Bulgarian Journal of Agricultural Science, 15 (No 2) 2009, 154-162
Agricultural Academy

IMPROVEMENT OF THE CHILLED SALMON SENSORY QUALITY BY PULVERISATION WITH NATURAL DIHYDROQUERCETIN SOLUTIONS

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Abstract

IVANOV, G., D. BALEV, H. NIKOLOV and S. DRAGOEV, 2009. Improvement of the chilled salmon sensory quality by pulverisation with natural dihydroquercetin solutions. *Bulg. J. Agric. Sci.,* 15: 154-162

The effect of superficial treatment with either 0.05% or 0.1% solution of dihydroquercetin isolate from Siberian larch (*Larix sibirica* Ledeb) on the sensory quality characteristics of chilled-stored (1±1^{0}C) salmon (*Salmo salar*) discs was investigated. The cross-section appearance color of raw salmon disc and the taste and odor of blanched samples were evaluated, both by ten member panel using nine point intensity scale, and 180 consumers using hedonic scale. Regression data analysis was performed. It was established that superficial treatment with 0.1% solution effectively preserved sensory evaluated color and taste of salmon allowing 4 d extending of the product shelf life.

Key words: salmon; sensory properties; taxifolin; sensory panel; consumer preference

Introduction

Atlantic salmon is a highly appreciated food. According to Baron et al. (2007) the positive effect of low temperatures is slightest for fatty fishes, like the members of *Salmonidae* family. Therefore the Coho salmon (*Oncorhynchus kisutch*) is more susceptible to lipid peroxidation and rancidity during chilled storage in ice (Aubourg et al., 2005). The oxidative changes of fish deteriorate its sensory properties and quality. This leads to reduction of fish shelf life and the consumer preference. Some primary and secondary products of lipid oxidation of the fish are considered as injurious to human health (Decker and Xu, 1998). According to Pastoriza et al. (1999) the shelf live of salmon discs largely depends on fish *post mortem* status, type and hygiene of preliminary treatment, initial microbial contamination and storage temperature. Tironi et al. (2007) established that the lipid and protein fractions of Sea salmon (*Pseudopercis semifasciata*) minced muscle oxidize to a great extend after 6 d of storage, and pronounced lipolysis was developed after 9 d of storage at 1 ± 1^{0}C. For prevention of such negative effects, Pastoriza et al. (1999) suggest salmon discs to be packaged in modified atmosphere of carbon dioxide, and Wierda et al. (2006) recommend packaging of King salmon (*Oncorhynchus tshawytscha*) in modified gas me-

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dium containing 40.00% CO_2 and 60.00% N_2 (v/v).

Due to safety reason the application of natural antioxidants for inhibition of chilled fish lipid and pigment oxidations increases during the last few years (Shahidi, 2000). Particularly attention is paid to some natural phenols (Pazos et al., 2006). Taking in account the consumer requirements Shahidi (2000) proposed mixture of tocopherols and rosemary, sage and black tea extracts. Weilmeier and Regenstein (2006) experimented with sodium threepolyphosphate, propylgalat, ascorbic and erythrobic acids and Vareltzis et al. (1997) have studied natural rosemary extract (*Rosmarinus officinalis*).

Investigating different natural antioxidants Montero et al. (2005) found that natural rosemary extract inhibited more effectively the lipid oxidation of minced fish compared to quercetin. Bioflavonoids constitute a large group of plant components, originally found in citric fruits by Bentsath et al. (1936). There are scientific reports about strongly expressed positive effect of bioflavonoids on human health (Sugihara et al., 1999; Pietta, 2000; Cao et al., 1997) and food quality (Rice-Evans, 2001).

We did not find scientific reports for inhibition of oxidative processes in chilled fish by the usage of dihydroquercetin. Therefore, the objective of the present study was to determine the effect of superficial treatment by spraying with solutions of the natural antioxidant "Flavit"® (dihydroquercetin isolate) on the sensory quality of salmon (*Salmo salar*) during storage at 1 ± 1^{0}C.

Materials and Methods

Fish and handling procedures

Atlantic salmon (*Salmo salar*) farmed by "Hallward Leroy" AS (Efta, Norway) was used in this study. The fish was bought free of internal organs, whole with head, tail and fins, chilled in flaked ice from the Metro store (Plovdiv, Bulgaria) after the sixth day from the death (*post mortem*). The fish was with excellent quality.

Natural antioxidant "Flavit"®

The natural antioxidant dihydroquercetin isolate „Flavit"® (taxifolin) was extracted from Siberian larch (*Larix sibirica Ledeb*). The product contains 96.00% dihydroquercetin, 3.00% dihydrokaempferol and approximately 1.00% naringenin. Its purity corresponds to the sanitary requirements of the EU and Russian Federation.

Experiment design

Sixty pieces of chilled and cleaned salmon were transported for 30 min from the shop to the fish processors „Nessi 5" Ltd (Plovdiv, Bulgaria) by specialized vehicle transport, equipped with refrigeration system. The fish was cut on 1.5 - 2.0 cm discs by saw, model Bizerba, type FK 32 (Bizerba GmbH, Balingen, Germany). The experiments were carried out with three samples: first - *control samples*, packed without antioxidant treatment; second - *samples 1*, packed after superficial treatment with a 0.005% solution of taxifolin and third - *samples 2*, packed after superficial treatment with a 0.01% solution of taxifolin. After treatment with taxifolin solutions the salmon discs were packed and quickly chilled at a temperature of -18^{0}C until the temperature in the samples' center reached 2 ^{0}C. They were then stored for 12 d at 1 ± 1^{0}C. The sensory properties were evaluated on 1, 4, 7 and 12 d of storage.

Preparation of samples for analysis

The samples can loose moisture during their preparation for analysis. The laboratory samples with greater weight (approximately 40 kg each) were used for error prevention. The samples were stored in pressurized containers at 0 ± 1^{0}C for no more than 6 h.

Sensory evaluation by trained panel

The color of discs cross-section appearance was determined immediately after opening of the containers with chilled fish, and the taste and odor – after blanching the fish for 10-15 min. The analysis was performed by 10 member's panel. Sensory analyses were carried out using ten assessors from the faculty staff of the Department of Meat and Fish Technology, University of Food Technology (Plovdiv, Bulgaria). The panelists have passed tests demonstrating their sensorial capacity (Meilgaard, Civille and Carr, 1991). For differentiation of so called "fresh" and "rancid" odor and taste, the assessors passed triangular test (Freeman and Hearnsberger, 1994). The panelists used nine point intensity scale developed by our team according the recommendations of Larmond (1977) and Note et al. (1988) (Table 1).

Consumer preference estimated by hedonic scale

The consumer preferences and evaluation of the quality of salmon were determined immediately after opening of the containers with chilled fish. The analysis was carried out with 180 consumers, randomly selected by age, gender and social status. The consumers expressed their opinion by means of hedonic scale. The taste, odor and color acceptability of the salmon discs were determined using a five point hedonic scale - 1 = dislike a lot, 5 = like a lot. Tests were repeated three times (Meilgaard et al., 1991). The average score for each parameter was calculated. For taste and odor analyses, the fish samples were steamed for 5 min and immediately presented to the panellists. Color analysis was conducted on raw discs, approximately 1.5 cm thick. Visual color analyses were conducted individualy with white light. The taste and odor analyses were conducted in a dark room to protect panellists taste perceptions from the influence of any side effects. In order to reach an accurate result, panellists were provided with distilled water to clean their palates after every tasting.

Data analysis

Data was analyzed using the Microsoft Excel program, Version 5.0 (SPSS Inc., Chicago, IL, USA). All determinations were carried out in triplicate and data was subjected to analysis of variance (ANOVA). ANOVA was carried out with the General Linear Models (GLM) with a significant level of $P \leq 0.05$ (Draper and Smith, 1998). The Fischer's test with a significant difference set at $P \leq 0.05$ was used to compare sample values (Kenward, 1987). In addition, the correlation coefficient between sensory characteristics of the samples both evaluated, by the panelist and by the consumers was calculated (Draper and Smith, 1998).

Results

The results obtained from the sensory analysis show that the color scores of salmon discs cross-section appearance constantly decrease for each of the three tested samples during the storage at 1 ± 1^0C (Figure 1). The decrease with 2.30% to 7.60% from the initial 8.80 score (on the 1 d of experiment) was established at the 12 d of experiment. The color assessments of control samples decreased most significantly and reached score 6.17 after 12 d of chilled storage. Such values characterize the fish color as satisfactory. A little bit higher, but in the same range was the color assessment value of samples 1 (Figure 1). The samples 2 received the highest sensory evaluated scores for the color cross-section appearance (Figure 1). Their mean values did not change significantly (*P > 0.05) and characterized the color of cross-section appearance of salmon as very satisfactory for the entire storage period (Figure 1). The results obtained prove that the superficial treatment of salmon discs by spraying with 1.0 g taxifolin.l^{-1} 5% water solution of ethanol limit the alterations in the color of cross-section appearance. The color was preserved bright, fresh and a little bit more orange red. The superficial treatment of salmon discs by spraying with 0.5 g taxifolin.l^{-1} 5% water solution of ethanol was not so much effective. These samples like the controls endure slight lost of color during the storage.

The results from the sensory assessment of the salmon odor and taste showed similar trends (Figures 2 and 3). The odor of the control samples deteriorated during the chilled storage and on the 12 d the sensory evaluated scores decreased by 61.40% compared to the first day. The odor scores of samples 1 decreased by 31.4% at the end of experiment (they stayed approximately two times higher compared to

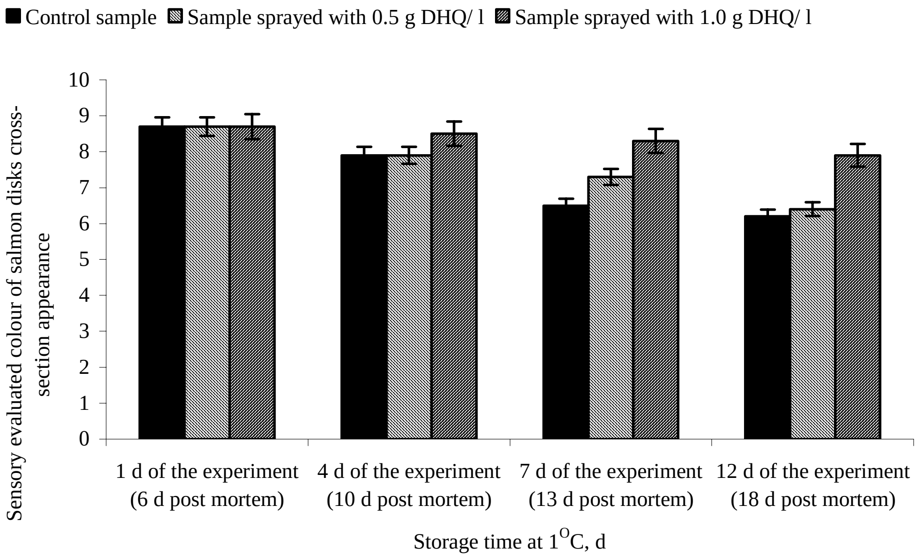

Fig. 1. Changes of sensory evaluated color of salmon disks cross-section appearance

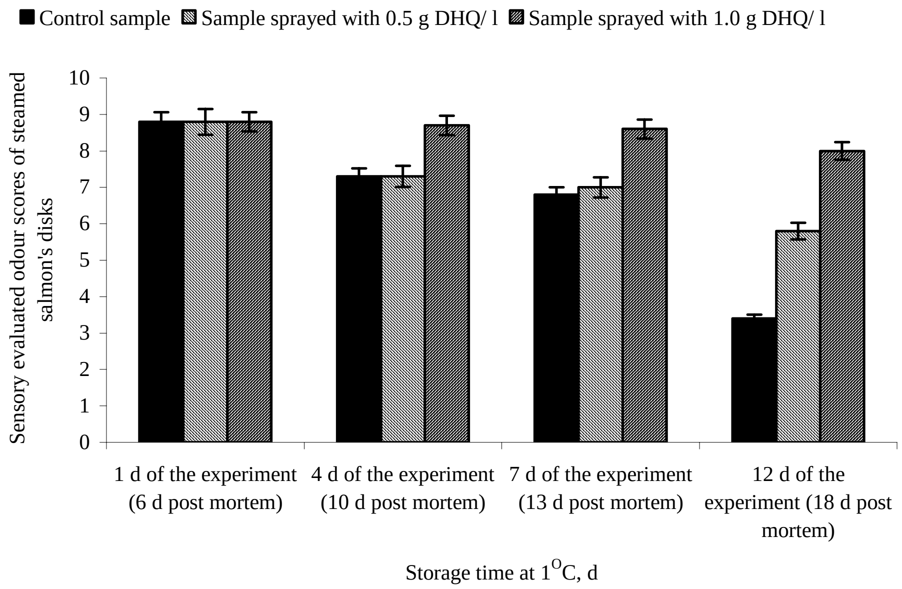

Fig. 2. Changes of sensory evaluated odor of steamed salmon disks and bouillon

the control samples) (Figure 2). The odor of samples 2 received the highest score. The sensory scores of samples 2 did not change significantly (*P > 0.05) during the first seven days of storage and on the 7 d they vary from 8.75 to 8.65 (Figure 2). The sensory assessment score for odor of samples 2 decreased only with 8.57% at the end of experiment (12 d of storage). Such results characterize the odor of steamed salmon during the entire storage period as very satisfactory.

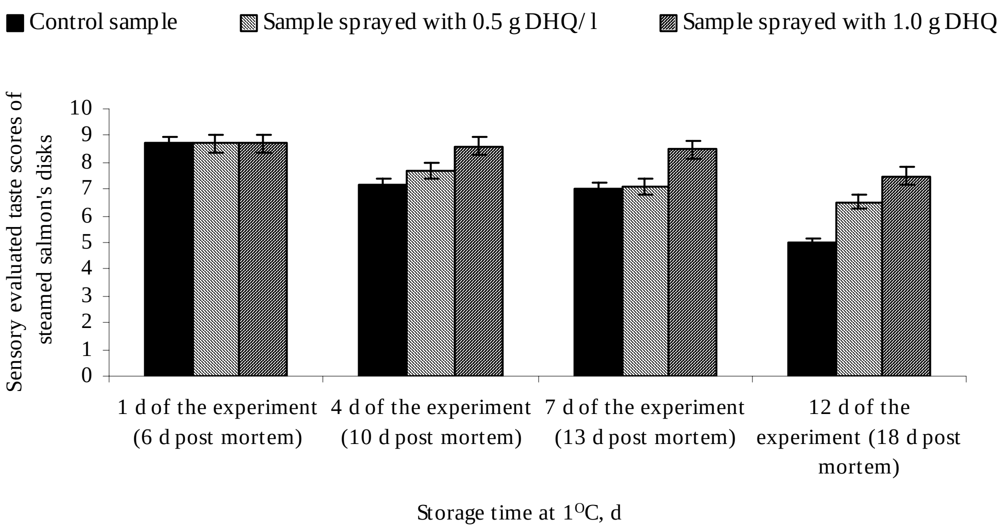

Fig. 3. Changes of sensory evaluated taste of steamed salmon disks and bouillon

There was a tendency to deterioration of the control samples taste during the storage. The taste score of the control samples decreased with 18.00% on the 7 d of experiment and with 41.90% on the 12 d (Figure 3). Similar tendency was found for the odor of the samples 1 where the score decreased with 15.7% on the 7 d of experiment and with 21.60% on the 12 d (Figure 3). These scores are closer to those for the control samples than the samples 2. The odor score of sample 2 did not change significantly (*P > 0.05) during the first seven days of experiment (Figure 3). For the next five days of storage the taste score of sample 2 decreased by 12.80% and reached 7.50 on the 12 d. Despite of the indicated score decrease, the salmon taste still remains very satisfactory.

The obtained results showed that after 12 d storage at 1±1^{0}C the samples 2 have typical of aged salmon odor, normal color and acceptable taste, while the control samples undergo slight taste changes towards non-characteristic and deteriorated ones. The color of the control samples remained unchanged, but the odor, especially of the bouillon and of the tissue from the abdominal region, was deteriorated and rancid. The bouillon and the separated fat were turbid and darker. Those results showed that the control samples could not be stored for more than 12 d.

The results obtained from the consumer panel and those from the trained panel were in very good correlative dependency (Tables 2 and 3). The strong correlation was determined between the color, odor and taste sensory assessments of trained panel and of the consumers (Table 3). Moderately strong correlation (Table 3) was found between the parameters sensory evaluated odor and tast /r/ =0.80. The relation between the sensory assessments for odor and taste of blanched salmon was statistically proved. It could be explained by the fact that most of the taste components are volatile compounds and directly affect the odor of fish.

Discussion

Better sensory characteristics were established for the samples superficially treated by spray containing 1 g taxifolin.l^{-1} 5% water solution of ethanol. Sensory deterioration of these samples was found only after the 12 d of storage at 1 ± 1^{0}C. The color of salmon muscles remained stable during the chilled storage by contrast with the taste and odor. The observed alterations in sensory characteristics could be explained

Table 1
Described characteristics with sensory evaluated scores for raw and steamed fish from a Salmonidae family

	Raw fish	Steamed fish	
Score	Color of the cross-section appearance	Odor of the meat and bouillon	Taste of the cross-section appearance
Very satisfactory – score 9	Orange pink to orange red color of the light musculature, with different hue, d depending on the of the fish species. The dark musculature has orange brown to brightly brown color	Oily smell, like well-baked bread or roasted meat	Strongly pronounced meaty taste, with sweet or metal flavor
Satisfactory - score 7	Orange to orange red color of the light musculature, with slight loss of the color brightness. The dark musculature has brown color	Soil /ground/ smell, slight hue of moulds	Waste of mawkishness, meat flavor, slightly pronounced taste of moulds
Middle satisfactory – score 5	Orange red to orange brown color of the light musculature, with certain unevenness and darker spots. The dark musculature has brown to dark brown color	Sour or acidic odor and hue of moulds	Sour. Mould taste
Slight unsatisfactory - score 3	Orange gray to orange brown color of the light musculature, with manifestly expressed spots with bright and dark areas. The dark musculature has dark brown to gray brown color	Acidic odor with a smell of spoiled fruits	Acid to bitter taste
Most unsatisfactory - score 1	Gray to yellow green color of the light musculature, with differently colored areas and apparent expressed spots. The dark musculature has dark gray to brown black color	Strong unpleasant sour odor, with perceivable touches of sweat	Putrefactive taste with sensation for nausea (vomiting)

Table 2

Consumer preference of the chilled salmon discs stored 12 d at 1 ± 1^{0}C superficially treated with taxifolin solutions, using five scores hedonic scale

Samples	Preference of the costumers using five score hedonic scale											
	Raw fish				Steamed fish							
	Color of the cross-section appearance				Odor of the meat and bouillon				Taste of the meat and bouillon			
	1 d	4 d	7 d	12 d	1 d	4 d	7 d	12 d	1 d	4 d	7 d	12 d
Control samples	4.92 ± 0.11	3.99 ± 0.14	3.56 ± 0.12	3.44 ± 0.17	4.83 ± 0.12	4.05 ± 0.13	3.83 ± 0.17	1.92 ± 0.13	4.78 ± 0.10	3.97 ± 0.11	3.89 ± 0.14	2.78 ± 0.15
Samples 1	4.92 ± 0.11	4.00 ± 0.131	3.87 ± 0.16	3.76 ± 0.19	4.83 ± 0.12	4.12 ± 0.19	3.92 ± 0.16	3.41 ± 0.14	4.78 ± 0.10	4.47 ± 0.19	4.11 ± 0.21	3.80 ± 0.18
Samples 2	4.92 ± 0.11	4.89 ± 0.151	4.87 ± 0.13	4.81 ± 0.18	4.83 ± 0.12	4.81 ± 0.20	4.79 ± 0.16	4.56 ± 0.12	4.78 ± 0.10	4.77 ± 0.14	4.76 ± 0.13	4.42 ± 0.17

Table 3

Determination of statistically significant correlation between examined parameters using correlation coefficient |r|

	Sensory evaluated odor	Sensory evaluated taste	Color assessed by consumers	Odor assessed by consumers	Taste assessed by consumers
Sensory evaluated color	0.60	0.56	0.99	0.91	0.93
Sensory evaluated odor		0.80	0.92	0.97	0.90
Sensory evaluated taste			0.94	0.88	0.98
Color assessed by consumers				0.91	0.94
Odor assessed by consumers					0.93

Footnote: $|r| \geq 0.85$ – strongly pronounced correlations; $0.70 \leq |r| < 0.85$ – moderately strongly pronounced correlations;
$0.60 \leq |r| < 0.69$ → moderately pronounced correlation; $0.50 \leq |r| < 0.59$ – slightly pronounced correlation

by the structure and properties of taxifolin. The dihydroquercetin (which constitutes approximately 96.00% of the taxifolin) is a strong polyphenol antioxidant (Shahidi, 2000). It has the ability to play role of chelator of the free hydroxyl radicals (Kondakova et al., 1998). The taxifolin takes part in oxidation-reduction reactions with radicals (Cao et al., 1997), where it reacts as quenchers towards the free radicals (Pietta, 2000). Thus it is converted to oxidation state – flavoxyl radical (Rice-Evans, 2001).

taxifolin-OH + R$^{\cdot}$ › taxifolin-O$^{\cdot}$ + RH

The couple taxifolin-O$^{\cdot}$/taxifolin-OH is characterized by low redox potential (0.23 - 0.75V). Therefore the taxifolin is capable to reduce substrates and to be converted into less aggressive flavoxyl radicals (Halliwell and Gutteridge, 2001). The mechanism of taxifolin antioxidant activity is associated with the limitation of liposome membranes oxidation, which is induced by the divalent iron-ascorbate system (Òesselkin et al., 1996) and activated by the polyunsaturated fatty acids peroxide enzyme activity (St. Angelo and Bailey, 1987). The polyunsaturated fatty acids are part of the cells phospholipids and are predominantly located in muscle cells membrane. The post mortem oxidation processes affects the lipids, as well as the pigments, proteins, carbohydrates, vitamins and overall quality of the product (Tironi et al., 2007).

Conclusions

It was established that after 12 d of storage at 1 ± 1^0C (18 days *post mortem*) of salmon (*Salmo salar*) discs superficially treated by spray containing 1 g taxifolin.l^{-1} 5% water solution of ethanol, the sensory evaluated fish color and taste were preserved unchanged, while the fish odor was slightly deteriorated. This type of preliminary treatment prolongs approximately with 4 days (≈ 33 %) the shelf life at 1 ± 1^0C – till the 17 d *post mortem*.

Acknowledgements

The authors express their gratitude for the leaderships of the Flavit Ltd (Pushtino, Russia), and the Institute of the Biological Instrument-making attached to Russian Academy of Sciences, which have produced and supplied the natural antioxidant dihydroquercetin isolate „Flavit"®, and to their representative Vitalife Joint-stock company (Sofia, Bulgaria), about the informative and organizing co-operation and financial support as well as to the team of the fish processing manufactory Nessy 5 Ltd (Plovdiv, Bulgaria) for their technical maintenance and the experiment implementation at industrial conditions.

References

Aubourg, S. P., J. Vinagre, A. Rodrígez, V. Losada, M. Angelica Larrain, V. Quitral, J. Gomez, L. Maier and E. Wittig, 2005. Rancidity development during the chilled storage of farmed Coho salmon (*Oncorhynchus kisutch*). *European Journal of Lipid Science and Technology,* **107** (6): 411-417.

Baron, C. P., I. V. H. Kjersgard, F. Jassen and Ch. Jacobsen, 2007. Protein and lipid oxidation during frozen storage on rainbow trout (*Onccorhynchus mykiss). Journal of Agriculture and Food Chemistry*, **55** (20): 8118 – 8125.

Bentsath, A., S. Rusznyak and A. Szent-Gyorgyi, 1936. Vitamin nature of flavones. *Nature,* **138:** 798-803.

Cao, G., E. Sofic and R. L. Prior, 1997. Antioxidant behavior of flavonoids: structure – activity relationship. *Free Radicals in Biology and Medicine*, **22** (5): 749-760.

Decker, E. A. And Z. Xu, 1998. Minimizing rancidity in muscle foods. *Food Technol.,* **52** (10): 54 – 59.

Draper, N. R. and H. Smith, 1998. Applied regression analysis, 3-rd ed. *John Willey*, New York, pp. 131-153.

Freeman, D. W. and J. O. Hearnsberger, 1994. Ransidity in selected sides of frozen catfish fillets. *Journal of Food Science*, **59** (1): 60 - 63.

Halliwell, B. and J. M. C. Gutteridge, 2001. Free radicals in biology and medicine. Oxford, pp. 904-921.

Kenward, M. G., 1987. A method for comparing profiles of repeated manuscripts. *Appl. Statistics,* **36:** 296-308.

Kondakova, N. V., V. V. Saharova and N. V. Rina, 1998. High-speed constants of the reaction between flavonoids and their related natural compounds and hydroxyl radicals during radiolysis in water solution. *Chemistry of High Energies*, **32** (2): 106-111 (Ru).

Larmond, E., 1977. Methods for sensory testing – ranking. In: "Laboratory methods for sensory evaluation of foods", (E. E. Larmond Ed.), *Canadian Governiment Publishing Centre,* Ottawa.

Meilgaard, M., G. V. Civille and B. T. Carr, 1987. Sensory evaluation techniques. *CRC Press,* Inc., Boca Raton, FL, **2**: 1 - 23.

Montero, P., B. Gimenez, M. Perez-Mateos and M. Gomez-Guillen, 2005. Oxidation stability of muscle with quercetin and rosemary during thermal and high-pressure gelation. *Food Chemistry,* **93:**

17 - 23.

Note, A. R., T. J. Han and J. Liston, 1988. Correlation between lipid peroxidation and phospholipid hydrolysis in frozen fish muscle. *Journal of Food Science*, **53** (6): 1917 - 1919.

Pastoriza, L., G. Sampedro, J. J. Herrera and M. L. Cabo, 1999. Effect of carbon dioxide atmosphere on microbial growth and quality of salmon slices. *Journal of the Science of Food and Agriculture*, **72** (3): 348 – 352.

Pazos, M., J. M. Gallardo, J. L. Torres and I. Medina, 2005. Activity of grape phenols as inhibitors of the oxidation of fish lipids and frozen fish muscle. *Food Chemistry*, **92:** 547 – 557.

Pietta, P. J., 2000. Flavonoids as antioxidants. *Journal of Natural Products*, **63** (7): 1035-1042.

Rice-Evans, C., 2001. Flavonoid antioxidants. *Current Medical Chemistry*, **8** (7): 797-807.

Shahidi, F., 2000. Antioxidants in food and food antioxidants. *Nahrung/Food*, **44:** 158-163.

St. Angelo, A. J. and M. E. Bailey, 1987. Warmed-over flavour of meat. *Academic Press,* New York.

Sugihara, N., T. Àrakawa, M. Ohnishi and K. Furuno, 1999. Anti- and pro-oxidative effects of flavonoids on metal-induced lipid hydroperoxide - dependent lipid peroxidation in cultured hepatocytes loaded with alpha-linolenic acid. *Free Radicals in Biolology and Medicine,* **27** (11-12): 1313-1323.

Òesselkin, Y. O., B. A. Jambalova and V. K. Kolhir, 1996. Antioxidant properties of dihydroquercetin. *Biophysics,* **41** (3): 620-624 (Ru).

Tiroini, V. A., M. C. Tomas and M. C. Anon, 2007. Lipid and protein deterioration during the chilled storage of minced sea salmon (*Pseudopercis semifasciata*). *Journal of the Science of Food and Agriculture*, **87** (12): 2239 – 2246.

Vareltzis, K., D. Koufidis, E. Gavriilidou, E. Papavergou and S. Vasiliadou, 1997. Effectiveness of a natural rosemary (*Rosmarinus officinalis*) extract on the stability of filleted and minced fish during frozen storage. *European Food Research and Technology*, **205:** 93 - 96.

Weilmeier, D. M. and J. M. Regenstein, 2006. Antioxidant properties of phosphates and other additives during the storage of raw mackerel and lake trout. *Journal of Food Science,* **69:** fct102 – fct108.

Wierda, R. L., G. Fletcher, L. Xu and J.-P. Dufour, 2006. Analysis of volatiles compounds as spolage indicators in fresh king salmon (*Oncorhynchus tshawytscha*) during storage using SPME-GC-MS. *Journal of Agriculture and Food Chemistry*, **54** (22): 8480 – 8490.

Received January, 12, 2009; accepted for printing February, 27, 2009.