ORIGINAL

Substituting Pre-Germinated Brown Rice for White Rice Reduced Body Weight in Healthy Overweight Vietnamese Women

Vu Anh Linh*[1], Bui Thi Nhung[2], Le Danh Tuyen[2], Nguyen Do Van Anh[2], Yukihiko Ito[3], Kei Yui[3], Shigeru Yamamoto[1]

[1]*International Nutrition, Graduate School of Human Life Science, Jumonji University, Saitama 352-8510, Japan,*
[2]*National Institute of Nutrition, Hanoi, Vietnam,*
[3] *FANCL Research Center, Yokohama 244-0806, Japan*

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ABSTRACT *Background:* Pre-germinated brown rice (PGBR) is slightly germinated by soaking brown rice (BR) in water, which reduces the hardness of BR and makes it easier and tastier to eat. There are studies that have shown the effectiveness of PGBR on high blood glucose and cholesterol concentrations mainly in diabetes mellitus (DM) patients but only a few have investigated the effect on body weight, perhaps because the subjects are usually instructed to reduce their energy intake and body weight. We observed a decrease in body weight in our previous study in pre-diabetes subjects who were not on energy restriction or drug treatment. Therefore, for confirmation, we conducted this study in healthy persons. *Purpose:* To study the effect of PGBR on weight reduction in healthy overweight Vietnamese women. *Design:* The study was a randomized control trial that was conducted in 72 healthy overweight women. All participants were randomly assigned to consume PGBR or white rice (WR) as staple foods for 16-wks. Anthropometric parameters, blood pressure, physical activity, and a nutrition survey were conducted at baseline, 8-wk, and 16-wk. Fasting blood was withdrawn and biochemical analysis was conducted at baseline and 16-wk. Acceptability was ascertained by questionnaire after the study. *Results:* After the 16-wk intervention, body weight in the PGBR group decreased from 63.3 ± 6.5 kg to 61.2 ± 6.5 kg ($p < 0.001$), while body weight in the WR group was maintained. Waist and hip circumferences in the PGBR group decreased, for waist -3.6 ± 2.0 cm;($p < 0.001$) and hip -1.8 ± 2.2 cm; ($p < 0.001$) but not in the WR group. Serum total cholesterol and triacylglycerol concentrations (mg/dL) were abnormally high in the both groups at baseline, however, at 16-wk in PGBR group decreased from 205 to 182 ($p < 0.001$) and from 133 to 108 ($p < 0.05$), respectively, but not in WR group. Energy intakes (kcal/day) in the PGBR group decreased significantly ($p < 0.05$) at baseline, 8-wk, and 16-wk were 1912, 1857 and 1803, respectively but not in the WR group (1902, 1882 and 1879, respectively). *Conclusion:* These findings suggest positive effects of PGBR on controlling body weight in overweight healthy women as well as on the blood lipid and sugar profiles.
Keywords: Body weight, obesity, pre-germinated brown rice, dietary fiber, Vietnamese.

INTRODUCTION

In Asian countries, as well as the rest of the world, the incidence of obesity has| been rising rapidly. For example, the percentage (%) of adult women aged 20 and older with Body Mass Index (BMI) higher than 25 in 2014 was 48.6 in Malaysia, 39.7 in Thailand, 32.5 in Singapore,

*[1] To whom correspondence should be addressed: shigeruy@juminji-u.ac.jp

30.9 in Taiwan, 30.6 in Indonesia, 27.4 in China, 27.2 in Korea, 20.7 in India and 17.6 in Japan (1). For Vietnamese adults aged 25-64 years, the prevalence (%) of overweight and obesity (BMI higher than 25) was 20.3 and that of non-communicable diseases was: high blood pressure 20.3, diabetes mellitus and impaired fasting blood glucose 5.7 and high blood cholesterol 32.4 (2).

There are studies that whole grains can prevent obesity, diabetes and heart disease (3-8). Brown rice (BR) is a whole grain, however, people prefer white rice (WR) because BR itself has an unappealing taste and texture. WR is made by polishing BR and removing its surface, which makes WR softer and tastier than BR. According to a Vietnam national nutrition survey in 2009-2010, more than 66% of the energy consumption came from WR (9).

Pre-germinated brown rice (PGBR) is slightly germinated by soaking BR in water; it becomes softer in texture and has a taste close to that of WR. It maintains the various qualities of BR, for example, the fiber in BR (10, 11). We have been studying the effects of PGBR on blood glucose and lipids, mostly in DM patients (12-15). We did not observe the effect of PGBR on body weight in most of these studies, because once patients are diagnosed as DM, they are taught to reduce energy intake and body weight decreases. However, in our previous study we studied the effects on blood glucose and lipids in pre-diabetes persons without any dietary or drug management (15). Unexpectedly, we observed a decrease in body weight, which made us interested in observing the effect of PGBR on body weight in healthy overweight persons, therefore this study was conducted.

MATERIALS AND METHODS

***Setting and participant study*:** The study protocol was approval by the Scientific and Ethical Committee of the National Institute of Nutrition, Hanoi, Vietnam**.** The study was designed in conformity with the Declaration of Helsinki on Human Studies. A total of 473 women living in 2 communes in suburban Hanoi City, Vietnam, were screened for body anthropometrics and were asked their medical history. All participants were fully informed of the content and schedule of the study. The eligibility criteria for participants were the following: 1) age range: 30-65 y, 2) BMI: 23-35 kg/m^2. The exclusion criteria for participants were the following: 1) those who were currently pregnant or had plans for pregnancy during the study period (by interview), 2) who were currently suffering from serious diseases such diabetes, kidney, mental, hepatic (by medical history), 3) who were using or had plans for weight loss therapy during the study period, 4) who were using or planning to use weight loss supplements or medicine during the study period, 5) who were already eating brown rice or PGBR. After screening, 72 participants met the inclusive criteria.

***Study design*:** The study was a randomized control trial that was conducted in 72 healthy overweight women. Subjects were randomized to be divided into PGBR (n=36) and WR (n=36) groups. All participants in the PGBR group were instructed to use PGBR as their staple food for 16-wk, and all participants in WR group were instructed to use WR as their staple food for 16-wk. At baseline and 16-wk of the study, blood samples and physical activity of both groups were determined. At baseline, 8-wk, and 16-wk, anthropometrics parameters, blood pressure, and nutrition survey were conducted. All participants were free-lifestyle living and instructed that they should not change lifestyles and food habits during the study period. The primary outcome was body weight loss.

***Trial foods*:** Both PGBR and WR samples were made from the same Japonica rice variety named Hoshinoyume, and obtained from Hokkaido, Japan (FANCL Tokyo, Japan). All participants were provided aseptic packaged boiled PGBR and WR. They were about 160g (about 220 kcal) which can be distributed at normal temperature and is eatable only by heating with a microwave oven for about 2 minutes or in boiling water for about 15 minutes.

Anthropometric measurements and blood pressure: Body height and weight were measured in the morning after a 12h-night fast and with light clothing and barefoot. Body mass index (BMI) was calculated by body weight per height squared (kg/m^2). Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest. Hip circumference was measured around the widest portion of the buttocks. Body fat percentage was measured by the bioelectrical impedance method using the Omron scale (HBF-212b, Omron Co., Kyoto, Japan). Blood pressure was measured by using a standardized automated sphygmomano-meter (Omron HEM-6113, Tokyo, Japan) after 10 minutes of resting in seated position.

Blood sample: Total 10 ml of blood was withdrawn via venipuncture after a 12h-night fast. Serum glucose was measured with the use of an enzyme-couple kinetic assay and blood serum was kept at -80ºC until analysis. Serum total cholesterol and triacylglycerol were measured by the enzymatic method. Serum HDL-cholesterol and LDL-cholesterol were measured by the enzymatic and direct methods. All measurements were conducted by AU480 analyzer-Beckman coulter-USA at the laboratory of the National Institute of Nutrition, Hanoi, Vietnam.

Nutrition survey and physical activity**:** We used a 24h dietary recall for 3 days (2 weekend days and 1 weekday) at baseline, 8-wk, and 16-wk. Each participant was interviewed by a skilled dietitian from the National Institute of Nutrition, Hanoi, Vietnam. Energy, carbohydrate, lipid, and dietary fiber intake were calculated based on the Vietnamese Food Composition Table 2007 (16). Physical activity at baseline, 8-wk, and 16-wk was assessed by pedometer for steps measurement. Each time steps were measured for 3 consecutive days.

Acceptability: Overall taste, softness and stickiness were evaluated by scores from 1 to 3 (3, good; 2, moderate; 1, poor)

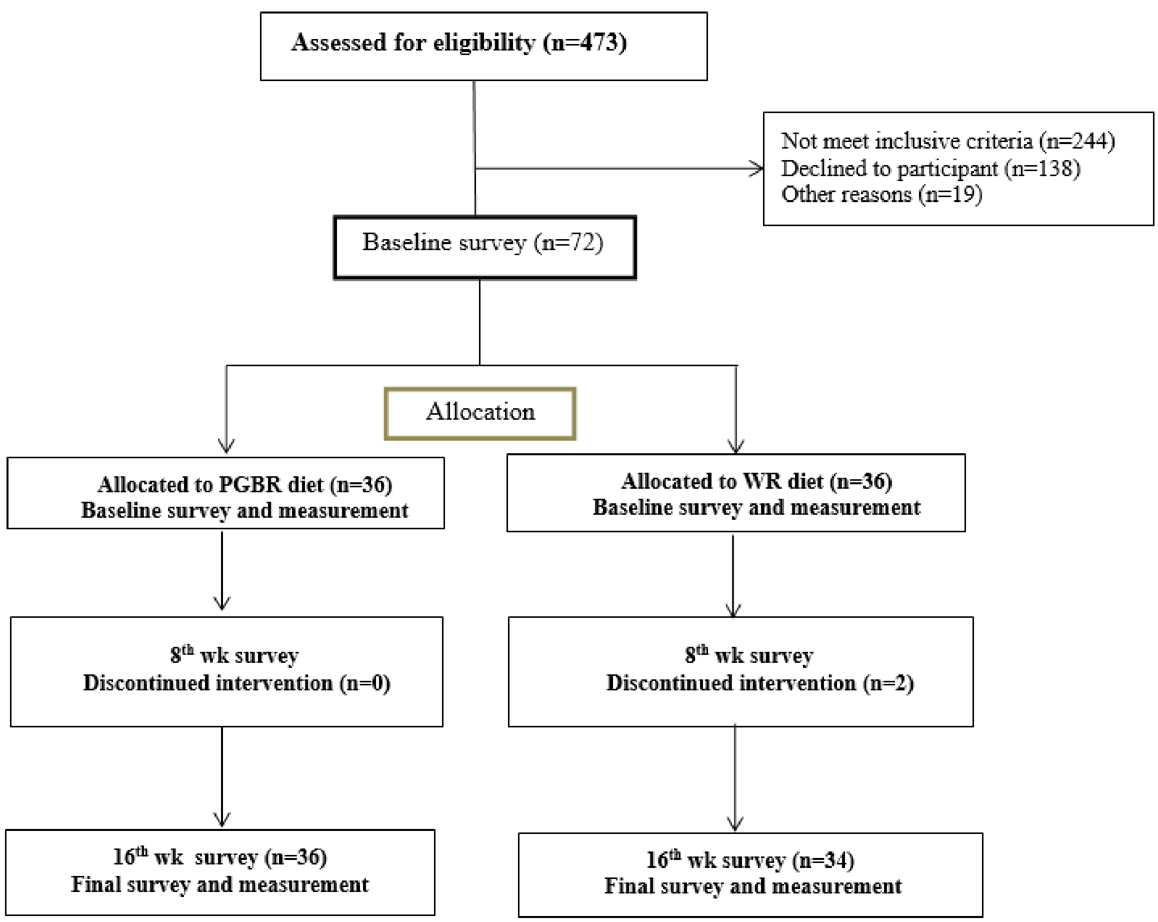

Fig.1. Flow chart of the study

Statistical methods**:** Data were analyzed by using JMP version 11 (SAS Institute Inc., Cary, NC). Values are reported as means ± standard deviations (SD). Quantitative variables were checked for normal distribution and compared by the Student *t*-test, *p*-values of less than 0.05 (with 2-sided) were considered statistically significant for all the analyses. Baseline characteristics of the 2 groups were compared using Student's *t*-test. Within-group differences were compared using the paired Student *t*-test.

RESULTS

Baseline characteristic of participants: The 72 enrolled participants were randomly assigned to the PGBR group (n=36) or the WR group (n=36). A total of 70 participants completed the study (2 participants in the WR group discontinued intervention due to personal reasons). Table 1 shows baseline characteristics of the study population. There was no significant difference in age ($p = 0.86$), body height ($p = 0.80$), body weight ($p = 0.55$), body fat percentage ($p = 0.71$), waist circumference ($p = 0.55$), hip circumference ($p = 0.90$), systolic blood pressure ($p = 0.06$), diastolic blood pressure ($p = 0.94$), total cholesterol ($p = 0.48$), LDL-cholesterol ($p = 0.68$), HDL-cholesterol ($p = 0.06$), triacylglycerol ($p = 0.66$), or blood glucose ($p = 0.16$) between the PGBR and WR groups at baseline. ***Change of body weight and body composition and blood pressure:*** Table 2 shows that the body weight and BMI in the PGBR group decreased from 63.3 ± 6.6 kg and 27.2 ± 2.5 at baseline to 62.1 ± 6.5 kg ($p < 0.001$) and 26.6 ($p < 0.001$) at 8-wk and 61.2 ± 6.5 kg ($p < 0.001$) and 26.3 ± 2.5 ($p < 0.001$) at 16-wk, while those in the WR group were not significantly different.

In addition, body fat percentage and waist and hip circumferences decreased significantly from 38.3 ± 3.2 %, 87.3±6 cm and 99.4 ± 5.1 cm at baseline to 37 ± 2.9 % (p < 0.001), 84.6 ± 6.1 cm (p < 0.001) and 97.8 cm ($p < 0.001$) at 8-wk, and to 35.3 ± 2.2 % ($p < 0.001$), 83.7 ± 5.8 cm ($p < 0.001$) and 97.6 cm ($p < 0.001$) at 16-wk, while only waist circumference in the WR group decreased significantly from 88.2 ± 7.3 cm at baseline to 86.5± 7.1 cm ($p < 0.05$) at 16-wk. In the PGBR group there was a slight decrease in systolic blood pressure (mmHg) from 127.4 ± 10.8 at baseline to 123.6 ± 10 ($p < 0.05$) at 8-wk and 119.8 ± 12.1 ($p < 0.001$) at 16-wk but in the WR group there was slight increase from 79.6 ± 7.3 at baseline to 82 ± 9.1 ($p < 0.05$) at 8-wk and 81.7 ± 8 ($p < 0.05$) at 16-wk.

Table 1. General characteristics of subjects

	PGBR (n=36)			**WR (n=34)**			**P-values**
	Mean	**±**	**SD**	**Mean**	**±**	**SD**	
Age (year)	43.3	±	7.0	43.6	±	7.7	0.81
Height (cm)	152.6	±	4.9	152.3	±	5.2	0.83
Weight (kg)	63.3	±	6.6	64.4	±	8.7	0.53
BMI (kg/m^2)	27.2	±	2.5	27.7	±	3.6	0.61
Body fat (%)	38.3	±	3.2	38.6	±	4.0	0.66
Waist circumference (cm)	87.3	±	6.0	88.2	±	7.3	0.61
Hip circumference (cm)	99.4	±	5.1	99.2	±	6.0	0.94
Systolic blood pressure (mmHg)	127.4	±	10.8	122.8	±	9.0	0.09
Diastolic blood pressure (mmHg)	79.6	±	7.3	81.5	±	8.0	0.84
Total cholesterol (mg/dL)	204.6	±	42.9	199.0	±	16.5	0.48
LDL cholesterol (mg/dL)	132.8	±	46.1	128.9	±	29.4	0.46
HDL cholesterol (mg/dL)	47.7	±	10.2	43.6	±	6.7	0.08
Triacylglycerol (mg/dL)	170.9	±	60.2	170.0	±	85.1	0.73
Blood glucose (mg/mL)	94.8	±	7.2	96.9	±	4.6	0.28

All values are means and standard deviations

P values obtain from independent sample t-test between PGBR and WR groups

However, mean values of both systolic blood pressure and diastolic blood pressure in the PGBR group were within normal range. The others parameters in table 2 were not significantly different in comparison with baseline data.

Blood biochemical parameters: The change in blood parameters are indicated in table 3. Concentrations of blood parameters (mg/dL) in the PGBR group at baseline and 16-wk decreased; total cholesterol from 204 ± 42.9 to 182.1 ± 31.6 ($p < 0.001$), LDL-cholesterol from 132.8 ± 46.1 to 108.4 ± 28.8 ($p < 0.05$), triacylglycerol from 170.9 ± 60.2 to 135.2 ± 71.7, and glucose from 94.8 ± 7.2 ($p < 0.05$) but in the WR group none of these changed. HDL-cholesterol of both the PGBR and WR groups increased significantly at 16^{th}-wk in comparison with baseline ($p < 0.05$).

Nutrition survey and physical activity: Table 4 shows the energy and nutrient intakes and physical activity of the PGBR and WR groups at baseline, 8-wk, and 16-wk. In the PGBR group, energy, protein and carbohydrate at 16-wk decreased significantly in comparison with baseline ($p < 0.05$). Dietary fiber intake of the PGBR group at baseline was 6.5 ± 1.7 g and increased to 12.6 ± 2.6 g ($p < 0.001$) at 8-wk and 14.0 ± 3.6 g ($p < 0.001$) at 16-wk. In the WR group, none of these items changed significantly.

Fig. 2 shows the comparison of scores of overall taste, softness and stickiness between PGBR and WR. They were evaluated by scores from 1 to 3 (3 good; 2 moderate; 1 poor). WR was softer and more sticky than PGBR (p<0.05) but the overall taste was similar.

Table 2. Change in anthropometric parameters and blood pressure

	PGBR (n=36)									White rice (n=34)								
	Baseline			8-wk			16-wk			Baseline			8-wk			16-wk		
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
Weight (kg)	63.3	±	6.6	62.1	±	6.5**	61.2	±	6.5**	64.4	±	8.7	64.4	±	8.8	63.8	±	9.0
BMI (kg/m^2)	27.2	±	2.5	26.6	±	2.5**	26.3	±	2.5**	27.7	±	3.3	27.7	±	3.4	27.5	±	3.4
Body fat (%)	38.3	±	3.2	37.0	±	2.9**	35.3	±	2.2**	38.2	±	4.0	38.6	±	4.0	38.0	±	4.2
Waist circumference (cm)	87.3	±	6.0	84.6	±	6.1**	83.7	±	5.8**	88.2	±	7.3	88.0	±	6.8	86.5	±	7.1*
Hip circumference (cm)	99.4	±	5.1	97.8	±	4.9**	97.6	±	5.0**	99.2	±	6.0	99.3	±	5.9	98.8	±	6.1
Systolic blood pressure (mmHg)	127.4	±	10.8	123.6	±	10.0*	119.8	±	12.1**	122.8	±	9.0	124.0	±	13.1	120.9	±	10.1
Diastolic blood pressure (mmHg)	79.6	±	7.3	82.0	±	9.1*	81.7	±	8.0*	79.5	±	6.0	81.5	±	8.0	80.1	±	7.8

All values are means and standard deviations

*, ** Significantly different compared to baseline by paired *t*-test; p<0.05 and p<0.001, respectively

Table 3.Blood parameters of PGBR and WR groups at baseline and final

	PGBR (n=36)						WR (n=34)					
	Baseline			16-wk			Baseline			16-wk		
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
Total cholesterol (mg/dL)	204.6	±	42.9	182.1	±	31.6**	199.0	±	16.5	205.6	±	22.7
LDL cholesterol (mg/dL)	132.8	±	46.1	108.4	±	28.8*	128.9	±	29.4	122.5	±	26.5
HDL cholesterol (mg/dL)	47.7	±	10.2	50.7	±	10.0*	43.6	±	6.7	47.1	±	9.1*
Triacylglycerol (mg/dL)	170.9	±	60.2	135.2	±	71.7*	178.7	±	86.8	170.0	±	85.1
Blood glucose (mg/mL)	94.8	±	7.2	90.2	±	10.9*	96.9	±	4.6	98.7	±	8.6

All values are means and standard deviations

*, ** Significantly different compared to baseline by paired *t*-test; p<0.05 and p<0.001, respectively

Table4.Nutrient intakes and physical activity

	PGBR (n=36)									WR (n=34)								
	Baseline			8-wk			16-wk			Baseline			8-wk			16-wk		
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
Energy (Kcal)	1911.7	±	271.8	1857.2	±	218.0	1803.1	±	211.5*	1901.9	±	186.9	1882.8	±	190.2	1878.9	±	205.6
Protein (g)	69.5	±	11.5	69.7	±	9.7	66.3	±	12.0*	70.4	±	12.0	68.7	±	10.0	69.2	±	8.1
Lipid (g)	46.0	±	8.4	44.8	±	8.1	46.4	±	7.4	41.5	±	8.1	40.5	±	6.5	42.5	±	6.8
Carbohydrate (g)	304.9	±	53.3	293.9	±	45.7	280.1	±	35.1*	311.8	±	41.7	310.9	±	36.7	304.8	±	39.7
Fiber (g)	6.5	±	1.7	12.6	±	2.8**	14.0	±	3.6**	6.5	±	2.6	6.5	±	3.3	6.8	±	1.8
Physical activity (steps)	6978	±	2821	7498	±	3732	7085	±	3514.1	6869	±	2523	7268	±	3540	6886	±	2100

All values are means and standard deviations

*, ** Significantly different compared to baseline by paired *t*-test; p<0.05 and p<0.001, respectively

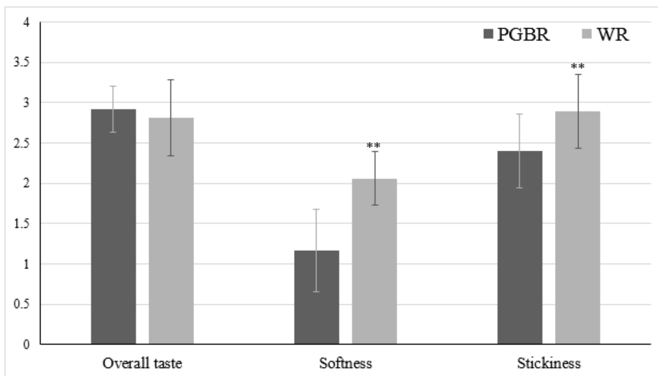

Fig. 2. Acceptability of PGBR (3 good; 2 moderate; 1 poor) ** Statistically different (p<0.01)

DISCUSSION

The present 16-wk randomized, controlled trial suggests that replacing WR with PGBR might have beneficial effects for controlling body weight in healthy overweight and obese women. The main focus of the study was reduction of body weight with PGBR; body weight (kg) of the PGBR group decreased from 63.3 to 61.2 (a 2.1 kg decrease in 16-wk), while the WR group changed only slightly, from 64.4 to 63.8 (only a 0.6 kg decrease). We also observed a decrease in waist and hip circumferences and beneficial effects in blood lipid profiles. It is well-known that body weight is controlled by energy balance: energy IN (food intake) and energy OUT (physical activity). We measured physical activity by pedometer and did not observe any difference at baseline, 8-wk, and 16-wk in either group. (Table 4). From these data total energy intake and physical activity (steps), it might be inferred that body weight in the PGBR group may have decreased from reducing their energy balance.

However, in our previous study of DM patients who had received nutrition education from doctors or dietitians (12-14), we did not observe a reduction of body weight in the PGBR group except for one study conducted in pre-DM patient without nutrition education (15). In the present study, we selected healthy overweight subjects without any health problems and confirmed clearly that PGBR was useful in reducing body weight.

In this study all the WR and PGBR was supplied by us for the whole study period (4 months). Rice is the subjects' staple food and subjects ate rice at least twice over 3 meal times (breakfast, lunch and dinner). Both the WR and PGBR were same strain of rice produced in the same area and packets of about 60g (250-300kcal) are available in the market. Packets could be stored at normal temperatures and made edible by heating in a microwave oven for about 2 minutes or in boiling water for about 15 minutes. The use of this pre-packaged rice made the study easier for subjects as well as for the researchers and dropouts were limited to only a few. Researchers were not concerned with rice for other family members.

With regard to the decreased energy intake in the PGBR group, we had to determine whether the taste of PGBR was acceptable to the subjects. People prefer WR to BR, because WR is softer and tastier than BR. WR is made by polishing BR and removing its surface. PGBR is slightly germinated by soaking BR in water. In the process, the BR skin is broken apart and becomes soft. From our sensory test, we found that although the PGBR was a little harder and less sticky than WR, the taste was evaluated as high as WR. From these results we concluded that the decrease of energy intake in the PGBR group was not due to its taste.

Dietary fiber might affect body weight through multiple pathways, including through modulation of insulin secretion and control of satiety (17-19). In our study, the intake of dietary fiber (g/day) in the PGBR group was 12.6 at 8-wk and 14.0 at 16-wk and much higher than that at baseline (6.5). There was no change in the WR group being 6.5, 6.5 and 6.8 at baseline, 8-wk and 14.0 at 16-wk, respectively.

Many studies have investigated the relation of low glycemic (GI) index foods and body weight. PGBR contains higher dietary fiber and has a lower GI than WR (8). Previous studies showed that rapid absorption of glucose after consumption of high GI foods could lead to sharp rises in blood glucose and insulin levels; thus, glucose enters body tissues, inhibits lipolysis and induces lipogenesis and obesity. (20, 21).

Increased fiber makes the subjects feel full for a longer time, which might be associated with reduced hunger or increased satiety, leading to reduced total energy intake (22-25). Birketvedt et al (26) found that the addition of dietary fiber to a low-calorie diet significantly improved weight loss, with the placebo group losing 5.8 kg and the fiber-supplemented group losing 8.0 kg in overweight subjects.

With a longer chewing time and slower digestion and absorption, nutrient receptors in the gastrointestinal tract are stimulated for a longer time; this will prolong feedback to the satiety center in the brain and reduce energy intake (22, 23).

However, fiber alone is not enough to explain the effect of PGBR on body weight, because PGBR has various functional ingredients different from WR (27) and we do not know their possible effects on body weight. PGBR is richer than WR in vitamins, minerals and dietary fiber, γ-oryzanol, and ferulic acid and acylated steryl glucosides.

In conclusion, the present study shows that replacing WR with PGBR for a 16-wk intake could reduce body weight in healthy overweight women. From these findings, the rapid increase in overweight and obesity in Vietnam could be controlled by the use of PGBR.

Conflict of interests

The authors declare no conflict of interests regarding the publication of this article.

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