Quality Evaluation of Cupcakes with Rice Bran, a By-product of Sake Brewing, on Nutrition and Glycemic Index

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Abstract

Sakamai rice is an important rice type used in brewing sake. The outer layers of Sakamai grains are removed by polishing before use in sake brewing. This outer layer is composed of three parts: the outer bran layer (*Akanuka*), middle bran layer (*Chunuka*), and inner bran layer (*Shironuka*). These sake-brewing rice brans have not ordinarily been used in food processing; therefore, we are investigating their use for making cupcakes. Rice brans were used to replace 50% of the soft white wheat flour in a standard recipe. Cupcakes made by substituting *Akanuka* for wheat flour were of highest quality in terms of polyphenols, dietary fiber, and antioxidant activity, and also had a low glycemic index (GI). These cupcakes were also softer and had higher specific loaf volume compared with standard cupcakes. A testing panel did not prefer these cupcakes in sensory evaluations, but evaluations were improved by the addition of cocoa or matcha powder.

Introduction

The food self-sufficiency rate in Japan is low at 39%, but the production of rice is more than 100% of domestic demand. Rice is an important source of nutrition and energy, and is one of the most suitable cereal grains used for preparing foods in Japan. However, its use is decreasing year after year. To increase the consumption of rice, the Japanese government has recommended the introduction of rice flour bread for school lunches. However, rice flour bread does not rise as much as wheat flour bread.

The main use of white rice in Japan is as a cooked staple food. After the rice is harvested, the husks of the rice grains are removed to leave brown rice, which is then polished to become white rice. Apart from producing cooked rice, polished rice can be milled to rice flour (known as *Komeko*) and is used for making noodles, sweets, among other foodstuffs. Rice flour can also be used as a wheat flour substitute and processed into bread. It has been reported that in making rice/wheat flour bread, substituting wheat flour with up to 30% rice flour is acceptable and does not

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compromise sensory qualities[1,2].

Rice called as Sakamai is also important in sake brewing. Prior to sake brewing, the outer layer of the Sakamai is removed by polishing. The polishing residue is separated into three parts; that is, an outer-layer bran (called Akanuka), a middle-layer bran (called Chunuka), and an inner-layer bran (called Shironuka). Shironuka has the same fundamental composition as common rice flour sold in the markets, except for the size of particles are different from each other. Akanuka and Chunuka are rich in proteins, lipids, vitamins, and minerals[3]. However, they are not used for food processing. Ito *et al*. reported the use of sake brewing rice bran in cookie making[3]. We also reported the use of these rice brans in breadmaking[4].

We investigated the potential use of the polishing residue of Sakamai in cupcake making. We predicted that the rice bran would enhance the physiological activities of the cupcakes by increasing polyphenols and dietary fiber. Increasing the dietary fiber and polyphenol content in cupcakes could be beneficial for consumers, particularly in the prevention of colon cancer[5,6].

On the other hand, high glycemic index (GI) foods, such as some cupcakes, generally make blood sugar levels higher. In addition, people who eat a lot of high GI foods tend to have greater levels of body fat measured by the body mass index (BMI). High BMI levels are linked to obesity, heart disease, and diabetes. GI is a measure of the effects of carbohydrates on blood sugar levels, thus people who, for example, experience a blood sugar spike after breakfast may be wanted to select a cereal that has a lower GI.

In this study, we investigated the use of rice bran as a partial substitute for soft wheat flour in the production of cupcakes, and compared the characteristics and GI of the finished products with standard wheat flour cupcakes.

Materials and Methods

Experimental materials Soft wheat flour, and baking powder were purchased from Nisshin Flour Milling Co., Ltd., Tokyo, Japan. Soft wheat flour was used as the standard. Common rice flour was purchased from Shimozu Rice Store Co., Ltd., Inazawa, Japan. Three kinds of sake-brewing rice brans derived from 'Akebono' rice were purchased from Kiyosuzakura Brewing Company, Ltd., Aichi Prefecture, Japan. The other ingredients used in the cupcakes included unsalted butter (Yotsuba Dairy Industry Co., Ltd., Sapporo, Japan), soft sugar (Nissin Sugar Manufacturing Co., Ltd., Tokyo, Japan), and liquid egg (Chita Egg Co., Ltd., Taketoyo, Japan). Other chemicals used were of analytical grade.

Componential analysis The moisture content was calculated as a measure of weight loss after drying at 130℃ using a moisture meter MF-50 (A & D Co., Tokyo, Japan). Starch content was determined using the Total Starch Assay Kit (Biocon (Japan) Ltd., Nagoya, Japan). Damaged starch content was determined using Starch Damage Assay Kit (Biocon (Japan) Ltd.). The soluble dietary fiber (SDF) and insoluble dietary fiber (ISF) contents were measured by using the modified enzymatic-gravimetric method[7].

Polyphenols were determined using the Folin-Denis method with gallic acid as the standard[8].

Antioxidative activity A spectrophotometric assay for 1,1-diphenyl-2-picrylhydrazyl (DPPH)-radical scavenging activity was used to determine antioxidant activity[9]. The sample solution (0.3 mL) extracted with 80% ethanol was added to a reaction mixture containing a solution of DPPH in ethanol (400 μM, 0.3 mL), 2-morpholinoethanesulphonic acid buffer (200 mM, 0.3 mL), and 20% ethanol (0.3 mL). After 20 min, the absorbance of the reaction mixture was measured at 520 nm. DPPH scavenging activity was estimated from the decrease in absorbance at 520 nm, and expressed as μmol-Trolox equivalent per 100 g of sample using the standard curve for Trolox.

Cupcake making Cupcakes were made using soft wheat flour (100 g), butter (100 g), soft sugar (100 g), liquid egg (100 g), and baking powder (1.5 g). The melted butter was mixed with the soft sugar, the liquid egg was added, and the ingredients were mixed together. The soft wheat flour was added with the baking powder by passing through mesh (aperture size, 500 μm), and then the mixture was stirred 25 times with a rubber spatula. The resulting paste was divided into 25 g portions and each was placed in an aluminium cup. Gas was removed by dropping the portions 10 times from a height of 10 cm. Each portion was put into a microwave oven fermentor (RO-EL2; Mitsubishi Electric Industrial Co., Ltd., Tokyo, Japan) and baked at 180°C for 15 min. For rice bran flour cupcakes or common rice flour cupcakes, 50 g of soft wheat flour was replaced by 50 g of Sake-brewing rice bran flour or 50 g of rice flour, respectively.

Measurement and evaluation of cupcake properties Cupcakes were allowed to stand at 23°C for 3 h before the specific loaf volume (SLV) was determined using the rapeseed displacement method. The SLV (mL/g) was calculated from the following equation:

$$\text{SLV} = \text{volume of cupcake (mL)}/\text{weight of cupcake (g)}.$$

The crust and crumb colors of the cupcakes were measured according to JIS Z 8729 using a NE 2000 color meter (Nippon Denshoku Industries Co., Ltd., Tokyo, Japan). The value of L^*, a^*, and b^* indicate lightness, redness, and yellowish, respectively. The color difference (ΔE^*) was calculated from the CIE $L^*a^*b^*$ value.

Firmness was determined with a Texturometer TDU-1 (Yamaden Co., Ltd., Tokyo, Japan) by measuring the compression force of ultrasonic waves (Yamaden Co., Ltd.) on cupcake slices ($20 \times 20 \times 20$ mm). Cubes of cupcake were compressed using a plunger (Φ 8 mm) at a speed of 5 mm/s with a 2 mm clearance.

Sensory evaluation The sensory characteristics of the cupcakes were evaluated by a panel of 15 female students (aged 22 years) from Sugiyama Jogakuen University who were trained to recognize cupcake tastes and flavors. The color, aroma, taste, mouthfeel, texture, and total acceptance were determined by a five-step scoring method. A rating of -2 to $+2$ was given to each cupcake, with a score of $+2$ being the best and -2 being the worst. Scores for each sample were totaled, and the means $\pm$ SD were calculated.

GI measurement The GI assay was performed as described previously[10,11]. The assay was approved by the Committee of Medical Ethics of Sugiyama Jogakuen University and 15 female students (aged 22 years) as subject gave informed consent in accordance with the Helsinki Declaration. All subjects were healthy with a BMI of less than 25 and were not taking medicines affecting blood sugar levels.

The blood glucose level of each subject was measured using Onetouch-ultra™ (Johnson & Johnson Co., Ltd., New Brunswick, NJ) after eating cupcake samples or 50 g of glucose dissolved in water as reference food. Both the samples and reference food contained equal amounts of available carbohydrates. Each subject started fasting from 21:00 the evening before the day of examination. Subjects monitored their postprandial blood sugar levels at 0, 15, 30, 45, 60, 90, and 120 min after the load. GI was defined as the area under the blood glucose response curve of a test cupcake divided by that of a reference food and given as a percentage.

Statistics Data were analyzed using the t-test or one-way ANOVA, following Tukey's multiple comparison test using SPSS Statistics version 19 (IBM, Chicago, US). *P*-values of <0.05 were considered significant.

Results and Discussion

The properties of soft wheat, common rice, and Sake-brewing rice bran flours are shown in Table 1. The moisture content of all flours was in the range of 9.55−13.59%. The total starch content of Akanuka was very low (38.2%). The proportion of damaged starch in Sake-brewing rice bran flours was very high compared with soft wheat flour or common rice flour. The percentages of damaged starch to total starch of Akanuka, Chunuka, and Shironuka were 25.6%, 14.7%, 11.2%, respectively, and those of soft wheat and common rice flours were 5.9% and 6.1%, respectively (Table 1).

Table 1 Properties of soft wheat, common rice, and Sake-brewing rice bran flours.

Flour	Moisture (%)	Starch (%)		Fiber (%)		Polyphenols	Antioxidative activity
		Total	Damaged	Insoluble	Soluble	(mg/100 g)	(μmol Trolox eq./100 g)
Soft wheat flour	13.59 ± 0.19	76.2 ± 0.8	4.53 ± 0.24	1.79 ± 0.02	1.21 ± 0.01	31.3 ± 0.6	56.9 ± 5.3
Common rice flour	10.44 ± 0.15	84.3 ± 0.4	5.20 ± 0.16	4.32 ± 0.08	0.39 ± 0.01	23.3 ± 0.2	49.9 ± 0.2
Sake-brewing rice flour							
Akanuka	9.55 ± 0.02	38.2 ± 0.7	9.80 ± 0.07	14.9 ± 0.1	1.70 ± 0.06	226 ± 3	443 ± 2
Chunuka	11.29 ± 0.02	62.0 ± 0.1	9.13 ± 0.24	11.9 ± 0.1	1.05 ± 0.02	150 ± 2	315 ± 6
Shironuka	9.74 ± 0.05	76.2 ± 0.8	8.60 ± 0.16	6.52 ± 0.03	0.39 ± 0.02	55.3 ± 2.4	120 ± 1

* Values are means ± SD, $n = 3$.

The constituents of Shironuka was similar to that of common rice flour in terms of value, but the damaged starch content levels were different. This is because the processing properties of common rice flour differ from those of Shironuka[12]. Most of common rice flour is prepared by Grain mill which produce the flour with low damaged starch and fine particle size. The common rice flour is used as the ingredient of food such as noodles, so the character of flour is very important. On the other hand, Sake-brewing rice bran flour is by-product manufactured polishing rice for Sake fermentation by Rice polishing machine. Most of Sake-brewing rice bran fluor is used as feed of livestocks, so the quality is not important.

There is extensive research to support the importance of dietary fiber in human nutrition[6], so the dietary fiber contents of the tested flours were also measured (Table 1). The ISF contents of Akanuka, Chunuka, and Shironuka were higher than those of soft wheat and common rice flour, but the SDF contents were no difference so much.

Polyphenol content of Sake-brewing rice bran flour was higher than that of soft wheat flour or common rice flowe. In the Sake-brewing rice bran flours, Akanuka was 7.2-fold higher than that of soft wheat flour (Table 1).

One report has shown that polyphenol content is related to antioxidative ability in a variety of foods[13]. Furthermore, antioxidant compounds in foods play an important role in protecting health. There are various methods used to measure antioxidant activity; we opted to measure DPPH radical scavenging activity. The antioxidative activitie of Sake-brewing rice bran flours were higher than that of soft wheat flour or common rice flour, and were proportional to the total phenolic content. Especially, Akanuka was 7.9-fold higher than that of soft wheat flour (Table 1). Thus, the high polyphenol and dietary fiber contents of Akanuka and Chunuka should improve the nutritional quality of cupcakes supplemented with sake-brewing rice bran flour.

The maximum rate of Sake-brewing rice bran flour replaced to soft wheat flour was tested preliminary. In results, more than 55% repracement of Sake-brewing rice bran flour could not making cupcake with good SLV (data not shown), so Sake-brewing rice bran flour was used at 50% replacement rate of soft wheat flour. The properties of cupcakes from soft wheat flour, common rice flour, and Sake-brewing rice bran flours are shown in Table 2.

Table 2 Properties of cupcakes with or without sake-brewing rice bran flours.

Cupcake[1)]	Moisture (%)	Fiber (%)		Polyphenols (mg/100 g)	Antioxidative activity (μmol Trolox eq./100 g)
		Insoluble	Soluble		
A	13.40 ± 0.58[a]	2.48 ± 0.13[a]	0.60 ± 0.02[a]	14.1 ± 0.2[a]	67.3 ± 5.3[a]
B	14.06 ± 0.12[a]	2.10 ± 0.08[b]	0.57 ± 0.02[a]	9.95 ± 0.10[b]	52.6 ± 1.6[b]
C	16.10 ± 0.29[b]	5.12 ± 0.05[c]	0.35 ± 0.03[c]	22.8 ± 0.2[c]	135.3 ± 2.4[c]
D	14.00 ± 0.71[a]	5.20 ± 0.08[c]	0.29 ± 0.00[b]	19.0 ± 0.4[d]	93.3 ± 3.3[d]
E	15.36 ± 0.90[b]	4.16 ± 0.12[d]	0.41 ± 0.02[c]	17.3 ± 0.4[e]	74.0 ± 1.6[e]

[1)] A, standard (soft wheat flour); B, common rice flour; C, Akanuka; D, Chunuka; E, Shironuka.

[*] Values are means ± SD, $n = 3$. Different superscripts indicate statistical difference ($p < 0.05$).

The ISF content in the cupcakes made with Akanuka and Chunuka was higher than that in the other cupcakes. Polyphenol content and antioxidative activities were also high in Akanuka and Chunuka cupcakes. These results suggest that the antioxidative activity in cupcakes might be influenced by polyphenol content.

The SLV was similar for all cupcakes whether they were prepared from soft wheat, common rice, or Sake-brewing rice bran flours; however, that of cupcakes made with Akanuka was slightly higher (Fig. 1). In breadmaking, it is known that high levels of damaged starch in wheat flour reduce the SLV of bread[14]. However, in this study, the SLV of the cupcakes remained very high and unaffected by the high damaged starch content of Sake-brewing rice brans flour, especially in

cupcakes made with Akanuka (Fig. 1).

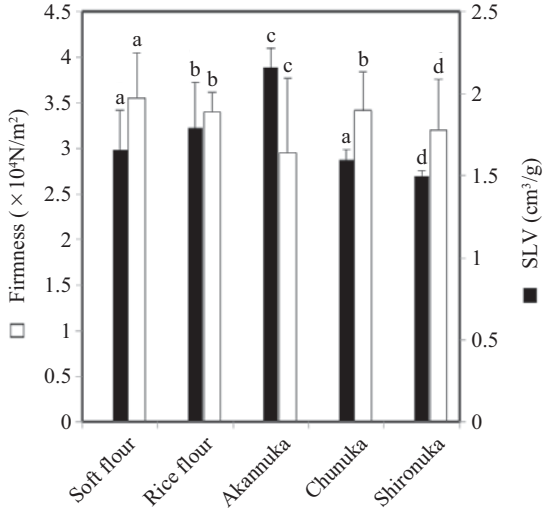

Fig. 1 SLV and firmness of cupcakes.
Within a category, different alphabets indicate statistical differences ($p < 0.05$). Values are means ± SD, $n = 3$.

Inner pieces of the cupcakes were used to measure firmness (Fig. 1). Cupcake made with Akanuka was softer and higher SLV than other cupcakes. It due to the high amount of fiber, which causes the formation of an extremely high number of holes in the crumb. The particle sizes of common rice flour, Akanuka, Chunuka, and Shironuka were found to be 0.100−0.150 mm, 0.150−0.250 mm, 0.100−0.150 mm, less than 0.100 mm in sieving tests, respectively. On the other hand, the particle sizes of soft wheat flour were finer (below 0.100 mm). The difference in the particle size of flours is also considered to be another reason of the higher SLV.

Table 3 shows the crust and crumb colors of the cupcakes. The lightness values (L^*), and yellowish values (b^*) of all cupcakes were similar. However, the redness values (a^*) of the crumb color of the soft flour and Akanuka cupcakes were lower than that of the other cupcakes. The crust and crumb color of Akanuka cupcakes was ochre-brown due to the color of Akanuka.

The color differences (ΔE^*) between the soft flour cupcakes and the other cupcakes were classified in accordance with National Bureau of Standards (NBS) units (National Institute of Standards & Technology, Gaithersburg, MD). NBS classification of the color differences in the cupcake crusts were 'Much' to 'Appreciable'. In contrast, the color differences in the crumbs were 'Slight' to 'Much'.

The sensory attributes and palatability of the 5 different cupcakes were compared using a five-step scoring method (Fig. 2). The standard soft flour cupcake was preferred by the panel in terms of qualities such as color, taste, mouthfeel, and total acceptance. For color and mouthfeel, all cupcake scores were the same except for Shironuka. Cupcakes made with Chunuka had higher

Table 3 Color of cupcakes.

Cupcake[1)]	Hunter value[2)]						⊿E*	
	L*		a*		b*			
	crust	crumb	crust	crumb	crust	crumb	crust	crumb
A	48.44 ± 3.86	69.30 ± 1.07	7.03 ± 2.82	− 0.59 ± 2.1	32.11 ± 1.37	37.20 ± 1.26	standard	standard
B	51.76 ± 3.67	68.73 ± 1.31	6.89 ± 2.39	1.05 ± 3.87	22.39 ± 3.55	31.89 ± 3.36	10.27	10.10
C	58.03 ± 5.17	63.60 ± 1.09	0.39 ± 4.24	− 0.59 ± 1.56	34.20 ± 3.03	30.13 ± 1.24	8.90	1.17
D	49.50 ± 4.59	64.25 ± 1.48	2.79 ± 1.40	1.16 ± 2.48	29.63 ± 5.54	33.61 ± 1.47	5.03	5.62
E	50.80 ± 3.69	60.67 ± 2.44	0.66 ± 3.26	0.51 ± 1.07	26.36 ± 5.62	37.31 ± 1.41	11.85	7.80

[1)] A, standard (soft wheat flour); B, common rice flour; C, Akanuka; D, Chunuka; E, Shironuka.
[2)] Values given as means ± SD, $n = 3$.

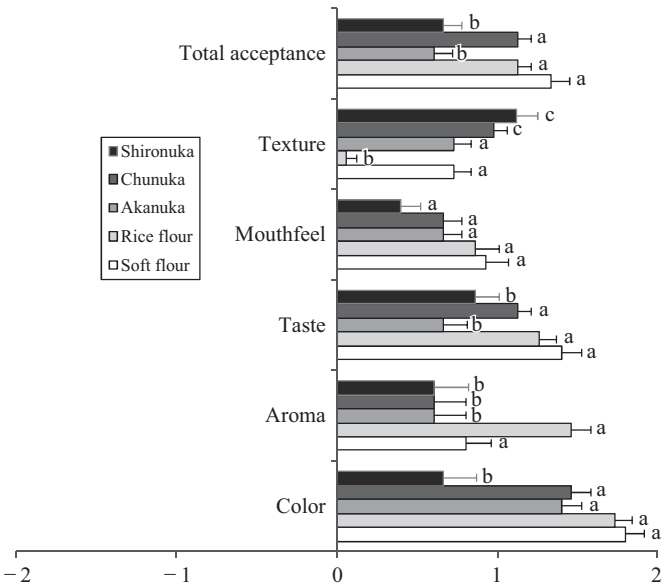

Fig. 2 Sensory evaluation of cupcakes.
Within a category, different alphabets indicate statistical differences ($p < 0.05$).
Values are means ± SD, $n = 15$.

scores for almost all qualities except for aroma. In contrast, cupcakes made with Akanuka were not favored in terms of aroma, taste, and total acceptance. The aroma of Chunuka cupcakes and the aroma and taste of Akanuka cupcakes resulted from the aroma and taste of rice bran. Total acceptance of the cupcakes showed similar scores for Chunuka and the common rice flour cupcakes. Although Akanuka cupcakes have better nutritional qualities, palatability was not favorable compared with the standard soft flour cupcakes. Although the aroma, taste, and total acceptance values of the Akanuka cupcakes were ranked significantly lower than those of the standard soft flour cupcakes ($p < 005$), the differences were not unacceptable to the panel. We also investigated making cupcakes with added flavorings, such as cocoa powder (Kataoka & Co., Ltd.,

Tokyo, Japan) and Matcha powder (Ito En Ltd., Tokyo, Japan). The addition of 5 g of each powder to the formula wholly improved the aroma, taste, and total acceptance ratings (Fig. 3).

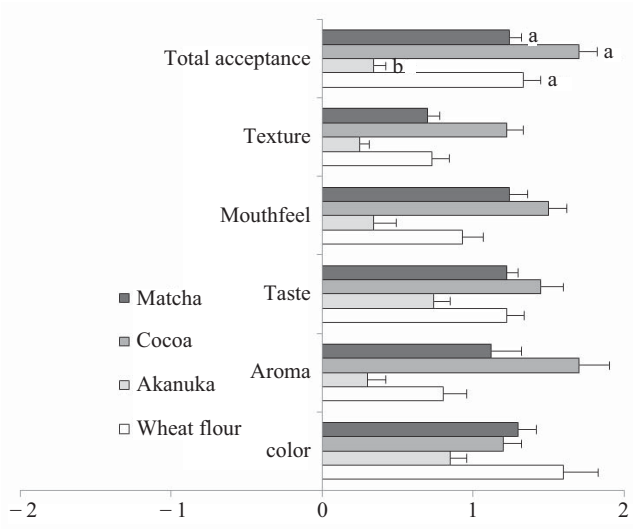

Fig. 3 Sensory evaluation of cupcakes added flavoring.
Within a category, different alphabets indicate statistical differences ($p < 0.05$).
Values are means ± SD, $n = 15$.

The GI levels of soft wheat flour and Akanuka cupcake are shown in Table 4 as means ± SD. All subjects found it easy to consume these cupcakes within the allotted time (5 min). The difference between the GI values of the soft flour and Akanuka cupcake was analyzed by the Student's t-test. The GI value of the cupcake with Akanuka (GI, 45) was less than that of cupcake made with soft flour (GI, 60), but the difference was not significant. The GI system is a physiological basis for classifying carbohydrate-containing foods. Thus, the cupcake with Akanuka could be classified as a low GI food. In general, fat and fiber is known to lower the GI of a food, but no significant relationship has been found between GI and dietary fiber, such as wheat fiber[15]. Phytic acid and polyphenols found in many plants inhibit α-glucosidase and α-amylase, which promote the digestion of carbohydrates[16]. Sake-brewing rice bran, especially Akanuka, contains many polyphenols and dietary fiber (Table 2). The low GI value of cupcake with Akanuka is considered for the high content of fiber and polyphenols.

Table 4 Glycemic index of cupcakes.

Cupcake	Glycemic index *
Soft wheat flour	60.1 ± 4.0
Akanuka	45.2 ± 4.7

* Glycemic index is the relative value compared with that of glucose as a standard.
* Values are means ± SD, $n = 15$.

Cupcakes made with rice bran flour, a by-product of sake-brewing, especially those made with Akanuka, would regulate postprandial blood sugar levels and promote health through antioxidative activity.

Conclusions

Cupcakes substituted with rice bran flour were of high quality in terms of nutritional qualities such as polyphenols, dietary fiber, and antioxidative activity. In addition, cupcakes made with Akanuka had a low GI. Foods with a low GI have significant health benefits. The sensory evaluations of the cupcakes with rice bran were not favorable compared with standard soft flour cupcakes in terms of aroma, taste, and total acceptance. Although the cupcakes with rice bran were not preferred, the quality of these cupcakes was still acceptable to the panel. The low sensory evaluation results were resolved by the addition of flavorings. Thus, a health-protecting cupcake can be prepared by using bran from Sake-brewing rice.

References

1) Watanabe, M., Maeda, T., Tsukahara, K., Kayahara, H. and Morita, N.: Application of pregerminated brown rice for breadmaking. *Cereal Chem*., **81**, 450−455 (2004).
2) Nakamura, S., Suzuki, K. and Ohtsubo, K.: Characteristics of bread prepared from wheat flours blended with various kinds of newly deveroped rice flours. *J. Food Sci*., **74**, 121−130 (2009).
3) Ito, S., Masuda, N., Yamamoto, A., Yoshimura, Y. and Kito, I.: Physicochemical properties and utilization of milling residue of sake-brewing rice grain. *Res. Bull. Aichi Agric. Ctr*. **33**. 71−76 (2001).
4) Mase, T. Kawaguchi, M., Kodama, C., Kato, Y., Esaki, H. and Isshiki, S.: Quality evaluation of bread containing rice bran, a by-product of sake-brewing. *J. Sugiyama Jogakuen Univ.*, **45**, 89−96 (2014).
5) Ames, B. N., Shigenaga, M. K. and Hagen, T. M.: Oxidants, antioxidant and the degenerative diseases of aging. *Proc. Natl. Acad. Sci*., USA., **90**, 7915−7922 (1993).
6) Michell, W. D. and Eastwood, M. A.: *Fiber in Human Nutrition* (ed. by Spiie, A. G. and Amen, J. R.) Plenum Press, New York, 185 (1976).
7) Prosky, L., Asp, N. G., Schneizer, T. F., Devies, J. W. and Furda, I.: Determination of insoluble, soluble and total dietary fiber. *Anal. Chem*., **71**, 1018−1023 (1988).
8) Ishida, H.: Measurment of vegetable color. *Jap. Soci. Cook. Sci*., **26**, 378−384 (1993).
9) Kogure, K., Goto, S., Abe, K., Ohiwa, C., Akasu, M. and Terada, H.: Potento antiperoxidation activity of the bisbenzylisoquinline alkaloid cepharanthine: The amino moiety is responsible for its pH-dependent radical scavenge activity. *Biochem. Biophys. Acta*., **1426**, 133−142 (1999).
10) Sugiyama, M., Tang, A. C., Wakagi, Y. and Koyama, W.: Glyemic index of single and mixed meal foods among common Japanese foods with white rice as a reference food. *Eur. J. Clin. Nutr*., **57**, 743−752 (2003).
11) Taguchi, Y., Goto, N., Kawada, Y., Nasu, R., Arai, R., Miura, M. and Gomyo, T.: Evaluation of herbal foods on α-glucosidase activity and glycemic index. *Food Sci. Technol. Res*., **16**, 39−44 (2010).
12) Nishita, K. D. and Bean, M. M.: Grinding Methods: Their impact on rice flour properties. *Cereal Chem*., **59**, 46−49 (1982). The particle sizes of common rice flour, Akanuka,

13) Yamada, J., Igarashi, E. and Matsuda, H.: Comparison between the Radical Scavenging Activity of Arabushi-dash and Karebushi-dashi. *J. Cookery Sci. Jpn*., **41**, 134−137 (2008).
14) Takahashi, K., Okunishi, T., Suzuki, K. and Yukizaki, C.: Processing suitability evaluation method for rice bread and evaluation of rice flour produced in miyazaki. *J. Food Sci. Technol*., **58**, 55−61 (2011).
15) Jenkins DJA, Wolever TMS, Leeds AR.: Dietary fiberes, fibre analogues and glucose tolerance: Importance of viscosity. *Br. Med. J*., **1**, 1392−1394 (1978).
16) Miura, M. and Gomyo, T.: Effects of commercial spices on the activities of α-amylase and α-glucosidase. *Nippon shokuhin Kagaku Kougaku Kaishi*, **43**, 157−163 (1996).