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Characteristics of Sprout Rice Grain in Japan

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Abstract

Rice grain has several styles, brown rice, white one, semi-white one, sprout one, etc. All of them are utilized as gohan(=boiled grain) in the dietary life. Among them, the sprout rice, recently developed on the industrial level, has been found to be so conspicuous for general functions in food science and for healthy functions in dietary life that would be worth to characteristically be called "super rice". Thus, the super rice should widely be promoted for production and consumption in the world.

Key words : Rice, sprout rice, super rice.

Introduction

Among the three main cereals, wheat, rice and corn, in the world, rice has long been a staple food mainly in Asia including Japan. The consumption of rice, however, has decreased down in Japan to below the half for 40 years, ca. 58 kg/person/year in 1999, owing to improvements of the food conditions in demands and supplies with high growth of the national economy and with speedy modernization of the national dietary life after the War.

The situations have brought, on one hand, an elevation of the national physique as well as a rise of average longevity of the national age(Being on the top level in the world at least for now; woman: 85 of age, man: 78 of age, 2003). On the other hand, a damage of the national health as well as an increase of the so-called civilization diseases, or the luxury ones-apoplexy, arteriosclerosis, myocardial infraction etc.

Therefore, various attempts for establishment of the healthy dietary life have widely been searched and proposed in these years in Japan, particularly on healthy and convenient utilization of rice grain as the principal meal in this country. Development studies on the sprout rice would be one of them.

The present paper will discuss the food-scientific functions of rice grain centering around the sprout rice. General and fundamental food science of rice grain has often been reviewed up to now(Chikubu *et al* 1995, Fujino *et al* 1999~2004, Henry *et al* 1996, Houston *et al* 1972, Yoshikawa H 1995), and instructively and valuably referred even in this paper basically.

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Result & Discussion

1. Development of Sprout Rice(Fujino Y *et al* 1999~2004)

1) Rice Grain

Rice grain has practically been taken in several styles as brown rice, white rice, semi-white rice and so on among the rice eating peoples in the world. In recent years, the white rice is exclusively taken as usual especially in Japan probably because of deliciousness in the mouth-feeling. It has generally been known, meanwhile, that the brown rice grain is nutritionally superior to the white one, being tastingly inferior to the white one. Thus, the sprout rice grain has begun to appear on the stage as an intermediate of the two styles.

Sprout rice, used in fact at the home level since old times in Japan(Japanese used to emerge the brown rice grain into water overnight for softening before boiling in the next morning. This means that the emerge ordinarily caused a faint germination to produce a kind of sprout rice. Thus, Japanese might possibly be said to have taken "sprout rice" since old days.), has become to be produced at the factory level in these years. The productive relationships of the three styles of rice

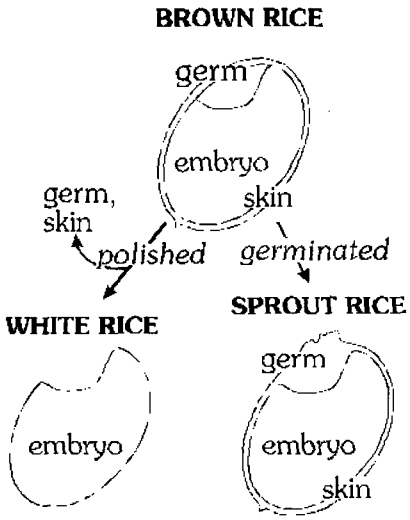


Fig. 1. Productive relationships of brown, sprout and white rice.

grain are shown in Fig. 1.

2) Gohan

Gohan is a Japanese word, which is popularly used in Japan as a polite and or respectful expression for boiled-rice grain.

The rice grain is usually eaten as gohan after having been boiled with water. Boiling brings swelling and softening to the structure and tissue of the raw grain, especially gelatinization to the raw starchy tissues. Thus, gohan is much easier to be taken than the raw grain. Relation of the raw rice grain to the gohan is similar to that of the raw wheat grain or the wheat powder to the bread.

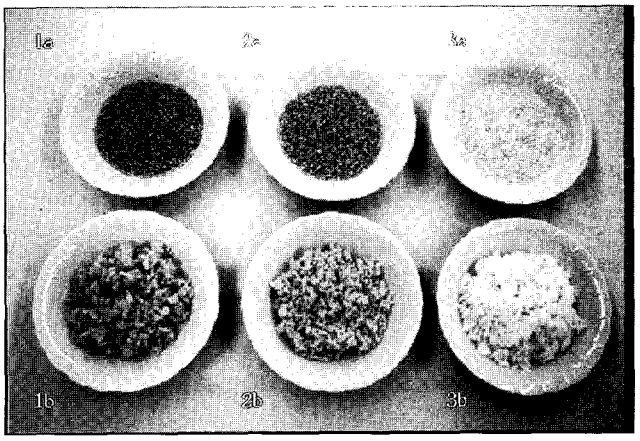
Appearance by photograph of three styles in rice grain is shown in Fig. 2.

3) Availability of Sprout Rice

Sprout rice is not always peculiar rice. It can be practically handled, treated, cooked and processed almost in the same way as the white and or brown rice like up to now.

The sprout rice is equally available to all the useful ways of the white and or brown rice, not only as the raw grain but also as the gohan.

Incidentally, the idea and the methodology for production of the sprout rice would widely be available to the various seed foods such as cereals, legumes and so forth. Sprouting technology might be recommendable to apply at least even to the other cereals for healthier utilization.



1a. brown rice, *raw* 2a. sprout rice, *raw* 3a. white rice, *raw*
1b. brown rice, *gohan* 2b. sprout rice, *gohan* 3b. white rice, *gohan*

Fig. 2. Brown, sprout and white rice grain.

2. Sensuous Function of Sprout Rice

Sensuousity for food generally consist of physical aspect (shape, size, texture, etc.) and chemical one(color, odor, taste, etc.). Sensuous function of sprout rice would be almost intermediate between brown rice and white one not only texturally but also chemically(Since the physical and chemical aspects are complicatedly and delicately related to one another, sensuousity for food should generally be understood comprehensively as a total or whole feeling.).

1) Texture(Fujino Y *et al* 1999~2004)

Texture of gohan is quite various depending on styles, species, cultivation and so on of rice. Human receptibility, meanwhile, is also varied according to age, race, nation, dietary custom, folkways and so forth of people.

In general, Indica rice, rich in amylose, and thus poor in viscosity, is favored by the people in the Indica-rice producing area(mainly the most of Asian areas): Japonica rice, rich in amylopectin, and thus abundant in viscosity, by the people in the Japonica-rice producing area(mainly parts of East-Asian areas).

Speaking of textural comparison among three styles of Japonica rice, the sprout gohan is texturally situated nearly in intermediate between the brown gohan and the white one being rather close to the latter(Table 1).

Sprout rice could texturally be said to be "to white rice-close rice" or "whitish brown rice". Further, it seems a tendency in these days that sprout rice and even brown rice are gradually becoming more acceptable than white rice in textural feeling.

Table 1. Texture of rice grain(gohan)[1)]

Texture	Grade	Brown gohan	Sprout gohan	White gohan
Fibrousity (crudeness, roughness etc.)	Rough	+	−	−
	Mostly	+	−	−
	Rather	+	±	±
	Somewhat	±	±	+
	Not	±	+	+
Visco-elasticity (viscousness, elasticness etc.)	Viscous	−	+	+
	Mostly	−	+	+
	Rather	±	±	±
	Somewhat	+	±	±
	Not	+	−	−
Passability (smoothness, swallowable ness etc.)	Smooth	−	+	+
	Mostly	−	+	+
	Rather	+	+	+
	Somewhat	+	−	−
	Not	+	−	−
Total feeling (favourableness, desirous ness etc.)	Good	+	+	+
	Mostly	+	+	+
	Rather	+	±	−
	Somewhat	+	−	−
	Not	−	−	−

[1)] Japonica rice sp., var. *uruchi*, was tasted by group in Hyogo Coll. of Nutrition.

2) Color(Chikubu S *et al* 1995)

(1) Brown · Red Rice

The outer part, consisting of skin and germ, being combinatively called rice bran, in brown grain bear brown color especially over the skin. Substancial components of the skin, outer coat of the grain are not always yet clarified in detail, but probably composed of protein, lipid, fiber and pigment. Principal pigment would possibly be catechin, one of flavonoid, postulated from the pigments in the red rice(Red rice is said to be one of the original species of Japonica rice.).

Brown rice sometimes contains a green color, which might come from variation of flavonoid, although a possibility of chlorophyll would not be excluded.

Catechin is a flavan pentaol, polyphenol, belonging to flavonoid group, which would cover the soluble pigment in plants. It is biochemically derived from leucocyanidin, a flavanol, and condensed to form catechol polymer, a kind of tannin with astringency(Fig. 3).

(2) Purple Rice

Pigment in purple rice is known as cyanidin, an aglycone of anthocyan, the representative pigment in flowers. Cyanidin is a flavan tetraol, polyphenol, belonging to flavonoid group. It is biochemically derived also from leucocyanidin(Fig. 3).

(3) Sprout · White Rice

Faint-brown color of the sprout grain would be brought by fading of brown grain during germination. White color of the white grain is based on superficial reflection of embryo after removement of the outer parts from the brown grain by polishing(Fig. 1).

3) Smell(Chikubu S *et al* 1995)

(1) White Rice

Aromatic smell of the fresh white gohan has been reported to be a mixture of several carbonyls(Fig. 4). The carbonyls would actually be degradatives by oxidation of fatty acids in acyl lipids(cf. Fig. 5). Characteristic odor of the aged white rice is said to be mainly hexanal which might come from linoleic acid.

(2) Sprout · Brown Rice

Flavor of the sprout grain is a little stronger than that of the white grain. Flavor of brown rice is called "bran odor", which is tolerably stronger than that of white□sprout rice, pro-

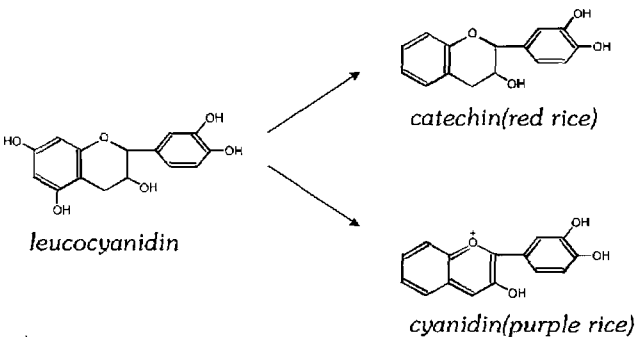


Fig. 3. Main flavonoid pigment in rice grain.

bably because brown rice is rich in lipid especially at the germ area.

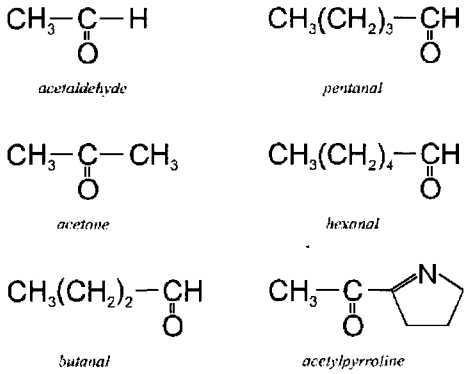


Fig. 4. Flavor in rice grain.

(3) Aroma Rice

A chief flavor of aroma rice has been described as acetylpyrroline(Fig. 4), a kind of carbonyl, which might be transformed from a nitrogenous compound(probably glutamic acid).

4) Savor(Fujino Y *et al* 1999~2004)

(1) White · Sprout Rice

White and sprout gohan usually give a sweet savor faintly. The sweetness depends mostly on glucose and even oligosaccharides, which generate by partial hydrolysis of starch with amylase in the grain and or in the human mouth(Fig. 5). Some amino acids and or even oligopeptides coming from enzymolysis of rice protein(Fig. 5) would contribute to formation of

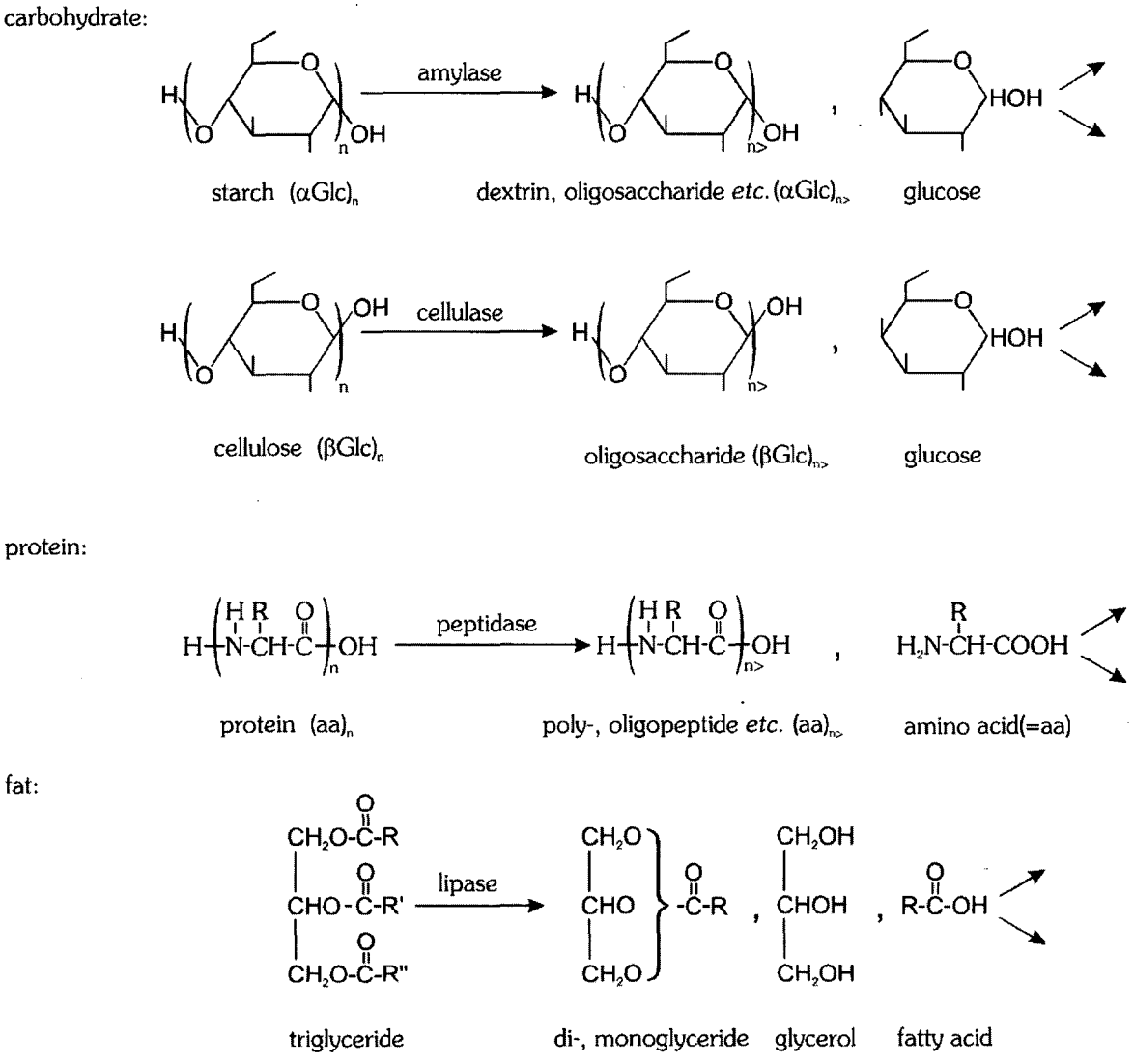


Fig. 5. Possible enzymolysis of principal nutrients in rice grain.

good taste by synergy with the sweetness above.

(2) Brown Rice

Brown grain could also give weakly the good taste, which might be somewhat inhibited or rather mixed with a faint astringent savor based on the pigment flavonoid, which has been missed mostly in sprout grain, absolutely in white grain.

Anyhow, brown rice, rich in various nutrients, would give a more concentrated and complicated savor than sprout and or white grain especially the latter, which is poor in nutrients.

3. Nutritional Function of Rice

1) Energy in Cereal

The value of nutrition in foods firstly depends on the amount of energy. Cereal group could supply in average the most amounts of energy among the other various food groups. Energy of the major cereals is shown in Table 2. The energy comes from the principal nutrients, i.e. carbohydrate(practically starch), protein and lipid. Among the cereals, rice is rather rich in energy.

Rice grain could be said to be one of the most conspicuous food among all the human foods as far as energy is concerned.

2) Nutrient in Rice Grain

(1) Component

Principal nutrients in rice are actually carbohydrate, mostly-starch consisting of amylopectin and amylose, protein, being mainly made up of glutelin and prolamine, and lipid, mostly meaning unsaturated triglyceride. Minor nutrients involve ash and vitamin. Among these nutrients, sensuous and biomedicative components would duplicatively and or independently exist scattered.

Table 2. Energy in cereals

Cereal	Energy	Cereal	Energy
	kcal/100 g		kcal/100 g
Barley	343	Oats	380
Buck wheat	361	Rice	350
Corn	350	Rye	334
Foxtail millet	364	Sorghum	352
Millet	356	Wheat	337

(Resource Search Comm, 2001)

(2) Composition

Nutritional composition of rice grain is shown in Table 3. Brown grain is rich in fiber, lipid, ash and vitamin; white grain in carbohydrate. Although the data for sprout grain have not yet been reported as the authorized one, the composition would be postulated to be almost close to that of brown grain. Composition of sprout grain would be changeable in accordance with germination of the brown grain. Since components in sprout grain would variously be degraded and or modified during germination, the composition might be different more or less between sprout rice and brown rice not only in quantity but also in quality. Grossly speaking, nevertheless, the sprout rice would nutritionally be called "brown-rice-like grain" or even "almost brown grain".

3) Amino Acid in Rice

(1) Composition

Composition of free amino acids in rice grain is shown in Table 4(Saikusa *et al* 1994). Since free amino acids are abundant in germ subsequently in bran, the brown rice is deservedly richer in free amino acids than the white rice.

In the sprout grain, some amino acids increase whereas the other ones decrease, though the data are not described in the table, indicating the enzymolysis for protein is passably various and diverse during germination of the brown grain(Fig. 5).

(2) Score

Speaking of amino acid composition of whole protein in

Table 3. Nutritional composition in rice grain

(per 100 g)

Grain	Water	Carbo-hydrate	Fiber	Pro-tein	Lipid	Ash	Vita-min
	g	g	g	g	g	g	mg
Brown	15.5	73.8	2.3	6.8	2.7	1.2	10>
Sprout*	–	–	–	–	–	–	–
White	15.5	77.1	0.5	6.1	0.9	0.4	3>

*The data have not yet officially been authorized.
(Resource Search Comm, 2001)

Table 4. Content of amino acid in rice

	Bran	Brown grain	White grain
	mg/100 g	mg/100 g	mg/100 g
Histidine	2.9	0.6	0.6
Isoleucine	2.6	0.8	0.7
Leucine	3.8	1.3	1.2
Lysine	5.4	0.7	0.6
Methionine	6.9	1.8	1.6
Phenylalanine	2.6	0.8	0.7
Threonine	5.6	1.0	0.8
Valine	4.8	0.7	0.6
Total	361.4	70.6	52.7

rice grain, the pattern is not always very good, but moderately good, although lysine, one of the essential amino acids, is a little poor, commonly to general cereals. The amino acid score, an index of nutritive evaluation for food protein, is for rice grain figured 64~67, which is in superior level to the other cereal grains(Resource Search Comm 2001).

(3) Protein Intake

Ratio of rice protein to food protein in-taken by Japanese has been reported around 18%, which is considered to be an adequate figure, not only quantitatively but also qualitatively in the dietary life of Japanese people(National Nutrition Examination, Japan.). The situation could almost be generalized even to the people in rice-taking countries.

4. Regulatory Function of Rice

Regulatory function, or biomedicative one, has fashionably been very much emphasized in these days among the several functions of foods. Therefore, it is a tendency that the biomedicative component and the biomedicative food are often called just "functional component" and "functional food", respectively. In fact, the concept historically coincides with the traditional notion in the Oriental Medicine since old times: yaku-shoku-dogen, which means that medicine and food have the common origin(route, value) mutually, or shortly that food is medicine. (Fujino Y *et al* 1999~2004)

1) General Biomedicative Component in Rice

Rice grain variously reveals biomedicative function in the human dietary life. The biomedicative compounds exist both in the bran and embryo especially in the former. Thus, they are quite rich in the brown grain, nextly in the sprout one, being poor in the white one. The regulatory substances known up to now are totally reviewed in the followings((4-1)-(1) and (4-1)-(2)).

(1) Regulatory Factor in Major Fraction of Rice

Several regulatory factors have been found in the major fractions(glucide, protein and acyl lipid) of rice grain.

Dietary fiber(in glucide) : Generally, lots of mono-, oligo- and polysaccharide would more or less be biomedicative. Well-known is dietary fiber, which involves the insoluble matter such as cellulose, hemicellulose etc. and the soluble one such as pectin, resistant starch, oligosaccharide, etc. The essential structure of hemicellulose in cereal has been reported to be arabinoxylan(Fig. 6).

Generally, dietary fiber, widely existing in plant foods, has such biomedicative functions as anti-colon troubles(constipation, colon cancer, etc.), anti-malnutrition(diabetes, obesity, etc.), anti-biooxidation(rough skin, fatigue, dementia, etc.), anti-allergy (atopy, pollenosis, etc.), anti-the other pathologicals(bacterial, viral disease, etc.) and so on.

Sugar alcohol(in glucide) : This concerns metabolically with monosaccharide series. The representative is inositol, from which phytic acid, phytin etc. are derived(Fig. 6). Inositol has been known as one of the vitamin B complex. Thus, it demonstrates several vitaminic bioactivities such as activation of biomembrane, promotion of growth, anti-fatty liver, elevation of immunity and so forth.

Polypeptide(protein) : Generally speaking, protein and the relatives(amino acid especially the essential fatty acid, oligo-, poly-peptide, etc.) would variously be biomedicative. Among them, some polypeptides have recently been noted for regulatory function(Yoshikawa *et al* 1995)(Fig. 7). Reportedly, oryzacystatin is anti-viral; a globulin allergenic.

Acyl lipid : Acyl lipid could give biomedicativity in several ways. Linoleic acid, linolenic acid, components of acyl lipid, are known nutritionally rather biofunctionally as the essential fatty acids, which contribute to construction of biomembrane and to transformation of prostaglandins with various hormonelike bioactivities in the humans. Rice grain is particularly rich in linoleic acid(Fig. 8). Glycerophospholipid, covering lecithin(=phosphatidylcholine), cephalin(=phosphatidylethanolamine), phosphatidylinositol, etc. in general organisms,

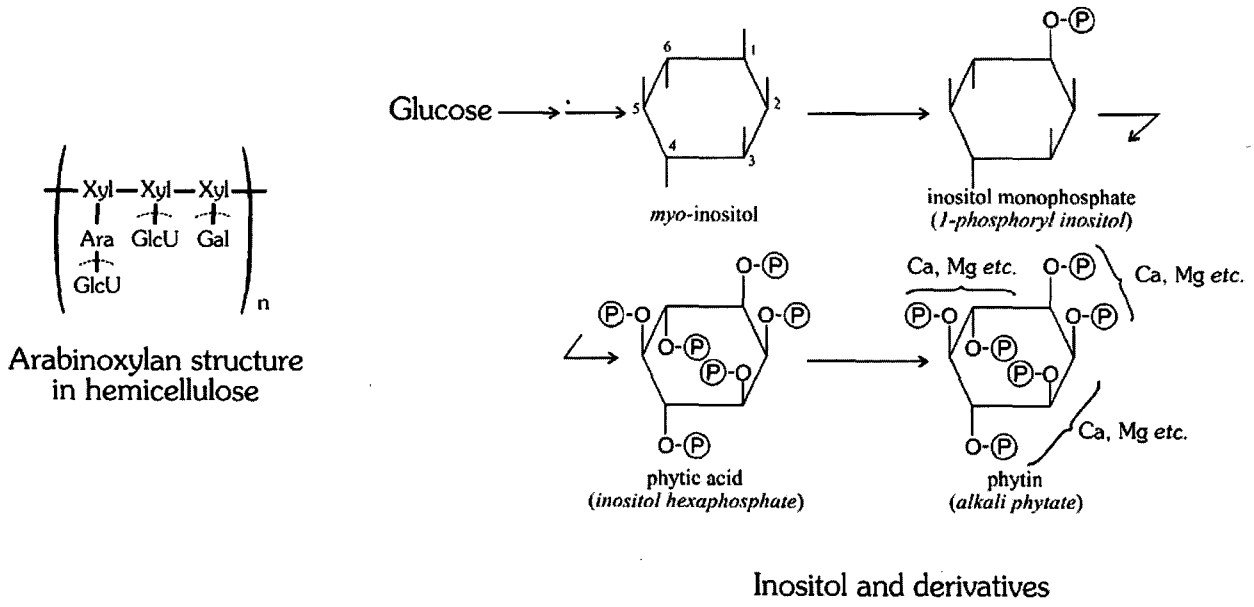


Fig. 6. Biomedicative factor in glucidic fraction of rice grain.

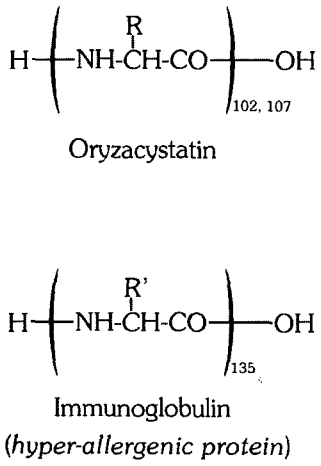


Fig. 7. Regulatory factor in proteinic fraction of rice grain.

could serve to construct the biomembranes. The representative in rice grain would quantitatively lecithin(Fig. 8), where choline, a moiety in the molecule, belongs to the vitamin B complex, and could reveal its own vitaminic bioactivities independently. Phytoceramide and phytocerebrocide(Fig. 8), belonging to sphingolipid in rice grain generally in plants, are said to regulate adequately the beautification on human skin dermatophysiologically, and have recently been found to effectively control the colon tumor pharmacodynamically.

(2) Regulatory Factor in Minor Fraction of Rice(Chikubu S *et al* 1995)

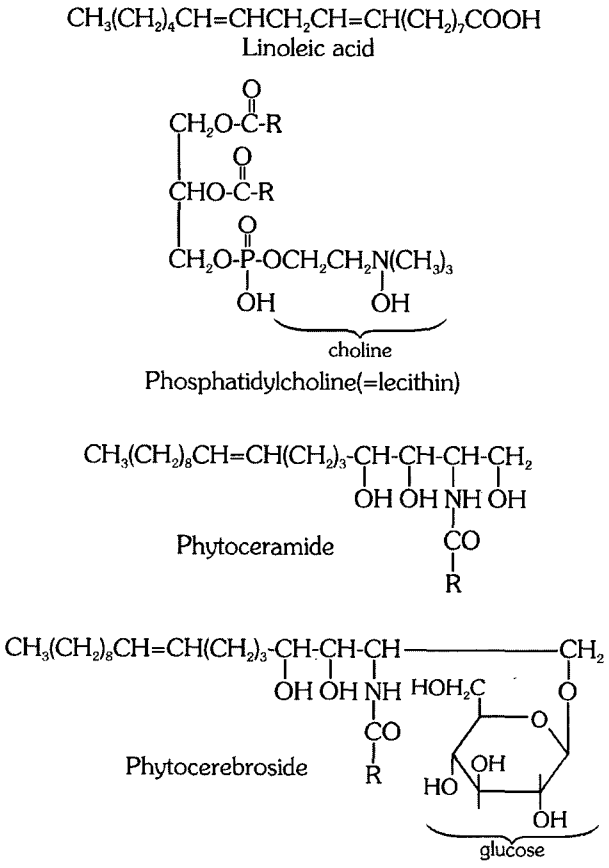


Fig. 8. Biomedicative factor in acyl lipid of rice grain.

Several regulatory factors have also been detected in the minor fractions(prenyl lipid, polyphenol, polyamine, vitamin,

mineral, phytohormone, etc.) of rice grain.

Prenyl lipid : Terpenic compounds such as tocopherol, phytosterol and oryzanol in rice grain give biomedicativities, respectively.

Tocopherol is structurally a combination of methylhydrochinone with non-cyclic diterpene C20. Among the several homologues, a-tocopherol has been known as the representative in cereal(Fig. 9). In rice grain, α-tocopherol, α- and γ-tocotrienol are major; in wheat grain, α- and β-tocopherol.

Tocopherol has long been famous in showing vitamin E activity animal-physiologically. Meanwhile, tocopherol is well noted to be effective scavenger, antioxidative compound based on the phenolic OH in the molecule, in biochemistry as well as in food science.

Tocopherol is thus quite useful to keep the skin surface and or the human body young(anti-aging), to protect against the climacteric disorders(anti-senility), to maintain the fatty food fresh and so forth.

Phytosterol, covering sitosterol, campesterol, stigmasterol, etc. all being structurally the relatives of cholesterol, is basically a derivative of tetracyclic triterpene C_{30}. Phytosterol is known to be biomedicative as anti-cholesterolemia compounds. The representative is quantitavely sitosterol in rice grain generally in plant seeds(Fig. 9). Oryzanol is a ferulic ester of phytosterol in cereal especially in rice grain. The representative has been reported to be feruloyl cycloartenol among the several homologues(Fig. 9). The compound has an anti-oxidativity based on phenolic OH at the ferulic moiety of the molecule, thus indicating the similar biomedicativities to those of tocopherol in anti-aging and in anti-senility. Oryzanol in rice grain might

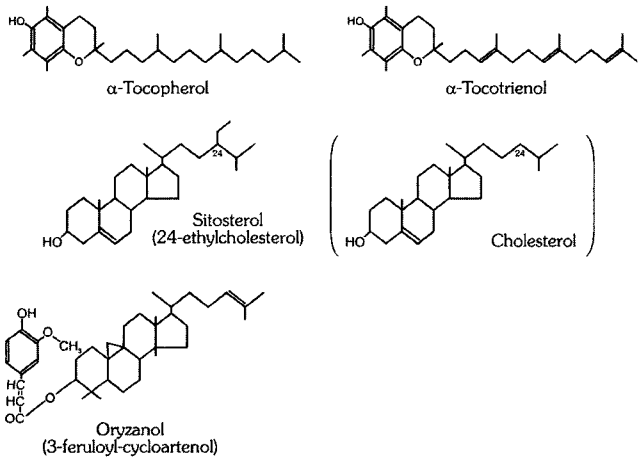


Fig. 9. Biomedicative prenyl lipid in rice.

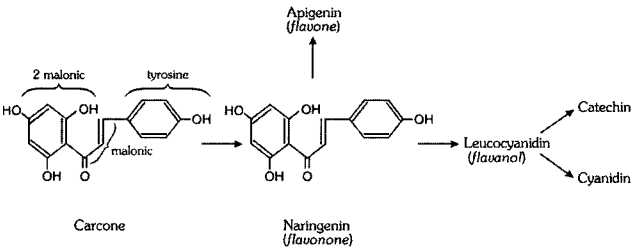


Fig. 10. Formation of polyphenol in plant.

be called alternative vitamin E, as far as the antioxidativity is concerned.

Polyphenol : Polyphenol(=polyhydroxyphenol) practically signifies flavonoid pigment in rice grain(Fig. 2). Generally in plant, three molecules of malonic acid combine with the phenolic moiety of tyrosine to form the carcone skeleton, which proceeds through cyclization and hydroxylation to produce naringenin, leucocyanidin, catechin, cyanidin and so on(Fig. 10). The carcone derivatives could all be called polyphenol.

Polyphenol has scavenger activity against the active oxygen in plant. In ripening of the rice seed, the surface seems to construct the protection system against UV radiation from the sun for protection the seed itself. The humans utilize the antioxidative biofunction as biomedicativity in the dietary life.

Polyamine : There exist in rice grain several polyamines, which are formed originally from ornithine, one of amino acid (Fig. 11). Polyamine generally promotes the cellular activity, consequently accelerate the differentiation and growth of cells and inhibit the aging and senility, probably in sprouting and growing of the rice plant. The pro-cellular activities could as well be functional even in the human nutrition and physiology.

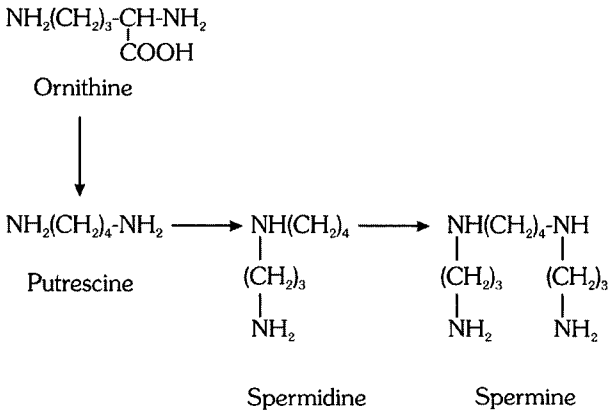


Fig. 11. Formation of polyamine in rice grain.

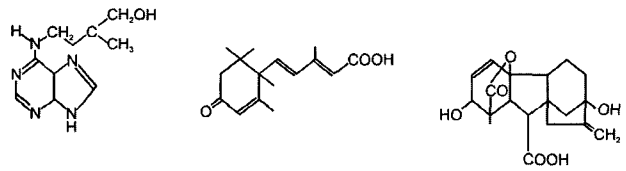


Fig. 12. Terpenic phytohormone in rice grain.

Phytohormone : Several phytohormones such as abscisic acid, auxin, ethylene, gibbelerin and so forth have been reported in rice. They are known to phytophysiologically function especially in sprouting and or ripening of the rice grain, but have not yet noted as to whether they could physiologically effect on the animal cells and tissues. It might be suggestive, however, some phytohormones bear terpenic structure in the molecule(Fig. 12), just like the fat soluble vitamins, A(retinol, diterpenic), D(calciferol, triterpenic), E(tocopherol, diterpenic) and K(phylloquinone, diterpenic).

Vitamin : Soluble vitamins(B_1, B_2, B_6, niacin, pantothenic acid, biotin, inositol, choline, folic acid, aminobenzoic acid, B_{12} etc. except C) are usually in better levels in the brown and sprout rice grain than the white one. Rice grain contains little or no fat-soluble vitamins(A, D, E, K etc., except E). The vitamins in rice grain could, of course, reveal biomedicatively their own vitaminic activities in the human dietary life.

Mineral : Ash is rich in the brown and sprout grain compared with the white one. The ash covers the major minerals (K, Mg, P etc.) and the minor minerals(Ca, Cl, Na, Mn, Cu, Si, Zn, I etc.).

Every mineral would of couse reveal biomedicatively it's own mineral activity, respectively, in the human dietary life.

2) Specific Regulatory Factor in Rice Grain

In sprout rice, some regulatory factors seem to specifically appear during sprouting. As metabolism of the grain nutrients proceeds in sprouting, the major components such as starch, fiber and protein should produce variously the lower molecular compounds(oligosaccharides, glucose, peptides, amino acids etc.) as intermediates(Fig. 5), which would possibly give more or less not only on consider another word, such as nutrition and deliciousness but also on medicativity of the rice grain, although details have not yet been well investigated.

Amino acid etc. : Amino acid and the relatives with biomedicativity might severally generate. Polyamine would be of example. Noteworthy is the following. γ-Aminobutyric acid has been reported to increase remarkably in sprouting(Fig. 13)(Saikusa *et al* 1994). This is well known as an inhibitive neurotransmitter, which is effective on cure of brain stroke, control of mental disease, inhibition of high-blood pressure and so forth.

Vitamin etc. : Vitamin, vitaminic matter, phytohormone, phytohormonic matter etc. with medicativity might possibly come into view. An obvious possibility would be vitamin C. Ascorbic acid could be rich at least in well-sprouted rice, just as in case of the bean sprouts. Such the sprout would be called not the rice grain but rather rice-sprout, or rice vegetable(Fig. 14).

5. Modificative Function of Rice

Rice grain has lots of applications in food use(Non-food parts of rice plant -straw, husk etc.- also have wide applications in non-food use, e.g. as materials for feed, fertilizer and or biomass.) through modification of the material itself and the components(Chikubu *et al* 1995). Modifications of rice grain are expediently divided into the classical one and the modernistical one(Fujino *et al* 1999~2004)(Table 5).

1) Classical Modification

Various processions, which have traditionally been applied for the brown rice, and white one could almost all available to the sprout rice. One of the beneficial characteristics of the processed sprout rice would be that it is abundant in the re-

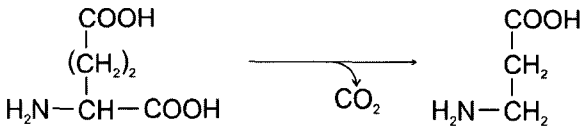


Fig. 13. Formation of γ-Aminobutyric acid in sprout rice.

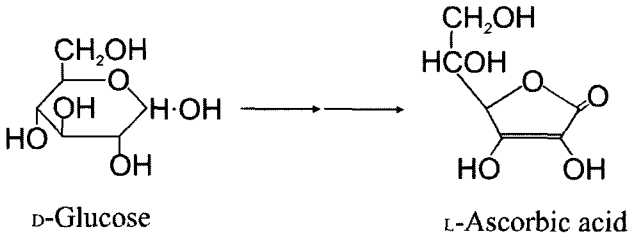


Fig. 14. Possible formation of ascorbic acid in rice sprout.

Table 5. Modification of rice grain

1. Classical modification*
simple procession
mixed procession
fermentative procession
2. Modernistical modification**
nutritive procession
sensuous procession
biomedicative procession

* traditional: empirical.
** biotechnological: genological.

gulatory factors with easier utilizabilities especially for fibers and scavengers than the brown and white rice.

(1) Simple Procession

Each rice grain can simply and at first be applied for food-use as gohan by boiling with water. Powders of rice grain can broadly used for cookies and confectionaries(mochi, dumpling, crackers, cakes, etc.)

(2) Mixed Procession

Rice grains can be made to gohan by mixing to one another.

Sprout mix : Mixing of sprout rice and white rice with ratio of 1:1~2 is said to adequately give nutritivity, deliciousness and biomedicativity.

Mixed gohan : Rice grains can be made to modified gohan by mixing with the other cereal grains(barley, rye, corn, etc.) and even beans(peas, red bean, etc.).

Mixed gohan has often been used not only traditionally but also modernistically rather in favour by Japanese in these days.

Combinative gohan : Rice grain can be made to various combinative gohan with being added by the several side-food-materials(cha-han, hashed rice, curried rice, sushi, etc.)

Rice co-operative : Rice grains especially sprout rice have been attempted to make the bread-series foods(rice bread, biscuits, rice noodle, etc.) by co-operatively mixing with wheat powder(Morita N *et al* 2002).

(3) Fermentative Procession

Brewery : Based on the traditional technology for white rice, breweries of sake(rice wine), miso(soybean paste), shoyu (soybean sauce), yone-zu(rice vinegar) are experimentally being carried out for sprout rice in Japan Rice red-wine including polyphenol might possibly be brewed in some future.

2) Modernistical Modification

Rice is often breeded biotechnologically even to the GMO (=genologically modified organism) to utilize for special purposes.

(1) Nutritionality

Modified-amylose rice : Low- and high-amylose rices have been breeded for nutrition. They concern as well with sensuousity(texture, taste etc.).

Modified protein rice : Low- and high-protein rices have been cultured for nutrition. The modification is being developed also for the specific protein(glutelin, prolamin, etc.). Theywould concern also with sensuousity as well as biomedicativity.

(2) Sensuousity

Aromatic rice : Smelled rice, which have been utilized from place to place in East-South Asia, is being biotechnologically developed as aromatic rice for one of dishes with high class.

Colored rice : Red and or purple rices, which have been cultured in some areas of East-South Asia, are being genologically developed as colored rice for the strange rice dish. The colored rice would also concern with biomedicativity(scavenger, etc.).

(3) Biomedicativity

Low-allergen rice : This has recently been developed for protection against the rice allergic diseases in Japan(Yoshikawa H 1995).

Enzyme-deficient rice : For example, lipoxygenase-deficient rice has been attained for protection of unsaturated fatty acid from oxidation to maintain the grain quality well.

6. Total Discussion(Fujino Y *et al* 1999~2004)

1) Healthy Function of Rice

(1) Academism · Pragmatism

It is academically said in food science that functions of

food consist physiologically of nutritional, sensuous and biomedicative ones, which are closely related to one another. The academic functions should objectively and practically contribute to the human health. Thus, the functions could pragmatically as well be called the healthy functions. The situation would of course be available to rice grain(Fig. 15).

(2) Super Rice

Brown and sprout rice, especially the latter, have often been reported in Japan to biomedicatively conspicuous in dietary life(Ishikawa K 2002). Judging from the data discussed in the present paper, the sprout rice would mostly in average be superior to brown and white rice in every function(Table 6). Thus, the sprout rice might possibly be called "super rice" from the standpoint of healthy functions(Idea itself of sprouting could be applicable also even to grains of almost all the other cereals.). Therefore, the sprout rice should positively and popularly be produced and consumed widely in the world, although standardization of quality, cost-down of marketing system and so on are still remained to be solved.

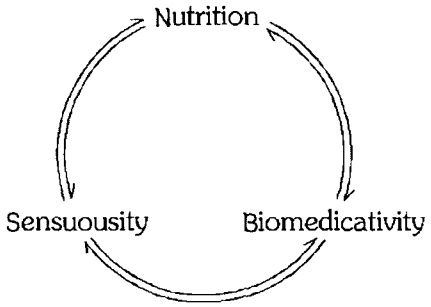


Fig. 15. Healthy funtion of rice grain, generally of food.

Table 6. Healthy function of sprout gohan

Quality	Brown gohan	White gohan	Sprout gohan
Nutritionality	+	+	+
Energiticity	+	+	+
Digestibility	−	+	+
Absorbability	−	+	+
Deliciousness	−	+	±
Texturality	−	+	±
Swellability	−	+	±
Sweetness	−	+	±
Medicativity	+	−	+
Illness-preventivity	+	−	+
Disease-restorativity	+	−	+
Health-regulatority	+	−	+

Utilization of the sprout rice would coincide well with various activities, which have recently been done for improvement of the dietary life in the world(Beautification meals (World), diet meals(World), five vegetables a day(USA), food pyramid(USA), Japanese-style food(Japan), plant major animal minor(Fujino *et al* 2004), slow food(South-Europe), whole grain (North-Europe) and so on.).

2) Comprehensive Function

(1) Physical · Metaphysical Function

All the foods generally have both the physical and metaphysical functions. Cereals including rice have as well not only the physical functions such as plant-biological, crop-scientific, food-scientific one and so on, but also metaphysical functions such as cultural, economic, historical, ethnological, political one and so forth. Foods should socially be evaluated comprehensively from both the functions(Yoshikawa H 1995).

(2) World-Wide Rice

Cereals are the principal foods in the world. Rice is one of three big cereals on the earth. There are still lots of people who can not take enough foods because of poverty. Rice especially sprout rice, together with all the other cereals, should contribute to health of the human being and repletion of the foods based on the comprehensive functions, in the world-wide level.

Conclusions

1. There are three styles of rice grain, i.e. brown, sprout and white grain, all of which are utilized as gohan(=boiled grain) in the dietary life.
2. In the sensuous function, sprout rice would be valued almost in the middle between brown and white rice, being rather close to white rice.
3. In the nutritive function, sprout rice would also be appraised inbetween of brown and white rice, being fairly close to brown rice.

4. In the biomedicative function, sprout rice could nearly be evaluated the same as brown rice.
5. In the modificative function, three rices are equally processed not only classically but also biotechnologically. Novel GM rices are being developed for elevation of qualities.
6. Healthy functions of sprout rice would comprehensively be so superior in average that the sprout rice could reportedly be called "super rice".
7. The super rice should positivelybe promoted in production and consumption in the world-wide level.

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*ICC: International Association of Cereal Chemistry (=of Cereal Science & Technology), Vienna, AUS.