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Investigating the effect of chitosan-chia seed gum coating on some chemical, microbial and sensory properties of Phytophagous fish (*Hypophthalmichthys molitrix*) during storage at refrigerator temperature

Mehrnoush Ebrahimi Valadani[a], Maryam Yousefpour[b,*], Mahshid Shamloofar[c], Shadi Mehdikhani[d]

a: ph.D. Student, Department of Food science & Technology, Nour Branch, Islamic Azad University, Nour, Iran

b: Assistant Professor, Department of Food Science& Technology, Nour Branch, Islamic Azad University, Nour, Iran

c: Assistant Professor, Department of Fisheries, Azadshahr Branch, Islamic Azad University, Azadshahr, Iran

d: Assistant Professor, Department of Food Science & Technology, Shahre-e-Qods Branch, Islamic Azad University ,**Tehran, Iran**

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*Corresponding Author E-

ABSTRACT

One of the main concerns in the production and processing of fishery products is the issue of storage and increasing its shelf life. In this regard, this study aims to investigate the effect of chitosan-chia seed gum coating (2% and 1.5% of the sample weight, respectively) on some chemical properties (the amount of free fatty acids, peroxide, thiobarbituric acid index, volatile nitrogenous bases and pH). , microbial (number of Escherichia coli bacteria) and sensory of phytophagous fish during storage period (0, 3, 6, 9 and 12 days) was done at refrigerator temperature. The results showed that the amount of free fatty acids, peroxide, thiobarbituric index, volatile nitrogenous bases and the number of Escherichia coli bacteria in all the samples increased with the increase in storage time, and this increase was less intense in the samples coated with chitosan-chia seed gum solution. The findings indicated that with increasing storage time, the pH level increased in the uncoated samples, but in the coated samples, the pH level decreased at first and then increased. The sensory evaluation of the samples also revealed that the overall acceptance of the samples decreased with the increase in storage time and after the third day of storage, the coated samples received more points than the uncoated samples from the evaluators. Finally, this study showed that the use of chitosan-chia seed gum coating can help increase the shelf life of fish fillets in the refrigerator.

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1. Introduction

Fish has the ability to compete with other foods in terms of good digestibility, high content of unsaturated fatty acids with multiple double bonds, as well as its amino acid profile. However, due to having relatively high fat and protein, neutral pH, and the presence of autolytic enzymes, fish has a high potential for chemical and microbial spoilage. Therefore, one of the main concerns in the production and processing of fishery products is the issue of maintaining and increasing its shelf life. [1]. Phytophagous fish with English name Silver carp and scientific name *Hypophthalmichthys molitrix*, is one of the most important species of tropical fish, which is considered to be the dominant species in the composition of cultivated tropical fish due to its fast growth ability, wide adaptability and delicious meat. The results of the analysis of chemical compounds in 100 grams of silver carp (phytophag fish) sample include 74% moisture, 1.3% total fat, 17.13% total protein and 2.44% ash. [2]. Bacterial growth is one of the main reasons for the spoilage of meat and meat products, which causes adverse changes in these products, and as a result, causes food poisoning and consumer deaths, as well as significant economic losses. [3]. In order to delay the spoilage of fish and its products, several solutions have been proposed, including temperature control and reduction, packaging in a modified atmosphere, coating, and the use of antioxidants. Edible coatings are a thin layer of edible material that is in liquid form and is placed on it as a coating by dipping, waxing and spraying. These coatings with the origin of polysaccharide, protein and fat can increase the shelf life of food products, because they act as a barrier against the transfer of moisture, gases and soluble substances. Also, these covers are very popular among consumers due to their biodegradable nature [4]. Chitosan is the second most important polysaccharide after cellulose in terms of abundance in nature. Chitosan, which consists of glucosamine and N-acetyl glucosamine units (with beta 1 and 4 connections), which is prepared by deacetylation of chitin. The main and commercial source of chitin is the shell of crustaceans such as crab, shrimp, lobster and artemia. Due to its anti-bacterial and anti-mold properties, chitosan is widely used in the preparation of edible films and coatings. Also, the presence of fatty acids in chitosan increases its antimicrobial properties. In addition to its antimicrobial properties, it has biodegradable, practical and environmentally friendly properties. Chitosan has a high potential for use in the food industry [5]. Among the researchers who used chitosan to cover meat products, we can mention Souza et al. (2010) on salmon, Ahangar et al. (2020) for elephant fish fillet, Kamani et al. (2020) on rainbow trout fillet. [6, 7 and 8]. However, pure chitosan coatings alone do not show good mechanical properties, resistance to moisture and good appearance characteristics. Also, the high price of chitosan compared to other biopolymers has led to finding a suitable solution for these coatings. Mixing chitosan with other polymers or resins can be a good way to improve its properties. [9]. Chia seeds with scientific name *Spanish sage L.* It is a plant belonging to the mint family, which contains 5% mucilage and can act as soluble fiber. Today, chia seeds, as a rich source of nutrients and biological additives, are considered one of the favorite seeds in food industry technology and are commercially grown and marketed in the countries of the American continent. In 2009, the European Union approved chia as a new food and added it up to 5% to bread formulation. [10]. On the other hand, chia seeds are a rich source of synergistic and main antioxidants such as flavonols, chlorogenic acid, caffeic acid, myrstein, quercetin, kaempferol as well as natural antioxidants such as tocopherols, phytosterols, carotenoids. have [11]. Among the researchers who used chia seed gum mucilage to coat meat products, we can refer to Akhwan Siasipour Fomeni et al. (2022) (chicken meat coating), Amiri et al. used for sea bass, pointed out [12, 13 and 14]. According to the contents in this section, the purpose of this study was to investigate the effect of chitosan-chia gum

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coating on some chemical and microbial properties of Phytophag fish fillet.

2- Materials and methods

1-2- Raw material

Phytophag fish purchased from the local market of Noor city were transported to the laboratory for filleting in insulated containers, in the vicinity of ice storage, and in polyethylene bags. The chia seed used was also obtained from one of the reliable attari, and chitosan with a degree of dissolution of 75-85% and a molecular weight of 760 kilodaltons was purchased from Merck.*Shershyaikli* 2019: PTCC were prepared from Iran Scientific and Industrial Research Center.

2-2- Preparation A solution of chia seed gum and chitosan

Chia seeds were added in a ratio of 40 units to 1 unit of distilled water (the desired ratio was chosen based on the research done by other researchers). Stirring was done for two hours at a temperature of 80°C and a constant pH below 8, and then a centrifuge (Thermo, Japan) was used at a temperature of 20°C for a period of 20 minutes. Supernatants (mucilage) were transferred to high-density polyethylene bags and then stored at 4°C until use. [15]. Chitosan solution was also obtained by dissolving 2% by weight/volume of chitosan in 1% by volume/volume of acetic acid. For better dissolution of chitosan, the solution was stirred for 3 hours at room temperature with a magnetic stirrer (Agimatic-E, Spain) and to prepare a 2% weight-volume solution of chitosan coating, first 20 grams of chitosan powder was added to one liter of distilled water and Stirring was done at a speed of 1200 revolutions per minute and then it was heated at 70 degrees Celsius for 30 minutes. Chia gum solution at 1.5% by weight was prepared by dissolving the gum in distilled water and vigorously stirring at a speed of 1200 rpm with a magnetic stirrer for 24 hours at ambient temperature. In the next step, 200 milliliters of chitosan solution was slowly added to the gum solution and stirring continued for 4 hours. [6 and 7].

2-3- Preparation of tested samples

First, the body surface of the fish was disinfected with 70% alcohol, and with the help of a scalpel, after emptying the intestines and viscera, skinning was done under a laminar hood. To reduce the microbial load to zero, meat samples were treated with KGy intensity gamma rays 8 were irradiated. Then, Phytofag fish fillet Butterflies were prepared and cut into pieces of 5 x 5 square centimeters in order to cover them with the combination of chitosan (2%) and chia seed gum (1.5%). (The reason for choosing 2% chitosan and 1.5% gum was based on the studies conducted by other researchers and also the error test) [12 and 16].

2-4- Measurement of free fatty acids

To measure free fatty acids from the method AOCS Cd 3–63 [1](1993) was used. First, 5 grams of oil were mixed with 20-30 ml of ethanol or other neutral alcohol and titrated by adding a few drops of phenolphthalein with a 0.1 normal solution until a pink color appeared. The amount of free fatty acids was obtained from equation 1.

Relationship 1) $$A = \frac{2/82 \times IN}{IN}$$

In the above relation, IN: The amount of profit consumed in milliliters, IN sample weight in grams, A Free fatty acids in terms of oleic acid per 100 grams of sample [17].

2-5- Determining the peroxide value

The amount of peroxide of the samples according to the method AOCS Cd 8–53 (1993), was measured. 5 grams of oil in a 250 ml Erlenmeyer flask and 50 ml of glacial acetic acid and isooctane solvent were added to it, and after stirring, 0.5 ml of saturated potassium iodide solution was added to it and left in the dark for 1 minute. 100 ml of distilled water was added to the resulting solution and slowly titrated with 0.01 normal sodium thiosulfate and the titration continued until the yellow color disappeared. Then 0.5 ml of starch detection reagent was added and the titration continued until the blue color disappeared and the amount of peroxide was obtained from equation 2.

relationship 2) $$P = \frac{(V-V0).\ C.\ F \times 100}{m}$$

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In equation 2, V is the volume of sodium thiosulfate solution used in milliliters, V_0 The volume of sodium thiosulfate solution used in milliliters for the control sample, C is the concentration of sodium thiosulfate solution in moles per liter, F is the normal sodium thiosulfate solution factor of 0.01, m is the oil weight in grams, and P is the oil peroxide in milliequivalents of oxygen per kilogram. It is an example [17].

6-2- Measurement of thiobarbituric acid index

This index shows the amount of milligrams of malonaldehyde in one kilogram of sample and indicates the secondary stages of fat oxidation and the presence of secondary oxidation compounds in the sample. To measure this index, one gram of sample, one milliliter of 0.75% thiobarbituric acid solution and 2 milliliters of 35% trichloroacetic acid solution were added in a 250 ml Erlenmeyer flask. The resulting mixture was placed in a boiling water bath for 20 minutes. Then the resulting mixture was centrifuged for 3 minutes at a speed of 3000 rpm. The aqueous phase was removed with a syringe and transferred to the spectrophotometer cell. The absorbance of the sample was read with a spectrophotometer (Biochrome, England) at a wavelength of 532 nm and considered as an indicator of thiobarbituric acid. [18].

7-2- Measurement of total volatile nitrogenous bases

This test is done by the Kjeldahl method by placing 10 grams of mixed fish fillets in 50 ml of distilled water and 2 grams of magnesium oxide as a catalyst, 2 drops of octanol as an antifoam and finally 300 ml of distilled water into a Kjeldahl flask (autoanalyzer, Denmark). Started. Then the Kjeldahl system was installed and under the outlet pipe of the system, Erlene containing 25 ml of 3% boric acid, 0.04 ml of methyl red and methylene blue mixture was poured as an indicator so that the end of the outlet pipe was completely inside the Erlene solution. Boiling the contents of the Kjeldahl flask and distilling the emitted gases, which represent volatile nitrogen bases, continued until the volume of the flask reached 125 ml and the color of the solution changed to green, and then it was titrated with 0.1 normal hydrochloric acid until a pink color was obtained. By putting the amount of acid used for titration in equation 3, volatile nitrogen loads were calculated in terms of milligrams of nitrogen per 100 grams of fish sample. [19].

Equation 3) Weight of the sample / (100 x 4.1 x the amount of hydrochloric acid consumed) = TVB-N

8-2- pH measurement

5 grams of each fish sample was added to 45 milliliters of distilled water and placed in a blender for 30 seconds. Then the pH of the samples was measured with a digital pH meter (Hi2211, USA) which was calibrated with 4 and 7 buffers. [20].

2-9- Counting Escherichia coli bacteria

to count *Escherichia coli* ECC chrome agar culture medium was used. To count bacteria at each sampling time, 5 grams of sample was added to 45 ml of physiological serum and then homogenized. Depending on the sample type, dilutions range from $^{2-}$10 to $^{4-}$There were 10 variables. 0.1 ml of the diluted sample was placed on ECC chrome agar surface culture medium and kept in a hot house at 44 degrees Celsius for 24 hours. 3 replicates were considered for each treatment, which were selected and counted after cultivation in standard plates. Because the purpose of counting the inoculated bacteria from *Ashershiakoli* It is in fish fillet, this environment will be very suitable. The purpose of using ECC chrome agar medium is to detect blue-green bacteria in less than 48 hours, which indicates *Ashershiakoli* are, is [21].

10-2- General acceptance

The sensory quality of the produced samples was evaluated with the help of 15 semi-trained evaluators simultaneously, using the graphic rating scale method. The basis for the selection of evaluators was physical health, having natural teeth, not smoking, not having allergies, and not having a strong desire to consume the examined foodstuff, and correctly identifying the color, smell, taste, and overall acceptance of fish fillet. Before conducting the test, the necessary training about general acceptance was given to the evaluator. Fresh water was made available to the evaluators to drink between each diagnostic step. For evaluation, the samples are fried using

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sunflower oil at a temperature of 170 degrees and then examined. [22].

2-11-Statistical Analysis

Data analysis was done in the form of factorial experiments and a simple completely randomized design with three replications. from the software SAS To analyze the data, Duncan's multiple range test was used at the 5% level to compare the mean of the data and to draw graphs using Excel 2007 software.

3. Results and Discussion

1-3- The effect of the studied parameters on the amount of free fatty acids

The results showed that the amount of free fatty acids in both control and coated samples increased with the increase in storage time, but the use of coating led to a decrease in the acidity of the samples compared to the control sample (Figure 1). The reason for the reduction of free fatty acids can be attributed to the reduction of water loss from the surface and inside of the fish body, preventing the contact of oxygen with the fish tissue and its combination with unsaturated fatty acids, and as a result, reducing the rate of oxidation and the lack of light reaching the surface of the fish body. gave [23 and 24]. After the death of fish, fat hydrolyzing enzymes can increase the amount of free fatty acids over time. Therefore, the measurement of free fatty acids can be considered as a good indicator to express the effect of lipolytic enzymes on fish fat and other meat products. [25]. On the other hand, free fatty acids are known as the cause of spoilage because they react with protein and cause protein denaturation and tissue changes. [26]. Pour Kargar and Rafati (2020) stated in line with the results of this section that with the increase in storage time, the amount of free fatty acids of rainbow trout increases during storage at refrigerator temperature. Chitosan coating led to the reduction of this index due to limiting the oxygen access of fish fillets [27]. The results of this section were consistent with the results of Ajaq et al. (2014) who investigated the effect of chitosan coating containing cinnamon essential oil on fish fillet. [28]. Akhwan Siasipour et al. (2022) also showed that the use of chia seed gum mucilage along with zinc oxide led to a decrease in the amount of free fatty acids in chicken fillets. [12].

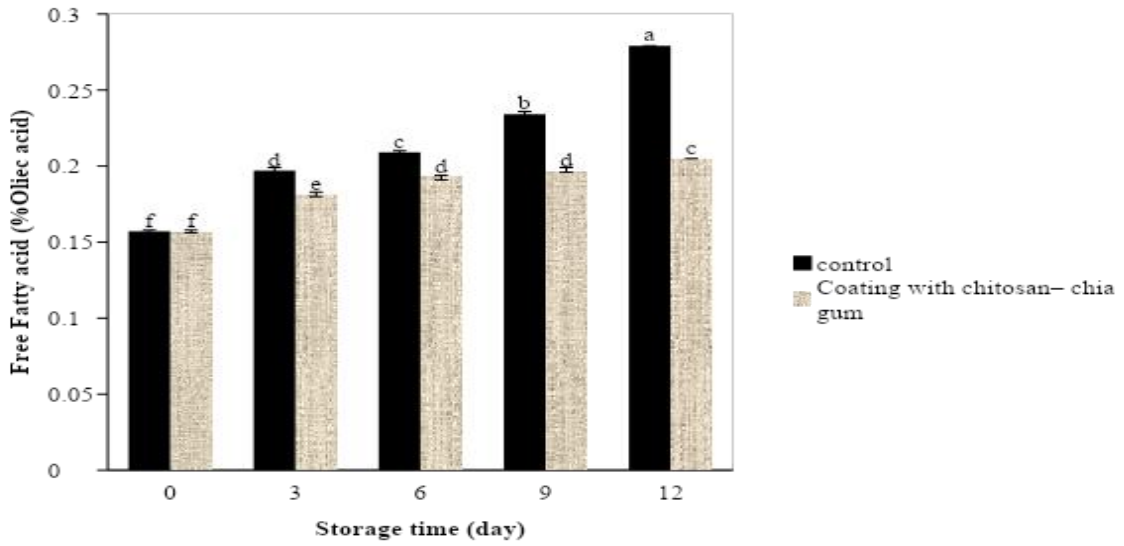

Figure 1- The effect of coating type and storage time on the amount of free fatty acids

2-3- The effect of the coating used and storage time on the amount of peroxide of the samples

The analysis of the data obtained from the measurement of the peroxide of the samples showed that the investigated parameters (storage time and type of coating) had a significant effect on the amount of peroxide of the samples at the level of 5%. On the other hand, the results showed that with increasing storage time, the amount of peroxide in the samples increased, and this amount increased less in the samples coated with chitosan-chia seed gum. In general, with

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the increase of the storage period, the oxidation process of lipids is done and the amount of peroxide increases. When the amount of fish hydroperoxide decreases, the rate of formation of these compounds is faster than their breakdown. At such a time, based on a molecular mechanism, the amount of peroxide in fish muscles starts to rise. With the passage of time and the increase in the concentration of hydroperoxides, based on the bimolecular mechanism, these compounds break down quickly. It is worth noting that at this stage, the speed of their decomposition is faster than the speed of formation [29]. Research has shown that fat oxidation in fish and its products is reduced by using chitosan [30 and 31]. Toloi et al. (2012) investigated the effect of chitosan coating enriched with alpha-tocopherol on the oxidative spoilage of farmed salmon during the storage period in the refrigerator and showed that the use of the coating led to the reduction of peroxide in the samples. [32]. Fan et al. (2009) considered the reduction of primary compounds resulting from oxidation in coated treatments compared to uncoated treatments to be due to the binding of chitosan with iron contained in iron-containing proteins in fish and preventing the production of free radicals. [32]. Akhwan Siasi Pour Fomeni et al. (2022) also reported a decrease in the amount of peroxide when using chia seed mucilage as a coating for chicken fillets, which was in line with the results of this section. [20].

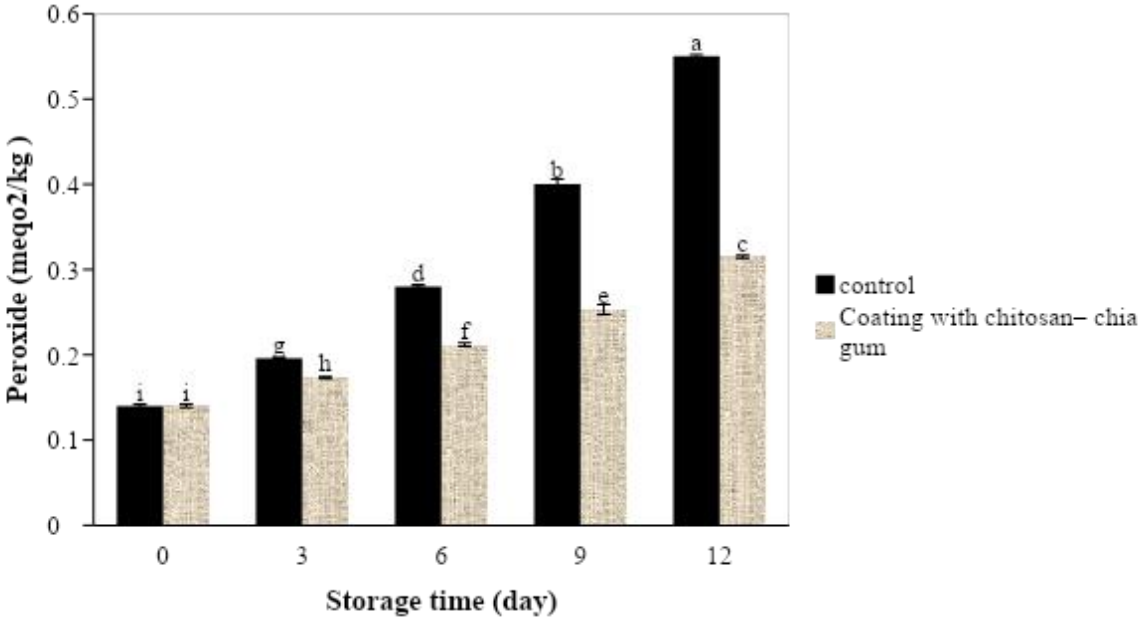

Figure 2- The effect of coating type and storage time on the peroxide

3-3- The effect of the coating used and storage time on the index of thiobarbituric acid

Sometimes, due to the spread of oil spoilage, the primary oxidation products such as hydroperoxides are decomposed into aldehydes and ketones and the peroxide value decreases, so the thiobarbituric acid test is performed to detect and measure secondary oxidation products such as aldehydes and ketones. Malon aldehyde is an aldehyde that is mainly formed by the decomposition of polyunsaturated fatty acids. In the measurement of thiobarbituric acid index, malonaldehyde reacts with thiobarbituric acid. Therefore, the amount of thiobarbituric increases during oxidation [33].. The results showed that the maximum amount of thiobarbituric acid index of the samples (0.69 mg of malonaldehyde/kg sample) was related to the uncoated sample after 12 days of storage in the refrigerator, and except for the first day of production, all coated samples had lower thiobarbituric acid index than The samples had no coating, and

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with the passage of storage time, the amount of this index increased (Figure 3). PThe fact that this index is present in the treatment containing the coating can be seen as preventing the coating on the surface of the fillet as a barrier between the fillet and the surrounding air and reducing the speed of oxygen diffusion through the creation of a strong polymer by the coatings used and limiting the reaction on the surface of the fillet. Also, the effect of chitosan takes place by inhibiting ferrous ions by chelating them, by preventing the activity of peroxides and delaying their exchange [30].. The results of Lee et al. (2012) and Jerjani et al. (2018) also confirm the results of this research, which indicates the positive effect of chitosan coating in reducing bacterial enzyme reactions related to fat oxidation. [29 and 34]. The results of this section with the findings Akhwan Siasipour Fomeni et al. (2022) and Amiri et al. (2021) were consistent.[12 and 13

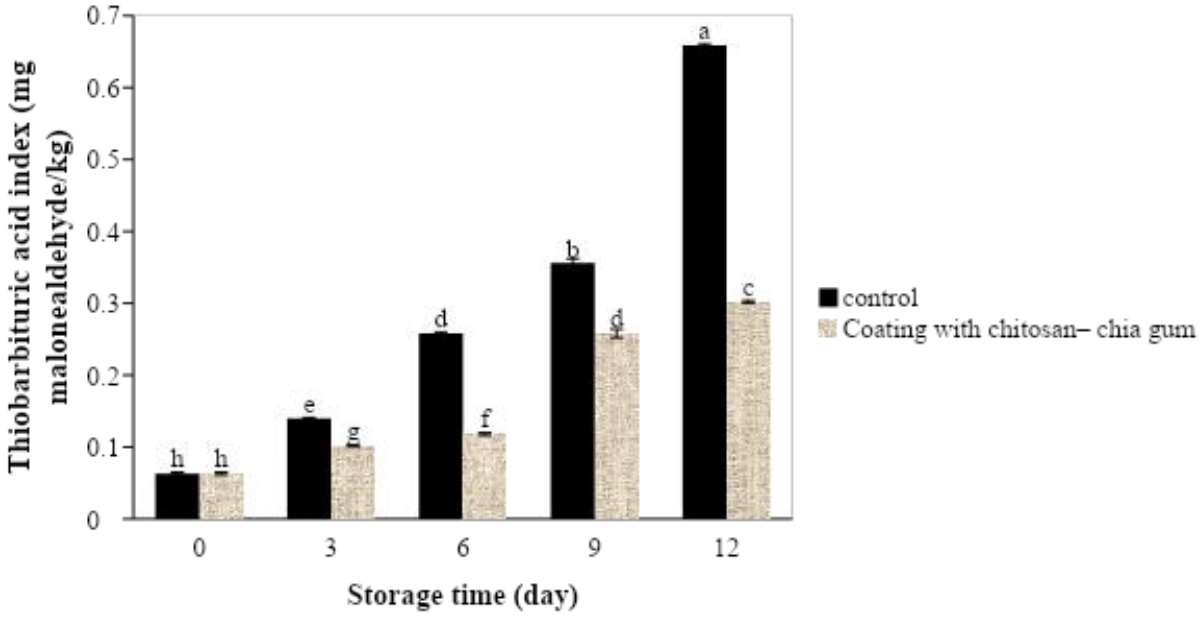

Figure 3- The effect of coating type and storage time on the thiobarbituric acid

4-3- The effect of the coating used and storage time on the index of volatile nitrogen bases

The results shown in Figure 4 showed that the amount of volatile nitrogenous bases increased with the increase in storage time, and the use of coating led to a decrease in the rate of this increase. The total index of volatile nitrogenous bases is considered as one of the main indicators of degradation, decomposition and quality determination of seafood, which includes trimethylamine (produced by bacterial spoilage), dimethylamine (produced by autoleptic enzymes during storage), ammonia (produced by deamination of amino acids and nucleotides) and other volatile basic nitrogen compounds are associated with spoilage of marine products.]35[. The highest acceptable level of volatile nitrogenous bases in fish meat has been suggested as 25 mg of nitrogen per 100 g of sample.]36[. Volpe et al. (2015) stated that the use of edible coatings on the surface of fish fillets due to the reduction of bacterial growth and the introduction of oxygen leads to a reduction in the amount of volatile nitrogenous bases.]37[. The findings of Pourkarger and Rafati (2020) were also in line with the results of this section]27[.

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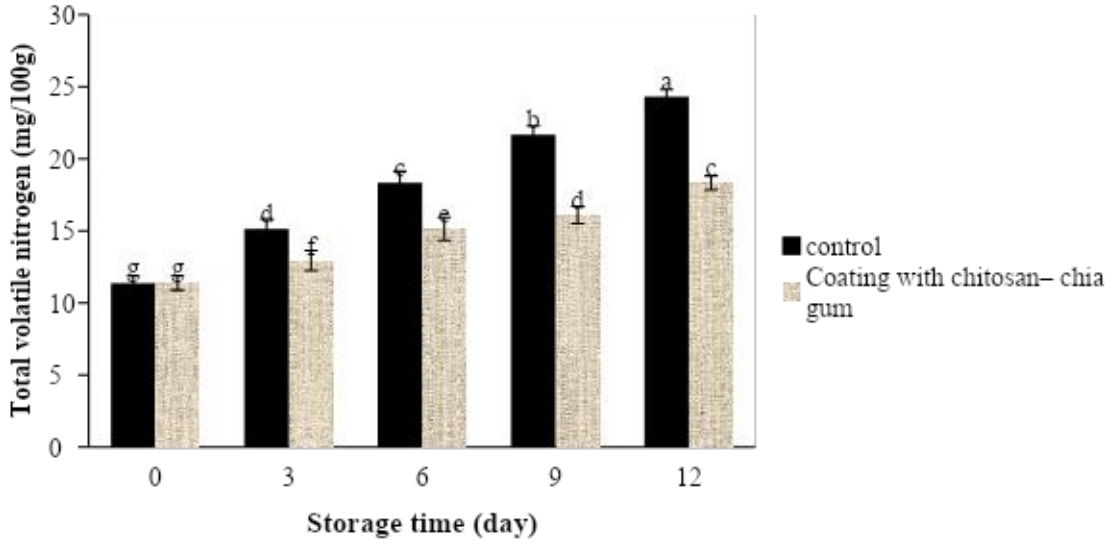

Figure 4- The effect of coating type and storage time on the total volatile nitrogen

5-3- The effect of the coating used and storage time on the pH level

The results showed that with increasing storage time, the amount pH It increased in uncoated samples, while in coated samples, the amount pH At first it decreased and then increased (Figure 5). you et al. (2017) and Motamedian et al (2022) showed that the use of chitosan coating in meat samples due to the acidic coating of chitosan (4.63-4.58) caused a slight decrease in the amount pH During the storage period, it is compared to the uncoated samples, which was consistent with the results of this section [16 and 38]. Increase The pH of samples with increasing storage time can also be attributed to the activity of autolytic enzymes and proteolytic bacteria of fish.]39[. Lato et al. (2014) considered the main reason for the increase in pH in raw chicken meat at refrigerator temperature to be the production of alkaline compounds such as ammonia and trimethylamine, which are caused by the breakdown of meat proteins by microorganisms, microbial proteins, and the activity of microbial and endogenous enzymes.]40[. In general, the pH of live fish muscle is close to 7, which changes from 6 to 7 after death based on the season, species and other factors.]41[. Motamedian et al. (2022) used three percentage levels of chitosan (0.5, 1.25 and 2%) and three storage times (1, 11 and 21 days) in order to investigate the process of coating perch fish fillet with chitosan, the results of this study It showed that the pH of the samples decreased with the increase of chitosan percentage, but it increased with the increase of the storage time] 16[.

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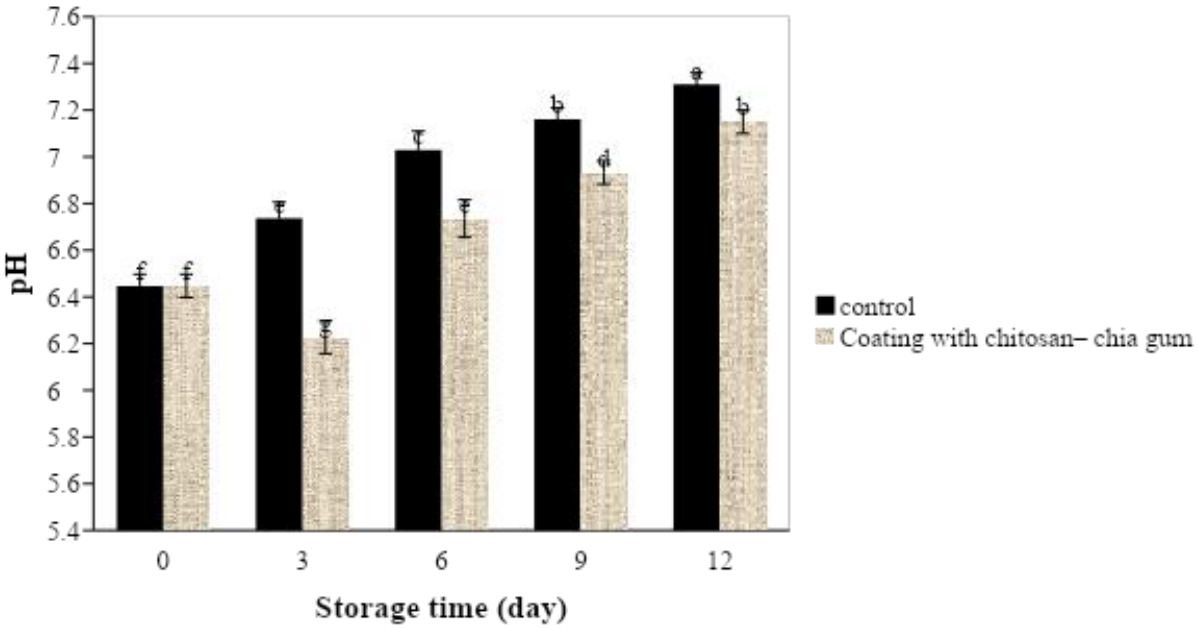

Figure 5- The effect of coating type and storage time on the pH

6-3- The effect of the coating used and storage time on the number of bacteria *Escherichia coli*

Figure 6 showed that with increasing storage time in all samples, the number of bacteria *Escherichia coli* increased, and this increase was more intense in uncoated samples. Chitosan, having a wide range of antibacterial activities, shows different inhibitory efficiency against fungi, Gram-positive and negative bacteria. The antibacterial effect of chitosan is due to the presence of positively charged amine groups that bond with negatively charged macromolecules on the surface of the bacterial cell and lead to the rupture of the bacterial cell membrane, leakage of intracellular substances, and eventually its death. In addition, its function can be as a barrier against the penetration of oxygen]31[. Several factors affect the antibacterial activity of chitosan. Although its exact mechanism is not yet clearly defined, different opinions have been given for it. Some have attributed this effect of chitosan to the presence of positively charged amine groups that bond with large negatively charged molecules on the surface of the microbial cell and lead to the rupture of the bacterial cell membrane, the leakage of intracellular substances and finally its death.]42[. In addition, chitosan can scratch the lipopolysaccharide layer of the bacterial outer membrane or act as a barrier against oxygen penetration.]30[. The observations of this research are consistent with the observations of Doan et al. (2007).]43[. These researchers reported that the use of chitosan coating in fish significantly reduced the count of aerobic and cold-loving mesophilic bacteria during cold storage. Akhwan Siasipour et al. (2022) stated that the sample covered with chia seed mucilage led to a decrease in the microbial load of the samples, which was in line with the results of this study.]12[.

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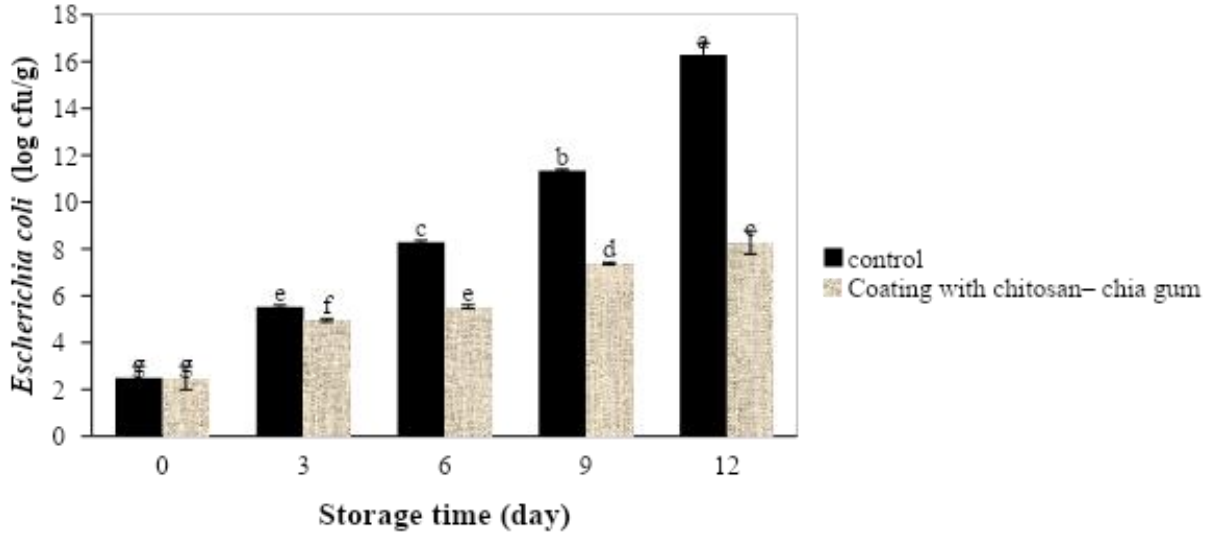

Figure 6- The effect of coating type and storage time on the *Escherichia coli*

7-3- The effect of the coating used and storage time on the overall acceptance of the samples

The results shown in Figure 7 showed that with the increase in storage time, the overall acceptance of the samples decreased and also the range of changes for the points obtained for the overall acceptance was from 1.00 to 5.00 and after the third day of storage of the coated samples, They got more points from the evaluators than the sample without coverage. Volatile nitrogenous compounds and the end products of fat oxidation (hydroperoxides, aldehydes, ketones and fatty acids) change the smell, taste, color and food value and quality and cause fish to be undesired.]44[. Creating antimicrobial and antioxidant properties as well as creating a protective layer against oxygen leads to increasing the storage period and maintaining the quality of fillets.]4[. Motamedian et al. (2022) also stated that increasing the storage time leads to a decrease in the overall acceptance of samples.]16[.

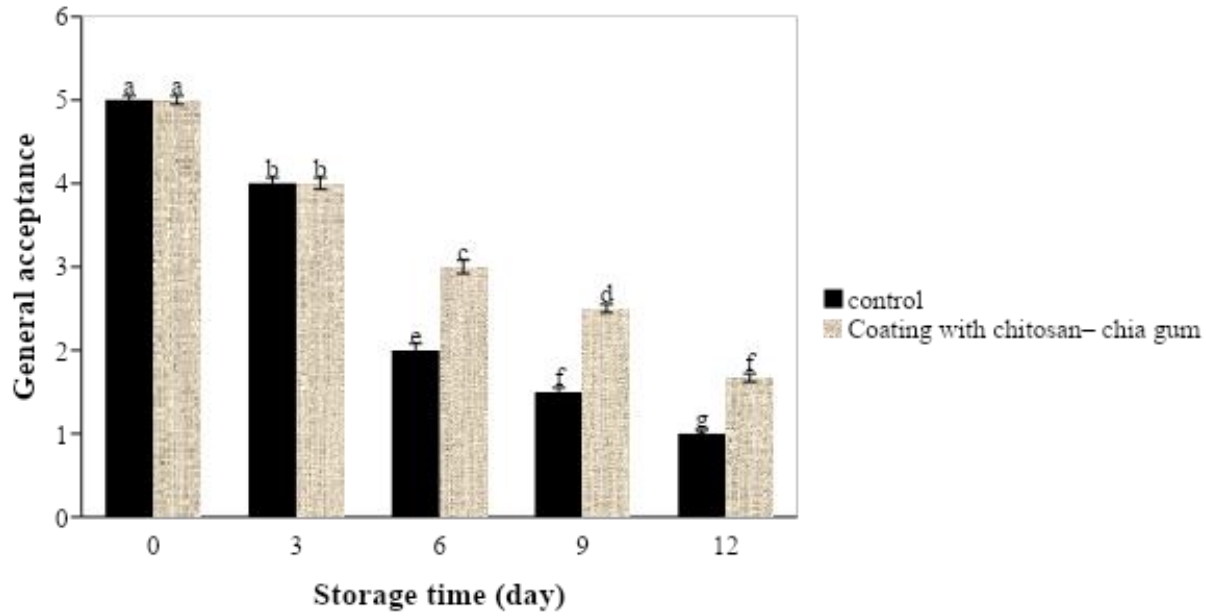

Figure 7- The effect of coating type and storage time on the *general acceptance*

4- General conclusion

Since bacterial growth and chemical spoilage are the main causes of spoilage of meat and meat products, which may cause food poisoning and the death of consumers, as well as cause significant economic losses,

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this study showed that the use of chitosan coating Chia seed gum can help increase the shelf life of fish fillets in the refrigerator. On the other hand, the results showed that the use of this coating led to a decrease in free fatty acids, thiobarbituric acid index, peroxide and the number of bacteria compared to the uncoated sample.

5- Resources

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مقاله علمی_پژوهشی

بررسی تاثیر پوشش کیتوزان – صمغ دانه چیا بر برخی از خواص شیمیایی، میکروبی و حسی ماهی فیتوفاگ (*Hypophthalmichthys molitrix*) طی مدت نگهداری در دمای یخچال

مهرنوش ابراهیمی ولدانی[a]، مریم یوسف پور*[b]، مهشید شاملوفر[c]، شادی مهدیخانی[d]

a: دانشجوی دکتری گروه علوم و صنایع غذایی، واحد نور، دانشگاه آزاد اسلامی ، نور، ایران

b: استادیار گروه علوم و صنایع غذایی، واحد نور، دانشگاه آزاد اسلامی، نور، ایران

c: استادیار گروه شیلات، واحد آزاد شهر، دانشگاه آزاد اسلامی، آزاد شهر، ایران

d: استادیارگروه علوم و صنایع غذایی ، واحد شهرقدس، دانشگاه آزاد اسلامی ، تهران ، ایران

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* مسئول مکاتبات:

چکیده

یکی از دغدغه‌های اصلی در تولید و فرآوری محصولات شیلاتی مسئله نگهداری و افزایش زمان ماندگاری آن می‌باشد. در همین راستا این مطالعه با هدف بررسی تاثیر پوشش کیتوزان– صمغ دانه چیا (به‌ترتیب به‌میزان ۲ و ۱/۵ درصد وزن نمونه) بر برخی از خصوصیات شیمیایی (میزان اسیدهای چرب آزاد، پراکسید، شاخص تیوباربیتوریک اسید، بازهای نیتروژنی فرار و pH)، میکروبی (تعداد باکتری‌های *اشرشیا کلی*) و حسی ماهی فیتوفاگ طی مدت زمان نگهداری (۰، ۳، ٦، ۹ و ۱۲ روز) در دمای یخچال صورت پذیرفت. نتایج نشان داد که با افزایش زمان نگهداری میزان اسیدهای چرب آزاد، پراکسید، شاخص تیوباربیتوریک، بازهای نیتروژنی فرار و تعداد باکتری‌های *اشرشیاکلی* تمامی نمونه‌ها افزایش یافت که این افزایش در نمونه‌های پوشش داده شده با محلول کیتوزان– صمغ دانه چیا، شدت کمتری داشت. یافته‌ها حاکی از آن بود که با افزایش زمان نگهداری، میزان pH در نمونه‌های فاقد پوشش افزایش یافت ولی در نمونه‌های پوشش داده شده میزان pH در ابتدا کاهش و سپس افزایش یافت. ارزیابی حسی نمونه‌ها نیز مشخص نمود که با افزایش زمان نگهداری پذیرش کلی نمونه‌ها کاهش یافت و بعد از روز سوم نگهداری نمونه‌های پوشش داده شده، امتیازات بیشتری نسبت به نمونه فاقد پوشش از ارزیاب‌ها کسب نمودند. در نهایت این مطالعه نشان داد که استفاده از پوشش کیتوزان– صمغ دانه چیا می‌تواند به افزایش مدت ماندگاری فیله‌های ماهی در یخچال کمک نماید.

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