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Quality Characteristics of Mackerel Immersed in Sea Wind Mugwort Extract

Sun-Kyung Oh[1], Hae-Reon Son[1], Ki-Woong Kim[2], Sang-Ok Bae[3], Sung-Young Kim[4] and Myeong-Rak Choi[1]*

[1]*Department of Biotechnology, Chonnam National University, Yeosu 59626, Korea*
[2]*Department of Marine Bio Food Science, Chonnam National University, Yeosu 59626, Korea*
[3]*Department of Culinary Art, Chodang University, Muan 58530, Korea*
[4]*Department of Food Science, Andong Science College, Andong 36616, Korea*

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This study examined the influence of sea wind mugwort extract treatment on quality characteristics of mackerel during storage. Mackerel were packaged individually and then immersed in 5% sea wind mugwort extract for 2, 3, or 4 hr and stored at -20℃. The salinity of a control (no treatment) and that of mackerel immersed in sea wind mugwort for 2 hr was lowest (0.07%). pH of 5.90-6.23, and the change in acidity was in the opposite range. Immersion for 2, 3, and 4 hr led to a decrease in the tensile strength of the samples following storage, whereas the tensile strength of the control increased. The volatile basic nitrogen (VBN) content of the mackerel immersed for 2 hr was significantly lower than that of the control (5.6-15.4 mg% vs. 4.2-50.7 mg%). In the mackerel immersed for 2 hr, the total polyphenol and total flavonoid content was 286.3-497.0 mg gallic acid equivalents (GAE)/100 g and 177.5-385.6 mg quercetin equivalents (QE)/100 g, respectively. The 1,1-diphenyl-2-picrylhydrazyl (DPPH) and 2,2-azino-bis(3-ethyl-benzothizoline-6-sulfonic acid) (ABTS) radical scavenging activities of the mackerel immersed in sea wind mugwort for 2 hr were 50.6% and 61.3%, respectively. Overall, the immersion of mackerel in sea wind mugwort for a short time significantly improved quality characteristics, such as salinity, pH, acidity, hardness, antioxidant activity, and perceptible quality, following storage.

Key words : Antioxidant activity, *Artemisia, Scomber japonicas,* volatile basic nitrogen

Introduction

Mugwort is a highly fertile, perennial herb, which belongs to *Artemisia* of Compositae. It is widely distributed in Europe as well as Asia, for example, Korea, China, and Japan. It is known that about 300 varieties grow widely in Korea [19]. Presently, in Korea, research is being conducted multilaterally on *Artemisia capillaris* Thunberg (Injinssuk), *absinthium* (Yakssuk), *Artemisia dubia* Wall. (Chamssuk), or *Artemisia montana* Pampan (Sanssuk). Among these, Injinssuk has been reported for its several physiological activities, for instance, antioxidant and anticancer activities, facilitating lipid metabolism, and reducing hepatotoxicity [7]. Concerning *absinthium* extract's antioxidative activity, ethyl acetate fractions demonstrate the highest activity, and this is attributed to the total phenol and flavonoid contents in the samples [5]. Ganghwasajabalssuk controls the expression of Bcl-2, the proto-oncogene, and reduces the accumulation of cancer cells [18]. Recently, *Artemisia annua* L. has been proved to have immense antioxidant and anticancer activities from its components like phenolic acids such as chlorogenic acids, salicylic acids and catechins, for example, epicatechins or catechin or gallo-catechin gallates. It is evaluated as herbal medicine, being highly noticeable throughout the world [26]. Several physiological activities have also been reported for Mugwort, this includes, its volatile aromatic components' anti-mutagenic activity [15], anti-inflammatory activity [32], antibiotic activity against *Staphylococcus aureus* [1], and four-season mugwort's anticancer activity against HeLa cells [20]. Meanwhile, mackerel (*Scomber japonicus*) is a Teleostean fish belonging to Scombridae of Perciformes. It is one of the "four famous external blue colored fishes"along with sardine, jackmackerel, and horse mackerel. Mackerel is a highly nutritive, high-fat fish containing plenty of taurine and nucleic acids [2]. Above all,

***Corresponding author**
Tel : +82-61-659-7303, Fax : +82-61-659-7309
E-mail : mrchoe@jnu.ac.kr

it is rich in n-3 fatty acids, such as, EPA (eicosapentaenoic acid, 20:5n-3) and DHA (docosahexaenoic acid, 22:6n-3) [9, 12, 29]. It is known that mackerel's polyunsaturated fatty acids (PUFA) are effective against arteriosclerosis, cerebral thrombosis, and myocardial infarction [4]. Mackerel tends to be caught in bulk at a time, and it is red-fleshed fish that contains a lot of lipids. In addition, as it contains abundant non-protein nitrogen components inside its muscle, they are consumed by bacteria while it decays; therefore, it is regarded to be more easily deteriorated than other kinds of high-protein food. Moreover, its freshness reduces rapidly. Furthermore, during processing it is acidified at a fast rate by lipid oxidation and produces bad odor. Since the product is hard to be used as fresh fish or as a processed food, it is mainly used in the form of salted products [29]. In order to solve such problems in use of mackerel and to promote its use, ways to improve mackerel's storage quality and preference are actively being searched. Methods such as radiation exposure [2, 14], UV-ray exposure [30], low-temperature osmotic dehydration [21], and heatless treatments like high hydrostatic pressure [10] have been employed. Further, natural oxidizers such as, citron juice [8], onion and ginger juice [22], Cho-phi, persimmon leaves, or betony extract [32] have also been employed. However, there has been no study on the use of sea wind mugwort to reduce fishy smell and enhance antioxidative activity. We have found that addition of citron or green tea to mackerel increases storage quality. In this study, we provide foundational data about mackerel's freshness as well as the utility of sea wind mugwort-treatment for improving the quality of mackerel upon storage.

Materials and Methods

Materials

The mugwort used in this experiment was sea wind mugwort (SWM), one of the specialties cultivated in Geomun-do. The powdered sea wind mugwort was purchased from Geomun-do Sea Wind Mugwort Agricultural Association. The mackerel (*Scomber japonicas*) was provided by ARAUM Co., Ltd., Mangyang-ro of Yeosu City, Jeonnam. Mackerels fillet were used, and thickness was 1.5 cm.

Preparation of sea wind mugwort

SWM was extracted using the following steps. Powdered samples (100 g) of SWM were immersed in 10 x volume of distilled water. The extract was obtained through reflux cooling [11]. Thereafter, the extract was filtered through a filter paper (Whatman No. 3, Maidstone, England), and concentrated in a rotary vacuum condenser. The final concentrate had a concentration of 100 mg/ml, and its antioxidant activity was measured.

Preparation of mackerel in the sea wind mugwort

SWM extract was diluted with water at the ratio 1:1(v/v), and mackerels were immersed for 2, 3, or 4 hr. After quenching for 1 hr at -35℃, they were vacuum-packed and stored at -18℃. The subsequent experiments were performed at intervals of 15 days. Samples were stored at room temperature for 30 min before analysis.

Salinity, pH and acidity measurements of mackerel in the sea wind mugwort during storage

The salinity of SWM mackerel was measured with a salimeter (TM-30D, Tokyo, Japan). To measure pH, samples were powdered finely in a blender (Hanil, HNF-340, Seoul, Korea), and filtered through a gauze to gain 35 ml juice. The pH of this filtered juice was measured using a pH meter (Orion 520A, Boston, USA). Acidity was measured on 20 ml juice of SWM mackerel. For this, it was titrated with 0.1 N-NaOH solution so that the samples pH reached 8.2. The volume of 0.1 N-NaOH in ml was converted into lactic acid (%, v/v) using the following formula.

$$\text{Acidity (\%, v/v)} = [(0.1\ \text{N-NaOH(ml)} \times 0.0091) \times \text{factor}) / \text{sample(ml)}] \times 100$$

[1)]The amount of lactic acid (g) corresponding to 1 ml of 0.1 N-NaOH solution

Hardness measurement

Samples of size 4×1 cm^2 were cut from the central part of mackerel in the SWM at each stage of storage. The hardness of the SWM-immersed mackerel was measured using a rheometer (CR-500DX, Osaka, Japan). A 10.00 kg load cell was installed at the rheometer cross-head and chart speeds were 5 and 1.0 mm/s, respectively. Hardness analysis is a type of compression test that was used to determine the hardness of the sample. Samples were stored at room temperature for 30 min before analysis. All samples were analyzed three times.

Quantification of volatile basic nitrogen (VBN) content of mackerel in sea wind mugwort during storage

To examine the degree of change in proteins, volatile basic

nitrogen was measured through microdiffusion analysis [25] employing the Conway unit. Sample medicine was manufactured by adding 10 g of sample to about 90 ml distilled water and homogenizing it in 100 ml. Thereafter, 1 ml of the sample solution was placed in the left side of the Conway's outer room, and 1 ml of 50% K_2CO_3 was placed in the right side of its outer room. In the inner room, 1 ml 0.01 N H_2BO_3 and 500 μl mixed indicator of methyl red and bromocresol green were placed. The lid was closed after applying glycerine, and the outer room's sample were reacted with K_2CO_3. The reaction was allowed to occur at 37℃ for 120 minutes. On the contrary, to the control group, K_2CO_3 was not applied. After opening the lid of the Conway where reaction was facilitated, the inner room's boric acid solution was titrated with 0.02 N H_2BO_3 solution to quantify volatile basic nitrogen.

Sensory evaluation of mackerel in sea wind mugwort during storage

Students of department of Biotechnology in Chonnam National University were asked to participate in the evaluation at intervals of 15 days while mackerel was stored at -18℃. The evaluation included 3 criteria, namely, color, smell, and overall acceptability, and a 5-point scale was adopted with 5 points, being for very good, and 1 point, for very bad.

Measurement of total polyphenol content

The total polyphenol content in SWM-immersed mackerel was measured using colorimetry by using Folin-Ciocalteu phenol reagent [24]. We added 2.6 ml of distilled water and 200 μl of Folin-Ciocalteu phenol reagent to 200 μl of the sample and mixed together; the mixture was allowed to react for 6 min at room temperature, subsequently, 2 ml of 7% (w/v) Na_2CO_3 solution was added. The mixture was allowed to react for 90 min, and the absorbance was recorded using a spectrophotometer (Ultraspec 2000; Pharmacia Biotech, Cambridge, England) at 750 nm. A standard curve was obtained using gallic acid as the standard, and the polyphenol content was reported in mg gallic acid equivalents (GAE)/100 g.

Measurement of total flavonoid content

The total flavonoid content in SWM-immersed mackerel was measured using the method described by Jia et al. [24]. Briefly, 1 ml of the sample, 3.2 ml of distilled water, and 150 μl of 5%(w/v) $NaNO_2$ were mixed together and allowed to react for 5 min. Thereafter, 10% $AlCl_3$ solution was added and the mixture was reacted for 1 min, and 1 M NaOH was added; subsequently, the absorbance was measured at 510 nm. A standard curve was obtained using quercetin as a standard substance, and the flavonoid content was reported in mg quercetin equivalents (QE)/100 g.

DPPH radical scavenging activity measurement

The DPPH assay was performed by using a modification of the method reported by Brand-Williams et al. [24]. Briefly, DPPH solution was prepared by dissolving 16 mg of DPPH in 100 ml of methanol and then 100 ml of distilled water was added, mixed, and filtered through Whatman No. 2 filter paper (Whatman International Ltd, England). Thereafter, 5 and 1 ml of DPPH solution and the sample, respectively, were mixed, and incubated for 30 min at room temperature. The absorbance of the mixture was recorded using a spectrophotometer (Ultraspec 2000, Pharmacia Biotech, Cambridge, England) at 528 nm. Ascorbic acid was used as the positive control, and the results were calculated using the following equation:

$$\text{DPPH radical scavenging activity (\%)} = 1-(Abs_{sample}/Abs_{control})\times 100$$

Where, Abs_{sample} and $Abs_{control}$ are the absorbance values of the sample and control solutions, respectively.

2,2-azino-bis(3-ethyl-benzothizoline-6-sulfonic acid) (ABTS) radical scavenging activity

The ABTS radical scavenging activity was measured using a slight modification of the method reported by Kriengsak et al. [24]. Briefly, equal volumes of 1.8 mM ABTS solution and 0.63 mM potassium persulfate were combined and were reacted in dark for 24 hr at 37°C to create an ABTS solution with ABTS free radicals. The solution was diluted such that the absorbance at 735 nm was 1.4±0.1. Next, 5 ml of the ABTS solution with ABTS radicals was mixed with 0.1 ml of the sample, and the mixture was allowed to react for 7 min; subsequently, the absorbance was recorded at 735 nm. The results were calculated according to the following equation:

ABTS radical scavenging activity (%)
= (1 - absorbance of the solution with the sample added/absorbance of the solution without sample)×100

Statistical analysis

All tests and analyses were repeated at least three times. The results are expressed as mean±standard deviation (SD). One way analysis of variance (ANOVA) and Duncan's test were used for multiple comparisons using the SPSS version 21.0 (SPSS Institute, Chicago, IL, USA). In all experiments, differences were considered to be statistically significant if $p<0.05$.

Results and Discussion

Salinity, pH, acidity, and hardness measurements of mackerel in the sea wind mugwort during storage

During storage, mackerel's salinity, pH, acidity, and hardness were measured. A control group (control) not immersed with SWM extract and experimental groups post 2 hr, 3 hr and 4 hr (2 hr, 3 hr, and 4 hr respectively) of SWM extract treatment were analyzed. In comparison with the control group, none of the experimental groups indicated changes in salinity up to 30 days (Table 1). It was observed that the 2 hr group showed salinity of 0.07% up to the 30 days, and it was the lowest amongst all groups. pH of samples ranged from 5.90 to 6.23 in the control group from the zero to 60 days. Whereas, that of the 2 hr, 3 hr, and 4 hr treatment groups ranged from 6.13 to 6.23, 6.32 to 6.54, and 6.04 to 6.20 respectively. Generally, it is known that the pH of fresh fish muscle ranges from 5.5 to 6.5. However, after being caught, there is loss of freshness, and the pH increases with the accumulation of basic materials like trimethylamine (TMA) or dimethylamine (DMA) [23]. Unlike the pH, acidity decreased on the 15th day of storage and then increased in general in the control and 2 hr-immersed group. However, the 3 hr and 4 hr treatment groups indicated gradually increasing pH as storage proceeded. In addition, as storage proceeded, the control tensile strength tended to increase while the treatment groups indicated a decrease (Table 2). Kim et al. [13] added marinated mackerel to extracts having different dried thyme contents and found that as thyme addition increases, it turns softer. In this experiment as well, as time of treatment in 5% SWM extract increased the samples progressively became softer.

Measuring the volatile basic nitrogen (VBN) content of mackerel in sea wind mugwort during storage

Although fresh fish and shellfish flesh contains a small amount of VBN, generally, it is known to increase after they are caught and as freshness decreases. This occurs because ammonia or nitrogen is generated as trimethylamineoxide

Table 1. Changes in pH, acidity, salinity during storage period of mackerel immersed with sea wind mugwort extract

Storage (days)		Treated time (hr)			
		Control[1)]	2 hr[2)]	3 hr[3)]	4 hr[4)]
Salinity (%)	0	0.11 ± 0.01^{aA}	0.08 ± 0.01^{bA}	0.08 ± 0.01^{bA}	0.08 ± 0.01^{bA}
	15	0.13 ± 0.01^{aA}	0.08 ± 0.01^{bA}	0.08 ± 0.01^{bA}	0.08 ± 0.00^{bA}
	30	0.11 ± 0.01^{aA}	0.07 ± 0.01^{bA}	0.08 ± 0.01^{bA}	0.08 ± 0.00^{bA}
	45	0.10 ± 0.01^{cA}	0.08 ± 0.01^{bA}	0.09 ± 0.01^{aA}	0.08 ± 0.00^{bA}
	60	0.09 ± 0.01^{aA}	0.08 ± 0.01^{aA}	0.09 ± 0.00^{aA}	0.08 ± 0.00^{aA}
pH	0	$5.90\pm0.02^{dC*}$	6.13 ± 0.11^{cB}	6.32 ± 0.04^{aB}	6.20 ± 0.02^{bB}
	15	6.14 ± 0.01^{cB}	6.30 ± 0.02^{bA}	6.61 ± 0.01^{aA}	6.26 ± 0.05^{bB}
	30	6.08 ± 0.00^{cB}	6.20 ± 0.02^{bA}	6.70 ± 0.02^{aA}	6.38 ± 0.06^{bB}
	45	6.01 ± 0.01^{cB}	6.14 ± 0.01^{cB}	6.84 ± 0.04^{aA}	6.50 ± 0.07^{bA}
	60	6.23 ± 0.01^{bA}	6.23 ± 0.02^{bA}	6.54 ± 0.06^{aB}	6.04 ± 0.04^{cC}
Acidity (%)	0	0.85 ± 0.04^{aB}	0.81 ± 0.02^{aB}	0.73 ± 0.06^{aB}	0.73 ± 0.02^{aB}
	15	0.73 ± 0.01^{bC}	0.68 ± 0.02^{bD}	0.85 ± 0.01^{aA}	0.85 ± 0.04^{aA}
	30	0.76 ± 0.02^{bC}	0.73 ± 0.01^{bC}	0.87 ± 0.01^{aA}	0.76 ± 0.01^{bB}
	45	0.80 ± 0.01^{bB}	0.75 ± 0.01^{cC}	0.89 ± 0.01^{aA}	0.80 ± 0.01^{bB}
	60	1.36 ± 0.02^{aA}	1.22 ± 0.03^{bA}	0.92 ± 0.01^{cA}	0.86 ± 0.02^{cA}

[1)]Control: No-treated with sea wind mugwort extract
[2)]2 hr: Sea wind mugwort extract, 2 hr immersion treatment
[3)]3 hr: Sea wind mugwort extract, 3 hr immersion treatment
[4)]4 hr: Sea wind mugwort extract, 4 hr immersion treatment
[*]Data represent the mean ± SD of experiments performed in triplicates. The different lower-case letters (superscript) in the same row (a-c) and column (A-C) indicate statistically significant difference by Duncan's multiple range test ($p<0.05$).

Table 2. Changes in hardness during storage period of mackerel immersed with sea wind mugwort extract

Storage (days)		Treated time (hr)			
		Control[1)]	2 hr[2)]	3 hr[3)]	4 hr[4)]
Hardness	0	11.07±0.02^{aB*}	11.08±0.02^{aA}	11.03±0.04^{bA}	11.01±0.02^{bA}
	15	11.05±0.02^{aC}	11.04±0.03^{aB}	11.00±0.02^{bB}	11.00±0.03^{bA}
	30	11.13±0.03^{aA}	11.04±0.02^{bB}	11.00±0.03^{cB}	10.99±0.04^{cB}
	45	11.11±0.06^{aA}	11.00±0.01^{bC}	10.97±0.01^{cC}	10.97±0.03^{cB}
	60	11.08±0.03^{aB}	11.08±0.03^{aA}	10.91±0.03^{bD}	10.91±0.03^{bC}

[1)]Control: No-treated with sea wind mugwort extract
[2)]2 hr: Sea wind mugwort extract, 2 hr immersion treatment
[3)]3 hr: Sea wind mugwort extract, 3 hr immersion treatment
[4)]4 hr: Sea wind mugwort extract, 4 hr immersion treatment
[*]Data represent the mean ± SD of experiments performed in triplicates. The different lower-case letters (superscript) in the same row (a-d) and column (A-D) indicate statistically significant difference by Duncan's multiple range test (p<0.05).

(TMAO), which is subsequently reduced by the functions of reductase or bacteria in fish flesh thereby generating basic materials like TMA. Further, proteins are degraded by the reproduction of bacteria. The measurement of the VBN content is now being widely used as a way to measure freshness of fish or shellfish [29, 30]. Fig. 1 presents the results of VBN quantification in SWM extract-immersed mackerel during storage. The VBN content in the control group was 4.2~50.7 mg%, while among the SWM extract-immersed groups, the 2 hr group indicated a significantly lower value than the control of 5.6~15.4 mg%. Generally, 5~10 mg% of the VBN content is a characteristic of extremely fresh fish flesh, 15~25 mg% indicates moderately fresh fish flesh, 30~40 mg% indicates fish flesh in early spoilage, and over 50 mg% indicates fish flesh in severe spoilage [10]. Therefore, all the treatment groups indicated freshness in early storage and moderate freshness on the 30th day of storage, however beyond that except for the 2 hr-immersed group, all other groups indicated flesh in early spoilage state. The results demonstrated that the VBN contents in immersed groups were significantly lower than those of the control group, citron or steamed juice-immersed mackerel fillet, and persimmon leave/betony/Cho-phi extract-immersed salted mackerel [8, 32]. Moreover, the results demonstrated lower VBN content than that of the mackerel fillet immersed with a solution of green tea, dill weed, ginger, chitosan, and oligosaccharides [28].

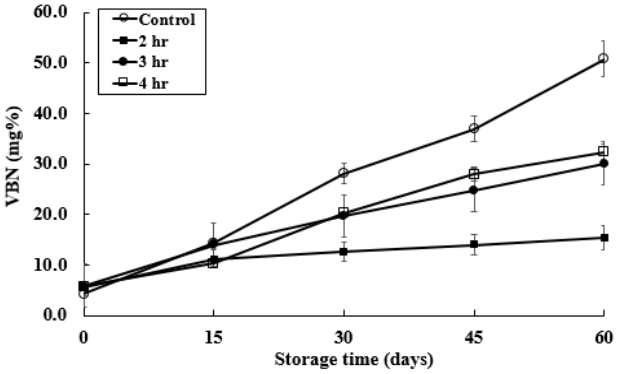

Fig. 1. Changes in volatile basic nitrogen (VBN) during the storage period of mackerel immersed with sea wind mugwort extract. Data represent the mean ± SD of triplicate experiments (n=3).

Sensory evaluation of mackerel in the sea wind mugwort during storage

SWM extract-immersed mackerel was evaluated in terms of its color, smell, and general preference (Table 3). The control group gained a lower point than the experimental groups, however, within the different experimental groups there was no significant difference. The control group scored between 2.7 to 3.4 for color, and it was lower than the treatment groups. Similarly, for flavor, the treatment groups received a higher point than the control group. Thus, it was speculated that SWM extract treatment hinders the generation of fishy smell or rancid odor. In terms of general preference, the 2 hr-immersed group gained a higher point, but it was not significantly different. Taken together, as per sensory evaluation, increased treatment time with SWM does not improve the perceptible quality of mackerel and the functional quality of the preserved mackerel can be improved through treatment for just 2 hr.

Total polyphenol and total flavonoid content

Phenolic compounds are one of the secondary metabolites widely distributed in plants. They have various structures and molecular weights. The phenolic hydroxyl (OH) groups

Table 3. Changes in sensory evaluation during storage period of mackerel immersed with sea wind mugwort

Sensory evaluation	Days	Control[1)]	2 hr[2)]	3 hr[3)]	4 hr[4)]
Color	0	3.40±0.01^{aC*}	4.18±0.03^{cB}	4.04±0.05^{cC}	3.82±0.07^{bD}
	15	3.35±0.06^{aC}	4.17±0.04^{cB}	3.87±0.03^{bB}	3.58±0.04^{aC}
	30	3.28±0.07^{aC}	4.00±0.01^{cB}	3.75±0.05^{bB}	3.45±0.05^{aB}
	45	3.03±0.04^{aB}	3.80±0.01^{cA}	3.47±0.03^{bA}	3.39±0.08^{bB}
	60	2.77±0.05^{aA}	3.67±0.03^{cA}	3.35±0.05^{bA}	3.16±0.04^{bA}
Smell	0	3.40±0.06^{aC}	4.40±0.01^{bD}	4.30±0.01^{bC}	4.22±0.08^{bD}
	15	2.78±0.02^{aA}	4.18±0.05^{bC}	4.13±0.04^{bC}	4.04±0.06^{bC}
	30	3.15±0.08^{aB}	3.86±0.05^{cB}	3.57±0.04^{bB}	3.78±0.02^{bcB}
	45	3.38±0.04^{aC}	3.76±0.04^{bB}	3.39±0.03^{aA}	3.68±0.04^{bB}
	60	2.99±0.02^{aA}	3.56±0.05^{cA}	3.53±0.04^{cB}	3.41±0.01^{bA}
Overall preference	0	3.66±0.06^{aC}	4.25±0.05^{bC}	4.16±0.04^{bD}	4.26±0.05^{bD}
	15	3.75±0.06^{aC}	4.07±0.04^{bB}	4.04±0.04^{bD}	4.00±0.01^{bD}
	30	3.18±0.03^{aB}	3.85±0.05^{cA}	3.76±0.05^{bC}	3.75±0.05^{bC}
	45	3.05±0.06^{aB}	3.76±0.05^{cA}	3.45±0.05^{bB}	3.47±0.05^{bB}
	60	2.76±0.05^{aA}	3.67±0.05^{cA}	3.16±0.05^{bA}	3.15±0.04^{bA}

[1)]Control: No-treated with sea wind mugwort extract
[2)]2 hr: Sea wind mugwort extract, 2 hr immersion treatment
[3)]3 hr: Sea wind mugwort extract, 3 hr immersion treatment
[4)]4 hr: Sea wind mugwort extract, 4 hr immersion treatment
[*]Data represent the mean ± SD of experiments performed in triplicates. The different lower-case letters (superscript) in the same row (a-c) and column (A-D) indicate the significant difference by Duncan's multiple range test (p<0.05).

of these compounds enable them to be easily combined with proteins or other giant molecules. They exhibit many physiological activities such as antioxidant or anticancer activities. It was observed that 5% SWM extract total polyphenol and total flavonoid contents were 357.34 mg GAE/100 g and 246.40 mg QE/100 g, respectively (not shown in Fig. 2). The control and the experimental groups immersed with 5% SWM extract indicate the total polyphenol and total flavonoid content as shown in Fig. 2. The control group showed the total polyphenol content as 99.6~120.1 mg GAE/100 g, and it was lower than that in the treatment groups. The 2 hr, 3 hr, and 4 hr-immersed groups indicated 497.0, 327.5, and 282.0 mg GAE/100 g on the 30th day of storage, suggesting that the 2 hr-immersed group showed a highest polyphenol content amongst different groups. Also, the control group indicated the total flavonoid content as 100.8~135.5 mg QE/100 g, and on the 30th day of storage, the 2 hr, 3 hr, and 4 hr-immersed groups indicated higher contents

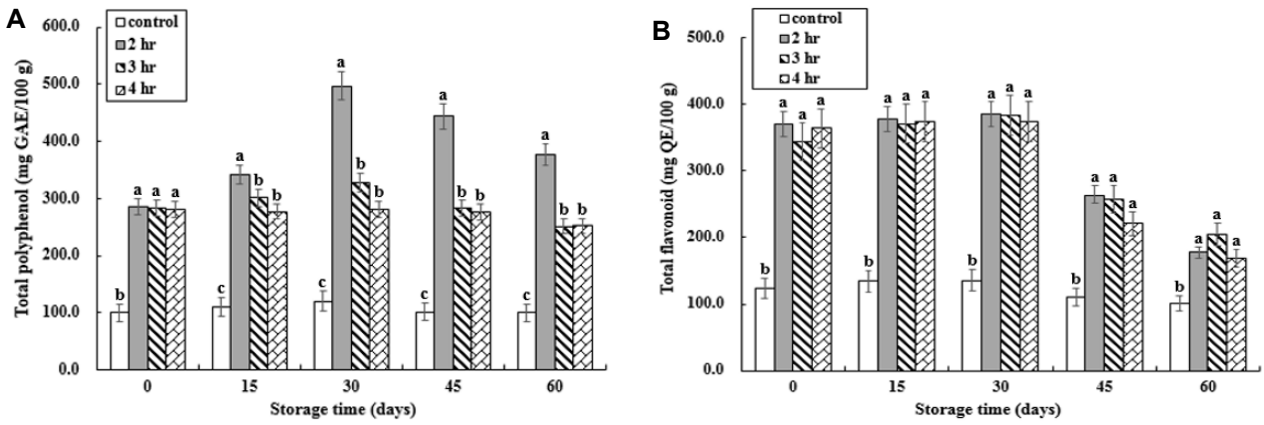

Fig. 2. Changes in total polyphenol (A) and total flavonoid content (B) during the storage period of mackerel immersed with sea wind mugwort extract. Data represent the mean ± SD of triplicate experiments (n=3). Columns with the same lower-case letters (a–c) are not significantly different by Duncan's multiple range test (p<0.05).

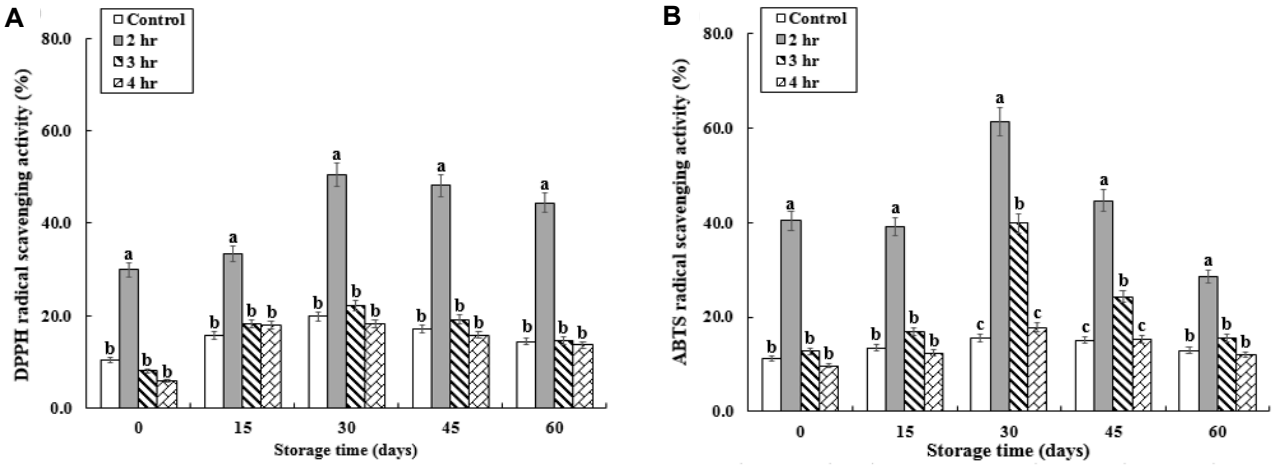

Fig. 3. Changes in DPPH (A) and ABTS (B) radical scavenging activity during the storage period of mackerel immersed with sea wind mugwort extract. Data represent the mean ± SD of triplicate experiments (n=3). Columns with the same lower-case letters (a - c) are not significantly different by Duncan's multiple range test (p<0.05).

of 385.6, 383.1, and 374.8 mg QE/100 g. Increased by the production of free phenolic components by the enzymatic action of microorganisms during the storage period, when comparing control group, mackerel immersed in SWM extract is considered to be due to by the effect of lignan-based substances and flavonoids and other components.

DPPH radical scavenging activity and ABTS radical scavenging activity

Lipid oxidation in food reduces its nutritive and sensory value, affects consumer preferences, and also brings about cell damage with the generation of peroxides, which results in aging or other kinds of diseases [28]. Accordingly, oxidizers that can get rid of free radicals generated in the process of lipid auto-oxidation are used to hinder lipid oxidation in food. In the human body, they are used to hinder aging and other diseases attributed to free radicals [6]. DPPH and ABTS radical scavenging activities of 5% SWM extracts are 32.08% and 66.92%, respectively. The control group indicated less than 20% DPPH radical scavenging activity during storage (Fig. 3A). In contrast, the 2 hr, 3 hr, and 4 hr experimental groups, demonstrated an increase in DPPH radical scavenging activity during storage, and on the 30th day, the 2 hr experimental group showed the highest activity of 50.6%. The ABTS radical scavenging activity was as high as 61.3% of 2 hr-immersed group (Fig. 3B). Notably SWM extract-immersed mackerel is equipped with antioxidant activity comparable to the natural antioxidants such as green tea and pine needles' hot water extract which showed DPPH radical scavenging activities of 55% and 53%, respectively [17]. This is attributed to the high total polyphenol and flavonoid content. Interestingly, mackerel immersed with mushrooms also possessed DPPH and ABTS radical scavenging activity of more than 50%. It was reported that the total phenolic compounds contained in the extract increased and the antioxidant activity increased, similar to the current report [27].

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초록 : 해풍쑥 추출물에 침지 처리한 고등어의 품질특성

오선경[1] · 손혜련[1] · 김기웅[2] · 배상옥[3] · 김성영[4] · 최명락[1]*

([1]전남대학교 생명산업공학과, [2]전남대학교 해양바이오식품학과, [3]초당대학교 조리과학부, [4]안동과학대학 식품영양과)

거문도 해풍쑥 추출물을 처리한 고등어의 저장 기간 동안의 품질 특성을 조사하였다. 5% 해풍쑥 추출물에 고등어를 2시간, 3시간, 4시간 처리한 후 개별 포장하여 -20℃에 저장하여 실험하였다. 해풍쑥 추출물을 처리하지 않은 고등어(control)와 해풍쑥에 2, 3, 4시간씩 처리한 고등어의 염도는 2시간 처리한 고등어가 0.07%로 가장 낮은 수치를 나타냈다. pH는 모두 5.90~6.23를 나타냈고 산도는 15일째 감소 후 증가하는 경향을 나타냈다. 또한, 저장기간이 길수록 인장강도는 control은 증가하고, 2, 3, 4시간씩 처리한 고등어는 감소하였다. Volatile basic nitrogen (VBN) 함량은 control은 4.2~50.7 mg%, 2시간 처리한 고등어는 5.6~15.4 mg%로 control보다 가장 낮은 수치를 나타냈다. 2시간 처리한 고등어 제품에서 total polyphenol, total flavonoid 함량은 286.3~497.0 mg GAE/100 g, 177.5~385.6 mg QE/100 g를 나타냈다. DPPH, ABTS radical scavenging activity은 2시간 처리한 고등어 제품에서 50.6%, 61.3%를 각각 나타냈다. 전반적으로, 고등어를 SWM으로 단시간 처리하면 염도, pH, 산도, 경도, 항산화 활성 및 저장기간 연장과 같은 품질특성이 크게 향상되었음을 알 수 있다.