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Original Article

Lowering effect of pre-germinated brown rice on dyslipidemia in Chinese patients

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Abstract: The present study aimed to assess the effects of pre-germinated brown rice (PGBR) on blood lipid concentrations in Chinese patients with hyperlipidemia. 191 hyperlipidemia patients was randomly divided into two groups: a PGBR intervention group (PGBR): subjects were instructed to consume 150 g/day of PGBR instead of equivalent staple food during 12 weeks; and a control group (WR). Biochemical parameters and nutritional status (dietary intake, anthropometry) were measured before and after intervention. PGBR diet reduced serum levels of fasting cholesterol, triglyceride, and LDL and increased HDL. Systolic and diastolic blood pressure and fasting blood glucose (FBG) significantly reduced. It has no effect on body weight, BMI, waist circumference. Over the intervention period, brown rice intake was significantly increased for the PGBR compared with the WR. These results suggest that the PGBR diet could be a valid alternative treatment for patients with dyslipidemia.

Keywords: Pre-germinated brown rice, dietary intervention, humans, dyslipidemia

Introduction

Dyslipidemia is a representative life-style related disorder caused by a carbohydrate- or fat-rich diet intake associated with a lack of physical exercise [1]. It can be significantly improved by therapeutic lifestyle changes, such as dietary modification, physical activity, and weight reduction [2-5]. The dietary modifications include reducing total fat intake, total saturated fat and dietary cholesterol intake [6]. Whole grains are also an important component in an energy-balanced die [7]. Whole grains are rich in various nutrients, including fiber, thiamin, niacin, pantothenic acid, and phytochemicals. Randomized controlled trials (RCTs) have shown that whole-grain interventions can lower total and LDL-cholesterol [8].

In recent years, a new type of whole grain has become available in Japan, called Pre-Germinated Brown Rice (PGBR). Pre-Germinated Brown Rice (PGBR) is distinct from brown rice (BR) due to its taste, texture, nutritional profile and multifunctional characteristics. It is slightly germinated by soaking brown rice (BR) in water as this reduces the hardness of BR and makes it easier to eat. During the germination γ-aminobutyric acid (GABA) is produced, and therefore, PGBR is rich in GABA. GABA is the chief inhibitory neurotransmitter in the mammalian central nervous system. GABA improves the nerve growth factor and the protein synthesis in the brain, improve many brain functions such as memory and study capability [9-11]. In addition, GABA has hypotensive, tranquilizing and antidiabetic effects [12-14]. PGBR also is a good source of dietary fiber, vitamins and minerals in the bran layer and germ. Recent researches have declared that, the PGBR has the function not only in nutriology, but also has good function in adjusting body weight, blood glucose and lipid levels, preventing chronic diseases such as atherosclerosis and so on [15-18]. Two studies showed that compared to the white rice (WR) diet, levels of serum lipid were significantly improved after the PGBR diet consumption in patients with impaired glucose tolerance or type 2 diabetes [15, 16]. Roohinejad et al using hypercholesterolaemic rats showed that compared to rats fed WR, levels of serum cholesterol were significantly lower for rats fed

PGBR [17]. However, clinical evidence does not yet support the usefulness of consumption of PGBR as a staple food in patients with dyslipidemia.

Therefore, in this study we tried to evaluate the clinical usefulness of PGBR consumption on the control of blood lipid concentration in patients with dyslipidemia.

Materials and methods

Study participants

Subjects with untreated mild to moderate hypercholesterolemia were recruited from four different districts in Wuxi. Subjects were screened on the basis of the following selection criteria: age 40 to 70 years and a fasting serum total cholesterol concentration of 205-290 mg/dl. The exclusion criteria were as follows: (1) use of lipid lowering medication or other medication that could significantly influence the lipid profile; (2) use of supplemented products (e.g., fish oil, plant sterol or stanol) likely to affect the lipid profile within 30 days; (3) history of cardiovascular disease, diabetes, liver or kidney disorder, cancer, and other metabolic disease; (4) pregnancy or lactation. This trial was conducted with the approval of the Ethics Committee of the Nanjing Medical University. Participants provided written informed consent before any study procedures were performed. Based on data obtained from a basic health questionnaire, food frequency questionnaire and results of a fasting blood lipid test, 238 subjects (109 females, 73 males) were randomly assigned to the PGBR group (INT) or the control group (CON). Participants were instructed not to change their exercise habits and to maintain their normal dietary habits during the study period.

Study design and diet

Dietary intake at the start and end of the study was assessed by the research dietitian using a Semi-quantitative food frequency questionnaire (FFQ). Food intakes were essentially similar in the two groups at baseline.

During the 12-week intervention period, the PGBR group consumed 150 g/day PGBR instead of equivalent staple food product (rice, steamed bread, noodles, etc). Consumption of PGBR could be split across two or three meals each day for the 12 week intervention period. Subjects in the PGBR group were asked to record the quantity of the test food they consumed each day. All subjects in the control group were requested to follow their normal diet. The participants were instructed to maintain their weight, physical activity, alcohol consumption during the study. Participants who smoked could not have plans to change smoking habits during the treatment period. Compliance was monitored by phone or face-to-face interview every 4-week, reviewing the record of their consumption.

Assessment of the effectiveness of the intervention

Anthropometric measurements were conducted at baseline and at the end of the 12-week intervention period. Body weight, standing height, waist circumferences and blood pressure (SBP/DBP) were measured. Body mass index (BMI) was calculated by dividing the weight (in kilograms) by the square of the height (in metres).

Fasting blood samples were collected at baseline and at the end of the intervention period. Biochemical parameters in plasma samples included fasting blood glucose (FBG), triglycerides (TG), total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), fasting blood glucose (FBG), uric acid (UA) and were measured by routine enzymatic methods. Low density lipoprotein cholesterol (LDL-C) was calculated from TC, HDL and TG concentrations.

Statistical analysis

Data were entered using SPSS for Windows V.16.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as the means ± SD. Independent sample t-test was used for comparing the levels of anthropometric parameters, serum lipids, glucose, uric acid and age at baseline and at the end of the intervention, between the two groups. The paired t-test was used to compare the data of pre and post intervention. Difference in gender between the 2 groups was assessed by Chi-square tests. A *p*-value of less than 0.05 was regarded statistically significant.

Results

Baseline characteristics

According to the record of the return visits, only 18 members in INT dropped out: 1 of them lost

Table 1. Baseline characteristics between the two groups

Characteristics	PGBR (n=94)	WR (n=97)	*P* value
Male	45 (48%)	50 (52%)	0.6117
Age (yr)	56.7±6.8	56.7±6.7	>0.999
BMI (kg/m^2)	25.6±3.0	25.9±2.8	0.4753
SBP (mmHg)	136.9±13.7	136.9±16.0	>0.999
DBP (mmHg)	87.4±9.0	89.1±9.7	0.2091
FBG (mmol/L)	5.26±0.76	5.16±0.44	0.2677
UA (μmol/L)	351.8±83.4	350.9±82.0	0.9401
TC (mmol/L)	5.04±0.99	4.91±0.90	0.3428
TG (mmol/L)	2.36±0.46	2.29±1.06	0.5518
HDL-C (mmol/L)	1.08±0.31	1.07±0.31	0.8236
LDL-C (mmol/L)	3.49±0.88	3.37±0.77	0.3165

The values are presented as number (percent) or mean ± standard deviation. yr, years; PGBR, pre-germinated brown rice; WR, white rice; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; UA, uric acid; TC, total cholesterol; TG, triglycerides; HDL-C, high-density lipoprotein; LDL-C, low-density lipoprotein.

to follow-up, 10 of them has not completed blood lipids measure, and 7 of them has not ingesting the products of PGBR accumulatively more than 3 days one week, the products of PGBR were well accepted; in CON group, 29 members dropped out, 15 of them lost to follow-up, 3 of them took medication to reduce blood-fat during the intervention treatment period, and 11 of them has not completed blood lipids measure. There were no adverse events reported during the intervention period. Consequently, a total of 94 subjects in the PGBR group and 97 subjects in the control group were included in the final data analysis. Baseline characteristics of the two test groups are provided in **Table 1**. There were no statistically significant differences between groups for any of the demographic characteristics, anthropometric measures and clinical variables.

Anthropometric measures, blood pressure and plasma glucose

Anthropometric measures, blood pressure and plasma glucose at baseline and the end of the intervention period for both groups are given in are presented in **Table 2**. While there was no significant difference in anthropometric measurements, there was a significant reduction of the DBP, SBP and FBG in the study compared to the controls groups,

Serum lipids

Serum lipids at baseline and the end of the intervention period for both groups are presented in **Table 2**. The PGBR group showed significant decrease in total cholesterol (TC), triglyceride (TG), LDL cholesterol (LDL-C) and increase in HDL-C level after the intervention. In contrast, in the control group there were no significant changes after the study. Serum total cholesterol (TC), triglyceride (TG), HDL cholesterol and LDL cholesterol were significantly different in the PGBR group than the control group after the intervention.

Dietary intake

Dietary intake at baseline and after 12 weeks of intervention is presented in **Table 3**. No significant differences were found at baseline between the groups. After 12 weeks of intervention, brown rice intake was significantly increased among the PGBR group compared to the control group. There were no significant differences in cereals, vegetables, fruits, milk products and meat between the groups after the study.

Discussion

In this study, it was shown that consumption of PGBR significantly reduced serum levels of TC, TG and LDL-C levels in patients with hyperlipidemia. Moreover, serum HDL-C levels were significantly increased after consumption of PGBR. The results also showed that consumption of PGBR significantly reduced blood pressure and serum levels of fasting blood glucose.

The reductions in TC, TG and LDL-C observed in this study are similar to previous reports. Hsu et al reported reduction in total cholesterol and triacylglycerol levels in the impaired fasting glucose (IFG) or type 2 diabetes patients consuming 540 g/day of pre-germinated brown rice for 14 weeks [16]. In a recent trial replacing WR with PGBR for 4 month reduced lipid levels in Vietnamese women with IGT [15]. Miura D et al showed that PGBR as well as BR suppresses hypercholesterolemia induced by hepatoma growth by up-regulating cholesterol catabolism in rats [19].

The hypocholesterolaemic effects of PGBR in hyperlipidemia individuals could partly be due

Table 2. Comparisons of changes in Physical characteristics and biochemical parameters between the two groups

Variable	Group	Week 0	Week 12	*P* values analysis within groups*
BW (kg)	PGBR (n=94)	68.2±10.8	67.6±11.0	0.7063
	WR (n=97)	67.1±10.0	67.9±10.4	0.5856
	P values analysis between groups†	0.4264	0.8466	
BMI (kg/m^2)	PGBR (n=94)	25.6±3.0	25.4±3.3	0.6642
	WR (n=97)	25.9±2.8	25.1±3.2	0.0654
	P values analysis between groups†	0.4753	0.5243	
WC (cm)	PGBR (n=94)	86.7±7.9	87.6±8.3	0.4473
	WR (n=97)	86.3±7.6	87.8±8.7	0.2025
	P values analysis between groups†	0.7218	0.8711	
SBP (mmHg)	PGBR (n=94)	136.9±13.7	126.9±15.5	<0.0001
	WR (n=97)	136.9±16.0	138.3±15.7	0.5392
	P values analysis between groups†	>0.999	<0.0001	
DBP (mmHg)	PGBR (n=94)	87.4±9.0	79.1±9.9	<0.0001
	WR (n=97)	89.1±9.7	89.6±9.1	0.7116
	P values analysis between groups†	0.2091	<0.0001	
FBG (mmol/L)	PGBR (n=94)	5.26±0.76	5.07±0.42	0.0007
	WR (n=97)	5.16±0.44	5.14±1.05	0.4011
	P values analysis between groups†	0.2677	0.5430	
UA (μmol/L)	PGBR (n=94)	351.8±83.4	353.6±93.2	0.8892
	WR (n=97)	350.9±82.0	347.6±82.7	0.7805
	P values analysis between groups†	0.9401	0.6382	
TC (mmol/L)	PGBR (n=94)	5.04±0.99	4.36±0.93	<0.0001
	WR (n=97)	4.91±0.90	4.75±0.94	0.2274
	P values analysis between groups†	0.3428	0.0044	
TG (mmol/L)	PGBR (n=94)	2.36±0.46	2.12±0.39	0.0002
	WR (n=97)	2.29±1.06	2.31±1.10	0.8975
	P values analysis between groups†	0.5518	0.1095	
HDL-C (mmol/L)	PGBR (n=94)	1.08±0.31	1.23±0.27	0.0005
	WR (n=97)	1.07±0.31	1.06±0.29	0.8168
	P values analysis between groups†	0.8236	<0.0001	
LDL-C (mmol/L)	PGBR (n=94)	3.49±0.88	2.68±0.84	<0.0001
	WR (n=97)	3.37±0.77	3.32±0.81	0.6600
	P values analysis between groups†	0.3165	<0.0001	

The values are presented as mean ± standard deviation. PGBR, pre-germinated brown rice group; WR, white rice group; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; UA, uric acid; TC, total cholesterol; TG, triglycerides; HDL-C, high-density lipoprotein; LDL-C, low-density lipoprotein. *Paired t-test. †Independent t-test.

to the presence of dietary fiber in the outer layer of PGBR. Cáceres et al found that total dietary fiber increases during germination (6.1%-13.6%), with a large proportion of insoluble fraction [20]. According to Ho et al, hormone-sensitive lipase was found to be up-regulated in mice group that administrated with GBR and hypothesized that vitamin E, oryzanol and GABA were the active compounds that improve lipid metabolism in obese mice [21]. Hormone-sensitive lipase is a key enzyme in the mobilization of free fatty acids from adipocytes. An in vitro study showed that, the GBR extracts has inhibitory effect on pancreatic lipase and lipid accumulation of adipocytes [22]. In another study, Ho et al showed that

Table 3. Comparisons of changes in food intakes between the two groups

Variable (g/day)	Group	Week 0	Week 12	*P* values analysis within groups*
Cereals	PGBR (n=94)	399.6±81.7	375.0±65.6	0.0228
	WR (n=97)	406.5±141.7	385.2±146.6	0.3088
	P values analysis between groups†	0.6790	0.5327	
Brown rice	PGBR (n=94)	13.4±7.5	127.2±10.7	<0.0001
	WR (n=97)	13.6±5.6	13.4±4.2	0.2603
	P values analysis between groups†	0.8345	<0.001	
Vegetables	PGBR (n=94)	310.5±76.9	312.7±63.1	0.8305
	WR (n=97)	311.4±114.6	296.1±101.7	0.3266
	P values analysis between groups†	0.9490	0.1738	
Fruits	PGBR (n=94)	106.6±21.0	103.6±27.7	0.4027
	WR (n=97)	112.3±31.1	110.2±39.9	0.6827
	P values analysis between groups†	0.1366	0.1831	
Milk	PGBR (n=94)	93.1±26.0	93.9±25.6	0.8319
	WR (n=97)	95.2±27.8	93.5±12.8	0.5843
	P values analysis between groups†	0.5907	0.8919	
Meat	PGBR (n=94)	153.2±57.5	155.4±59.2	0.7963
	WR (n=97)	144.9±92.3	157.2±90.8	0.3506
	P values analysis between groups†	0.4542	0.8707	

The values are presented as mean ± standard deviation. PGBR, pre-germinated brown rice; WR, white rice. *Paired t-test. †Independent t-test.

Germinated brown rice extract inhibits adipogenesis through the down-regulation of adipogenic genes in 3T3-L1 adipocytes [23]. These results suggest that GBR may be a useful alternative to limit the lipogenesis, absorption and accumulation in adipocytes since rice is a daily staple food in some of the countries.

There was also significant effect of PGBR consumption on blood glucose at the end of the 12 week treatment period in this study. Previous studies have reported results of the effect of PGBR on blood glucose. Bui et al found that consumption for 4 months in Vietnamese women with impaired glucose tolerance (IGT) can significantly lower fasting plasma glucose levels [15]. Some other studies showed similar results in this regard [16, 24-26]. The blood glucose-lowering effect of PGBR may be derived from the properties of PGBR involving substantially higher content of dietary fiber than white rice [21, 26], and PGBR exhibits the lower postprandial glycemic response [25]. It is well known that increased dietary fiberintake was associated with better glycemic control [27].

In conclusion, consumption of 150 grams of PGBR per day significantly reduced TC, TG, LDL-C and FBG in moderately hyperlipidemia patients. These results suggest that replacement of a staple food with PGBR has beneficial effects on risk factors for CVD. Prospective studies with larger number of participants and longer duration together with the evaluation of the effect of PGBR on lipid profile are needed.

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Disclosure of conflict of interest

None.

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