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Study of polylactic acid film containing silver nanoparticles on shelf life of chicken fillet

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ABSTRACT

Plant extracts and nanoparticles prepared from them can be used to increase the shelf life of meat due to their antimicrobial and antioxidant properties. In the current research, the effect of polylactic acid films containing silver nanoparticles synthesized from *Satureja rechingeri* extract on the physicochemical and microbial properties of chicken fillets at refrigerator temperature in time intervals of 0, 3, 7 and 14 days was investigated. The samples include the control (code 1), chicken fillet coated with polylactic acid film (code 2), chicken fillet coated with polylactic acid film containing *Satureja rechingeri* extract (code 3) and coated chicken fillet. They were coated with polylactic acid film containing silver nanoparticles synthesized from the extract of Marza Rishengari (code 4). The results showed that the mean diameter of the growth inhibition zone against *Staphylococcus aureus* and *Escherichia coli* for the *Satureja rechingeri* extract containing silver nanoparticles was significantly higher than the *Satureja rechingeri* extract ($p\leq0.05$). In all the studied days, except for the first day, the lowest pH and thiobarbituric acid levels belonged to sample 4 ($p\leq0.05$). On the third and seventh days, the highest L* color component belonged to sample 4 ($p\leq0.05$). In all the studied days, except for the first day, the lowest population of mesophilic bacteria, psychrophilic, coliform, *Staphylococcus aureus*, mold and yeast, as well as the highest score of all sensory factors (smell, color, texture, overall acceptance) belonged to sample 4 ($p\leq0.05$). Sample 4 was selected as the superior treatment due to its higher sensory score and more favorable microbial characteristics.

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1-Introduction

Chicken meat is considered as a very popular protein source all over the world and its consumption has been increasing in the last decade in many countries due to its lower production cost compared to red meat, low fat content and high nutritional value. Since chicken meat belongs to the group of perishable foods and must be kept in cold conditions, one of the important concerns of the relevant industry is to increase the shelf life of these products [1]. Packaging based on common synthetic materials has led to serious environmental problems due to their non-biodegradability. In this context, biopolymers can be considered as an alternative source for packaging development. The use of edible films and coatings based on natural polymers and permitted food additives It is important [2]. On the other hand, the desire of consumers to consume "healthier" products that are free of chemical preservatives has caused the food industry to look for a solution that will increase the shelf life of the products and also meet the demands of the consumers. In recent years, one of the proposed solutions has been the use of biodegradable and antimicrobial coatings [1]. Polylactic acid is a thermoplastic polyester with a linear chain and lactic acid as the forming monomer. [1]PLA It is considered [3]. PLA It is a biodegradable biopolymer that is usually produced from the fermentation of sugar compounds such as corn starch and is polymerized by two methods: condensation polymerization and ring-opening [4].PLA It has desirable features such as high mechanical strength and transparency and inhibition against ultraviolet light. Also, using it as substances in contact with food from the side FDA It is considered permissible [5]. PLA While benefiting from many possibilities in terms of production resources and production process, as well as biodegradability for use in food and medicine packaging, it also has disadvantages such as brittleness and brittleness and low formability, which has reduced its efficiency. As a result of improving its mechanical properties by adding suitable reinforcements and determining the effect of their different levels, this biopolymer can be used as a main packaging material in various industries, especially materials turn it into food [6]. Research has shown that by using nanotechnology, many advantages can be created in antimicrobial substances, such as reducing the consumption of antimicrobial substances, increasing efficiency, high compatibility with the environment and improving quality [7]. Nanoparticles are materials with a three-dimensional structure whose size varies from 1 to 100 nm. Nano particles can be made using green and non-green methods. Non-green methods include chemical and physical methods]8[. Nanoparticles show good antimicrobial properties due to their high surface to volume ratio [9]. Chemical compounds found in plants, such as antioxidants and sugars, play an important role in making nanoparticles. Plants containing regenerative compounds are a very suitable option in the synthesis of nanoparticles, because metal ions can be regenerated to the corresponding metals [10, 11]. Metal nanoparticles are used in various scientific and industrial fields[12]. Meanwhile, silver nanoparticles (AgNPs) Due to its good conductivity, chemical stability, catalytic, photonic and optoelectronic properties, it is very popular. have been [13]. Silver has long been considered as a disinfectant, but due to its low bactericidal properties and the development of antibiotics and antibacterial chemicals, its use was limited. However, with the development of production AgNPs The reuse of silver as a

1- Poly Lactic acid

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powerful antibacterial material has flourished is [14]. Nanosilver can act on gram positive bacteria, gram negative bacteria, mold and fungus and destroy them.]15[. Marzeh Reshingari is a native plant of Iran that is widely spread in the northern parts of the country. This plant belongs to the genus contained and family Lamiaceae and in traditional medicine, this plant is known as an anti-pain and anti-infection. It is from the plant family Lamiaceae (mints) and is a species with remarkable antioxidant properties. A lot of evidence has been reported on the antiviral, antibacterial and antifungal properties of essential oil and savory extract components and researches A lot has been done to determine which of the functional groups or spatial structures of essential oil compounds are responsible for their properties [16]. In connection with nanoparticles synthesized from plant extracts and their use in antimicrobial coatings, various researches have been conducted. Rasaee et al. (2018) to investigate the biosynthesis of silver nanoparticles using the leaf extract of Marzeh plant *hortensis* treated with Nacl and its antibacterial properties. values FTIR It showed a relatively spherical shape with a size of 2.9 to 3.4 nm. The results showed that aromatic aromatic monoterpenes play an effective role in the biosynthesis of nano silver. Also, the highest antimicrobial effect against Bacillus subtilus was reported[17]. The Ozog et al. (2017) in the study of nanoemulsion based on plant essential oils (rosemary, bay leaf, thyme, marjoram) on the sensory, chemical and microbiological properties of rainbow trout fillets during storage in ice, they stated that the nanoemulsion led to the improvement of the organoleptic properties of the fillets. And the duration of keeping the fillets increased from 14 days in the control sample to 17 days in the samples containing nanoemulsion. It also led to the reduction of microbial parameters and the reduction of bacteria growth, the amount of peroxide, the amount of volatile nitrogen, and the highest antimicrobial effect was observed in the rosemary group, followed by thyme.]18[. In this research, with the aim of improving the microbiological characteristics, physicochemical and sensory properties of chicken fillet, coating with polylactic acid biodegradable film containing silver nanoparticles synthesized from Rishnigari's savory extract was used.

2- Materials and methods

2-1 Preparation of raw materials

Rishengari savory plant from Medicinal Plants Research Institute, nano silver powder with 99.9% purity, Sigma Aldrich Company (Sigma aldrich) United States of America and pure polyvinyl alcohol granules (Food Grade) which was produced by Bandar Imam Petrochemical Complex was used. Fresh chicken fillets were procured from the local market.

2-2 Extraction of Rishengari savory plant

In this method, the aerial parts of the plant (that is, without roots because the amount of the tuber for extraction is small in the root) were prepared and washed in the flowering stage (the highest amount of extract is in this stage and the highest amount is in the leaves) and at a temperature of 50 degrees Celsius. It dried in the oven for a day. Dried marza was powdered in a mill and 10 grams of it was dissolved in 90 milliliters of distilled water. In indirect heat, i.e., a bain-marie, 90°C water was placed for 10 minutes. First, it was smoothed with a Buchner funnel and then with Whatman No. 2 filter paper and kept at a temperature of 4 degrees [19].

2-3 measuring the minimum inhibitory concentration[2] and the minimum lethal concentration[3]

The minimum inhibitory concentration was determined using broth microdilution method. Standard strains based on standard laboratory and clinical guidelines [4]CLSI (M100-S16) In order to perform antibiogram, they were examined in terms of resistance to

2-Minimum Inhibitory Concentration

3-Minimum Bactericidal Concentration

4-Clinical and Laboratory Standards Institute

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antibiotics. Fresh overnight culture of the tested microorganism for the preparation of Müller Hinton Broth cell suspension (MHB)[5] Double for bacterial strains to get 10^6 Unit formation annual(CFU/ml) andcells/ml 10^3It was magnified 1-2×. The studied extract is in 4% dimethyl sulfoxide (DMSO)[6] And then µl100 of each dilution were placed in microwaves and separately with µl100 bacterial suspensions were inoculated. After thorough mixing, the inoculated microplates were incubated at 37°C for 24 hours. The minimum inhibitory concentration was defined as the lowest concentration to inhibit the significant growth of microorganisms. To determine the minimum microbial concentration, 100 microliters of a portion of the broth was taken from each well, spread on Mueller Hinton agar culture medium and incubated at 37°C for 24 hours for bacteria. The lowest concentration at which the incubated microorganisms are completely killed (99.9% reduction in CFU/ml in comparison with the control) was defined as the minimum lethal concentration. Gentamicin was used as a positive antimicrobial control [20,21].

2-4 synthesis of silver nanoparticles

Silver nitrate M 001/0 Merck, Germany)) With the extract *S. Rechingeri* It was combined so that the ratio of extract to silver nitrate was considered to be one to four. The color change of the solution from light yellow to dark brown indicated the reaction and synthesis of nanoparticles. This process in 7=pH And it was done at room temperature for 24 hours]22[.

5-2 well diffusion analysis in agar

Standard tested bacterial and fungal strains, including Gram-positive Staphylococcus aureus bacteriaPTCC1112 (ATCC 6735) and Gram-negative Escherichia coli PTCC1330 (ATCC 8739)، Aspergillus nigerPTCC 5010 (ATCC 9029) *and*Candida albicans 5027 (ATCC 10231) It was lyophilized from the Iranian Scientific and Industrial Research Organization. Microbial samples were recovered according to standard methods. From the fresh microbial culture, a few colonies were transferred to sterile Hinton Brath Mueller culture medium until the turbidity of the resulting cultures was visually similar to the turbidity of the 5/0 McFarland tube (10^8 1.5 x bacteria per milliliter) after vortexing. Then, the sterile cotton swab was placed next to the flame and under the laminar hood into the prepared microbial suspension with the opacity equivalent to McFarland's 0.5 tube and soaked in it, and by pulling the swab to the wall of the tube, the excess amount of the suspension was taken and uniformly applied to the swab. Mueller Hinton agar was spread on the plate containing the culture medium to culture the bacteria. Then, pits or wells were created on the surface of the plate by a sterile Pasteur pipette with a diameter of 5 mm and a distance of 2 cm from each other. Each well was filled with different dilutions of the extract. as a positive witness of the antibiotic streptomycin test and as a negative witness of dimethylsulfoxide (DMSO) was used In order to prevent the evaporation of the test samples, the perimeter of the plates was completely covered with sterile laboratory parafilm. After finishing the work, all the tested plates are placed at room temperature for 30 minutes and then placed in an incubator at a temperature of 37 degrees Celsius for 24 hours. The said operation was done with three repetitions. After the passage of this time, the bacterial culture was measured in terms of the formation or non-formation of the non-growth aura in millimeters by calipers and their average was calculated [20,21].

2-6 Production of films

To make a film polylactic acid, solution polylactic acid It was prepared in chloroform and stirred for 4 hours at room temperature until the granules were completely dissolved and a uniform solution was created. The solution casting method was used to prepare the film. For this purpose, a certain amount of solution polylactic acid It was poured on 10 cm diameter glasses and dried at room temperature for 24 hours. For biodegradable

5-Mueller Hinton Broth

6-Dimethyl sulfoxide

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film polylactic acid Contains salt extract and silver nanoparticles synthesized from Rishengari salt extract, 10 grams of salt was dissolved in 90 cc of ethanol and placed in an 80°C bath for half an hour, and then the solution was cooled and filtered through a funnel and Whatman filter paper. became. The extract was used once in the polylactic acid solution and added to the polylactic acid film together with the extract and silver nanoparticles. But how to calculate the percentage of the extract based on the minimum level of lethality It was [23].

2-7 Coating of chicken fillet samples

The samples were bought from the market and transported to the laboratory less than 1 hour apart, washed with cold water and cut with sterile tools. Then they were covered by film samples and then transferred to special refrigerators with thermometers. and were examined on days 1, 3, 7 and 14 (Table 1).

Table 1. The treatments used in the present study

Treatment	Specifications
Cod (1)	**Control sample (chicken fillet without coating)**
Cod (2)	**Chicken fillet coated with polylactic acid film**
Cod (3)	**Chicken fillet coated with polylactic acid film contains Satureja rechingeri extract**
Cod (4)	**Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from Satureja rechingeri extract**

8-2. Tests of chicken fillet samples during the storage period

2-8-1 Changes pH

by using pH m was measured on the suspension obtained by mixing 15 grams of the sample with 150 milliliters of deionized water for 2 minutes. It is necessary to clarify that pH The meter was calibrated with buffer solutions 4 and 7 before use]24[.

2-8-2 Measurement of reactive substance with thiobarbituric acid (TBARS[7])

amount TBARS Colorimetrically using a correction method Pikul et al. (1989) was done. About 10 grams of fish meat sample was weighed and with 1 milliliter of BHT (1 mg/ml) and 35 ml of trichloroacetic acid (5%) was homogenized. The obtained homogenous solution was transferred to a flask and then 100 ml of distilled water was added and distilled. After collecting 50 ml of the distilled (extract), the solution was filtered through a filter paper (Whatman number one). 5 ml of the filtered solution was mixed with 5 ml of thiobarbituric acid solution (0.02 M) and placed in a water bath at 100 degrees Celsius for 60 minutes. After cooling, the absorbance at 532 nm was measured against water as a control. amount TBARS It was expressed based on the milligram of malonaldehyde equivalent per kilogram of sample. By the way" from the article TEP (1, 1, 3, 3-tetraethoxypropane) was used to prepare the standard curve. Determination test TBARS، in time intervals 1, 3, 7 and 14 The day was done]25[.

2-8-3 Colorimetric test

Test to determine the color of the samples by Huntlab colorimeter[8] Done and color indicators a*، b* and L*، The color parameter of the samples was determined. Indicator L* It shows the lightness and darkness of the samples. Indicatora* Indicates whether the samples and indicators are red or green b* It indicates whether the samples are yellow or blue. amount L* Brightness level (0= dark, 100= bright), value a* Redness level (+60 = red, -60 = green) and quantity b* It shows the amount of yellowness (yellowish + 60, blue = 60) [26]. Colorimetric test, in time intervals 1, 3, 7 and 14 The day was done.

2-9 Microbial analysis

First, samples of chicken fillet with sterile salt water inside Stomaker It was

7-Thiobarbituric acid reactive substance

8-Hunter-Lab

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homogenized and dilution was done.[9] The inoculated plates were incubated at 37°C for 2 days and for psychrotrophs at 10°C for 7 days to count the total live mesophyll. became and Plates containing 30-300 colonies were counted. Ncrown in the face $\log_{10}$ cfu/gStatement from examples Shd]27[. The number of coliforms in violet red bile glucose agar culture medium was determined after incubation at 37 degrees Celsius for 24 hours. Counting of salmonella according to Iranian standard No. 1810, Staphylococcus aureus using Brad Parker agar culture medium according to Iranian standard No. 8606-1, mold and yeast using yeast extract-dextrose-caramphenicol agar culture medium and incubation at 25 degrees Celsius for a period of 3-5 days according to the standard number 997 of Iran and Eshri Shiakli using the maximum possible number (MPN)[10] It was carried out according to Iranian standard number 2946 [28].

2-11 sensory analysis

Sensory evaluation of different treatments of cooked chicken fillets was determined using a hedonic test (the level of liking or enjoyment) in a five-point scale according to the parameters of texture, color, smell, taste and overall acceptance of the samples. The samples with a blind three-digit code (using a table of random numbers) were placed in the hands of the evaluators (7 trained evaluators) in a complete block design. The samples were given to the evaluators along with a special evaluation questionnaire. The evaluated sensory characteristics include color change (5, no color change, 1, severe color change); Smell (5, very favorable; 1, very unacceptable or bad smell), taste (5, very favorable; 1, very unacceptable or bad taste) and texture (5, hard; 1, very soft). The values of these grades were defined as general acceptance (5, very favorable, 1, very unacceptable). It should be noted that the sensory evaluation was done after the microbial safety test of the samples, which confirms the consumption of the fish samples.]29[.

2-12 statistical analysis method

The results obtained in experiments for experimental data are averaged ± Standard deviation was expressed from measurements with three replicates. colony-forming units (CFUs) In all experiments, they were converted to logarithmic values before statistical analysis. Experiment data with one-way analysis of variance (One-way ANOVA) were compared Statistically significant differences between mean values (in cases where the overall effect of treatments is significant) were determined using Duncan's multi-range follow-up test. Statistical tests of the results obtained using the software SPSSVersion 26 was done. The significance level is $0.05 \geq p$ was considered for all data comparisons.

3- Results and discussion

3-1 Investigation of antimicrobial activity Savory extract against Staphylococcus aureus and Escherichia coli bacteria

The results of the present research (Table 2) showed that the minimum inhibitory concentration and the minimum lethal concentration against Staphylococcus aureus and Escherichia coli bacteria for the salty extract containing silver nanoparticles were significantly lower than the salty extract. ($0.05 \geq p$). On the other hand, for each two items (Savory extract and savory extract containing silver nanoparticles)، The minimum inhibitory concentration and the minimum lethal concentration against Staphylococcus aureus bacteria are lower than Escherichia coli bacteria. was ($0.05 \geq p$). Also, the mean diameter of the non-growth halo against Staphylococcus aureus and Escherichia coli bacteria For the salty extract containing silver nanoparticles, it was significantly higher than the salty extract ($0.05 \geq p$). On the other hand, for each two items (Savory extract and savory extract containing silver nanoparticles)، The diameter of the halo of non-growth against Staphylococcus aureus bacteria is more than that of Escherichia coli bacteria was ($0.05 \geq p$). Minimum lethal concentration (MBC)، It is

9-Nutrient agar

10 -Most Probable Number

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the lowest concentration of the antimicrobial substance that causes the death of the microorganism and the minimum inhibitory concentration. (MIC)، It is the lowest concentration of an antimicrobial substance that has an inhibitory effect on the growth of a specific microorganism. This means that the microorganism exists in the environment, but it is not able to multiply. The decrease in the number of microorganisms in these conditions is not due to the lethal effect of the extract, but because the microorganism has reached the death phase and it no longer reproduces and its number decreases [30]. Plant extracts are widely used in the food industry and have antimicrobial properties against a wide range of microorganisms [31]. In general, it is very difficult to compare the results reported about the antimicrobial properties of different plant extracts. Among the reasons, we can mention the difference in different methods of investigating these properties, sources of their preparation, plant cultivation conditions, different microbial strains and even different concentrations of bacteria used as inoculation material [32]. There are different opinions about the mechanism of extracts on microorganisms. Considering the numerous chemical groups in the constituent components of the extracts, their antimicrobial activity is probably not directed to a specific mechanism and these substances affect multiple targets in the cell [31]. Antimicrobial properties of silver nanoparticles and its beneficial use in biotechnology and the specific inhibition of microbes have been investigated and proven in various studies, so that silver nanoparticles can affect the metabolism and reproductive processes of microorganisms by inhibiting the respiratory system of bacteria. and cause damages in the cell membrane of bacteria]33[. Foroughikia et al. (2015), in the study of the antimicrobial effect of the hydroalcoholic extract of white salt and nanooxider on Staphylococcus aureus, the amount MIC They reported 3000 and 1500 micrograms per milliliter of the hydroalcoholic extract of the white savory plant for the standard and clinical strains of Staphylococcus aureus, respectively. Also MIC Zinc oxide nanoparticles on standard and clinical isolates were expressed as 40 and 20 micrograms per milliliter [34]. Asma et al. (2015), in the study of the antimicrobial effect of Marza extract on the formation of biofilm in some important human bacterial pathogens, found the lowest inhibitory concentration to be around ppm 50-12-50 stated that the highest inhibitory concentration against Staphylococcus aureus bacteria and the lowest inhibitory concentration was the concentration of the savory extract. ppm It was reported that it was observed against Proteus mirabilis [35].

Table 2. Comparison of the minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC) and the diameter of the non-growth halo diameter of *Saturate sharks* extract and *Saturate sharks* extract containing silver nanoparticles against *Staphylococcus aureus* and *Escherichia coli* bacteria

	Against microorganism	*Saturate sharks* extract containing silver	*Saturate sharks* extract
Minimum inhibitory concentration (MIC)	***Staphylococcus aureus***	**b 1.56±0.2**	**a 5.2±0.1**
	Escherchia coli	**b 0.1 2.086 ±**	**0.1a 6.25±**
Minimum bactericidal concen	***Staphylococcus aureus***	**b 0.1 2 ±**	**0.1a 4±**
	Escherchia coli	**0.1b 3±**	**0.1a 8±**

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tration (MBC)			
Non-growth halo diameter (mm)	***Staphylococcus aureus***	**16.66±0/68 a**	**7.66±0.1 b**
	Escherchia coli	**± 0.68 a 15.66**	**± 0.2 b 6.33**

Different lowercase letters indicate a significant difference in the row ($p<0.05$).

3-2 Evaluation of the test results of chicken fillet samples during the storage period

3-2-1 Changes pH

The results of the present research (Table 3) showed that on the first day, there was a significant statistical difference in the amount of pH There were no samples (05/0p>) and the highest amount on other days under investigation pH Belonging to samples 1 (control sample) and 2 (chicken fillet coated with polylactic acid biodegradable film) and the lowest amount pH It belonged to sample 4 (chicken fillet covered with a biodegradable film of polylactic acid containing silver nanoparticles synthesized from the extract of Marza Rishengari). (05/0p≤) In the study Bazargani et al. (2015) values pH Control samples increased during storage, while other samples showed a decreasing trend, and it was attributed to the presence of acidified antimicrobial treatments such as pomegranate extract, chitosan, and Shirazi thyme essence [25]. Moulay Aghaei et al. (2014) in the study of the effect of packaging with chitosan biodegradable films and formulated with garlic essential oil on the chemical characteristics of chicken fillet, stated that by adding different levels of garlic essential oil, the factors pH and TVN During the study, the products were accompanied by a decrease compared to the control group [26]. This shows that chitosan film, especially with essential oil, is able to prevent the creation and development of amino and nitrogenous compounds that cause spoilage in packaged chicken fillets. increase pH In control samples, it can be caused by the activity of microbial or endogenous enzymes such as proteases and lipase, which leads to the increase of volatile bases during long storage [27]. In the current research, it seems that in the samples covered with the biodegradable film of polylactic acid containing silver nanoparticles synthesized from the extract of the savory Rishnigari, due to its higher antimicrobial properties, it leads to a reduction in spoilage and a reduction in production more than other samples. Nitrogen has escaped. Over time, the amount pH All samples increased significantly (05/0p≤). Decomposition of nitrogenous compounds during meat storage leads to an increase pH It is said that part of this increase may be related to the production of alkaline compounds. increase pH In this case, it indicates the growth of bacteria, the decrease in quality and eventually corruptionbecame [28]. FAO (1995) stated in a report that pH Food can be a good indicator for health and safety conditions of food. According to the report of Codex organization (2003) for animal meatpH It should be less than 7-5.5 to be safe for consumers according to the Codex [29]. As the results of this research showed, changes pH During the storage time, there was an increasing trend, and these changes are mainly due to microbial activities and enzyme activities during the storage period. Over time, meat tissue is destroyed by the enzymatic activity of meat microorganisms. In fact, this destruction takes place by breaking down protein compounds, the result of which is the production of nitrogen compounds. The production of these compounds increases pH It is in meat [30]. The process of changes pH It is directly related to the trend of changes in the microbial population of the target sample, that is, with the increase of the microbial population and as a result of the enzyme activity, the trend of increasing pH It also gets faster and this increase was also observed in the control sample. The results obtained from the changes pH It was completely consistent with the results of the total microbial population test; In this way, the coated samples have a lower microbial population due to the increasing trend pH They were slower than the control sample. Comparing the results obtained in this research with the results reported by other researchers showed that in some cases pH Meat samples at the beginning of the reduction period and after that in all cases, pHIt increases. Initial reduction pH It is mainly due to the growth of lactic acid bacteria and as a result

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the accumulation of lactic acid, while after that the increase pH It is mainly due to the growth of spoilage bacteria that lead to the accumulation of alkaline compounds such as ammonium and trimethylamine [31].

Table 3. pH changes of chicken fillet samples during the storage time

Samples	Storage time (days)			
	Day 1	Day 3	Day 7	Day 14
Cod (1)	5.63±0.00^{aD}	5.80±0.01^{BC}	6.03±0.00^{aB}	6.58±0.00^{aA}
Cod (2)	5.63±0.00^{aD}	5.80±0.01^{BC}	6.02±0.00^{aB}	6.57±0.00^{aA}
Cod (3)	5.63±0.00^{aD}	5.70±0.00^{bC}	5.86±0.00^{bB}	6.18±0.01^{not}
Cod (4)	5.63±0.00^{aD}	5.68±0.00^{cC}	5.78±0.00^{cB}	6.00±0.00^{that}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-2 Thiobarbituric acid changes

The results of the current research (Table 4) showed that there was no significant statistical difference in the amount of thiobarbituric acid in the samples on the first day. (05/0p>) And on the other days under investigation, the highest amount of thiobarbituric acid belongs to samples 1 (control sample) and 2 (chicken fillet coated with polylactic acid degradable biofilm) and the lowest amount of thiobarbituric acid belongs to sample 4 (chicken fillet coated with degradable biofilm) polylactic acid containing silver nanoparticles synthesized from the extract of Marzah Rishengari) was acceptable (05/0p≤) And with the passage of time from the first day to the fourteenth day, the amount of thiobarbituric acid in all samples decreased significantly. (05/0p≤). It seems that the silver nanoparticles synthesized from the extract of Rishoneri along with the biodegradable film of polylactic acid are more effective in reducing the products of the Second, oxidation has acted Amount of thiobarbituric acid (TBA) It is widely used to show the degree of lipid oxidation and the presence of active compounds TBA It indicates the second stage of oxidation during which peroxides are oxidized to aldehydes, ketones and alcohols. Malonaldehyde is the only aldehyde capable of producing red pigment TBA is not Other aldehydes may also enter in the reaction. Therefore, the amount of secondary oxidation products in the form of reactive compounds of thiobarbituric acid (TBARS) (milligrams of malonaldehyde equivalent per kilogram of sample) is expressed]32[. Indicator TBA It shows the amount of secondary oxidation products, especially aldehydes. The increasing trend of this index during the storage period may be due to the increase of free iron and other peroxides in the meat. Also, aldehydes are created as secondary oxidation products from the decomposition of hydroperoxides. The increasing trend of hydroperoxides can be a reason for this issue. Reports show that due to the antioxidant activity of the savory plant, its consumption as natural additives has increased. This plant has tannins, fatty substances, various sugars, phenolic compounds and aromatic compounds (essence) [33]. Ezdi et al. (2019) is the most important compounds present in Carvacrol (42.10%), thymol (19.74%) and para-cymene (19.8%) were mentioned as savory essential oils [34]. amount IC50 The essence of this plant is 10.63 micrograms on milliliter was determined, while this parameter for BHT، 9.45 micrograms on was 1 ml. Parasemen is one of the most important monoterpenes known in herbal medicines, which has antioxidant, antimicrobial and anticancer properties, as well as cytokine

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modulation.[11] It is known [35].

Table 4. Changes in thiobarbituric acid of chicken fillet samples during the storage period

Samples	Storage time (days)			
	Day 1	Day 3	Day 7	Day 14
Cod (1)	0.29±0.00^{aD}	0.78±0.01^{BC}	1.03±0.00^{aB}	1.38±0.00^{aA}
Cod (2)	0.29±0.00^{aD}	0.77±0.01^{BC}	1.03±0.01^{aB}	1.37±0.01^{aA}
Cod (3)	0.28±0.00^{aD}	0.53±0/00^{bC}	0.75±0.00^{bB}	1.06±0.00^{not}
Cod (4)	0.28±0.00^{aD}	0.33±0.00^{cC}	0.44±0.00^{cB}	0.60±0.00^{that}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-3 Evaluation of colorimetry test results

3-2-3-1 Color component changes L*

The results of the present research (Table 5) showed that on the first day, there was a significant statistical difference in the amount of cultural factorsL* There were no samples (05/0p>) and on the third and seventh days, the highest productivityL* It belonged to samples 3 (chicken fillet covered with biodegradable polylactic acid biofilm containing Rishengari savory extract at 4 degrees Celsius) and 4 (chicken fillet coated with polylacticacid biodegradable film containing silver nanoparticles synthesized from Rishengari savory extract) (05/0p≤). On the 14th day of the lowest MoulfaharangiL* It belonged to the control sample and its highest amount was observed in sample 4 (chicken fillet coated with polylactic acid biodegradable film containing silver nanoparticles synthesized from the extract of Rishnigari savory).(05/0p≤) And with the passage of time from the first day to the fourteenth day, the color componentL* All samples decreased significantly (05/0p≤) and reducing the color componentL* From the first day to the third day, it was more obvious than other days. It seems that the silver nanoparticles synthesized from the extract of Rishoneri along with biodegradable biofilm of polylactic acid are more effective in reducing Oxidation And reducing the microbial load of chicken fillet has worked and therefore the darkness of the mentioned sample was lower than other samples. color index L* Darkness and lightness (light-dark, 0-100) measures [36]. Linares et al. (2007) reported that the increase in oxidation during the storage period is directly related to the increase in the colorimetric factor. L* It is related in meat [37]. In the present research, in the treatments that have used Rishnigari's savory extract and the extract containing nanoparticles in their coating, due to the antioxidant and antimicrobial properties of the phenolic compounds present in this extract, the process of lipid oxidation and the growth of bacteria are carried out at a slower rate, which This helps to preserve the color of the method in the coated samples. Based on studies Zhang and colleagues (2016), adding rosemary and clove extracts to raw chicken meat samples increases the L* in the samples and also, with the passage of time, the value of the factor L* It increased in the samples containing the extracts of the mentioned plants, while its value decreased in the control sample during storage in the refrigerator. The brightness of chicken meat decreases during storage due to microbial activities, oxidation of fats and proteins [38]. In the samples of chicken meat where vegetable extracts have been used for their coating, due to the antioxidant and antimicrobial properties of the phenolic compounds present in these extracts, the process of lipid oxidation and the growth of bacteria are done at a lower speed, which in itself helps to preserve the color of the method.

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Samples coated with coatings containing plant extracts help [39].

Table 5. Changes of L* of chicken fillet samples during the storage period

Samples	Storage time (days) Day 1	Day 3	Day 7	Day 14
Cod (1)	69.95±0.22^{aA}	63.45±0.50^{bB}	63.57±0.46^{cB}	63.40±0/70^{dB}
Cod (2)	70.03±0.25^{aA}	64.20±1.03^{bB}	65.01±0/51^{bB}	64.64±0.10^{cB}
Cod (3)	69.68±0.59^{aA}	68.40±0.22^{aB}	67.79±0.06^{aB}	66.31±0.14^{bB}
Cod (4)	70.00±0.87^{aA}	69.10±0.75^{aB}	68.30±0.50^{aB}	67.52±0.56^{aB}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-3-2 Color component changes a*

The results of the present study (Table 6) showed that there was a statistically significant difference in the amount of color component on the first and fourteenth days.a* There were no samples (05/0p>) And on other days under investigation, the highest color componenta* Belonging to samples 1 (control sample) and 2 (chicken fillet covered with polylactic acid biodegradable film) and the lowest color componenta* It belonged to sample 4 (chicken fillet coated with polylactic acid biodegradable film containing silver nanoparticles synthesized from the extract of the savory Rishnigari). (05/0p≤). With the passage of time from the first day to the fourteenth day, the amount of thiobarbituric acid in all samples increased significantly. (05/0p≤). color index a* It indicates redness in the samples (absolute red-absolute green, +120-120)]40[. A positive score indicates that the sample is red, while a negative score indicates that the sample is greenish]41[. Zhang and colleagues (2016), The reason for the decrease in the intensity of the red color during storage was attributed to the dependence between the oxidation of lipids and the oxidation of pigments. According to these researchers, the oxidation of pigments can speed up the oxidation of lipids, and the free fatty acids produced during the oxidation of lipids cause the oxidation of iron atoms and the denature of myoglobin molecules and affect the color of meat products.]38[.

Table 6. Changes of a* of chicken fillet samples during the storage period

Samples	Storage time (days) Day 1	Day 3	Day 7	Day 14
Cod (1)	5.26±0.29^{aD}	5.64±0.23^{BC}	5.84±0.49^{aB}	7.20±0.41^{aA}
Cod (2)	5.39±0.08^{aD}	5.69±0.25^{BC}	5.92±0.29^{aB}	6.99±0.14^{abA}
Cod (3)	5.24±0.19^{aD}	5.29±0.22^{abC}	5.53±0.25^{abB}	6.44±1.15^{abA}
Cod (4)	5.61±0.40^{aD}	5.90±0.26^{bC}	5.06±0.16^{bB}	5.77±0.30^{not}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

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3-2-3-3 Color component changes b*

The results of the current research (Table 7) showed that on all the days under investigation, the color component b* of sample 2 (chicken fillet coated with polylactic acid biodegradable film) was significantly higher than other samples. (05/0p≤). With the passage of time from the first day to the fourteenth day, the color component b* of all samples increased significantly. (05/0p≤). Positive score values of the index colored b* It shows the degree of yellowness of the sample, and its negative value indicates the tendency of the sample to turn blue (Index score colored b* and The negative amount of that inclination to the blue color of the sample) shows (yellowabsolute- blue absolute، 120+-120-)]41[. Rahmon and colleagues (2017), investigating the effect of alginate coating containing pomegranate peel extract on shelf life and characteristics of texture and color of chicken breast meat, stated that the amount b* The sample coated with the extract was significantly higher than the other samples and the reason was attributed to the presence of different color compounds inside the extract [42].. Zhang and colleagues (2016), comicsandWeiss (2012) and Maqsood and colleagues (2012) also stated that the use of rosemary and clove extract, grape seed extract and kiyam wood extract, respectively, reduced the amount b* In the samples of chicken meat, raw and fried veal, and fish during storage [38, 39, 40].

Table 7. Changes of b* of chicken fillet samples during the storage period

Samples	Storage time (days)			
	Day 1	Day 3	Day 7	Day 14
Cod (1)	5.97±0.19^{usa}	6.69±0.23^{BC}	7.07±0.13^{abB}	7.47±0.34^{aA}
Cod (2)	6.56±0.32^{aD}	6.81±0.13^{BC}	7.21±0.39^{aB}	7.47±0.19^{aA}
Cod (3)	5.58±0.32^{bD}	5.87±0.04^{bC}	6.08±0.72^{bB}	6.36±0.50^{not}
Cod (4)	6.17±0.49^{usa}	5.47±0.28^{cC}	6.11±0.58^{bB}	6.20±0.52^{not}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-4 Evaluation of the results of microbial tests

3-2-4-1 Changes in mesophyll bacteria

The results of the present research (Table 8) showed that on the first day there was a significant statistical difference in the population of mesophilic bacteria. There were no samples (0.05p>) and on the other days under investigation, the highest population of mesophilic bacteria Belonging to samples 1 (control sample) and 2 (chicken fillet coated with polylactic acid biodegradable film) and the lowest population of mesophilic bacteria Belonging to sample 4 (chicken fillet covered with polylactic biodegradable filmThe acid contained silver nanoparticles synthesized from the extract of Marza Rishengari (05/0p≤) and with the passage of time from the first day to the fourteenth day, the population of mesophilic bacteria in all samples increased significantly (0.05p≤). According to the maximum limit defined for the total count of chicken by the standard of the country's veterinary organization (2007).]43 [، Log cfu/g 6, all the samples were within the standard range until the third day and only Sample 4 (chicken fillet covered with polylactic biodegradable filmThe acid containing silver nanoparticles synthesized from the extract of Rishnigari's savory extract) had a permissible microbial contamination until the seventh day, and other samples had a microbial contamination exceeding the

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permissible limit on the seventh day. Among the various compounds found in plant extracts, the antimicrobial effects of phenolic structures have been proven in previous studies, and it has also been observed that their antimicrobial power depends on the location and number of hydroxyl groups on the phenolic ring.]44[٠ In this direction Geissman It was observed that oxidized phenols have a stronger effect. The possible mechanism of these compounds such as flavonoids and flavonols is enzyme inhibition through reaction with sulfhydryl groups or non-specific reactions with microbial proteins such as extracellular proteins and forming a complex with the cell wall or causing disruption in the cell membrane of microorganisms.]45[. Choulitoudiet al. (2016) in the study of the antimicrobial and antioxidant activity of Marzeh *thymbra* In the edible cover of goldfish[12] They stated that the savory essential oil alone showed moderate antimicrobial and antioxidant protection.]46[. Bukvicki et al. (2013) in the study of the effect of Marzeh essential oil *in advance* In laboratory conditions and local control *Listeria monocytogenes* In pork, the minimum inhibitory concentration (MIC) For bacteria from ٠٣/٠ until ٥٧/٠milligrams per milliliter and for yeasts from ٥۶/٠ until ٢٣/٢ Milligrams per milliliter were variable, while the minimum concentration of bacteria/yeast MBC/MYC from٠٧/٠ until١٥/١ and ١١/١ until ٥٧/٥ mg/ml was variable for bacteria and yeast. This essential oil was more effective against bacteria than yeasts, and they generally stated that the savory essential oil can be useful for preserving and increasing the shelf life of raw or processed meat products.]47[.

Table 8. Changes of Mesophilic bacteria population of chicken fillet samples during the storage period**) Log CFU/g(**

Samples	Storage time (days)			
	Day 1	Day 3	Day 7	Day 14
Cod (1)	3.95 ± 0.02^{aD}	5.21 ± 0.01^{BC}	7.12 ± 0.02^{bB}	10.47 ± 0.05^{aA}
Cod (2)	3.95 ± 0.01^{aD}	5.19 ± 0.01^{BC}	7.10 ± 0.00^{aB}	10.46 ± 0.03^{aA}
Cod (3)	3.94 ± 0.02^{aD}	5.06 ± 0.01^{bC}	6.38 ± 0.01^{bB}	10.23 ± 0.00^{not}
Cod (4)	3.95 ± 0.00^{aD}	4.88 ± 0.01^{cC}	5.55 ± 0.07^{cB}	9.14 ± 0.02^{that}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-4-2 Changes of psychrophilic bacteria

The results of the present research (Table 9), showed that On the first day, there was no significant statistical difference in the population of psychrophilic bacteria in the samples (05/0*p*>) and on the other days under investigation, the highest population of psychrophilic bacteria belonging to samples 1 (control sample) and 2 (chicken fillet coated with polylactic acid degradable biofilm) and the lowest population of psychrophilic bacteria belonging to sample 4 (coated chicken fillet) With polylactic biodegradable filmThe acid contained silver nanoparticles synthesized from the extract of Marza Rishengari ($p\leq0.05$) and with the passage of time from the first day to the fourteenth day, the population of psychrophilic bacteria in all samples increased significantly ($p\leq0.05$). Ibrahim Salam (2007) reported that cryophilic bacteria are the most important group of microorganisms responsible for spoilage in products stored at low temperatures.]48[. The effect of essential oils such as thyme and marjoram, which contain high thymol and carvacrol, has also been reported on

Gilthead seabream[12]

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the total count of cold-oriented bacteria present on meat.]49[.

Table 9. Changes of Psychrophilic bacteria population of chicken fillet samples during the storage period) **Log CFU/g(**

Samples	Storage time (days) Day 1	Day 3	Day 7	Day 14
Cod (1)	3.80±0.03^{aD}	5.05±0.00^{BC}	6.92±0.03^{bB}	10.30±0.01^{aA}
Cod (2)	3.80±0.02^{aD}	5.03±0.02^{BC}	6.90±0.03^{aB}	10.30±0.01^{aA}
Cod (3)	3.83±0.03^{aD}	4.82±0.03^{bC}	6.22±0.02^{bB}	9.37±0.01^{not}
Cod (4)	3.82±0.02^{aD}	4.48±0.06^{cC}	5.45±0.03^{cB}	9.52±0.08^{that}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-4-3 Changes in coliform bacteria

The results of the present research (Table 10), showed that On the first day, there was no significant statistical difference in the coliform bacteria population of the samples ($p>0.05$) and on the other days under investigation, the highest coliform bacteria population belonged to samples 1 (control sample) and 2 (chicken fillet covered with polylactic acid biodegradable film) and the lowest coliform bacteria population belonged to sample 4 (fillet Chicken covered with polylactic biodegradable filmThe acid contained silver nanoparticles synthesized from the extract of Marza Rishengari ($05/0p\leq$) And with the passage of time from the first day to the fourteenth day, the coliform bacteria population of all samples increased significantly. ($05/0p\leq$). The most common contaminants of meat and meat products are Enterobacteriaceae bacteria, which produce biogenic amines as a result of their activity, and the formation of these products causes food poisoning and reduces the quality of the product.]50[. According to the maximum limit defined for chicken coliform bacteria by the standard of the country's veterinary organization (1387), Log cfu/g 2.7, all the samples were within the standard range on the first day. It is believed that most essential oils and extracts exert their antimicrobial activities by interacting with processes related to the bacterial cell membrane, including electron transfer, ion gradient, protein translocation, phosphorylation, and other enzyme-dependent reactions.]51[. Kazem Elwandi et al. (2009) and prevention of ATPase Inhibitory effect on flagellum synthesis pump activity in Gram negative bacteria such as Escherichia coli compared to some phenolic compounds O157:H7 they gave]52[.

Table 10. Changes of coliform bacteria population of chicken fillet samples during the storage period) **Log CFU/g(**

Samples	Storage time (days) Day 1	Day 3	Day 7	Day 14
Cod (1)	2.68±0.08^{aD}	4.20±0.01^{BC}	6.26±0.01^{bB}	9.34±0.00^{aA}
Cod (2)	2.68±0.02^{aD}	4.19±0.01^{BC}	6.25±0.00^{aB}	9.33±0.00^{aA}
Cod (3)	2.64±0.10 ^{aD}	3.69±0.04^{bC}	5.08±0.01^{bB}	8.21±0.02^{not}

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Cod (4)	2.65±0.05^{aD}	3.29±0.03^{cC}	4.67±0.04^{cB}	6.49±0.05^{that}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-4-4 changes in Staphylococcus aureus bacteria

The results of the present research (Table 11), showed that On the first day, there was no significant statistical difference in the population of Staphylococcus aureus bacteria in the samples (0.05p>) And on the other days under investigation, the highest population of Staphylococcus aureus bacteria belonging to samples 1 (control sample) and 2 (chicken fillet covered with polylacticacid biodegradable film) and the lowest population of Staphylococcus aureus bacteria belonging to sample 4 (chicken fillet covered with film) Polylactic biodegradableThe acid contained silver nanoparticles synthesized from the extract of Marza Rishengari (05/0*p*≤) And with the passage of time from the first day to the fourteenth day, the population of Staphylococcus aureus bacteria in all samples increased significantly (0.05p≤). Antimicrobial activities AgNPs It is more on Gram-negative bacteria than on Gram-positive bacteria, which is attributed to the smaller wall thickness of Gram-negative bacteria.]53[. Hajj et al. (2016) showed that S. aureus Compared to Ashershiakli to chitosan nanocomposite/PVA It was more sensitive]52[. Monoterpenes, the main components (more than 90٪) Savory extract increases the growth of Staphylococcus aureus more than Escherichia coli They restrain]55[. Other findings of researchers (Alboofetileh et al., 2014; Walls et al., 2014; Pirtarighat et al. (2019), was also in line with the present study, which showed the sensitivity of Staphylococcus aureus to Escherichia coli. is more]56، 57، 58[. The aforementioned differences regarding efficiency in both bacteria may be due to several factors such as size AgNP، The types of nanoparticles, bacterial resistance, growth stages, main compounds of the extract and test method have been attributed]59[.Cheng et al. (2021) in the study of polylactic acid film containing silver nanoparticles synthesized from mango skin extract for food packaging stated that the said film had excellent antibacterial properties and the rate of inhibition of Escherichia coli and Staphylococcus aureus was over 95%.]60[.

Table 11. Changes of *Staphylococcus aureus* population of chicken fillet samples during the storage period) **Log CFU/g(**

Samples	Storage time (days) Day 1	Day 3	Day 7	Day 14
Cod (1)	2.78±0.02^{aD}	4.36±0.01^{BC}	6.33±0.01^{aB}	10.22±0.01^{aA}
Cod (2)	2.75±0.03^{aD}	4.34±0.00^{BC}	6.33±0.01^{aB}	10.20±0.01^{aA}
Cod (3)	2.74±0.03^{aD}	4.20±0.01^{bC}	5.28±0.01^{bB}	9.31±0.00^{not}
Cod (4)	2.77±0.01^{aD}	3.82±0.04^{cC}	4.76±0.02^{cB}	7.81±0.03^{that}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

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3-2-4-5 changes in mold and yeast population

The results of the present research(Table 12), showed that On the first day, there was no significant statistical difference in the mold and yeast population of the samples (05/0p>) and on the other days under investigation, the highest mold and yeast population belonged to samples 1 (control sample) and 2 (chicken fillet covered with polylactic acid biodegradable film) and the lowest mold and yeast population belonged to sample 4 (coated chicken fillet Covered with polylactic biodegradable filmThe acid contained silver nanoparticles synthesized from the extract of Marza Rishengari (05/0p≤) And with the passage of time from the 1st day to the 14th day, the mold and yeast population of all samples increased significantly (0.50p≤). The reason for this can be attributed to the antifungal effects of savory extract and savory extract containing silver nanoparticles. Moradi et al. (2015) also investigated the effect of coating containing silver nanoparticles in increasing the shelf life of caviar and stated that in coatings containing nano silver, the population of fungi was much lower compared to coatings without nano silver.]61[. Pour Mutlaq et al. (2010) in the study of the effect of polyethylene coating containing silver nanoparticles on barberry stated that coatings containing one and two percent nanosilver decreased the growth of molds and the amount of bacteria.]62[.

Table 12. Changes of mold and yeast bacteria population of chicken fillet samples during the storage period) **Log CFU/g(**

Samples	Storage time (days) Day 1	Day 3	Day 7	Day 14
Cod (1)	2.46±0.06^{aA}	5.37±0.01^{aA}	6.31±0.00^{aA}	7.40±0.00^{aA}
Cod (2)	2.44±0.04^{aA}	5.37±0.00^{aA}	6.30±0.01^{aA}	7.38±0.01^{aA}
Cod (3)	2.39±0.01^{aA}	4.35±0.01^{not}	5.34±0.00^{not}	6.31±0.02^{not}
Cod (4)	2.46±0.03^{aA}	3.73±0.04^{that}	4.72±0.03^{that}	5.53±0.03^{that}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-6 Evaluation of sensory test results

3-2-6-1 Bo scores

The results of the present research (Table 13), showed that On the first day, there was no significant statistical difference in the odor score of the samples (0.05p>) and on the other days under investigation, the highest odor score belongs to sample 4 (chicken fillet covered with polylactic biodegradable filmThe acid contained silver nanoparticles synthesized from the extract of Marza Rishengari (05/0p≤) and with the passage of time from the first day to the fourteenth day, the odor score of all samples decreased significantly (0.05p≤). The obtained results were in line with the results of the microbial and oxidation tests and sample 4 (chicken fillet coated with polylactic biodegradable film)Acid containing silver nanoparticles synthesized from the extract of Marza Rishengari) It had minimal baromicrobial, total volatile nitrogen and thiobarbituric acid. Since oxidation in chicken meat ultimately causes the formation of aldehyde, ketone, acids and alcohol and causes changes in the flavor of the meat, in this research, sample 4 had the least oxidation compared to other samples.]63[. The threshold of the beginning of corruption and bad taste, which is the permissible limit for TBA is considered mg/kg It is 1-2]64[Sample 4 (chicken fillet covered

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with polylactic biodegradable filmAcid containing silver nanoparticles synthesized from the extract of Marza Rishengari) It had the lowest amount compared to other samples. Volatile nitrogen compounds also cause bad and unpleasant odors in mobile phone products and reduce consumer acceptance, and high levels of bacterial load can be a justification for increasing these compounds. The high level of bacterial activity breaks down compounds such as trimethylamine oxide, peptides and amino acids into volatile bases.]65[.The amount is 25 milligrams N-TVB 100 grams of the product is the highest acceptable level for human consumption]66[.

Table 13. Changes in odor score of chicken fillet samples during the storage time

Samples	Storage time (days)			
	Day 1	Day 3	Day 7	Day 14
Cod (1)	5.00±0.00^{aA}	3.00±0.00^{not}	1.33±0.57^{that}	1.00±0.00^{not}
Cod (2)	5.00±0.00^{aA}	3.00±0.00^{not}	1.66±0.57^{bcA}	1.00±0.00^{not}
Cod (3)	5.00±0.00^{aA}	3.00±0.00^{not}	2.66±0.57^{not}	1.33±0.57^{not}
Cod (4)	5.00±0.00^{aA}	5.00±0.00^{aA}	4.66±0.57^{aA}	3.33±0.57^{aA}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-6-2 color score

The results of the present research (Table 14), showed that On the first day, there was no significant statistical difference in the color score of the samples (05/0p>) And on the other days under investigation, the highest color score belongs to sample 4 (chicken fillet covered with polylactic biodegradable filmThe acid contained silver nanoparticles synthesized from the extract of Marza Rishengari (05/0p≤) and with the passage of time from the first day to the fourteenth day, the color score of all the samples decreased significantly (0.05p≤). The color and smell of meat is an indicator that is used by the consumer to ensure that it is not spoiled [67]. Oxidation of myoglobin in chicken breast meat samples, which leads to a decrease in the amount of redness and an increase in the amount of yellowness of the meat, by creating an unfavorable color in the meat, will reduce the sensory evaluation score of the color [68]. In the current research, the higher score of the color assigned to sample 4 (chicken breast covered with biodegradable polylactic acid film containing silver nanoparticles synthesized from the extract of Rishnigari) can be attributed to its lower oxidation.

Table 14. Changes in color score of chicken fillet samples during the storage time

Samples	Storage time (days)			
	Day 1	Day 3	Day 7	Day 14
Cod (1)	5.00±0.00^{aA}	2.00±0.00^{that}	2.00±0.00^{not}	1.00±0.00^{not}
Cod (2)	5.00±0.00^{aA}	2.00±0.00^{that}	2.00±0.00^{not}	1.00±0.00^{not}
Cod (3)	5.00±0.00^{aA}	3.33±0.57^{not}	2.33±0.57^{not}	1.33±0.57^{not}
Cod (4)	5.00±0.00^{aA}	4.66±0.57^{aA}	3.66±0.57^{aA}	2.66±0.57^{aA}

Different lowercase letters indicate a significant difference in the column and different uppercase letters

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indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-6-3 tissue points

The results of the present research (Table 15), showed that On the first day, there was no significant statistical difference in the texture score of the samples (0.05p>) and on the other days under investigation, the highest tissue score belongs to sample 4 (chicken fillet covered with polylactic biodegradable filmThe acid contained silver nanoparticles synthesized from the extract of Marza Rishengari (05/0p≤) and With the passage of time from the first day to the fourteenth day, the texture score of all the samples decreased significantly (0.05p≤). Texture is the most important factor indicating the quality of meat from the consumer's point of view. Therefore, improving the quality of meat and its crispness are of particular importance [67]. The tissue is affected by the oxidation of meat, which may be due to the loss of thiol groups, because the oxidation of meat proteins is associated with the formation of carbonyl and the removal of thiol groups [69]. It can also be due to the effect of the extract on the activity of microorganisms and as a result of reducing the degradation and denaturation of proteins. In meat, with the passage of time, the tissue is destroyed by the enzymatic activity of the meat microorganisms, this destruction of the tissue is associated with the breakdown of protein compounds, the softening of the tissue and the production of nitrogen compounds [70]. In the current research, it can be stated that in sample 4 (chicken fillet coated with polylactic acid biodegradable film containing silver nanoparticles synthesized from Rishnigari savory extract) higher antimicrobial and antioxidant activity. was observed and therefore had a higher texture score.

Table 15. Changes in texture score of chicken fillet samples during the storage time

Samples	Storage time (days)			
	Day 1	Day 3	Day 7	Day 14
Cod (1)	5.00 ± 0.00^{aA}	4.33 ± 0.57^{aA}	3.66 ± 0.57^{aA}	1.00 ± 0.00^{not}
Cod (2)	5.00 ± 0.00^{aA}	4.33 ± 0.57^{aA}	3.66 ± 0.57^{aA}	1.33 ± 0.57^{not}
Cod (3)	5.00 ± 0.00^{aA}	4.66 ± 0.57^{aA}	4.00 ± 0.00^{aA}	2.33 ± 0.57^{aA}
Cod (4)	5.00 ± 0.00^{aA}	5.00 ± 0.00^{aA}	4.00 ± 0.00^{aA}	3.00 ± 0.00^{aA}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

3-2-6-4 acceptable score

The results of the present research(Table 16), showed that On the first day, there was no significant statistical difference in the acceptability score of the samples (05/0p>) and on the other days under investigation, the highest malleability score belongs to sample 4 (chicken fillet covered with polylactic biodegradable filmThe acid contained silver nanoparticles synthesized from the extract of Marza Rishengari (05/0p≤) and with the passage of time from the first day to the fourteenth day, the acceptability score of all samples decreased significantly (0.05p≤). Based on the scoring by Bunnies et al. (2009), chicken samples that score up to 2.5 (1 to 4) can be consumed by humans.]71[. Forman et al. (2003) reported that rosemary extract, in addition to preventing lipid oxidation and microbial spoilage, prevents meat color changes

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during the storage period and increases meat quality in terms of sensory factors. The reason for this was attributed to the structural compounds of the rosemary plant, its antioxidant and antimicrobial properties, and the prevention of oxidative damage.]72[.

Table 16. Changes in overall acceptance score of chicken fillet samples during the storage time

Samples	Storage time (days)			
	Day 1	Day 3	Day 7	Day 14
Cod (1)	5.00±0.00^{aA}	3.33±0.57^{aA}	2.66±0.57^{not}	1.00±0.00^{that}
Cod (2)	5.00±0.00^{aA}	3.33±0.57^{aA}	2.66±0.57^{not}	1.00±0.00^{that}
Cod (3)	5.00±0.00^{aA}	3.66±0.57^{aA}	3.00±0.00^{not}	2.33±0.57^{not}
Cod (4)	5.00±0.00^{aA}	5.00±0.00^{not}	4.00±0.00^{aA}	3.00±0.00^{aA}

Different lowercase letters indicate a significant difference in the column and different uppercase letters indicate a significant difference in the row ($p<0.05$).

Cod (1): Control sample (chicken fillet without coating), **Cod (2):** Chicken fillet coated with polylactic acid film, **Cod (3):** Chicken fillet coated with polylactic acid film contains *Saturate sharks* extract, **Cod (4):** Chicken fillet coated with polylactic acid film Contains silver nanoparticles synthesized from *Saturate sharks* extract

4-7 General conclusion

The results of the present research showed that the savory extract contained silver nanoparticles and had more antimicrobial properties than the savory extract (0.05).p≤). So that the minimum inhibitory concentration and the minimum lethal concentration against Staphylococcus aureus and Escherichia coli for the salty extract containing silver nanoparticles were significantly lower than the salty extract. (05/0p≤) And the chicken fillet coated with a biodegradable film of polylactic acid containing silver nanoparticles synthesized from the salty extract of Rishengari (sample 4), had better microbiological and sensory characteristics than other samples and was chosen as the superior treatment. Based on the above, the films are an active, antimicrobial and biodegradable packaging and can be used as an innovative packaging in maintaining the quality of different foods.

6- Resources

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مقاله علمی_پژوهشی

مطالعه فیلم پلی‌لاکتیک‌اسید حاوی نانو ذرات نقره بر مدت ماندگاری فیله مرغ

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چکیده

عصاره‌های گیاهی و نانوذرات تهیه شده از آن‌ها به جهت دارا بودن خواص ضد میکروبی و آنتی اکسیدانی می‌توانند در افزایش مدت ماندگاری گوشت مورد استفاده قرار گیرند. در تحقیق حاضر تاثیر فیلم‌های پلی‌لاکتیک‌اسید حاوی نانو ذرات نقره سنتز شده از عصاره مرزه ریشنگری بر خواص فیزیکوشیمیایی و میکروبی فیله مرغ در دمای یخچالی در بازه‌های زمانی ۰، ۳، ۷ و ۱٤ روز مورد بررسی قرار گرفت. نمونه‌ها شامل شاهد (کد۱)، فیله مرغ پوشش‌دهی شده با فیلم پلی‌لاکتیک‌اسید (کد۲)، فیله مرغ پوشش دهی شده با فیلم پلی-لاکتیک‌اسید حاوی عصاره مرزه ریشنگری (کد۳) و فیله مرغ پوشش‌دهی شده با فیلم پلی-لاکتیک‌اسید حاوی نانو ذرات نقره سنتز شده از عصاره مرزه ریشنگری (کد٤) بودند. نتایج نشان داد که میانگین قطر هاله عدم رشد بر علیه باکتری‌های استافیلوکوکوس اورئوس و اشریشیاکلی برای عصاره مرزه حاوی نانوذرات نقره به طور معنی‌داری بالاتر ازعصاره مرزه بود ($p\leq$۰/۰۵). در تمامی روزهای مورد بررسی به جز روز یکم، پائین ترین میزان pH و تیوباربیتوریک اسید متعلق به نمونه ٤ بود ($p\leq$۰/۰۵). در روزهای سوم و هفتم، بالاترین مولفه رنگی L* متعلق به نمونه ٤ بود ($p\leq$۰/۰۵). در تمامی روزهای مورد بررسی به جز در روز یکم، پائین ترین جمعیت باکتری‌های مزوفیل، سایکروفیل، کلی فرم، استافیلوکوکوس اورئوس و کپک و مخمر و کپک و مخمر و همچنین بالاترین امتیاز کلیه فاکتورهای حسی (بو، رنگ، بافت، پذیرش کلی) متعلق به نمونه ٤ بود ($p\leq$۰/۰۵). نمونه ٤ به جهت امتیاز حسی بالاتر و ویژگی‌های میکروبی مطلوب‌تر به عنوان تیمار برتر انتخاب شد.

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