Physicochemcal Properties of *Jeungpyun*, Korean Traditional Fermented Rice Cake Prepared with Brown Rice and Barley Flour

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Abstract - The functional *Jeungpyuns* with dietary fiber containing cereals such as brown rice and barley flour were developed and physiochemical properties were investigated. The water binding capacity had significantly the highest value of 28.4% in raw rice flour, followed by brown rice flour and barley flour. The lowest reducing sugar value was seen in unpolished rice substituted *Jeungpyun* with value of 5.420 ($P<0.05$). The amount of reducing sugar decreased slightly after steaming, due to the increased degree of sugar dissociation. The L value of the lightness decreased significantly with the substituted samples ($P<0.05$). The barley substituted samples were darker than that of brown rice sample groups with less green and yellow color. Microstructures of starch particles after fermentation showed completely dispersed starch particles with air bubbles and sponge-like structure in all samples after steaming. Thus, functional *Jeungpyun* replaced with brown rice and barley flour can be successfully formulated and has been influenced by the physicochemical properties.

Key words : *Jeungpyun*, brown rice, barley, sensory, quality

INTRODUCTION

Rice is the main staple in Korea as a major country that produces rice having the optimal weather and rain conditions for producing rice. There are a lot of trials and requirements in the development of processed rice products that would be appropriate to the Korean diet pattern and various taste preferences. Researches on the processing of *Jeungpyun*, a traditional steamed rice cake with fermentation, have been tried in various ways for one of the promotion of rice consumption (Choi and Lee 1993; Kim and others 1999; Chun and others 2002). Having the texture between rice cake and bread, *Jeungpyun* is digested and absorbed by the body easily. It is the processed rice product having viscoelasticity and aerated texture unlike other rice cakes (Kim and others 1999). However, the specific mechanism has not been determined yet. Structure of *Jeungpyun* is unique in the sense that it forms sponge-like texture only with rice flour without using additives. In the present study, *Jeungpyun* containing natural dietary fiber materials such as brown rice and barley were developed to obtain basic data for physiochemical properties of the *Jeungpyun*.

MATERIALS AND METHODS

1. Materials

The rice (Japonica type) and brown rice used in the present study produced in Kimpo city, Kyunggido were

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purchased from a local supermarket. The amylose content of the rice was 16.9%. Other materials used including raw barley flour (Taekwang Food Co., Kyungsangdo, Korea), sugar (Cheil Jedang Corporation, Seoul, Korea), activated dry yeast (Ottogi Corporation, Seoul, Korea), brown rice vinegar (Ottogi Corporation, Seoul, Korea), and salt (Hanju salt, Seoul Korea) were purchased from a department store and kept at 2°C refrigerator until use.

2. Preparation of *Jeungpyun*

Jeungpyun was prepared with modification of the standard formula, given in Table 1. Rice and brown rice were washed, soaked in water for 3 hr, drained of water, and ground with a roller type mill (3HP, Kyung Chang Machinery, Daegu city, North Kyungsangdo, Korea). As the barley could not be ground and sifted as rice or brown rice after soaking due to cohesiveness, raw barley flour was used. The rice, brown rice and barley flour were sifted using a 40 mesh sift, air-tightly packaged 500 g each using a vacuum sealer (Ellyon, Kyunggido, Korea), and kept frozen at −40°C until use. Six gram of dry yeast was dissolved in 30 g (flour weight basis) sugar in 150 g water at 40°C and left to stand at room temperature for 20 min. Six hundred gram rice flour, 6 g salt, 6 g vinegar, another 30 g sugar, and 150 g water were added and mixed. The batter was placed in a 35°C incubator (J-IM3 JISI-Co, Sanyo, Tokyo, Japan) for the first fermentation for 1.5 hr. The first fermented batter was degassed and the second fermentation was carried out in the same incubator for 1 hr using a container ($45 \times 45 \times 8$ cm^3) specially manufactured for this whole experiment. The samples were steam cooked for 30 min and allowed to sit for 10 more min without further heating. The rice cakes were cooled down to room temperature for 1 hr before measurements.

Table 1. [1]Formulation ratios for partial substitution of rice flours with brown rice and barley in preparation of *Jeungpyun*

Ingredients / Sample	Rice flour	Brown rice	Barley	Salt	Sugar	Dry yeast	Water
Control	100	0	0	1	10	1	50
Brown rice	40	60	0	1	10	1	60
Barley	40	0	60	1	10	1	70

[1]Rice flour weight basis (%)

3. Moisture content and water binding capacity

The moisture contents of raw and substituted samples were measured. 5 g of each sample was placed in a container and dried for 5 hr at 105-110°C in a drying oven (HO80 Hanwon Testing Machine Co., Seoul, Korea) using constant pressure. The weight of each sample was measured after cooling in a decicator and the moisture contents were calculated.

Water binding capacity was measured to decide the hydration ratio of water to each treated group according to the method by Deshpands and others (1982) and Medcal and Gilles (1965). The 2 g of freeze dried and sifted raw and *Jeungpyun* samples were added to 40 ml of distilled water in 100 ml beaker, stirring using a magnetic stirrer for 1 hr, and left for 30 min. Centrifugation was done at 2000 rpm for 15 min using a centrifuge (Hanil, Seoul, Korea) and removed the supernatant. After leaving the precipitant for 5 min by standing the centrifugation tube upside down, the resulting precipitant was measured. The water binding capacity was calculated from the precipitated and initial sample weight ratio.

$$\text{Water binding capacity (\%)} = \frac{\text{Precipitated sample weight (g)}}{\text{Initial sample weight (g)}} \times 100$$

4. Reducing sugar and free sugar

The amount of reducing sugar was measured by modifying the Somogyi method (Chae SK 1998). The amount of free sugar was measured in *Jeungpyun* samples collected before fermentation, after first and second fermentation and after steamed according to the Dinitrosalicylic acid (DNS) method (Chae SK 1998). The standard used was glucose solution.

5. Color measurements

The color of the sample was measured with a colorimeter (Chroma Meter, CR-300, Minolta, Osaka, Japan) to get L (lightness), a (redness), and b (yellowness) values. The colorimeter was standardized with a white tile (C/2, L = 98.63, a = 0.19, b = −0.67).

6. Observation of microstructure using Scanning Electron Microscope (SEM)

In order to observe the microstructure of particle condition and aerated state after steaming *Jeungpyun*, 20 g of the batter and 1 piece of *Jeungpyun* ($1\times1\times1$ cm^3) were freeze dried. Tiny small portion of these samples were mounted on a circular aluminum specimen stub with adhesive tape, coated with gold-palladium using a sputter-coater (Hitachi E-1010 10 N, Tokyo, Japan) and observed under a scanning electron microscope (Hitachi 2500, Tokyo, Japan).

7. Statistical analysis

Three replications of the entire experiments were conducted and analyzed by randomized complete block design. Analysis of variance procedure of the SAS was performed using SAS package (SAS 1996). For the determination of difference between samples, Duncan's multiple range test (Song MS and others 1989) was used.

RESULTS AND DISCUSSION

1. Moisture content and water binding capacity

Table 2 shows moisture contents and water binding capacity of rice flour, brown rice flour, raw barley flour, and those of *Jeungpyuns* prepared with substituting brown rice and barley flour by weight immediately after preparation. Moisture contents in ground rice flour and brown rice flour and commercially sold barley flour were 29.1%, 28.3% and 9.37%, respectively. The moisture content in raw barley flour was significantly low at 9.37% compared with the control sample. Thus, the water addition level was determined for each sample through a pre-test as shown in Table 1.

The water binding capacity had significantly the highest value of 28.4% in raw rice flour, followed by brown rice flour and barley flour. This result is similar to the result found by Choi and Kim (1993) who reported that rice flour compared with brown rice flour showed higher water binding capacity and the one found by Lee (1994) and Cho (1994) who reported that the water binding capacity was significantly higher in rice hull compared with barley hull. This result was probably related with the contents of dietary fiber containing various types and various components. In *Jeungpyuns* after steaming, the water binding capacity was significantly higher in control and barley substituted samples compared with brown rice substituted samples ($P<0.05$). Barley contains the soluble fiber β-D-glucan or pentosans such as xylan and arban (Gohl and others 1997). These viscous materials hydrate with water easily through hydrogen bonding under the presence of organic acids (Goh YS and Lee IS 1985). Furthermore, Halick and Kelly (1959) reported that water molecules bound in heat treated starch include the water molecules that infiltrated starch particles and ones that adhere to the particle surfaces and water absorption is larger in molecules with lower internal density such as barley particles rather than rice particles.

Table 2. Moisture contents and water binding capacity of freeze dried raw and *Jeungpyun* flours substituted with brown rice and barley flour at rice flour basis

Sample	Moisture content (%)		Water binding capacity (%)	
	Raw	*Jeungpyun*	Raw	*Jeungpyun*
Control	29.1[a]	49.5[a]	284.9[a]	428.7[a]
Brown rice	28.3[a]	50.5[a]	268.9[b]	404.0[b]
Barley	9.37[b]	49.5[a]	224.0[c]	432.8[a]

Same letters in a column are not significantly different each other ($p<0.05$)

2. Reducing sugar and free sugar

Table 3 shows the amount of reducing sugar and free sugar in *Jeungpyun* samples according to the progres-

Table 3. Changes in reducing sugar for batters and the *Jeungpyun* replaced with flours of brown rice and barley

Sample	Reducing sugar			
	Before fermentation	First fermentation	Second fermentation	After steaming
Control	[A]2.436[d1]	[A]5.172[b]	[A]5.853[a]	[A]5.397[b]
Brown rice	[A]2.267[d]	[B]4.527[c]	[B]5.420[a]	[B]5.060[c]
Barley	[A]2.397[d]	[A]4.930[c]	[A]5.680[a]	[AB]5.180[b]

Same letters are not significantly different each other($p<0.05$)
[1]Mean values of reducing sugar for various fermentation stage and after steaming at each treatment (row)
Mean values at of reducing sugar for treatments at each fermentation stage (column)

Table 4. Changes in free sugar for batters and the *Jeungpyun* replaced with flours of brown rice and barley

Sample	Free sugar			
	Before fermentation	First fermentation	Second fermentation	After steaming
Control	$^{A}1.204^{a}$	$^{A}1.184^{b}$	$^{A}1.035^{d}$	$^{A}1.102^{c}$
Brown rice	$^{C}1.068^{a}$	$^{C}1.041^{b}$	$^{C}0.965^{d}$	$^{C}1.001^{c}$
Barley	$^{B}1.195^{a}$	$^{B}1.136^{b}$	$^{B}0.985^{d}$	$^{B}1.036^{c}$

Same letters are not significantly different each other ($p<0.05$)
[1]Mean values of free sugar for various fermentation stage and after steaming at each treatment (row)
mean values of free sugar for treatments at each fermentation stage (column)

sion of fermentation. Reducing sugar increased with increasing fermentation time. In each sample, the amount was the highest after second fermentation and decreased slowly after steaming. Similar result was also seen in other study (Choi and Lee 1993) of *Jeungpyun*. The amount of reducing sugar in each sample after second fermentation had values of 5.853 and 5.680 in control and barley substituted sample, respectively, showing no significant difference. The lowest reducing sugar value was seen in unpolished rice substituted *Jeungpyun* with value of 5.420 ($P<0.05$). In all samples, the amount of reducing sugar decreased slightly after steaming. The increased amount of the reducing sugar after second fermentation was probably due to the production of increased sugar with the great increase of amylase activation. The decreased amount of reduced sugar after steaming was due to the increased degree of sugar dissociation.

Free sugar, unlike reduced sugar, decreased gradually with fermentation time and increased slightly after steaming (Table 4). After second fermentation, the amount of free sugar was the highest in control sample with a value of 1.035, followed by barley substituted and unpolished rice substituted samples with values of 0.985 and 0.965, respectively. The same pattern was seen in all fermentation groups and after steaming. The decrease in free sugar during fermentation was because of the proliferation of microorganisms and fermentation. The slight increase of the free sugar after steaming was probably due to the heat treatment. Sugar is one of the important factors participating in the production of flavor in the final product.

Table 5. Colorimeter characteristics of *Jeungpyun* substituted with flours of brown rice and barley

Sample	L	a	b	ΔE
Control	75.03^{a1}	-1.88^{c}	5.09^{c}	0
Brown rice	68.80^{b}	-0.97^{b}	12.74^{a}	9.05
Barley	62.85^{c}	-0.36^{a}	12.22^{ab}	13.59

[1]substitution level: rice flour weight basis
Means of three replications; Same letters in a column are not significantly different each other ($p<0.05$)
L: Light scale (100 = pure white, 0 = black, a: (+ red, − green), b (= yellow, −blue)

3. Color differences

L value of the lightness decreased significantly with the substituted samples (Table 5). The L value was significantly high in control group with 75.03 and it was 62.85 in the barley substituted sample, showing the lowest value. The a value was all negative representing slightly green color tone in all sample groups. The b value of yellowness was the highest in brown rice substituted sample with the value of 12.74 and control had the lowest b value of 5.09 ($P<0.05$). According to the study by Choi and Kim (1993) who examined white rice prepared by adding brown rice, lower b values were seen in substituted samples, similar to the result of the present study. The largest color difference of $\Delta\varepsilon$ was seen in barley substituted sample compared with the control sample. According to these results, when brown rice and barley flours are substituted in place of rice flour in the preparation of *Jeungpyun*, barley substituted samples were darker than that of brown rice sample groups with less green and yellow color

4. Observation of microstructure using SEM

Cross-sectional structure of *Jeungpyun*s made by substituting rice flour with brown rice and barley flours were observed under SEM as shown in Figs. 1-3. Starch particles before fermentation in control sample were well-aligned polygons with each angle caved in. It was reported that polygonal shape with well aligned angle in rice starch particles before gelatinization is due to particles that went in as starch particles and came off during synthesis (Esau 1997). Starch particles before

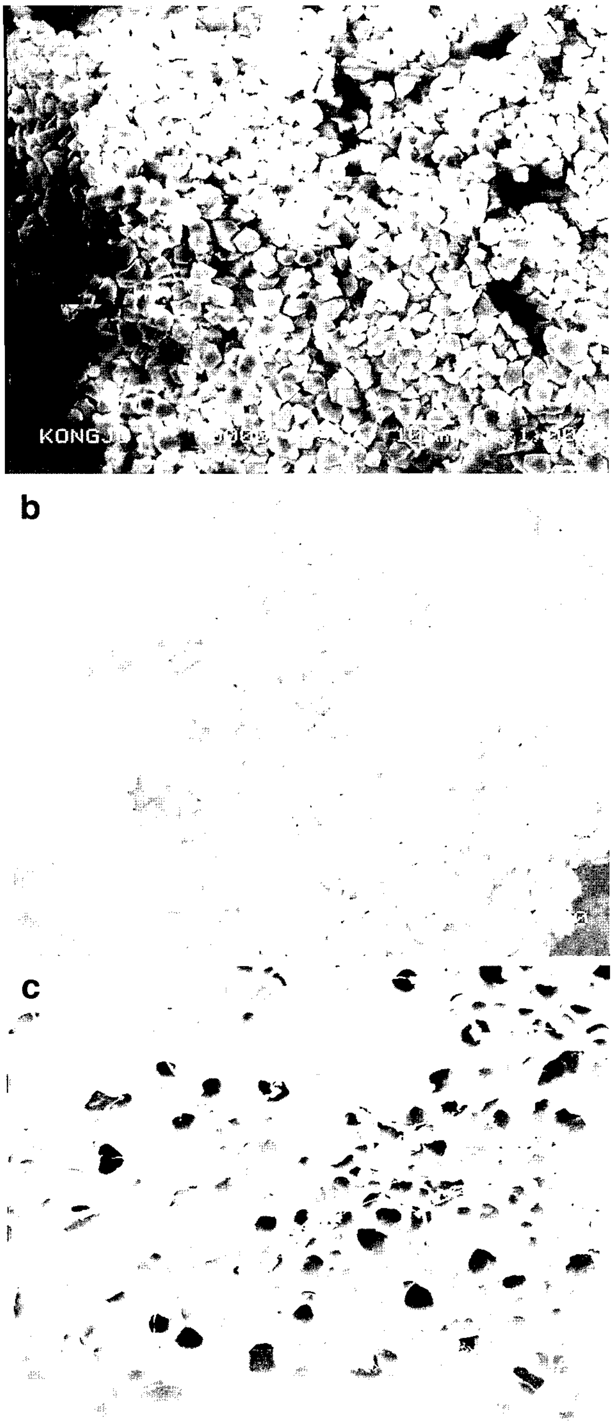

Fig. 1. Scanning electron micrographs for the control batter and *Jeungpyun*. a: before fementation, b: after fermintation, c: after steaming

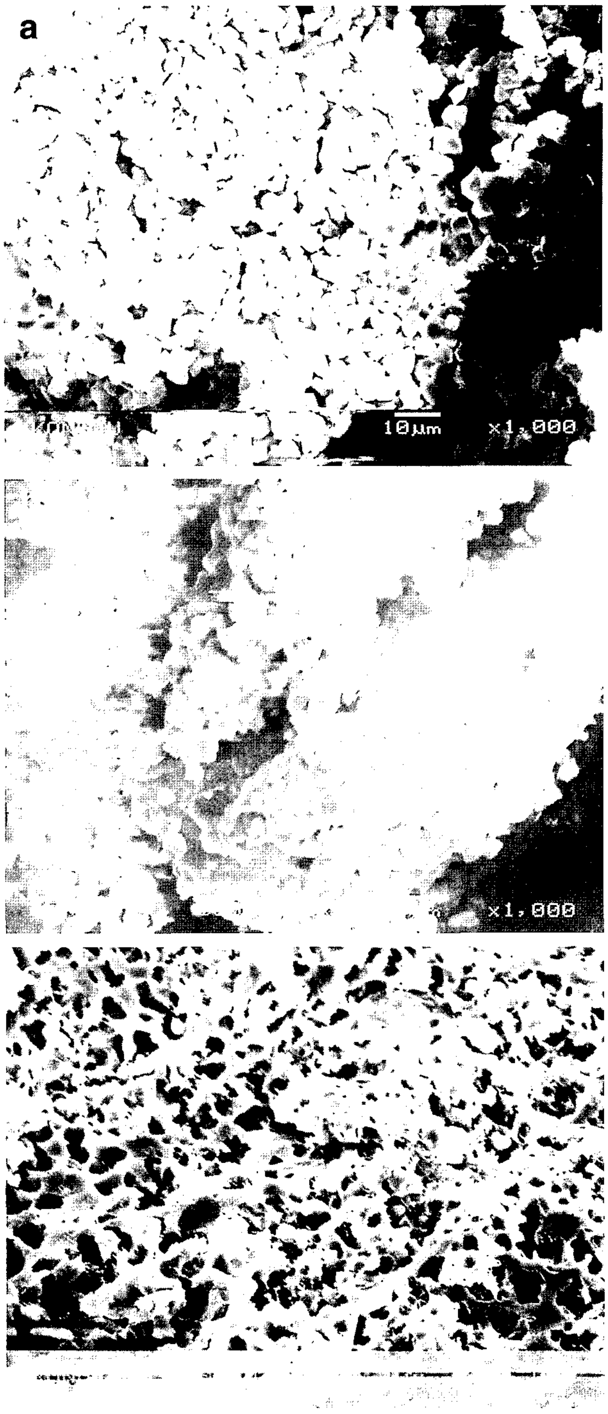

Fig. 2. Scanning electron micrographs for the batter and *Jeungpyun* substituted with brown rice flour. a: before fementation, b: after fermintation, c: after steaming

fermentation in brown rice substituted sample showed slightly large polygons compared with those in control sample. They were round shapes in barley substituted sample. Microstructures of starch particles after fermentation showed much CO_2 gas collected in small crevasses between particles with no destruction of particles

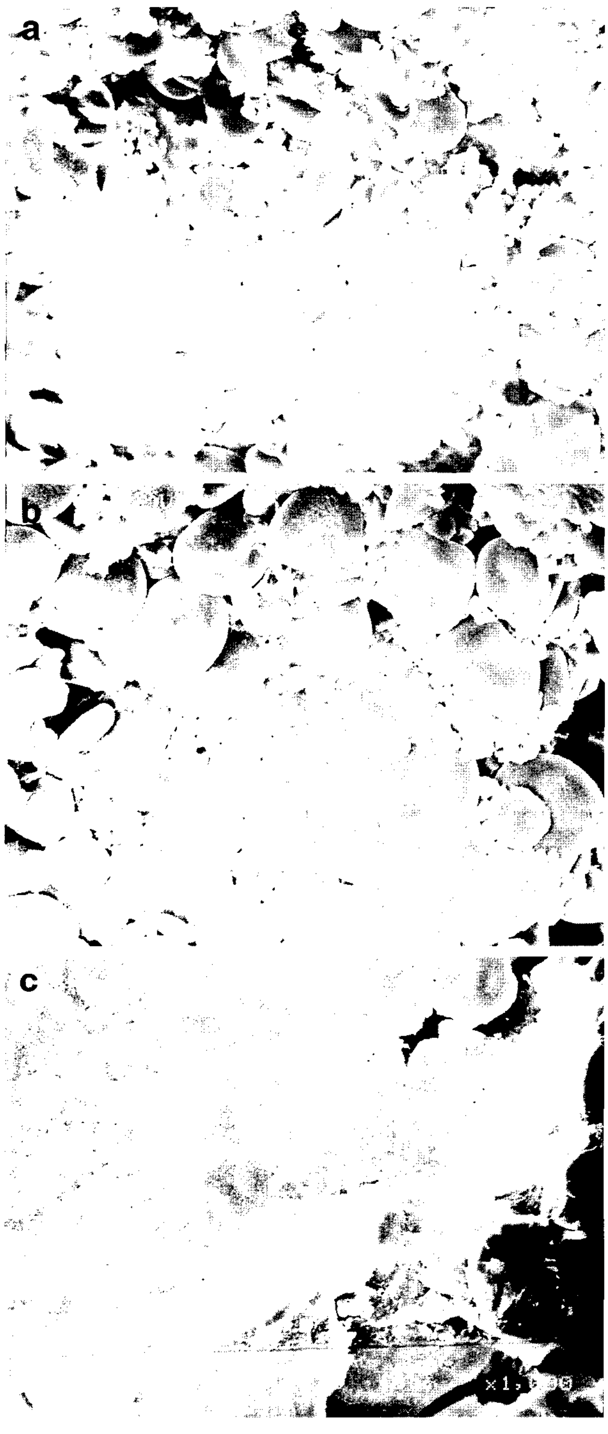

Fig. 3. Scanning electron micrographs for the batter and *Jeungpyun* substituted with barley flour. a: before fementation, b: after fermintation, c: after steaming

in all samples. In control and brown rice substituted samples, since the samples were ground after being sufficiently soaked in water, particle sizes did not different significantly before or after fermentation. Since barley samples were prepared with raw barley flour, increased particle size was shown after fermentation due to hydration and the collected CO_2 gas. After steaming, all *Jeungpyun* samples showed completely dispersed starch particles with air bubbles formed in several places and internal empty areas, forming a sponge-like structure, unlike other rice cakes.

5. Conclusion

The functional *Jeungpyun* replaced with brown rice and barley flour, samples were darker, more red and yellow than control. Microstructures of starch particles after fermentation showed completely dispersed starch particles with air bubbles a sponge-like structure in all samples after steaming. From the observations above, it can be concluded that the The functional *Jeungpyun* replaced with brown rice and barley flour can be successfully formulated and has been influenced by the physicochemical properties. Future study is expected to find out optimum level of substitution.

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Manuscript Received: September 27, 2003
Revision Accepted: November 19, 2003
Responsible Editorial Member: Ae-Son Om
(Hanyang Univ.)