Effect of blanching time on the quality characteristics of elderly-friendly *kkakdugi*

Sun-Ock Park, Wan-Keun Kim, Dong-June Park¹, and Seung-Joo Lee*

Department of Culinary and Food Service Management, Sejong University, Seoul 05006, Korea

¹Korea Food Research Institute, Seongnam, Gyeonggi 13539, Korea

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*Corresponding Author
Tel: +82-10-4039-6026
Fax: +82-2-3408-4313
E-mail: sejlee@sejong.ac.kr

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Abstract For the development of elderly-friendly food, the physicochemical properties and preferences of cooked *kkakdugi* prepared with various blanching times were examined. As fermentation progressed, significant differences in samples were observed with overall decreasing trends of pH, reducing sugar, lightness (L), yellowness (b), and hardness. Titratable acidity, redness (a), and lactic acid increased during the storage time. The preference test showed that the sample blanched for 3 min (SK3) scored the highest in aroma, taste, texture, and overall acceptance. Overall, SK3 was the most preferred as cooked *kkakdugi*, which helps elderly people suffering from mastication and deglutition.

Keywords: elderly-friendly, texture, blanching, *kkakdugi*, fermentation

Introduction

Kimchi is a traditional Korean fermented food that is prepared with pickled vegetables using fermentation (1,2). *Kimchi* can be classified into more than 200 variations based on raw materials, ingredients, manufacturing methods, producing regions, or several other factors (3). *Baechukimchi* and *kkakdugi* are the most common types among the various types of *kimchi* (4). *Kkakdugi* is one of the most representative types among radish *kimchi*, which has a simple recipe and a unique flavor (5). Radish containing fiber, pectin, various minerals, enzymes, and vitamins is used as the main ingredient in *kkakdugi*. To date, there have been various studies about *kkakdugi*, including a study on the salting method of *kkakdugi* (6,7), fermentation characteristics according to the storage temperature and packaging method (5), effect of sweeteners on the quality of *kkakdugi* (8), and effect of addition of food additives such as calcium acetate and potassium sorbate during fermentation (9). However, there have been few reports on the physicochemical properties of *kkakdugi* using different preparation methods except a salting method.

Kimchi is found its modern-day form in the Joseon dynasty, as documented in various *Gojoliseo* (old Korean cooking books) such as Joseon-mussang-sinsik-yorijebeop (10) and the Korean folklore synthesis survey report (11). In addition, a type of cooked *kkakdugi* was recorded as *ssukkkakdugi*. It can be prepared with softened radish by blanching. Thus, it is beneficial for elders, children, or patients with weak teeth because of its ease for mastication. It can

be referred as an elderly-friendly food (10).

Countries such as Japan, the United States, and European nations have encountered an aging society and developed physically and nutritionally valuable senior- or elderly-friendly foods that offer broad choices to elderly people (12). In Japan, wide varieties of elderly-friendly foods, called Universal Design Foods, have been developed and consumed. Various types of texture-modified foods have also been widely used in western countries to reflect eating capabilities of elders. These types of foods are specially prepared to deal with difficulties in mastication and deglutition (13). Many elders suffer from decreased sensory and neural regulation, appetite and digestive function with teeth loss, and difficulties in swallowing foods and beverages (14). In addition, more than half of the elderly population is exposed to health risks due to malnutrition (15,16). A longer life expectancy and lower birth rate have accelerated the growth of the aging population. Thus, elderly people over 65 years of age accounts for 17.32% of the total population in Korea (Ministry of Government Administration and Home Affairs Statistics, 2014). However, means of improving the quality of life for elderly people have not been established. In addition, the educational level and life quality of elders today have been enhanced compared to those in the past. However, the circumstances related to dietary life still needs to be improved (15,16).

In Japan and many European countries, diverse studies have been reported about elderly-friendly foods. Sensory, preference, and textural properties of various types of texture-modified foods such as

yogurt-type snack, meat, and carrots have been reported and preferences were compared between young and elderly consumers (17,18). Objective and quantitative definitions of sensory texture terms for texture-modified foods were also studied (18). On the other hand, the elderly-friendly industry particularly related to food is in the initial step in Korea. Currently, some fluid thickeners are sold, whereas other special foods for elderly are not yet commercialized. Many surveys reported about the dietary habits and nutritional status of elderly people residing at various regions of Korea (13,19).

In this study, elderly-friendly *kkakdugi* was prepared by blanching based on old cooking recipes. The fermentation processes and physicochemical properties of *kkakdugi* were monitored and investigated for the development of elderly-friendly *kkakdugi*.

Materials and Methods

Materials Red chili pepper powder (E-mart, Seochon, Korea), white sugar (CJ Cheiljedang, Co., Incheon, Korea), salt (Sajo Haepyo, Seoul, Korea), and anchovy sauce (CJ Hasun Jung Co., Eumseong, Korea) were purchased from a local market (Seoul, Korea). Radish (Jeju, Korea), minced garlic, minced ginger, and pieces of green onion were purchased from a market in Seoul on the day of preparation.

Preparing *kkakdugi* using blanching method *Kkakdugi* was prepared using the center part of radish cut into $2.5 \times 2.5 \times 2.5$ cm³ cubes. For each blanching time (0, 3, 6, 9 or 12 min), a total of 3,000 g cut radish was parboiled in 5 L of boiling water at 100°C, and then salted in 3% brine for 30 min. Each 250 g of salted radish was well mixed with 5 g salt, 2.5 g sugar, 16 g scallions, 6.6 g red chili pepper powder, 0.8 g ginger, 4 g garlic, and 6.6 g fish sauce, and then packed in a glass jar. After fermenting for 24 h at 20°C, each sample was stored for 27 days at 4°C, and used for further analysis at a respective sampling time. The preparation recipe was basically based on the book by Lee (10).

Physicochemical analysis

pH, titratable acidity, and salinity: Samples were homogenized in a homogenizer (Nihon Seiki, ACE, Yaogikita, Japan) and filtered through a gauze to obtain the filtrate. The filtrate was diluted 10-fold, centrifuged at 10,000 $\times$ g for 10 min (GP8; IEC Centra, Waltham, MA, USA), and then the supernatant was used for further analysis. pH was measured by a pH meter (PB-10; Sartorius AG, Göttingen, Germany). Titratable acidity of the supernatant (10 mL) was measured by a pH meter electrode method using AOAC (20). The samples were neutralized with 0.01 N NaOH to pH 8.2. The used amount of 0.01 N NaOH was converted into lactic acid content (% w/w). Salinity was measured by a digital salinity meter (ES-421; Atago Co., LTD, Tokyo, Japan). All analyses were replicated three times.

Color: The color of sample was measured as Hunter L (Lightness), a (redness), and b (yellowness) values using a colorimeter (Chroma meter, MCR-200b; Minolta, Tokyo, Japan).

Reducing sugar: Reducing sugar content was measured by the Miller-dinitrosalicylic acid (DNS) method using glucose as a standard using the supernatant after centrifuging the filtrated sample (21).

Lactic acid analysis by HPLC: For the lactic acid analysis, the sample (250 g of *kkakdugi*) was prepared using a homogenizer (Nihon Seiki, ACE) and filtered through a gauze to obtain the filtrate (GP8, IEC Centra). The filtrate was diluted 10-fold and centrifuged at 10,000 $\times$ g for 10 min (Centrifuge 5415C; Brinkmann Instruments Inc., Westbury, NY, USA). The supernatant was filtered through a 0.2 μ m membrane filter and used for the analysis. Lactic acid content was measured by HPLC (Waters 1525; Waters Co., Milford, MA, USA) using an SUN FIRE–C18 column (4.6 $\times$ 250 mm, 5 μ m, Waters Co.), coupled with a UV detector (UV-2489; Waters Co.). The mobile phase was 50 mM KH₂PO₄ with a flow rate of 0.5 mL/min and injection volume of 20 mL. A standard solution of lactic acid (Sigma-Aldrich, St. Louis, MO, USA) was used for the identification.

Enumeration of lactic acid bacteria and total viable cells Diluted supernatant was used for the analysis. To count the number of lactic acid bacteria, the diluted solution was spread on MRS agar medium (KisanBio, Seoul, Korea) with 0.005% sodium azide (Duksan, Ansan, Korea). Total viable cell was enumerated with plate count agar medium (KisanBio). The medium was incubated at 30°C for 48 h and the colonies formed from each culture were presented as colony forming unit/mL.

Texture profile analysis Texture profile analysis was measured using a texture analyzer (Model TA-XT2i; Stable Micro Systems, Godalming, UK). Prior to the analysis, *kkakdugi* was prepared in a cubed shape ($2.5 \times 2.5 \times 2.5$ cm³). The samples were pressed twice to 30% of their initial height with a compression probe (25 mm diameter) at a speed of 1 mm/s. Texture analysis was performed at room temperature. Hardness (kgf/mm), cohesiveness, and chewiness (kgf/mm) were evaluated. Texture was evaluated seven times and the averages and standard deviations were reported.

Preference test The 5-day fermented samples at 4°C were used for the preference test. Fifty elderly people (male: 11, female: 39) over 65 years old from local communities in Gwangjin-gu, Seoul, participated in the preference tests. The participants evaluated sensory preferences of appearance, aroma, taste, texture, and overall acceptance using a 9-point hedonic scale (1: Extremely dislike, 5: neither like nor dislike, 9: Extremely like). Each sample was provided in a disposable white plastic dish labeled with a random three-digit number. Samples were monadically presented in a random order. Water was provided to the participants for rinsing their palate between samples.

Statistical analysis Statistical analyses were conducted using SPSS program (SPSS 12.0 for windows, SPSS Inc., Chicago, IL, USA). Analysis of variance was performed using the general linear models procedure to determine significant differences among the samples.

All experiments except texture analysis were conducted in triplicate and means were compared by Duncan's multiple range test ($p < 0.05$).

Results and Discussion

pH, titratable acidity, salinity, and reducing sugar Changes of various physicochemical properties in *kkakdugi* prepared with different blanching times are shown in Fig. 1. Samples were fermented immediately after preparation at 20°C for 24 h, followed by a 27-day fermentation at 4°C. The initial pH was 5.8 and significant variation was observed between samples and fermentation period ($p < 0.05$) (Fig. 1A). The pH of SK0 decreased gradually by day 12, increased temporarily by day 15, and decreased by day 18. After day 24, the pH was maintained at 4.11. For SK9, the change of pH was similar with those in SK0. For SK6 and SK12, pH decreased gradually by day 6, increased temporarily by day 15, and decreased by day 18. After day 24, the pH was maintained at 4.14 and 4.12, respectively. For SK3, the pH decreased gradually by day 6, increased temporarily after day 6, and then decreased by day 15. Although slight variations in pH changes were observed in SK3, the other samples showed an overall similar trend. A previous study reported a similar changing trend of

pH in *kkakdugi* during fermentation (22). All the samples reached the optimum ripening period in the pH range of 4.2–4.6 around 1–3 days after fermentation, as reported in previous studies (22,23). In SK3, there was a significant difference in the fermentation pattern since the time required for reaching the optimum ripening was different in comparison to the other samples (7), which was probably due to the temporary decrease in lactic acid bacteria at days 10–15. Moreover, the final pH was not lower than 4.02 in all samples. This result coincided with that of a previous study wherein the pH of over-fermented *kimchi* did not fall below 3.5 as *kimchi* fermentation was associated with a low ionization rate due to microorganisms and enzymes contained in various ingredients and seasonings (24).

Titratable acidity in all samples increased as fermentation proceeded (Fig. 1B). Except for SK3, titratable acidity increased by day 12, decreased by day 15, and increased again gradually from day 15. For SK3, titratable acidity increased by day 9, decreased by day 12, and increased gradually from day 15. As titratable acidity is related to the level of organic acids produced during fermentation (25), there were differences because the organic acids vary with fermentation time (26). Despite different degrees of change, a similar trend was observed. Titratable acidity finally increased in all samples over the fermentation period.

Fig. 1. Changes in the physicochemical properties of *kkakdugi* prepared with various blanching time. ●, blanching 0 min; ○, blanching 3 min; ▼, blanching 6 min; △, blanching 9 min; and ■, blanching 12 min. A, pH; B, Titratable acidity; C, Salinity; D, Reducing sugar; $p < 0.05$.

Fig. 2. Changes in the lactic acid contents of *kkakdugi* prepared with various blanching times. -●-, blanching 0 min; -○-, blanching 3 min; -▼-, blanching 6 min; -△-, blanching 9 min; and -■-, blanching 12 min.

Initial salinities of samples were 1.6–1.7% and no significant variation among the samples was observed (Fig. 1C). Salinity in all samples decreased temporarily during the early phase of fermentation. Furthermore, it increased to 2.0–2.6% and was maintained at 2.0–2.4% until day 27 except for SK0. This observation could be explained by osmosis between the juice of sample and white radish tissue as the salts diffused, dehydrated, and penetrated the white radish tissue during early fermentation, affecting the final salinity balance (27). Significant variations among samples were observed at days 1, 3, and 9 of fermentation ($p < 0.05$). However, the water balance of radish tissue in each sample was different depending on the duration of blanching. Balance of salinity in all samples was achieved around day 12 of fermentation. No significant variations were observed among the samples from days 12 to 27, which could be attributed to the completion of osmosis between the juice and radish tissue (28).

Because the sugar contents were eluted out of the white radish while blanching, SK0 had the highest reducing sugar content (15.34 mg/mL) than those in the blanching samples, which ranging from 7.01 to 8.89 mg/mL at the initial time of fermentation (Fig. 1D). The reducing sugar contents decreased as the blanching time increased. The reducing sugar contents repeatedly decreased and increased during fermentation, which was also reported in many other *kimchi* studies. It could be due to the elution of sugar from the radish tissue during the early phase of fermentation, dissolution of polysaccharides (29), and decomposition of pectin in radish by enzymes (5). In SK9 and SK12, the action of enzyme could be inactivated with longer blanching time. By boiling radish, the reducing sugar was eluted at the beginning of fermentation and the enzyme was inactivated. However, the concentration of lactic acid bacteria was increased in the latter fermentation period, and it seems to be similar to the control group. Decrease of reducing sugar is probably due to the action of microorganisms using reducing sugar for nutrients during fermentation (30). It was considered that the increase in reducing

Fig. 3. Changes in the total microbial counts and lactic acid bacteria concentrations of *kkakdugi* prepared with various blanching times. -●-, blanching 0 min; -○-, blanching 3 min; -▼-, blanching 6 min; -△-, blanching 9 min; and -■-, blanching 12 min. A, Total microbial count; B, lactic acid bacteria.

sugar at the initial fermentation of SK3 and SK6 was caused by lower lactic acid bacteria. Significant variations among samples by fermentation period were found ($p < 0.05$).

Lactic acid contents The changes in lactic acid content are shown in Fig. 2. Sugar contents in the ingredients affected lactic acid levels during fermentation (24). Lactic acid contents fluctuated during fermentation and tended to increase, despite a low initial lactic acid contents. As also reported in many other studies, organic acids such as lactic acid, acetic acid, citric acid, malic acid, and succinic acid were produced from various microorganisms generated during fermentation of ingredients (28,31). Overall trends of lactic acid contents during fermentation were similar to those of titratable acidity. Lactic acid is known as the main organic acid component in *kimchi* related products (28).

Total viable cells and lactic acid bacteria The changes in the number of total viable cells and lactic acid bacteria are shown in Fig. 3. In all samples except SK0, the growth of total viable cells and lactic acid bacteria were lagged with the inactivation of enzymes and micro-organisms through blanching, respectively. These results were consistent with a previous study (29). Fluctuations were observed in

Table 1. Changes in color values of *kkakdugi* prepared with various blanching times

days	L					F-value
	SK0	SK3	SK6	SK9	SK12	
0	51.47±4.65 ^{B2)}	52.70±4.01	54.85±1.56 ^B	63.72±21.14 ^A	50.90±1.51 ^C	0.845 ^{NS}
1	59.08±4.51 ^{abA}	61.76±0.60 ^{a1)}	55.25±1.51 ^{bB}	55.79±2.33 ^{bA}	63.11±1.69 ^{aA}	5.861*
3	53.91±3.00 ^{bB}	61.45±4.06 ^a	63.58±1.72 ^{aA}	59.64±1.98 ^{aA}	58.66±2.07 ^{abB}	5.354*
6	51.85±2.62 ^B	52.37±3.11	52.42±3.27 ^C	55.87±4.73 ^A	57.24±0.38 ^B	1.789 ^{NS}
9	36.35±0.13 ^{aC}	32.57±0.05 ^c	33.48±0.38 ^{bD}	36.35±0.13 ^{ab}	32.57±0.05 ^{cdE}	303.220***
12	33.48±0.31 ^{aCD}	31.26±0.03 ^c	32.42±0.02 ^{bD}	33.37±0.28 ^{ab}	31.94±0.39 ^{bE}	26.793***
15	33.81±0.10 ^{bCD}	33.70±0.29 ^b	33.74±0.00 ^{bD}	34.29±0.10 ^{ab}	33.27±0.21 ^{cdE}	13.451***
18	32.85±0.04 ^{cdD}	34.23±0.05 ^b	32.90±0.04 ^{cd}	34.43±0.16 ^{ab}	29.41±0.07 ^{dF}	1758.860***
21	31.87±0.01 ^{cd}	33.19±0.14 ^b	31.87±0.01 ^{cd}	33.18±0.13 ^{bB}	33.40±0.03 ^{adE}	238.153***
24	30.84±0.06 ^{bD}	32.23±0.23 ^a	32.27±0.33 ^{ad}	32.82±1.01 ^{ab}	32.74±0.48 ^{adE}	6.722**
27	31.89±0.03 ^{cd}	32.82±0.07 ^c	31.95±0.07 ^{cd}	33.17±0.03 ^{bB}	34.28±0.07 ^{ad}	985.273***
F-value	67.527***	121.727***	269.115***	11.134***	548.060***	

days	a					F-value
	SK0	SK3	SK6	SK9	SK12	
0	4.09±0.23 ^{dF}	4.08±0.37 ^{dF}	6.64±0.33 ^{bEF}	5.73±0.79 ^{cG}	11.57±0.42 ^{aA}	129.668***
1	12.50±1.80 ^{cA}	13.57±0.50 ^{b cA}	20.71±1.11 ^{aA}	15.50±1.55 ^{bA}	8.31±0.95 ^{dCDE}	38.167***
3	6.32±0.90 ^{bE}	4.40±0.80 ^{cF}	4.88±0.66 ^{cG}	10.33±0.41 ^{aC}	10.64±0.06 ^{ab}	65.066***
6	10.79±0.43 ^{bB}	11.24±0.33 ^{bB}	12.22±0.29 ^{ab}	11.39±0.66 ^{bB}	8.51±0.21 ^{cdD}	33.427***
9	4.15±0.07 ^{dF}	4.39±0.06 ^{cF}	6.42±0.17 ^{bF}	9.14±0.07 ^{ad}	6.43±0.04 ^{bG}	1370.972***
12	7.49±0.09 ^{cdDE}	8.30±0.04 ^{bD}	7.20±0.06 ^{dE}	7.40±0.23 ^{cdEF}	8.88±0.15 ^{aC}	83.831***
15	7.49±0.09 ^{cdDE}	8.30±0.04 ^{bD}	7.20±0.06 ^{dE}	7.40±0.23 ^{cdEF}	8.88±0.15 ^{aC}	83.831***
18	7.33±0.04 ^{cdE}	7.53±0.12 ^{bE}	7.18±0.02 ^{dE}	6.96±0.06 ^{eF}	7.81±0.08 ^{aeF}	60.562***
21	6.69±0.04 ^{dDE}	9.58±0.03 ^{aC}	7.96±0.06 ^{bE}	7.81±0.05 ^{ceF}	7.75±0.04 ^{ceF}	1677.365***
24	8.55±0.02 ^{aC}	8.53±0.03 ^{ad}	8.77±0.12 ^{aC}	8.16±0.34 ^{bDE}	8.19±0.21 ^{bDEF}	5.847*
27	7.57±0.05 ^{dCD}	8.03±0.03 ^{adE}	8.13±0.06 ^{acd}	7.87±0.03 ^{bEF}	7.68±0.10 ^{cf}	50.857***
F-value	47.010***	244.588***	321.431***	62.360***	54.030***	

days	b					F-value
	SK0	SK3	SK6	SK9	SK12	
0	17.34±1.92 ^{abC}	14.73±1.29 ^{bC}	16.58±0.60 ^{abC}	14.79±1.81 ^{bC}	18.58±1.00 ^{ad}	4.157*
1	28.55±0.40 ^A	28.78±0.45 ^A	31.61±6.06 ^A	27.03±0.33 ^A	26.79±1.03 ^A	1.451 ^{NS}
3	19.54±1.45 ^{cb}	21.83±0.54 ^{bB}	21.75±0.54 ^{bB}	25.02±0.77 ^{ab}	25.19±0.57 ^{ab}	17.886***
6	19.92±1.43 ^{cb}	20.94±2.06 ^{bCB}	22.56±1.65 ^{abCB}	25.45±2.88 ^{abAB}	23.75±0.05 ^{abC}	4.180*
9	11.15±0.05 ^{cd}	9.18±0.04 ^{dDE}	11.20±0.43 ^{cd}	13.99±0.06 ^{aC}	12.94±0.01 ^{bE}	262.648***
12	7.84±0.07 ^{cE}	7.91±0.04 ^{ceFG}	8.51±0.03 ^{bDE}	8.57±0.33 ^{bD}	12.11±0.29 ^{af}	234.720***
15	6.88±0.07 ^{dE}	7.28±0.26 ^{ceG}	7.89±0.02 ^{bDE}	8.52±0.11 ^{ad}	8.40±0.16 ^{ah}	67.067***
18	7.78±0.04 ^{cE}	9.56±0.02 ^{ad}	7.78±0.03 ^{cdE}	8.56±0.16 ^{bD}	9.70±0.10 ^{ag}	358.469***
21	7.69±0.03 ^{bE}	8.77±0.12 ^{adEF}	7.00±0.01 ^{cE}	8.76±0.08 ^{ad}	8.65±0.06 ^{ah}	365.259***
24	6.77±0.01 ^{abE}	7.19±0.17 ^{ag}	6.44±0.19 ^{bE}	7.21±0.56 ^{ad}	7.09±0.13 ^{ai}	4.146*
27	6.81±0.10 ^{dE}	7.44±0.06 ^{ceG}	7.44±0.06 ^{cE}	8.05±0.04 ^{bD}	8.76±0.11 ^{ah}	288.592***
F-value	227.582***	236.715***	58.096***	160.476***	727.896***	

1) a-d Means within the same row with different letters are significantly different ($p < 0.05$, Duncan's multiple range test)

2) A-C Means within the same column with different letters are significantly different ($p < 0.05$, Duncan's multiple range test)

3) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; NS, Not Significant

blanching samples but overall trends were similar in all samples. Proliferation and death of various microorganisms proceeded during fermentation of various ingredients in *kimchi* related products (32). Repetitive microbial succession in *kimchi* occurs throughout fermentation, thereby promoting the growth and proliferation of microorganisms. In a previous study, it was reported that lactic acid bacteria were decreased by the acid generated during fermentation after the lactic acid bacteria grew to some extent in *kimchi* (33).

Color, texture, and sensory preference The changes in color are shown in Table 1. All values showed similar trends except SK12, which was consistent with a previous study (34). Lightness (L) of samples temporarily increased, and then gradually decreased in all samples. This phenomenon was caused by the extraction of turbid components due to softened tissue cell as fermentation proceeded (25). Initial redness was much higher in SK12 (11.57) compared to those in other samples (4.08–6.64). However, as fermentation

Fig. 4. Changes in texture properties *kkakdugi* prepared with various blanching times. -●-, blanching 0 min; -○-, blanching 3 min; -▼-, blanching 6 min; -△-, blanching 9 min; and -■-, blanching 12 min. A, Hardness; B, Chewiness; C, Cohesiveness; $p=0.05$.

proceeded, the levels of redness in SK0, SK3, SK6, and SK9 increased, whereas it decreased in SK12. The redness was influenced by the carotenoid pigment of red chili pepper powder, deposited in the radish tissue by homogenization or melting during fermentation (32). There were significant differences among samples in redness (a) across all fermentation periods ($p<0.05$). Variations in blanching times affected the softening of radish, which influenced the rate of pigmentation (31). Yellowness (b) of samples fluctuated during fermentation but decreased from the initial value.

Texture changes of *kkakdugi* samples were determined during fermentation (Fig. 4). Hardness decreased gradually during fermentation and significant variations were observed among the samples ($p<0.05$) (Fig. 4A). These results were similar to a previous study reported wherein hardness decreased during fermentation (25). Decomposition of pectin decreases hardness and pectin hydrolase in various ingredients influences textural properties of *kimchi* related products (29). Overall cohesiveness and chewiness decreased across fermentation; however, different patterns compared to that of hardness were observed. Initial level of chewiness was much higher in SK0 (8.06 kgf/mm) and SK3 (5.09 kgf/mm) (Fig. 4B). Other samples ranged in lower levels from 0.66 to 1.78 kgf/mm. Chewiness in SK0 drastically decreased and the final value was 1.34 kgf/mm. Chewiness in other blanched samples were also decreased but the variations

were much smaller and reached a plateau after 9 days of fermentation. Chewiness was fluctuated temporarily but finally decreased from the beginning of fermentation, as reported in previous study (24). Cohesiveness also showed a similar trend as those in chewiness (Fig. 4C).

Fifty elderly consumers aged over 65 were recruited and their preferences in appearance, taste, texture, and overall acceptances of *kkakdugi* samples were evaluated at day 5 of fermentation, which was the optimal ripening period (pH 4.2–4.6) (Table 2). The preference score in appearance was the highest for SK0 (6.52), followed by SK3 (6.47), SK6 (6.05), SK9 (5.85), and SK12 (5.40) ($p<0.05$). As blanching time increased, appearance preferences decreased. For preference in aroma, SK3 was the highest as 6.17, followed by SK0, SK6, SK9, and SK12 ($p<0.05$). Similarly, preference scores of taste, texture, and overall acceptance were the highest in SK3, followed by SK0, SK6, SK9, and SK12. SK3 was the most preferred *kkakdugi* prepared with radishes using 3 min blanching. Even though SK3 showed higher levels in hardness, chewiness, and cohesiveness from texture analysis, it was the most preferred by elderly consumers. It seemed that the elderly recruited in this study preferred the crunchiness of *kkakdugi* with a minimum blanching time. In future, the easiness levels of chewing and swallowing in elderly need to be investigated for the development of elderly-friendly foods.

Table 2. Preference scores¹⁾ of *kkakdugi* prepared with various blanching times (n=50)

	SK0	SK3	SK6	SK9	SK12	F-value
Appearance	6.52±1.61 ^{b2)}	6.47±2.27 ^b	6.05±1.73 ^{ab}	5.85±1.73 ^{ab}	5.40±1.59 ^a	2.60* ³⁾
Aroma	5.77±1.70 ^{ab}	6.17±2.16 ^b	5.60±2.06 ^{ab}	5.12±2.01 ^a	4.97±1.81 ^a	2.43*
Taste	5.87±1.87 ^{bc}	6.47±2.12 ^c	5.30±2.03 ^b	4.00±1.99 ^a	3.92±2.08 ^a	12.24***
Texture	6.42±1.70 ^c	7.25±2.15 ^c	4.85±1.94 ^b	3.87±1.96 ^a	3.47±2.19 ^a	25.77***
Overall acceptance	6.37±1.78 ^c	7.20±1.93 ^d	5.20±1.76 ^b	3.95±1.70 ^a	3.95±1.80 ^a	25.40***

¹⁾9 point hedonic scale (1: extremely dislike, 5: neither dislike nor like, 9: extremely like)

²⁾Mean±SD; Means within the same column with different letters are significantly different ($p < 0.05$, Duncan's multiple range test)

³⁾* $p < 0.05$, *** $p < 0.001$

Based on the above mentioned results, the texture of radish was softened by blanching, which could help the elderly people who have difficulty in mastication and deglutition. SK3 with moderate texture level and similar aroma and taste with a regular *kkakdugi* was the most preferred. The longer the blanching time, the shorter the fermentation period and the preference was rather decreased. In addition, the more difficulty they had in mastication and deglutition, the more blanched *kkakdugi* they prefer. Therefore, the application of cooked radish using different blanching times could be used in elderly-friendly *kimchi*.

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