FOOD QUALITY and CULTURE
Food Quality Culture 2(1): 43~47 (2008)

Evaluation of Physicochemical Properties of *Jeungpyun* Prepared with Membrane-filtered Tofu Whey Concentrates

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ABSTRACT This study examined the quality characteristics of *Jeungpyun* prepared with different additions of nano-filtered (NF) tofu whey concentrates. The initial pH values of the *Jeungpyun* batters ranged from 5.64 to 5.78, and decreased to 4.77-4.98 after 4 hours of fermentation at 35°C. The volume and specific volume values of the control *Jeungpyun* were lower than those of *Jeungpyun* samples prepared with 1%, 2%, and 3% NF powder. The color of the *Jeungpyun* became increasingly greenish-yellow as the NF powder level increased. Hardness and brittleness decreased with increasing NF powder content, while cohesiveness and springiness were not significantly different. Sensory evaluations revealed that as the level of NF powder increased, takju smell and sourness increased, but no significant differences were observed for sweetness and moistness between the control and NF powder groups. In terms of overall acceptability, the results revealed that *Jeungpyun* can be prepared with up to 1% NF powder in place of rice powder and be deemed as acceptable as a control *Jeungpyun* product.

KEYWORDS: *Jeungpyun,* tofu whey, nanofiltered powder

INTRODUCTION

Jeungpyun is a traditional Korean rice cake prepared by fermenting rice powder with takju (a traditional Korean liquor), providing it a sour taste and sponge-like soft texture (Seo et al 1992). *Jeungpyun* is also valued for its longer shelf stability as compared to other rice cakes, in which it is more favorably consumed during the summer months.

Consumer interest in healthier foods has led to the introduction of adding diverse functional ingredients to *Jeungpyun* (Hong et al 2007, Jang and Park 2007, Kang et al 2006, Kim et al 2001, Kim et al 2002, Park et al 2004, (Park 2007, Yoo and Shim 2006).

Tofu is prepared by coagulating soybean protein in the presence of divalent cations such as Mg^{+2} or Ca^{+2}; this process produces a large amount of tofu whey, which is a waste product (Chung et al 2006). Recently, it was reported that tofu whey includes various functional components such as isoflavones, oligosaccharides, and phytic acids (Kim 1996, Ryoo et al 2004), and much research has examined the separation of these components from the tofu whey (Kim et al 1992, Kim et al. 2005, Seo et al 1997) in order for them to be utilized (Chung et al 2005).

The aim of this study was to investigate the effects of replacing rice powder with different amounts of membrane-filtered tofu whey concentrate on the quality characteristics of *Jeungpyun*.

MATERIALS AND METHODS

Materials

The tofu whey concentrates for this study were prepared by a previously described nanofiltration method (Kim et al 2005, Kim et al 2005). Proximate composition analysis showed that the nanofiltered (NF) powder contained 5.63% moisture, 17.50% ash, 0.62% crude fat, and 5.23% crude protein (Kim et al 2004). Distilled water was used in the formulations, and rice (Cheolwon, Korea), takju (Jangsoo Makgeolli, Korea, pH 3.40±0.05), sugar (CJ Co., Korea), and salt (Hanju salt, Korea) were purchased from a local market.

Jeungpyun Preparation

The ingredients used in the formulations are shown in Table 1. The rice was rinsed with tap water 5 times, soaked overnight, and then drained for 1 hour. The drained rice was milled to pass through a 20 mesh sieve and then vacuum packaged in a polyethylene bag and stored at −20°C.

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Received March 12, 2008; Accepted April 3, 2008

Table 1. Formulas for *Jeungpyun* prepared with different levels of NF powder

Groups	Ingredients (%)					
	Rice powder	NF powder	Sugar	Salt	Takju	Water
NF-0[1)]	100	0	21	1	15	45
NF-0.5	99.5	0.5	21	1	15	45
NF-1	99	1.0	21	1	15	45
NF-2	98	2.0	21	1	15	45
NF-3	97	3.0	21	1	15	45

[1)]NF-0: nanofiltered powder-0%, NF-0.5: nanofiltered powder-0.5%, NF-1: nanofiltered powder-1%, NF-2: nanofiltered powder-2%, NF-3: nanofiltered powder-3%.

NF powder was used to replace portions of the rice powder (0, 0.5, 1, 2, 3%) in the *Jeungpyun* recipe. The NF powder substitution levels were determined from preliminary data, based on sensory tests (data not shown). All ingredients were mixed with a hand mixer (62680, Proctor-Silex, USA) at speed 2 for 1 min, and the *Jeungpyun* batter was placed in a 35°C incubator (EP-20, Daeyung Co., Korea) for 4 hr for the first fermentation. Then, the batter was degassed by mixing at speed 2 for 30 seconds, and the second fermentation was carried out for 20 min under the same conditions. Next, the *Jeungpyun* batter was steamed for 20 min and then allowed to sit for 10 additional minutes without heating. Finally, the *Jeungpyun* was cooled to room temperature for 1 hr and packaged in polyethylene bags that were sealed until analyses were performed.

pH measurement

To determine pH, 5 g of each *Jeungpyun* batter was blended with 25 mL of distilled water, followed by measurement with a pH meter (level II, inoLab, Germany).

Weight, volume, and specific volume measurements

The weight of the *Jeungpyun* was determined with a precision scale (Mettler GB 3002, Switzerland) and volume was measured using the seed replacement method. The specific volume of the *Jeungpyun* was obtained from the ratio of weight (g) to volume (mL).

Color measurements

The color of the *Jeungpyun* was determined by measuring tristimulus L (lightness), a (redness), and b (yellowness) values with a colorimeter (JX 777, Juki, Japan). The interior color was measured from 5 different points per one *Jeungpyun* sample, and three samples were tested per each treatment; Averages of these reading were then calculated. The colorimeter was calibrated against a standard white plate (L=+98.5, a=+0.07, b=−0.40).

Texture analysis

The textural characteristics of the *Jeungpyun* were determined with a rheometer (Compac-100, Sun Scientific Co., Japan). *Jeungpyun* samples were cut into cubes of 4×4 ×2 cm and compressed twice using a aluminum plunger (diameter 10 mm) to 40% of their initial height, at a speed of 120 mm/min. The textural variables were hardness, cohesiveness, springiness, and brittleness. An average of three values per one *Jeungpyun* sample was taken and three samples were tested per each treatment.

Sensory evaluation

Sensory evaluations were conducted after cooling the *Jeungpyun* for 1 hr at room temperature. The *Jeungpyun* was cut in half, placed on a plastic dish coded by a three-digit random number, and offered to 8 trained panelists in an individual booth with lighting. Takju smell, sweetness, sourness, moistness, and air cell uniformity were evaluated for each sample using a seven-point scale, where 1=none, 3 =moderate, 7=intense. The overall acceptability score was based on a similar scale, where 1=very bad, 3=neither good nor bad, 7=very good.

Statistical analysis

The data are expressed as mean±standard deviation of at least triplicate measurements. Analysis of variance (ANOVA) was applied to study the differences among the samples using SAS (Statistical Analysis System, version 8.12). Comparisons between mean values were performed by Duncan's multiple range test at $\alpha=0.05$.

RESULTS AND DISCUSSION

pH of *Jeungpyun* batters

Figure 1 shows the changes in pH for the *Jeungpyun* batters during fermentation. The initial pH of the batters ranged from 5.64 to 5.78, and gradually decreased over time. After 4 hr of fermentation, the pH levels ranged from 4.77 to 4.98, and the NF groups had higher values than the control *Jeungpyun.* The reduction of pH during fermentation is attributable to the production of organic acids such as succinic and lactic acid by microorganisms (Park and Suh 1994). Nam and Woo (2002) reported that the pH values of *Jeungpyun* batters prepared with chitosan-oligosaccharide

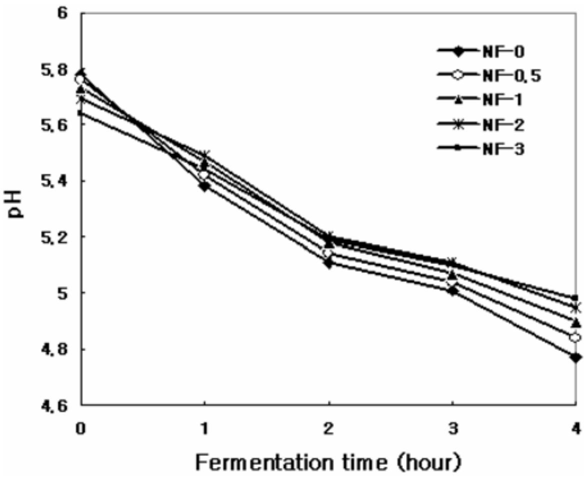

Fig. 1. Changes in pH for *Jeungpyun* batters prepared with different levels of NF powder.

varied between 4.89 and 5.05 after 3 hr of fermentation. Park et al (2004) reported pH values of 5.69-5.94 for *Jeungpyun* batters containing *Paecilomyces japonica* after 3 hr of fermentation. Differences between our study's findings of and those of other studies may have resulted from several factors, including fermentation time, temperature, and ingredients in the formulations.

Weight, volume, and specific volume

The weight, volume, and specific volume values of the *Jeungpyun* are presented in Fig. 2. The weights of the groups ranged from 27.79 g to 28.18 g, showing no significant differences between the control and the treatments. The volume of the control was 46.3 mL, and the 1%, 2%, and 3% NF groups had higher volumes of 49.67 mL, 51.00 mL, and 50.67 mL, respectively ($p<0.05$). This increase in volume could be explained by the fact that NF powder contains oligosaccharides such as sucrose and raffinose (Kim et al 2005), which stimulate the propagation of yeasts, thereby stimulating gas production. The specific volume (mL/g) followed a similar trend to the volume as the NF powder level increased. The control *Jeungpyun* had the lowest specific volume value of 1.65, and the *Jeungpyun* containing 2% NF powder showed the highest value at 1.82. Similar trends were found in *Jeungpyun* products prepared with milk (Jang and Park 2007) and red ginseng powder (Kim 2005).

Color values

The Hunter color characteristics of the *Jeungpyun* are presented in Table 2. The L-values (lightness) of the groups ranged from 67.74 to 69.41, showing no significant differences between the control and the treatments. The a-value (redness) of the control *Jeungpyun* was −0.07, and the a-values of the NF powder groups ranged from −0.52 to −1.66, which

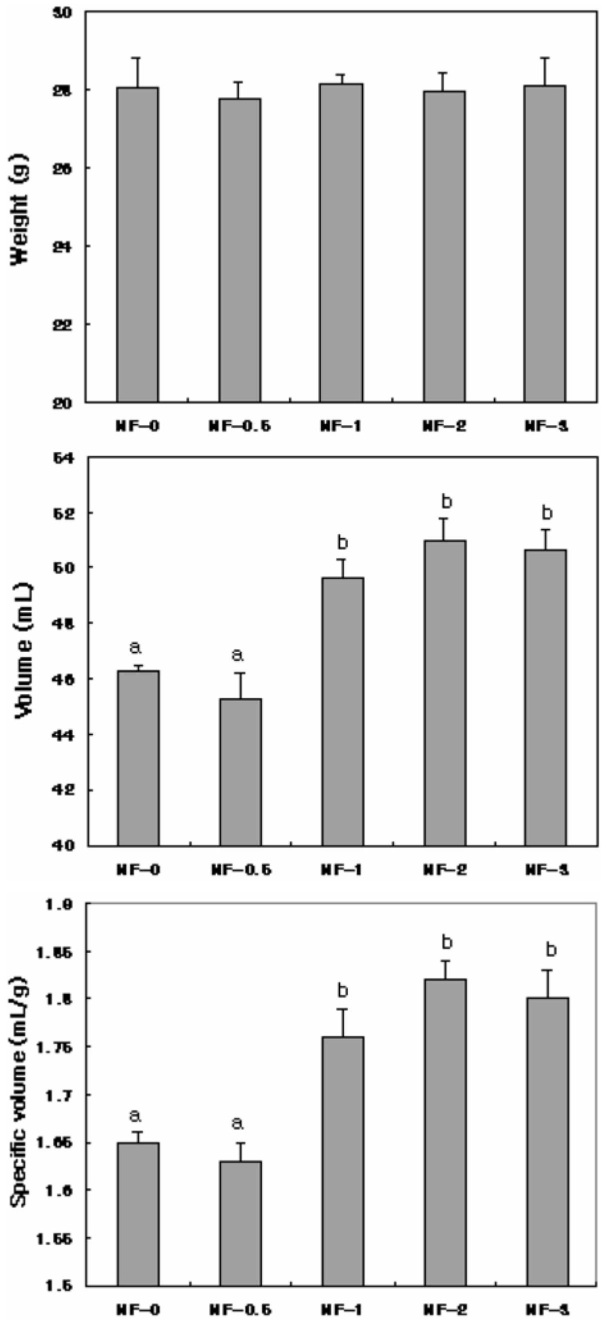

Fig. 2. Weight, volume, and specific volume of *Jeungpyun* prepared with different levels of NF powder.

became increasingly green as the amount of NF powder increased. The b-values (yellowness) of the *Jeungpyun* groups varied from 3.24 to 8.99, and increasing NF powder content produced a remarkable increase in their b-values ($p<0.05$). This may be due to the higher b-value of NF powder as compared to rice powder. Ko and Kim (2007) reported that *Jeungpyun* containing *Pleurotus eryngii* powder had a reduced L-value, but increasing a- and b-

Table 2. Hunter color values of *Jeungpyun* prepared with different levels of NF powder

	Color value		
	L	a	b
NF-0	67.79±2.48	-0.07 ± 0.13^{a}	3.24 ± 0.19^{a}
NF-0.5	68.32±2.94	-0.52 ± 0.22^{b}	4.47 ± 0.12^{b}
NF-1	67.83±2.63	-0.56 ± 0.19^{b}	5.43 ± 0.26^{c}
NF-2	67.74±1.95	-1.07 ± 0.14^{c}	7.30 ± 0.07^{d}
NF-3	69.41±3.12	-1.66 ± 0.12^{d}	8.99 ± 0.08^{e}

[1)]Means with different letters within a column are significantly different from each other at α=0.05 as determined by Duncan's multiple range test.

values as the addition level of *Pleurotus eryngii* powder increased. Kim and Lee (2002) reported that the incorporation of *Opuntia ficus-india* var. *saboten* powder into *Jeungpyun* lowered L- and b-values but increased the a-value.

Texture properties

Table 3 presents the textural property results of the *Jeungpyun* groups. The hardness value of the control *Jeungpyun* was 287.3 kg/cm^2, and the value of the 0.5% NF powder group was not significantly different; however, in the *Jeungpyun* containing 1, 2, and 3% NF powder, values were significantly lower at 262.4 kg/cm^2, 249.5 kg/cm^2, 251.5 kg/cm^2, respectively ($p<0.05$). Chung et al (2005) reported similar results in *Jeungpyun* made with ultrafiltered sunmul powder, in which hardness decreased with increasing amounts of ultrafiltered powder. Dissimilar results were found by Yoo and Shim (2006) where the addition of tapioca flour produced an increase in hardness. According to Kim and Lee (2002), *Opuntia ficus-india* var. *saboten* powder increased the hardness of *Jeungpyun.* In the present study, cohesiveness and springiness were not affected by the addition of NF powder. Springiness is related to the weight of the *Jeungpyun*, which was relatively constant in all treatment groups, as shown in Fig. 1. Brittleness values were higher in the control and 0.5% NF powder group than in the groups containing 1, 2, and 3% NF powder.

Sensory evaluation

The sensory evaluation results are presented in Fig. 3. Takju smell became stronger in the *Jeungpyun* samples as the level of NF powder increased. This may be due to the characteristic tofu smell of the NF powder, which would affect the takju smell. The panelists did not evaluate differences in sweetness, moistness, or air cell uniformity between the control and NF powder *Jeungpyun* groups. Furthermore, there were no significant differences in sourness between the control and the formulations with 0.5% and 1% NF powder, however, significant differences were found between the control and 2% and 3% NF powder groups ($p<0.05$), which may be attributed to the free amino acids present in the NF powder (Kim et al 2004). Overall acceptability scores were not different between the control and 0.5% and 1% NF powder groups; however, significant differences ($p<0.05$) were found for the groups containing higher percentages of NF powder, showing the lowest score with the 3% NF powder addition. Therefore, based on the results, *Jeungpyun* that is prepared with up to 1% NF powder in place of rice powder is as acceptable as a control *Jeungpyun* product.

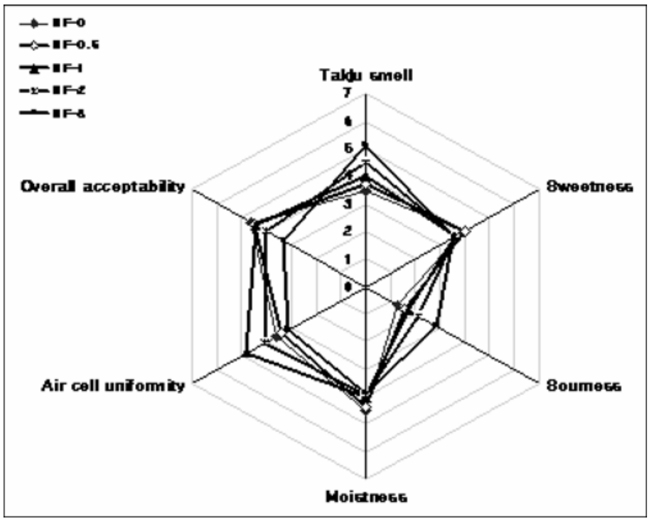

Fig. 3. Sensory scores for *Jeungpyun* prepared with different levels of NF powder.

ACKNOWLEDGMENT This research was supported by the Agricultural R&D Promotion Center in Korea (ARPC, 102001-02-HD110). Authors deeply appreciated this financial supports.

Table 3. Texture values of *Jeungpyun* prepared with different levels of NF powder

	Hardness (g/cm^2)	Cohesiveness (%)	Springiness (%)	Brittleness (%)
NF-0	287.3 ± 9.5^{a}	76.4±12.0	78.4±13.4	46.9 ± 0.8^{a}
NF-0.5	281.5 ± 16.2^{a}	77.6±14.1	79.4±25.4	47.0 ± 0.7^{a}
NF-1	262.4 ± 15.3^{b}	77.5±17.8	79.4±10.6	43.6 ± 0.2^{b}
NF-2	249.5 ± 14.1^{b}	78.6±19.5	78.9±12.8	42.3 ± 0.8^{b}
NF-3	251.5 ± 7.8^{b}	78.6±19.9	77.5±13.4	41.2 ± 0.2^{b}

[1)]Means with different letters within a column are significantly different from each other at α=0.05 as determined by Duncan's multiple range test.

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