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RESEARCH ARTICLE

Determination of shelf life during cold storage of fish fingers coated addition of goji berry

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ABSTRACT

The present study was aimed to evaluate shelf life of Pike Barbell (*Luciobarbus esocinus* Heckel, 1843) experimental samples of fish finger, that ordinarily packed and stored at 4±1°C. Together with the control group, three experimental groups fish finger were obtained with the addition of the goji berry extract into this content by 1% and 2%. According to the findings obtained in this study, it was concluded that fish fingers with goji berry addition had a positive effect on chemical, microbiological and sensory qualities and this study could also establish a basis for many scientific studies with the application of herbal extracts used in experimental samples on various fish products in more different concentration.

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Introduction

Demand for seafood has consistently increased during recent years with fish protein being the major animal protein consumed in many parts of the world. To assure the quality of raw material used for processing, fish has to be treated carefully before and after harvest. Often fish and shellfish undergo some type of handling or primary processing (washing, gutting, filleting, shucking, etc.), before the main processing occurs, to assure their quality and safety, as well as to produce new, convenient and added-value products (e.g., packed fish fillets instead of unpacked, whole ungutted fish). Processing of seafood mainly inhibits and/or inactivates bacteria and enzymes which results in shelf-life extension and also assures food safety. While the main role of processing is preservation, processing not only extends shelf life but also creates a new range of products (Boziaris, 2014).

The literature on fishery fast foods is quite new. Concerns regarding the safety of synthetic food additives and the toxicity of such chemicals have lately been on a rise. The essential ingredients of coating materials largely consist of flour and water (Vareltzis et al., 1997).

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People are tended to produce ready-to-serve foods since women who do not have the opportunity to cook at home are tended to ready-to-serve foods with the increasing number of working women today, working people have short time for lunch; places such as schools, hospitals, cafeterias and restaurants want to serve in a short time. This service is carried out in a short while with developments in world food technology. Ready-to-serve foods are the products which are made of food by processing either directly or heated and consumed by themselves or with some nutrients, having a certain shelf life and on which favourable processing techniques and methods are applied (Gökoğlu, 1994).

It is known that microbial and chemical reactions lead to the quality deterioration of fish. Fish fingers are made from fish slices as battered and breaded foods. They are usually stored and marketed as frozen (Sarma et al., 2000).

Extracts are antiseptic, antioxidant, digestive stimulant antimicrobial and enzymatic effects as natural products used in food preservation. Plant extracts are a very large part of the GRAS list Goji berry (*Lycium barbarum*) or wolfberry in the world known as wolfberry but in our country, little-known Wolf is one of the highest nutritional value rape fruits. This is a very powerful antioxidant fruit has been used for 2000 years in the medical field in China. Goji berry high antioxidant activity of β-carotene and phenolic components have been found to have originated from. Other natural antioxidants present in Goji berries are tannin, lignin, and flavonoids (Lee et al., 2002; Kammerer et al., 2007).

In this study, it was aimed to determine the chemical, microbiological and sensory changes during the storage of Pike barbell (*Luciobarbus esocinus* Heckel, 1843) fish fingers coated addition of goji berry at 4°C and to investigate the shelf life of this products.

Material and Methods

Materials

In this study, Pike barbell (*Luciobarbus esocinus*) which are caught from Keban Dam Lake was used. Fresh fishes were brought to the laboratory in cold and fish slices were obtained and aseptic conditions.

Goji berry extract was obtained from a commercial company (Xi'a Xin Sheng Bio-chem Co., Ltd, China) to add to coverings prepared in the study. This extract used is for food purpose, and has ISO 22000, GMP, FDA and halal certificates. The study was carried out as two repeats and two parallel in the research.

Preparation of Experimental Samples

Fish slices prepared were kept on the fridge for 1 hour in brine of ratio as 1.5%. Liquid and solid coverings were prepared to cover the fish slices.

Briefly, egg white (75%), carbonate (3%), breadcrumbs (15%), wheat starch (5%), salt (1%) and sugar (1%) were prepared by mixing for liquid coating. Additionally, onion powder (2%), garlic powder (2%), red pepper (1%) crumbs bread (40%), corn flour (30%) and wheat flour (25%) were mixed as solid covering.

Firstly, salted fish slices were covered with liquid, and then covered with simple solid covering (control), solid covering with additional 1% goji berry extract (1% GB) and solid covering with an additional 2% goji berry extract (2% GB). Thus, were created 3 groups.

All of the fish fingers were fried for 1 min in oil at 180 C°. In this way the samples would be pre-cooked. After that each treatment was packaged in styrofoam packages and was stored at +4°C before the analyses on 0^{th}, 3^{rd}, 6^{th}, 9^{th}, 12^{nd}, 15^{th} and 18^{th}days.

The analyzes would be carried out in three stages, before fish processing, after processing and under storage conditions. In order to determine the shelf life of experimental fish finger, chemical, microbiological and sensory analyzes were performed with 3 replications every three days. Nutritional composition was determined before processing fish meat and after making fish finger. In addition, in the treatments, pH, Thiobarbituric Acid Numbers (TBARs), Total Volatile Basic Nitrogen (TVB-N) in certain days of the storage and sensory analyzes were performed.

Analytical Methods

Proximate composition

The moisture content of experimental samples was measured according to the official method 950.46. Crude protein of samples was determined according to the micro Kjeldahl method (method 928.08). Soxhlet method was used (method 960.39) to determine lipid content. Ash was determined according to method (920.153). The pH values of samples were measured with a pH meter (Thermo Scientific Orion 3-Star). The sample was homogenized in distilled water in the ratio 1: of 10 (wt/vol), and the measurement was done with a pH meter (AOAC, 2002a, 2002b, 2002c, 2002d, 2002e).

Total volatile basic nitrogen

The TVB-N content was determined according to the method stated by Antonacopoulos (1973). Volatile bases were kept in the H_3BO_3 solution of 3% with the distillation after that MgO was minced to the sample. The distillate was collected in a flask containing a 3% (w/v) aqueous solution of boric acid and a mixed indicator produced by dissolving 0.1g of methyl red and 0.05g of methylene blue to 100ml of ethanol. The boric acid solution turned green when the distilled TVB-N made it alkaline. Finally, the boric acid solution was titrated with a 0.01 mol/L HCl solution until it turned pink. The quantity of TVB-N in mg/100 g sample was then calculated.

Determination of thiobarbituric acid number

The method stated by Tarladgis et al. (1960) was applied. Absorbance of red colour at 538 nm given by malondialdehydes formed by oil oxidation, with thiobarbituric acid at glacial acetic acid environment was read on spectrophotometer. Malondialdehyde value was calculated by multiplying the read absorbance value with 7.8 factor.

Microbiological analyses

For microbiological analyzes of samples were weighed as 10 g in the special bag, and it was homogenized in the stomacher (Stomacher 400) for 60 s by adding 90 ml from the sterile 0.1% peptoned water on it for the microbiological analyses. Thereby, dilution of samples of 10^{-1} (1/10) were prepared. Other decimal dilutions were made by means of using the same diluting agent from this dilution e.g., up to 10^{-6} (Harrigan 1998).

Plate Count Agar (PCA Merck1.05463) medium was used for total viable counts (TVC) and psychrotrophic bacterial counts (PTC) in samples. Colonies consisted after cultured plates were incubated for 72 hours at 30±1 C° were counted TVC. PTC were evaluated after incubated for 7 days at ±5 C°. Plates using Potato Dextrose Agar (PDA Merck1.10130) medium, of which pH was reduced to 3.5 by adding 10% tartaric acid (Merck1.00802) for the count of yeast-mold (YMC) in the samples, was evaluated after 5 days incubation at 21±1°C (ICMSF 1986; Harrigan 1998).

Sensory evaluation

Sensory characteristics of the fish fingers were evaluated by 10 panelists in terms color, appearance, odor, flavor, texture and overall acceptability. Scores were measured as "like extremely" = 5 to "dislike extremely" = 1, and tests were conducted storage days of 0^{th}, 3^{rd}, 6^{th}, 9^{th}, 12^{nd} and 15^{th} (Kurtcan & Gönül, 1987).

Statistical analyses

In this study, results during the production of samples fish finger which were prepared experimentally were reported statistical analysis. The statistical analysis was run using SPSS® version 22.0 software computer package statistical program (SPSS, Chicago, IL, USA). Kruskal-Wallis test was applied to determine whether there is a meaning difference between the groups or not, and the difference between the groups was determined with Duncan test.

Result and Discussion

Quality of Raw Fish

Proximate composition, chemical and microbiological quality of *Luciobarbus esocinus* used in the study is presented in Table 1.

Table 1. The properties of fish meat used in the study

Parameters	Values
Moisture (%)	70.35±1.85
Crude Protein (%)	15.66±0.83
Crude Fat (%)	11.68±1.66
Ash (%)	0.93±0.17
pH	6.26±0.35
TVB-N (mg/100 g)	7.59±0.58
TBA (mg MDA/kg)	0.90 ±0.22
TVC (log cfu/g)	1.88±0.01
PTC (log cfu/g)	2.69±0.30
YMC (log cfu/g)	1.87±0.18

Proximate Composition

The results of proximate composition analysis belonging to simple fish fingers (control) and fish finger samples with the addition of goji berry extract 1.0% and 2.0% are determined in this study.

As a result of the analyses, 63.80% moisture, 15.74% protein, 14.82% fat and 3.01% ash were calculated in control. In other samples with the addition of 1% goji berry extract, 61.96% moisture, 16.39% protein, 15.73% fat, 3.42% ash were determined in the samples of 1%GB, 61.99% moisture, 16.76% protein, 16.32 % fat and 2.92% ash were found in the samples of 2% GB.

When the data obtained as results of the study were analyzed statistically, this difference between the groups was found significant in terms of moisture, protein, fat and ash

amounts determined in control fish finger samples and the samples prepared with the addition of extract ($p<0.05$).

Tokur et al. (2006) respectively found the water, protein, fat and ash amounts in carp sticks as follows: 68.50%, 15.50%, 6.00% and 2.20%. In their study, Gülyavuz & Timur (1991) obtained very similar amounts as a result of their investigation on the nutrient components of carp: 15.92% protein, 9.50% fat, 1.13% ash and 73.02% moisture.

In a different study, water, protein, fat, ash and carbohydrate amounts were investigated in sardine sticks (52.04%, 14.39%, 16.16%, 2.61% and 14.80%), in the whiting sticks (63.01%, 6.71%, 15.98%, 3.33% and 10.97%) and the sander sticks (69.73%, 4.28%, 15.75%, 2.75% and 7.49%) (Çaklı et al., 2005). In Yanar & Fenercioglu's (1999) studies, the amounts of 16.67% crude protein, 8.45% lipid, 73.04% moisture and 1.18% ash were found in carp meat, and the amounts of 15.34 crude protein, 6.98 lipid, 75.89 moisture and 1.09 crude ash were discovered in minced meat as percentage. In different study fish fingers were produced from *Carassius gibelio* and evaluated through nutritional parameters. The moisture, crude fat, crude protein and crude ash contents of fish fingers were determined as 56.543 ± 0.113, 10.507 ± 0.116, 15.577 ± 0.382 and 2.027 ± 0.133, respectively (Izci, 2010).

Chemical Changes

The chemical changes of samples fish fingers prepared during storage are displayed in Table 2.

Table 2. Physico/chemical deterioration of samples fish fingers

Parameters	Groups	Storage Days						
		0	**3**	**6**	**9**	**12**	**15**	**18**
pH	**Control**	6.19±0.06^{aA}	6.13±0.01^{aA}	6.47±0.12^{aA}	5.93±0.42^{aA}	5.13±0.18^{bB}	**N.A.**	**N.A**
	1%GB	6.09±0.11^{aA}	6.26±0.03^{aA}	6.35±0.34^{aA}	6.31±0.22^{aA}	6.30±0.23^{aA}	5.86±0.36^{aA}	5.82±0.05^{aA}
	2%GB	6.24±0.04^{abA}	6.54±0.62^{aA}	5.89±0.35^{abA}	6.48±0.35^{aA}	6.46±0.10^{abA}	5.92±0.09^{abA}	5.62±0.05^{bA}
TVB-N	**Control**	8.11±0.13^{dA}	12.92±1.19^{cA}	21.26±0.74^{bA}	24.01±2.24^{bA}	29.19±1.32^{aA}	**N.A.**	**N.A.**
mg/100g	**1%GB**	5.99±1.40^{dAB}	6.04±1.12^{dB}	8.99±0.78^{dB}	14.02±1.22^{cB}	18.37±1.59^{bB}	22.49±1.84^{aA}	26.06±2.76^{aA}
	2%GB	3.76±0.51^{dB}	4.16±0.23^{dB}	5.78±0.59^{dC}	9.75±0.46^{cB}	13.28±2.80^{bB}	15.94±0.5^{abB}	16.94±0.54^{aB}
TBARs	**Control**	1.26±0.08^{dAB}	2.80±0.12^{cA}	3.14±0.11^{cA}	4.31±0.15^{bA}	5.45±0.64^{aA}	**N.A.**	**N.A.**
mgMDA/kg	**1%GB**	1.58±0.08^{cA}	2.31±0.33^{bA}	2.53±0.17^{bB}	3.74±0.12^{aA}	3.76±0.34^{aB}	4.12±0.15^{aA}	4.21±0.16^{aA}
	2%GB	1.09±0.16^{cB}	2.07±0.35^{bA}	2.05±0.10^{bC}	2.35±0.25^{bB}	2.87±0.17^{aB}	3.22±0.04^{aB}	3.14±0.11^{aB}

Note: $^{a, b, c}$ shows the statistical differences between the storage days of the same group. $^{A, B, C}$ indicate the statistical differences between the groups in the same storage period.

Table 3. Microbiological growth in samples of fish fingers log cfu/g.

Parameters	Groups	Storage Days						
		0	**3**	**6**	**9**	**12**	**15**	**18**
TVC	**Control**	2.10±0.06^{aA}	3.16±0.51^{bA}	5.47±0.34^{cA}	5.94±0.43^{cA}	6.40±0.62^{cA}	**N.A.**	**N.A.**
	1%GB	2.09±0.15^{aA}	2.74±0.57^{bA}	3.56±0.47^{cB}	4.27±0.14^{dB}	4.88±0.85^{dAB}	5.85±0.14^{eA}	6.71±0.12^{fA}
	2%GB	2.26±0.02^{aA}	2.45±0.03^{bA}	2.80±0.14^{cB}	3.30±0.42^{cB}	4.27±0.26^{dB}	4.50±0.58^{dA}	4.19±0.15^{dB}
PTC	**Control**	2.13±0.18^{aA}	3.53±0.14^{bA}	6.38±0.60^{cA}	6.27±0.11^{cA}	6.60±0.49^{cA}	**N.A.**	**N.A.**
	1%GB	2.83±0.57^{aA}	2.73±0.67^{aA}	4.33±0.21^{bB}	4.83±0.66^{bAB}	5.59±0.09^{cB}	6.41±0.05^{dA}	8.07±0.16^{eA}
	2%GB	3.16±0.16^{aA}	3.12±0.07^{aA}	3.34±0.19^{aB}	3.59±0.80^{aB}	4.59±0.17^{bC}	4.94±0.66^{bB}	5.64±1.19^{bB}
YMC	**Control**	2.54±0.54^{aA}	3.05±0.14^{aA}	3.39±0.12^{bA}	3.89±0.18^{cA}	5.51±0.33^{dA}	**N.A.**	**N.A.**
	1%GB	2.35±0.21^{aA}	2.64±0.48^{bA}	2.69±0.41^{bAB}	3.01±0.28^{cAB}	3.57±0.60^{cB}	3.92±0.78^{cA}	6.28±0.27^{dA}
	2%GB	1.68±0.13^{aA}	2.67±0.32^{bA}	1.77±0.26^{aB}	2.18±0.31^{cC}	3.33±0.16^{dB}	3.58±0.11^{eA}	4.58±0.59^{fB}

Note: $^{a, b, c}$ shows the statistical differences between the storage days of the same group. $^{A, B, C}$ indicate the statistical differences between the groups in the same storage period.

pH Values

The changes in pH give information about quality of fish products. The average pH of freshness fish muscle is 7.0 (Kyrana et al., 1997). However, postmortem pH can vary from 6.0 to 7.1 depending on some factors such as species, season, and gender (Church, 1998; Simeonidou et al., 1998).

pH values of the control fish finger and the samples with the addition of goji berry extract in certain proportions were determined during the storage at 4°C. These determined values are presented in Table 1.

When the data obtained as a result of the study were analyzed statistically, it was found that the difference of the pH values between the groups end of storage was significant in the simple samples and the samples with the addition of extract ($p<0.05$).

It was reported that pH value increased from 6.25 to 6.48 after 6 days of storage in Sardine meatballs (Kılınç et al., 2008). Similarly, the pH value of anchovy meatballs increased from 6.33 to 6.56 after 10 days of storage. In another study, it was reported that the pH value of anchovy meatballs increased throughout the storage (Turhan et al., 2001). In general, the pH value of fresh fish is stated as 6.0-6.5, consumability limit value as 6.8-7 (Gülyavuz & Ünlüsayın, 1999). Öksüztepe et al. (2010) expressed researchers that the value was found between 6.12 and 6.49 in meatballs of rainbow trout stored at 4±1°C when the effect of sodium lactate addition on the meatballs of Rainbow trout (*Oncorhynchus mykiss* W.) was investigated. In a study conducted by Varlık et al. (2000) in order to determine the shelf life of the marinated fish meatball, the initial pH value of the meatball marinades stored in cold was 4.19, that is, it firstly increased. Then, it decreased depending on the storage duration. In the study on making meatballs from remaining fillets of sander and tench, the pH values of sander and tench meatballs at +4°C were initially determined as 6.16±0.02 and 6.93±0.42, respectively. During the study, the values first decreased and then increased; they were then discovered as 9.12±0.88 and 6.78±0.09 on the 14th day of the study (Ünlüsayın et al., 2002). The pH value of 6.279 was determined in fish fingers obtained from *Carassius gibelio* by Izci (2010). At the end of the storage, the pH values in all the meatball groups were observed between 4.92±0.00-5.56±0.01. In the study investigating the effect of sodium lactate and thymol on meatballs made from mirrored carp, the pH value which was 6.69 on the 0th day dropped to 6.58 on the 6th day. Again, in the other groups with sodium lactate and thymol addition, pH which was initially in the range of 6.58-6.70 decreased in general during the storage (Erol & Ilhak, 2015). The pH values obtained in our study show similarities and differences with the findings in the aforementioned studies. The reasons behind the differences can be attributed to the applied solution proportions, fish species, storage temperature and the extracts used.

TVB-N value

The TVB-N value is used as an indicator of spoilage in aquaculture products. This value increases as a result of the activities of endogenous enzymes and bacteria causing spoilage (Kyrana et al., 1997). In other words, Huss (1995) reports the amount of TVB-N contained in the newly caught fresh fish as 5-20 mg/100g and the acceptable freshness limit value as 30-40 mg/100g. The concentration of TVB-N in freshly caught fish is typically between 5 and 20 mg TVB-N/100 g flesh, whereas levels of 30–35 mg/100 g flesh are generally regarded as the limit of acceptability for iced stored cold-water fish (Connell, 1995).

The high initial content of TVB-N may be attributed to the high level of NPN present in the flesh of gilthead sea bream. Breakdown of low molecular weight nitrogenous compounds occurs under the conditions of analysis, releasing volatile base nitrogen (Perez-Villarreal & Howgate, 1987; Whittle et al., 1990).

When the data (Table 1) obtained in this research were analyzed statistically, in generally the difference between the simple samples and the samples with the addition of goji berry in terms of the TVB-N amount during the storage was found to be significant ($p<0.05$). In addition, the difference between the days of analysis in terms of the amount of TVB-N determined during the storage of the samples was also significant ($p<0.05$).

When the findings were examined, the mean TVB-N value of the control fish finger was discovered as 8.11±0.13mg/100g on the first day. In other fish finger samples prepared with the addition of goji berry, the mean TVB-N value was found as 5.99±1.40 for group 1% GB and 3.76±0.50 mg/100g for group 2% GB. These values increased during the storage time of the samples.

In a study, the TVB-N value, which was found as 11.0 in the 6th month of the storage of the sander meatballs at -18°C, was obtained as 12.0 in fish meatballs with rice (Yanar & Fenercioglu, 1999). In the study conducted on investigating some quality parameters of meatballs made from raw and boiled fish meat, the TVB-N value of meatball samples made from raw anchovy increased depending on the storage duration. 39.33 mg/100 g was obtained on the 18th day of the storage in the 1st experiment, and 36.03 mg/100 g was

discovered on the 15th day of the storage in the 2nd experiment, which means both values exceeded the limit (Akkuş et al., 2004). In the studies executed on making meatballs from remaining Sander and tench fillets, Ünlüsayın et al. (2002) initially found the TVB-N values in sander and tench meatballs as 11.4±1.10 mg/100 g and 11.2±1.14 mg/100 g at +4±1°C, respectively. On the 14th day of the study, 39.6±1.90 mg/100 g and 36.2±1.57 mg/100 g were obtained, respectively. In the study of Varlık et al. (2000), the TVB-N value was initially determined as 10.70 mg/100g in marinated meatballs, which is a sign of fish spoilage, and it was 10.45 mg/100g at the end of the storage. In Erol & Ilhak's (2015) study, the TVB-N value was discovered as 16.27 on the 0th day and 22.87 at the end of the storage in the control group. Again, in the meatball groups with different contents, this value was determined as 15.83-17.83 on the first day and 20.28-23.08 on the last day of the storage. In the study of Öksüztepe et al. (2010), the TVB-N value increased from 8.16 mg/100g to 22.56 mg/100g in the control group. In the other meatball groups, it changed as 7.13-23.65 mg/100g. When the TVB-N values are examined during the storage in our study, there is an increase in all the groups depending on time, and the TVB-N amounts can be said to increase later in meatball groups with extract addition compared to group A. The increases in the TVB-N value were determined to be significant as the storage time passed ($p<0.05$), and the change in the TVB-N values between the groups was found statistically significant ($p<0.01$). When all the groups were compared in terms of TVB-N values during storage days, significant differences were discovered ($p<0.05$). Izci et al. (2011) determined total volatile basic nitrogen (TVB-N) as 6.737±0.012, 19.583±0.087 mg/100 g in fish fingers during frozen storage in their study. Emir Coban (2013) determined the effect of ginger oil (0.5% and 1%) on chemical and sensorial quality and production of fingers from *Sarda sarda*. In this study the amount of TVB-N in fish finger 7.76 mg/100 g was determined. When compared to different studies, these values obtained depending on the storage are similar.

Thiobarbituric Acid (TBARs) Value

When the findings (Table 1) were examined, they were found to increase during the storage. When the data obtained as a result of the study were analyzed statistically, it was found that the difference in the TBARs amounts of the control samples and the samples with extract addition between the groups and days during the storage was significant ($p<0.05$).

The amount of TBARs is an indicator of lipid oxidation and it is another method used to determine the freshness of fish and fish products. The amount of thiobarbituric acid (TBA) may vary depending on fish species, hunting places and methods, storage conditions. The TBA value, which emerges as a result of fat oxidation in aquaculture products and is the index of bitterness, is considered as "good quality" between 1−3 mg MDA/kg, "medium quality" between 3−5 mg MDA/kg, "low quality" between 5–8 mg MDA/kg, and the products exceeding 8 mg MDA/kg is classified as "inconsumable" (Sinnhuber & Yu, 1958; Varlık et al., 2007). In the study conducted on the making fish meatballs from carp meat, the TBA values of the product ranged from 0.8 to 2.2 (mg MDA/kg) at -18±1°C during the storage (Yanar & Fenercioğlu, 1999). In the study conducted on making meatballs from remaining fillets of sander and tench fillets, the TBA values of sander and tench meatballs were initially determined at 4±1°C as 1.71±0.87 mg MDA/kg and 1.41±0.6 mg MDA/kg, respectively. On the 14th day of the study, 9.12±0.88 mg MDA/kg and 8.56±1.23 mg MDA/kg were obtained respectively (Ünlüsayın et al., 2002). Izci et al. (2011) determined total volatile basic nitrogen (TBA) as 0.293±0.013 mgMDA/g in fish fingers during frozen storage in their study. In another study, Can (2012) found the value as 0.79 mg MDA/1000g on the first day and 4.8 mg/100g on the last day in the control group within the storage days, but it was determined as 0.74-0.79 mg/kg on the first day and 1.74 mg MDA/kg-1.79 mg MDA/kg on the last day of the storage in other meatball samples. In our study, increases in TBARs values were determined in all the groups as the storage time passed ($p<0.05$) and significant differences were also observed in all the groups when they were compared within the days of storage ($p<0.05$). In different study was examined the effect of ginger oil (0.5% and 1%) and value TBA in fish finger was found as 0.69 mg MDA/kg (Emir Coban, 2013). In our study, the TBARs values determined during the storage were assessed and found similar to the aforementioned studies. In another study, the value was 0.08 during the storage in the control group, but it varied between 0.06- 0.10 in other carp meatball groups (Erol & Ilhak, 2015). In addition, the TBARs number determined in our study during preservation were lower in goji berry extract groups than in other groups. Its reason can be expressed as the antioxidant effect caused by the components in the extract used. The reason behind the similarities and differences in our findings can be attributed to the applied solutions and their proportions, fish species, storage temperature and the extracts used.

Microbiological Changes

In general, the muscle of a newly caught healthy fish is sterile. Microorganisms are normally found in the skin, gills and intestines of the fish. Depending on the operations, temperature and duration applied after the fish are caught, microorganisms can move to muscle from gills, skin and intestines. As a result, the quality of the product deteriorates depending on the type of the microorganism, so consumers may be exposed to infection or toxicity. Therefore, the number and type of microorganisms in the muscle of the fish are important for health and storage (Gram & Huss, 1996, 2000).

Total viable count (TVC), psychrotrophic bacterial count (PTC), and yeast-mold count (YMC) of the control fish finger and the samples with the addition of goji berry extract in certain proportions were determined during the storage at 4°C. These determined values are presented in Table 3.

Total Viable Count (TVC)

The activity of microorganisms is one of the main factors causing fish spoilage. The total viable counts (TVC) as a traditional and helpful indicator are used to assess the freshness of different kinds of aquatic products. Meanwhile, most of countries have established standards, guidelines, and specifications of fish freshness evaluation based on TVC index with diverse storage conditions of temperature, time, and atmosphere. This indicator is useful for accurate detection of the degree of fish freshness and for predicting the remaining shelf life of fish (Cheng et al., 2015). TVC are taken the 7 log cfu/g as an upper acceptable level for precooked breaded fish (ICMSF, 1986).

In the study TVC of group 2% GB were enumerated as 2.26±0.02 log cfu/g on the first day of the storage, it reached 4.19±0.15 log cfu/g on the 18th day.

An increase was observed in the TVC depending on spoilage throughout the storage. When the data obtained as a result of the study were analyzed statistically, it was determined that the intergroup difference between all the experimental groups in terms of aerobic mesophilic bacteria counts was statistically significant ($p<0.05$).

TVC was determined in our study to exceed the acceptable limit on the 12th day in group control and on the 15th day in groups 1%GB and 2%GB, which were stored at 4°C. In the study conducted on making meatballs from remaining pike perch and tench fillets, TVC of pike perch and tench meatballs were initially determined as 4.0×10^4 cfu/g and 4.2×10^4 cfu/g at +4±1°C, respectively; afterwards, they increased and appeared respectively as 1.2×10^7 cfu/g and 1.4×10^7 cfu/g on the 14th day of the study (Ünlüsayın et al., 2002). Erol & Ilhak (2015) discovered in a study on meatballs that the TVC generally increased during the storage. In the study conducted on the shelf life of anchovy meatballs stored in cold, TVC increased by the storage duration and was determined as 4 log cfu/g (1.0×10^4 cfu/g) at the beginning of storage, reaching 7.76 log cfu/g (5.8×10^7 cfu/g) on the 10th day of the storage (Turhan et al., 2001). In the study investigating some quality parameters of the meatballs made from raw and boiled fish meat, TVC of the meatballs made from raw anchovy increased depending on the storage duration and it was found as 4.8±0.007 log cfu/g in the 1st experiment and 4.6±0.021 log cfu/g in the 2nd experiment at the beginning of the storage, exceeding the limit value by reaching 7.4±0.014 log cfu/g in the 1st experiment and 7.3±0.002 log cfu/g in the 2nd experiment on the 12th day of the storage (Akkuş et al., 2004). In the study where Öksüztepe et al. (2010) investigated the effect on the fresh rainbow trout (*Oncorhynchus mykiss* W.) meatballs prepared with sodium lactate addition, the following levels were reached: 8.83 log cfu/g on the 8th day of the storage in the control group, 8.79 log cfu/g on the 10th day in group A, 8.90 log cfu/g on the 12th day in group B and 8.80 log cfu/g on the 16th day in group C. It can be expressed that these findings are in parallel with our findings. In addition, when we look at the total viable counts determined in our study, it can be seen that herbal extracts have antibacterial effect. When the findings are compared, we can attribute the reason behind some similarities and differences to the differences in the applied solutions and their proportions, fish species, storage temperature and the extracts used.

Psychrotrophic Bacterial Count (PTC)

PTC are the most important group of microorganisms responsible for aerobic spoilage of fresh fish stored at low temperatures (Sallam, 2007). In our study, the counts of psychrophilic bacteria increased in all the groups during the storage depending on time. When the data of psychrotrophic bacterial count obtained as a result of the study were analyzed statistically, the difference between the groups in terms of PTC was not significant in control samples and samples with goji berry addition ($p>0.05$). In addition, the differences between PTC within days during the storage were found significant ($p<0.05$).

In a study conducted on the suitability of tench (*Tinca tinca* L., 1758) for making meatballs and the changes in the nutritional properties after processing, the total PTC load values ranged between 3.99±0.11 log cfu/g and 6.91±0.014 cfu/g

at +4°C. The PTC increased time-dependently. All the samples remained below the limit value (Çapkın, 2008). In the study investigating some quality parameters of the meatballs made from raw and boiled fish meat, the PTC of the meatballs made from raw anchovy increased depending on the storage duration; it was found as 4.0±0.001 log cfu/g in the 1st experiment and 4.5±0.004 log cfu/g in the 2nd experiment at the beginning of the storage, exceeding the limit value by reaching 7.7±0.002 log cfu/g in the 1st experiment and 7.8±0.014 log cfu/g in the 2nd experiment on the 12th day of the storage (Akkuş et al., 2004). Erol & Ilhak (2015) discovered in a study on meatballs that PTC generally increased during the storage. On the 6th day of the storage, the PTC increased above 7 log cfu/g in the control group and groups containing 0.1% thymol and 1% sodium lactate + 0.1% thymol. In the group containing 1% sodium lactate + 0.25% thymol, almost 7 log cfu/g was reached on the 8th day, 7 log cfu/g was exceeded on the 10th day of the storage in the group containing 1% sodium lactate. Similar results were also obtained in this study. It can be stated that the antibacterial effect of goji berry extract used in our study influenced the results.

Yeast & Mold Count (YMC)

YMC are not found in normal flora in fish. They are generally of earth-origin and transmitted from water as soon as they are caught or tools and materials used after catching the fish. In our study YMC of the control fish finger and the samples with goji berry addition determined by incubation at 21°C. The YMC at the end of the storage were determined in samples stored at 4°C as 6.47±0.37 log cfu/g in group control, 4.96±0.69 log cfu/g in group 1%GB and 4.58±0.59 log cfu/g in group 2% GB. When the data obtained as a result of the study were analyzed statistically, the difference between the groups in terms of yeast-mold count during the storage was found to be significant in the control samples and samples with extract addition ($p<0.05$). Erol & Ilhak (2015) discovered in a study on meatballs prepared from mirrored carp that the yeast-mold counts had increases during the storage. Only in the group containing 1% sodium lactate + 0.25% thymol, the yeast-mold count on the 4th day of the storage was slightly lower than the 0th day. In another study, the YMC of fish meatballs obtained from Rainbow trout was determined as 1.56 log cfu/g in the fillet. This number increased in all the groups, including the control, due to the progress of the storage and it was observed to be at the same levels in the other groups except the group C with 2% sodium lactate addition (Öksüztepe et al., 2010). In terms of the YMC, the effect of storage duration on all groups was found to be statistically significant ($p<0.05$). In our study, when the change in YMC during the storage was examined considering the antimicrobial properties of goji berry, the difference in group B and C with extract addition is seen compared to the control group.

Sensory Evaluation

During the sensory evaluation of the control fish finger samples and samples prepared with the addition of goji berry extract in different proportions, the appreciation of the samples' the color, smell, appearance, taste and texture were evaluated by 10 panelists using the hedonic scale. Throughout the storage, the panelists evaluated the control (without the addition of goji berry extract) fish finger samples and the samples with the addition of goji berry extract, which were made ready for consumption, according to their color, smell, appearance, taste and texture. The data obtained as a result of the panelists scoring were evaluated and the change in the general appreciation levels of the samples during the storage were presented. The sample of group A lost its consumability on the 12th day of the storage and the samples of group B and C with fish finger samples containing extract on the 18th day; samples were not included in the analysis.

Overall Acceptability

Overall acceptability of group control, 1% GB and 2% GB in term of storage days (0th, 3rd, 6th, 9th, 12nd and 15th) are given in Figure 1.

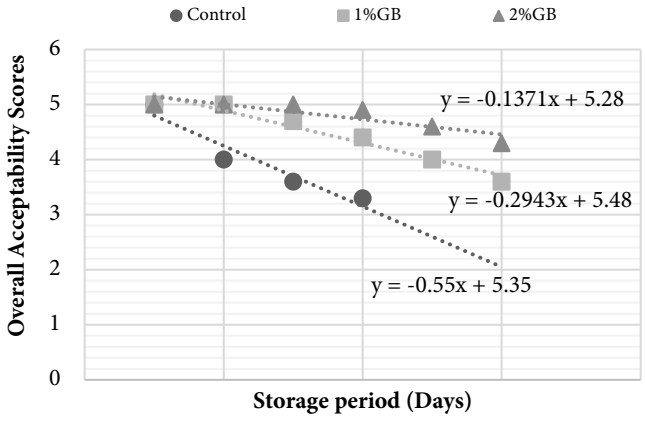

Figure 1. Regression of storage time equation for total acceptability of fish finger samples. Linear regression plot with time

It was found that the effect of groups and duration on the overall acceptability level of the samples' during storage was significant ($p<0.05$).

In terms of the overall acceptability scores in the evaluation between the groups, there was no statistically significant

difference between the groups on the 0th day ($p>0.05$) while the difference between the control group and the groups with coating was significant during storage ($p<0.05$).

When the data obtained as a result of the study were analyzed statistically, it was found that the difference between the groups in terms of the general appreciation level of the control group A and group C sample from samples (group B and C) containing goji berry extract was significant ($p<0.05$).

The sensory analysis used when purchasing any food product is the first method, we apply to determine the freshness of the product. It is widely used in determining the quality of foods because it gives fast results. Chemical, microbiological and physical analyses are associated with sensory analyses in determining the shelf life.

Although physical, chemical and microbiological analyses used to determine the freshness level of the fish can significantly evaluate the shelf life, sensory analyses have a much more important place in consumption, because people make use of sensory analyses instead of experiments organized under laboratory conditions when deciding on consuming a food.

As a result of the sensory analyses on the products prepared in the research, a major part of the panelists liked the fish finger samples very much. In terms of the examined fish finger samples, group B and C received higher scores due to some specific physical properties of the goji berry extract.

Conclusion

The results obtained from this study showed that goji berry extract prolongs the shelf life of food. The use of goji berry extract in the food industry will contribute to the shelf life of the products in a positive way. The results show that fish fingers prepared with goji berry addition can contribute to the national economy.

Now, the positive effect of fish consumption on human health is known through scientific studies conducted in various fields. Increasing fish consumption in our country is an important matter for both economy and health. Countries that are aware of balanced nutrition are looking for new products which will satisfy the consumer in sensory terms in order to further enrich the protein sources and can be prepared easily, and they make investments accordingly. Although the consumption of fish is low in our country, the consumption form of fresh fish is limited to a few cooking methods. In this study, fish finger was prepared with mirror carp as a ready-to-use product. As it is understood from the sensory data, the product prepared in the study was highly appreciated by the panelists and the appreciation continued during the storage duration.

With this study, it is possible to express that the shelf life can be extended through natural extracts without the use of chemical additives, which are used to prolong the duration of lasting that can also be defined as the shelf life of the food, and if used unconsciously, threaten the consumer health.

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Compliance With Ethical Standards

Authors' Contributions

AGI: Designing, draft checking, editing
BLMA: Analyzing, writing
Both authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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