

## Effect on Cryopreservation Stability of Kimchi Duruchigi Supplemented with *Rubus coreanus* Miquel Extract

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The goal of this study was done for evaluating stability according to low-temperature storage of kimchi duruchigi supplemented with a hot water extract of *Rubus coreanus* Miquel (RCM). Total polyphenol and flavonoid contents in the RCM extract prepared from the hot water were detected by 293.34 µg CA/mg and 90.57 µg quercetin/mg, respectively. DPPH and superoxide radical scavenging activities of the extract were showed by relatively high values of 70.63 and 57.87%, respectively. Kimchi duruchigi was designed by control (non-treated), T1 (3% RCM extract), T2 (6% RCM extract), and T3 (0.1% ascorbic acid, a positive control). When compared with control and T3 groups, pHs of T1 and T2 groups supplemented with the RCM extract were gently changed depending on the storage time, and water holding capacities of T1 and T2 groups were improved in comparison with control group. Although meat color showed a tendency to most of increase according to the elapsed time, T1 and T2 groups showed less changes than that of control group. Lipid peroxidation appeared in a little bit changes regardless of the processing and storage days, but protein spoilages in T1 and T2 groups were found by lower changes when compared with the control group. As the results of sensory evaluation, T1 and T2 groups during storage had the better taste, flavor and acceptability than those of control and T3 groups. Therefore, we suggest that kimchi duruchigi supplemented with the RCM extract is a possible of improving the storage stability and product preference.

**Key words** : Antioxidant activity, hot water extraction, kimchi duruchigi, sensory evaluation, storage stability

### Introduction

As accumulation of active oxygen causes oxidative damage by attacking lipid, protein, carbohydrate, DNA and RNA, various diseases and aging induce through interference with normal cellular functions [12, 20]. The intake of foods to maintain a rich phenolic compound is positively correlated with decrease of risk and mortality from cancer, heart disease, and Alzheimer's disease [12]. Many of the plants have been used in Korean traditional medicine for treatments of anti-inflammatory, analgesics, emmenagogues, antispasmodics, sedatives, and health-improving agents. Especially, as oxidative stress is estimated to associate with these diseases, researchers have suggested that antioxidant

activities in these plants play an important role in the treatment of the diseases [16].

RCM has been discovered in the southern area of South Korea, and its immature fruit has been used for centuries for the treatment of asthma, allergy, and inflammation as an herbal medicine, especially, for stamina improvement [23]. Antioxidants in RCM have been identified by saponins including 19a-hydroxyursanetype triterpenoids and their glycosides, anthocyanins, epicatechin, ellagic acid, and ferulic acid [13, 24]. Niga-ichigoside F1 and 23-hydroxytormentonic acid induce anti-nociceptive, anti-inflammatory, anti-gastro-pathic, and anti-rheumatic effects [6, 15, 22]. In addition, these materials decrease lipid peroxidation and hydroxyl radical levels in gastric tissues, but increases the activities of superoxide dismutase (SOD) and glutathione peroxidase [15]. Antioxidant potential through the formula intake of berries is partially associated with cardiovascular disease, obesity, cancer, and other degenerative diseases [11, 21, 28, 30].

Duruchigi is a food fried using a variety of food materials corresponding to the intermediate degree of jjigae and jeongol. Kimchi duruchigi is a food with increased nutri-

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tional properties by adding kimchi to these materials. In this study, we tried to improve the storage stability of kimchi duruchigi by adding the RCM extract. We examined the storage stability via physicochemical properties and sensory evaluation.

## Materials and Methods

### Extraction of RCM

The applied RCM was purchased from a traditional market at Jinju in South Korea. Air-dried RCM was additionally dried by a dry oven for 2 hr at 100°C. The ground RCM was mixed with water of 3 volume and then extracted by 3 times for 3 hr at 100°C. The extract was concentrated by an evaporator and then powdered by a freeze-dryer (RW-0252G 4000/G1, Heidolph, Germany). The lyophilized powder was used by dilution to 0~1,000 µg/ml for assay.

### Total polyphenol and flavonoid contents

Total polyphenol content was determined by method of Peschel *et al.* [27]. The reaction solution was prepared with 0.1 ml of the extract (100 µg/ml), 7.9 ml of distilled water, 0.5 ml of Folin - Ciocalteu's reagent, and then 1.5 ml of a 20% sodium carbonate anhydrous solution was added at 2 min after addition of the Folin - Ciocalteu's reagent. The treated solution was reacted for 2 hr, and then measured at 765 nm with a microplate reader (Multiscan GO, Thermo Scientific co. ltd., USA). Total polyphenol content was presented as an mg galic acid/g equivalent.

Total flavonoid content was evaluated by method of Chang *et al.* [5]. The reaction solution was mixed with 0.5 ml of 100 µg/ml extract, 1.5 ml of 95% ethanol, 0.1 ml of 10% aluminum chloride, 0.1 ml of 1 M potassium acetate, and 2.8 ml of distilled water. The mixed solution was reacted for 30 min at room temperature, and then measured at 415 nm with a microplate reader (Multiscan GO, Thermo Scientific co. ltd., USA). Total flavonoid content was indicated as an mg catechine (CE)/g equivalent.

### Preparation of a kimchi duruchigi supplemented with the RCM extract

The kimchi duruchigi was prepared by a formula as shown in Table 1, and then each analysis was done during storages of 1, 5 and 10 days. The applied *longissimus dorsi* muscle was purchased from an industrial market, which the meat was elapsed in 24 hr post-mortem. The prepared kim-

Table 1. Formula of Kimchi duruchigi for evaluation of processing suitability (unit: g)

	Treatments			
	C	T1	T2	T3
Pork meat	45.3	45.3	45.3	45.3
Kimchi	30.1	30.1	30.1	30.1
Red pepper paste	9.0	9.0	9.0	9.0
Soy bean sauce	2.2	2.2	2.2	2.2
Sugar	1.6	1.6	1.6	1.6
Sesame oil	1.0	1.0	1.0	1.0
Gound garlic	0.8	0.8	0.8	0.8
Ginger powder	0.4	0.4	0.4	0.4
Mirim	1.6	1.6	1.6	1.6
Pepper	0.4	0.4	0.4	0.4
Water	7.6	4.6	1.6	7.5
<i>Rubus coreanus</i>	-	3.0	6.0	-
Miquel extract	-	-	-	0.1
Ascorbic acid	-	-	-	0.1
Total	100.0	100.0	100.0	100.0

chi duruchigi was stored at a refrigerator adjusted to 4°C.

### Radical scavenging ability

DPPH radical scavenging activity was determined by a few modified method of Brand-Williams *et al.* [3] and evaluated for reducing power of sample owing to an electron-donating effect to 1,1-diphenyl-2-picrylhydrazyl (DPPH).

Hydroxyl radical, Superoxide anion radical, and nitrite scavenging abilities were evaluated by methods of Halliwell *et al.* [8], Liu *et al.* [17], and Gray and Dugan [7], respectively.

### Evaluations of pH and meat color

For an assay of pH, the meat in kimchi duruchigi was minced, mixed with water of 9 fold, and then homogenized with a homogenizer (T25basic, IKA Malaysisa) for 1 min at 14,000 rpm. The pH value of the treated sample was determined by a pH-meter (MP230, Mettler Toledo, Swiss).

Meat color was measured by 3 times for surface meat color with a Minolta Chromameter (CR-300, Minolta Co. LTD. Japan). A light source of illuminant C (2° observer) was standardized to white standard plate ( $L^* = 93.5$ ,  $a^* = 0.3132$ ,  $b^* = 0.3198$ ).

### Lipid peroxidation

Lipid peroxidation (Thiobarbituric acid reactive substances, TBARS) was measured by method of Buege and Aust [4]. Briefly, 5 g sample was mixed with 50 µL of the butylated hydroxyanisole (BHA) and 15 ml of the distilled

water, and then homogenized by a homogenizer (T25basic, IKA Malaysisa) for 10 sec at 13,500 rpm. An aliquot (2 ml) of the homogenized solution was completely mixed with 4 ml of thiobarbituric acid (TBA)/trichloroacetic acid (TCA), boiled for 15 min at 90°C, cooled into room temperature, and then centrifuged for 15 min at 3,000 rpm. The centrifuged supernatant was recovered, measured at 531 nm using a spectrophotometer (Spectronic model Genesys 5, USA), and then presented by mg malonaldehyde (MA)/kg sample.

#### Volatile basic nitrogen (VBN)

VBN was evaluated by a few modification of micro-diffusion method described by Pearson [26]. Each sample (10 g) was mixed with 90 ml of the distilled water, homogenized by a homogenizer (T25basic, IKA Malaysisa) for 1 min at 75,000 rpm, and filtered through Whatman No. 2 filter paper. One milliliter of the filtrate was pipetted into the Conway dish occupied with 1 ml-saturated K<sub>2</sub>CO<sub>3</sub> solution and then allowed for reaction at 37°C for 120 min. Boric acid solution with an indicator (methyl red and bromocresol green) was used to absorb volatile nitrogen. The solution was titrated with 0.01 N HCl and VBN value was expressed as mg VBN/100 g of the sample.

#### Sensory evaluation of pork patty

Samples were assessed by 10-trained panelists. To acquaint panelists with product attributes and intensities, 6 training sessions, 1 hr each, took place over a week period prior to sample testing. During this phase, samples from a variety of manufacturers corresponding to maximum and minimum intensities that might be found for each attribute (1: extremely undesirable, to 10: extremely desirable) were presented to panelists. To test the panel reproducibility, one additional sample was presented at each session. It was the replicate of the second sample of the set and was served at the end of the session. Slices (3 mm thick) of randomly coded samples were obtained and served on plates to panelists. The color, flavor and overall acceptability of the samples were evaluated using a 10-point descriptive scale where (1) refers to extremely undesirable and (10) refers to extremely desirable. Panelists were required to cleanse palate between samples with water and bread. Three samples from different packages at 1, 5 and 10 days of storage were successively evaluated in each session. The sample order was randomized within sessions at room temperature.

#### Statistical analysis

An analysis of variance was performed according to the general linear model procedure of the SAS statistical package [29]. The Duncan's multiple range test ( $p < 0.05$ ) was applied for significant assay between means of treatments.

## Results and Discussion

#### Change of pH during storage of kimchi duruchigi supplemented with the RCM extract

RCM maintains a lot of materials to have the better antioxidant and antibacterial activities, as well as a variety of organic acids and mineral substances [13, 15, 24]. It is estimated that RCM is possible to improve the storage and functionality of the food owing to various functional substances. Therefore, functional substances of RCM was extracted by hot water, and yield of the extraction was showed by 116.25 mg/100 g. Total polyphenol and flavonoid contents in the RCM extract were showed by 293.94 µg CA/mg and 90.57 µg quercetin/mg, respectively (Table 2). The evaluated radical scavenging activity was detected by higher values of 70.63% and 57.87% in DPPH and superoxide radicals, respectively (Table 2). Especially, DPPH radical scavenging activity showed relative high activity by 84% of ascorbic acid activity, which the activity of ascorbic acid was detected by 84.23% (data not shown).

In order to evaluate the storage stability of kimchi duruchigi, the RCM extract was added into the kimchi duruchigi with 3% (T1) and 6% (T2) (Table 1). As a result of pH changes during storage, the initial pHs of T1 and T2 groups treated with the RCM extracts appeared significantly lower than that of control (Table 3). Furthermore, the initial pHs of T3 group treated with ascorbic acid had significantly lower pH value than those of T1 and T2 groups. As the same phenomenon, the initial pH value is detected by lower value

Table 2. Results of analysis for the extracted *Rubus coreanus* Miquel

Assay	Content
extraction yield (mg/100 ml)	116.25±1.77
total polyphenol content (mg CA/mg)	293.94±24.18
total flavonoid content (mg quercetin/mg)	90.57±8.96
DPPH (%)	70.63±0.19
superoxide radical (%)	57.87±0.32
hydroxyl radical (%)	10.00±5.77
Nitrite radical (%)	11.39±4.76

Table 3. Changes of pH and water holding capacity in cryopreservation storage of Kimchi duruchigi supplemented with *Rubus coreanus* fruit powder

Traits	Storage (days)	Treatments				p
		C	T1	T2	T3	
pH	1	5.46±0.09 <sup>Aa</sup>	5.18±0.03 <sup>Ab</sup>	5.24±0.05 <sup>Ab</sup>	4.96±0.02 <sup>Ac</sup>	0.01
	5	4.53±0.02 <sup>Bb</sup>	4.49±0.01 <sup>Bb</sup>	4.54±0.01 <sup>Bb</sup>	4.68±0.07 <sup>Ba</sup>	0.01
	10	4.02±0.02 <sup>Cbc</sup>	4.00±0.02 <sup>Cc</sup>	4.04±0.01 <sup>Cab</sup>	4.06±0.02 <sup>Ca</sup>	0.05
	p	0.01	0.01	0.01	0.01	
Water holding capacity	1	60.65±5.09 <sup>Aa</sup>	52.45±6.62 <sup>Aa</sup>	59.84±2.16 <sup>Aa</sup>	41.47±4.59 <sup>Bb</sup>	0.01
	5	43.22±3.60 <sup>Bb</sup>	44.09±2.81 <sup>Ab</sup>	49.87±3.39 <sup>Bab</sup>	52.23±3.91 <sup>Aa</sup>	0.05
	10	36.27±0.52 <sup>Bb</sup>	34.37±3.07 <sup>Bb</sup>	48.86±0.83 <sup>Ba</sup>	47.93±1.80 <sup>ABa</sup>	0.01
	p	0.01	0.01	0.01	0.05	

<sup>a-c</sup>Values are significantly different in the same column from each other.

<sup>A-C</sup>Values are significantly different in the same row from each other.

when compared to the control group in the study of addition of tomato powder [14]. Therefore, in this study, it is assumed that pH of the kimchi duruchigi tends to decrease due to acidity of kimchi and the acidic substances in the RCM extract.

In experimental results of storage for pork patty supplemented with tomato powder, the patty do not decrease pH even if the storage period has elapsed, on the contrary, it tends to be maintained or slightly increased [14]. In this study, pH values at 5 and 10 days in control group were reduced by 0.93 and 1.44, respectively. However, pH values at 5 and 10 days in T1, T2 and T3 were decreased by 0.69, 0.7 and 0.28, and 1.18, 1.2 and 0.9, respectively. T1 and T2 showed lower pH changes than those of control, but higher changes than those of positive control. Therefore, it is assumed that the RCM extract is a possible to play a buffering role to pH change

#### Change of water holding capacity

Since water holding capacity is an important indicator to determine the state of meat as an important element of meat quality trait [9, 10], we measured water holding capacity in cryopreservation of kimchi duruchigi supplemented with the RCM extract (Table 3). The changes of water holding capacity at 5 and 10 days for control, T1, T2 and T3 were presented by results of 17.43, 8.36, 9.97 and -10.76, and 24.38, 18.08, 10.98 and -6.46, respectively. Water holding capacity of fresh meat is influenced by lateral and transverse shrinkage of rigor myofibrils, range of interfilament spacing, membrane permeation of water, occurrences of drip channels and external space, and skeletal protein degradation post mortem [10]. Catechins improves water holding capacity via in-

crease of heat stability of collagen through hydrogen bond and hydrophobic interaction [19].

In this study, all of the treated groups showed lower changes of water holding capacity than those of control. Therefore, we suggest that antioxidant reaction of polyphenol compounds in RCM prevents water loss from intracellular molecules and space owing to inhibition of spoilage for intracellular polymeric substances. Especially, it is assumed that the lower initial water holding capacity in T3 group supplemented with ascorbic acid results in rapid water loss due to weak acidity of ascorbic acid. It is estimated to be similar to the exudative corresponding to lower pH post mortem [25]. However, it is assumed that water holding capacity tends to rather increase owing to antioxidant activity and loss of this material during storage. This property was matched with phenomenon of sharply decreased pH of T3 group as shown in Table 3. Furthermore, it was also consistent with partially reduced pH trends at T1 and T2 groups.

#### Change of meat color

Since change of meat color during storage is directly correlated with meat quality [9, 10], we examined change of meat color during storage at low temperature of kimchi duruchigi supplemented with the RCM extract (Table 4). The initial meat colors in the sample groups were not significantly different in lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ) and hue angle. However, chroma values maintained lower in control and T2, but higher in T1 and T3.

Lightness and yellowness in the storage period were significantly higher at 10 day than those of initial meat colors ( $p < 0.05$ ). Redness of T1 group appeared significantly differ-

Table 4. Changes of meat color in cryopreservation storage of Kimchi duruchigi supplemented with *Rubus coreanus* fruit powder

Index	Storage (days)	Treatments				p
		C	T1	T2	T3	
L*	1	48.53±1.99 <sup>b</sup>	47.23±0.57 <sup>b</sup>	48.53±1.42 <sup>b</sup>	48.60±0.72 <sup>c</sup>	0.01
	5	52.10±1.56 <sup>a</sup>	49.80±0.92 <sup>a</sup>	51.37±1.04 <sup>ab</sup>	51.40±0.35 <sup>ab</sup>	
	10	54.63±1.06 <sup>Aa</sup>	49.33±1.19 <sup>Ca</sup>	52.60±0.56 <sup>Ba</sup>	54.33±0.55 <sup>Aa</sup>	
	p	0.01	0.05	0.01	0.01	
a*	1	13.70±1.06	14.80±0.69 <sup>b</sup>	12.37±1.34	14.20±0.70	0.01
	5	15.83±1.40	16.50±1.06 <sup>b</sup>	14.00±1.39	16.03±1.66	
	10	13.90±0.87 <sup>B</sup>	19.03±1.15 <sup>Aa</sup>	14.97±1.90 <sup>B</sup>	16.00±1.21 <sup>B</sup>	
	p		0.01			
b*	1	12.37±1.79 <sup>b</sup>	14.63±1.45 <sup>b</sup>	13.73±1.96 <sup>b</sup>	15.93±0.87 <sup>b</sup>	0.01
	5	19.43±0.61 <sup>BCa</sup>	20.80±0.62 <sup>ABa</sup>	18.13±1.37 <sup>Ca</sup>	21.53±0.67 <sup>Aa</sup>	
	10	19.67±2.11 <sup>a</sup>	21.47±1.31 <sup>a</sup>	19.87±2.08 <sup>a</sup>	21.33±1.42 <sup>a</sup>	
	p	0.01	0.01	0.05	0.01	
Chroma	1	18.03±1.07 <sup>Bc</sup>	20.80±1.56 <sup>Ab</sup>	16.83±1.86 <sup>Bb</sup>	21.37±0.76 <sup>Ab</sup>	0.01
	5	25.10±0.53 <sup>ABa</sup>	26.53±0.96 <sup>Aa</sup>	22.90±1.85 <sup>Ba</sup>	26.90±0.95 <sup>Aa</sup>	0.05
	10	23.40±0.75 <sup>Cb</sup>	28.73±0.75 <sup>Aa</sup>	25.03±2.40 <sup>BCa</sup>	26.63±1.85 <sup>ABa</sup>	0.05
	p	0.01	0.01	0.01	0.01	
Hue angle	1	48.37±2.24	46.87±3.19	50.73±3.87	48.20±2.23	
	5	50.87±3.30	51.57±1.53	52.30±1.23	53.33±3.31	
	10	53.20±2.74	48.40±3.22	53.33±3.23	53.23±0.31	
	p					

<sup>a-c</sup>Values are significantly different in the same column from each other.

<sup>A-C</sup>Values are significantly different in the same row from each other.

ences depending on the storage period. Discoloration during storage of meat patty is mainly defined by the loss of redness [18]. In this study, we suggest that the sample groups supplemented with the RCM extract to have similar or higher redness, when compared to the control group, are an effect of preventing discoloration owing to physiologically active substances in RCM. The chroma values in T1 and T3 groups in all of the storage period were significantly higher than those of control group. The chroma values in the treated groups presented significantly higher values at 5 and 10 days than those of the initial products ( $p < 0.01$ ). The hue values were not significant differences in the treated groups and in storage days.

#### Lipid peroxidation and protein spoilage

Since the value of lipid peroxidation during storage serves as a reference for evaluation in meat quality [1], we examined the changes in lipid oxidation during storage of kimchi duruchigi supplemented with the RCM extract (Table 5). As a result of analysis, lipid peroxidation of products was significant differences depending on all the storage period, but TBARS values of the test groups were reduced rather with the exception T3 group. The lower pH values (pH 5.5~6.5)

is not coordinated to the oxidation of lipids because of inducing rapid re-arrangement in intra-molecules via cross-linkage between globin (myoglobin and hemoglobin) and prosthetic group [2]. In this study, it is estimated that this trend is prevented lipid from rancidity owing to antioxidant function of organic acid in the added kimchi, of the RCM extract, and of ascorbic acid.

As the results of protein spoilage during storage of kimchi duruchigi supplemented with the RCM extract, the changes of protein spoilages at 5 and 10 days in control, T1, T2, and T3 groups were presented by 7.47, 6.59, 7.0, and 6.39 and 10.51, 7.75, 6.81, and 6.93, respectively (Table 5). The changes of protein spoilage from this result were decreased in all of the treated groups when compared with those of control group. Perferrylmyoglobin [MbFe (IV)], a product of myoglobin oxidation, is possible to provide a protein radical for the other proteins, and to generate reactive secondary protein radicals of extremely long half-lives [1]. Therefore, it is assumed that low pH in this study reduces the protein spoilage due to fact that disrupts the distribution of the radical [2] and the protein deterioration values in each group are associated with the change values of pH.

Table 5. Changes of lipid peroxidation and protein spoilage in cryopreservation storage of Kimchi duruchigi supplemented with *Rubus coreanus* fruit powder

Traits	Storage	Treatments				p
		C	T1	T2	T3	
TBARS	1	0.87±0.08 <sup>Aa</sup>	0.84±0.02 <sup>Aa</sup>	0.74±0.05 <sup>b</sup>	0.81±0.03 <sup>B<sup>ab</sup></sup>	0.05
	5	0.70±0.04 <sup>Ab</sup>	0.76±0.03 <sup>Bb</sup>	0.69±0.10	1.07±0.07 <sup>Aa</sup>	0.01
	10	0.58±0.01 <sup>Cc</sup>	0.69±0.04 <sup>Cb</sup>	0.65±0.00	0.82±0.03 <sup>Ba</sup>	0.01
	p	0.01	0.01		0.01	
VBN	1	5.99±0.06 <sup>Cc</sup>	7.58±0.50 <sup>b</sup>	7.84±1.46 <sup>b</sup>	8.23±1.20 <sup>b</sup>	
	5	13.46±1.29 <sup>b</sup>	14.17±3.01 <sup>a</sup>	14.84±0.87 <sup>a</sup>	14.62±1.11 <sup>a</sup>	
	10	16.50±1.44 <sup>a</sup>	15.33±1.15 <sup>a</sup>	14.65±0.62 <sup>a</sup>	15.16±0.34 <sup>a</sup>	
	p	0.01	0.01	0.01	0.01	

<sup>a-c</sup>Values are significantly different in the same column from each other.

<sup>A-C</sup>Values are significantly different in the same row from each other.

**Sensory evaluation**

Sensory evaluation was done for analysis of sensory properties of kimchi duruchigi supplemented with the RCM extract (Table 6). Meat color increased temporarily at 5 day in control and T3 groups, and then T3 group at 10 day re-

duced below the start point, whereas control group presented higher than that of the start point. T1 and T2 groups showed a tendency to decrease. Although T2 group showed the highest value in the initial meat color, the group reduced to the lowest value at the end. Although taste maintained

Table 6. Changes of sensory evaluation in cryopreservation storage of Kimchi duruchigi supplemented with *Rubus coreanus* fruit powder

Index	Storage (days)	Treatments				p
		C	T1	T2	T3	
Color	1	4.50±1.00 <sup>a</sup>	5.00±1.41 <sup>a</sup>	5.75±2.36 <sup>a</sup>	5.00±1.41 <sup>a</sup>	
	5	6.50±1.73 <sup>a</sup>	5.00±0.82 <sup>a</sup>	5.25±0.96 <sup>a</sup>	6.50±2.65 <sup>a</sup>	
	10	5.13±2.52 <sup>b</sup>	4.00±1.00 <sup>b</sup>	3.50±1.32 <sup>b</sup>	4.17±1.61 <sup>a</sup>	
	p	0.05	0.05	0.05	0.05	
Taste	1	5.50±1.29 <sup>a</sup>	5.25±1.85 <sup>a</sup>	6.25±1.94 <sup>a</sup>	6.13±2.39 <sup>a</sup>	
	5	5.88±1.44 <sup>a</sup>	6.38±1.80 <sup>a</sup>	6.00±0.82 <sup>a</sup>	6.13±0.63 <sup>a</sup>	
	10	2.00±1.73 <sup>b</sup>	3.17±1.44 <sup>b</sup>	3.83±1.89 <sup>b</sup>	3.67±2.08 <sup>b</sup>	
	p	0.01	0.01	0.01	0.01	
Flavor	1	4.50±1.00 <sup>a</sup>	4.25±0.96 <sup>a</sup>	5.75±0.96 <sup>a</sup>	5.13±1.03 <sup>a</sup>	
	5	4.00±2.00 <sup>a</sup>	5.75±1.71 <sup>a</sup>	5.50±1.73 <sup>a</sup>	4.63±1.60 <sup>a</sup>	
	10	3.00±0.00 <sup>b</sup>	3.83±1.26 <sup>b</sup>	3.00±2.00 <sup>b</sup>	2.33±2.08 <sup>b</sup>	
	p	0.05	0.05	0.05	0.05	
Juiciness	1	5.75±1.50 <sup>a</sup>	6.13±2.17 <sup>a</sup>	5.63±2.29 <sup>a</sup>	5.50±2.12 <sup>a</sup>	
	5	4.75±2.06 <sup>a</sup>	4.88±1.03 <sup>a</sup>	5.25±1.89 <sup>a</sup>	4.75±1.26 <sup>a</sup>	
	10	2.33±0.58 <sup>a</sup>	3.33±0.58 <sup>b</sup>	3.67±2.02 <sup>b</sup>	3.00±1.73 <sup>b</sup>	
	p	0.05	0.05	0.05	0.05	
Texture	1	6.00±1.41 <sup>a</sup>	5.75±1.26 <sup>a</sup>	6.88±1.55 <sup>a</sup>	6.50±2.12 <sup>a</sup>	
	5	4.88±1.31 <sup>ab</sup>	6.13±1.44 <sup>a</sup>	5.75±0.96 <sup>a</sup>	5.00±1.41 <sup>a</sup>	
	10	3.33±2.52 <sup>b</sup>	3.83±0.76 <sup>b</sup>	3.17±1.02 <sup>b</sup>	2.33±0.58 <sup>b</sup>	
	p	0.05	0.01	0.05	0.05	
Accept-ability	1	6.00±1.22 <sup>a</sup>	5.88±1.65 <sup>a</sup>	7.25±1.50 <sup>a</sup>	5.75±1.50 <sup>a</sup>	
	5	5.00±2.16 <sup>a</sup>	6.50±1.73 <sup>a</sup>	6.25±0.50 <sup>a</sup>	5.75±1.50 <sup>a</sup>	
	10	2.33±1.89 <sup>b</sup>	2.00±1.46 <sup>b</sup>	3.00±1.36 <sup>b</sup>	2.33±1.79 <sup>b</sup>	
	p	0.05	0.05	0.05	0.05	

<sup>a-c</sup>Values are significantly different in the same column from each other.

similar or slightly higher level at 5 day, it showed a tendency to rapidly decrease at 10 day, especially, which was highly reduced in control group. All the treated groups maintained high taste values at 10 day when compared with control group, especially, which T2 group showed the highest value. Flavor showed the same tendency with taste, but T2 group maintained the highest value at 10 day. Pork patty including tomato powder maintains proper flavor during storage period [14]. In this study, it is assumed that functional substance of the RCM extract lowers the reducing rate of flavor.

Juiciness and texture in all the group were decreased in response to passage of time, except for T2 of texture. Juiciness had the lowest value in control group at 10 day, but the highest value in T2 group. Texture had the lowest value in T3 group at 10 day, but the highest value in T1 group. Total acceptability showed the best values in T2, T1 and T2 groups at 1, 5 and 10 days, respectively, but the worst values in T3, control and control/T3 groups at each day, respectively. Pork patty including tomato powder improves total acceptability [14]. In this study, we suggest that total acceptability and storage stability improve owing to sweetness and a variety of anti-oxidizing substance of the RCM extract.

## Conclusions

Kimchi duruchigi supplemented with the RCM extract occurred in mild change of pH. Water holding capacity in the treated groups was excellent after a lapse of the pre-determined time for storage period. Lipid peroxidation was not detected in any applied groups, and protein spoilages were lower than those of control. Overall acceptability was excellently evaluated by groups treated with the RCM extract when compared with control and positive control.

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### 초록 : 복분자 추출물을 포함하는 김치 두루치기의 저온 저장 특성

양미라<sup>1</sup> · 노건영<sup>1</sup> · 강석남<sup>2</sup> · 김삼웅<sup>1\*</sup> · 김일석<sup>1\*</sup>

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본 연구는 열수 추출된 복분자 분말을 김치두루치기에 첨가한 후 저온저장에 따른 품질 안정성을 평가하기 위해 수행되었다. 복분자 추출물의 DPPH와 수퍼옥사이드 라디칼 소거 활성은 70.63%와 57.87%로 각각 비교적 높게 나타났다. 샘플은 대조구(무처리), T1 (15% 복분자 추출물), T2 (30% 복분자 추출물), T3 (0.5% 아스코르빅산; 양성대조구)를 첨가하여 제조하였다. 복분자 추출물 첨가 샘플은 대조구와 양성 대조구에 비교하여 저장 기간에 따라 pH는 온화하게 변화되는 것으로 나타났고, 대조구에 비교하여 보수력이 개선되었다. 육색은 대부분 시간 경과가 될수록 증가되는 경향성을 보였으며, 대조구보다 더 낮은 변화의 폭을 보였다. 지질 과산화는 저장일수와 처리에 상관없이 거의 변화가 없는 것으로 나타났으며, 단백질 변패도는 대조구에 비교하여 낮은 것으로 나타났다. 관능분석 결과 T1과 T2는 대조구와 양성대조구에 비교하여 더 좋은 맛과 풍미를 가지며, 전체 기호도가 더 좋은 것으로 나타났다. 따라서 복분자 첨가 김치 두루치기는 제품의 저장 안정성을 개선하고, 제품의 기호도를 개선하는 것이 가능한 것으로 제의된다.