

ORIGINAL RESEARCH PAPER

**THE NEW GASTRONOMIC PRODUCT: DRIED AND VACUUMED
RAINBOW TROUT ROE**

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Abstract

In this study, it was aimed to investigate that the effect of drying process on rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) roes in terms of the proximate composition, a_w , pH, TVB-N, TBARs, microbiological counts and color parameters. Drying was lasted 42 hours including, 18 hours at 30°C and 24 hours at 45°C. The dried fish roes were vacuum-packed (vacuum degree 0.02MPa) and stored at 4°C for 90th days. The crude lipid, crude protein, crude ash and moisture contents of fresh fish roe was 6.67%, 18.51%, 2.67%, and 71.99%, respectively. No change detected in terms of a_w value in vacuum packed dried eggs between the first and 90 days ($p>0.05$). While the pH value of the fresh roe decreased with pretreatments and drying, TVB-N and TBARs value increased. At the end of the storage period, TVB-N value reached to 42.57mgN / 100g. The total mesophilic aerobic bacteria count of dried roes did not exceed the limit value at the end of the storage period. Total anaerobe mesophilic bacteria, Total Coliform, *E. coli*, H_2S producing bacteria (including *S. putrefaciens*) and Lactic acid bacteria counts of fresh and vacuumed dried roes were below detectable limit values (<0.30 LogCFU/g). In conclusion, it has been determined that vacuum-packed dried rainbow trout roes can be safely consumed for 60 days at $\pm 4^\circ C$.

Keywords: rainbow trout, roe, caviar dried roe, vacuum package

Introduction

The rapidly increasing world population increases the need for nutrients, and especially the insufficiency of animal protein sources makes the protein resources valuable day by day. While achieving healthy and safe food is the primary goal of people, the demands of individuals in different beliefs and cultures are different. These social differences also increased the types of food sources, but primarily the

limited number of protein sources increased the necessity of utilizing waste products, especially those that come from the main sources. In this context, considering seafood in terms of both health and taste, it is a food product with high preferability compared to other protein sources.

But being used as food, fish is also increasingly demanded use as feed. Nearly one-third of the world's wild-caught fish are "reduced" to fishmeal and fish oil, which are then used in feeds for livestock like poultry and pigs and feeds for farmed carnivorous fish (Delgado *et al.*, 2003). This restricted people's access to seafood. In 2016, the apparent food fish consumption was only 20.3 kilograms per capita. Out of the 171 million tons of total fish production, about 88 percent or over 151 million tons were utilized for direct human consumption. The most preferred and highly-priced form of fish is live, fresh or chilled (45% percent), followed by frozen (31%), prepared and preserved (12%) and cured (dried, salted, in brine, fermented smoked) (12 %) (FAO, 2018). It was reported that people in developing countries have a higher share of fish protein in their diets than those in developed countries (FAO, 2018). This led to an acceleration in aquaculture as well as wild-capture seafood in developing countries. Rainbow trout is one of the most produced cultured fish. The share of salmon and trout in world trade has increased strongly in recent decades, becoming the largest single commodity by value in 2016 (Köstekli *et al.*, 2019). Also, the primary species are rainbow trout (103.192 tons in inland water, 9235 tons in the sea) aquaculture in Turkey in 2018 (TÜİK, 2020). These fish are usually exported live, fresh, chilled and frozen. Especially the fish that are filleted had more waste. The use of these products is important. One of the products that are produced as a surplus from trout is their roes. Rainbow trout (*O. mykiss*) is the main source of red caviar, which is extremely popular in the world (Özden *et al.*, 2018). Although it is a waste product in Turkey, it is an expensive food with a gastronomic value processed in many countries. Among popular products, salted and frozen roe retained longer shelf life (Rao *et al.*, 2015). Generally, salted fish roe is referred as "caviar" (Caprino *et al.*, 2008, Özpolat and Patır 2009, İnanlı *et al.*, 2010, Kaba *et al.*, 2013, Özden *et al.*, 2018, Rao *et al.*, 2015). There are many studies in the literature on salting of different fish roes (Rodrigo *et al.*, 1998, Caprino *et al.*, 2008, Özpolat and Patır 2009, İnanlı *et al.*, 2010, Patır *et al.*, 2010, Çelik *et al.*, 2012, İnanlı *et al.*, 2019, Pourashouri *et al.*, 2015, Chen *et al.*, 2020). The salted fish roe can be used as a gastronomic product. This product, which has an intense and unique taste, can be used alone or added to salads. When used alone, it can be served as an alternative in gourmet restaurants. It increases both the flavor and nutritional quality of the product it is added to. Provides visual and nutritional saturation. It can also be used diluted in sauces to give flavor.

In this study, it was aimed to obtain a gastronomic product by drying the roes obtained as the production waste output of the rainbow trout (*Oncorhynchus mykiss* Walbaum 1792) aquaculture in Black Sea (Sinop region, Turkey).

Materials and methods

Materials

In the study, a total of 12 kg of rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) (7 pcs) were used. The average length of trout is 44.93 ± 0.93 cm; the average weight is 1669.60 ± 99.40 g. Fish were obtained from a special aquaculture facility in Samsun-Turkey. Fish killed by hypothermia in the facility and placed in styrofoam boxes and delivered to the laboratory within 2 hours. The roes were taken out of the fish. Roe yield of fish is $\%15.02 \pm 0.3$.

Chemicals

Ethyl alcohol, Boric acid, sulfuric acid (99.9%), hydrochloric acid (37%), Kjeldahl catalyst tablets, sodium hydroxide pellets, Brom-cresol: Green/Methyl Red mixed indicator solution, petroleum ether, 3,5-di-tert-4buthlyhydroxytoluene (BHT), Trichloroacetic acid (TCA), Glacial acetic acid, 2-Thiobarbituric acid were purchased from Sigma Aldrich (St. Louis, MO, USA). Buffered Peptone Water, Peptone from Casein, Cysteine chloride monohydrate, NaCl, Plate Count Agar (PCA), Cetrimide agar, Iron agar, Baird Parker (BP) agar, Violet Red Bile Agar (VRBA), Man Rogosa Sharpe Agar (MRS), Potato Dextrose Agar (PDA) were purchased from Merck (Darmstadt, Germany) and Reinforced Clostridial Agar (RCA) were purchased from Oxoid Limited (UK).

Preparations of dried roes

Roes were washed several times in a 5% salt solution until blood was completely removed (Figure 1) (a). Then it was kept in boiled cooled 4-5% salt solution and its membrane was separated (Figure 1) (b). It was filtered and washed again and submerged in a 0.3% alcohol solution. Then, it had been kept on paper towels for 12 hours at 4°C, after it was completely removed from the water, it was dried in the air-conditioning cabinet (Delta NKD-250 Basic Model). Drying was lasted total 42 hours, including 18 hours at 30°C and 24 hours at 45°C and 42% humidity (Figure 1) (c-d). The dried fish roes were vacuum-packed (vacuum degree 0.02MPa, PA/PE vacuum bag (30x40 cm, 80 μ thickness, oxygen transmission rate of 52.4 ml/m²/day at 23°C) with vacuum packaging machine (Abant Group, MG42, Hellas, Sydney, Australia) and stored at 4°C for 90 days.

Determination of proximate composition

The roe's crude protein (by Kjeldahl method 952.52), crude ash (heating at 550°C) and moisture (by air-drying method, 925.10) contents were analyzed by AOAC procedures (1995). Total crude fat contents of roes were analyzed by the soxtec method (AOAC 2005). The energy was calculated by applying the numbers of Atwater. The factors for protein and carbohydrate contents were 4 kcal/g and for the fat was 9 kcal/g (Falch et al., 2010).

Determination of water activity, pH, total volatile basic nitrogen, thiobarbituric acid reactive substance, and color analyses

An automatic water activity machine (Novasina) was used for the analysis of water activity (aw). pH, total volatile basic nitrogen (TVB-N mgN/100 g) and thiobarbituric acid reactive substance (TBARs mg MDA/kg) values of roes were

determined according to the Manthey et al (1988), Ludorf and Meyer (1973) and Erkan and Özden (2008), respectively.

Color measurements were made with HunterLab Conica Minolta Color Meter device. Color measurement adopted by Commission Internationale de l'Eclairage (CIE) is used (Oleari, 2008). It was performed according to the Hunter colorimeter scale and there are three color values in the analyses; *a value is red or green, *b value is yellowness or blueness, The *L value determines the degree of brightness between 0 (black) and 100 (white).

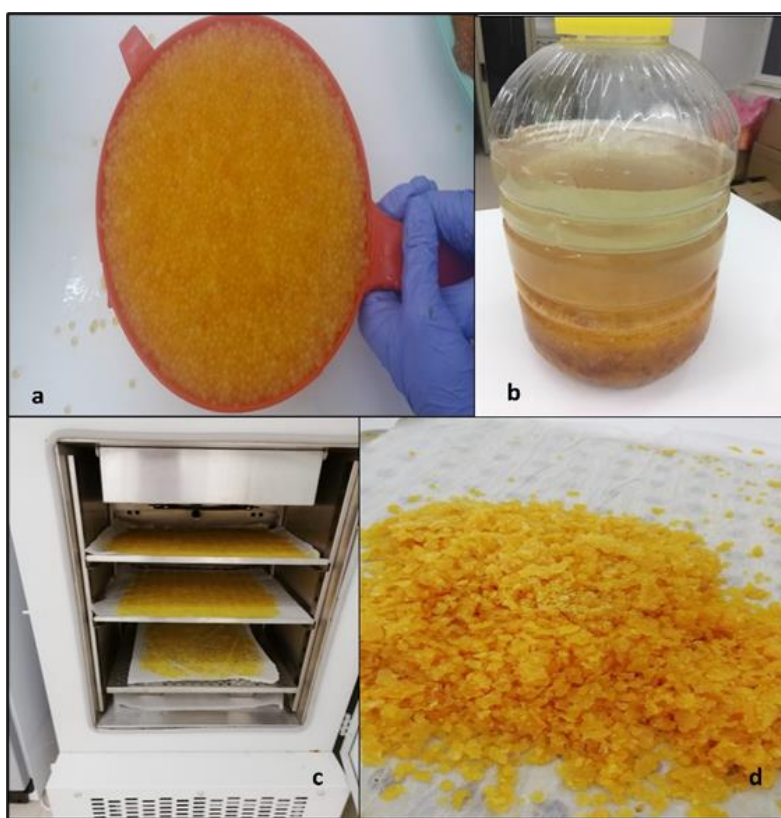


Figure 1. Processing steps in dried roe: a - washing, b - salting, c and d - drying.

Microbiological analysis

For the microbiological analysis except for total anaerobe bacteria, 10 g of the samples were diluted in 90ml buffered peptone water and homogenized in the stomacher for 2 min. For total anaerobe bacteria special dilution mixture was used (Pepton from Casein (Merck 1.07213) 0.1%; Cysteine chloride monohydrate (Merck 1.02839) 0.05%; NaCl (Merck 1.06404) 0.85%). The total mesophilic aerobe bacteria (TMAB), total psychotropic aerobic bacteria (TPAB), total mesophilic anaerobic bacteria (TANB), total coliform (TC), total yeast and mold (TYM), E. coli,

S. Aureus (Coagulase positive), *Pseudomonas spp.* loads were identified according to Halkman (2013). The H₂S producing bacteria (including *Swenella putrefaciens*) and lactic acid bacteria (LAB) were analyzed according to Kostaki *et al.* (2009).

Statistically analysis

The study was carried out in two replications and three parallel. A one-way analysis of variance was used to evaluate the differences in proximate, physical, chemical contents and microbiological loads using MINITAB 17.2.1.0. software program (Minitab Inc., State College, PA, USA). Differences between means was determined by Tukey's test (a level of $p < 0.05$ was used to establish significant differences among means).

Results and discussion

Changes in the proximate composition of roes

The proximate composition and energy values of fresh fish roe, dried roe on the first day and after 90 days of storage period was given in Table 1.

Table 1. The proximate compositions and energy values of fresh and dried fish roe.

	Fresh roe	Dried roe	
		First day	90 th day
Crude Lipid %	6.67±0.01 ^c	21.25±0.02 ^a	20.32±0.03 ^b
Crude Protein %	18.51±0.04 ^c	54.13±0.00 ^b	57.44±0.03 ^a
Crude Ash %	2.67±0.02 ^c	12.11±0.07 ^a	11.48±0.08 ^b
Moisture %	71.99±0.02 ^a	12.37±0.05 ^b	10.58±0.06 ^c
Carbohydrates %	0.16±0.00 ^a	0.14±0.00 ^a	0.19±0.02 ^a
Energy (kcal/100g)	134.75±0.07 ^c	408.31±0.18 ^b	413.34±0.26 ^a

Mean values followed by different superscripts in the same column are significantly different ($P < 0.05$)

The crude lipid, crude protein, crude ash and moisture contents of fresh fish roe were 6.67%, 18.51%, 2.67%, and 71.99%, respectively. Özpölat and Patır (2009) reported the crude lipid, crude protein, crude ash and moisture contents of rainbow trout (Keban Dam, Elazığ, Turkey) roes as 11.1%, 23.2%, 2%, and 63.9%, respectively. Similarly, İnanlı *et al.* (2010) found that fish roes obtained from the same dam contained 11.70% crude lipid, 24.87% crude protein and 61.60% moisture. The fat and protein contents in roes obtained from rainbow trout was determined to be 9.14% and 24.32% (İnanlı *et al.*, 2019). The crude lipid and protein contents of the roes used in this study were lower than this literature. The high moisture content of the roes used in this study proportionally reduced the dry matter content. There are many factors that include the nutritional composition of fish roes, for example, fish species, fishing area, fishing region, season, spawning, (Bledsoe *et al.*, 2003, Mahmoud *et al.*, 2008, İnanlı *et al.*, 2019).

After the pretreatment and drying process applied to fresh roe, the content of crude oil, crude protein, and crude ash increased. Similar results had been reported by

different researchers. It is said that especially the salting process applied to caviar causes dehydration and increases dry matter (Rodrigo *et al.*, 1998, Pourashouri *et al.*, 2015, Şengör *et al.*, 2002). It was observed that crude ash and moisture content of the dried roes on day 90 decreased compared to day 0 ($p<0.05$). And it was determined that the processing and storage process had an effect on proximate composition ($p<0.05$) except for carbohydrate values ($p>0.05$). Decreasing moisture content along with pretreatments and drying also affected the energy amount of the roes. The maximum energy value (413.34 Kcal/100g) was found in dried roe on the 90th day. The energy values of dried salted hake and ling roes were 328 and 320 Kcal/100g (Rodrigo *et al.*, 1998).

Changes in the water activity, pH, TVB-N and TBARs values of roes

The water activity changes occurring in the product during the drying process and the fresh roes are given in Figure 2. The a_w value of fresh roe was 0.980, it decreased during the drying process.

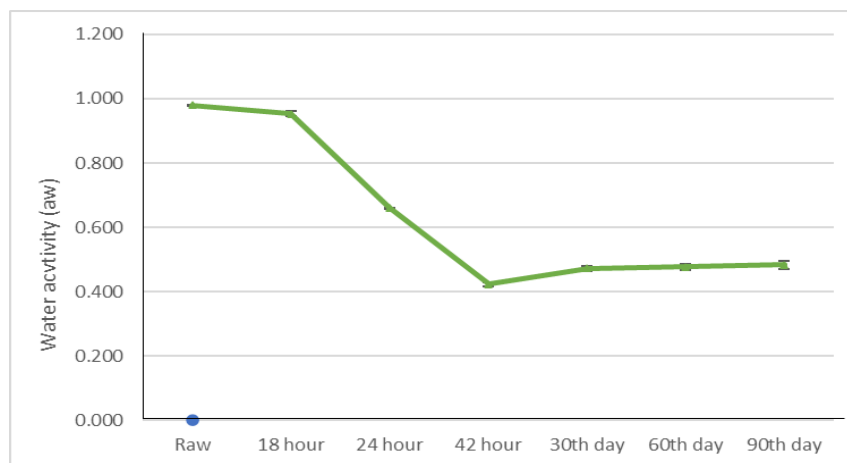


Figure 2. The water activity of fresh and dried roes.

No statistically significant change was observed in the water activity of the roe during the first 18 hours of drying. It was detected as 0.662 at the 24th hour and 0.424 at the 42nd hour of the drying process ($p<0.05$). No change in a_w value was detected in vacuum packed dried eggs for 90 days ($p>0.05$). It is seen that there is a lot of water loss during the drying period (Figure 2). The yield of the product obtained after drying was $26.11\pm1.21\%$. A similar rate (22.9%) was seen from dry salted roes (Özpolat and Patır, 2009).

The pH, TVB-N and TBARs values of roes are given in Table 2. The pH contents of different fish roe's varieties vary such as 7.49 in kutum roe (*Rutilus frisii kutum*) (Pourashouri *et al.*, 2015), 5.79 in grey mullet roe (Çelik *et al.*, 2012), 6.50 in fresh cod roe (Lapa-Guimarães *et al.*, 2011), 6.55 in whiting roe (Kaba *et al.*, 2013). The rainbow trout which caught from Atatürk Dam (Turkey) roe pH values were reported

as 7.70 and 7.80 by Özpolat and Patır (2009) and İnanlı *et al.* (2010), respectively. The pH of the roes (6.57) used in the study is lower than the literature. The pH level of fresh caviar decreased with the effect of salt, alcohol, and drying used in pretreatments. It has been reported by different researchers that pH values of roes' decrease with salting (Pourashouri *et al.*, 2015, Özpolat and Patır, 2009, İnanlı *et al.*, 2010), ripening (Lapa-Guimarães *et al.*, 2011) and smoking (Kaba *et al.*, 2013). An increase in pH was observed during the storage period, and the pH measurement at first and third months were statistically similar ($p>0.05$).

Table 2. Changes in the pH, TVB-N and TBARs values of fresh and dried roes.

Storage period		pH	TVB-N	TBARs
Dried and vacuumed roes	Fresh roe	6.57±0.01 ^c	6.86±1.34 ^d	0.37±0.02 ^d
	First day	6.35±0.01 ^d	11.66±0.56 ^c	0.70±0.10 ^c
	30 th day	7.02±0.00 ^a	15.13±0.05 ^c	1.56±0.06 ^a
	60 th day	6.83±0.00 ^b	27.12±0.04 ^b	1.51±0.07 ^b
	90 th day	7.00±0.00 ^a	42.57±0.17 ^a	1.55±0.22 ^a

Mean values followed by different superscripts in the same column are significantly different ($P<0.05$).

The volatile basic nitrogen includes several compounds such as; ammonia, monomethyl amine, dimethylamine and TMA, especially ammonia can be formed by bacterial or endogenous enzymatic activity (Lapa-Guimarães *et al.*, 2011). In this study the fresh rainbow trout roe TVB-N values were detected as 6.86 mgN/100g, it increased with pretreatment process and drying (Table 2). Similar to this study results, Özpolat and Patır (2009) had reported the TVB-N values of fresh Rainbow trout roe as 6.10 mgN/100g. At the end of the storage period, it was exceeded the limit value (32-34mgN/100g) which stated by Alperden *et al.* (1981). It is known that TVB-N value of fresh roe varies according to the species (10.9mgN/100g in fresh Kutum roe, 9.84mgN/100g in fresh whiting roe, 16.1 mgN/100g in fresh cod roe and processing methods (Pourashouri *et al.*, 2015, Kaba *et al.*, 2013, Lapa-Guimarães *et al.*, 2011).

TBARs value used in the measurement of lipid oxidation in seafood was found as 0.37mgMDA/kg in fresh roe. Similarly, İnanlı *et al.* (2010) found that the TBARs of Rainbow trout roe was 0.02 mg MDA/kg. In the present study, the TBARs value of the fresh roe was increased with processing and storage periods. TBARs content of the product is 1.55mgMDA/kg at the end of storage and this value was the same within the 30th day in statistically ($p>0.05$). Also, Çelik *et al.* (2012) reported that the drying process increased the TBARs value of the red mullet roe.

Changes in the microbiological composition of roes

Microbiological analysis results of fresh roes and vacuum-packed dried roes are given in Figure 3. Fresh roes are highly susceptible to microbial spoilage due to high moisture, protein, and lipid contents (Rao *et al.*, 2015). Total mesophilic aerobe

bacteria (TMAB), total psychotropic aerobic bacteria (TPAB), total mesophilic anaerobic bacteria (TANB), total coliform (TC), total yeast and mold (TYM), *E. coli*, *S. aureus* (Coagulase positive), *Pseudomonas* spp., H_2S producing bacteria (including *S. putrefaciens*) and lactic acid bacteria (LAB) were analyzed. TANB, TC, *E. coli*, H_2S producing bacteria (including *S. putrefaciens*) and LAB loads of fresh and vacuumed dried roes were below detectable limit values (<0.30 LogCFU/g). At the beginning of the study, TMAB, TPAB, *S. aureus* (Coagulase positive), TYM and *Pseudomonas* spp. counts of fresh roes were <0.30 , 2.11, <0.30 , <0.30 and <0.30 LogCFU, respectively.

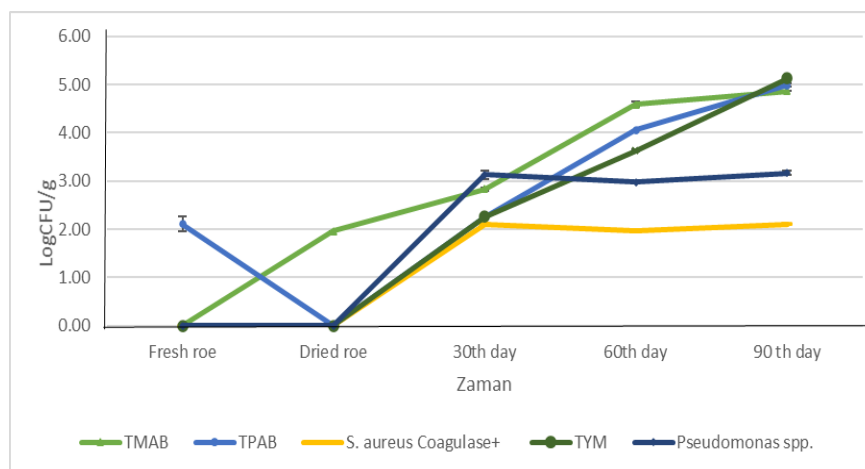


Figure 3. Changes in the microbiological composition of fresh and dried roes.

Patır *et al.* (2010) the TMAB, TC, *E. coli*, *S. aureus* and TYM load of fresh rainbow trout roes had reported as 2.05 LogCFU, $<0.48 \log \text{EMS/g}$, not detected, <1 and 0.97 LogCFU, respectively. The fish used in the present study were harvested at the aquaculture facility under suitable conditions and brought to the laboratory by a cold chain. Microbiological results show that cross-contamination was very low during the harvesting and carrying process. With the pretreatments and drying applied, TMAB increased, TPAB decreased, and no change was observed in other microorganisms. TMAB counts of roes increased during storage ($p < 0.05$). The TMAB count of roes did not exceed the ICMSF (1986) limit value for TMAB. While the *S. aureus* (Coagulase positive) counts of roes were minimum until 30th day ($p > 0.05$), it was detected as 1.96 and 2.11 LogCFU/g from the 30th day to the end of storage ($p > 0.05$). Unlike the present study results, Patır *et al.* (2010) determined that *S. aureus* count of dried-salted and vacuumed rainbow trout roe was <1 LogCFU/g for 324 days. According to the Turkish Food Codex (2001), the limit of *S. aureus* counts in the ready to eat food is 1×10^2 CFU/g. At the end of the 90th day, the count of *S. aureus* was close to this limit value. It may be due to the excess of salt used in this literature. Salt has been shown to effectively control microbial

spoilage (Rao *et al.*, 2015), and other processing methods applied can alter specific spoilage bacteria in the final product.

Changes in the color parameters of roes

The values of color parameters are shown in Figure 4. L^* is the luminous component that varies in the range of 0-100 (from black to white), a^* (green (-), red (+)) and b^* (blue (-), yellow (+)) are two chromatic (color) components with parameters ranging from -120 to +120 (Papadakis *et al.*, 2000; Yam and Papadakis, 2004; Girolami *et al.*, 2013). L^* , a^* and b^* values of fresh roe were 60.08, 1.25 and 38.01, respectively. The L^* values of fresh roes decreased with the drying process ($p < 0.05$) and it increased after the 60th day. Similarly, the b^* values of fresh roes decreased firstly ($p > 0.05$) and then increased after 60th days.

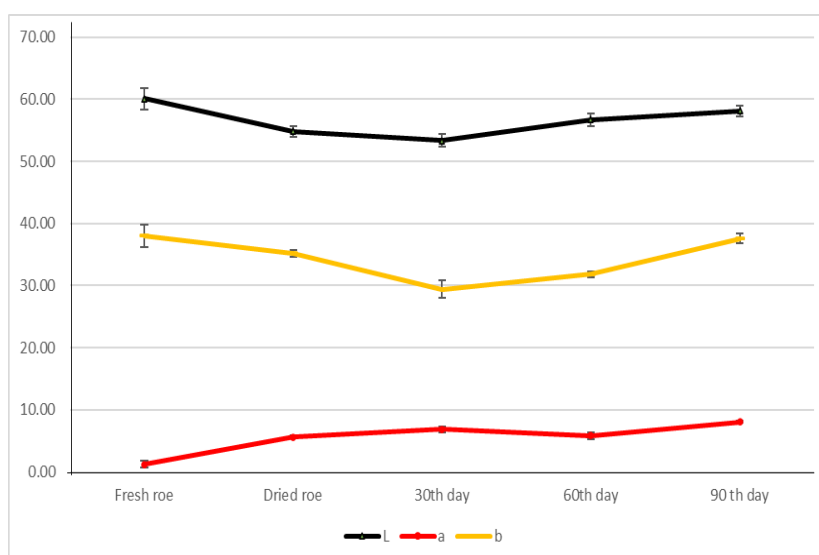


Figure 4. Changes in the color parameters of fresh and dried roes.

Celik *et al.* (2012) reported similar results for L^* and b^* values of dry salted flathead grey mullet. But the values of roes firstly increased with a dried process ($p < 0.05$), however, the value of on the 30th and 90th days was statistically similar ($p > 0.05$). It is clear that the drying process considerably increased the redness value of the roe and caused fluctuation in brightness and yellowness values. L^* values of seafood have a positive relationship with moisture contents (Park 1995; Özkan *et al.*, 2003; Bekhit *et al.*, 2009). With the pretreatments and drying applied, approximately 10% lightness loss occurred in the roes ($p < 0.05$). Drying of the fish roe is a complex process as many variables are involved in the regulation of moisture migration and drying kinetics such as chemical composition, roe size, skein thickness and osmolality (Bekhit *et al.*, 2009).

Conclusions

In the present study, rainbow trout roes that are harvesting as waste products were pre-treated and dried under suitable humidity and temperature conditions. It has been determined that it is possible to store the new nutrient product, both chemically and microbiologically, under vacuum packaging for 60 days at 4°C. In future studies, first of all, it should be aimed to bring a product with a very intense flavor to the industry, to combine it with flavor components and different technologies to reveal a product with a longer shelf life.

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