J Nutr Sci Vitaminol, **60**, 183–187, 2014

Pre-Germinated Brown Rice Reduced Both Blood Glucose Concentration and Body Weight in Vietnamese Women with Impaired Glucose Tolerance

Thi Nhung BUI[1], Thi Hop LE[1], Do Huy NGUYEN[1], Quang Binh TRAN[2], Thi Lam NGUYEN[1], Danh Tuyen LE[1], Do Van Anh NGUYEN[1], Anh Linh VU[3], Hiromichi AOTO[4], Yasuhide OKUHARA[4], Yukihiko ITO[4], Shigeru YAMAMOTO[5] and Mitsuo KISE[4,5,*]

[1] *National Institute of Nutrition, Hanoi, Vietnam*
[2] *National Institute of Hygiene and Epidemiology, Hanoi, Vietnam*
[3] *Hanoi University of Pharmacy, Hanoi, Vietnam*
[4] *FANCL Corporation, Yokohama 231–8528, Japan*
[5] *Asian Nutrition and Food Culture Research Center, Jumonji University, Saitama 352–8510, Japan*

(Received October 23, 2013)

Summary We have reported that newly diagnosed type 2 diabetes mellitus (DM) patients in Vietnam have a low body mass index (BMI) of around 23 and that the major factor for this is high white rice (WR) intake. Brown rice (BR) is known to be beneficial in the control of blood glucose levels; however, it has the property of unpleasant palatability. Pre-germinated brown rice (PGBR) is slightly germinated by soaking BR in water as this reduces the hardness of BR and makes it easier to eat. This study was designed to evaluate the effect of a 4-mo PGBR administration on various parameters in Vietnamese women aged 45–65 y with impaired glucose tolerance (IGT). Sixty subjects were divided into a WR or PGBR group. For the first 2 wk, WR was replaced by 50% PGBR, then for 2 wk by 75% PGBR and from the second month 100%. Before the beginning of the study and at the end of the study, 1) anthropometric measurements, 2) a nutrition survey for 3 nonconsecutive days by the 24 h recall method and 3) blood biochemical examinations were conducted. Fasting plasma concentrations of glucose and lipids and the obesity-related measurements and blood pressure were favorably improved only in the PGBR diet group. The present results suggest that replacing WR with PGBR for 4 mo may be useful in controlling body weight as well as blood glucose and lipid levels in Vietnamese women with IGT.

Key Words pre-germinated brown rice, blood glucose, lipid, body weight, Vietnamese

The prevalence of type 2 diabetes mellitus (DM) has recently increased world-wide and has become a global public health problem (*1*). Asians are thought to be susceptible to DM (*2*). It is estimated that more than 115 million people in India, Malaysia, China, Thailand, Indonesia, Australia, Korea, Singapore, Taiwan and Japan are living with diabetes. According to national surveys of diabetes, in Vietnam the prevalence of DM and impaired glucose tolerance (IGT) in 2003 was 2.7% and 7.7%, respectively (*3*), but in 2012 reached 5.7% and 12.8% (*4*). It is estimated that the number of Vietnamese DM cases will double by 2030 compared to 2010 (*5*).

We have shown that newly diagnosed Vietnamese diabetics have a body mass index (BMI) of about 23 (*6–8*) and this is similar to that of the Japanese standard (*9*). The use of white rice (WR) as a staple food may be the major factor, since it has been demonstrated to be and classified as a high glycemic index (GI) food and has been considered a risk factor for DM (*10, 11*). Vietnamese like eating WR and have high-carbohydrate diets. According to the National Nutrition Survey 2009–2010, approximately 70% of the energy intake was contributed by carbohydrates (*12*). Our previous study (*13*), which was designed to elucidate the effect of a typical Vietnamese diet with a high WR content on postprandial blood glucose levels, showed that a diet high in WR was not favorable for the control of blood glucose levels, especially for middle-aged and elderly persons. However, if WR is taken together with other foods such as vegetables or lipids, this reduces the problem. Willett et al. (*14*) recommend low consumption of WR and higher consumption of whole grains including brown rice (BR) to prevent elevation of blood glucose. However, BR itself has an unfavorable taste and texture. Recently, a new type of rice called pre-germinated brown rice (PGBR) has become widely available in Japan. PGBR ameliorates the problems of BR. PGBR is softer in texture and tastier than BR. Our previous studies (*15–17*) show that PGBR is better than WR in preventing the rapid increase in postprandial blood glucose and insulin concentrations. However, clinical evidence does not yet support the long-term effect of PGBR consumption because the studies were short-term (6 wk cross-over design) with a small numbers of subjects (11 subjects) (*17*). Therefore,

*To whom correspondence should be addressed.
E-mail: anfcrc@jumonji-u.ac.jp

in this study we tried to evaluate the effect of PGBR consumption for longer time (4 mo) on the control of blood glucose concentration with a larger number of subjects (60 subjects) with IGT.

MATERIALS AND METHODS

Setting and study subjects. The study was designed as a controlled clinical trial and was conducted in 2011 in Hai Duong Province, located in the Red River Delta 57 km from Hanoi. The population was approximately 1.7 million (14% living in urban areas and 86% living in rural areas). The study was designed in conformity with the Helsinki Declaration on Human Studies. The protocol of this study was approved by the Scientific Board of the National Institute of Nutrition in Vietnam. In addition, the potential beneficial health effects of whole grains (including PGBR) were explained to all subjects and informed consent was obtained from each participant.

About 1,000 women aged 45–65 y in urban communities and not under medication for DM participated in the screening. To facilitate screening, we measured fasting capillary blood glucose using the One Touch Ultra Smart device (Johnson & Johnson, New Brunswick, NJ). Participants were asked to fast for at least 10 h and then to report to their local health center where blood was drawn. From the screening survey we selected all women who had blood glucose over 5.6 mmol/dL; these women were then subjected to a further oral glucose tolerance test and IGT was defined by a 2-h post-50 g glucose load, a blood glucose level of 7.8 to 11.0 mmol/L (140 to 199 mg/dL) (*18*). Hemoglobin A1c (HbA1c) was also measured from these samples. Then, 30 matched pairs were created according to these IGT and HbA1c results. Subjects with IGT were selected because people with IGT are not likely to be taking diabetes medication; DM patients often are on medication and so were not included in this study. During the intervention period of 4 mo, subjects were divided into two groups consuming either WR or PGBR as a staple food. To help the subjects in the PGBR group to adapt, WR was replaced over the course of a month. Half (50%) of WR was replaced by PGBR in the first 2 wk, then 75% in the 2 following weeks. After the adaptation period, participants were instructed to consume either WR or PGBR exclusively as a staple food. Participants were allowed to continue normal activities of daily life without restriction. PGBR was produced in Vietnam with technological support from FANCL Corp., Japan. PGBR was produced by the Tam Rice Company of Hai Hau, Nam Dinh Province. PGBR was provided to subjects of the PGBR group every week.

Blood collection. Intravenous fasting blood samples were taken in the morning during the several days before the beginning of the study (baseline) and at the end of the study (final). The baseline blood samples were used to identify IGT. Serum was separated by centrifuge and kept frozen for the analyses of glucose, HbA1c, triacylglycerol (TG), total cholesterol (TC), LDL-cholesterol (LDL-C), and HDL-cholesterol (HDL-C). Blood collection and analyses were done at Hai Duong Provincial Hospital.

Table 1. Comparison of physical characteristics and blood biochemical parameters between PGBR and WR groups at baseline.

Variables	PGBR (n=30)	WR (n=30)	p-value
Age (y)	56.9±5.8	56.6±5.0	0.488
Height (m)	153.2±5.5	153.5±5.7	0.836
Weight (kg)	55.4±8.0	55.8±8.6	0.852
BMI (kg/m^2)	23.9±3.0	23.5±3.2	0.624
Body fat (%)	34.3±3.6	34.0±3.6	0.762
Waist (cm)	85.1±7.4	83.9±8.5	0.555
Hip (cm)	91.4±5.3	92.1±5.1	0.604
Waist-hip ratio	0.93±0.05	0.91±0.07	0.208
SBP (mmHg)	131.9±20.6	125.3±15.7	0.168
DBP (mmHg)	80.0±10.7	77.0±11.1	0.064
Glucose (mmol/L)	6.05±0.85	5.73±0.91	0.166
TC (mmol/L)	5.18±1.02	5.01±1.21	0.549
HDL-C (mmol/L)	1.02±0.31	1.04±0.34	0.837
LDL-C (mmol/L)	3.50±0.82	3.44±0.82	0.531
TG (mmol/L)	2.85±2.58	2.72±2.58	0.847
HbA1c (%)	6.44±1.14	6.16±0.70	0.260

Data are mean±SD. p-values obtained by unpaired t-test. SBP: systolic blood pressure, DBP: diastolic blood pressure, TC: total cholesterol, HDL-C: high-density lipoprotein-cholesterol, LDL-C: low-density lipoprotein-cholesterol, TG: triacylglycerol, HbA1c: hemoglobin A1c.

Anthropometric measurements. Weight, height, waist and hip circumferences and body fat percentage were measured twice (baseline and final) in each individual and the mean was used for analysis. Body weight and height were measured in light clothing and without shoes. Body mass index (BMI) was calculated as weight per square of height (kg/m^2). Waist circumference was measured mid-way between the lower rib margin and the iliac crest, while hip circumference was measured at the broadest circumference around the buttocks. Waist-hip ratio (WHR) was calculated as waist circumference (cm) divided by hip circumference (cm). Body fat percentage was measured by the bioelectrical impedance method using the OMRON scale (HBF-351, Omron Co., Kyoto, Japan). Blood pressure was measured twice in a sitting position after participants had rested for at least 5 min. The mean of the two values was used for the analysis.

Nutrition survey. A nutrition survey for 3 nonconsecutive days by the 24 h recall method was conducted before (baseline) and in the last week of the study (final). Energy and nutrient intakes were calculated based on the Vietnamese Food Composition Table 2005 (*19*). Fiber of PGBR was calculated by using the data published by us on short grain rice (Japonica) (*20*).

Statistical analyses. Quantitative variables were checked for normal distribution and compared by the Student t-test (paired and unpaired). p-values of less than 0.05 were considered statistically significant for all the analyses. The above statistical procedures were per-

Table 2. Comparison of physical characteristics and blood biochemical parameters at baseline and final in PGBR and WR groups.

Variables	PGBR group (n=30)			WR group (n=30)		
	Before	After	p-value	Before	After	p-value
Weight (kg)	55.4±8.0	51.8±5.8	<0.0001	55.8±8.6	55.2±8.7	0.702
BMI (kg/m^2)	23.9±3.0	22.4±2.6	<0.0001	23.5±3.2	23.3±3.2	0.122
Body fat (%)	34.3±3.6	31.4±4.5	<0.0001	34.0±3.6	33.7±3.4	0.425
Waist (cm)	85.1±7.4	78.5±7.6	<0.0001	83.9±8.5	82.8±8.1	0.146
Hip (cm)	91.4±5.3	89.9±5.2	<0.0001	92.1±5.1	91.6±5.0	0.789
Waist-hip ratio	0.93±.05	0.87±0.06	<0.0001	0.91±.07	0.90±0.08	0.608
SBP (mmHg)	131.9±20.6	122.3±179	0.002	125.3±15.7	119.4±25.2	0.237
DBP (mmHg)	80.3±10.7	72.3±9.6	<0.0001	77.0±11.1	73.5±9.2	0.059
Glucose (mmol/L)	6.05±0.85	5.31±0.63	<0.0001	5.73±0.91	5.89±0.96	0.246
TC (mmol/L)	5.18±1.02	4.91±0.86	0.324	5.01±1.21	5.62±0.93	0.002
HDL-C (mmol/L)	1.02±0.31	1.43±0.23	<0.0001	1.04±0.34	1.32±0.32	<0.0001
LDL-C (mmol/L)	3.57±0.82	3.18±0.51	0.01	3.44±0.82	3.52±0.57	0.573
TG (mmol/L)	2.85±2.58	1.58±0.68	0.003	2.72±2.58	2.12±1.19	0.095
HbA1c (%)	6.44±1.14	5.72±0.55	0.001	6.16±0.70	6.32±0.46	0.282

Data are mean±SD. p-values obtained by unpaired t-test. SBP: systolic blood pressure, DBP: diastolic blood pressure, TC: total cholesterol, HDL-C: high-density lipoprotein-cholesterol, LDL-C: low-density lipoprotein-cholesterol, TG: triacylglycerol, HbA1c: hemoglobin A1c.

Table 3. Energy and nutrient intakes of PGBR and WR groups at baseline and final.

Variables	Before			Final		
	PGBR (n=30)	WR (n=30)	p-value	PGBR (n=30)	WR (n=30)	p-value
Energy (kcal)	1,520±284	1,509±225	0.868	1,529±226	1,532±197	0.956
Protein (g)	58.7±11.1	55.7±12.7	0.334	56.4±12.7	57.8±11.7	0.659
Lipid (g)	30.3±10.3	29.9±9.7	0.877	30.2±10.7	29.7±8.7	0.843
Carbohydrate (g)	253±53	254±36	0.962	258±42	258±36	0.954
Dietary fiber (g)	6.7±2.3	6.4±2.2	0.607	13.1±4.3	6.8±4.1	<0.001

p-values obtained by unpaired t-test.

formed using SPSS version 16.0 (SPSS, Inc., Chicago, IL).

RESULTS

Table 1 shows the physical characteristics and blood biochemical parameters of the participants at baseline. Between the PGBR and WR groups, there were no statistically significant differences in age, height, weight, BMI, body fat percent, waist, hip, blood pressure, glucose, HbA1c, triglyceride (TG), total cholesterol (TC), LDL-C, or HDL-C. The mean BMI of both the PGBR group (23.9) and the WR group (23.5) exceeded the cut-off point for obesity as defined by the Vietnamese government (BMI 23.0), indicating that more than half of the subjects would be considered obese.

Table 2 shows the comparison of physical characteristics and blood biochemical parameters of the WR and PGBR groups at baseline and final. In the PGBR group, body weight, BMI, waist, hip, waist-hip ratio, and blood pressure were significantly reduced after intervention compared to the baseline. Such reductions were not found in the WR group. Parameters of blood biochemistry tests were significantly improved in the PBGR group but only HDL-C in the WR group.

Table 3 shows the energy and nutrient intakes of the PGBR and WR groups at baseline and final. The intakes of energy, protein, lipid and carbohydrate were similar between the two groups. However, mean fiber intake was 13.1 g and 6.8 g/d in the PGBR and WR groups, respectively at final, although they were similar at baseline.

DISCUSSION

The present 4-mo intervention study suggests that replacing WR with PGBR is useful in controlling blood glucose and lipid levels as well as body weight in people who consume rice as a staple food. The main focus of the study was reduction of blood glucose with PGBR; however, we also observed an unexpected and significant reduction in body weight as well as an improvement in blood lipid levels and blood pressure in the PGBR group.

As we have recently reported, the average BMI of Vietnamese who were newly diagnosed as DM was about 23 (*6–8*), which was within the classification of normal BMI (18.5–24.9) for Japanese (*9*). The GI of WR is high, which suggests that WR may be a major cause of DM (*10*, *11*), especially for East Asians, such as Vietnamese who take about 70% of their energy from rice (*12*). The effectiveness of BR in controlling DM has been reported; however, many people prefer not to continue a BR diet because BR is hard to chew. Recently, PGBR has become widely available in Japan. PGBR alleviates the problems of BR. It is slightly germinated by soaking BR in water and this softens the hull of BR and makes it easier to chew. To adopt this finding to daily life, the taste of PGBR will be the crucial factor. The acceptability of PGBR was fine in the 4 mo; there were no dropouts.

Although studies of the effect of PGBR on health are limited (*21–25*), those of the effects of whole grains including BR are numerous. Recently Ye et al. (*26*) reviewed 66 papers published between 1996 and 2012 and evaluated the effects of whole grains on such factors as DM, heart disease, and body weight. An approximately 26% decrease in DM, a 21% decrease in heart disease, and a 48–80 g decrease in body weight through the intake of 370 g of whole grain per day were reported by cohort studies. Through meta-analysis, fasting blood glucose indicated 18 mg/dL lower blood glucose, l32 mg/dL lower total cholesterol, and 28 mg/dL lower LDL-cholesterol in people who consumed whole grains compared to those who did not. Wirström et al. (*27*) studied 5,477 people aged 35–56 y (males 2,297, females 3,180) for 8–10 y and found that people who consumed 59.1 g of whole grain per day had a 22% lower risk of glucose metabolism disorder than those who ate less than 30.6 g a day when the data were adjusted for age, family history of DM, physical activity, smoking, education and blood pressure. Hu et al. (*10*) reviewed 4 papers and reported about 2 times higher risk of DM in people who ate WR every day than in those who did not eat it every day.

The favorable effects of PGBR found in this study can be explained by several mechanisms. Among them, dietary fiber may be the most important factor. Dietary fiber is known to control blood glucose and lipid concentrations (*28–35*). Whole grains rich in fiber have beneficial effects of lowering fasting insulin level and decreasing the risk of cardiac disease in diabetes and obese adults (*32–34*).

In this study, since the fiber concentration of PGBR is not available in Vietnam, we used the data shown in our previous study (*20*). The concentrations of fiber of BR, PGBR and WR from the same type of short grain rice (Japonica) produced in the same area in Japan were 2.0, 1.9 and 0.4 g/100 g, respectively. Mean fiber intake in this study was 13.1 g and 6.8 g/d in the PGBR and WR groups, respectively (Table 3). Fiber slows carbohydrate digestion and glucose absorption. The greater the rate of increase in blood sugar, the more the body secrets insulin, which stimulates the synthesis of body fat and blood fatty acids and induces insulin resistance. Slower and lower absorption rates induce lower GI. We (*22*) studied GI values of PGBR, BR and WR in the same subjects on different days. After fasting more than 10 h, each type of cooked rice containing 50 g carbohydrate was given with 150 g water to subjects and blood was drawn at 0, 30, 60, 90 and 130 min and GI was calculated. GI values of PGBR, BR and WR were 57, 62 and 76, respectively.

The PBGR group's body weight decreased from 55.4 to 51.8 kg (a 3.6 kg decrease in 4 mo), while the WR group's changed only slightly, from 55.8 to 55.2 kg (Table 2) in spite of a similar energy intake (Table 3). Energy intake was estimated by the nonconsecutive 3-d 24-h recall method, which is generally regarded as reliable, at least for energy intake. It is well known that body weight is controlled by the energy balance. This means that there was a significant negative energy balance in the PGBR group, perhaps through a lower absorption rate of PGBR. Fiber absorbs some of the calories in a meal by trapping nutrients in its gel so that it is harder for them to be absorbed before leaving the body as eliminated waste. Mean fiber intake in this study was 13.1 g and 6.8 g/d in the PGBR and WR groups, respectively (Table 3). However, we may not be able to explain such a great decrease of body weight only by fiber. We are now planning to confirm the results by further studies together with the absorption study.

In conclusion, the present study in Vietnamese with IGT shows that replacing WR with PGBR can improve the blood glucose and lipid levels as well as reducing body weight. The taste of PGBR was also well accepted. For these reasons, the rapid increase of DM in Vietnamese could be to a large extent controlled by the use of PGBR.

Acknowledgments

This study was supported by Vietnam's National Foundation for Science and Technology Development (NAFOSTED), grant no. 106.99.140.09 from the Ministry of Science and Technology, Vietnam. The authors would like to thank Mrs. Thu, Mr. Thuan, Mr. Chinh, and Mrs. Nhan for their kind help and support. We are grateful to all the participants and teachers and dietetic students of Hai Duong Technical Medical University and Hai Duong Provincial Hospital. The authors would like to thank Andrew R. Durkin, Professor Emeritus of Indiana University, Bloomington, USA, for his careful editing of the English for this article.

REFERENCES

1) Cockram CS. 2000. Diabetes mellitus: perspective from the Asian-Pacific region. *Diabetes Res Clin Pract* **50**: 3–7.

2) WHO Expert Consultation. 2004. Appropriate body mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* **363**: 157–163.

3) Binh VT, Uoc KH. 2005. Treatment methods and preventive measures. *In*: Epidemiology of Diabetes in Vietnam (Binh VT, ed), p 111–129. Hanoi Medical Publisher, Hanoi (in Vietnamese).

4) Quoc PS, Charles MA, Cuong NH, Lieu LH, Tuan NA,

Thomas M, Balkau B, Simon D. 1994. Blood glucose distribution and prevalence of diabetes in Hanoi. *Am J Epidemiol* **139**: 713–722.
5) Shaw JE, Sicree RA, Zimmet PZ. 2010. Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Res Clin Pract* **87**: 4–14.
6) Le Nguyen TD, Tran TM, Kusama K, Ichikawa Y, Nguyen TK, Yamamoto S. 2003. Vietnamese type 2 diabetic subjects with normal BMI but high body fat. *Diabetes Care* **26**: 1946–1947.
7) Son LNTD, Hanh TT, Kusama K, Duc Son le NT, Hanh TT, Kusama K, Kunii D, Sakai T, Hung NT, Yamamoto S. 2005. Anthropometric characteristics, dietary patterns and risk of type 2 diabetes mellitus in Vietnam. *J Am Coll Nutr* **24**: 229–234.
8) Yamamoto S, Le Nguyen TD, Hsu TH, Huang KC, Hung NV, Wong Y, Huang PC. 2013. Vietnamese may develop type 2 diabetes with smaller increases in body mass index and waist circumference than those in Taiwanese. *Int J Diabetol Vas Dis Res* **1**: 1–5.
9) Kanazawa M, Yoshiike N, Osaka T, Numba Y, Zimmet P, Inoue S. 2002. Criteria and classification of obesity in Japan and Asia-Oceania. *Asia Pac J Clin Nutr* **11** (Suppl 8): S732–S737.
10) Hu EA, Pan A, Malik V, Sun Q. 2012. White rice consumption and risk of type 2 diabetes: meta-analysis and systematic review. *BMJ* **344**: e1454.
11) Sun Q, Spiegelman D, van Dam RM, Holmes MD, Malik VS, Willett WC, Hu FB. 2010. White rice, brown rice, and risk of type 2 diabetes in US men and women. *Arch Intern Med* **170**: 961–969.
12) National Institute of Nutrition. 2010. National Nutrition Survey 2009–2010. Hanoi Medical Publisher, Hanoi (in Vietnamese).
13) Lin PY, Nhung BT, Khan NC, Sarukura N, Kunii D, Sakai T, Kassus A, Yamamoto S. 2007. Effect of Vietnamese common diet on postprandial blood glucose level in adult females. *J Nutr Sci Vitaminol* **53**: 247–252.
14) Willett W, Manson J, Liu S. 2002. Glycemic index, glycemic load, and risk of type 2 diabetes. *Am J Clin Nutr* **76**: 274S–280S.
15) Seki T, Nagase R, Torimitsu M, Yanagi M, Ito Y, Kise M, Mizukuchi A, Fujimura N, Hayamizu K, Ariga T. 2005. Insoluble fiber is a major constituent responsible for lowering the post-prandial blood glucose concentration in the pre-germinated brown rice. *Biol Pharm Bull* **28**: 1539–1541.
16) Usuki S, Ito Y, Morikawa K, Kise M, Ariga T, Rivner M, Yu RK. 2007. Effect of pre-germinated brown rice intake on diabetes neuropathy in streptozotocin-induced diabetes rats. *Nutr Metab* **23**: 4–25.
17) Hsu TF, Kise M, Wang MF, Ito Y, Yang MD, Aoto H, Yoshihara R, Yokoyama J, Kunii D, Yamamoto S. 2008. Effects of the pre-germinated brown rice on blood glucose and lipid level in free living patients with impaired fasting glucose or type 2 diabetes. *J Nutr Sci Vitaminol* **54**: 163–168.
18) World Health Organization and International Diabetes Federation. 2006. Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia. *In*: Report of a WHO/IDF Consultation, p 1–37. World Health Organization, Geneva.
19) National Institute of Nutrition. 2005. Vietnamese Food Composition Table, p 20–50. Hanoi Medical Publisher, Hanoi (in Vietnamese).
20) Aoto H, Sugino T, Shimura H, Mizukuchi A, Kise M, Teramoto S, Someya S, Tshuchiya K, Ishiwata K. 2003. Germinated brown rice, Patent No. p3423931, JP.
21) Hagiwara H, Seki T, Ariga T. 2004. The effect of pre-germinated brown rice intake on blood glucose and PAT-1 levels in streptozotocin-induced diabetic rats. *Biosci Biotechnol Biochem* **68**: 444–447.
22) Ito Y, Mizukuchi A, Kise M, Aoto H, Yamamoto S, Yoshihara R, Yokoyama J. 2005. Postprandial blood glucose and insulin responses to pre-germinated brown rice in healthy subjects. *J Med Invest* **52**: 159–164.
23) Sakamoto S, Hayashi T, Hayashi K, Murai F, Hori M, Kimoto K, Murakami K. 2007. Pre-germinated brown rice could enhance maternal mental health and immunity during lactation. *Eur J Nutr* **46**: 391–396.
24) Torimitsu M, Nagase R, Yanagi M, Homma M, Sasai Y, Ito Y, Hayamizu K, Nonaka S, Hosono T, Kise M, Seki T, Ariga T. 2010. Replacing white rice with pre-germinated brown rice mildly ameliorates hyperglycemia and imbalance of adipocytokine levels in type 2 diabetes model rats. *J Nutr Sci Vitaminol* **56**: 287–292.
25) Usuki S, Ariga T, Dasgupta S, Kasama T, Morikawa K, Nonaka S, Okuhara Y, Kise M, Yu RK. 2008. Structural analysis of novel bioactive acylatedsterylglucosides in pre-germinated brown rice bran. *J Lipid Res* **10**: 2188–2196.
26) Ye EQ, Chacko SA, Chou EL, Kugizaki M, Liu S. 2012. Greater whole-grain intake is associated with lower risk of type 2 diabetes, cardiovascular disease, and weight gain. *J Nutr* **142**: 1304–1313.
27) Wirström T, Hilding A, Gu HF, Östenson CG, Björklund A. 2013. Consumption of whole grain reduces risk of deteriorating glucose tolerance, including progression to prediabetes. *Am J Clin Nutr* **97**: 179–187.
28) Chandalia M, Garg A, Lutjohann D, von Bergmann K, Grundy SM, Brinkley LJ. 2000. Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. *N Engl J Med* **342**: 1392–1398.
29) Jenkins DJ, Kendall CW, Axelsen M, Augustin LS, Vuksan V. 2000. Viscous and nonviscous fibres, nonabsorbable and low glycaemic index carbohydrates, blood lipids and coronary heart disease. *Curr Opin Lipidol* **11**: 49–56.
30) Riccardi G, Rivellese AA. 1991. Effects of dietary fiber and carbohydrate on glucose and lipoprotein metabolism in diabetic patients. *Diabetes Care* **14**: 1115–1125.
31) Noriega E, Bouix O, Brun JF, Mestres C, Gauthier J, Oresetti A. 1993. Glycaemic and insulinaemic responses to white, brown and germinated rices in healthy subjects. *Diab Nutr Metab* **6**: 215–221.
32) Pereira MA, Jacobs DR Jr, Pins JJ, Raatz SK, Gross MD, Slavin JL, Seaquist ER. 2002. Effect of whole grains on insulin sensitivity in overweight hyper-insulinaemic adults. *Am J Clin Nutr* **75**: 848–855.
33) Liu S. 2002. Intake of refined carbohydrates and whole grain foods in relation to risk of type 2 diabetes mellitus and coronary heart disease. *J Am Coll Nutr* **21**: 298–306.
34) Montonen J, Knekt P, Jarvinen R, Aromaa A, Reunanen A. 2003. Whole grain and fiber intake and the incidence of type 2 diabetes. *Am J Clin Nutr* **77**: 622–629.
35) Riccardi G, Rivellese AA. 1991. Effects of dietary fiber and carbohydrate on glucose and lipoprotein metabolism in diabetic patients. *Diabetes Care* **14**: 1115–1125.