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The effect of the type of packaging on the physicochemical and microbial characteristics of rainbow salmon (*Oncorhynchus mykiss*) fillets stored at refrigerator temperature

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ABSTRACT

Considering the sensitivity of fish meat to rapid spoilage, storage conditions and type of packaging are very effective factors in maintaining its quality and nutritional value after catching. In this research, rainbow trout fillets packed with aluminum and polystyrene as treatment and polyethylene bag as control were kept at 4°C for 12 days. Physical, chemical and microbial factors of fillets by recording changes in moisture, total protein, fat, total ash, free fatty acids, peroxide (PV), pH, Thiobarbituric acid (TBA), Total Volatile Basic Nitrogen (TVB-N) and also total microbial load It was measured .The results showed that with the passage of time, moisture and fat decreased significantly. Total protein, total ash, free fatty acids, PV, TBA, TVB-N and total microbial load increased significantly during storage. Also, pH had an increasing trend, but this increase was not significant. The highest amount of TVB-N on the twelfth day was related to the control package with a value of 24.52 mg/g. The lowest amount of total microbial load on the twelfth day was related to aluminum packaging with a log value of 6.86 cfu/g. According to the results, the priority of using packaging to increase shelf life and maintain the nutritional value of fillets was first with aluminum packaging and then with polystyrene. The polyethylene bag was declared unrecommended for consumption due to the lack of nutritional value and reduced product quality. Aluminum packaging worked significantly in maintaining the physicochemical and microbial properties of the product and according to the declared permissible limits of TVB-N and total microbial load, which are important indicators of spoilage, only fillets packed with aluminum containers could be consumed until the end of the storage period.

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1- Introduction

Rainbow trout with scientific name(*Oncorhynchus mykiss*) It is a domestic, cultured, cold-water and freshwater species that originates from North America and Russia and is widely cultivated as a recreational and food fish all over the world..[1] Maintaining the quality of salmon due to the increasing growth of this type of fish, as well as gaining the first place in the world in terms of popularity and in general the high perishability of fish and fishery products, has led to the increase of its shelf life, one of the issues significant in the fisheries industry and the consumer market.[2] Due to the short shelf life of fresh fish and the inappropriate view of consumers regarding chemical additives and their harm in food to increase the shelf life, as well as the lack of economic efficiency in the use of antimicrobial and antioxidant extracts and edible coatings for Producers, society's tendency is to use products that bring good quality in addition to good cost[3]. As a result, it can be said that the best option is to use suitable and cheap packaging that is both economical for the producer and meets the needs of consumers as much as possible. Fish meat is one of the most valuable nutritional sources, because fishery products are rich in protein, essential minerals, polyunsaturated fatty acids and low cholesterol. Fish unsaturated fatty acids have shown positive effects on reducing cardiovascular diseases and cancers. Also, fish meat plays an important role in providing protein needed by humans[1,4,11]. Freshwater fish due to their special biological compounds and also factors such as differences in species, environmental habitats, food habits and autolytic enzyme activity.[1] as well as hydrolytic enzymes[2] Microorganisms are very susceptible to numerous changes in terms of quality, which ultimately lead to spoilage of this product.[5,6]. According to the statistics published by the World Food and Agriculture Organization[3](FAO), while a large population of people have been facing hunger for years, every year an important part of the world's food production, approximately one third of the food, is wasted in the chain of distribution, harvest and consumption. 20 million tons out of 1.3 billion tons of food and agricultural products produced in the world that are lost and wasted within a year are related to fish.[7]. According to the mentioned materials, in this article, the effect of different packaging on the physico-chemical and microbial properties of salmon fillet stored at 4 degrees has been compared, and the innovative aspect of this research has been from two perspectives, which is as follows. :

Due to the lack of economic efficiency and the disadvantages of using preservatives, antioxidants and the like, in this research, only different types of packaging were used along with cellophane coating in addition to temperature control, and no preservatives were used to increase The storage period was not used, which had not been done in similar studies in Iran. On the other hand, in similar researches, monitoring was done for a maximum of one week, and the purpose of choosing twelve days of monitoring in the current research was to investigate the effect of the packaging used on the physicochemical properties of fish, so that it can be found with the results that proper packaging

1- Autolysis
2 -Hydrolysis
3 -Food and Agriculture Organization of the United Nations

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alone How much can be effective on increasing the shelf life of this product?

2- Materials and methods

Preparation of samples:

Using the fish preparation method that was carried out by Babakhani and his colleagues in 2017, salmon samples with an average weight of 25±290 grams were purchased from the fish breeding center in Tehran and transferred to the laboratory in the vicinity of ice inside the unilith. then in the laboratory under sanitary conditions; They were washed, deflated and weighed and divided into equal pieces (60 grams) and packed in pre-sterilized polyethylene packages until preparation. The packaging used in this research included three types, including a polystyrene container and an aluminum container with cellophane cover for the treatments, as well as a polyethylene bag (freezer bag) for the control, and the brand of these containers was Kohsar. In each of the packages, three fillets of 60 grams and a total of 180 grams of fish were placed in each package along with two blood absorbent pads, and the treatments were covered by cellophane with a thickness of 0.8 microns and kept at a temperature of four degrees Celsius. were kept Physical, chemical and microbial analysis of the samples was done in three days (zero, 6 and 12) along with 3 repetitions and the overall quality of the samples was determined. The tests performed were as follows:

1-2- Humidity: Moisture measurement according to the national standard of Iran (year 2012) with number 745 of meat and its products by the reference method, that is, drying, using a 105 degree oven (modelB404, ManufacturerTermas and country of manufacture Germany) and scale (modelGF-600, ManufacturerA&D and the manufacturing country of Japan) was measured.

2-2- Total protein: Measurement of total protein according to the national standard of Iran (year 1352) No. 924 in meat and its products in terms of nitrogen, using a protein digestion device (manufacturer company)Bakhshi and the manufacturing country of Iran), protein distillation machine (modelV-40, ManufacturerBakhshi and the manufacturing country of Iran) and automatic port50ml (ManufacturerDuran and the country of manufacture, Germany) was done, as well as the brand of all the solutions usedMerc Was.

2-3- Fat: Measurement of total fat in accordance with the national standard of Iran (year 2012) No. 743 in meat and its products by Soxhlet method and using Soxhlet siphon devices.100ml (ManufacturerDuran and the country of manufacture, Germany), Libra (modelGF-600, ManufacturerA&D and country of manufacture Japan) and circulator (modelLTD6, ManufacturerGrant and the country of manufacture, England) and also the brand of solution used,Merc Was.

4-2- Total ash: The measurement of total ash according to the national standard of Iran (year 1371) No. 744 in meat and its products was carried out by the oven method.

5-2- pH: Using the devicepHmeter (model654, Manufacturermethrom, Switzerland) was done, for this purpose, five grams of the mixture was homogenized with 45 ml of distilled water in a beaker completely by a stirrer, and then measuringpH Was performed.

2-6- Free fatty acid[1](FFA): First, add 25 ml of ethyl alcohol neutralized with normal soda to the oil sample that was already extracted, and in the next steps, with the help of 2 to 3 drops of phenolphthalein reagent and the amount of normal soda consumed, the amount of acidity in terms of oleic percentage by The formula mentioned below was measured[8]. Measurement using a buret 50ml (Company

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ManufacturerIsolab and the country of manufacture was Germany) as well as the brand of solution usedMerc It was Germany.

Free fatty acid= profit volume N × 2.28×10/ Weight of oil sample

7-2- Peroxide index[2](PV): For this purpose, first, the fat of each sample was extracted using the soxole method and used to determine the peroxide value. In order to determine the peroxide index, 1 gram of the extracted fat is mixed with acetic acid and chloroform solution (the ratio of chloroform to acetic acid is 2:3), then 0.5 ml of saturated iodorpotassium, 30 ml of distilled water and 0.5 ml of 1% starch solution are mixed. It was added to the mixture and the amount of released iodine was normalized with 0.01 potassium thiosulfate solution and the amount of peroxide index was calculated using the mentioned formula.[8]. Measurement using a Soxhlet siphon100ml (ManufacturerDuran and the country of manufacture, Germany), Libra (modelGF-600, ManufacturerA&D and country of manufacture Japan) and circulator (modelLTD6, ManufacturerGrant and the producing country of England) andPort 50ml (ManufacturerIsolab and the country of manufacture was Germany) as well as the brand of solution usedMerc It was Germany.

Thiobarbituric acid= $50\times(A_s\times A_b)/200$

8-2- Thiobarbituric index[3](TBA): LevelTBA with a spectrophotometer[4] Visible-UV (ModelUV-260, ManufacturerShimadzu and the producing country of Japan) was determined and expressed in terms of milligrams of malondialdehyde per kilogram of sample. measurementTBA It was done colorimetrically, so that 200 mg of each sample was transferred to a 25 ml flask and then it was made up to volume with 1-butanol, then 5 ml of the above mixture was transferred to a test tube with a lid and 5 ml of the reagent was added to it.TBA added, each of the tubes in a water bath with a temperature of 95 degrees Celsius using a boiling bain-marie (modelBJE-440Y, ManufacturerGallen Kamp and country of manufacture England) were placed for 2 hours and then cooled to ambient temperature and In the following, the absorption value of each sample at 532 nm (As) in contrast to the absorption of the control sample (1-butanol) (Ab) read. This method was based on the spectrophotometric values of the pink complex resulting from the reaction of one mole of malondialdehyde obtained from distillation with two moles of thiobarituric acid added to the solution obtained from distillation, and finally the amountTBA Each sample was calculated using the following formula[8]. The brand of solution used is alsoMerc It was Germany.

peroxide index= 1000 × normality × volume of thiosulfate consumed/ Weight of oil sample

2-9- Total volatile nitrogen bases[1](TVB-N): To determine the amount of volatile nitrogenous bases in the samples, 3 grams of rainbow salmon fillet samples were poured with magnesium oxide and distilled water into the flask of the Keldal device, and boiling stone and octane (as an antifoam) were added to it. The collected distilled solution was titrated with 0.1

1- Free fatty acid
2- peroxide value

3 -Thiobarbituric acid
4- Spectrophotometer

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normal sulfuric acid until red color reappeared. the amount ofTVB-N It was calculated as milligrams per 100 grams of sample according to the volume of sulfuric acid consumed and the weight of the sample from the following equation.[9]. Measure usingProtein digestion device (manufacturer companyBakhshi and the manufacturing country of Iran), protein distillation machine (modelV-40, ManufacturerBakhshi and the manufacturing country of Iran), automatic port50ml (ManufacturerDuran and the country of manufacture, Germany) was done, as well as the brand of all the solutions usedMerc Was.

Volatile nitrogen bases= 100 × 1.4 × the amount of acid/Sample weight

2-10- Total microbial load count: Ciscos method was used to determine the microbial load. In this way, 10 grams of the sample was transferred to a sterile Stomaker bag with 90 ml of distilled water and homogenized by the Stomaker machine. Then the samples are diluted[5-]It was diluted to 10 g/ml. 1 ml of each dilution was placed in the plate and Kant agar culture medium[2](PCA) was added to it, and the culture medium of each plate was carefully shaken in order to homogenize the sample, and after a few minutes, the plates were turned upside down and placed in an incubator for 48 hours at a temperature of 37 degrees. Finally, after 48 hours, all colonies were counted[10]. To measure from a 220 degree oven (modelOven-70, ManufacturerBehdadand the manufacturing country of Iran), scale (modelGF-600, ManufacturerA&D and the country of manufacture is Japan), incubator (modelTim 55, the manufacturing company of Fan Azmagaster and the manufacturing country of Iran), cultivation environmentPCA (CompanyIBERCO), class laminar hoodII (Model26900817, Manufacturer Behdad and the manufacturing country of Iran), Ben Mari Josh (model80101, ManufacturerBehdad and the manufacturing country of Iran) and 75 liter autoclave (75 liter model, Kavash Mega manufacturing company and the manufacturing country of Yaran) were used and also peptone buffer of the companyIBERCO used.

3- Statistical analysis

The homogeneity of the data was first checked by a completely random statistical design, and due to the normality of the data, the final analysis was done by the analysis of variance (ANOVA) was done unilaterally and Duncan's multi-range test was used to compare the averages and finally the data was evaluated using the softwareSPSS Done.

4-Results

1-4- Humidity: With the passage of time, the amount of moisture decreased significantly and the lowest amount of moisture reduction was observed in aluminum, control and polystyrene packaging, respectively.Table 1).

1- Total Volatile Basic Nitrogen
2- Principal component analysis

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Table 1. Comparison table of the average effect of packaging type on the moisture content of rainbow salmon fillet during storage

Day 12	Day 6	Day 0	Treatment
^{Not}0.04±68.74	^{Aa} 0.31±69.70	^{Aa} 0.21±70.24	Control (Polyethylene)
^{Not}0.16±68.79	^{Aa} 0.10±69.66	0.03 ^{Aa}±69.91	Polystyrene
^{Not}0.19±68.55	^{Aa} 0.05± 69.74	^{Aa} 0.01±70.21	Aluminum

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$).

2-4- Total protein: The total protein values indicate that with the passage of time the amount of protein increased significantly and the highest amount of protein increase was observed in aluminum, polystyrene and control packaging, respectively.Table 2).

3-4- Fat: With increasing time, the amount of fat decreased significantly, and the lowest amount of fat reduction was found in aluminum, polystyrene and control packaging, respectively.Table 3).

4-4- ash: During the test, total ash increased significantly, and the lowest amount of total ash increase was related to aluminum, polystyrene and control packaging, respectively.Table 4).

5-4- pH: The results of measuring this parameter show an increasepH It was during storage that this increase was not significant (Table 5).

Table 2. Comparison table of the average effect of the type of packaging on the protein percentage of rainbow salmon fillet during storage

Day 12	Day 6	Day 0	Treatment
0.55 ^{Ab}±20.14	0.13 ^{Bb}±19.45	0.12 ^{That}± 18.70	Control (Polyethylene)
0.23 ^{Ab} ±20.56	0.56 ^{Bb}± 19.90	0.43 ^{Aa}±19.02	Polystyrene
0.21 ^{Aa}±22.45	0.53 ^{Aa}±21.67	0.40 ^{Not}±19.04	Aluminum

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$).

Table 3. Comparison table of the average effect of the type of packaging on the fat percentage of rainbow salmon fillet during storage

Day 12	Day 6	Day 0	Treatment
0.54 ^{Bb}±2.24	0.54 ^{Aa}±4.86	0.20 ^{Aa}±4.88	Control (Polyethylene)
0.50 ^{Bb}±2.75	0.32 ^{Aa}±4.87	0.04 ^{Aa}±4.78	Polystyrene
0.51 ^{Not}±3.74	0.41 $^{Aa\pm}$4.84	0.23 ^{Aa} ±4.85	Aluminum

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$).

Table 4. Comparison table of the average effect of the type of packaging on the ash percentage of rainbow salmon fillet during storage

Day 12	Day 6	Day 0	Treatment
0.13 ^{Aa}±8.91	0.12 ^{Not}±6.13	0.10 ^{That}±6.45	Control (Polyethylene)
0.26 ^{Ab}±7.93	0.53 ^{Bb}±5.79	0.03 ^{That}±6.24	Polystyrene
0.11^{Ad}±5.54	0.07 ^{Ab}±5.20	0.02 ^{Aa}±5.88	Aluminum

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$).

Table 5. Comparison table of the average effect of the type of packaging on the pH of rainbow salmon fillet during storage

Day 12	Day 6	Day 0	Treatment
0.54 ^{Aa}±6.84	0.10 ^{Aa}±6.45	0.10 ^{Aa}±6.54	Control (Polyethylene)
0.53 ^{Aa}±6.84	0.46 ^{Aa}±6.34	0.20 ^{Aa}±6.54	Polystyrene
0.51 ^{Aa}±6.68	0.55 ^{Aa}±6.10	0.03 ^{Aa}±6.64	Aluminum

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$).

4-6- Free fatty acid(FFA): The values of free fatty acid are shown in Table 6, which shows a significant increase during the storage period. The highest increase in free fatty acid was observed in control, polystyrene and aluminum packaging, respectively(Table 6).

7-4- Peroxide index(PV): The results from Table 7 showed that the amount of peroxide increased significantly, and the highest increase in peroxide was reported in the control, polystyrene and aluminum packaging, respectively.(Table 7).

4-8- Thiobarbituric index(TBA): Information about thiobarbituric acid is given in Table 8. According to the numbers mentioned in the table, a significant increase in the amount of thiobarbituric acid in the samples was observed, and the highest increase in thiobarbituric acid was reported in the control, polystyrene and aluminum packaging, respectively.(Table 8).

9-4- Total volatile nitrogen bases(TVB-N): Information about volatile nitrogen bases for fillets stored in the refrigerator for 12 days is given in Table 9 and it shows a significant increase that the highest increase of volatile nitrogen bases was observed in control, polystyrene and aluminum packaging, respectively.(Table 9).

10-4- Counting the total microbial load: The values obtained from counting the total microbial load are given in Table 10, which indicates a significant increase. The highest total microbial load was related to control packaging and the lowest was related to aluminum packaging (Table 10).

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Table 6. Comparison table of the average effect of the type of packaging on free fatty acids of rainbow salmon fillet during storage

Day 12	Day 6	Day 0	Treatment
0.08 ^{Aa}±2.78	0.10 ^{Not}±1.45	0.10 ^{That}±1.08	Control (Polyethylene)
0.00 ^{Aa}±2.41	0.43 ^{Not}±1.36	0.40 ^{Not} ±1.15	Polystyrene
0.50 ^{Ab}±1.21	0.50 ^{Aa}±1.10	0.01^{Aa}±1.14	Aluminum

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$).

Table 7. Comparison table of the average effect of packaging type on peroxide of rainbow salmon fillet during storage

Day 12	Day 6	Day 0	Treatment
0.08 ^{Aa}±2.95	0.12 ^{Not}±1.84	0.10 ^{That}±0.00	Control (Polyethylene)
0.09 ^{Ab}±1.99	0.05 ^{Ab}±1.74	0.15 ^{Not}±0.00	Polystyrene
0.01 ^{Ad}±1.02	0.04 ^{Ad}±0.96	0.00 ^{Not}±0.00	Aluminum

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$).

Day 12	Day 6	Day 0	Treatment
0.48 ^{Aa}±1.95	0.20 ^{Not}±0.94	0.10 ^{Not}±0.87	Control (Polyethylene)
0.48 ^{Aa} ±1.87	0.55 ^{Not} ±0.50	0.40 ^{Not} ±0.88	Polystyrene
0.41 ^{Ab} ±1.01	0.44 ^{Not} ±0.68	0.02 ^{Not}±0.84	Aluminum

Table 8. Comparison table of the average effect of packaging type on TBA of rainbow salmon fillet during storage time

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$).

Table 9. Comparison table of the average effect of packaging type on TVB-N of rainbow salmon fillet during storage time

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Day 12	Day 6	Day 0	Treatment
0.32 ^{Aa}±24.52	^{Not} 0.17±17.65	^{That} 0.21±11.28	Control (Polyethylene)
^{Ab} 0.26±23.10	^{Bb} 0.45±16.44	^{That} 0.14±11.34	Polystyrene
^{Ad} 0.32±17.65	^{Bd} 0.51±13.84	^{That} 0.02±11.46	Aluminum

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$).

Table 10. Comparison table of the average effect of the type of packaging on the logarithm of bacteria count of rainbow salmon fillet during storage

Day 12	Day 6	Day 0	Treatment
0.42 ^{Aa}±7.95	0.38 ^{Not}±6.48	^{That} 0.22±2.84	Control (Polyethylene)
0.56 ^{Aa}±7.82	0.48 ^{Not}±6.48	0.12 ^{That}±2.86	Polystyrene
0.40 ^{Ab}±6.86	0.37 ^{Aa}±6.10	0.05 ^{That}±2.87	Aluminum

The numbers are expressed as mean ± standard deviation. Different lowercase letters indicate significance in the column ($p<0.05$). Different uppercase letters indicate significance in the row ($p<0.05$)

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5- Discussion

The approximate analysis of the fillets showed that the lowest amount of moisture reduction was related to aluminum packaging with cellophane coating, which could be due to the mixing of aluminum with polyethylene materials and also creating a barrier resistant to water vapor and oxygen.[13]. on the other hand; After aluminum, polystyrene had the lowest amount of moisture reduction, which can be related to the high permeability coefficient, which leads to the formation of a suitable barrier against moisture.[14]. These results, which had a significant decreasing trend, were consistent with the results of other researchers. For example, Abrumand and Khatiri reported in a similar study thatThe amount of water content has decreased significantly during the storage time in the refrigerator[12]. Also, this significant decrease in humidity was consistent with the reports announced by Kamani and his colleagues in 2015 and the report of Islami and his colleagues in 2013 and other similar researches. of the reasonsThe decrease in moisture content can be caused by the drop of water in the product during the storage time, change in pH Product and water retention power pointed out that in this case, the water is removed from the fish and along with it, it removes some of the water-soluble nutrients such as vitamins from the muscle and leads to a decrease in the nutritional value of the fish.[15,16,17]. The measured amounts of protein showed that during the storage period, the amount of protein increased and this increase was significant. The highest amount of protein increase was observed in aluminum packaging, which is probably due to the extraordinary ability of aluminum to prevent the entry of oxygen, and since aluminum is considered as a suitable barrier and barrier against oxygen, as a result, it leads to a delay in the entry of oxygen into packaged foods. in such a way that the oxygen level in the packaging is kept low, and this reduces the growth of organisms and the production of destructive substances, and as a result, the protein content is preserved.[18]. In general, according to other researchers, protein content in dry products decreases with increasing storage time and increases in fresh products[13,14,19] . Analysis and comparison of the values obtained from fat measurement showed that the lowest amount of fat reduction was observed in aluminum packaging. Aluminum packaging, minimal transmissionO_2 has compared to others and this is while the transfer polystyreneO_2It is less than polyethylene[20]. The approximate analysis of salmon fillets in some reports and other researches have shown different values, especially in the amount of fat, that this difference can depend on factors such as season, feeding, fish size and the conditions of the rearing environment, and it is necessary to mention. that the increase of spoilage in fish fat causes adverse changes in color, taste, appearance, texture and nutritional value. [21,22]. The results of ash measurement, like other similar researches, had a significant increasing trend [23, 24]. It is possible that the cause of this slight increase in the amount of ash in fish fillets is due to a slight decrease in the moisture content and fat content of the fillets during the storage period.[25]. AmountspH showed that the overall rate pHAfter the death of the fish, due to the production of lactic acid from glycolysis, it decreases, and with the increase in storage time due to the action of proteolytic enzymes, the amount of free amines increases, which causes an increase in the amountpH It is found in the

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samples[26]. In the upcoming researchpH All samples increased as in other previous researches, but this increase was not significant. The reason for this increase can be due to the decomposition of nitrogenous compounds during the storage period in the refrigerator. The lowest increasepH Related to aluminum packaging with a value of 6.61 and the highest increasepH It was related to the control package with a value of 6.98. It is predicted that the reason for the lack of significant difference in the amountpH Because of the packaging. Among the other investigated parameters was the comparison of the values obtained from the measurement of free fatty acid, which is a suitable index to show the effect of lipolytic enzymes on fish fat.[8]. According to other researches, the values obtained from the free fatty acid measurement had a significant increasing trend, which is related to the progress of the fat oxidation process and the reduction of fat quality in the product.That As the oxidation process continues, fat turns into ketones and aldehydes[24]. The measured amounts of peroxide, like other similar researches, showed that peroxide in fresh food has a significant increasing trend with the increase of time. Similar results are also found in the research byCoban, Ojagh and his colleagues were done, it was achieved[27,28]. The lowest amount of peroxide increase was in aluminum packaging with cellophane coating, and it is expected that the reason for the increase in the rate of peroxide production during storage is the attack of the produced peroxide radicals on other fat molecules, which leads to the production of new free radicals and an increase in the peroxide index.[29,30]. The analysis of the values obtained from the measurement of thiobarbituric acid also showed a significant increasing trend, which can be related to the increase in the oxidation of unsaturated fatty acids, the partial dehydrogenation of fish fillets and the production of volatile metabolites in the presence of oxygen.[31,32]. The lowest increase of thiobarbituric acid was related to fillets packaged with aluminum and cellophane coating. The values of volatile nitrogenous bases during the storage time had a significant increasing trend, as in previous studies, and this increasing trend is according to the report.Ocane-Higuera and his colleagues in 2009 may be related to the breaking of proteins by internal proteolytic enzymes or may be done through the activity of spoilage bacteria. The slight increase in the amount of volatile nitrogen bases in the early stages of storage is due to the breakdown of nucleotides and amino acids, while the increase in the amount of volatile nitrogen bases in the final stages of storage is due to the increase in microbial activity.[33]. According to the results, the lowest increase of volatile nitrogen bases was related to aluminum packaging with cellophane coating. Finally, the values obtained from the measurement of the total microbial load had a significant increasing trend as in other previous researches The lowest increase in microbial load was observed in aluminum packaging. The amount of microbial load depends on various factors such as the initial amount of bacteria, the amount of contamination transferred during fish preparation, the contamination of the equipment used, and other similar cases. [31,32].

6-Conclusion

The examination and comparison of the results of this research between the mentioned treatments showed a significant difference between the tested factors of the

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packaged fillets during storage. In general, the treatment is packaged with an aluminum containeDuring the storage period, the cellophane coating had more acceptable physico-chemical and microbial parameters than the polystyrene treatment and the control, and its nutritional value was preserved better than other samples, which is due to the mixing of polyethylene with aluminum, which prevents And it creates a suitable barrier against moisture and gases, especially against oxygen. It should be noted that according to the permissible limits of the two main indicatorsTVB-N And the total microbial load, which is one of the main factors determining product spoilage, only the sample packed with an aluminum container was able to be consumed until the end of the storage period. As a result, it can be concluded that aluminum packaging with cellophane coating has performed better in every way to preserve the nutritional value and quality of salmon fillets kept at low temperature (4 degrees Celsius) and can replace containers and packaging available in the market.

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مقاله علمی_پژوهشی

تاثیر نوع بسته‌بندی بر ویژگی های فیزیکوشیمیایی و میکروبی فیله ماهی قزل آلای رنگین کمان (*Oncorhynchus mykiss*) نگهداری شده در دمای یخچال

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چکیده

با توجه به حساس بودن گوشت ماهی نسبت به فساد سریع، شرایط نگهداری و نوع بسته‌بندی از فاکتور های بسیار موثر بر حفظ کیفیت و ارزش تغذیه ای آن پس از صید می‌باشد. در این پژوهش، فیله ماهی قزل‌آلا بسته‌بندی شده با جنس های آلومینیومی و پلی‌استایرن به عنوان تیمار و کیسه پلی اتیلن به عنوان شاهد به مدت ۱۲ روز در دمای ۴ درجه سانتی گراد نگهداری شدند. فاکتورهای فیزیکی، شیمیایی و میکروبی فیله ها با ثبت تغییرات رطوبت، پروتئین تام، چربی، خاکسترکل، اسیدهای چرب آزاد، پراکسید(PV)، pH، تیوباربیتوریک اسید(TBA)، بازهای نیتروژنی فرار(TVB-N) و همچنین بار میکروبی کل اندازه‌گیری شد. نتایج نشان داد که با گذشت زمان، رطوبت و چربی به طور معنی‌داری کاهش یافتند. پروتئین تام، خاکسترکل، اسیدهای چرب آزاد، PV، TBA، TVB-N و بار میکروبی کل در مدت نگهداری به طور معنی داری افزایش یافتند. همچنین pH روند افزایشی داشت که این افزایش معنی دار نبود. بالاترین مقدار TVB-N در روز دوازدهم مربوط به بسته‌بندی شاهد با مقدار ۲۴/۵۲ $^{mg}/_{g}$ بود وکمترین مقدار بار میکروبی کل در روز دوازدهم مربوط به بسته‌بندی آلومینیومی با مقدار ۶/۸۶ log $^{cfu}/_{g}$ بود. با توجه به نتایج، اولویت استفاده از بسته‌بندی ها جهت افزایش ماندگاری و حفظ ارزش تغذیه ای فیله ها به ترتیب ابتدا با بسته‌بندی آلومینیومی سپس با پلی‌استایرن بود. کیسه پلی اتیلن به دلیل عدم حفظ ارزش تغذیه ای و کاهش کیفت محصول غیر قابل توصیه جهت مصرف اعلام شد. بسته‌بندی آلومینیومی به طور چشمگیری در حفظ خواص فیزیکوشیمیایی و میکروبی محصول عمل نمود و با توجه به حدود مجاز اعلام شده TVB-N و بارمیکروبی کل که از شاخص های مهم جهت تشخیص فساد می باشند، تنها فیله بسته‌بندی شده با ظرف آلومینیومی تا پایان دوره نگهداری قابل مصرف بود.