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Analysis and comparison of general compositions, amino acids, fatty acids and collagen of abalone harvested in three different regions in Korea

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한국에서 생산되는 전복의 영양성분 비교 분석

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Abstract

In this study, the general compositions, amino acids, fatty acids and collagen content of three abalones, which were harvested in Wando, Heuksando and Jeju Island in Korea, were analyzed and compared. The abalone body and viscera were separated from each other and the physicochemical properties were investigated. The moisture and protein contents of the viscera were lower than that of the body; while the lipid, carbohydrate, and mineral contents were higher. The general compositions and mineral contents also presented fluctuation among the three abalone groups. The amino acid content via hydrolysis in the abalone viscera ranged from 93.16 to 127.02 mg/g, which was lower than the amino acid content of the abalone body of approximately 145 mg/g. However, the free amino acids level in the abalone viscera ranged from 16.81 to 20.10 mg/g, which was higher than that of the abalone body level of approximately 7.90 to 10.59 mg/g. The fatty acid analysis revealed that while the saturated fatty acid percentages in the abalone body were higher than in the abalone viscera, the percentages of the monoenoic and polyenoic fatty acids of the body were significantly lower. The body of the abalone harvested in Wando contained the highest level of collagen (2.26±0.46 mg/g), followed by the abalone harvested in Jeju Island and Heuksando. The abalone viscera contained much lower collagen, which ranged from 0.37±0.15 mg/g to 0.20±0.03 mg/g. The results of this study will provide useful information for the future research of abalone.

Key words : abalone body, abalone viscera, amino acids, fatty acids, collagen

Introduction

Abalone is an important aquatic economic species widely cultured in East Asia, Australia, America and many other regions (1). The production of abalone has increased greatly in the recent two decades with the introduction of farm aquaculture system (1). It is estimated the world total output of abalone is more than 30,000 metric tonnes per year (1). Abalone is a seafood delicacy, famous for its unique color, texture and flavor (2). In Korea, Japan, China and many other Asian countries, abalone has been used as a traditional medicine and tonics (3,4). In the oriental medicine books, such as 'Dongui Bogam', 'Mingyi Bielu' and 'Haiyao Benlun', abalone was recorded as a useful medicine for the eye, lung and liver (5). In recent years, several research articles have been published on the nutritional and pharmacy values of abalone. González M et al. (6) examined the nutritional value of abalone and the effects on serum cholesterol concentration in rats. Maoka T and his coworkers (7) studied the characteristics of carotenoid pyropheophorbide A esters obtained from abalone. Peng WD et al. (8) investigated the learning and memory improving ability of abalone extracts on mice. Li G et al. (9) purified a glycosaminoglycan-like polysaccharide from abalone whose anticoagulant activity was investigated in vitro .

Generally, the visceral part of abalone is not regarded as

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edible by the producers as well as customers (10). The viscera is treated as by-product and most of them is discarded directly or used as fish silage (10,11). However, the nutritional and health value of the visceral part of abalone should not be overlooked since more researchers have paid attention to the bio-activities and health promoting activities of the abalone viscera. Sun L et al. (12) discussed the activities of a sulphated polysaccharide obtained from the abalone viscera. Ping K and Qiukuan W (13) studied the potential application of the enzyme extract of abalone viscera. Several other articles mentioned the antioxidant potential of polysaccharide extracted from abalone viscera (14,15). The application of abalone viscera as the food ingredient has also been researched (3). Our previous study has discussed the anti-skin-ageing activities of extract from abalone viscera (16). The results indicate that abalone viscera possess very high nutritional and functional value, suggesting its widely application possibility.

As mentioned above, Korea is the main abalone producer and the main consumer as well (1). The primary abalone aquiculture area in Korea located in the south coastal region, especially Wando, Heuksando and Jeju Island (1). In this study, we analyzed and compared the chemical constituents, amino acids, fatty acids and collagen content of the abalone produced in Wando, Heuksando and Jeju Island. We also examined and compared the difference between the abalone body and viscera. Since the similar researches on this topic are rare, this study will be meaningful to the related researches.

Materials and methods

Chemical and reagents

The abalone was obtained from the local aquatic market of Wando, Heuksando and Jeju Island respectively in February 2012. All the abalone was shucked and eviscerated. After that, the abalone body and viscera was gathered and homogenized and stored at -20℃ in refrigeratory until use. BF3-methanol reagent, chloramine T, perchloric acid, collagen from calf skin and p-dimethylaminobenzaldehyde was purchased from Sigma-Aldrich Co. (St. Louis, MO, USA). All other reagents used in the experiments in this study were reagent grade chemicals.

Analysis of the general compositions and mineral element

Moisture content, crude protein content, crude lipid and ash content of abalone body and viscera were analyzed in accordance with the AOAC methods (17). Conversion factor for the examination of protein content was 6.25. Minerals include Ca, Cu, Fe, Zn, K and Na presented in abalone body and viscera were analyzed with an atomic absorption spectroscopy (Spectra AA-220FS, Verian, Australia). Phosphorus content (P) was measured by a spectrophotometer (Agilent 8453, Agilent, Santa Clara, CA, USA) at 650 nm according to the molybdenum blue method described previously (18,19).

Analysis of hydrolysis amino acid compositions

All the samples were hydrolyzed with 6 M hydrochloric acid for 22 hr at 110℃. After the hydrolysis, the hydrolysate was concentrated in vacuum and diluted by 0.02 M hydrochloric acid (10 v/v). The samples were filtered with 0.45 μm membrane filter for the amino acid composition analysis using the Hitachi L-8800 amino acid analyzer (Tokyo, Japan) according to the method described previously (20,21).

Analysis for free amino acid composition

The free amino acid of abalone body and viscera was extracted with twice of 5% trichloroacetic acid solution for 24 hr. Once extracted, the solution was centrifuged at 10,000g for 10 min. The supernatant was neutralized by three times 0.05 M hydrochloric acid and then diluted with five times of distilled water. All the samples were filtered with 0.45 μm membrane filter and the free amino acid composition was analyzed by the same amino acid analyzer stated above.

Analysis for fatty acids composition

The total lipid of all the samples was extracted according to the method recorded by Bligh and Dyer with some modifications (22). To a certain quality of sample contained 1 g water, added 3.75 mL of a mixture prepared with chloroform, methanol, 0.88% KCl solution (5/10/4 by volume) and then homogenized for 30 sec. After homogenization, 1.25 mL chloroform and 0.88% KCl solution (5/4 by volume) was added to the sample solution and homogenized for 30 s before centrifuged at 2,500g for 20 min. The lower phase was collected, desiccated and evaporated. The lipid extract was then transferred to a test tube, filled with nitrogen gas and stored at 4℃. The fatty acids was methylated using the AOCS Official Method (23). To 1 g fatty acids, 24 mL of 0.5 N methanolic NaOH was added to a round-bottomed flask and the mixture was heated and boiled for 20 min until all the lipid globules went into solution. After that, the flask was heated at 80℃ for 10 min. About 28 mL of BF_3-methanol reagent was added to the flask and the flask was boiled for 2 min before 20 mL of hexane was added and the mixture was boiled again for 1 min. After cooling to the room temperature, about 25 mL of saturated sodium chloride solution was added to the flask and shook the solution vigorously for 15 sec. A small amount of hexane was transferred to a test tube with appropriate amount of anhydrous sodium sulfate. The dry hexane solution was injected into a gas chromatograph for fatty acid analysis. The gas chromatography working conditions were listed in Table 1.

Table 1. The working conditions of the gas chromatography for the fatty acids

Instrument	Hewlett-Packard 6980 Series Gas	Chromatography
Column	DB-23 (J&W Scientific,	Folsom, CA, USA)
	0.25 mm i.d.×30 m, 0.25 μm	film thickness
	Initial 160℃	Holding 2 min
	3.5℃/min 250℃	5 min
	25.0℃/min 260℃	5 min
Injector	250℃	Split ratio 50:1
Detector	260℃	FID detector
Carrier gas	Helium	Flow rate: 1.4 mL/min

Collagen content

We measured the collagen content in abalone body and viscera using the Woessner's method (24) with some modifications. All the samples were grinded and 10 mg of sample was mixed with 1 mL of 6 N HCl solution in a glass test tube. The test tube was heated at 100℃ for 24 hr before several drops of 0.02% methyl red was added to it. Added 2.5 N NaOH solution to neutralize the test sample until the color changed to faint yellow. After centrifugation at 1,000g for 10 min, 1 mL of the supernatant was mixed with 1 mL of distilled water and 1 mL of chloramine T into a test vial. The mixture was vortexed for about 1 min and then the solution was allowed to stand for 20 min before 1 mL of perchloric acid solution was added. After 5 min of standing, the solution was mixed with 1 mL of p-dimethylaminobenzaldehyde, vortexed, incubated at 60℃ in a water bath for 20 min. Collagen from calf skin which was used as the standard was treated under the same procedures. The collagen content was measured at 557 nm by the same spectrophotometer listed above.

Results and Discussions

Analysis of the general compositions and mineral elements

The general compositions of abalone body and viscera is influenced by the abalone species, harvested regions, harvested time, feed, abalone age and several other factors, as have been mentioned in the previous studies (25-28). The results of the general compositions and mineral elements are presented in Table 2 and 3 respectively. As we can see from the Table 2, the protein, lipid and carbohydrate content of body part of abalone produced in Wando, Heuksando and Jeju Island show no significant difference. The moisture content of abalone body produced in Wando and Jeju Island is higher than that of Heuksando. While abalone body produced in Heuksando possess significant higher crude ash content than that of the other two groups. The general compositions of abalone viscera show that the moisture and

Table 2. The proximate composition of abalone body and viscera (%)

Origin		Wando	Heuksando	Jeju Island
Abalone body	Moisture	80.80±0.36[b1)]	81.16±0.45[ab]	81.48±0.55[a]
	Protein	11.06±0.34[NS2)]	10.44±0.37	11.10±0.66
	Lipid	0.26±0.05[NS]	0.32±0.04	0.27±0.02
	Carbohydrate	6.06±0.66[NS]	5.76±0.75	5.40±0.97
	Ash	1.82±0.08[b]	2.32±0.47[a]	1.77±0.07[b]
Abalone viscera	Moisture	77.82±0.68[NS]	78.16±0.54	77.60±0.46
	Protein	4.88±0.33[a]	4.08±0.24[b]	4.62±0.37[a]
	Lipid	2.97±0.16[ab]	3.06±0.06[a]	2.88±0.09[b]
	Carbohydrate	9.51±0.55[NS]	9.54±0.31	10.16±0.46
	Ash	4.82±0.08[b]	5.16±0.12[a]	4.75±0.06[b]

[1)]Mean±SD (n=3) in the same row with different superscripts are significantly different at $p<0.05$.
[2)]Not significantly different in the same row at $p<0.05$.

carbohydrate content had no significant difference among the three groups. Abalone viscera produced in Wando and Jeju Island present higher amount of protein but lower amount of lipid and crude ash. When comparing between the body and visceral part of abalone produced in the same region, the moisture (77.82±0.68, 78.16±0.54 and 77.60±0.46 respectively for Wando, Heuksando and Jeju Island) and protein (4.88±0.33, 4.08±0.24 and 4.62±0.37 respectively in the same region sequence as above) content of viscera are relatively lower than that of body (80.80±0.36, 81.16±0.45, 81.48±0.55 and 11.06±0.34, 10.44±0.37 and 11.10±0.66 for moisture and protein content with the same region sequence) but the other components are higher than that of body part, even though the statistical comparison was not undertook in this study. The general compositions show the difference between the visceral and the body part of abalone as well as the influence of the different origin regions. The mineral compositions also suggest the same trend between body and viscera of abalone (listed in the Table 3). Except for the potassium, the abalone viscera showed significant higher level of the mineral elements examined in this study than that of abalone body. The body part of abalone produced in Heuksando presented nearly three times of potassium content than the other two groups. And the calcium and sodium level was also higher than the abalone body produced in Wando and Jeju Island. At the same time, the visceral part of abalone produced in Heuksando presented higher ferrum and sodium content than the other ones. The compositions difference between the body and visceral part of abalone can be attributed to the different functions of the two part. The body part, in fact the foot muscle, is the main edible part according to the conventional view. However, the visceral part of the abalone contain significant amount of digested and partial digested brown seaweeds such as *Alaria esculenta, Laminaria digitata* and several red seaweeds which may contribute to the difference of the chemical composition between abalone body and viscera (29). As to the three abalone groups the variations may be attributed to the regions, feed, weather and several other factors.

Analysis of hydrolysis amino acid composition

Abalone has long been regarded as a rich source of protein which can provide human with balanced and ample amino acids (30). The hydrolysis amino acids and free amino acids contents of body and visceral part of the three abalone harvested in three different regions are listed in Table 4 and 5 respectively. The hydrolysis amino acids and free amino acids compositions fluctuate along with several factors such as abalone species, ages, harvested regions and others (26,31). The total hydrolysis amino acids content of the abalone body showed little difference among the three groups. The most abundant amino acids in the abalone body are glutamic acid, aspartic acid, arginine, glycine and leucine which range from 10 to 26 mg/g of the abalone body. Both the body and the viscera of the abalone contain all the essential amino acids for human; hence both of them are high quality protein sources. The total content of hydrolysis amino acid of the visceral part of abalone is relatively lower than that of the body part since the viscera possesses lower crude protein content. Aspartic acid, glutamic acid, glycine and arginine are the most abundant amino acids in the abalone viscera. In the free amino acids analysis, 27 and 34 kinds of free amino acids had been detected in the body and visceral part of abalone respectively. The abalone viscera also contained much more free amino acids in quantity than that of abalone body. Among the free amino acids, taurine is the most abundant one both in the body and viscera which ranged from 3 to 4 mg/g and which is nearly 10 times than the content of most of the other free amino acids. As have been pointed out by several researchers, taurine has many physiological roles in human and is crucial to maintain human health (32,33). On the other hand, the free amino acids are the main contributor to the characteristic flavor of the abalone (34). As the results indicate, both the body and the viscera of abalone are very good sources of amino acids for human.

Fatty acids composition of abalone

The fatty acids composition of abalone body and viscera was analyzed by gas chromatography the working condition of which was listed in the Table 1. As indicated in the Table 2, abalone body and viscera contained approximately 0.28% and 3.00% of crude lipid respectively. In Table 6, the fatty

Table 3. Mineral content of abalone body and viscera

(mg/100 g)

Origin		Ca	Cu	Fe	K	Mg	Na	P	Zn
Body	Wando	33.78±1.29$^{a1)}$	0.60±0.04^{a}	3.20±0.36^{b}	57.02±5.89^{b}	52.78±1.20^{c}	537.26±12.90^{ab}	115.36±5.25^{a}	0.90±0.16$^{NS2)}$
	Heuksando	35.12±1.50^{a}	0.44±0.03^{c}	2.74±0.25^{c}	158.12±9.41^{a}	55.52±2.10^{b}	543.52±8.24^{a}	98.48±3.76^{b}	0.80±0.10
	Jeju Island	31.68±0.78^{b}	0.52±0.03^{b}	3.82±0.19^{a}	65.66±3.89^{c}	62.72±2.19^{c}	529.12±3.41^{b}	114.3±3.76^{a}	0.72±0.13
Viscera	Wando	59.78±3.65^{a}	1.32±0.24^{b}	23.32±1.63^{b}	117.22±5.93^{a}	84.56±1.62^{a}	603.07±17.71^{b}	137.84±6.29^{b}	2.48±0.31^{a}
	Heuksando	50.56±2.38^{b}	0.93±0.06^{c}	27.4±1.46^{a}	105.48±0.63^{b}	70.34±3.90^{b}	631.40±20.01^{a}	157.08±5.55^{a}	1.82±0.23^{b}
	Jeju Island	46.74±3.12^{b}	1.96±0.12^{a}	20.92±1.21^{c}	119.14±3.58^{a}	84.72±3.81^{a}	587.16±9.33^{b}	159.44±5.59^{a}	2.04±0.18^{b}

[1)] Mean±SD (n=3) in the same column with different superscripts are significantly different at $p<0.05$.
[2)] Not significantly different in the same column at $p<0.05$.

Table 4. The hydrolysis amino acids composition of abalone body and viscera

(mg/g)

Amino acid	Abalone body			Abalone viscera		
	Wando	Heuksando	Jeju Island	Wando	Heuksando	Jeju Island
Aspartic acid	15.44	14.15	14.03	10.97	11.04	7.38
Threonine	6.32	6.81	6.73	5.82	6.14	4.15
Serine	8.17	8.47	8.94	5.72	5.55	3.76
Glutamic acid	26.72	22.49	23.63	24.45	22.04	18.65
Glycine	14.87	14.96	17.15	12.06	10.75	9.34
Alanine	9.10	9.15	9.45	8.21	8.13	6.66
Cysteine	0.94	1.01	1.00	1.81	1.83	1.50
Valine	5.04	5.52	5.37	4.65	5.04	3.44
Methionine	3.36	3.49	3.53	2.05	1.99	1.22
Isoleucine	4.40	4.72	4.48	3.39	3.67	2.41
Leucine	10.00	10.35	10.09	9.42	10.01	7.52
Tyrosine	3.89	4.17	3.98	3.96	4.14	2.44
Phenylalanine	4.54	4.79	4.49	4.35	4.72	3.05
Lysine	8.41	8.97	8.25	6.77	7.28	4.38
Tryptophan	1.65	1.69	1.78	1.43	1.73	1.02
Histidine	1.98	2.24	2.09	2.97	2.73	2.08
Arginine	16.38	17.20	13.01	14.45	13.62	10.94
Proline	6.74	6.89	7.86	4.54	4.23	3.22
Total	147.95	147.07	145.86	127.02	124.64	93.16

acids composition of abalone body and viscera was expressed as the percentage of respective total lipid content. The saturate fatty acids of abalone body was about 31% of the total lipid while the abalone viscera contained relatively lower percentage of saturate fatty acids which was about 26%. In the saturate fatty acids, palmitic acid (16:0) is the most abundant fatty acid and followed by lignoceric acid (24:0), stearic acid (18:0) and myristic acid (14:0) both in the body and viscera. The monoenes account for about 14% of the abalone body lipid but the range for abalone viscera is from 15% to 20%. The monoenes contents show no significant difference among the three abalone body groups. But the viscera of abalone produced in Wando possess highest monoenes content which is followed by Heuksando and Jeju Island. The oleic acid (cis-9 18:1) and vaccenic acid (cis-11 18:1) are the most abundant fatty acids both in the abalone body and viscera. The polyenes in the abalone body also shows no significant difference among the three groups which is about 25% of the total lipid. At the same time, abalone viscera contains higher percentage of polyenes than that of abalone body, ranged from 30% to 34%. The arachidonic acid (20:4) and eicosapentaenoic acid (20:5) are the most abundant fatty acid both in the abalone body and viscera. The distribution of the fatty acids in the abalone body and viscera is confirmed by several previous researches (22,27,35). While the viscera possess relatively lower percentage of saturate fatty acids compared with that of body, the unsaturated fatty acids content in viscera is higher than that of body part. As is well known, monoenoic and polyenoics can raise the HDL concentration and reduce the LDL concentration and related with tumorigenesis, diabetes, coronary heart disease (36-38). The fatty acids compositions in the abalone body show little variation among the three abalone groups. However, the viscera compositions present variation which may be influenced by the different harvested regions.

The collagen content

It was reported that two types of fibril-forming collagen have been examined in abalone (39). In the present study, the collagen content in the abalone body and viscera was investigated and the result was listed in Figure 1. Compared to the viscera, abalone body possesses much larger amount of collagen which ranges from 1.85±0.06 to 2.26±0.05 mg/g.

Table 5. The free amino acids composition of abalone body and viscera

(mg/g)

Amino acid	Abalone body			Abalone viscera		
	Wando	Heuksando	Jeju Island	Wando	Heuksando	Jeju Island
o-Phosphorserine	0.13	0.05	0.06	0.39	0.43	0.26
Taurine	3.68	4.65	3.25	3.92	3.54	3.75
Urea	-	-	0.33	-	0.21	-
Aspartic acid	0.14	0.13	0.13	1.33	1.27	1.48
Threonine	0.38	0.46	0.46	0.72	0.69	0.61
Serine	0.45	0.35	0.54	0.94	0.32	0.47
Scacosine	-	-	-	-	0.06	0.09
Glutamic acid	0.65	0.51	0.49	2.78	2.15	2.22
L-2-aminoadipic acid	-	0.07	-	0.12	0.07	0.10
Glycine	0.75	1.31	0.87	1.02	1.00	0.90
L-citrulline	-	-	-	-	0.02	0.25
Alanine	1.18	0.50	0.54	1.21	1.14	1.05
DL-2-aminobutyric acid	-	0.01	-	0.01	0.01	0.01
Valine	0.39	0.16	0.23	0.88	0.41	0.63
Cysteine	-	-	-	0.10	0.16	0.08
Methionine	0.27	0.06	0.08	0.04	0.13	0.18
L-cystathionine	0.34	0.11	0.07	-	0.07	-
Isoleucine	0.27	0.10	0.15	0.58	0.28	0.44
Leucine	0.36	0.11	0.19	0.15	0.30	0.63
Tryptophan	0.59	0.25	0.21	0.53	0.28	0.55
Phenylalanine	0.35	0.12	0.15	0.15	0.20	0.41
β-alanine	0.21	0.12	0.02	0.05	0.08	0.04
DL-3-aminoisobutyric acid	0.11	0.02	0.02	0.05	0.03	0.03
γ- aminobutyric acid	-	-	-	0.01	0.02	0.02
ethanolamine	-	-	-	0.06	0.03	0.01
ammonium chloride	0.14	0.07	0.07	0.46	0.51	0.17
DL-plus *allo*-δ-hydroxylysine	0.20	0.02	0.04	0.05	0.04	0.04
L-ornithine	0.05	0.02	0.02	0.08	0.12	0.03
Lysine	0.31	0.30	0.12	1.20	0.43	0.76
Histamine	0.20	0.13	0.16	0.25	0.12	0.25
L-anserine	-	-	-	0.29	0.24	0.29
L-carnosine	0.34	0.17	0.24	0.02	0.08	0.02
Arginine	2.92	2.56	2.17	2.16	2.07	1.87
Proline	0.66	0.10	0.59	0.55	0.30	0.55
Total	10.59	9.18	7.90	20.10	16.81	18.19

Abalone body produced in Wando contains the highest collagen level and is followed by abalone produced in Jeju Island and Heuksando. Abalone viscera shows much lower collagen level which ranged from 0.20±0.03 to 0.37±0.15 mg/g. Collagen is the main component of connective tissue and the most abundant protein in the human body. It is crucial for skin health since its degradation is one of the incentives of the wrinkle and skin ageing. Our previous work revealed the beneficial effects of abalone extracts on the skin and collagen synthesis in the human dermal fibroblasts (16).

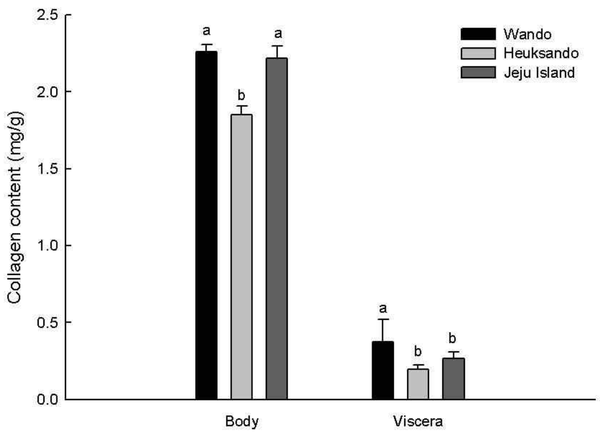

Fig. 1. Collagen content of abalone body and viscera.
Bars with different superscripts are significantly different at $p<0.05$.

Combined with the results of the present study, it is concluded that abalone, especially the body part, contains significant amount of collagen and is beneficial for the human skin health.

Conclusion

Abalone viscera are not taken seriously as food by most of the researchers. Apart from a few articles discussing the novel bio-active compounds such as sulphated polysaccharide, carotenoid pyropheophorbide A esters and glycosaminoglycan-like polysaccharide isolated from abalone viscera, their nutrition value compared with the abalone body is largely overlooked. In this study, abalones harvested in three regions

Table 6 Fatty acids composition of abalone body and viscera

(area %)

Fatty acids	Abalone body			Abalone viscera		
	Wando	Heuksando	Jeju Island	Wando	Heuksando	Jeju Island
12:0	0.08±0.02$^{b1)}$	0.02±0.01^{c}	0.18±0.01^{a}	0.13±0.02^{b}	0.15±0.04^{a}	0.13±0.01^{a}
14:0	4.14±0.06$^{NS2)}$	4.00±0.22	3.96±0.21	5.88±0.37^{a}	5.23±0.40^{b}	5.79±0.12^{a}
16:0	15.93±0.74^{NS}	15.49±0.72	15.72±1.43	13.63±1.10^{b}	13.5±0.04^{b}	15.56±0.89^{a}
18:0	4.19±0.76^{NS}	4.09±0.95	4.13±0.29	2.49±0.01^{b}	3.12±0.44^{a}	2.84±0.39^{a}
20:0	0.33±0.14^{b}	0.64±0.06^{a}	0.09±0.01^{c}	0.11±0.02^{c}	0.26±0.01^{b}	0.38±0.03^{a}
24:0	6.87±0.18^{NS}	6.89±0.37	6.94±0.52	3.25±0.02^{b}	3.47±0.47^{b}	3.67±0.44^{a}
26:0	0.42±0.08^{a}	0.08±0.01^{b}	0.08±0.01^{b}	0.34±0.02^{NS}	0.30±0.07	0.32±0.09
Total saturates	31.96±1.37^{NS}	31.20±0.94	31.1±1.02	25.83±1.77^{b}	26.03±1.17^{ab}	28.69±1.33^{a}
14:1	0.13±0.03^{NS}	0.14±0.0^{4}	0.13±0.04	0.26±0.06^{a}	0.23±0.07^{b}	0.17±0.01^{c}
16:1	0.98±0.27^{b}	1.25±0.01^{a}	0.99±0.30^{b}	2.58±0.45^{a}	2.34±0.69^{a}	1.83±0.08^{b}
18:1	5.15±0.73^{a}	5.06±0.07^{a}	4.75±0.13^{b}	8.13±0.70^{a}	6.50±1.00^{b}	6.09±0.26^{b}
18:1 (11-cis)	6.01±0.98^{c}	7.06±0.35^{a}	6.40±1.47^{b}	6.76±1.84^{a}	5.87±0.29^{b}	5.06±0.40^{c}
20:1	1.56±0.28^{a}	1.27±0.21^{b}	1.40±0.08^{ab}	2.56±0.30^{NS}	2.67±0.07	2.35±0.02
Total monoenoic	13.83±1.41^{NS}	14.78±0.66	13.67±1.51	20.29±2.21^{a}	17.61±1.54^{b}	15.5±0.79^{a}
18:2	1.93±0.12^{NS}	2.08±0.08	1.97±0.01	2.79±0.40^{c}	3.28±0.04^{b}	3.63±0.14^{a}
18:2 (9-11-cis)	0.71±0.01^{NS}	0.75±0.01	0.70±0.06	3.91±0.87^{b}	3.39±0.62^{b}	4.37±0.39^{a}
18:2 (10-12-cis)	1.94±0.51^{ab}	1.74±0.54^{b}	2.07±0.11^{a}	0.22±0.11^{b}	0.17±0.04^{b}	0.39±0.08^{a}
18:3	1.62±0.37^{NS}	1.62±0.35	1.57±0.46	4.29±0.79^{b}	4.33±0.53^{b}	5.11±0.73^{a}
20:2	0.58±0.20^{a}	0.44±0.02^{b}	0.54±0.14^{ab}	0.80±0.05^{c}	0.94±0.03^{b}	1.12±0.02^{a}
20:3	0.14±0.07^{a}	0.37±0.33^{b}	0.13±0.05^{a}	0.40±0.02^{b}	0.42±0.02^{b}	0.57±0.05^{a}
20:4	11.53±1.08^{a}	10.35±0.02^{b}	11.52±0.31^{a}	9.84±0.91^{b}	9.86±0.96^{b}	11.63±0.28^{a}
20:5	7.35±0.05^{b}	7.68±0.06^{a}	7.37±0.18^{b}	8.19±1.40^{a}	8.00±0.47^{a}	7.77±0.52^{b}
20:6	0.06±0.02^{b}	0.17±0.02^{a}	0.06±0.02^{b}	0.04±0.01^{b}	0.10±0.01^{a}	0.09±0.07^{a}
Total polyenoics	25.86±1.71^{NS}	25.2±1.28	25.93±0.83	30.48±1.51^{b}	30.49±1.66^{b}	34.68±1.53^{a}
Unknown	28.35±0.78^{NS}	28.82±1.11	29.3±0.94	23.4±0.58^{b}	25.87±0.72^{a}	21.13±0.45^{c}

[1)]Mean±SD (n=3) in the same column with different superscripts are significantly different at $p<0.05$.
[2)]Not significantly different in the same column at $p<0.05$.

in Korea, Wando, Heuksando and Jeju Island was investigated for the general compositions of the body and viscera part. The body part of abalone harvested in Jeju Island presented higher moisture content (81.48±0.55%) than that of Heuksando and Wando while the ash content of body part of abalone produced in Heuksando (2.32±0.47%) is higher than both of Jeju Island and Wando. On the other hand, the visceral part of abalone produced in Heuksando shows lower protein content (4.08±0.24%) than that of Jeju Island and Wando but higher lipid (3.06±0.06%) and ash content (5.16±0.12%). The mineral compositions also reflect the influence of the different origin regions. In the body part, except for Zn all the other minerals examined presented variation among different regions. While all the minerals examined in the visceral part of the abalone reflect the region difference.

Hydrolysis amino acids and free amino acids are important flavor chemicals and their variation among different regions may related the tastes and evaluations by the consumers (40). Collagen content of the three abalones shows variation among the three regions. The comparison between the abalone body and viscera revealed in the results is interesting. Abalone body possesses higher amount of protein, ranges from 10.44±0.37% for Heuksando to 11.10±0.66% for Jeju Island, than that of viscera which ranges from 4.08±0.24% for Heuksando to 4.88±0.33% for Wando. However, the lipid, carbohydrate and ash contents in viscera are much higher than that of body. The total hydrolysis amino acids level of the body is higher than the viscera but the free amino acids show the reverse outcome. Moreover, the fatty acids analysis results indicate that unsaturated fatty acids level in the viscera is higher than that of the abalone body. On the other hand, abalone body is the main contributor for collagen whose contents range from 1.85±0.06 mg/g to 2.26±0.46 compare with that of the viscera which is lower than 0.40 mg/g. It is hoped that this study will be helpful for the future researches on the abalone.

요 약

전복의 기능성과 성분에 대한 연구와 한국 전복의 지역별 성분특성에 대한 연구는 거의 없는 실정이다. 본 연구에서는 한국의 주요 전복 생산지인 완도를 중심으로 남쪽인 제주도와 북쪽인 흑산도 전복의 육과 내장에 대하여 일반성분, 미네랄, 아미노산, 지방산 및 콜라겐 함량을 비교 분석하였다. 전복내장 중의 수분과 단백질 함량은 전복육에 비하여 낮은 경향을 보였으나 지방과 탄수화물 함량은 더 높았다. 지역간 전복의 일반성분과 미네랄 함량은 다소 차이가 있는 것으로 나타났으며 수온이 낮은 지역일수록 지방함량이 약간 높았다. 전복내장의 구성아미노산 함량은 93.6~127.02 mg/g이었으며 이는 전복육의 평균 145 mg/g에 비해 낮은 편이었다. 반면에 전복내장의 유리아미노산 함량은 16.81~20.10 mg/g으로 전복육의 7.90~10.59 mg/g에 비하여 2배 높은 값을 보였다. 전복육의 총 구성아미노산 지역별 차이는 없으며 전복내장의 결과를 살펴볼 때 완도와 흑산도 높고 제주도 낮은 것을 나타났다. 전복육 총 유리아미노산은 완도 전복은 가장 높았으며 이어서 흑산도와 제주도 순이었고 내장의 경우는 완도, 제주도와 흑산도 순으로 총 유리아미노산 함량이 낮아졌다. 전복육의 지방산조성은 불포화지방산이 약 41%로 포화지방산 약 31%에 비하여 높았으며, 전복육보다 전복내장이 높은 결과를 보였다. 콜라겐 함량은 완도 전복육에서 2.26±0.46 mg/g으로 가장 높았으며 이어서 제주도와 흑산도 순이었다. 전복내장에서는 0.20±0.03~0.37±0.15 mg/g으로 전복육보다 낮은 값을 보였다. 본 연구 결과는 향후 전복에 관한 연구에서 유용한 정보로 활용될 수 있을 것으로 기대된다.

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