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Original article

Effects on skin by dewaxed brown rice: An open label test.

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Abstract

***Purpose*:** In this study, we compared the subjective symptoms and changes in skin condition of university students and staffs with brown rice from which the bran layer had been removed (dewaxed brown rice: DBR) for one month, in comparison with the polished rice free intake group.

***Methods*:** The 65 subjects in the analysis group consisted of 43 in the DBR group (25 males and 18 females 23.8 ± 8.8 years) and 22 in the control group (13 males and 9 females 22.0 ± 1.2 years). In the DBR group, a test meal of 150 g or more was ingested once a day for one month, and in the control group, polished rice was usually taken freely. Before and after the test, the questionnaire, skin condition (Clreo-Pro), and skin AGE fluorescence (by AGEs sensor) were evaluated.

***Results*:** DBR intake compliance was at 87.5%, and no adverse events due to dyspepsia were observed. Skin age, an index of skin condition, was significantly improved in the DBR group compared to the control. There was no significant difference in skin AGE fluorescence. Gender analysis showed that wrinkles and porphyrin levels were significantly improved in the DBR group in women.

***Conclusion*:** It was suggested that DBR could contribute to health promotion including skin condition by reducing the indigestibility of brown rice and ensuring nutritional value, which facilitates continuous intake.

***KEY WORDS*:** brown rice, dewaxed brown rice (DBR), advanced glycation endproducts (AGEs), skin AGE fluorescence, skin condition

Introduction

It has been pointed out that whole grains, i.e. brown rice, may be effective in preventing lifestyle-related diseases such as obesity, type 2 diabetes (T2DM), and coronary artery disease [1,2]. The brown rice diet is rich in vitamins, minerals and dietary fiber, and is clearly nutritionally superior to polished rice. However, there are some problems with continuous intake of brown rice. Problems include the need for long-term water immersion on the cooking side, the time required for digestion on the physical side, and the need for sufficient chewing.

Various measures have been attempted to reduce the disadvantage of indigestibility while utilizing the nutritional advantages of brown rice. Brown rice from which the wax bran layer has been removed is called dewaxed brown rice (DBR) and there are reports of ingredients [3], improvement of constipation [4] and amerioration of fatty liver [5] in animal experiments. In this study, we investigated changes in subjective symptoms, skin condition, and the accumulation of advanced glycation end products (AGEs), which is an index of glycation stress, when the test product DBR was ingested for one month in young people, and compared with a group that ingested polished rice.

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Method

Subjects

The subjects were male and female students and staffs from a university in Tokyo (including Yokohama campus). This study was conducted with 66 subjects who agreed to participate in this trial in advance in writing, who met the selection criteria, did not conflict with the exclusion criteria, and were judged to be appropriate to participate by the principal investigator. The subjects enrolled in this study were randomly designated by the assigners to the DBR group and the control group.

The selection criteria are shown below.

1) Men and women 18 to 60 years old at the time when the consent for participation in the study was obtained.
2) Persons in good health without chronic physical illness, including skin diseases.
3) Persons with the ability to give consent after receiving an adequate explanation of the purpose and content of the study, and who volunteered to participate of their own accord after proper understanding and providing a written consent to participate in this study.
4) Persons who could attend the designated examination date to undergo examination.
5) Persons determined to be suitable as a subject of this study by the principal investigator.

The exclusion criteria are shown below.

1) Persons who are currently receiving medication due to illness
2) Persons with a history of, or currently suffering from impaired glucose tolerance, mental illness, sleep disorders, hypertension, diabetes mellitus, dyslipidemia, or a serious illness.
3) Persons who have been taking drugs for the treatment of a disease for the past one month (excluding those with a history of taking temporary-relief medication for headaches, menstrual pain, and colds)
4) Persons with a history of, or currently suffering from a severe disease of the liver, kidney, heart, lungs, digestive organs, or a hematologic disease.
5) Persons with a history of, or currently suffering from a severe disease of the gastrointestinal tract, excluding appendicitis.
6) Persons with a body mass index (BMI) of more than 30 kg/m^2.
7) Those who may have allergic reactions to the test food, and those who may have serious allergic reactions to other foods or drugs.
8) Pregnant women, lactating women,or women who may possibly be pregnant.
9) Currently, and within the past three months, those who have a habit of continuously ingesting functional foods and health foods that claim to be related to skin quality improvement, and those who plan to take them during the test period (ingestion for the purpose of maintaining health was permitted).
10) Persons with photosensitivity.
11) Persons who have been determined by the principal investigator as not suitable to be a subject of this study.

Figure 1 shows the transition of the number of test subjects. The breakdown of 65 subjects analyzed was 43 in the DBR group (25 men and 18 women) and 22 in the control group (13 men and 9 women). The DBR group includes 7 university staffs (5 men and 2 women). The average age of each group was 23.8 ± 8.8 years in the DBR group (men 24.2 ± 8.8 years, women 23.1 ± 9.1 years) and 22.0 ± 1.2 years in the control group (men 22.4 ± 1.2 years, women 21.4 ± 1.0 years). The control group was the same as in the previous report [6].

Exam design

This study was an open label study between parallel groups.

The DBR group ingested brown rice from which the

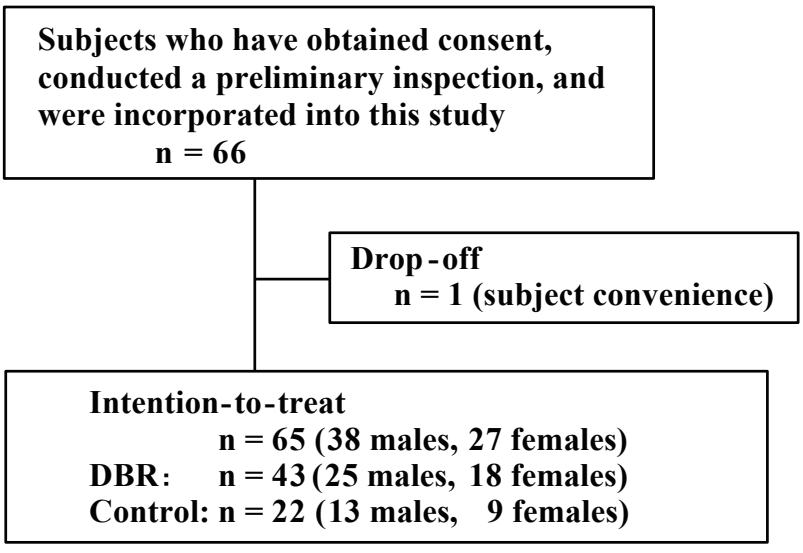

Fig. 1. **Changes in the number of test subjects.**

wax layer had been removed, and a control group was set in which normal polished rice without DBR was ingested freely. The DBR group always ingested the test product once a day during the test period by any of the following methods.

• DBR was cooked in the on-campus cafeteria, weighed, served at 150 g or more, and ingested.

• Packaged DBR (150 g) was heated in the microwave and ingested.

The test product was provided by Toyo Rice Co., Ltd. (Wakayama, Japan). The subjects participated in the pre-ingestion test 1 day, the ingestion period 33 days, and the post-intake test 1 day.

Pre-intake tests for each group included a background survey via questionare on lifestyle and skin condition, skin condition measurement via device Clreo-Pro (Fujitex, Shinjuku-ku, Tokyo), and skin AGEs score via AGEs sensor device (RQ-AG01J: Sharp Life Sciences, present Air Water Biodesign, Kobe, Hyogo, Japan). Post-ingestion tests included a survey of lifestyle-related and skin conditions, skin condition measurement, and AGEs score. In both the pre-ingestion test and the post-intake test, female subjects washed their face 20 minutes or more prior to the test to remove cosmetics, and performed skin diagnostic measurements after acclimation. The test period was from June 2019 to July 2019.

Dewaxed brown rice (DBR)

DBR is brown rice from which rice husks have been removed from whole rice that have been dried after harvesting, and the wax bran layer that covers the surface of the brown rice has been removed by special processing (***Fig. 2***). The non-edible part of the rice husk, the wax layer, hinders water absorption, while the bran layer contains various nutrients. The sub-glue powder layer is located between the starch layer and the bran layer, the nutritional components of brown rice are concentrated, it has a unique flavor and sweetness, and the taste is also preferable. Sub-aleurone-remaining wash-free rice (SARFR) has a part of the wax layer and the bran layer removed, but DBR only removes the wax layer, thus being closer to brown rice. The nutritional components in rice differ depending on the amount of cultivated soil bacteria and the rice milling process. In general, DBR is four times higher in vitamin B1, fourteen times higher in vitamin E, and seven times higher in dietary fiber than ordinary polished rice (***Table 1***).

Brown rice is covered with a highly waterproof layer (wax layer) so that it does not germinate as seeds by absorbing water until the growing conditions are met. The strong waterproofing of the wax layer hinders water absorption, and the rice grains do not swell sufficiently, which can make them difficult to eat. It usually takes about 20 hours to soak before cooking rice. This time is longer than the immersion of polished rice for about 1 hour. Since the presence of the wax layer hinders water absorption, the rice does not expand sufficiently even when cooked, and the rice grains are hard. Therefore, it has low digestibility even though it contains high nutritional value. On the other hand, since DBR removes the wax on the surface, water is easily absorbed during soaking and cooking rice, as with polished rice. The starch of rice is pregelatinized and swells well when heated during cooking, so the color is whitish like polished rice, and the rice is cooked into plump rice with good digestion and absorption.

Evaluation item

Skin index

The skin indices included functions, skin age, overall skin health, pores, wrinkles, moisture, elasticity, skin tone, pigmentation (epidermis layer, dermis layer), oil content, and porphyrin, that were measured via Clreo-Pro as in the previous report [6].

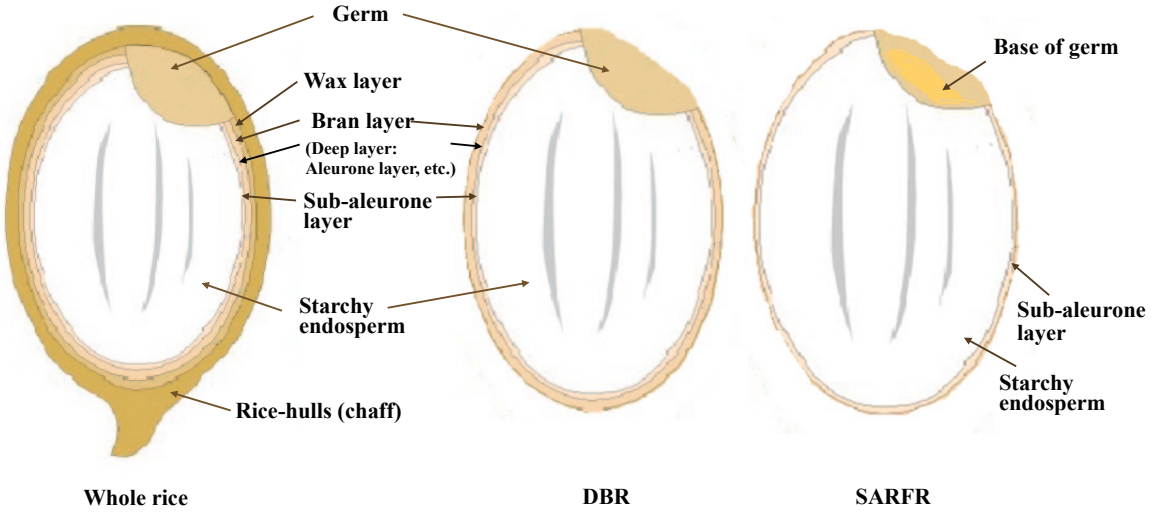

Fig. 2. **Structure of rice and DBR.**

DBR, dewaxed brown rice; SARFR, sub-aleurone-remaining wash-free rice.

Table 1. Ingredient composition of polished rice, brown rice and DBR.

	Polished rice	Traditional brown rice	DBR
Dietary fiber	0.5 g	3.0 g	3.5 g
Calcium	5 mg	9 mg	6 mg
Vitamin B1	0.08 mg	0.41 mg	0.36 mg
Vitamin E (α-Tocopherol equivalent)	0.1 mg	1.2 mg	1.4 mg
Niacin	1.2 mg	6.3 mg	3.1 mg
γ-oryzanol	0 mg	46 mg	33 mg

Data are shown as nutrient content per 100 g. polished rice, traditional brown rice, data according to Standard Tables of Food Composition in Japan (value before rice washing); DBR, values after non-washing (according to the Food Environment Inspection Association); γ-oryzanol, survey by Japan Food and Fat Inspection Association; diaetary fiber, there may be a difference since the content value differs depending on the brown rice used as the raw material; DBR, Kinme dewaxed brown rice.

AGEs measurement

The AGEs score was measured using AGEs sensors [10,11].

Subjective symptoms

The contents of the questionnaire were questions about changes in eating habits, lifestyle habits (exercise, sleep, bowel movements, drinking, smoking, and mental stress), and skin conditions. The average value of compliance (the intake rate of the test product) was calculated based on the questionnaire.

Statistical analysis

For analysis, a software SPSS (Statistics25: IBM Japan, Chuo-ku, Tokyo, Japan) was used to perform paired-t test or Wilcoxon signed rank test. A risk rate of less than 5% was defined as a significant difference.

Ethical standards

This study was conducted in compliance with the Declaration of Helsinki (revised at the 2013 WMA Fortaleza General Assembly) and the ethical guidelines for human-based medical research (notification by the Ministry of Education, Culture, Sports, Science and Technology [MEXT] and Ministry of Health, Labour and Welfare [MHLW]). This research obtained the approval of the Ethical Committee of the Society for Glycative Stress Research (GSE 2019-004), which has discussed the ethics and validity of the study. The clinical trial for this study was pre-registered (UMIN #000037017).

Results

Intake compliance

The compliance of the DBR group was 87.5%, 1 out of 45 patients (dropout rate 2.2%), and no dropouts were caused by ingestion of the test product (***Fig. 1***). There were no dropouts in the control group. The reason for dropping out was due to personal reasons.

Subjective symptoms

No notable findings were found regarding lifestyle-related symptoms (exercise, sleep, bowel movements, drinking, smoking, stress) and subjective symptoms related to skin condition. No adverse symptoms were observed.

Skin index

Table 2 shows the measurement results of the skin index. The rejuvination in skin age (change amout) was significantly greater in the DBR group than in the control, and was improved in the DBR group ($p = 0.023$, ***Fig. 3-a***). Skin age was significantly improved in the DBR group in women ($p = 0.011$, ***Fig. 3-c***), but not significantly in men (***Fig. 3-b***).

There was a significant difference in the change rate in wrinkles between the groups, which was significantly improved in the DBR group ($p = 0.039$, ***Fig. 4-a***). No significant difference was observed in males (***Fig. 4-b***), but in females ($p = 0.049$, ***Fig. 4-c***). Regarding the change rate in porphyrin, there was no significant difference between the groups for men and women (***Fig. 5-a, b***), but there was a significant improvement for women in the DBR group ($p = 0.044$, ***Fig. 5-c***)

Measurement of AGEs

There was no significant change in skin AGE fluorescence intensity before and after the test in both groups, and there was no significant difference in the amount of change between the groups (***Table 2***).

Safety

No adverse events thought to be caused by the test product were observed during the observation period.

Table 2. Results of skin condition and AGE fluorescence.

		Before ingestion	One month after ingestion	Comparison between groups (by variation)
		Mean ± SD	Mean ± SD	vs. control
Age (year)	DBR	23.8 ± 8.7		
	Control	22.0 ± 1.2		
Pores (%)	DBR	-0.3 ± 12.6	-2.8 ± 11.9	0.885
	Control	-2.0 ± 13.5	-4.6 ± 11.3	
Wrinkles	DBR	3.5 ± 8.8	1.4 ± 7.3	0.300
	Control	0.5 ± 6.1	-0.4 ± 4.9	
Pigmentation (PL) stratum corneum (%)	DBR	2.6 ± 4.7	1.3 ± 4.4	0.533
	Control	1.9 ± 4.1	0.8 ± 3.7	
Pigmentation (UV) stratum corneum (%)	DBR	6.2 ± 8.8	4.6 ± 7.7	0.615
	Control	3.9 ± 5.3	2.8 ± 5.0	
Porphyrin	DBR	31.4 ± 7.7	30.3 ± 6.4	0.393
	Control	32.8 ± 9.9	30.1 ± 10.6	
Skin tone	DBR	61.8 ± 4.7	62.6 ± 4.4	0.630
	Control	61.7 ± 4.7	62.8 ± 4.8	
Elasticity (angle)	DBR	43.8 ± 4.9	44.8 ± 5.0	0.973
	Control	42.7 ± 7.7	43.6 ± 5.2	
Skin health score	DBR	45.0 ± 12.9	50.5 ± 12.4	0.405
	Control	47.3 ± 9.6	50.9 ± 10.0	
Skin age (year)	DBR	24.2 ± 9.2	23.8 ± 8.8	**0.023**
	Control	22.2 ± 1.6	22.0 ± 1.6	
AGE Score	DBR	0.44 ± 0.06	0.46 ± 0.05	0.260
	Control	0.44 ± 0.21	0.46 ± 0.05	

DBR, dewaxed brown rice; AGE, advanced glycation endproduct; PL, polarized right; UV, ultraviolet; SD, standard deviation; skin condition measured by Clreo-Pro (Fujitex); AGE score measured by AGEs sensor (Sharp); DBR group, n = 43; the control group, n = 22; Statistical analysis by Student's t test.

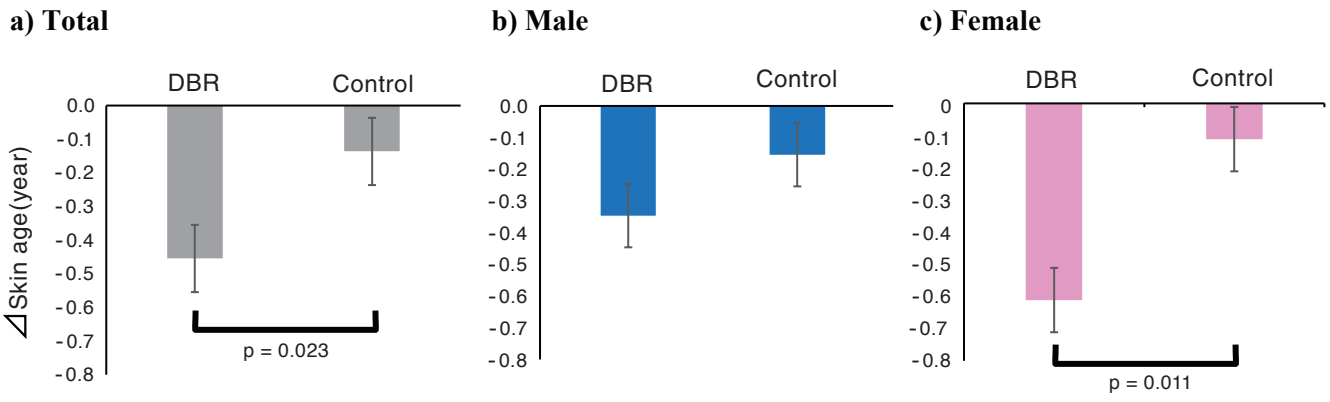

Fig. 3. **Change of skin age.**

a) Total, DBR group, n = 43; the control group, n = 22. **b)** Male, DBR group, n = 25, the control group, n = 13. **c)** Female, DBR group, n = 18 the control group, n = 9. Skin age evaluated by Clreo-Pro (Fujitex). Results are expressed as mean ± SEM; Statistical analysis by Wilcoxon signed rank test. DBR, dewaxed brown rice; SEM, standard error mean.

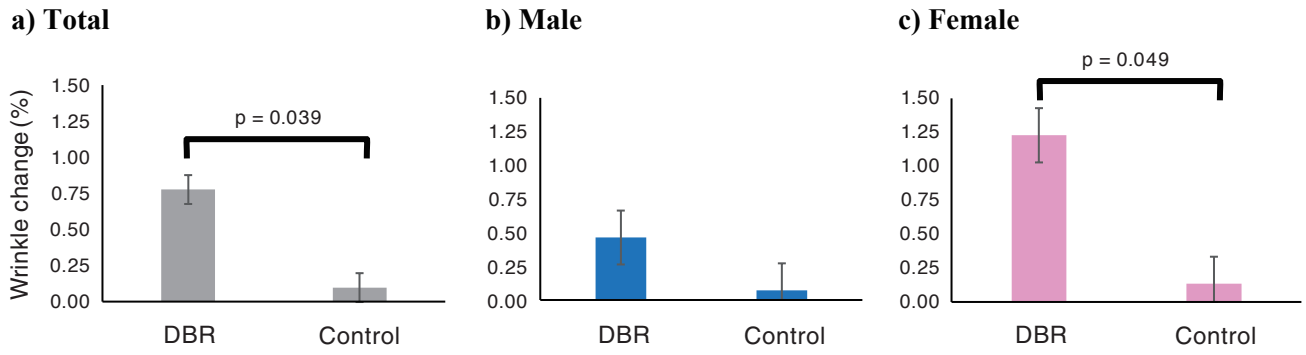

Fig. 4. **Change of wirinkles.**

a) Total, DBR group, n = 43; the control group, n = 22. **b)** Male, DBR group, n = 25, the control group, n = 13. **c)** Female, DBR group, n = 18 the control group, n = 9. Winkles are evaluated by Clreo-Pro (Fujitex). Results are expressed as mean ± SEM; Statistical analysis by Wilcoxon signed rank test. DBR, dewaxed brown rice; SEM, standard error mean.

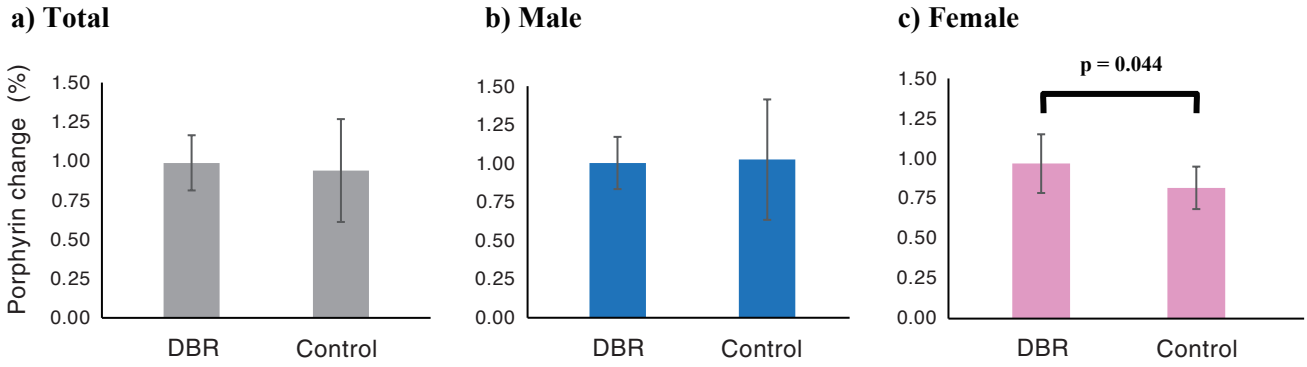

Fig. 5. **Change of porphyrin.**

a) Total, DBR group, n = 43; the control group, n = 22. **b)** Male, DBR group, n = 25, the control group, n = 13. **c)** Female, DBR group, n = 18 the control group, n = 9. Winkles are evaluated by Clreo-Pro (Fujitex). Results are expressed as mean ± SEM; Statistical analysis by Wilcoxon signed rank test. DBR, dewaxed brown rice; SEM, standard error mean.

Discussion

Whole-grain brown rice contains a variety of nutrients. When brown rice was the major staple food in Japan, vitamins, i.e. vitamin B1, could be supplemented, however, during the Genroku era (1688-1704), beriberi became popular in Edo, where polished rice was prevalent, this caused what was called "Edo illness." Later, from the Meiji era (1868-1912) to the Taisho era (1912-1926), beriberi developed in so many people that it was said to be one of the two major national diseases along with tuberculosis. In the Showa era (1926-1989), when the "Funpu Rice Milling Method" was developed in 1955, the "over-polished rice" began to spread, beriberi and other illnesses had then begun to be seen mainly among young people with unbalanced diets and persons with chronic diseases. This method (Funpu meaning blasts) is a modification of the conventional friction type rice milling machine, which uses the high pressure inside the machine (200 to 300 g/cm^2) to increase the frictional force between rice particles and polishes them, followed by blowing off the adhered bran and residues with a blast (30 m/sec or more). Although brown rice contains various ingredients and is clearly superior to polished rice in terms of nutrition, it is difficult to cook, has a taste and texture different from that of polished rice, and is difficult to digest. Brown rice has moved away from its main staple food position.

At this time, we conducted a clinical trial for university students using DBR, which was developed to reduce the disadvantageous characteristics of brown rice and take advantage of it. In the group (43 subjects) who took DBR 150 g or more per day for 1 month, intake compliance was maintained as high as 87.5%, no adverse events were observed, and skin age, an index of skin condition, was improved significantly compared with the control (22 subjects). These actions are due to the functional ingredients contained in brown rice. Brown rice contains B vitamins such as vitamins B1, B2, B6, nicotinic acid, patent acid, inositol, choline, and folic acid. Other components will be described below.

The ingredients of brown rice

γ-Oryzanol

γ-Oryzanol is a combination of ferulic acid and food sterols and is the main component of rice bran oil. Excessive intake of animal fat causes ER stress in pancreatic β cells and nerve cells in the hypothalamus, and γ-oryzanol has the effect of relieving these ER stresses [9]. As a result, it exerts a central effect that helps improve tension, anxiety, depression, and withdrawal from animal fat dependence. In the pancreas, it enhances β-cell glucose-responsive insulin secretion and reduces α-cell glucagon hypersecretion. These actions lead to the reduction of glycation stress. It is known that the intake of brown rice diet improves animal fat addiction, and it is presumed that γ-oryzanol plays an important role in this [10]. Supplements containing γ-oryzanol have also been developed [11].

Brown rice may contain unknown functional ingredients. It has been reported that the triterpene alcohol and sterol fractions (TASP) contained in the oil-soluble fractions in rice bran have an effect of ameriorating postprandial hyperglycemia [12] and an effect of suppressing high-fat diet-dependent obesity [13]. As its mechanism of action, it is supposed that TASP suppresses the increase in postprandial blood concentration of glucose-dependent Insulinotropic polypeptide (GIP), a gastrointestinal hormone, and interferes with the translocation of Sodium-dependent Glucose Transporter 1 (SGLT1), a glucose transporter, onto the cell membrane [14].

Ferulic acid

Ferulic acid has strong antioxidant power and weak cytotoxicity [15]. It is experimentally known to have an effect of reducing amyloid β oligomers, and is expected to have an anti-dementia effect in humans [16, 17]. Regarding glycative stress, ferulic acid could not confirm the formation inhibitory effect on AGEs in our laboratory, and the amount of fluorescent AGEs tends to increase [18]. Further studies are needed on the effects on AGEs other than fluorescent AGEs.

Dietary fiber

Rice bran and germ are rich in dietary fiber. It is an essential substance for "healthy intestinal-brain correlation" that contributes to the healthy growth of the intestinal flora and the enhancement of brain mental function. It is an essential substance for the healthy growth of the intestinal flora and the homeostasis of the "gut-brain axis" that contributes to the enhancement of brain mental function. Dietary fiber acts as a probiotic to promote the growth of beneficial bacteria in the intestinal flora, and increases, in particular, the number of bacteria that produce short-chain fatty acids, *i.e.*, acetic acid, butyric acid, and propionic acid. Short-chain fatty acids promote body temperature elevation, heart rate increase, lipolysis in adipose tissue via specific receptors (i.e., GRP41), and have the effect of increasing basal metabolism when overdosed [19]. Dietary fiber has the effect of suppressing postprandial hyperglycemia [20]. Both actions can be expected to have the effect of reducing glycative stress.

GABA is contained in a trace amount in brown rice and acts as an inhibitory neurotransmitter in the body. It is related to long-term object recognition memory and working memory, and it has been reported in animal experiments that it has an effect of reducing mental and physical stress [21] and an effect of improving memory deterioration after head injury [22]. Human clinical trials have reported the antihypertensive effect of GABA-containing koji amazake [23, 24].

Phytic acid

Phytic acid, also called inositol 6-phosphate, has an antioxidative effect, and is known to suppress the increase in plasma uric acid levels, prevent renal stone formation, and reduce serum cholesterol [25]. In addition, it has been pointed out that it may reduce the risk of carcinogenesis [26]. Although phytic acid has a chelating effect, the content of brown rice does not deplete the useful minerals.

Lipopolysaccharide (LPS)

Brown rice contains LPS. This is a component common to the surface membranes of *Escherichia coli* and Salmonella, however, LPS is not pathogenic. When a small amount of LPS enters the intestinal tract together with brown rice, the bowel movement becomes active and activates macrophages having a bacterial phagocytosis [27]. LPS is known to increse the secretion of mucus and bactericidal substances from the intestinal mucosa. As a result, innate immunity is strengthened. Also, LPS prevents the onset of allergic diseases such as pollinosis and reduces the symptoms [28]. It has been reported that it stimulates microglial cells to stimulate the phagocytosis of amyloid β in the brain [29].

The mechanism and components involved in improving skin condition

Next, we will discuss the mechanism and components involved in improving skin condition observed by DBR ingestion. In general, skin condition changes due to aging and various environmental factors. Among these factors, the effect of ultra violet (UV) exposure is the largest. This is called photoaging, and the main mechanism is oxidative stress [30]. As menopause approaches, complaints of skin problems increase as estrogen secretion decreases. However, since the subjects this time are young people, the involvement of these factors is small. It is presumed that the effect of glycative stress is greater than these. When collagen and elatin that make up the skin are denatured by glycative stress, elasticity is reduced, thus causing skin sagging. Accumulation of AGEs causes yellowing in skin. Glycation of keratin and filaggrin (a natural moisture factor) increases transepidermal water loss (TEWL) and reduces the moisturizing function. A decrease in filaggrin promotes the breakdown of the skin barrier and increases the risk of developing atopic dermatitis [31].

Effects known for brown rice (including processed brown rice) include the amerioration of triglyceridenia and total cholesterolemia [32, 33], improvement of postprandial hyperglycemia [34, 35], reduction of fasting blood glucose [36] and HbA1c [37, 38] and reduction of visceral fat in metabolic syndrome [39], which are all actions that reduce glycative stress. Dietary fiber is known to have an improving effect on the intestinal flora [40, 41], and promotes basal metabolism via elevated

production of short-chain fatty acids [19], thus contributing to the reduction of glycative stress. The restoration of the intestinal flora leads to the improvement of skin condition via improvement of bowel movement [42]. In addition, for photoaging [30], which is a major cause of skin disorders, antioxidants such as ferulic acid reduce oxidative stress associated with UV exposure. As a result of these mechanisms acting in an integrated manner, it is possible that they had a fevorable effect on skin condition (*Fig. 6*).

The effect of sntioxidant ferulic acid and dietary fiber that regulates the intestinal environment

There are also some reports on the effects of DBR. It contains about 100 times more LPS than polished rice, and LPS activates macrophages mainly via TLR4 [3]. LPS is derived from symbiotic bacteria and is also abundant in the bran layer. Animal experiments have shown that ingestion of DBR powder into antibiotic-induced constipation model mice significantly suppressed weight loss and improved bowel movements compared to control mice to which antibiotics alone were administered [4]. In pollinosis model mice, an anti-allergic effect was observed by the supplemented feed of DBR subglue powder layer extract as compared with to the control (mice administed with no additive feed) [28]. In a clinical trial in humans, the cognitive ability evaluation scale, HDS-R (Revised Hasegawa's Dementia Scale), improved as a result of ingesting DBR for six months in the elderly, where an association was found between DVR intake and the scale scores [43]. Brown rice, which is rich in LPS, is expected to be useful as a staple food that helps maintain good health.

One of the causes of skin disorders is allergic disease. Adult atopic dermatitis has been on the rise in the last 30 years, it is said that it has finally reached a plateau in recent years. There are many cases with a latent predisposition to easily produce the IgE antibody, and it is expected that it will affect the skin condition of young people in particular. It is possible that the allergic symptom-reducing effect of LPS in brown rice [28] had a positive effect on this problem. The details of the action mechanism of LPS for allergy relief remains unclear. Further research is needed in the future.

Comparison of DBR and SARFR

The test product (DBR) is processed from brown riceto be easy to eat, leaving nutrients by removing only the wax layer of the epidermis and the outer layer containing a large amount of indigestible fiber.

In SARFR, the wax layer and part of the bran layer are removed, while, in DBR, only the wax layer is removed, which is closer to brown rice and rich in nutrients. Since dietary fiber is contained in a slightly large amount, the effect varies from person to person, and some people can accept the positive effect, while others may exhibit discomfort due to dietary fiber.

Comparing the previous report using SARFR [6] with this study, there was no difference in intake compliance between DBR and SARFR, and there was no safety problem in either case.

Furthermore, both showed improvement in skin condition (skin age as an index), and there was no difference in the magnitude of the effect between the two. The feeding period was one month in this study. If DBR was taken for a longer period of several years or more, it might be more effective. When individuals want to start a processed brown rice diet, they should choose DBR or SARFR according to their taste and physical condition.

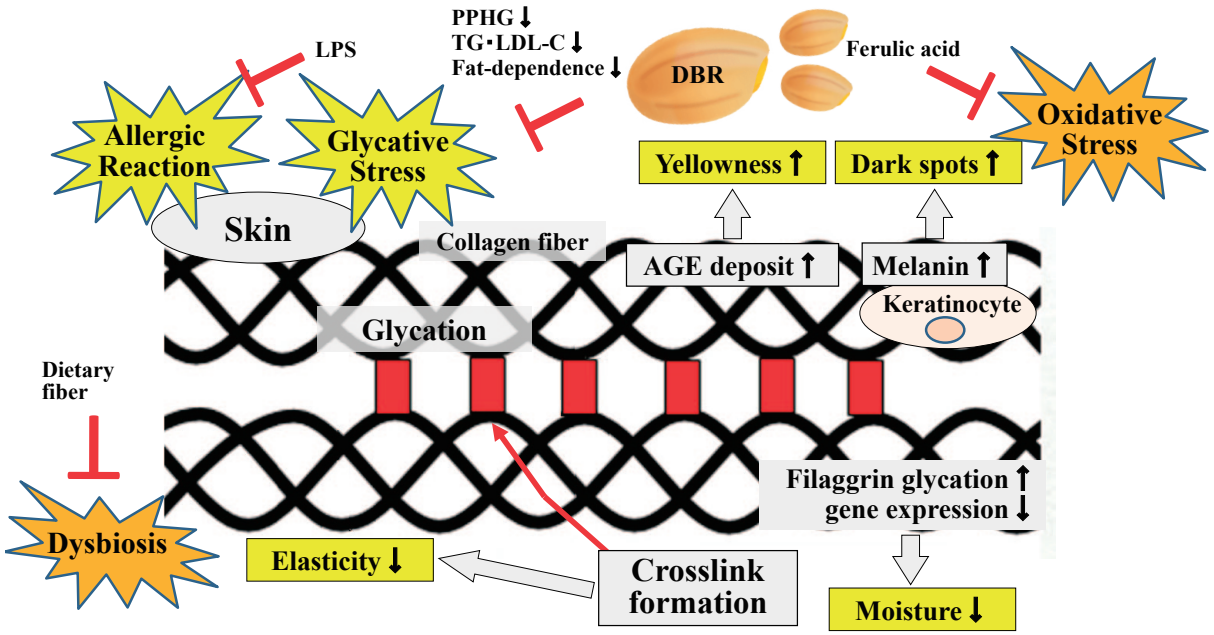

Fig. 6. **The possible suppressive actions by DBR.**

DBR, dewxwd brown rice; AGEs, advanced glycation endproducts; PPHG, post-prandial hyperglycemia: TG, triglycemide, LDL-C, low-desity lipoprotein-cholesterol; LPS, lpopolysaccharide;

Safety

Brown rice, DBR, and polished rice are basically staple foods. Therefore, they have abundant food uses and are fully guaranteed for food safety. There was a time when pesticide residues in brown rice were regarded as a problem, but all recent test results are within the standard values [44,45]. Even if a small amount of foreign matter adheres to the outer layer, it will be scraped off by special rice milling, so no problem will occur. No adverse events related to DBR have been reported in this study or in past clinical studies [42]. After all, it was judged that there was no problem with the safety of DBR.

Abscisic acid is known as a phytohormone that regulates plant growth and physiological activity, and is present in all plants including brown rice. It has an anti-inflammatory effect and is a food ingredient expected for impaired glucose tolerance and inflammatory bowel disease [46,47]. In a report [48] that integrated information and evaluated the safety of the ingestion of brown rice, indicating that the harm event was not reported, it is considered that danger is hardly a problem and the health effect is greater.

Conclusion

As a result of ingesting a test meal (DBR) of 150 g or more once a day for one month for university students and staffs, no gastrointestinal symptoms were observed, intake compliance was good, and a significant skin condition improving effect was observed. It was suggested that DBR may contribute to health promotion such as improvement of skin condition by reducing the indigestibility of brown rice and ensuring nutritional value.

Conflict of interest declaration.

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