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EFFECTS OF THE COOKING PROCESS ON THE CHARACTERISTICS OF AROMATIC RED RICE WINE

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Fermentation tests were performed with cooked and/or uncooked, polished aromatic red rice (*Oryza sativa* var. *Indica, Tapol*) and aromatic red rice bran using compressed baker's yeast and a preparation of glucoamylase produced by *Rhizopus*, sp. as saccharifying agent. The quality in terms of both aroma and taste of the red rice wine made with uncooked, unpolished aromatic red rice was much higher than that of rice wine made with cooked, unpolished aromatic red rice. However, the bran fraction of aromatic red rice was fairly resistant to the cooking process and this fraction was hardly affected or degraded by the cooking process. Furthermore, the bran fraction improved the quality of rice wine made from mash that contained cooked, polished rice which had a rather lower-quality aroma. In red rice wine brewing, the polished rice fraction of aromatic red rice may suffer from undesirable effects during the cooking process.

Key Words: *Aromatic red rice (Oryza sativa var. Indica, Tapol), red rice wine brewing, ethanol fermentation without cooking, ethanol fermentation with cooking, effects of cooking process on rice wine brewing*

Introduction

In Japanese sake brewing, the cooking of rice grains is an important process[2,3]. To produce rice koji, namely, the saccharifying agent used in sake brewing, cooked rice grains are inoculated with spores of koji mold and large amounts of cooked rice grains are used as the dominant starchy material for sake brewing.

By contrast, an economical, uncooked ethanol-fermentation system has been established using a raw-starch-digesting glucoamylase from black koji mold[6]. This system operates without the need for cooking and raw starchy materials can be applied directly to ethanol fermentation.

We previously reported the production and characteristics of aromatic red rice wine and its quality, both in terms of aroma and color, when such rice wine was made from aromatic red rice (*Oryza sativa* var. *Indica, Tapol*). We also showed that an ethanol fermentation system without cooking generated much better wine than that made from cooked aromatic red rice[4].

In this study we investigated in detail the effect of the cooking process on the characteristics, in particular the aroma, of red rice wine.

Materials and Methods

Rice grains

Unpolished aromatic red rice (*Oryza sativa* var. *Indica, Tapol*) was used for fermentation tests (Figure 1). Polished aromatic red rice grains were ground to particles of 2–3 mm in diameter and the bran fraction of aromatic red rice grains was also used as material for fermentation tests.

Preparation of glucoamylase

Sumizyme, a preparation of glucoamylase from *Rhizopus* sp. (Shinnihon Kagaku Kogyo Co. Ltd., Anjo) was used as the saccharifying agent for ethanol fermentation.

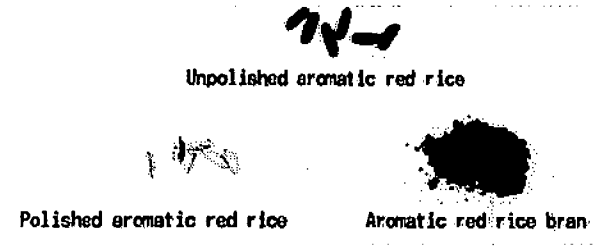

Fig. 1. Photographs of unpolished aromatic red rice, polished aromatic red rice and aromatic red rice bran.

Procedure for brewing red rice wine

i) Ethanol fermentation of polished aromatic red rice and aromatic red rice bran with and without cooking

Thirty grams of uncooked, polished aromatic red rice (run 1) or uncooked aromatic red rice bran (run 3) and 60 ml of tap water were dispensed into a 300-ml Erlenmeyer flask and autoclaved at 121°C for 15 min. After cooling, 0.2 g of the preparation of glucoamylase, 40 ml of tap water and 3 g of compressed baker's yeast were added to the cooked mash in the 300-ml Erlenmeyer flask.

For comparison, 30 g of uncooked, polished aromatic red rice (run 2) or aromatic red rice bran (run 4), 0.2 g of the preparation of glucoamylase, 3 g of compressed baker's yeast and 100 ml of tap water were dispensed into a 300-ml Erlenmeyer flask with a gas trap[4].

The pH of the initial mash was adjusted to 4.0 with 1 N HCl and 1 N NaOH. Ethanol fermentation was performed at 30°C. The decrease in weight of the entire Erlenmeyer flask and its contents, as a result of the evolution of CO_2 gas, was recorded at 24-h intervals.

ii) Ethanol fermentation of cooked and/or uncooked polished aromatic red rice and aromatic red rice bran

Twenty-one grams of uncooked, polished aromatic red rice, and 60 ml of tap water were dispensed into a 300-ml Erlenmeyer flask and autoclaved at 121°C for 15 min. After

cooling, 9 g of uncooked aromatic red rice bran, 0.2 g of the preparation of glucoamylase, 40 ml of tap water and 3 g of compressed baker's yeast were added to the cooked mash in the 300-ml Erlenmeyer flask (run 5).

For comparison, ethanol fermentation was performed with 21 g of uncooked, polished rice and 9 g of cooked aromatic red rice bran (run 6), with 21 g of uncooked, polished aromatic red rice and 9 g of uncooked aromatic red rice bran (run 7), and with 21 g of cooked, polished aromatic red rice and 9 g of cooked aromatic red rice bran (run 8) according to the procedure described above.

Analysis of ethanol and aroma

Ethanol and volatile aromatic compounds in the rice wines were analyzed on a Shimadzu model GC-14A gas-chromatograph equipped with a 3.1-m PEG-HT column (Gasukuro Kogyo Inc., Tokyo), as previously described[4,5].

General analytical procedures

Reducing sugars were quantitated by the method of Bertrand[1]. Acidity was measured by titrating 10 ml of rice wine with 0.1 N NaOH[4,5]. Organoleptic tests were also performed to evaluate the various rice wines[4,5].

Results

The rice grains used in our experiments are shown in Fig. 1.

Ethanol fermentation of polished aromatic red rice and aromatic red rice bran with and without cooking

Fermentation rates of mashes that contained cooked starchy materials (runs 2 and 4) were higher than those of mashes that contained uncooked starchy materials (runs 1 and 3) (Fig. 2). The final amounts of CO_2 generated from mashes that contained cooked and uncooked starchy materials were almost equal (Table I). The final extent of consumption of starchy material was not affected by the cooking process. The acidity of the filtrate of the fermented mash, namely, the rice wine, made from rice bran was higher and that of rice wines made from uncooked starchy materials were slightly higher than the acidity of the other rice wines.

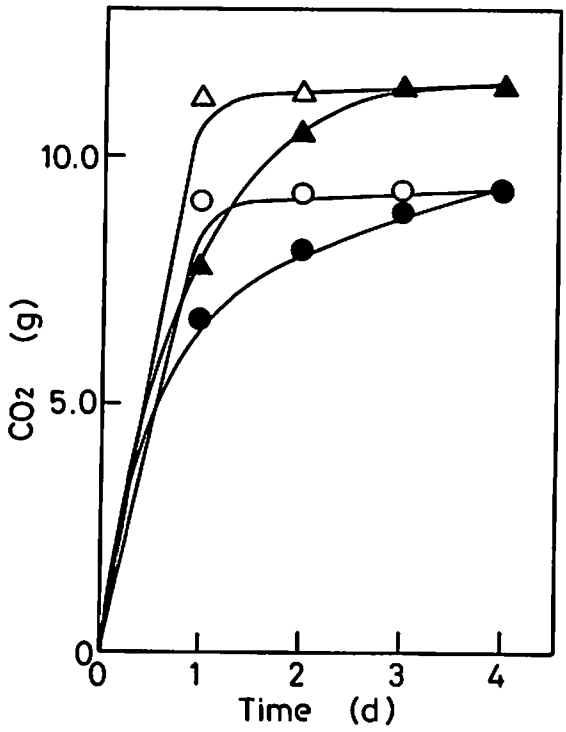

FIG. 2. Time courses of fermentation of mashes composed of polished aromatic red rice or aromatic red rice bran with and without cooking.
Symbols: ▲, uncooked polished aromatic red rice (run 1); △, cooked polished aromatic red rice (run 2); ●, uncooked aromatic red rice bran (run 3); ○, cooked aromatic red rice bran (run 4).

TABLE I. Characteristics of rice wines made from polished aromatic red rice and aromatic red rice bran with and without cooking

Runs	1	2	3	4
	Polished rice		Rice bran	
Cooking[a]	●	○	●	○
CO_2 output (g)	11.5	11.4	9.3	9.3
Total glucose in feed (g)	22.7	22.7	20.0	20.0
Total glucose in fermented mash (g)	0.4	0.4	2.0	1.6
Consumption of glucose (%)	98	98	90	92
pH	4.2	4.2	4.1	4.2
Acidity (ml)	5.8	5.7	11.3	10.9

a) Cooking: ●, without cooking; ○, with cooking.

The amounts of ethyl acetate contained in rice wines made from uncooked starchy materials (runs 1 and 3) were larger than those in the rice wines made from cooked starchy material (runs 2 and 4) (Table II). Organoleptic tests revealed that the aromatic characteristics of the rice wine made from uncooked, polished rice (run 1) were better than those of rice wine made from cooked, polished rice (run 2). The quality of rice wines made from aromatic red rice bran was not affected by the cooking procedure.

Ethanol fermentation of cooked and/or uncooked, polished aromatic red rice and aromatic red rice bran

The fermentation rates of mashes composed of cooked starchy materials were much higher than those of mashes composed of uncooked starchy materials (Fig. 3). The total amount of CO_2 generated from the various mashes was 9.5–9.8 g. The acidity of the rice wine made from cooked starchy material was higher than that of the rice wine made from uncooked starchy material (Table III).

The amount of ethyl acetate contained in the rice wines from runs 5–7 was much larger than that contained in the rice wine from run 8 (Table IV). Organoleptic testing revealed that the rice wine made from the mash composed

TABLE II. Analysis of the aroma of rice wines made from polished aromatic red rice and aromatic red rice bran with and without cooking

Runs	1	2	3	4
	Polished rice		Rice bran	
Cooking[a]	●	○	●	○
Ethyl alcohol (%, v/v)	11.4	11.3	8.6	9.0
Isobutyl alcohol (ppm)	421	458	199	122
Isoamyl alcohol (ppm)	450	342	286	291
n-Propyl alcohol (ppm)	70	23	27	23
Ethyl acetate (ppm)	314	191	137	113
Ethyl lactate (ppm)	1.1	ND[b]	0.5	ND
Isoamyl acetate (ppm)	5.7	1.0	1.6	2.0
Acetaldehyde (ppm)	99	60	51	2.0
Organoleptic test[c]	+	−	++	++

a) Cooking: ●, without cooking; ○, with cooking.
b) ND, not detected.
c) Organoleptic test: ++, good; +, moderately good; −, bad.

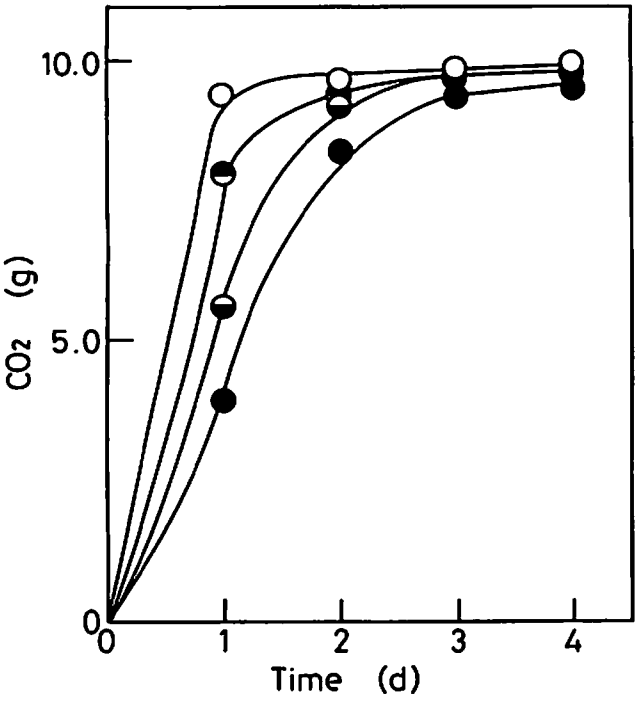

FIG. 3. Time courses of fermentation of mashes composed of cooked and/or uncooked, polished aromatic red rice and aromatic red rice bran.
Symbols: ◓, cooked, polished aromatic red rice and uncooked aromatic red rice bran (run 5);
◒, uncooked, polished aromatic red rice and cooked aromatic red rice bran (run 6);
●, uncooked, polished aromatic red rice and uncooked aromatic red rice bran (run 7);
○, cooked, polished aromatic red rice and cooked aromatic red rice bran (run 8).

TABLE III. Characteristics of rice wines made from cooked and/or uncooked, polished aromatic red rice and aromatic red rice bran

Runs	5	6	7	8
		Cooking[a]		
Polished rice	○	●	●	○
Rice bran	●	○	●	○
CO_2 output (g)	9.5	9.8	9.5	9.6
Total glucose in feed (g)	19.5	19.5	19.5	19.5
Total glucose in fermented mash (g)	0.7	0.6	0.7	0.7
Consumption of glucose (%)	96	97	96	96
pH	4.1	4.3	4.0	3.9
Acidity (ml)	8.0	8.7	8.1	8.6

a) Cooking: ●, without cooking; ○, with cooking.

of uncooked aromatic red rice bran had a refined aroma. The quality of rice wine made from the mash composed of cooked, polished aromatic red rice (run 8) was relatively low but was improved by addition to the mash of uncooked aromatic red rice bran (run 5).

Discussion

In order to produce red rice wine of refined quality both in terms of aroma and taste, uncooked, unpolished aromatic red rice grains should be used as the material for red rice wine brewing[4]. With the cooking process, the rate of fermentation of the mash was accelerated. During the cooking process, however, the red color and fine aroma of the red rice were destroyed.

TABLE IV. Analysis of the aroma of rice wines made from cooked and/or uncooked, polished aromatic red rice and aromatic red rice bran

Runs	5	6	7	8
		Cooking[a]		
Polished rice	○	●	●	○
Rice bran	●	○	●	○
Ethyl alcohol (%, v/v)	10.9	10.9	10.6	10.8
Isobutyl alcohol (ppm)	200	314	313	151
Isoamyl alcohol (ppm)	382	401	405	387
n-Propyl alcohol (ppm)	17	44	53	10
Ethyl acetate (ppm)	228	378	336	211
Ethyl lactate (ppm)	ND[b]	1	1	ND
Isoamyl acetate (ppm)	2	3	3	4
Acetaldehyde (ppm)	213	198	244	111
Organoleptic test[c]	+++	+++	++++	−

a) Cooking: ●, without cooking; ○, with cooking.
b) ND, not detected.
c) Organoleptic test: −+, good; +, moderately good; −, bad.

Fermentation tests using fractionated red rice grains revealed that the polished rice fraction of the red rice was badly affected by the cooking process. By contrast, the bran fraction of aromatic red rice was fairly resistant to the cooking process. The bran fraction was hardly affected or spoiled by the cooking process and this fraction, when added to the mash, improved the quality of rice wine made from mash that contained cooked polished rice.

We speculated that the undesirable effects of the cooking process occurred in the polished rice fraction of aromatic red rice. The bran fraction of aromatic red rice is closely associated with the formation of the color and aroma of aromatic red rice wine. The bran fraction of aromatic red rice had, furthermore, a compensatory effect on the aroma component of the red rice wine made from cooked polished rice.

In Japanese sake brewing, the bran fraction of rice grains is usually removed for production of sake with an excellent flavour and a refined taste. Aromatic red rice wine brewing with uncooked, unpolished rice grains is quite different from traditional Japanese sake brewing in which cooked polished rice grains are used as starting material.

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