Assessment of Hormonal and Metabolic Effects of Dietary Fiber in Young Thai Women

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Objective: *To investigate whether daily dietary fiber intake at the reference level has any impact on studied hormones in a population of Thai women.*
Material and Method: *Twenty-eight healthy Thai women (aged 18-20 years, BMI 18.5-25 kg/m^2) with a history of regular menstrual cycles committed themselves to prepared food without changing the usual ratio of three major macronutrients. Dietary fiber from natural source at the amount of 8-10 g/day equal to their regular consumption was added to their daily diet for one menstrual cycle, then, increased to be 25-30 g/day for another 2 successive cycles. A single blood sample on midluteal day (day 18-23) was obtained in all three cycles. Plasma luteinizing hormone, follicle stimulating hormone, prolactin, estradiol, progesterone, cortisol, and insulin together with total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and triglycerides were analyzed.*
Results: *The measured hormones and lipids did not change significantly when compared between a control and two experimental cycles ($p > 0.05$).*
Conclusion: *Short-term consumption of 25-30 g/day fiber diet as recommended by the Reference Daily Intake (RDI) in a Thai population did not alter the studied hormones and lipids thus did not create any health problems.*

Keywords: *Dietary fiber, Reference daily intake (RDI), Hormones, Asian women*

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Physiological effects of dietary fiber and recommendation of their usage for some diseases are widely accepted. Dietary fiber consumption has been shown to be associated with a lower risk of cardiovascular disease incidence in the elderly[4] and in young adults[5] as well as reducing the mortality rate of coronary heart disease[6]. Furthermore, a fiber diet especially in soluble form was reported to reduce blood lipids and lipoprotein in hyperlipidemic patients[3,8,9]. High fiber intake has been shown to increase insulin sensitivity and enhance glucose metabolism rate in healthy and in diabetic patients[1-3]. It has been shown to be useful for weight reduction and lowering blood pressure in normotensive and hypertensive subjects[5,7]. Moreover, high fiber diets decrease the production and enhance an excretion of some hormones including the sex steroid, estrogen[10,11]. Thus, it may help in prevention of breast cancer[11,12]. Finally, the benefits from high fiber intake in reducing colorectal cancer have been shown in many, if not all studies[13-15].

However, evidence of some disadvantages from consuming high dietary fiber has also been reported. Oriental women have lower plasma estrogen and may have a different hormonal milieu from Caucasian women[16,17]. Therefore, high-fiber consumption may cause unwanted effects from hypoestrogen[18] such as osteoporosis[19] or reproductive dysfunction among a population having low basal estrogen. A

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borderline statistically significant inverse trend for estradiol on day 11 of the cycle with fiber intake (p = 0.05) was seen among 50 premenopausal healthy Japanese women[20]. Nine healthy, regularly cycling women who consumed an isoflavone-free soya diet had a reduction in ovarian steroids over the entire menstrual cycle without affecting gonadotropins[21].

Vegetables and fruits are rich sources of a variety of nutrients, including dietary fiber and many other classes of biologically active compounds that have complementary and overlapping mechanisms of action[25]. Several studies in animal and cell-culture models as well as the epidemiologic data from humans support an association between high intake of vegetables and fruits and low risk of chronic disease[25]. It has been recommended that an adequate amount of dietary fiber in a healthy diet of Western and Asian should be at least 25-30 g/day from a variety of plant foods[22-24]. As many kinds of fruits and vegetables are found all year round in Thailand it should be easy to meet this requirement. However, Thai people, mainly the young generation and hard-working groups, consume fiber levels that are less than the Thai RDI[23]. This may be due to a higher demand of energy-rich food and the minor side-effects from a fiber diet.

To the authors' knowledge, the effect of short term pre and post intervention of high dietary fiber intake from vegetables and fruits among non-vegetarian Thai women has not been studied. The authors assessed the effect of adding the recommended amount of 25-30 g mixed-type fiber from vegetables and fruits to a daily regular consumption controlled diet in young healthy Thai women. Several plasma reproductive and stress hormones as well as insulin, glucose, lipids, lipoproteins, blood pressure, body weight and Body Mass Index (BMI) were measured. The objective of the present study was to find if this daily amount of dietary fiber alters the hormonal and metabolic levels that may lead to health problems in a population of Asian women.

Material and Method

Subjects

Twenty-eight healthy nurse students volunteered. They were aged 18-20 years, BMI 18.5-25 kg/m², and 5.9 $\pm$ 0.3 years since menarche. Subjects reported previous regular menstrual cycles ranging between 26-35 days and a 3 month-record of cycle length prior to the present study was 29.6 $\pm$ 0.1 days. Subjects were free from major illness, hormones and drugs for the past six months. They were non-vegetarian and regularly consumed three meals per day from the college's kitchen. The dietary menu and receipts for students are similar to meals prepared by the Thai population in general. The 14 day-food record of daily meals provided for students prior to the experiment was analyzed[26]. The daily energy intake of subjects was approximately 6698 kJ/day which came from 60% total energy from carbohydrate, 21% from fat, 16% from protein and 3% from dietary fiber. This indicates that the amount of dietary fiber in the regular diet of young Thai women (8-10 g/day) is still below the recommendation level.

Studied method

Prepared food of 7535-8372 kJ/day containing 60% total energy from carbohydrate, 20-30% from fat and 10-20% from protein were served in three separate meals to all subjects separately from other students throughout three successive experimental cycles. This was done to minimize the variation of other macronutrients except the dietary fiber. The main source of carbohydrate in a regular Thai meal came from white cooked rice that has zero value of resistant starch[27]. The rice should not have much contribution to the total dietary fiber intake of subjects. Dietary fiber provided in the meals was adjusted to 8-10 g/day during the first menstrual cycle, and then increased to 25-30 g/day for two successive cycles. The various kinds of vegetables, fruits, beans, nuts that were easily obtained in Thailand were used as soluble and insoluble fiber sources in the present study. Every meal tray was checked by the assigned personnel to make sure that all foods were finished. Subjects were interviewed at least once a week for any side effect from increasing dietary fiber. The studied protocol was approved by the Human Ethics Committee of the Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand.

A single blood sample was drawn between 700-900 a.m. after 10-12 hours over-night fast on the expected-midluteal phase day (day 18-23) of each studied cycle. Body weight and blood pressure were recorded before venepuncture. Blood was collected into a sodium fluoride tube for plasma glucose measurement and into heparin-containing tubes for the analyses of plasma hormones and lipids. Plasma was immediately separated and kept at -20°C until it was analyzed. Luteinizing Hormone (LH), Follicle Stimulating Hormone (FSH), prolactin, estradiol, progesterone, cortisol and insulin were measured using the radioimmunoassay kits (Diagnostic Products Corporation). The enzymatic colorimetric method was used for

analyses of Total Cholesterol (TC), High-Density Lipoprotein Cholesterol (HDL-C), and Tri-Glycerides (TG) (Boehringer Mannheim Kits). The Low-Density Lipoprotein Cholesterol (LDL-C) was calculated using Friedewal formula[28]. Plasma glucose was measured by glucose oxidase method with Automatic Hitachi 750 Machine.

Statistical analysis

Data were checked for normalcy and the variation of parameters among three studied cycles was compared using the one-way ANOVA followed by the Bonnferoni's test for normal distributed data. The Kruskal Wallis test was performed for estrogen and progesterone that were not normally distributed. Significance was set at $p \leq 0.05$. Data are expressed as mean $\pm$ SEM. Calculation of results was done using SPSS for Windows 11.5 program.

Results

No significant changes in menstrual cycle length, body weight, BMI, and blood pressure were observed during the two-cycles on high fiber diet when compared to the control cycle on regular intake of dietary fiber (Table 1). Also, fasting plasma glucose, insulin, TC, HDL-C, LDL-C including LDL-C/ HDL-C ratio[29] were not statistically different between cycles of regular and high fiber intake. In addition, plasma gonadotropins (LH and FSH), prolactin, ovarian steroids (estradiol and progesterone) and stress hormone (cortisol) did not showed significant change among the three studied cycles (Table 2).

Increased dietary fiber intake was well tolerated by all the subjects. Mild abdominal discomfort, belching, flatulence or soft stools were rare complaints and did not interfere with the experiment. No subjects reported menstrual abnormalities.

Discussion

Short-term increase in dietary fiber without lowering fat intake as in the present study did not alter plasma gonadotropins, prolactin ovarian steroids-estradiol, progesterone, stress hormone and cortisol. In addition, there was no menstrual disturbance in these subjects. The present data agreed with the previous study of 62 premenopausal women where the serum estrogen was unaffected after a two months increase of dietary-fiber supplementation with wheat, oats, or corn bran from an average of 15 g to 30 g/day, without any significant decrease in dietary fat consumption[30]. Moreover, no associations between dietary fiber intake and hormones-estrone, estradiol, cortisol, or gonadotropins in 325 healthy Massachusetts women at climacteric, who reported having a normal menstrual period within the previous 12 months, has been shown[31]. These data suggest that a high intake of dietary fiber

Table 1. Body weight, body mass index (BMI), blood pressure, together with plasma glucose, insulin, lipids and lipoproteins in studied subjects[1] during cycle 1 on low dietary fiber and cycles 2-3 on high dietary fiber[2,3]

	Cycle 1	Cycle 2	Cycle 3
Menstrual cycle length (day)	30.53 $\pm$ 0.83	29.50 $\pm$ 1.07	31.04 $\pm$ 1.27
Body weight (kg)	55.82 $\pm$ 1.12	54.91 $\pm$ 1.06	54.09 $\pm$ 1.03
BMI (kg/m^2)	21.88 $\pm$ 0.31	21.52 $\pm$ 0.29	21.20 $\pm$ 0.28
Systolic BP (mmHg)	106.71 $\pm$ 1.44	103.86 $\pm$ 1.23	108.71 $\pm$ 1.19
Diastolic BP (mmHg)	69.21 $\pm$ 1.66	69.28 $\pm$ 1.26	73.50 $\pm$ 1.03
Glucose (mM/L)	5.26 $\pm$ 0.10	5.08 $\pm$ 0.08	5.20 $\pm$ 0.07
Insulin (pM/L)	62.99 $\pm$ 7.15	56.46 $\pm$ 4.72	60.91 $\pm$ 4.58
TC (mM/L)	4.48 $\pm$ 0.11	4.72 $\pm$ 0.13	4.47 $\pm$ 0.08
HDL-C (mM/L)	1.10 $\pm$ 0.05	1.11 $\pm$ 0.05	1.14 $\pm$ 0.05
LDL-C (mM/L)	2.87 $\pm$ 0.10	3.07 $\pm$ 0.13	2.81 $\pm$ 0.09
TG (mM/L)	1.10 $\pm$ 0.05	1.16 $\pm$ 0.04	1.11 $\pm$ 0.04
LDL-C/HDL-C	2.60 $\pm$ 1.90	2.77 $\pm$ 2.81	2.46 $\pm$ 1.80

[1] n = 28

[2] values are mean $\pm$ SEM

BMI = body mass index, BP = blood pressure, TC = total cholesterol, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, TG = triglycerides

[3] By ANOVA, no significant difference between the three cycle ($p > 0.05$) for all variables

Table 2. Measured plasma hormone concentrations during cycle 1 on low and cycles 2-3 on high dietary fiber consumption[1,2,3]

	Cycle 1	Cycle 2	Cycle 3
LH (IU/L)	7.67 ± 1.45	7.58 ± 1.70	10.04 ± 1.90
FSH (IU/L)	2.26 ± 0.32	2.13 ± 0.27	2.79 ± 0.27
Prolactin (pM/L)	338.01 ± 39.26	278.10 ± 27.96	269.17 ± 26.99
Estradiol (pM/L)	396.04 ± 40.93	435.78 ± 68.33	476.73 ± 56.72
Progesterone (nM/L)	16.40 ± 3.49	19.76 ± 3.79	11.94 ± 3.33
Cortisol (nM/L)	411.23 ± 30.58	340.30 ± 19.35	376.00 ± 20.75

[1] n = 28
[2] values are mean ± SEM
LH = luteinizing hormone, FSH = follicle stimulating hormone
[3] No significant difference between the 3 cycle ($p > 0.05$) for all variables

without reduction of dietary fat did not interfere with reproductive hormones in healthy women.

Estrogens are biomarkers for breast cancer risk and dietary macro- and micronutrients seem to play an important role in estrogen metabolism[32]. Dietary fiber may cause a partial interruption of the enterohe-patic circulation of the estrogens, due to alterations of the intestinal metabolism and speeding up intestinal transit thus reducing reabsorption of these steroids[18,33]. Lower incidence rates of breast cancer have been found in Thailand as well as in other Asian countries compared to Western countries[34]. Among the underlying risk factors for the development of breast cancer in the two groups of women may be their different diets and patterns of estrogen metabolism and excretion. Caucasian women consume a higher fat diet; have higher estrogen production and circulating levels, and lower fecal estrogen excretion in comparison to Asian women[16]. According to the present result, short-term consumption of 25-30 g dietary fiber did not lower the plasma estradiol levels. A longer period of study is required before the long-term effect of consuming this amount of dietary fiber can be definitely established. However, a previous cross-sectional study in Thai women consuming a vegetarian diet for more than 1 year showed that plasma estrogen and progesterone levels during the menstrual cycle did not differ from non-vegetarian women[35]. Thus, Asian women should still benefit from a lower incidence of estrogen-induced cancer without the risk of hypoestrogenic problems.

In addition, daily consumption of dietary fiber at the recommended amount for 2 months as in the present study did not cause intolerable side effects nor produce an adversely impact on plasma insulin, glucose, lipids or blood pressure and body weight in this group of normal Asian women. Other investigators have shown that adding 19.5 g/day fiber cellulose (insoluble fiber) or 3 types of gum (soluble fiber) in the diet for 4 weeks did not affect the plasma TG, glucose and insulin response curves after a standard glucose tolerance test when compared with low fiber diet[36]. A randomized crossover study of increasing dietary fiber content from 11 to 27 g/4200kJ in type 2 diabetes for two 4-week diet periods showed no significant difference in overall plasma glucose, insulin, or lipid metabolism[37]. Furthermore, no consistent effect of change in dietary fiber intake on group mean systolic or diastolic blood pressures in 88 normotensive omnivores randomly allocated to low or high fiber diet for one of two 6-week experimental periods has been reported[38].

The beneficial or adverse effect on lipid and hormonal change from an increased intake in fruits and vegetables as recommended for Thais is not shown in the present study. While an unwanted effect of high dietary fiber intake was suggested in a longitudinal study[20], the benefits of dietary consumption have been demonstrated in several studies of longer duration and/or higher amount of fiber intake. The effects of feeding a diet very high in fiber (~140 g/day) containing cereals and legumes in comparison with starch-based and low-fat diets have been tested in ten healthy volunteers[39]. The high-fiber vegetable diet resulted in the largest reduction in LDL-C and largest fecal steroid losses. A multicentered population-based cohort study over 10 years in healthy young Caucasian adults showed inverse linear associations of dietary fiber consumption with body weight, waist-to-hip ratio, fasting and 2-hour postglucose insulin, blood pressure and plasma

lipids[5]. Also, a previous study using a Thai diet as a control demonstrated that lipid concentrations, except TG, were lower in Thai vegetarians compared to the control group, and the HDL-C correlated negatively with the body weight and BMI in the vegetarian group[40].

In conclusion, 2 months intake of 25-30 g/day dietary fiber from natural sources caused neither reproductive and stress hormone changes nor observed menstrual disturbances, and was without intolerable side effects. The authors believe that this recommended amount of dietary fiber should be adequate in long-term and do no harm among young healthy Asian women.

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การประเมินผลทางฮอร์โมนและเมตาบอลิสมของเส้นใยอาหารในหญิงสาวชาวไทย

สุพรพิมพ์ เจียสกุล, นวพร สุปิงคลัด, อาณดี นิติธรรมยง, ประไพศรี สิริจักรวาล

วัตถุประสงค์: *เพื่อหาว่าการรับประทานเส้นใยอาหารในปริมาณที่แนะนำสำหรับชาวไทยจะมีผลต่อระดับฮอร์โมนที่ศึกษาในหญิงสาวชาวไทยหรือไม่*

วัสดุและวิธีการ: *หญิงไทยสุขภาพดี 28 คน (อายุ 18-20 ปี, ดัชนีมวลกาย 18.5-25 กิโลกรัม/เมตร^2) มีประวัติประจำเดือนสม่ำเสมอ อาสาสมัครที่จะรับประทานอาหารโดยไม่มีการเปลี่ยนแปลงอัตราส่วนของสารอาหารหลัก โดยในวงจรประจำเดือนแรกแต่ละคนได้รับเส้นใยอาหารจากธรรมชาติปริมาณ 8-10 กรัม/วันซึ่งเท่ากับปริมาณที่เคยได้รับมาก่อนและเฉลี่ยให้ในอาหารทั้ง 3 มื้อ ในวงจรประจำเดือนที่ต่อเนื่องมาอีก 2 วงจร เพิ่มปริมาณเส้นใยอาหารเป็น 25-30 กรัม/วัน ทำการเจาะเลือดอาสาสมัครในวันกึ่งกลางระยะลูเทียล(วันที่ 18-23 ของวงจรประจำเดือน)ทั้ง 3 วงจร วัดระดับในพลาสมาของลูทีไนซิงฮอร์โมน, ฟอลลิเคิลสติมูเลติงฮอร์โมน, โพรแลกติน, เอสตราไดออล, โพรเจสเทอโรน, คอร์ทิซอล และอินซูลิน รวมทั้งระดับโคเลสเตอรอลรวม, ลิโพโปรตีนชนิดความหนาแน่นสูง, ลิโพโปรตีนชนิดความหนาแน่นต่ำ และไทรกลีเซอไรด์*

ผลการศึกษา: *พลาสมาฮอร์โมนและไขมันที่วัดไม่มีการเปลี่ยนแปลงอย่างมีนัยสำคัญทางสถิติเมื่อเปรียบเทียบระหว่างวงจรประจำเดือนที่ได้รับเส้นใยอาหารต่ำกว่าหรือเท่ากับที่ควรได้รับ*

สรุป: *ในช่วงระยะที่ศึกษา ไม่พบการเปลี่ยนแปลงระดับฮอร์โมนและไขมันในเลือดไปในทางที่เป็นโทษต่อสุขภาพของหญิงสาวชาวไทยซึ่งรับประทานเส้นใยอาหารเท่ากับปริมาณที่ชาวไทยควรได้รับ*