fiber to exclude any possible interference from factors other than the experimental tea. We also excluded any soup in the menu because water intake influenced food intake in previous study [16]. Exactly the same menu was provided to subjects for the first, second and third day of experiment.

Lunch buffet and food consumption

During screening we referred to the survey on eating habits (added questions on food preference) completed by the participants and prepared a menu with their favorite foods to minimize differences in energy intake due to food preferences. All menus consisted of Korean-style foods with steamed rice, soup, and seven different side dishes. We did not place a time limit on finishing the meal in order to allow subjects to con-

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concentrate on eating. In addition, subjects were asked to eat as much as they wished without consideration of others.

To evaluate lunch buffet consumption, we weighed the food selected by subjects before and after they had lunch buffet. Consumption of calories and nutrients from lunch buffet were analyzed with CAN pro version 4.0 (Computer aided nutritional analysis program, Korea Nutrition Society, 2010).

Subjective appetite measurement

To assess the subjective appetite of study participants, we used a VAS [11], which is a very sensitive and reliable tool designed to determine subjective appetite [17]. To represent the satiety status, we set a 100-mm-line to show appetite status before and after meals. The survey was filled in a total of 7 times, beginning with a fasting state (-15 min), 15, 30, 60, 90, and 120 min after the start of breakfast, and again before the start of lunch (210 min). The VAS contained 4 statements to assess 'Hunger, Fullness, Desire to eat, and Prospective food consumption'. The text 'very much so' and 'not at all' was placed at either end of the 100 mm line, and participants wrote in their appetite status.

Statistical analysis

Data were analyzed using SPSS (IBM SPSS statistics 21, IBM Co., Armonk, NY, USA). The results were expressed as the mean and standard error of the mean (SEM). VAS was analyzed using two-way repeated measures ANOVA. In addition, VAS was compared using the area under the curve (AUC) calculated by the trapezoidal rule. AUC and energy intake were analyzed using one-way ANOVA, and the post-hoc test was arranged as Tukey's range test. The significance level of all examinations was set at $p < 0.05$.

Results

The mean age of the subjects was 49.7 ± 1.5 years and the mean BMI was 24.6 ± 0.2 kg/m². A total of six subjects had experienced menopause at least 1 year prior to the study (data

was not shown).

There was no significant difference in food consumption and energy intake during the lunch buffet among groups of drinking three different teas (Table 1).

Figure 2 demonstrates the results of VAS consist of Hunger, Fullness, Desire to eat, and Prospective food consumption, respectively. Subjective appetite was measured for the first time at -15 min after emptying the stomach for 12 hours. After the first measurement, the subject drank a given tea, had breakfast (0 min) and VASs were measured again at 15, 30, 60, 90, 120 and 210 min after starting breakfast (Figure 2).

Subjects who drank FGT felt significantly less hunger than those who had PT (by two-way repeated measures ANOVA; $p < 0.05$), while those who drank FT showed no difference from PT and FGT. Fullness was higher in subjects who drank FT and FGT compared with subjects who drank PT. With respect to the subjects' desire to eat, subjects who drank FT recorded lower values on the VAS compared with those who drank PT, while subjects who drank FGT showed no difference from PT and FT. In addition, prospective food consumption was lower in subjects who drank FT and FGT than in those who drank PT.

The AUC of the VAS data was calculated and compared among the three teas. Fullness was significantly higher in subjects who drank FGT (182.9 ± 15.6 , respectively) than in subject who drank PT (95.4 ± 17.1 , $p < 0.05$). However, there was no significant difference among all three teas with respect to hunger, desire to eat, or prospective food consumption (Table 2).

Discussion

We examined the effects of fennel and fenugreek tea on subjective appetite. Although there was no significant difference in the level of food intake after drinking the fennel and fenugreek teas. The VAS showed that the subjects felt more fullness and had a lower level of prospective food consumption after drinking of FT or FGT compared with after drinking of this result is consistent with the findings of a previous

Table 1. Energy intake after drinking teas

Parameter	PT	FT	FGT	p value
Calories eaten at buffet, kcal	878.0 \pm 61.0*	746.0 \pm 78.0	653.0 \pm 51.0	0.06
Calories eaten after buffet, kcal	787.0 \pm 38.0	688.0 \pm 39.0	726.0 \pm 47.0	0.22

All analyses were arranged using one-way ANOVA.

PT: placebo tea, FT: fennel tea, FGT: fenugreek tea.

*Mean \pm standard error of the mean (SEM).

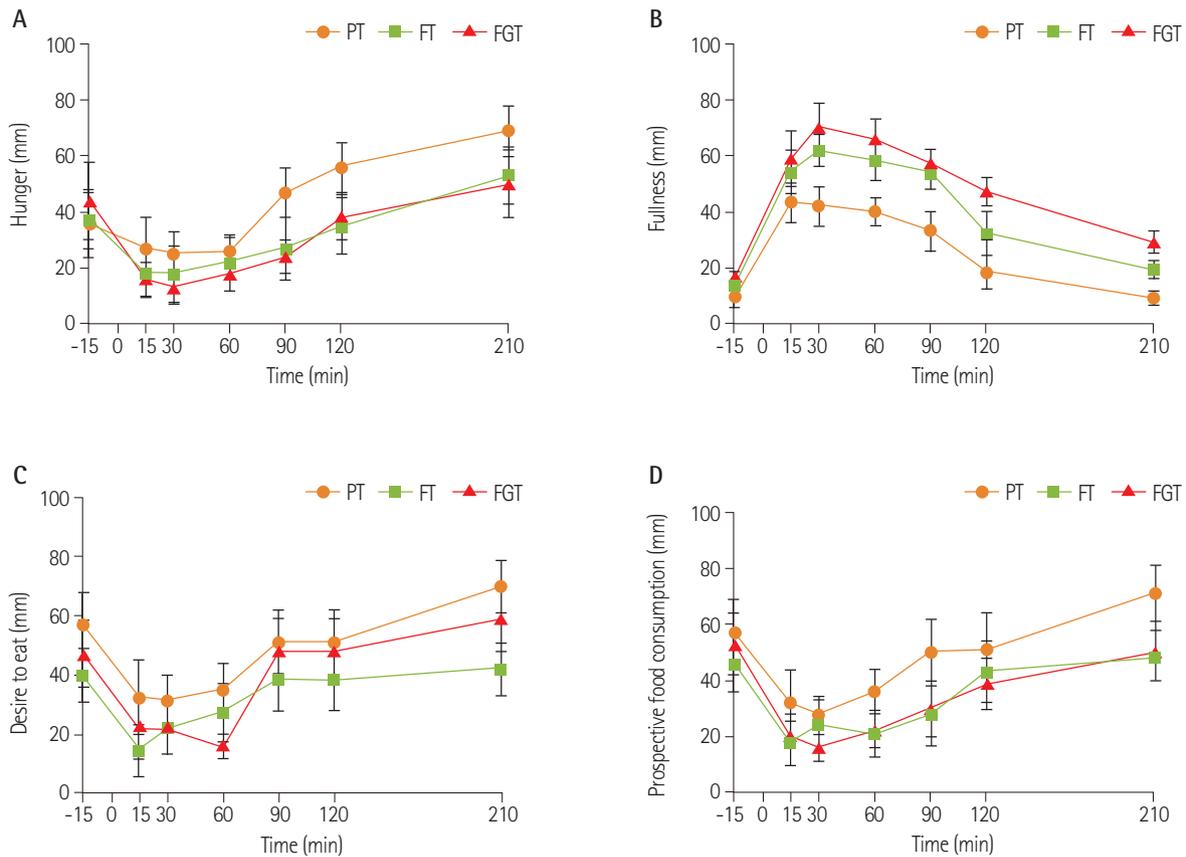


Figure 2. Visual Analog Scale (VAS) according to time passage. Mean \pm standard error of the mean (SEM) for PT: placebo tea (control), FT: fennel tea, FGT: fenugreek tea. All analyses were arranged using two-way repeated measures ANOVA and verified using the Tukey's range test ($p < 0.05$). (A): Hunger (210 min) was significantly lower for FGT than PT, (B): Fullness at 90 min and 210 min were significantly higher for FT and FGT than PT, (C): Desire to eat (210 min) was significantly lower for FT than PT, (D): Prospective food consumption at 90 min and 210 min were significantly lower for FT and FGT than PT.

Table 2. Area under the curve (AUC) analysis of visual analog scale (VAS) after tea consumption

Parameter	PT	FT	FGT	p value
Hunger, mm, 210 min	172.2 \pm 25.1*	122.0 \pm 32.4	118.0 \pm 25.5	0.33
Fullness, mm, 210 min	95.4 \pm 17.1 ^a	150.4 \pm 20.3 ^{a,b}	182.9 \pm 15.6 ^b	0.01
Desire to eat, mm, 210 min	181.8 \pm 33.3	123.3 \pm 27.5	144.9 \pm 29.1	0.40
Prospective food consumption, mm, 210 min	183.8 \pm 35.3	131.3 \pm 30.9	148.0 \pm 17.8	0.38

AUC values were calculated using the trapezoidal rule. All analyses were arranged using one-way ANOVA, and verified using the Tukey's range test ($p < 0.05$). Different letter subscripts indicate a significant difference among the groups ($p < 0.05$).

PT: placebo tea (control), FT: fennel tea, FGT: fenugreek tea.

*Mean \pm standard error of the mean (SEM).

study showing the efficacy of fennel essential oil [2] on appetite control, as well as a study showing increased feeling of fullness in the subjects who took fenugreek fiber extracted from fenugreek seed [9].

Trans-anethole, an ingredient of fennel volatile oil known

to exhibit efficacy on appetite control is structurally similar to catecholamine, and acts similarly to amphetamine with respect to appetite control. Previous studies have verified the efficacy of trans-anethole on appetite control by conducting tests with fennel's essential oil [2,3]. Our subjects consumed

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fennel in the form of a tea, and although its efficacy was not stronger than that of trans-anethole inhaled from a concentrated essential oil, which clearly had an effect on appetite control. The total content of trans-anethole in the fennel used in FT was 3.1% (ingredient analysis certification of the fennel from the medical herbs institute of New Zealand), which may have contributed to the efficacy on appetite control in this study; however, the effects of other phytochemicals present in fennel tea cannot be discounted. Further studies are needed to determine which components of fennel are responsible for its efficacy of controlling appetite.

Studies on fenugreek have focused primarily on its fiber content, as its fiber contents are much higher than those found in other medicinal herbs [18]. In particular, fenugreek contains significant levels of galactomannan, a water-soluble fiber (galactose/mannose ratio is 1.5:1) [19]. Many clinical and animal studies have verified the antidiabetic and hypocholesterolemic effects of fenugreek seeds [4,20-23], suggesting that its efficacy is due to a large amount of fiber and saponins, including galactomannan, which in turn may lower the absorption of glucose, cholesterol, and bile acids in the digestive tracts [7]. As an extension of these findings, a previous study on fenugreek's appetite-related functions focused on its fiber contents [9].

In the previous studies on fenugreek's appetite-related function [9], subjects who ingested 8 g of fiber extracted from fenugreek exhibited significantly higher fullness than those who ingested 4 g and those in the control group. Fiber extracted from fenugreek contains both soluble and insoluble fiber; however, the fenugreek tea used in this study contained only water-soluble substances. Specifically, when 24 g of dried fenugreek, the amount present in each cup of the was dried again, the resulting weight was 19 g. We did not analyze the ingredients present in the water-soluble fraction of fenugreek, but we estimated that it contained less than 5 g of fiber. Accordingly, our results may not have been due to the same substances contributing to previous observations of increased feelings of fullness by consuming fenugreek fiber [9]. Thus, it is necessary to consider our findings from various angles, particularly, rather than assuming that the reason of increased fullness by FT and FGT is solely due to fibers. We can think of other ingredients of the fenugreek and their mechanisms of action.

Of many kinds of phytochemicals in fenugreek 4-hydroxyisoleucine has been assigned an American patent as a substance to increase fullness [24]. Likewise, 4-hydroxyiso-

leucine is the primary ingredient extracted from fenugreek for commercialization. It is possible that 4-hydroxyisoleucine and/or other unknown phytochemical may have contributed to the increase of fullness. A synergistic effect of fiber and 4-hydroxyisoleucine may also explain the increase of fullness; however, more studies are required to evaluate this possibility.

In our randomized cross-over controlled clinical trial showed that FT and FGT significantly suppressed subjective appetite in overweight women. Despite being conducted under restricted conditions with a small sample size and short-term trial, and weight change could not be observed, there were two significant findings in this study. First, the test herbs, as a form of a tea, was effective to appetite control as shown in previous studies which uses these herbs as an extract. Second, from a statistical viewpoint, a randomized, three-way crossover protocol decreased the variance of errors. As a tea is relatively safe and easy to consume, access of these herbs as a drink of tea may have efficacy on appetite control, although this result needs to be verified in a long-term investigation. Further studies need to be conducted to identify the aspect of the appetite control by drinking FT and FGT in effective weight maintenance.

Conclusion

Drinking the FT and FGT might be helpful on appetite control by reducing further food intake in overweight women. A longer trial with larger number of subjects would be beneficial to evaluate the long-term effects (e.g. body weight, body fat etc.) of these teas on obesity treatment in conjunction with the appetite control. In addition, various parameters to evaluate an appetite control, including hematologic outcomes would be required for future research.

Conflict of Interest

The authors have declared no conflict of interest.

References

1. Ouwens MA, van Strien T, van der Staak CP. Tendency toward overeating and restraint as predictors of food consumption. *Appetite* 2003;40:291-8.
2. Kim SJ, Kim KS, Shin SU, Choi YM, Kang BG, Yoon YS, Oh MS, Yoon IJ. A clinical study of decrease appetite effects by aromatherapy using *foeniculum vulgare* mill (fennel) to female obese patients. *J Korean Orient Assoc Stud Obes* 2005;5:9-20.
3. Hur MH, Kim CH, Ahn HC, Han JW, Kim C. The effects of inhalation of

- essential oils on the body weight, feeding amount, food efficiency rate and serum leptin of obese SD rats. *J Korean Soc Plants People Environ* 2006;9:113-24.
4. Mishkinsky J, Joseph B, Sulman FG. Hypoglycaemic effect of trigonelline. *Lancet* 1967;2:1311-2.
 5. Sharma RD. Effect of fenugreek seeds and leaves on blood glucose and serum insulin responses in human subjects. *Nutr Res* 1986;6:1353-64.
 6. El-Soud NA, El-Laithy N, El-Saeed G, Wahby MS, Khalil M, Morsy F, Shaffie N. Antidiabetic activities of foeniculum vulgare mill. essential oil in streptozotocin-induced diabetic rats. *Maced J Med Sci* 2011;4:139-46.
 7. Al-Habori M, Raman A. Antidiabetic and hypocholesterolaemic effects of fenugreek. *Phytother Res* 1998;12:233-42.
 8. Fazli FR, Hardman R. The spice, fenugreek (*Trigonella Foenum graecum* L.): its commercial varieties of seed as a source of diosgenin. *Trop Sci* 1968;10:66-78.
 9. Mathern JR, Raatz SK, Thomas W, Slavin JL. Effect of fenugreek fiber on satiety, blood glucose and insulin response and energy intake in obese subjects. *Phytother Res* 2009;23:1543-8.
 10. Tea Industry Research Institute [Internet]. Busong: Jeonnam Agricultural Research & Extension Services. Available from <http://bosung.tjares.go.kr/> [cited year month day]. c1997-2007.
 11. Flint A, Raben A, Blundell JE, Astrup A. Reproducibility, power and validity of visual analogue scales in assessment of appetite sensations in single test meal studies. *Int J Obes Relat Metab Disord* 2000;24:38-48.
 12. van Strien T, Frijters JE, van Staveren WA, Defares PB, Deurenberg P. The predictive validity of the Dutch Restrained Eating Scale. *Int J Eat Disord* 1986;5:747-55.
 13. Gori L, Gallo E, Mascherini V, Mugelli A, Vannacci A, Firenzuoli F. Can estragole in fennel seed decoctions really be considered a danger for human health? A fennel safety update. *Evid Based Complement Alternat Med* 2012;2012:860542.
 14. Rao PU, Sesikeran B, Rao PS, Naidu AN, Rao VV, Ramachandran EP. Short term nutritional and safety evaluation of fenugreek. *Nutr Res* 1996;16:1495-505.
 15. Tóth L. [Studies on the etheric oil of *Foeniculum vulgare*. II. Changes of different fennel oils before and after harvest]. *Planta Med* 1967;15:371-89.
 16. Rolls BJ, Bell EA, Thorwart ML. Water incorporated into a food but not served with a food decreases energy intake in lean women. *Am J Clin Nutr* 1999;70:448-55.
 17. Blundell J, de Graaf C, Hulshof T, Jebb S, Livingstone B, Luch A, Mela D, Salah S, Schuring E, van der Knaap H, Westerterp M Appetite control: methodological aspects of the evaluation of foods. *Obes Rev* 2010;11:251-70.
 18. Chatterjee A, Prakash SC; Council of Scientific and Industrial Research (IN). The treatise on Indian medicinal plants. New Delhi: Publications & Information Directorate; 1995.
 19. Bruneton J. Polysaccharides derived from mannose - "neutral mucilages". In: *Pharmacognosy: phytochemistry medicinal plants*. 2nd ed. Paris: Lavoisier; 1999. p.99-105.
 20. Ribes G, Sauvare Y, Da Costa C, Baccou JC, Loubatieres-Mariani MM. Antidiabetic effects of subfractions from fenugreek seeds in diabetic dogs. *Proc Soc Exp Biol Med* 1986;182:159-66.
 21. Bever BO, Zahnd GR. Plants with oral hypoglycaemic action. *Pharm Biol* 1979; 17:139-96.
 22. Hannan JM, Ali L, Rokeya B, Khaleque J, Akhter M, Flatt PR, Abdel-Wahab YH. Soluble dietary fibre fraction of *Trigonella foenum-graecum* (fenugreek) seed improves glucose homeostasis in animal models of type 1 and type 2 diabetes by delaying carbohydrate digestion and absorption, and enhancing insulin action. *Br J Nutr* 2007;97:514-21.
 23. Mowla A, Alauddin M, Rahman MA, Ahmed K. Antihyperglycemic effect of *Trigonella foenum-graecum* (fenugreek) seed extract in alloxan-induced diabetic rats and its use in diabetes mellitus: a brief qualitative phytochemical and acute toxicity test on the extract. *Afr J Tradit Complement Altern Med* 2009;6:255-61.
 24. Konishi A, Ishibashi I, Kitahara Y, Miura K, Narasaka S, inventors; Ajinomoto Co., Inc., assignee. Agent for suppression of gastric emptying comprising 4-hydroxyisoleucine. United States patent US 20090247636 A1. 2009 Oct 1.