

## Antioxidant Properties (ABTS, FRAP, Total Phenolic Content) of Alaska and Gochujang Pollock Roes and Fermented Pollock Roe Seasoning

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The Alaska Pollock (*Gadus chalcogrammus*) is distributed in an arc across the North Pacific Ocean. Distilled water extracts (DWE) and ethanol extracts (ETE) of 1.0 mg/ml concentrations of raw Alaska Pollock roe, premium Gochujang Pollock roe, and premium fermented Pollock roe seasoning were evaluated for estimated 2,2'-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) (ABTS), ferric reducing antioxidant potential (FRAP), and total phenolic content. The ABTS scavenging activity of the raw Alaska roe DWE and ETE were evaluated at 50.1% and 53.1%, respectively. The ABTS scavenging activity of the Gochujang roe DWE was 68.7% and of the ETE was 70.4%; for the fermented seasoning it was 71.3% and 71.6% for the DWE and ETE, respectively. The ABTS EC<sub>50</sub> values of the raw roe DWE and ETE were 12.49 ug/ml and 12.21 ug/ml, respectively. The FRAP EC<sub>50</sub> values of the Gochujang roe DWE and ETE were 10.67 ug/ml and 10.56 ug/ml, respectively, and the EC<sub>50</sub> values for total phenolic content for the fermented seasoning DWE and ETE were 10.45 ug/ml and 10.31 ug/ml, respectively. When Gallic acid was used as a control, the relative total phenolic content scavenging activity in each ETE was 52.0% (raw Alaska roe), 61.1% (Gochujang roe), and 63.6% (fermented seasoning). In the present study, higher ABTS, FRAP, and total phenolic content were observed in the Gochujang Pollock roe and fermented roe seasoning than in the Alaska Pollock roe.

**Key words** : Alaska Pollock roe, 2,2'-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) (ABTS+), Ferric Reducing Antioxidant Potential (FRAP), Gochujang, total phenolic content

### Introduction

The Alaska Pollock or walleye Pollock (*Gadus chalcogrammus*) is distributed in an arc across the North Pacific Ocean from the Pacific Northwest to northern Japan and are particularly abundant in the Sea of Okhotsk and Bering Sea. Alaska Pollock support one of the largest fisheries in the world - the largest fishery where catches are used for human consumption [22]. Alaska Pollock is also a preferred base for is prized for its fillets, surimi, roe, and milt, a protein paste used for a variety of final products [8]. The highest quality surimi is sold to Japan, where it is a food staple. Fillets are frequently used for popular products such as fish and chips. If collected, roe and milt are commonly exported to South Korea and Japan. Alaska Pollock roe, or fish eggs,

is a popular treat in Korea and Japan. As with most fish species, female Alaska Pollock have two ovaries, and roe is obtained from each fish as a pair of connected egg skeins. The eggs are small, and it can be hard to distinguish individual eggs while they are still in the skeins. On average, eggs in harvested roe are 1.3-1.5 mm in diameter [2]. Alaska Pollock roe may also be used as an ingredient in salad dressing or dried and used as seasoning for a variety of products, including sea vegetable snacks and salads.

In Korea, the roe is called Myeongnan (literally "Alaska Pollock's roe"), and the salted roe is called Myeongnan-jeot (literally Pollock roe Jeotgal). Myeongnan-jeot is salt fermented Pollock roe and is one of many fermented food products used in Korean cuisine. For health benefits include anti-oxidants and anti-diabetics, reducing body fat, and boosting immune systems with intensive research and development on low sodium Jeotgal, this high value-added Myeongnan will be helpful to keep reputation as one of the important traditional Korean fermented food globally [20].

The phrases "free radicals" and "reactive oxygen species" (ROS) are frequently used interchangeably although this is not always correct [16]. Free radicals are waste substances

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produced by cells as digestive processes of foods in body. Antioxidants are substances that can prevent or slow damage to cells caused by free radicals that the body produces to their participation in the normal cellular functions, i.e. cellular homeostasis and its regulation. The sources of antioxidants can be natural or artificial. Certain plant-based foods are thought to be rich in antioxidants. Plant-based antioxidants are a kind of phytonutrient, or plant-based nutrient.

Based on the special chemical properties of formed free radicals, 2,2'-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) (ABTS+) assay has been used to determine the antioxidant capacity of food products [24]. For example, polyphenol compounds, which widely exist in fruit, can quench free radicals inside human body, thus prevent oxidative damage by free radicals.

The Ferric Reducing Antioxidant Potential (FRAP) assay is one of the most widely cited assays for total antioxidant capacity [3]. Phenolic compounds such as flavonoids, phenolic acid and tannins are considered to be major contributors to the antioxidant activity in plants. These antioxidants also possess diverse biological activities such as anti-inflammatory, anti-carcinogenic and anti-atherosclerotic effects. These activities may be related to their antioxidant activity [5].

Many researches have been taken regarding anti-oxidative effect from fish and shellfish, as well as their by-products [7, 11, 12]. However, little information regarding antioxidants of a Pollock roe and its application has been reported. Many assays are available to measure antioxidant capacity, but no single method can truly measure the total antioxidant activity. The main objective of the study was to determine the antioxidant activity of Alaska Pollock roe extracts, Gochujang Pollock roe and fermented seasoning Pollock roe by ABTS+, FRAP, and total phenolic content radical scavenging assay.

## Materials and Methods

### Sample extract

Raw Alaska Pollock roe, premium Gochujang Pollock roe, and premium fermented seasoning Pollock roe were obtained from Deok-Hwa Food Co., Busan-ci, Korea. The premium brand is a special processing of the company, which has made the raw material more advanced. Each roe of *G. chalcogrammus* (100 g) was ground with pestles and liquid nitrogen at  $-70^{\circ}\text{C}$  and homogenized prior to beginning ex-

traction experiments. Two solvents were used for the preparation of the extracts, distilled water and 80% ethanol conc. The distilled water extract (EWE) was prepared by weighing out (100 g) of the milled powdered roes were soaked in 500 ml of distilled water in a conical flask and stirring vigorously with a glass rod for proper extraction. For the ethanol extract (ETE), 100 g of the pulverized powdered roes and were soaked in 500 ml of ethanol for 24 hr also. The samples were treated with ultrasound (5510, Branson, USA) at room temperature for one hour. The mixture was further stirred with a magnetic bar at  $65^{\circ}\text{C}$  for 6 hr. They were squeezed out with the muslin cloth and filtered through Whatman filter paper No. 1. The sample was evaporated to remove solvent or excess water under reduced pressure and controlled temperature ( $60^{\circ}\text{C}$ ) by using rotary vacuum evaporator (N-1001S-W, Eyela, Tokyo, Japan). To get dry powder, samples placed in a low temperature vacuum chamber (HyperCool, HC3110, Gyrozen Co., LTD, Korea). The extract was dried, weighed (5.0 g) and stored at  $-20^{\circ}\text{C}$  in storage vials for experimental use.

### ABTS+ free radical

The great diversity of methods and modifications is evident from its different names. 2,2'-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) (ABTS+) is a stable free radical. The antioxidant activity of the seaweed extracts was measured on the basis of the scavenging activity of ABTS+ free radical according to the method described by Brand-Williams et al. [4] with slight modifications. ABTS+ free radical method is an antioxidant assay based on electron-transfer that produces a violet solution in ethanol [6]. 1 ml of 0.1 mM ABTS+ solution in ethanol was mixed with 1 ml of the previous extracts of various concentrations (0.1, 0.5, and 1.0 mg/ml). ABTS+ was added to the solutions prepared with extracts and standard antioxidant substances and stirred. A solution of ABTS+ was prepared by dissolving 5 mg ABTS+ in 2 ml of ethanol, and the solution was kept in the dark at  $4^{\circ}\text{C}$ . A stock solution of the compounds was prepared at 1 mg/ml in DMSO. The stock solution was diluted to varying concentrations in 96-well microplates. Then, 5  $\mu\text{l}$  of ethanol ABTS+ solution (final concentration 300  $\mu\text{M}$ ) was added to each well. The plate was shaken to ensure thorough mixing before being wrapped with aluminum foil and placed into the dark. The radical scavenging reaction was carried out at  $37^{\circ}\text{C}$  in dark for 30 min. The optical density (OD) of the solution was read using the Microplate Reader

at the wavelength 515 nm. Corresponding blank sample was prepared and L-Ascorbic acid (1.0 µg/ml) was used as reference standard (positive control). Relative inhibitor rate of raw materials and other samples for L-Ascorbic acid was calculated.

#### Ferric Reducing Antioxidant Potential Assay (FRAP Assay)

The antioxidant capacity by ferric ion reducing power was measured according to the method of Oyaizu [19] with modifications. 1 ml of various concentrations of sample and 1 ml of 1% w/v potassium ferricyanide solution were added to 1 ml of the phosphate buffer solution (0.2 M, pH 6.6), and the mixture was reacted at 50°C for 20 minutes, and then 1 ml of 10% w/v trichloroacetic acid was added thereto. The reaction mixture was centrifuged at 12,000 rpm for 10 minutes, 1 ml of distilled water was added to 1 ml of supernatant, and 0.2 ml of 1% ferric chloride was added. Blank samples were prepared for both ethanol and deionized water extracted samples. Vitamin C (L-ascorbic acid) were used as antioxidant standards. After 10 minutes of reaction, the absorbance was measured at 700 nm. A calibration curve of ascorbic acid was established; the antioxidant capacity of the plant extracts was then expressed as mmol ascorbic acid equivalent/g dry extract.

#### Determination of total phenolic content

The total phenolic content of the sample extracts was determined by using Folin-Ciocalteu reagent following a slightly modified method of Ainsworth [1]. Gallic acid was used as a reference standard for plotting calibration curve. A volume of 0.5 ml of the plant extract (100 µg/ml) was mixed with 2 ml of the Folin-Ciocalteu reagent (diluted 1:10 with de-ionized water) and were neutralized with 4 ml of sodium carbonate solution (7.5%, w/v). The reaction mixture was incubated at room temperature for 30 min with intermittent shaking for color development. The absorbance of the resulting blue color was measured at 765 nm using double beam Microplate Reader. The total phenolic contents were determined from the linear equation of a standard curve prepared with Gallic acid. The content of total phenolic compounds expressed as mg/g Gallic acid equivalent (GAE) of dry extract.

#### Statistical analysis

The samples were prepared in triplicate for each analysis

and the mean value of absorbance was obtained. The results were expressed as the mean ± SD. Correlation co-efficient (R) to determine the relationship between two or more variables among Radical Scavenging activity tests were calculated using the SPSS software (Release 21.0). The percent inhibition was calculated as the decolorization percentage of the test sample using the following formula:

$$\text{Inhibition \%} = (IA - A_s) / IA \times 100$$

Where IA is the absorbance of the 100% initial and  $A_s$  is the absorbance of the sample. IA and  $A_s$  were the values which were subtracted the average absorbance of the blank wells.

The 50% inhibition (IC<sub>50</sub>) is defined as the concentration sufficient to obtain 50% of a maximum scavenging capacity. A dose response curve was plotted to determine IC<sub>50</sub> values. To determine the IC<sub>50</sub> value of the active component, the technique using 96-well microplates was employed.

## Results

#### ABTS scavenging assay

ABTS scavenging activity of DWE of raw Pollock roe was evaluated 39.6% at 0.1 mg/ml, 44.0% at 0.5 mg/ml, and 50.1% at 1.0 mg/ml. ABTS scavenging activity of ETE of raw Pollock roe was evaluated 41.9% at 0.1 mg/ml, 46.2% at 0.5 mg/ml, and 53.1% at 1.0 mg/ml (Table 1). Thus, the inhibition of ABTS+ scavenging activity increases with increasing extract concentrations. The all values of ABTS scavenging activity of ETE for Pollock roe were higher than those of DWE for Pollock roe. However, the all did not show a statistically significant difference ( $p < 0.05$ ). ABTS+ scavenging activity of DWE with premium Gochujang Pollock roe evaluated was 68.7% at 1.0 mg/ml and that of ETE was 70.4% at same concentration. ABTS+ scavenging activity of DWE with fermented seasoning premium Pollock roe evaluated was 71.3% at 1.0 mg/ml and that of ETE was 71.6% at same concentration. The all values of fermented seasoning Pollock roe were showed the highest inhibition activity of ABTS+ among three treated groups. There was significant difference among the three experimental groups ( $p > 0.001$ ).

The EC<sub>50</sub> values of DWE and ETE of raw Pollock roe on ABTS were 12.49 µg/ml and 12.21 µg/ml, respectively (Table 4). The EC<sub>50</sub> values of DWE and ETE of Gochujang Pollock roe were 10.59 µg/ml and 10.42 µg/ml, respectively. The EC<sub>50</sub> values of DWE and ETE of fermented seasoning Pollock roe on total phenolic content were 10.03 µg/ml and

Table 1. The assay of 2,2'-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) scavenging activity of premium Pollock roe at different concentrations

Pollock roe	Concentration (mg/ml)	Water	Ethanol	t-test
Raw	0.1	39.55±0.99	41.89±0.50	0.562
	0.5	44.02±0.31	46.23±0.48	
	1.0	50.12±0.99	53.12±1.39	
Gochujang seasoning	0.1	55.93±1.03	57.71±0.61	0.323
	0.5	60.90±0.15	62.52±2.34	
	1.0	68.71±1.41	70.40±2.05	
Fermented seasoning	0.1	62.00±1.48	64.25±1.82	0.462
	0.5	67.20±0.67	68.39±0.75	
	1.0	71.32±0.99	73.01±1.36	
F-test		22.402***	27.646***	0.380

\*\*\* =  $p < 0.001$ .

Table 2. The ferric reducing antioxidant potential (FRAP) assay of premium Pollock roe at different concentrations

Pollock roe	Concentration (mg/ml)	Water	Ethanol	t-test
Raw	0.1	48.29±1.03	50.85±0.86	0.418
	0.5	60.49±2.30	63.86±1.24	
	1.0	65.31±2.12	68.53±2.01	
Gochujang seasoning	0.1	51.08±1.11	52.81±1.02	0.131
	0.5	62.58±2.35	63.02±0.38	
	1.0	70.63±1.40	71.55±2.22	
Fermented seasoning	0.1	54.13±1.61	55.19±0.49	0.176
	0.5	63.88±1.02	65.90±1.45	
	1.0	72.43±0.47	73.30±0.92	
F-test		0.442	0.208	0.462

9.88 µg/ml, respectively. When the L-Ascorbic acid used as a control, relative ABTS scavenging activities of ETE raw Pollock roe, Gochujang Pollock roe, and fermented seasoning Pollock roe extracts were 64.8%, 67.3%, and 68.9%, respectively (Fig. 1).

#### Ferric ion reducing antioxidant power (FRAP) assay

Antioxidant capacity of extracts was determined using

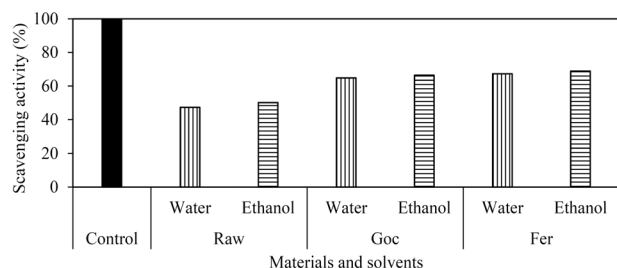


Fig. 1. Relative inhibitory effects on ABTS+ by ethanol extracts from various Pollock roes. Control is L-Ascorbic acid. Raw: raw Pollock roe, Goc: Gochujang Pollock roe, Fer: fermented seasoning Pollock roe.

FRAP assay (Table 2). Raw Pollock roe was showed the lowest inhibition activity of FRAP among three groups. FRAP of DWE of raw materials was evaluated at 0.1 mg/ml was 48.3% and that FRAP scavenging activity at 0.5 mg/ml was 60.5%, and that of at 1.0 mg/ml was 65.3%. FRAP of ETE of raw Pollock roe was evaluated 50.9% at 0.1 mg/ml, 63.9% at 0.5 mg/ml, and 68.5% at 1.0 mg/ml. FRAP scavenging activity of DWE with Gochujang Pollock roe evaluated was 70.6% at 1.0 mg/ml and that of ETE was 71.6% at same concentration. FRAP scavenging activity of DWE with fermented seasoning Pollock roe evaluated was 72.4% at 1.0 mg/ml and that of ETE was 73.3% at same concentration. FRAP values were higher in fermented seasoning Pollock roe samples compared to other samples. However, there was a significant difference at  $p < 0.05$ .

The  $EC_{50}$  values of DWE and ETE of raw Pollock roe on FRAP were 11.02 µg/ml and 10.70 µg/ml, respectively (Table 4). The  $EC_{50}$  values of DWE and ETE of Gochujang Pollock roe were 10.67 µg/ml and 10.56 µg/ml, respectively. The  $EC_{50}$  values of DWE and ETE of fermented seasoning

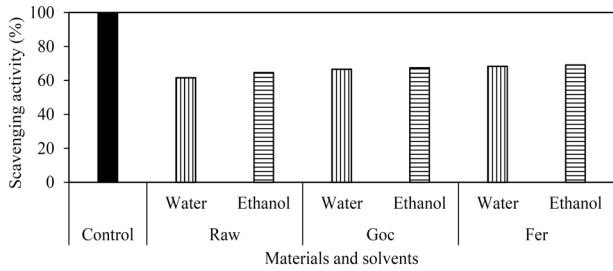


Fig. 2. Relative inhibitory effects on FRAP by ethanol extracts from various Pollock roes. Control is L-Ascorbic acid. Abbreviations of Raw, Goc, and Fer are same as Fig. 1.

Pollock roe on total phenolic content were 10.45 ug/ml and 10.31 ug/ml, respectively. When the L-Ascorbic acid used as a control, relative FRAP scavenging activities of ETE raw Pollock roe, Gochujang Pollock roe, and fermented seasoning Pollock roe extracts were 64.7%, 67.5%, and 69.1%, respectively (Fig. 2).

**Total phenolic content**

The inhibition effects (%) in DWE and ETE of raw Pollock roe was found to be 34.2% and 34.9% on 0.1 mg/ml (Table 3). The inhibition effects (%) of total phenolic content on 1.0 mg/ml DWE and ETE of raw Pollock roe were found to be 51.6% and 53.1%, respectively. These results suggest that the higher levels of antioxidant activity were due to the presence of phenolic components. The total phenolic content of DWE with Gochujang Pollock roe evaluated was 59.3% at 1.0 mg/ml and that of ETE was 59.9% at same concentration. The total phenolic content scavenging activity of DWE with fermented seasoning Pollock roe evaluated was 62.3% at 1.0 mg/ml and that of ETE was 64.9% at same concentration.

The EC<sub>50</sub> values of DWE and ETE of raw Pollock roe on total phenolic content were 12.48 ug/ml and 12.30 ug/ml, respectively (Table 4). The EC<sub>50</sub> values of DWE and ETE of

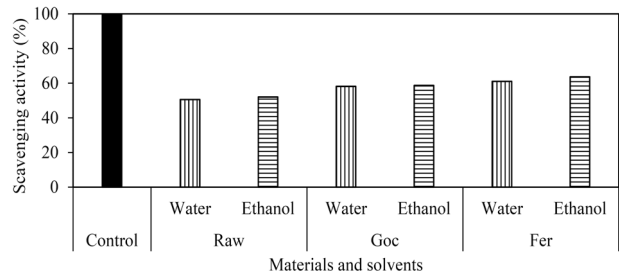


Fig. 3. Relative inhibitory effects on total phenolic content by ethanol extracts from various Pollock roes. Control is L-Ascorbic acid. Abbreviations of Raw, Goc, and Fer are same as Fig. 1.

Gochujang Pollock roe were 11.55 ug/ml and 11.49 ug/ml, respectively. The EC<sub>50</sub> values of DWE and ETE of fermented seasoning Pollock roe on total phenolic content were 11.37 ug/ml and 11.13 ug/ml, respectively. When the Gallic acid used as a control, relative total phenolic content scavenging activities of ethanol extracts raw Pollock roe, Gochujang Pollock roe, and fermented seasoning Pollock roe extracts were 52.0%, 61.1%, and 63.6%, respectively (Fig. 3).

**Discussion**

Much study has been conducted to the recovery of bio-active compounds from different industrial food residues: leaves, peels, barriers, seeds, wood, culls, rinds, pits, pulp, press cakes, marc, malts, hops, hulls, husks, spent grain, carapace of crustaceans and shrimp, algae and other fish by products [10, 21].

In this study, it seems that the anti-oxidative power of the natural production, raw materials is not much stronger than that of the antioxidant capacity of the Gochujang and fermented seasoning materials. Alaska Pollock roe contained 82.0% water, 17.2% protein, 0.8% total lipid, and other some

Table 3. The assay of total phenolic content of premium Pollock roe at different concentrations

Pollock roe	Concentration (mg/ml)	Water	Ethanol	t-test
Raw	0.1	34.22±1.15	34.94±1.23	0.219
	0.5	43.99±1.38	46.56±1.39	
	1.0	51.56±0.63	53.05±0.52	
Gochujang seasoning	0.1	40.22±2.56	41.10±1.40	0.068
	0.5	54.41±1.97	54.59±0.78	
	1.0	59.30±0.84	59.86±2.85	
Fermented seasoning	0.1	41.21±2.04	43.29±1.09	0.242
	0.5	55.59±2.88	57.31±0.35	
	1.0	62.37±3.75	64.91±2.98	
F-test		1.409	1.396	0.312

Table 4. The 50% inhibition (EC<sub>50</sub>) of ABTS+, FRAP, and total phenolic content of Alaska Pollock roe at different solvents

Sample	ABTS+		FRAP		Phenolic content	
	Water	Ethanol	Water	Ethanol	Water	Ethanol
Raw Pollock roe	12.489	12.205	11.018	10.698	12.482	12.296
Pollock roe with Gochujang	10.590	10.415	10.673	10.557	11.554	11.486
Pollock roe with fermented seasoning	10.053	9.877	10.447	10.308	11.367	11.129

minerals [23]. Gochujang and fermented seasoning Pollock roes may be useful natural radical scavenging and potential supplement for the food. It can be corrupted due to a lot of nutrients. Korean Gochujang and fermentation treatments can reduce corruption by red pepper and high salt which is the cap sign of pepper. Fermented fish products have been consumed as the fish itself, fish sauce, fish paste, and other types of food throughout the world. Some of the examples of fish sauces are Jeotkal in Korea [18].

The additive Myeongnan-jeot could provide a complementary approach to increase the production of specific anti-oxidative compounds for use as nutraceuticals or as ingredients in the design of functional foods. Korea's Gochujang is an ethnic food made with representative food ingredients and has a history of thousands of years [14]. Gochujang was mainly used for making enhancing the taste of food and for aiding the digestive system. Many studies have shown the effects of additives on the taste of gochujang [15] and the effect of different microflora on the quality improvement of gochujang [9, 13]. However, there is limited information regarding the physicochemical characteristics and antioxidant properties of gochujang fortified with various types of red pepper varieties during the fermentation period [25]. Yang et al. [25] performed antioxidant activity measurements such as DPPH radical scavenging activity and FRAP assay, the total polyphenols and total flavonoids contents to evaluate the antioxidant activities of gochujang. The results showed that Gochujangs had consistently high values of total polyphenols and total flavonoids with antioxidant activities during the 90 days of fermentation with five different varieties of red pepper. The strong the antioxidant activity observed various seasoning and fermented foods using fish products [17]. In the present study, ABTS+ scavenging activities of ETE of Pollock roe with Gochujang seasoning and Pollock roe with fermented seasoning were evaluated 70.4% and 73.0% at 1.0 mg/ml, respectively (Table 1). FRAP scavenging activity of ETE of Pollock roe with Gochujang seasoning and Pollock roe with fermented seasoning were evaluated 71.6% and 73.3% at 1.0

mg/ml, respectively (Table 2). The values of total phenolic content of ETE of Pollock roe with Gochujang seasoning and Pollock roe with fermented seasoning were evaluated 59.9% and 64.9% at 1.0 mg/ml, respectively (Table 3). Although Gochujangs and fermented seasoning could be high antioxidant function, Pollock roe has some antioxidant properties. We could conclude that Alaska Pollock roes with proper seasoning, are good nutria with free radical scavenging activities. Raw Pollock roe (a) was 39.6% on 0.1 mg/ml at water extraction (Table 1). Gochujang seasoning (b) and Fermented seasoning (c) were 55.9% and 62%, respectively. If b is subtracted from a, it has 16.4% antioxidant. If c is subtracted from a, it has 22.5% antioxidant. The both values were low than 39.6% at raw Pollock roe.

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## References

1. Ainsworth, E. A. and Gillespie, K. M. 2007. Estimation of total phenolic content and other oxidation substrates in plant tissues using Folin- Ciocalteu reagent. *Nat. Protoc.* **2**, 875-877.
2. Bledsoe, G., Bledsoe, C. and Rasco, B., 2003. Caviars and fish roe products. *Crit. Rev. Food Sci. Nutr.* **43**, 317-356
3. Bolanos de la Torre, A. A. S., Henderson, T., Nigam, P. S. and Owusu-Apenten, R. K. 2015. A universally calibrated microplate ferric reducing antioxidant power (FRAP) assay for foods and applications to Manuka honey. *Food Chem.* **174**, 119-123.
4. Brand-Williams, W., Cuvelier, M. E. and Berset, C. 1995. Use of free radical method to evaluate antioxidant activity. *Food Sci. Technol.* **28**, 25-30.
5. Chung, K. T., Wong T. Y., Huang, Y. W. and Lin, Y. 1998. Tannins and human health: a review. *Crit. Rev. Food Sci. Nutr.* **38**, 421-464.
6. Cornish, M. L. and Garbary, D. J. 2010. Antioxidants from macroalgae: potential applications in human health and

- nutrition. *Algae* **25**, 155-171.
7. Harada, K., Maeda, T., Hasegawa, Y., Tokunaga, T., Tamura, Y. and Koizumi, T. 2010. Antioxidant activity of fish sauces including puffer (*Lagocephalus wheeleri*) fish sauce measured by the oxygen radical absorbance capacity method. *Mol. Med. Rep.* **3**, 663-668.
  8. Hintermeiste, C. 2017. Nutritional composition changes in Alaska Pollock (*Gadus chalcogrammus*) during and between Bering Sea A and B seasons. Master, thesis, Oregon State University, Oregon, USA.
  9. Jang, S. J., Kim, Y. J., Park, J. M. and Park, Y. S. 2011. Analysis of microflora in Gochujang, Korean traditional fermented food. *Food Sci. Biotechnol.* **20**, 1435-1440.
  10. Kallel, F., Driss, D., Chaari, F., Belghith, L., Bouaziz, F., Ghorbel, R. and Chaabounia, S. E. 2014. Garlic (*Allium sativum* L.) husk waste as a potential source of phenolic compounds: influence of extracting solvents on its antimicrobial and antioxidant properties. *Ind. Crop Prod.* **62**, 34-41.
  11. Kim, J. S., Moon, G. S., Lee, K. H. and Lee, Y. S. 2006. Studies on quality changes and antioxidant activity during the fermentation of the salt fermented whangseoke. *J. Kor. Soc. Food Sci. Nutr.* **35**, 171-176.
  12. Kim, S. M. 2003. The functionality of anchovy sauce. *Food Industry and Nutrition* **8**, 9-17.
  13. Kim, Y. S., Oh, B. H. and Shin, D. H. 2008. Quality characteristics of Kochujang prepared with different Meju fermented with *Aspergillus* sp. and *Bacillus subtilis*. *Food Sci. Biotechnol.* **17**, 527-533.
  14. Kwon, D. Y., Chung, K. R., Yang, H. J. and Jang, D. J. 2015. Gochujang (Korean red pepper paste): A Korean ethnic sauce, its role and history. *J. Ethnic Foods* **2**, 29-35.
  15. Lee, S. Y., Park, S. L., Yi, S. H., Nam, Y. D. and Lim, S. I. 2011. Quality characteristics of low-salt Gochujang added with *Glycyrrhiza uralensis* and *Brassica juncea*. *J. Food Sci. Nutr.* **16**, 348-356.
  16. Lushchak, V. I. 2015. Free radicals, reactive oxygen species, oxidative stresses and their classifications. *Ukr. Biochem. J.* **87**, 11-18.
  17. Mheen, T. 1993. Microbiology of salted-fermented fishery products in Korea, pp. 231-247. In: Lee, C. H., Steinkraus, K. H. and Alan Reilly, P. J. (eds.), *Fish Fermentation Technology*, United Nation University Press: Tokyo, Japan.
  18. Mun, E. G., Kim, B., Kim, E. Y., Lee, H. J., Kim, Y., Park, Y. and Cha, Y. S. 2018. Research trend in traditional fermented foods focused on health functional evaluation. *J. Kor. Soc. Food Sci. Nutr.* **47**, 373-386.
  19. Oyaizu, M. 1986. Studies on products of browning reactions: antioxidant activities of products of browning reaction prepared from glucosamine. *J. Nutr.* **44**, 307-315.
  20. Park, K. Y., Kwon, D. Y., Lee, K. W. and Park, S. 2018. Korean Functional Foods. Composition, Processing and Health Benefits. CRC Press, Boca Raton, FL, USA.
  21. Sadeghi, A., Hakimzadeh, V. and Karimifar, B. 2017. Microwave assisted extraction of bioactive compounds from food: a review. *Intl. J. Food Sci. Nutr. Engin.* **7**, 19-27
  22. Strong, J. and Criddle, K. R. 2013. Fishing for Pollock in a Sea of Change: A Historical Analysis of the Bering Sea Pollock Fishery. Alaska Sea Grant, University of Alaska Fairbanks, Fairbanks, Alaska, USA.
  23. USDA. 2018. National Nutrient Database for Standard Reference Legacy Release. Basic Report: 15266, Fish, Pollock, Alaska, raw. The National Agricultural Library, USA.
  24. Walker, R. B. and Everette, J. D. 2009. Comparative reaction rates of various antioxidants with ABTS radical cation. *J. Agric. Food Chem.* **57**, 1156-1161.
  25. Yang, H. J., Lee, Y. S. and Choi, I. S. 2017. Comparison of physicochemical properties and antioxidant activities of fermented soybean-based red pepper paste, Gochujang, prepared with five different red pepper (*Capsicum annuum* L.) varieties. *J. Food Sci. Technol.* **52**, 792-801.

**초록 : 고추장과 발효액이 첨가된 알래스카 산 프리미엄 명란의 ABTS, FRAP, total phenolic acid의 항산화 특성 분석**

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알래스카 산 대구(*Gadus chalcogrammus*)는 북태평양에 분포하는 대구과 한류 어종이다. 알래스카 산 대구의 명란 원료, 프리미엄 고추장 명란, 프리미엄 발효 명란을 증류수와 에탄올로 추출하여 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS+), 철 환원 항산화능(Ferric Reducing Antioxidant Potential, FRAP), 총 페놀 함량을 평가하였다. 명란 원료의 증류수와 에탄올 추출물의 ABTS+ 소거능은 1.0 mg/ml 농도에서 각각 50.1%, 53.1%였다. 고추장 명란의 증류수와 에탄올 추출물의 ABTS+ 소거능은 1.0 mg/ml 농도에서 각각 71.3%, 71.6%였다. 발효 명란의 증류수와 에탄올 추출물의 ABTS+ 소거능은 1.0 mg/ml 농도에서 각각 68.7%, 70.4%였다. 명란 원료의 증류수와 에탄올 추출물의 ABTS+에 대한 최소 저해 농도 값(EC<sub>50</sub>)은 각각 12.49 ug/ml과 12.21 ug/ml이었다. 고추장 명란의 증류수와 에탄올 추출물의 FRAP에 대한 최소 저해 농도 값(EC<sub>50</sub>)은 각각 10.67 ug/ml과 10.56 ug/ml이었다. 발효 명란의 증류수와 에탄올 추출물의 총 페놀 함량에 대한 최소 저해 농도 값(EC<sub>50</sub>)은 각각 10.45 ug/ml과 10.31 ug/ml이었다. Gallic acid를 대조구로 할 때 총 페놀 함량에 대한 상대적 활성은 명란 원료가 52.0%, 고추장 명란이 61.1%, 발효 명란이 63.6%였다. 명란 원료보다 고추장 명란과 발효 명란에서 ABTS+, FRAP 소거능 및 총 페놀 함량이 우수하였다.