Hindawi
Journal of Food Quality
Volume 2019, Article ID 8383619, 9 pages
https://doi.org/10.1155/2019/8383619

Research Article

Effects of *Bacillus subtilis* and *Leuconostoc mesenteroides* on the Quality Characteristics of Potato *Garaetteok*

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Received 13 September 2018; Revised 27 November 2018; Accepted 18 December 2018; Published 20 January 2019

Academic Editor: Teresa Zotta

To investigate the texture and cooking properties of *garaetteok* elaborated with potato flour, experimental products were elaborated replacing partially the rice flour, traditionally used, with nonfermented (NF) or fermented potato flour with *Bacillus subtilis* (BS) or *Leuconostoc mesenteroides* (LM) in percentages of 15% (NF15, BS15, and LM15) and 20% (NF20, BS20, and LM20). The control product (CON) was made using only rice flours. The pH of *garaetteok* was significantly lower in the BS and LM groups compared to CON and NF. Titratable acidity was the highest in BS20 and LM15. LM groups showed similar textural profiles to CON. The addition of potato flour to *garaetteok* increased the turbidity of soup (*tteokguk*), but the fermentation significantly lowered its turbidity. During storage for 24 h, *garaetteok* with fermented potato flour showed the inhibition of starch retrogradation. All scores of LM15 and LM20 were better than other potato *garaetteoks* and similar to those of CON with the exception of color acceptance. Consequently, *garaetteok*-added potato flour fermented with *L. mesenteroides* was the most preferable in terms of texture, cooking, and sensory characteristics.

1. Introduction

According to the 2016 Food Industry Statistical Information System (FIS), Korea's health functional food market grew at an average annual rate of 8.4% since 2011 and amounted to U.S. $ 2.06 billion as of 2015; since then, the growth of the market has continued to accelerate [1]. Growing attention is being paid to fermentation as a way of enhancing functionality of food by using fermentation with strains of lactic acid bacteria (LAB), *Bacillus* sp., and yeast, while minimizing the physical and chemical processing of food [2]. *Garaetteok* is a long, cylindrical rice cake made by steaming nonglutinous rice flour, pounding it, and rolling it. *Garaetteok* is often used as a main ingredient in *tteokguk* (rice cake soup) and *tteokbokki* (rice cake pasta) [3]. The consumption of these processed foods as a substitute for staple foods and as a popular snack throughout the year in food service, catering, and home is increasing [4]. *Garaetteok* is within the range of moisture content that is vulnerable to starch retrogradation. This means that gelatinized starch is recrystallized in the process of distribution and storage. This starch retrogradation leads to deterioration in the quality of *garaetteok*, which can include a hardening of its texture and reduced digestibility and taste [5]. Previous studies have recorded attempts to inhibit starch retrogradation by adding trehalose, modified starch [6], maltitol [7], surfactant [8] and other ingredients to *garaetteok*. As well, other studies have reported that the addition of rice bran [9] and germinated brown rice flour [10], cactus fruit (*Opuntia humifusa*) powder [11], ginseng powder [12] or *Lentinus edodes* powder [13] to *garaetteok* improves the nutritional and functional quality or enhances the shelf-life of *garaetteok*. Thus far, no study has been conducted on the inclusion of potato flour in *garaetteok*.

Potatoes are high in nutritional value because they have a high starch content, protein, vitamin C, vitamin B_6, vitamin B_3, potassium, phosphorus, magnesium, iron, dietary fiber, and phenolic substances [14]. It was reported that the substitution of potato flour in wheat flour at various ratios can increase nutritional values of fiber and carotenoid [15].

On the other hand, Han et al. [16] reported that white loaf bread containing potato juice has the potential to inhibit

the growth of malignant tumor cells in human skin due to its glycoalkaloids. Seo et al. [17] reported an increase in quantities of organic acids, free amino acids, and volatile components in vinegar fermented of potato by using *Acetobacter* sp.

Bacillus subtilis, which is commonly found in Korean traditional fermented soybean products, is a microorganism generally recognized as safe (GRAS). It has been reported that in the fermentation process, *B. subtilis* produces various enzymes such as protein and carbohydrate hydrolytic enzymes, as well as physiologically active substances such as functional peptides and γ-polyglutamic acid (PGA), a viscous sticky mucilage of amino acid or sugar [18, 19]. Tanimoto et al. [20] reported that PGA, which is a polymer with water-holding capacity produced by *B. subtilis*, not only increases calcium solubility in the lower small intestine as it has a low pH, but also potentially prevents osteoporosis by delaying intestinal transit time and facilitating intestinal calcium absorption.

Heterofermentative lactic acid bacteria produce metabolites such as organic acids, carbon dioxide, and ethanol, which improve the flavor and texture of dough and delay starch retrogradation and reduce the risk of contamination by harmful bacteria or mold [21, 22].

In particular, some strains of *Leuconostoc mesenteroides*, known as the main fermenting bacteria of kimchi, can produce dextran by the extracellular enzyme (dextransucrase) in the presence of sucrose. Dextran is a homopolysaccharide of glucose and has been reported to be important for control of the physical properties of foods with stickiness, hygroscopicity, and thermal stability [23]. This study intended to identify the quality characteristics of *garaetteok* with added fermented potato flour by varying the amount of the flour fermented using *B. subtilis* and *Leuconostoc mesenteroides* separately. The study also intended to examine the possibility of developing a *garaetteok* with a high nutritional value and good storage and cooking characteristics.

2. Materials and Methods

2.1. Raw Materials. The strains used in this experiment were *L. mesenteroides* (KCTC 3719) obtained from Korean Collection for Type Cultures (KCTC) and *B. subtilis* (ATCC 6633) from Korean Agricultural Culture Collection (KACC). Both strains were selected as the starter culture through the preliminary study on pasting properties of potato flours fermented by ten strains including *Bacillus* sp., *Leuconostoc* sp., *Lactobacillus* sp., and *Saccharomyces cerevisiae*. The potato (*Solanum tuberosum* L.), harvested on July 7, 2017, in Gangneung-si, Korea, was supplied by the National Institute of Highland Agriculture. Rice was purchased from the local market.

2.2. Fermentation of Potato Flour. The potatoes were washed, peeled, and immersed in a solution of 0.05% sodium bisulfite (Poohung Photo-Chemical Co., Ltd., Ansan, Korea) at room temperature for 3 h. The potatoes were cut into 2 mm thick slices, dried at 40°C for 12 h using an air dryer, pulverized, and passed through a 100 mesh standard sieve to obtain potato flour. *L. mesenteroides* was cultured in optimal medium (LM broth; 0.5% (w/v) yeast extract, 0.5% (w/v) peptone, 2% (w/v) K_2HPO_4 0.02% (w/v) $MgSO_4{\cdot}7H_2O$, 0.001% (w/v) NaCl, 0.001% (w/v) $FeSO_4{\cdot}7H_2O$, 0.001% (w/v) $MnSO_4{\cdot}H_2O$, 0.013% (w/v) $CaCl_2{\cdot}2H_2O$) with 2% (w/v) glucose at 30°C for 24 h in an incubator (HB-101S, Hanbaek Co., Ltd., Bucheon, Korea). After twice enrichment culture, cells (1%, v/v) were inoculated in LM broth with 10% (w/v) sucrose and cultured at 30°C for 24 h at 80 rpm in a shaking incubator (HB-201SF, Hanbaek Co., Ltd., Bucheon, Korea). *B. subtilis* were cultured in nutrient broth (NB) containing 0.5% (w/v) of peptone and 0.3% (w/v) of beef extract at 30°C for 24 h. Cells were subcultured (1%, v/v) in NB at 30°C and 80 rpm for 24 h. Potato flour (4.5 kg) was mixed with 9 L of sterilized distilled water, and about 4% (v/v) of each of *B. subtilis* or *L. mesenteroides* culture was inoculated at a concentration of 1.3×10^7 or 1.9×10^7 CFU/mL. After fermentation of the dough for 24 h at 30°C, the number of viable cells of *B. subtilis* and *L. mesenteroides* reached to 1.1×10^9 and 1.2×10^9 CFU/mL and the pHs of dough were 4.65 and 4.68.

2.3. Preparation of Garaetteok. Nonfermented and fermented potato flours by *B. subtilis* and *L. mesenteroides* were designated to NF, BS, and LM, and rice flour was replaced with 15% potato flour (NF15, BS15, and LM15) and 20% (NF20, BS20, and LM20) based on 100% of rice. As a control, *garaetteok* with 100% rice flour was prepared (CON). Figure 1 shows the flow chart for potato *garaetteok*. Rice (20 kg) was soaked for 12 h in water and drained; 176 g sea salt was added and then grounded with a roller mill to generate flour (Shinpung doll roller, Eumseong, Korea). Rice flour (30.7% moisture content on wet basis) was mixed with nonfermented potato flour (3.9% moisture content on wet basis), potato flour fermented with *B. subtilis* (55.9% moisture content on wet basis) or with *L. mesenteroides* (53.8% moisture content on wet basis). The amount of each potato flour added was 15% and 20% (w/w) based on the weight of rice flour on dry basis, and water was added to adjust moisture content of the final dough to 46.0% on dry basis. The mixture was grounded with a roller mill, cooked for 35 min in a steamer, and then kept for 5 min without heating. *Garaetteok* was extruded twice using an extruder with the size of 2 cm in diameter.

2.4. Determination of pH, Total Titratable Acidity (TTA), and Chromaticity. The values of pH were determined using a pH meter (pH 510 bench meter, Fisher Scientific Pte Ltd., Clementi, Singapore) after 1 g of dough was homogenized with 9 mL of distilled water. The tenth diluted sample was titrated with 0.1 N NaOH until reaching the pH 8.3 to determine titratable acidity (mL) [24].

The chromaticity was determined by a Hunter value including L^* value (lightness), a^* value (redness), and b^*

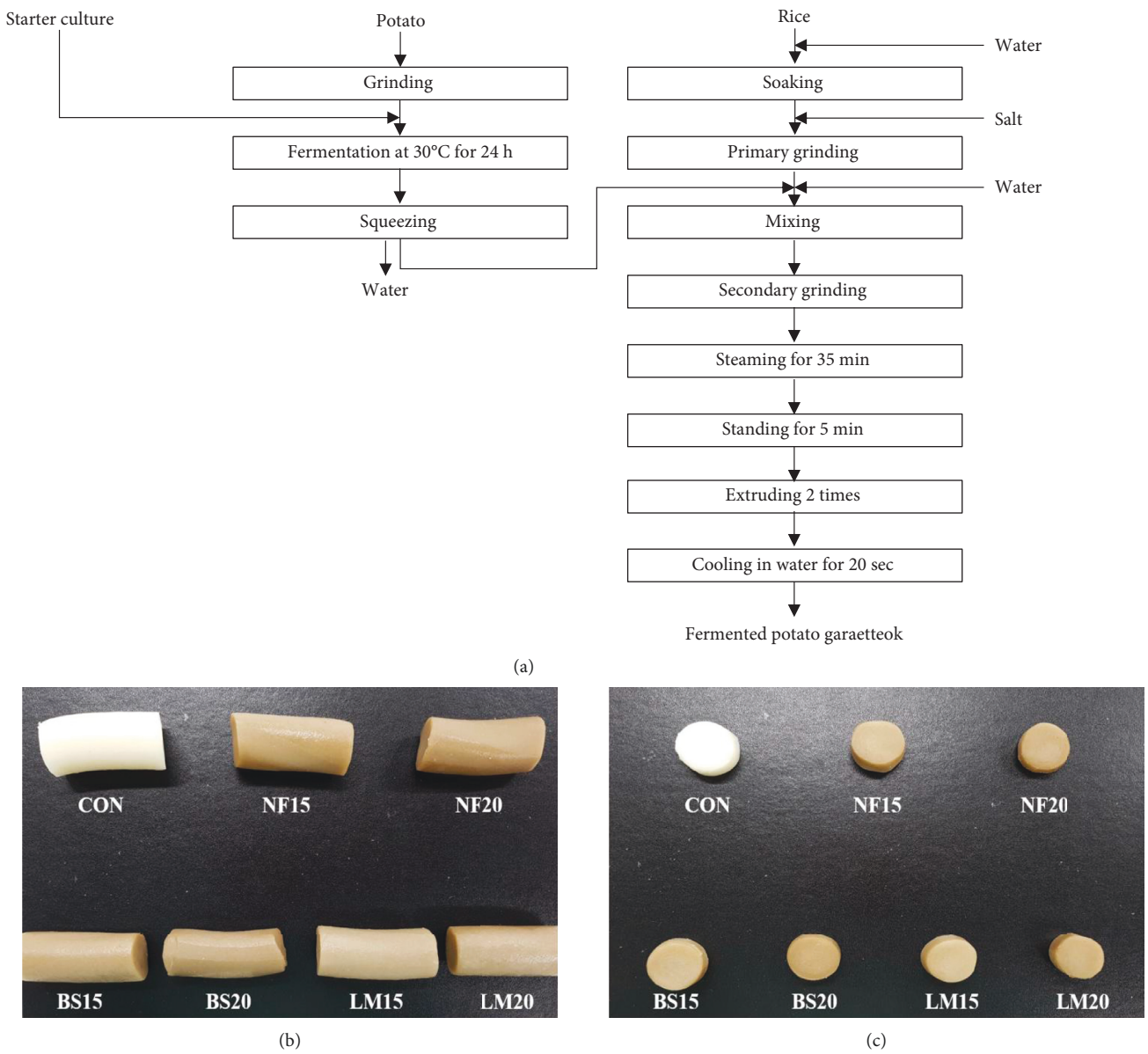

Figure 1: Processing flow chart of potato *garaetteok*.

value (yellowness) using a colorimeter (Model CR-300, Minolta, Tokyo, Japan). The value of standard was $L^* = 98.9$, $a^* = -0.7$, and $b^* = 1.2$.

2.5. Texture Profiles Analysis. Texture profiles analysis (TPA) was performed using a texture analyzer (TA.ST plus C, Stable Micro Systems Ltd., Surrey, England) to measure hardness, springiness, cohesiveness, gumminess, and chewiness immediately after preparation. It was tested for 5 sec at 5.0 mm·sec^{-1} for pretest speed, 3.0 mm·sec^{-1} for test speed, and 5.0 mm·sec^{-1} for posttest speed with a 55% strain distance and 5.0 g of trigger force using a 36 mm stainless probe. *Garaetteok* (1 cm length), cooked for 3 min in boiling water and stored for 0, 6, and 24 h at room temperature, was also determined for changes of its textural characteristics during storage [13].

2.6. Turbidity of Soup. Turbidity of soup (*tteokguk*) was determined by measuring at 675 nm using a UV/Vis Spectrophotometer (Cary 60 UV/Vis, Agilent Technologies, Petaling Jaya, Malaysia) after cooking 30 g of *garaetteok* for 1 min in 300 mL of boiling water [13].

2.7. Sensory Analysis. Quantitative descriptive analysis of *garaetteok* was conducted by a modified method of Chung et al. ([25]; IRB approval #DKU 2017-03-036). It was carried out by 8 trained panelists in duplicate. Rice *garaetteok* was used as a reference, and potato *garaetteoks* were used as experimental groups. *Garaetteok* with 2 cm in diameter was cut into 1 cm in length, and two slices were served in white paper cups. After one sample was evaluated, the mouth was rinsed with bottled water and other samples were evaluated. The sample number was designated as a three digit number

using a random number table. The whiteness, sourness, potato flavor, hardness, springiness, chewiness, and adhesiveness were used as the descriptive index and evaluated by using a 15-point scale. All potato *garaetteoks* were compared with the standard scales of rice *garaetteok*—8 points in whiteness, 3 points in sourness, 1 point in potato flavor, 8 points in hardness, 10 points in springiness, 8 points in chewiness, and 4 points in adhesiveness.

Consumer test was carried out by 60 students at Dankook University and used a 9-point scale. The prepared *garaetteok* was cooked in boiling water for 3 min and cut into 2 cm in diameter and 1 cm in length, and two slices were served in white paper cups. The sample number was designated as a three digit number using a random number table. The samples were presented by Williams's design to minimize carry-over effect [26]. After one sample was evaluated, the mouth was rinsed with bottled water and other samples were evaluated.

2.8. Statistical Analysis. Mean and standard deviation were presented using a Minitab 16 (Minitab Inc., State College, PA, USA) statistical program. A one-way ANOVA was used to verify significant differences between the samples with the Tukey test at the $P < 0.05$ level. All the analytical tests were carried out in triplicate of each duplicated *garaetteok* elaborations.

3. Results and Discussion

3.1. pH and TTA. Table 1 shows the results of pH and TTA of rice and potato *garaetteoks*. The pH levels of the BS and LM groups (5.13–5.66) were significantly lower than that of CON ($P < 0.05$). This is because *L. mesenteroides* produced lactic acid and acetic acid through heterolactic fermentation [27], and *B. subtilis* also produced organic acids such as lactic acid, acetic acid, and succinic acid [28]. The TTA was significantly higher in BS20 and LM15 than in the CON ($P < 0.05$). The TTA was increased as the pH of *garaetteok* was decreased. Such results are attributable to the *B. subtilis* and *L. mesenteroides*, both of which produce organic acids. It also appeared that the titratable acidity was higher in the NF, BS, and LM groups than in the CON due to the effect of the organic acids in the potatoes, such as oxalic acid, citric acid, malic acid, succinic acid, and fumaric acid [29].

3.2. Chromaticity. Table 1 shows the chromaticity of rice and potato *garaetteoks*. The L^*, a^* and b^* values of CON were 82.5, 0.30, and 9.80, respectively. The L^* value decreased as the amount of added potato flour increased ($P < 0.05$). This tendency of a decrease in the L^* value was similar to the findings of previous studies in which supplementary ingredients were added to *garaetteok* with cactus fruit (*Opuntia humifusa*) [11] and *seolgidduk* with added *Houttuynia cordata* Thunb [30]. This could be attributable to the intrinsic color of potatoes and the browning enzymes such as polyphenol oxidase (PPO) and phenylalanine ammonia lyase (PAL). The first browning reaction occurs by PAL to generate phenolic compounds. These act as a substrate for PPO to catalyze the oxidation, which cause browning at the cut surface of fruits and vegetables compounds [31, 32]. The addition of potato flour to rice *garaetteok* significantly increased the a^* value of redness and b^* value of yellowness ($P < 0.05$).

3.3. Texture Properties. Table 2 shows the results of measuring the instrumental texture properties of rice and potato *garaetteoks* immediately after they were prepared. The hardness of NFs was significantly lower than that of CON ($P < 0.05$). However, there was no significant difference in hardness of all fermentation groups including BSs and LMs compared to CON ($P > 0.05$). A similar tendency was found in terms of gumminess and chewiness, both of which occur as a secondary characteristic of hardness. In other words, it is possible to make a potato *garaetteok* that is similar to rice *garaetteok* in terms of hardness, gumminess, and chewiness through fermentation of potato. In terms of springiness, there was no significant difference between the CON and all the other groups ($P > 0.05$). All texture profiles of LMs were similar to CON.

Figure 2 shows the results of measuring the instrumental texture properties of *garaetteok* during storage for 0, 6, and 24 h after cooking. The hardness of CON rapidly increased during 24 h storage, but that of all potato *garaetteok* slowly increased. The hardness of potato *garaetteoks* was lower than that of rice *garaetteok* during the storage period. The inhibitory effect of retrogradation was shown with the addition of potato. Potato is known to have a low rate of retrogradation compared to cereal starches such as rice and wheat due to its size and phosphorous content [33, 34]. The potato starch granule (5–100 μm) is larger than that of rice (1.5–9 μm), and potato starch contains phosphorous (0.06–0.1%), but rice does not. The phosphate ester groups of potato starch give amylopectin a slight negative charge, leading to some columbic repulsion that may contribute to the low rate of retrogradation [35]. Hardness was lower in the BS and LM groups than in the NF group ($P < 0.05$). Yu et al. [36] reported that starch retrogradation progressed slowly with low amylose content. It appears that, during fermentation, the amylase produced by *B. subtilis* decreased the amylose content of starch. *B. subtilis* also produces such fermentation metabolites as γ-polyglutamic acid (PGA), polymerized with glutamic acid, and fructan-type levan, a fructose polymer [19]. Shyu et al. [37] reported that the hardness of wheat loaf bread made by adding PGA was decreased during storage, effectively retarding the staling of bread. *Leuconostoc* strains secrete dextransucrase, an extracellular enzyme, and biosynthesize high-molecular dextran, a polymer of glucose [38]. Therefore, *Leuconostoc* strains are considered to affect the physicochemical properties of food, such as glutinosity, hygroscopic property and thermostability, while playing an important role in controlling rheological properties [23, 39].

The initial springiness was the lowest in the NF15, and there was no significant difference between the other groups ($P > 0.05$). After 24 h, springiness was lowest in the BS20 group, and there was no significant difference between the other groups ($P > 0.05$).

Table 1: The pH, titratable acidity, and Hunter color values of rice and potato *garaetteoks*.

Sample	pH	Titratable acidity (mL of 0.1 N NaOH)	Color value		
			L^*	a^*	b^*
CON	6.41 ± 0.14^{a}	0.01 ± 0.00^{c}	82.5 ± 0.56^{a}	0.30 ± 0.10^{e}	9.80 ± 0.44^{e}
NF15	6.21 ± 0.23^{a}	0.06 ± 0.02^{b}	66.0 ± 2.25^{b}	4.77 ± 0.23^{c}	16.43 ± 0.06^{c}
NF20	6.27 ± 0.05^{a}	0.09 ± 0.02^{ab}	54.77 ± 0.81^{d}	6.53 ± 0.21^{a}	15.8 ± 0.17^{d}
BS15	5.66 ± 0.17^{b}	0.08 ± 0.03^{ab}	60.93 ± 0.15^{c}	3.97 ± 0.12^{d}	15.7 ± 0.10^{d}
BS20	5.18 ± 0.02^{c}	0.12 ± 0.01^{a}	54.43 ± 0.35^{d}	5.37 ± 0.21^{b}	17.53 ± 0.12^{b}
LM15	5.13 ± 0.04^{c}	0.12 ± 0.01^{a}	55.03 ± 0.15^{d}	5.70 ± 0.10^{b}	18.10 ± 0.10^{a}
LM20	5.22 ± 0.01^{c}	0.10 ± 0.01^{ab}	54.17 ± 0.06^{d}	5.43 ± 0.06^{b}	16.67 ± 0.12^{c}

All the analytical tests were carried out in triplicate of each duplicated *garaetteok* elaborations. Values are means ± SD ($n = 6$). Different superscript letters in the same column indicate a significant difference (one-way ANOVA, $\alpha = 0.05$, Tukey's post hoc test). L^*, a^*, and b^* values indicate lightness, redness, and yellowness, respectively. CON: *garaetteoks* was made with rice flour; NF15 and NF20: *garaetteoks* was made with a mix of rice and potato flour in a ratio of 85 : 15 and 80 : 20, respectively; BS15 and BS20: *garaetteoks* was made with a mix of rice and fermented (with *B. subtilis*) potato flour, in a ratio of 85 : 15 and 80 : 20, respectively; LM15 and LM20: *garaetteoks* was made with a mix of rice and fermented (with *L. mesenteroides*) potato flour, in a ratio of 85 : 15 and 80 : 20, respectively.

Table 2: Texture profiles and soup turbidity of rice and potato *garaetteoks*.

Sample	Texture profiles					Turbidity of soup (at 675 nm)
	Hardness (g)	Springiness	Cohesiveness	Gumminess	Chewiness	
CON	$37{,}193 \pm 1315^{a}$	0.97 ± 0.01^{a}	0.76 ± 0.02^{ab}	$30{,}839 \pm 1286^{a}$	$29{,}962 \pm 1188^{a}$	0.73 ± 0.04^{c}
NF15	$29{,}463 \pm 1100^{bc}$	0.92 ± 0.06^{a}	0.76 ± 0.02^{ab}	$24{,}403 \pm 1208^{bc}$	$22{,}378 \pm 2182^{bc}$	1.06 ± 0.02^{a}
NF20	$29{,}031 \pm 2393^{c}$	0.95 ± 0.03^{a}	0.71 ± 0.04^{b}	$22{,}674 \pm 2322^{c}$	$21{,}503 \pm 2945^{c}$	1.02 ± 0.02^{a}
BS15	$34{,}790 \pm 2871^{ab}$	0.90 ± 0.02^{a}	0.79 ± 0.02^{a}	$28{,}616 \pm 2421^{ab}$	$25{,}673 \pm 2140^{abc}$	0.28 ± 0.01^{f}
BS20	$34{,}836 \pm 1778^{a}$	0.88 ± 0.01^{a}	0.71 ± 0.01^{b}	$26{,}772 \pm 1432^{abc}$	$23{,}466 \pm 1070^{bc}$	0.84 ± 0.01^{b}
LM15	$39{,}497 \pm 1301^{a}$	0.89 ± 0.05^{a}	0.74 ± 0.03^{ab}	$31{,}115 \pm 1090^{a}$	$27{,}635 \pm 2231^{ab}$	0.54 ± 0.01^{d}
LM20	$37{,}906 \pm 2006^{a}$	0.90 ± 0.04^{a}	0.73 ± 0.03^{ab}	$29{,}767 \pm 1113^{a}$	$26{,}797 \pm 2172^{abc}$	0.38 ± 0.02^{e}

All the analytical tests were carried out in triplicate of each duplicated *garaetteok* elaborations. Values are means ± SD ($n = 6$). Different superscript letters in the same column indicate significant difference (one-way ANOVA, $\alpha = 0.05$, Tukey's test post hoc). CON: *garaetteoks* was made with rice flour; NF15 and NF20: *garaetteoks* was made with a mix of rice and potato flour in a ratio of 85 : 15 and 80 : 20, respectively; BS15 and BS20: *garaetteoks* was made with a mix of rice and fermented (with *B. subtilis*) potato flour, in a ratio of 85 : 15 and 80 : 20, respectively; LM15 and LM20: *garaetteoks* was made with a mix of rice and fermented (with *L. mesenteroides*) potato flour, in a ratio of 85 : 15 and 80 : 20, respectively.

As for cohesiveness, meaning the force to maintain the shape of *garaetteok*, after 24 h, the highest level of cohesiveness was found in the CON at a significant level, followed by the NF15, NF20, and LM15 ($P < 0.05$).

A similar tendency was found in terms of gumminess. Chewiness also did not change in 6 h after cooking. Chewiness was significantly lower in NF, BS, and LM than in CON ($P < 0.05$).

3.4. Turbidity of Soup. Table 2 shows the turbidity of *garaetteok* soup, which represents the degree of solid loss into the cooking water. Turbidity was higher in the NF15 and NF20 (1.06, 1.02) than in the CON (0.73; $P < 0.05$). It seems that potato *garaetteok* was easily dissolved in water, while being cooked as potato starch gel is smooth and springy but the gel strength is weak [32]. In contrast, the turbidity was significantly lower in BS and LM groups than in the NF group ($P < 0.05$). This seems to be the result of a decreasing elution volume as the rheological properties of *garaetteok* were changed by polymers—fermentation metabolites. The high turbidity of the soup indicates that there was a large elution of solid components, meaning that the *garaetteok* can be easily dissolved in water when cooked [40]. This study shows that fermented potato flour can help prevent *garaetteok* from easily dissolving in water when cooked and can help *garaetteok* maintain a good appearance.

3.5. Sensory Evaluation. Table 3 shows the results of a quantitative descriptive analysis of potato *garaetteoks*. Whiteness was evaluated and found to be higher in the fermentation groups than in the nonfermented groups. It was higher in BS15 and LM15 than others. As for potato flavor, the NF20 had the highest score, with no significant difference compared to other groups. Regarding hardness, chewiness, and adhesiveness, there was no significant difference among potato *garaetteok*. In terms of springiness, no significant difference was found between any of the groups in both TPA measurement and descriptive analysis ($P > 0.05$).

Table 4 shows the sensory quality characteristics of rice and potato *garaetteoks*. For color, there was no significant difference between NF, BS, and LM groups. Regarding potato flavor, LM15 and LM20 had the highest score ($P < 0.05$). The diacetyl, acetic acid, and ethanol produced by *L. mesenteroides* seemed to contribute to the creation of the flavor [41]. Potato *garaetteoks* showed no significant difference from CON in texture ($P > 0.05$). NF20 and BS20 were significantly lower than CON ($P < 0.05$), but LM20 was

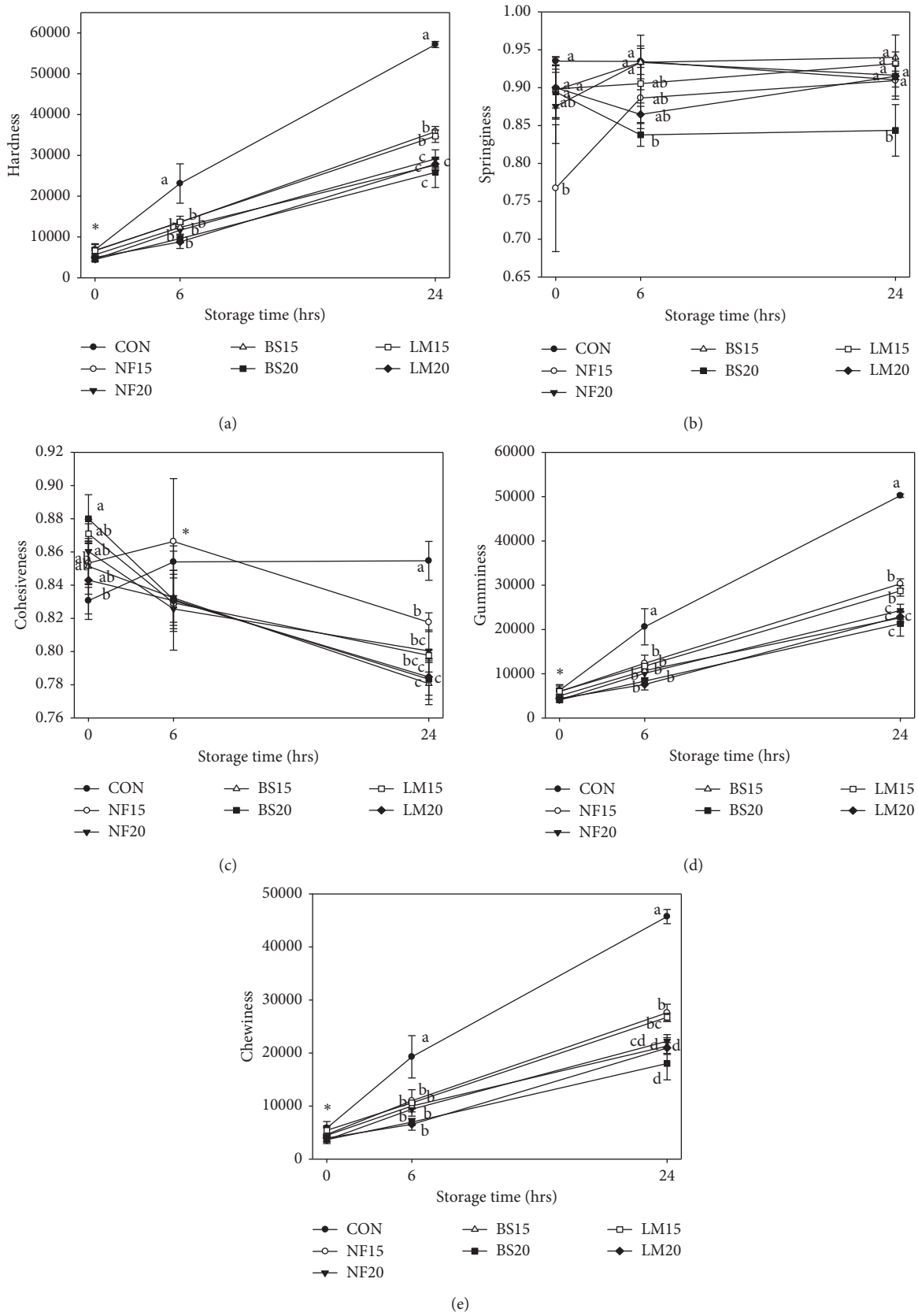

Figure 2: Change of texture profiles of cooked *garaetteoks* during storage 0, 6, and 24 h: (a) hardness; (b) springiness; (c) cohesiveness; (d) gumminess; (e) chewiness. Means with different superscript letters measured at the same time are significantly different (one-way ANOVA, $\alpha = 0.05$, Tukey's post hoc test).

Table 3: Quantitative descriptive analysis scores of potato *garaetteoks*

Sample	Characteristics						
	Whiteness	Sourness	Potato flavor	Hardness	Springiness	Chewiness	Adhesiveness
CON	8	3	1	8	10	8	4
NF15	$6.13 \pm 2.13^{ab**}$	3.56 ± 1.50^{b}	$4.75 \pm 3.04^{a**}$	$6.56 \pm 1.90^{a**}$	$8.31 \pm 1.89^{a**}$	7.19 ± 1.72^{a}	4.56 ± 1.79^{a}
NF20	$4.00 \pm 2.83^{b**}$	3.75 ± 1.53^{ab}	$6.13 \pm 2.83^{a**}$	$5.75 \pm 2.08^{a**}$	$7.13 \pm 2.06^{a**}$	$7.13 \pm 0.96^{a**}$	4.25 ± 1.65^{a}
BS15	6.81 ± 2.61^{a}	$4.42 \pm 1.73^{ab**}$	$5.38 \pm 3.12^{a**}$	$6.25 \pm 1.44^{a**}$	$7.79 \pm 1.63^{a**}$	$6.50 \pm 1.90^{a**}$	3.38 ± 1.26^{a}
BS20	$5.06 \pm 2.59^{ab**}$	$5.50 \pm 1.24^{a**}$	$4.25 \pm 1.91^{a**}$	$5.63 \pm 2.47^{a**}$	$6.57 \pm 1.99^{a**}$	$6.06 \pm 1.57^{a**}$	3.44 ± 1.41^{a}
LM15	$6.56 \pm 2.00^{a**}$	3.94 ± 2.05^{ab}	$4.25 \pm 1.69^{a**}$	$6.00 \pm 1.16^{a**}$	$8.38 \pm 1.93^{a**}$	$6.56 \pm 1.63^{a**}$	4.31 ± 1.92^{a}
LM20	$5.75 \pm 2.65^{ab**}$	$4.19 \pm 1.72^{ab*}$	$4.25 \pm 1.84^{a**}$	$5.75 \pm 2.44^{a**}$	$7.06 \pm 1.88^{a**}$	$6.25 \pm 1.81^{a**}$	3.56 ± 1.46^{a}

Values are means ± SD ($n = 16$). Different superscript letters in the same column indicate a significant difference (one-way ANOVA, $\alpha = 0.05$, Tukey's post hoc test). Marks with asterisks * and ** are significantly different from CON (*rice garaetteok*) at $\alpha = 0.05$ and $\alpha = 0.1$ (one-way ANOVA, Tukey's post hoc test). CON: *garaetteoks* was made with rice flour; NF15 and NF20: *garaetteoks* was made with a mix of rice and potato flour in a ratio of 85 : 15 and 80 : 20, respectively; BS15 and BS20: *garaetteoks* was made with a mix of rice and fermented (with *B. subtilis*) potato flour, in a ratio of 85 : 15 and 80 : 20, respectively; LM15 and LM20: *garaetteoks* was made with a mix of rice and fermented (with *L. mesenteroides*) potato flour, in a ratio of 85 : 15 and 80 : 20, respectively.

Table 4: Sensory evaluation scores of rice and potato *garaetteoks*

Sample	Characteristics			
	Color	Flavor	Texture	Overall acceptance
CON	7.12 ± 1.30^{a}	5.93 ± 1.25^{a}	5.98 ± 1.96^{a}	6.27 ± 1.51^{a}
NF15	5.07 ± 1.46^{b}	5.03 ± 1.67^{b}	6.12 ± 1.67^{a}	5.52 ± 1.59^{ab}
NF20	4.97 ± 1.41^{b}	5.03 ± 1.64^{b}	5.72 ± 1.65^{a}	5.18 ± 1.58^{b}
BS15	5.00 ± 1.34^{b}	4.82 ± 1.81^{b}	5.43 ± 1.58^{a}	5.17 ± 1.42^{b}
BS20	5.13 ± 1.38^{b}	5.02 ± 1.51^{b}	5.38 ± 1.67^{a}	5.33 ± 1.52^{b}
LM15	5.15 ± 1.46^{b}	5.23 ± 1.57^{ab}	5.82 ± 1.69^{a}	5.50 ± 1.48^{ab}
LM20	4.97 ± 1.37^{b}	5.52 ± 1.51^{ab}	5.75 ± 1.50^{a}	5.57 ± 1.42^{ab}

Values are means ± SD ($n = 60$). Different superscript letters in the same column indicate a significant difference (one-way ANOVA, $\alpha = 0.05$, Tukey's post hoc test). CON: *garaetteoks* was made with rice flour; NF15 and NF20: *garaetteoks* was made with a mix of rice and potato flour in a ratio of 85 : 15 and 80 : 20, respectively; BS15 and BS20: *garaetteoks* was made with a mix of rice and fermented (with *B. subtilis*) potato flour, in a ratio of 85 : 15 and 80 : 20, respectively; LM15 and LM20: *garaetteoks* was made with a mix of rice and fermented (with *L. mesenteroides*) potato flour, in a ratio of 85 : 15 and 80 : 20, respectively.

similar to CON in overall acceptance. *Leuconostoc* sp. produce fructose and mannitol, giving sweetness and a refreshing taste to fermented products [42]. This could be the reason that *garaetteok* with added potato flour fermented with *L. mesenteroides* had a higher score of acceptability than *garaetteok* with other kinds of potato flour.

4. Conclusion

In this study, the effects of *garaetteok* with potato flour nonfermented and fermented by *B. subtilis* or *L. mesenteroides* on texture and cooking qualities were evaluated. The LM group was similar to CON in terms of texture profiles. During storage after cooking, *garaetteoks* with nonfermented and fermented potato flour saw decreases in hardness. *Garaetteok*-added potato flour was increased in the turbidity of soup. However, fermentation was significantly decreased its turbidity. Rice *garaetteok* showed the highest preference in consumer test and potato *garaetteoks* had low preference, but the LM group was the highest for flavor and had overall acceptability among potato *garaetteoks*. Therefore, it is expected that potato *garaetteok* can be commercialized as a functional *garaetteok* as it offers the benefits of intake of potassium, phosphorus, magnesium, iron, vitamin C, vitamin B_6, vitamin B_3, dietary fiber and phenolic substances, and it can improve the inhibition effect of retrogradation and cooking characteristics through the fermentation process. It was suggested that the addition of 15–20% potato flour fermented with *L. mesenteroides* is suitable for commercialization of potato *garaetteok* considering sensory characteristics.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

This study was supported by the Rural Development Administration (no. PJ01123904) and National Research Foundation of Korea (no. 2016R1D1A1B03934137), Republic of Korea.

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