Chapter

The Potential Health Benefits of Brown Rice

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Abstract

In many countries, rice contributes to better health by supplying dietary energy, proteins, fat, and various micronutrients. Many different rice species are cultivated in Japan and other rice-producing countries, in which we expect some varieties to prevent many diseases. In particular, the health effects of brown rice are apparent. In particular, rice bran ingredients accumulated evidence about their physiological and pharmacological activity. The Japanese diet has become a world heritage and famous worldwide, but knowledge about the benefits of rice eating is limited. Here, we would like to focus on the benefits of eating brown rice and recently developed low-protein fermented brown rice (LPFG) to improve the gut-kidney axis's negative spiral in kidney disease patients. Other potential benefits of brown rice are the suppression of dementia and celiac disease. The category of "medical rice" represents the health effects of rice eating.

Keywords: Brown rice, functional ingredients, gut microbiota, short-chain fatty acids, medical rice, low protein fermented genmai, GENKI study

1. Introduction

Approximately 70 percent of the world's population eats rice as a staple food, especially in areas of the Asia-Pacific region [1]. Rice can supply energy, proteins, and fat, which accounts for more than half of the diet in southeastern countries [2]. In the 19th century, traditional Japanese meals were of unpolished brown rice, miso soup, and dishes of soybean products, vegetables, potatoes, and other roots. In the Meiji era, polished white rice became popular, and beriberi increased in the nation. After World War II, western life habits introduced white bread, meat, eggs, and dairy products, which became the significant foods composing main and side dishes. Consequently, obesity and other lifestyle-related chronic diseases have increased [3].

Another traditional way of eating in Japan is macrobiotics. Yukikazu Sakurazawa (George Ohsawa) made the foundation and emphasized genmai (brown rice) and whole foods as the central dogma of the macrobiotic diet [4]. Macrobiotic meals, such as seasonal vegetables, beans, and sea vegetables with brown rice, are plant-based and contain functional factors in addition to ordinary nutrients.

In this regard, the nutritional effects of rice should be more studied, especially the integrated composition of functional ingredients [5, 6]. We cultivate more than 200 different rice species in Japan. We can use some varieties for dietary therapy. For example, high-amylose hard rice is available for diabetic patients [7]; low-protein rice for patients with chronic renal disease [8, 9]; GABA-rich large germ rice for mental health [10]; and rice with high antioxidant activity may be effective for the prevention of cancer and other diseases [11, 12].

The health effects of brown rice are traditionally well known. We proposed to summarize the above rice in the new concept, “medical rice.” Examples are medical rice for diabetes, medical rice for chronic kidney disease (CKD), medical rice for mental health, medical rice for cancer prevention, etc. [13].

In response to the enormous increase in medical costs in many countries, achieving healthy longevity by changes in dietary habits is mandatory. The proper food labeling of evidence-based medical rice can treat people who want to improve their health [14].

Human data are increasing, so we believe it is time to implement the concept of medical rice for disease prevention and treatment [15].

2. Functional ingredients in rice

2.1 Functional ingredients in rice

Rice can supply energy, proteins, fat, vitamins, and minerals [5, 6, 15]. Red rice and black rice have rich dietary fiber, but it is not popular because of their taste (**Table 1**).

Whole brown rice contains rich vitamins, minerals, dietary fibers, and various functional chemicals compared with white rice. About 8.5 million tons of brown rice are produced annually in Japan, and rice bran makes up about 10% of unprocessed rice by weight and contains 18–22% oil. Rice oil contains up to 5% of unsaponifiable dark oil. The active ingredients in the oil are γ-oryzanol, tocotrienol, GABA, and inositol [16–18].

We can apply rice bran to food, animal feed, and fertilizer but discard most of the bran. Recently, we have paid much attention to rice bran because of the various pharmacological properties of its ingredients [19–21]. We separate into gum, wax, dark oil, and scum at different boiling temperatures, and further extraction yields many chemicals with biological activities.

γ-oryzanol is a potent functional ingredient in the nonsaponifiable fraction of rice bran. γ-oryzanol is bound in 4 chemical forms to ferulic acid and thus belongs to the family of ferulated sterols [20, 21]. The solubility of γ-oryzanol is only 0.06% in water and 0.2% in 20% ethanol. The absorption of γ-oryzanol may not be optimal by oral intake of brown rice, but it is possible to take 300 mg of γ-oryzanol orally from brown rice. Kokumai et al. [22] administered a single oral administration of 300 μmol/kg body weight of rice bran γ-oryzanol to rats and showed that intact γ-oryzanol, along with ferulic acid and ferulic acid conjugates, existed in the blood.

2.2 Nutritional aspect of brown rice

We have studied the macrobiotic practitioners by GENKI study (genmai epidemiology nutrition and kenko innovation) [23]. They consumed more magnesium, iron, vitamin Es, vitamin Bs, and dietary fibers, although their energy intake is less than that of ordinary Japanese. Their blood pressure, body mass index (BMI), and low-density lipoprotein cholesterol levels are low, while blood glucose and glycated hemoglobin (HbA1c) remained within normal levels.

boiled rice 100 g	**unit**	**Brown rice**	**White Indica rice**	**White Japonica**	**White no amylose**	**Red rice***	**Black rice***
Energy	kJ	647	781	663	801	636	634
Energy	kcal	152	184	156	188	150	150
Water	g	60.0	54.0	60.0	52.1	61.3	62.0**
Protein	g	2.8	3.8	2.5	3.5	3.8	3.6
Fat	g	1.0	0.4	0.3	0.5	1.3	1.4
Carbohydrate	g	32.0	37.3	34.6	41.5	28.2	28.2
Fiber	g	1.4	0.4	0.3	(0.4)	3.4	3.3
Soluble	g	0.2	0	0	0	0.2	0.3
Insoluble	g	1.2	0.4	0.3	0.4	2.3	2
Polyalcohol	g	—	—	—	0	0	—
Carbohydrate_all	g	35.6	41.5	37.1	43.9	32.7	32.2
Organic acid	g	—	—	—	—	—	—
ash	g	0.6	0.2	0.1	0.1	0.6	0.6
Na	mg	1	0	1	0	1	Tr
K	mg	95	31	29	28	120	130
Ca	mg	7	2	3	2	5	7
Mg	mg	49	8	7	5	55	55
P	mg	130	41	34	19	150	150
Fe	mg	0.6	0.2	0.1	0.1	0.5	0.4
Zn	mg	0.8	0.8	0.6	0.8	1.0	0.9
Cu	mg	0.12	0.10	0.10	0.11	0.12	0.11
Mn	mg	1.04	0.42	0.35	0.50	1.00	1.95
Se	mg	1	3	1	1	1	2
Cr	mg	0	1	0	0	Tr	1
Mo	mg	34	32	30	48	24	33
Beta carotene	mg	0	(0)	0	(0)	1	8
Vitamin D	mg	(0)	(0)	(0)	(0)	—	—
Tocophrol α	mg	0.5	0	Tr	(Tr)	0.6	0.3
Vitamin K	mg	(0)	(0)	(0)	(0)	—	—
Thiamin	mg	0.16	0.02	0.02	0.03	0.15	0.14
Riboflavin	mg	0.02	Tr	0.01	0.01	0.02	0.04
Niacin	mg	2.9	0.3	0.2	0.2	2.8	3.0
Niacin eq.	mg	3.6	1.3	0.8	1.0	3.4	3.6
Vitamin B6	mg	0.21	0.02	0.02	(0.02)	0.19	0.18
Vitamin B12	µg	(0)	(0)	(0)	(0)	—	—
Folate	µg	10	6	3	(4)	9	19
Pantothenic acid	mg	0.65	0.24	0.25	(0.30)	0.47	0.40

boiled rice 100 g	unit	Brown rice	White Indica rice	White Japonica	White no amylose	Red rice*	Black rice*
Biotin	μg	2.5	0.5	0.5	(0.5)	2.8	2.7
Vitamin C	mg	(0)	(0)	(0)	(0)	—	—
NaCl eq.	mg	0	0	0	0	0	0

**Polyphenol 0.2 g.*
***DF by AOAO2011.25 method.*
Insoluble dietary fiber is rich in brown rice, especially red and black rice. Red and black rice contain about 0.2 g of polyphenol, so the taste is not good. No amylose rice is used for "mochi" (sticky rice cake).

Table 1.
Nutrients in 100 g boiled rice.

The macrobiotic dietary habit of eating brown rice contributed to their healthy state [24–29]. The consumption of small fish provided vitamin B12, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). Genmai-shoku (diet) provides enough energy, fat, protein, and several times more minerals and vitamins than required [26, 30].

In addition to the functional effects of ingredients, chewing frequency influences brain function in genmai eaters [31]. In Japan, fast foods with soft textures have recently become popular with a younger generation, and the oral biting frequency has decreased in the younger proportion. Boiled brown rice increases the chewing number of times than meat or fish dishes, and it was only 800 times per American dish compared to the 30,000 times by the genmai diet. Longer eating time prevents fast eating, which used to lead to obesity and gives relaxation to solve stress.

So, brown rice could be a core of "medical rice for health" strategy. In addition, organic rice is free from arsenic and other toxic chemicals absorbed from fertilizers and insecticides [5, 31].

2.3 Functional ingredients in rice bran

2.3.1 Lipophilic ingredients

Phenolic compounds are rice's primary antioxidant and radical scavenging ingredients [32–35]. In brown rice, the three most abundant ones are 6'-O-feruloylsucrose, 6'-Osinapoylsucrose, and ferulic acid. Their representative concentrations of 1.09, 0.42, and 0.33 mg/100 g rice flour represent 84.0% by weight of the total amount of soluble phenolic compounds (2.19 mg/100 g brown rice flour). Polished rice contains only 0.28 mg of phenolic compounds/100 g of rice flour.

Lipophilic ingredients can decrease total and LDL cholesterol; triacylglycerol and ApoB. They increase HDL cholesterol and inhibit platelet aggregation. Ferulic, caffeic, sinapinic, p-coumaric, vanillic, protocatechuic, syringic, hydroxybenzoic, and chlorogenic acid are also present, but the dose is scanty.

Tocopherol, triacylglycerol, and ApoB are lipid-soluble antioxidants that prevent cardiovascular diseases and cancer. Squalene, an isoprenoid compound structurally similar to beta-carotene, is an intermediate metabolite in synthesizing cholesterol. In humans, about 60 percent of dietary squalene is absorbed. Lipophylic antioxidant is rich in genmai [36].

2.3.2 Water-soluble ingredients

Inositol and phytic acid are water-soluble ingredients like GABA [37–39]. Magnesium, calcium, and other trace elements are also present in this fraction. In 2008, Maeba et al. [40] gave inositol orally to obese people for two weeks and observed improvement in waist circumference, high-sensitivity CRP, and fasting blood glucose level. He suggested plasmalogen was a key factor mediating the beneficial effect of inositol on metabolic syndrome. Myoinositol is a ring-shaped polyalcohol and element of the vitamin B complex. Taking large amounts of inositol (more than 10 g daily) could improve panic syndrome [41]. Phytic acid is phosphatized inositol and has a solid chelating and pH adjustment effect.

2.3.3 Healthy feeling and rice eating

Large-germ brown rice and pre-germinated brown rice contain functional ingredients to prevent dementia. Large germ rice and pre-germinated brown rice contain a high amount of GABA. GABA and γ-oryzanol are involved in the metabolism of hypothalamic catecholamines. γ-Oryzanol is known to have anti-stress effects, to palliate menopausal disorders and dysautonomia. The curative effect of Alzheimer's disease and amelioration in muscular fatigue is also present. GABA and γ-oryzanol have many activities, but the main hope is to improve cognitive function [42, 43].

The effect of ferulic acid mixed with Angelic archangelica extract on cognitive functions and behavioral and psychological symptoms of dementia has been examined by Kimura et al. [44], and many symptoms were shown to improve.

Pregnant women often become unstable in their mood. In an intervention study, pregnant women were randomized to take germinated rice or white rice for 14 days. They carried out a psychological test profile of mood states (POMS) before and after the study and employed salivary amylase as a stress marker.

Other components of rice bran, like steryl glucosides, were found to be effective for coping with stress. So, medical rice for mental health is at least defined to contain high GABA and γ-Oryzanol or ferulic acid.

Otsubo et al. [7] adopted the blend of super-hard genmai, wax-free genmai, and ordinary genmai at the rate of 4:4:2, adding 2.5% bran and 0.3% rice oil for the taste. This boiled rice is rich in dietary fiber, anthocyanin, and free ferulic acid and shows β-secretase inhibitory activity. A randomized study on 24 subjects for 12 weeks exhibited significant improvement in language memory by cognitive test.

3. Rice eating, gut microbiota, and short chain fatty acids

3.1 Rice eating and intestinal microbiota

Our study in Japan and community-wide analyses of the gut microbiota in Ireland showed that the intestinal microbiota varied by their dietary habits and living conditions [45, 46]. Intestinal microbiota change very rapidly in cases of fasting and Ayurveda (*Virechana* and *Basti*) [47, 48].

Numerous human studies, however, consistently demonstrated that gut microbiota could modulate host health [49, 50]. We focused on the people who had eaten brown rice in 2016 and 2017 (GENKI study I). We found that genmai eaters keep a healthy body weight (BMI 22.5) and have a good bowel movement. They preferred plant-based Japanese foods, avoiding meat and dairy products [26]. They disliked the oily and spicy taste and selected new, organic, with no additives, without genetically modified foodstuff, or domestic production. One hundred nine of them (male: 18; 50.1 ± 15.1 years old, female: 91, 55.8 ± 13.8 years old) agreed to examine the fecal bacteria [45].

Common bacterial profiles at phylum level were *Fermicutes* 44.3 *Bacteroides* 20.7 ± ±9.9%, 8.8%, *Actinobacteria* 8.3 ± 6.3%, *Proteobacteria* 1.7 ± 2.7%, and *Verrucobacteria* 1.2 ± 4.2% (max 39.4%). It represented only a minute fraction of gut microbiota, but they showed a characteristic pattern of rice eaters. The number of genera more than 1.0% was 15, more than 0.01%, and max more than 1.0% was 57 among 214 genera. The more than 80% prevalence of microbiota among participants was 31 (**Figure 1**). Common bacteria more than 1% profile were *Bacteroides* (12.7%), *Blautia* (8.3%), *Faecalibacterium* (7.9%), *Bifidobacterium* (6.3%), *Prevotella* (5.3%), *Eubacterium* (4.9%), *Ruminococcus* (3.8%), *Fusicatenibacter* (2.6%), *Collinsella* (1.9%), *Streptococcus* (2.4%), *Subdoligranulum* (2.1%), *Anaerostipes* (1.7%), *Ak*kermansia (1.2%), and *Roseburia* (1.7%). Individual variety was large, and we had to be careful about analyzing the network among the microbiota.

Correlation among these bacteria showed that *Firmicutes* negatively correlated with all other phyla. Although *Lachnoclocstridium Lactobacillus, Interstinibacter, Enterococcus, Mitsuokella, Tyzzerella*, and *Erysipelatoclostrium* in *Firmicutes* phylum, and *Alistipes* and *Odoribacter* in *Bacteroides* phylum showed a significant correlation. *Ruminococcus, Fusicaternibacter,* and *Anaerostipes* negatively correlated with the above genera. *Bifidobacterium* only showed a positive correlation with *Fusobacterium*.

Bacterial communication for growth should be further analyzed in the future [46–48].

3.2 Short chain fatty acids and gut environment (immunity)

Intestinal microbiota produces short chain fatty acids, such as acetate, propionate, butyrate, valeric, and caproate [49–52].

Genmai diets contain high levels of nondigestible dietary fiber, passing through the small intestine and leading to bacterial fermentation in the colon. The mildly acidic condition in the proximal colon fits butyrate production [50]. From the recent intestinal bacterial research, short chain fatty acid, especially butyrate-producing bacteria, is a focus of studies. Butyrate becomes an energy source for the colonic epithelial cells, maintains the gut barrier functions, and develops immune regulation and anti-inflammatory properties [52].

Butyrate was produced not only from dietary fiber but also from lactate, encompassing *A. caccae, A. butyraticus, A. hadrus, and E. hallii*. Furthermore, bacteria related to *Eubacterium hallii* and *Anaerostipes caccae* convert acetate and lactate into butyrate.

We had done the intervention study with a brown rice lunch five times/week as a business lunch for 12 weeks [51]. The results suggested that brown rice-eating induced stable innate immunity by short-chain fatty acids (SCFA), which stimulated the proliferation of regulatory T cells [52–54]. In that study, brown rice genmai omusubi (rice cake) was provided. We measured IL-6, CRP, and TNFα, as inflammatory markers for correlation analysis with microbiota changes.

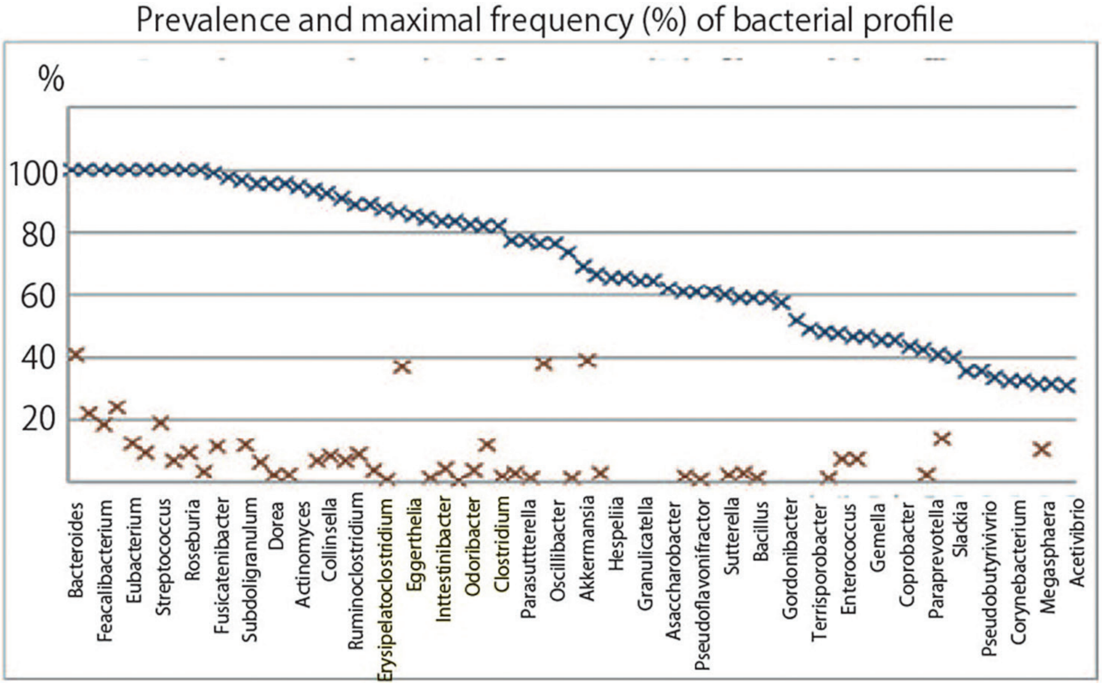

Figure 1.

Prevalence and maximal frequency (%) of bacterial profile among rice eaters. All people have Bacteroides, Faecalibacterium, Eubacterium, Streptococcus, Roseburia, Fusicatenibacter. More than one-third of rice eaters have the common 41 bacteria. Honda's [53] eleven microbiota for adaptive immune reaction are Parabacterium distasonis, Parabacterium gordonii, Alistipes senegalensis, Parabacteroides johnsonii, Parabacteroides xylaniphila, Bacteroides dorei, Bacteroides uniformis JCM5823, Eubacterium limosum, Rumonococcaceae bacterium cv2, Phascolarctobacterium faecium, and Fusobacterium ulcerans. Most people in our study have these bacteria. About 70% of people have Akkermancia [middle]. x shows max occupancy among people.

After three months of eating brown rice lunch, the body weight decreased in about half of the participants, and bowel movements and stool status improved significantly [51]. Brown (genmai) rice favored a gut microbiota with highly prevalent *Firmicute*s and a low prevalence of *Fusobacterium*. Significant microbiotic change was an increase in *Actinobacteria* and a decrease in *Proteobacteria. Blautia wexlerae, Collinsella aerofacience,* and *E. hallii* significantly increased at the species level.

Kenya Honda [53] found 11 rare, low-frequent human microbiome compositions suggesting potential biotherapeutics. Brown rice eaters have most of these, and the difference between brown and white rice eaters by microbiota profile was in high butyrate production. The upper tertial of genmai eaters tended to show low IL-6 and CRP, while TNFα was high. Butyrate binds the GRP109 receptor of the epithelial surface, which signal is transferred to the submucosal layer and stimulates the proliferation and maturation of regulatory T cells [54–56].

We recognized the importance of dendritic cells as the first playmaker because they were tissue-fixed cells and kept intimate communication with T cells [57]. We studied the maturation and distribution of dendritic cells in the human fetus. They first appeared in the thymus of a two-month-old human fetus and then spread to the peripheral lymphoid tissues with T lymphocytes. This movement was independent of the monocyte–macrophage lineage.

Dendritic cells and macrophages processed viral antigens to T4, and T8 lymphocytes, which secreted cytokines and chemokines to cause tissue inflammation. If the secreted cytokines were overshooting [58, 59], any suppressive mechanisms to stabilize immune reaction should be present to avoid severe progression.

4. Processed rice with Japanese agriculture standard (JAS)

4.1 Need of dietary therapy

Kaibara Ekiken (1630–1714) and Ishizuka Sagen's (1851–1909) dietary regimen is the traditional backbone of the Japanese well-being practice. The oriental worldview is more modest and emphasizes sustainability as much as possible. The traditional regimens influence oriental medicine, which promotes dietary therapy for chronic diseases. Integrative nutriology and medicine are grounded in this cultural background.

The longevity of the Japanese provides historical evidence of the above regimens. The Cabinet Office certifies foods for sick people and functional foods in Japan. The Ministry of Agriculture, Forestry, and Fisheries has decided on JAS (Japan Agriculture Standard) and is trying to expand it internationally.

A good example of the necessity of dietary therapy is chronic kidney disease (CKD).

The number of CKD patients is increasing worldwide [60]. The low protein diet was a traditional treatment to decrease proteinuria [61–64], and it was the only method until the 1960s' when invented hemodialysis. Since the 1980s, the development of antihypertensive, antidiabetic, diuretics, and recent SGL-2 inhibitors discarded the usefulness of low protein diet therapy. Even though, these therapies have not decreased the number of end-stage renal disease (ESRD) [65]. Rigorous multidrug treatment in the FROM-J and Doit3 studies in Japan did not show a significant reduction in a complication of CKD in diabetic patients [66, 67]. Recently, the negative spiral of the gut-kidney axis has been found behind CKD [68]. Uremic dysbiosis is associated with endotoxemia and chronic inflammation, disrupting the intestinal barrier and depletion of beneficial bacteria producing short-chain fatty acids. So, it is impossible to halt CKD progression without controlling uremic dysbiosis and leaky gut.

4.2 Low protein fermented genmai (Manufacturing Process Control JAS for LPFG)

We succeeded in deleting the rice protein from the brown rice bran by a particular combination of enzyme solution and *Lactobacillus plantaris* [9, 68, 69]. In addition to the remaining carbohydrate (energy source), low protein, low potassium, low phosphate character of low-protein rice, presence of dietary fiber, γ-oryzanol, and antioxidant activity were the characteristic biomarkers of brown rice.

The combination of four steps was the optimal process to produce LPFG [9, 68]. In *Lactobacillus* fermentation, the ability to produce lactic acid was high, and the pH was rapidly reduced in the early fermentation stage, resulting in an acidic environment. In the optimum pH range, protease activity increased, proteolysis was promoted, and a sharply decreased pH suppressed the growth of other bacteria.

This processed or fermented low protein genmai (LPFG) is approved for the product and process JAS (Japan Agriculture Standard) from the Ministry of Agriculture, Fisheries, and Forestry. These improved the negative spiral of the gut-kidney axis caused by uremic dysbiosis and leaky gut.

Dietary therapy for CKD patients must simultaneously control energy source intake and protein restriction. We asked the patients to replace their staple foods with an LPFG package without severely restricting protein from side dishes. A preliminary intervention study of 3 months of LPFG improved constipation by increasing *B. wexlerae*, *Bifidobacteria*, acetic acid, and decreasing harmful bacteria. As expected, the protein intake decreased from 60 g to 50 g daily. If 60 kg man eat 48 g protein (0.8 g/kg body weight), 10 g decrease becomes 38 g (0.62 g/kg). If a 50 kg woman takes 40 g protein, 10 g decreased intake becomes 30 g (0.6 g/kg). So, people can easily practice a low protein diet to decrease protein intake.

There are several RCTs about the low protein diet, but the results are still debatable [65, 69, 70] . The programmed protein intake often became over at the end of the study, and the difference between control became small. Or total energy intake often becomes insufficient by reducing the diet. So, we would say that almost all RCTs failed due to difficulty keeping the programmed amount of protein and energy source intake throughout the study period.

Individual difference is more significant if we consider the gut-kidney axis and other intrabody metabolic networks. Taste preferences and receptivity to dietary advice are also influenced by personality [71].

As RCTs could not be performed successfully, the basis of the guideline is unstable in CKD. We would start the LPFG intervention study on CKD patients through the pro- and post-comparison study. Diet is essential for patients with renal insufficiency, but compliance is not easy. However, a diet that only substitutes white rice for the LPFG package and has no strict limitations for side dishes is easy to maintain good adherence to protein control.

Comparing pre-and post-assessment is a more straightforward and practical method under the solution-oriented strategy. Diet therapy is the key to success through the patient's self-reliant will and is suitable for efforts involving patients. CKD's silent nature, with its unpredictable symptoms, is a significant barrier to motivating patients' behavioral changes and therapeutic decision-making by healthcare providers [72–74].

4.3 Celiac disease and low gluterin rice

Celiac disease is a long-term autoimmune disorder that primarily affects the small intestine [75–77]. Classic symptoms include gastrointestinal problems such as chronic diarrhea, abdominal distention, malabsorption, loss of appetite, and failure to grow in normal children [78]. Non-classic symptoms are common in children older than two years [79]. There may be mild or absent gastrointestinal symptoms involving any part of the body or no apparent symptoms. A reaction to gluten causes coeliac disease, a group of various proteins found in wheat. Upon exposure to gluten, several different autoantibodies are made, which affect several organs [80, 81]. In the small intestine, this causes an inflammatory reaction and may cause villous atrophy.

The only known effective treatment is a strict lifelong gluten-free diet, which improves symptoms and reduces the risk of complications in most people [78]. It is estimated that 80% of cases remain undiagnosed, usually because of minimal or absent gastrointestinal complaints and a lack of knowledge of symptoms and diagnostic criteria [80].

The term "gluten-free" is not mean "complete absence." A recent systematic review concluded that consuming less than 10 mg of gluten daily is unlikely to cause histological abnormalities.

Regulation of the "gluten-free" label differs. The European Union issued rules in 2009 limiting the use of "gluten-free" labels for food products to those with less than

20 mg/kg of gluten and "very low gluten" labels for those with less than 100 mg/kg [82, 83]. The USFDA issued regulations in 2013 limiting the use of "gluten-free" labels for food products to those with less than 20 ppm of gluten [83]. The international Codex Alimentarius standard allows for 20 ppm of gluten in so-called "gluten-free" foods [84].

In October 2020, the Ministry of Agriculture, Forestry, and Fisheries announced that the product's gluten content should be one ppm or less by identifying where gluten may be mixed in the rice flour manufacturing process and preventing gluten from being mixed. The "Manufacturing Process Control JAS for Non-Gluten Rice Flour (JAS0014)" standard started for managing the manufacturing process. Regarding the JAS, since June 2021, the Japan Agricultural Standards Certification Alliance, which is a registered certification body, has just started certification.

Promoting the spread of Japanese gluten-free rice flour would help many patients in Europe and the USA.

5. Conclusion

Genmai eaters in the macrobiotic groups are usually calm and peaceful. Many functional ingredients are related to keeping healthy and preventing diseases, such as obesity, diabetes, hypertension, and impaired recognition. In addition to the health benefit, a recent study on the microbiota-gut-brain relationship is also a target for future research [74]. Diets focused on certain rice types influenced the bacterial profile and production of short-chain fatty acids. These affect the innate immunity and control immune response after that [85].

CKD is increasing worldwide, and recently it happened in an aging society and the diabetic complication and end-stage glomerulonephritis. A low-protein diet is the most effective intervention for the prevention of CKD. LPFG could provide enough energy with low protein, low potassium, and low phosphate, and brown rice's health benefits by dietary fiber, γ-oryzanol, and antioxidant activity for CKD patients. LPFG could be available for patients with renal insufficiency at any stage, and it may be the first clear target of "medical rice." Celiac disease, common in Europe and USA, can be controlled by a gluten-free rice powder. The gluten-free powder with JAS certification can yield many foods that assure celiac disease prevention.

Although the shreds of evidence of dietary therapy for various diseases are still insufficient, the concept of "medical rice" could be widened in the future (**Table 2**).

Medical rice for chronic kidney disease (CKD) (protein<1/20),
Medical rice for wellbeing (enough nutrients and organic culture).
Medical rice for diabetes (glycemic index<55),
Medical rice for mental health (high GABA, γ-oryzanol, and/or ferulic acid).
Medical rice for cancer prevention (high antioxidant capacity).
Organic cultivation is necessary to avoid toxic substances from fertilizers and insecticides and it contributes to natural environment. Fair trade for farmers is also employed by the purchase of rice at more than 800 yen/kg.

Table 2.
Candidate of medical rice.

Abbreviations

GABA	γ-aminobutylic acid
CKD	chronic kidney disease
LPFG	low protein fermented genmai
BMI	Body Mass Index
EPA	eicosapentaenoic acid
DHA	docosahexaenoic acid
HDL	high-density lipoproteins
RCT	Randomized Clinical Trials
POMS	Profile of Mood States
JAS	Japan Agriculture Standard

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