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Biodegradable packaging based on chitosan–potato starch biopolymer containing *Apium graveolens* seed extract for chicken fillets

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ABSTRACT

The consumer demand to use natural preservatives in food products instead of synthetic ones and awareness about not using plastic is increasing. In this research, chitosan-potato starch film containing celery seed extract was prepared at different concentration levels (0.5, 2 and 8%) and the physical properties of the film (thickness, moisture content and solubility), mechanical properties and antioxidant activity also determined. Then, the chicken fillet wrapped by the film was kept in the refrigerator for 15 days and the microbial growth and primary and secondary oxidation compounds formation with peroxide value and thiobarbituric acid and sensory evaluation was also monitored during the storage time. The results showed that the total phenol and flavonoid content of celery seed extract was 70.67±7.8 mgGA/g of extract and 62.81±5.65 mg Quercetin/g of extract, respectively. Addition of celery seed extract (2 and 8%) decreased the moisture content and solubility of the film due to the increase of the film hydrophobicity. Also, by adding the celey seed extract, the elongation at break of the film increased, while the tensile strength and elastic modulus decreased. With the increase in the concentration of the celery seed extract in the film, the DPPH free radical inhibition increases from 14.69 to 73.94%. According to the results of microbial and oxidation tests as well as sensory evaluation, coating a chicken fillet with a chitosan-potato starch film containing 8% celery seed extract would increase its shelf life by up to 15 days.

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1- Introduction

Despite the development of methods to increase the shelf life and safety of food products, diseases caused by microbial spoilage of food and undesirable metabolites resulting from the activity of bacteria and oxidation of fats are considered to be one of the main challenges of the food industry. Microbial and chemical spoilage in chicken, in addition to contributing to food poisoning and the occurrence of various diseases such as cancer, also causes significant economic losses [1]. Packaging, as one of the effective solutions, protects food against adverse microbial and chemical changes. Edible coatings and films have attracted the attention of consumers due to their compatibility with the environment, diversification of food products and increasing their shelf life by reducing or inhibiting the growth of microorganisms [2]. The use of natural biopolymers containing natural antioxidant and antimicrobial compounds has been considered in order to prevent the oxidation of fats and microbial growth. Edible films made from carbohydrates, in addition to being biodegradable, maintain quality, increase shelf life and minimize moisture loss [3]. With the increase in people's awareness of the dangers of synthetic preservatives on health, their desire to use natural preservatives, especially plant compounds, in food products has increased [4]. The use of herbal compounds in edible films is a practical solution in order to achieve safer and longer lasting food products and also reduces waste [5]. When antimicrobial compounds are used in edible films, they are slowly released in food and therefore have a longer effectiveness on food [6]. In recent years, in order to make edible films, many polysaccharides have been researched, including methyl cellulose [7], potato starch [8], safflower seed gum [9], cassava starch and chitosan [10], tapioca.[1] [11], cellulose and cellulose derivatives such as hydroxypropyl methyl cellulose, carboxymethyl cellulose, methyl cellulose [12, 13], kefiran polysaccharide[2][14], Karginan [15], seed gum - Shahi[16] and basil seed gum [17] has been used. Considering the high capacity of our country in terms of medicinal plants and the acceptance of these plants as medicine in general culture, the need to use plant compounds to increase the shelf life of food products, especially in the form of biodegradable edible films, seems essential.
celery seed*Celery*) due to the presence of valuable antioxidants, vitamins and mineral salts, it has many health-giving properties [18]. Also, this plant has anti-inflammatory and antibacterial properties [19]. In this article, using chitosan-potato starch biopolymer in combination with celery seed extract, a suitable coating was designed and produced, which not only increased the shelf life of chicken fillet, but it is expected that due to its polysaccharide nature, it can easily be used in nature. was analyzed.

1- materials and methods

1-2 raw materials

Chitosan with medium molecular weight (190-310 kDa) and deacetylation degree of 75-85% with medium methoxy degree was purchased from Sigma-Aldrich, USA. Glycerol, 2,2-diphenyl-1-picrylhydrazyl[3] (DPPH), microbial culture medium[4] and other chemicals were purchased from Merck, Germany. Celery seeds were procured from the local market.

[1]-Tapioca
[2]- Kefiran
[3]- 2,2-diphenyl-1-picrylhydrazyl (DPPH)
[4]- Plate Count Agar

2-2 Methods

1-2-2 Celery seed extract extraction

After being powdered, celery seeds were mixed in a ratio of 1 to 10 (10 grams of sample with 100 milliliters of methanol solvent) and placed in an ultrasound bath for 20 minutes. In order to better extract the effective compounds, the obtained suspension was mixed in a shaker for 24 hours at room temperature at a speed of 300 rpm and finally filtered by Buchner funnel under vacuum and with the help of Whatman filter paper 0.45 µm. The concentration process was done in a rotary evaporator (temperature 70 degrees Celsius). Finally, the resulting extract was freeze-dried[5] (Operon company made in Korea) was completely dried [20].

2-2-2 Measurement of total phenolic content

The amount of total phenolic compounds by Folin Ciocaltio method[6] Measurements and results were expressed in terms of milligrams of gallic acid per gram of celery seed extract. So, 2.5 milliliters of Siocaltio reagent (diluted 10 times) and 2 milliliters of 7.5% sodium carbonate solution were added to celery extract and distilled water was added to it in a volumetric flask until the volume reached 50 milliliters. After 12 to 15 hours, their absorption was read with a spectrophotometer at a wavelength of 765 nm [21]. The standard curve in terms of gallic acid was determined from the relation $y = 0.008x + 0.23$ with an explanation coefficient of 0.98.

3-2-2 Measurement of flavonoid amount

The amount of flavonoids was measured by aluminum chloride colorimetric method. In this method, 250 microliters of celery seed extract were mixed with 75 microliters of 5% sodium nitrite. After 6 minutes, 150 microliters of 10% aluminum chloride and 500 microliters of one molar sodium hydroxide were added to the mixture. At the end, the resulting mixture was homogenized with 2.5 ml of distilled water. The absorbance of the solution was read at a wavelength of 510 nm [22]. The standard curve was drawn in terms of milligrams of quercetin per gram of extract.

4-2-2 Preparation of film based on chitosan-potato starch containing celery seed extract

In order to prepare chitosan-starch film, potato starch solution (150 mg/liter) was first prepared and then mixed at a temperature of 75 degrees Celsius on an electric heater to obtain a clear solution. Then one gram of chitosan powder was dissolved in 100 ml of aqueous acetic acid solution and the obtained solution was mixed for 24 hours at room temperature. Then, different concentration levels of celery seed extract (0.5, 2 and 8%), one milliliter of 10 g/liter sodium tripolyphosphate ($Na_5P_3O_{10}$) (to increase the contact between chitosan and starch) and one percent of glycerol was added. Finally, 60 milliliters of suspension was prepared on a circular surface of polyethylene terephthalate (269 cm2) with a thickness of 0.1 cm by casting method. The films were dried in an incubator at 35 degrees Celsius for 36 to 48 hours at a relative humidity of 40 to 45%. Then the dried films were separated from the plates and placed in the oven for another 48 hours to evaporate the remaining solvent. Before use, the films were placed in a desiccator saturated with magnesium nitrate salt at a temperature of 25 degrees Celsius for 48 hours for moisture balance [23].

[5]- Freeze drier

[6]- Folin–Ciocalteu

5-2-2 Determination of film characteristics based on chitosan-potato starch

1-5-2-2 film thickness

Film thickness with digital micrometerMitutoyoModel 293-821-30 was measured in 5 different parts and its average was determined as film thickness.

2-5-2-2 film moisture content

To measure the moisture content of the films, the samples are cut into 3 x 3 cm and weighed and dried in an oven at 110 degrees Celsius until a constant weight is reached. After the weight of the samples was fixed, their weight was measured and the moisture level of the films was determined by the following formula, where m_{wet} Wet weight and m_{dry} dry weight [24].$Moisture\ content\ (\%) = \frac{m_{wet} - m_{dry}}{m_{dry}}$

3-5-2-2 film solubility in water

The films were cut into pieces of 2 x 3 cm and dried in an oven at 110 degrees Celsius until a constant weight was reached. The speed of mixing was 200 rpm. Then the resulting solution was poured on a Whatman filter paper and dried in an oven at 110 degrees Celsius and weighed. In this way, the percentage of film solubility in water was determined from the following formula [25].

$$Water\ solubility = \frac{initial\ dry\ weight - final\ dry\ weight}{initial\ dry\ weight} \times 10$$

4-5-2-2 Measuring the mechanical properties of films

Using a histometer[7] Mechanical tests including tensile strength, elastic modulus, tensile strength to breaking point were performed. In order to perform this test, the films are divided into rectangles with dimensions of 25.4 x 100 mm and conditioned for two days before performing this test.[8] became. The samples were set on the clamps of the machine at a distance of 50 mm between the two jaws, and the amount of tension and force required to stretch the films at a speed of 50 mm per minute until the breaking point of the film was recorded. Tensile strength and elastic modulus were reported in megapascals, the increase in length of the films was reported in percent [26].

5-5-2-2 Determination of antioxidant power by free radical inhibition testDPPH

This test is according to the method of Moradi et al. (2012) to determine the free radical inhibitory powerDPPH Was performed. In this way, 25 mg of the film was dissolved in 5 ml of distilled water. Then 0.1 ml of this solution with 3.9 ml of solutionDPPH Methanolic (0.1 mM) mixture and the resulting solution were kept in a dark place for one hour, and in the next step, the absorbance of the solutions was determined against the absorbance of pure methanol at a wavelength of 517 nm by a spectrophotometer using the following formula, where A_B Attracting Shahid and A_A sample absorption [27].

Free radical inhibition (%) = $(A_B - A_A) / A_B$ *100

[7]-Texture Analayzer

[8]-Conditioning

6-2-2 Investigating the effect of celery seed extract concentration on microbial spoilage and fat oxidation in chicken fillet coated with chitosan-potato starch based film

The chicken fillet is divided into pieces with an approximate weight of 10±0.5 grams and in compliance with the hygiene principles, with a chitosan-potato starch film with dimensions of 70x70 mm containing celery seed extract (with a concentration of 0.5, 2 and 8 percent) and The pure films (without extract) were coated so that they were completely enclosed and covered with it and no residue was left. Each of the treatments and the uncoated control sample were placed separately in a petri dish and wrapped with a 0.5 mm thick polyethylene plastic with dimensions of 13 x 13 cm with a sewing machine. The chicken fillets covered with film and the control sample were stored in the refrigerator at 4 degrees Celsius for 15 days. Then, the amount of microbial spoilage and oxidation of fats on the first, fifth, tenth and fifteenth day compared to the negative control sample (without celery seed extract) and the control sample (without coating) through microbial tests including the total count of viable and cold-loving bacteria, peroxide index and Thiobarbituric acid was monitored [28].

1-6-2-2 Microbial tests of chicken fillet covered with film

In order to perform this test, 10 grams of chicken fillet in aseptic form[9] along with 45 ml of 0.9% peptone water solution by a mixer[10] It was mixed well for one minute at room temperature. After that, the required dilutions are prepared and one milliliter of each dilution is used to culture bacteria in the culture medium using the porplate method.PCA it placed. Total count of live bacteria[11] (TVC) according to standard methods No. 5272 (Iran Institute of Standards and Industrial Research, 2016) and cold-loving bacteria[12] (PTC) was carried out according to standard methods No. 2629 (Iran Institute of Standards and Industrial Research, 2012). In order to increase the accuracy of this test, 3 repetitions for each sample and 4 appropriate dilutions for each repetition were evaluated.

2-6-2-2 Determining the peroxide index (PV)

In order to determine the peroxide number, chicken fillet was mixed with chloroform (100 ml) and filtered with Whatman filter paper. The filtered solution (25 ml) was poured into the skin to extract the fat and placed in a 37°C oven until the chloroform evaporates completely (we consider the difference in the skin's weight after evaporation of the chloroform as the weight of the oil). . Then add acetic acid (37 ml) and saturated potassium iodide (1 ml) to the filtered solution (25 ml) and after a minute add distilled water (30 ml) and starch (1 ml) became. The resulting solution was titrated with 0.01 normal sodium thiosulfate until the color changed from yellow to milky white. The amount of peroxide index was calculated in terms of milliequivalents of oxygen per kilogram of chicken fillet [29].

3-6-2-2 determination of thiobarbituric acid index[13] (TBARS)

To determine the thiobarbituric index, chicken fillet (0.2 g) was transferred to a 25 ml volumetric flask and then adjusted to volume with 1-butanol. Then pour this solution (5 ml) into a dry tube with a lid and incubate itTBA (5 ml) was added. The closed tubes were placed in a water bath for 2 hours at a temperature of 95 degrees

[9]- Aseptic
[10]-Stomacher
[11]-Total Viable Count
[12]-Psychrotrophic Count
[13]- Thiobarbituric Acid

Celsius and then cooled to room temperature. Then absorb it at a wavelength of 530 nm and read the amountTBARS It was determined in terms of milligrams of malondialdehyde per kilogram of meat [28].

4-6-2-2 Sensory evaluation

For sensory evaluation, raw chicken fillet was evaluated by panelists (15 people) in terms of color, smell, and texture. Then the chicken fillet was fried under the same conditions and sensory evaluation by hedonic method[14] 5 points were analyzed in terms of taste, smell, color, texture and overall acceptance as (5: excellent, 4: very good, 3: good, 2: acceptable, 1: poor) [30].

2-7 Statistical analyses

The data obtained with the help of a factorial experiment in the form of a completely random design in three concentration levels of celery seed extract (0.5, 2 and 8%) and on the first, fifth, tenth and fifteenth days, analysis and comparison of the average physicochemical data and Microbiological analysis was done with the help of Duncan and Tukey's multiple range test with three replications by SAS software version 9.1 at the level of 5%.

3. Results and Discussion

In this research, the methanol extract of celery seed was added to the biopolymer chitosan-potato starch mixture at three concentration levels (0.5, 2 and 8 percent) and the antimicrobial and antioxidant effects of celery seed extract in an edible film based on chitosan-apple starch. The field was investigated in a period of 15 days. Celery seeds were extracted with methanol solvent and finally dried by freeze dryer. The extraction efficiency of celery seed extract was 6.37%.

1-3 The amount of phenolic and flavonoid compounds in celery seed extract

Phenolic compounds are secondary metabolites in plants that can prevent the production of free radicals in oxidative systems and trap active metal ions [31]. Their solubility is affected by various factors such as the type of solvent used, the degree of polymerization of phenolic compounds, the interaction of ions between phenolic compounds and other plant components, as well as the structure of insoluble complexes. In this research, after extracting the celery seed extract with methanol, the phenolic compounds were measured by Folin Ciocaltio method and the results were expressed in terms of milligrams of gallic acid per gram of the extract. Methanolic extract of celery seed contained 70.67 ± 7.8 mg of gallic acid per gram of extract, phenolic compounds.

Flavonoids are present in plant tissues and have significant antioxidant properties. Flavonoids with the main structure of diphenylpropane with differences in the central pyran ring are widely distributed in plants. Flavonoids are the compounds responsible for the color in flowers and fruits. Flavonoids and phenolic compounds have been known to prevent the development of cancer and heart diseases [32].

The mechanism of action of flavonoids is free radical trapping or ion chelation. Using aluminum chloride method, flavonoids can react with aluminum ion and form a red complex. This complex has absorption maxima at 510 nm. Flavonoid content of the total extract

[14]-Hedonic

Celery seed is 62.81 ± 5.65, which was expressed in terms of milligrams of quercetin per gram of the extract. Delal et al. (2016) investigated the conditions of extracting phenolic compounds of celery seeds with the response surface method. In this study, the effect of time and solvent (methanol and ethanol) were optimized. So that the highest phenolic content (825.85 ± 0.89 mg of gallic acid per 100 grams of dry weight) was obtained in the concentration of 31.71% ethanol after 204.85 minutes. The highest flavonoid content (177.57 ± 0.49 mg of gallic acid per 100 grams of dry weight) during the extraction time of 34.14 minutes with 74.14% ethanol and the highest total tannin content (243.36 ± 0.94 mg of gallic acid per 100 g of dry weight) 100 grams of dry weight) was also obtained with 60% ethanol concentration in 204.85 minutes [33]. Mehdizadeh et al. (2013) also investigated the antioxidant properties of starch-chitosan edible film (50:50 ratio) containing the alcoholic extract of pomegranate peel. The results showed that films containing pomegranate peel extract increase the amount of phenol compound and consequently the antioxidant power increases with the increase in the percentage of the extract [34].

2-3 The results of physical properties of chitosan-potato starch film containing celery seed extract

3-2-1 film thickness

Thickness is one of the effective factors on the properties of the film, which is effective in the transparency, permeability to water vapor and textural characteristics of the film. The effect of different amounts of celery seed extract on film thickness is shown in Table 1. For this purpose, the thickness of the film was measured at 5 points and it was observed that there is no significant difference between the samples. Previously, Hogue et al. (2011) reported that the addition of plant extracts did not affect the thickness of the gelatin film [35].

3-2-2 film humidity

The effect of different amounts of celery seed extract on moisture content is shown in Table 1. The addition of celery seed extract with a concentration of 0.5% did not have a significant effect on the moisture content of the film. These results are consistent with the research results of adding one percent of oregano essential oil to the film prepared with whey protein [36]. But the addition of celery seed extract by 2 and 8% decreased the moisture content of the film. The reason can be due to the increase in the hydrophobicity of the film. Mahdavi et al. (2018) discussed the effect of fennel essential oil in chitosan film on the shelf life of chicken burgers. The results showed that adding fennel to the film reduces moisture, solubility and permeability to water vapor [37]. In the research of adding thyme and clove essential oil to chitosan film, similar results were observed, which were attributed to the hydrophobic nature of these compounds, which caused moisture to escape from the film structure, and as a result, the amount of moisture decreased [25].

3-2-3 Film solubility

Film solubility in water is an important feature in determining the possibility of using a film as a packaging coating, and its high amount in fresh and frozen foods is considered a disadvantage [38]. The effect of different amounts of celery seed extract on film solubility is shown in Table 1. The addition of celery seed extract to the films decreased the solubility in water compared to the control samples. Ajaq et al. (2010) conducted a research on the properties of chitosan film containing cinnamon essential oil. The results showed that by increasing the concentration of essential oil from 0.4% to 2%, the permeability to water vapor and

solubility decreases [24]. The solubility of films in water is related to the structural characteristics and the presence of compounds in the film, including phenolic compounds. The addition of celery seed extract probably reduces the film's solubility by reducing the hydrophilicity of the film.

Table 1 Physical properties (thickness, moisture and solubility) of chitosan-potato starch film containing celery seed extract.

Each value represents as mean±SD of triplicate experiments. Different letters in the column indicate significant differences ($p<0.05$)

3-2-4 Mechanical properties of chitosan-potato starch film containing celery seed extract

Mechanical properties of chitosan-potato starch films containing celery seed extract including tensile strength[15], elastic modulus[16] and increase in length[17] It is given in Table 2. The tensile strength for the negative control film was 20.69 ± 0.9 MPa. By adding celery seed extract from 0.5% to 8% to the films, the tensile strength value from 18.27±0.61 to 9.38±0.24 MPa and the elastic modulus from 20.26±1.11 to 5. 0 ± 8.58 MPa decreased, which indicates the weaker structure of the films containing the extract compared to the control film. Paranoto et al. (2005) added garlic oil to alginate films and investigated the physical and mechanical properties of the films, and the results showed that the tensile strength of the films decreases due to the addition of garlic oil [39]. Adding celery seed extract to the film creates a non-uniform structure, which ultimately leads to a decrease in tensile strength. Also, the reduction of elastic modulus is related to the ease of movement of polymer chains. Increasing the concentration of celery seed extract increased the elongation to breaking point. The reason for this can be related to the replacement of weak polymer-extract interactions instead of stronger polymer-polymer bonds, which reduces the tensile strength and increases the elasticity of the films.

Table 1 Physical properties (thickness, moisture and solubility) of chitosan-potato starch film containing celery seed extract.

Film treatment	**Thickness** (mm)	**Moisture** (%)	**Solubility** (%)
Negative control	0.12±0.004[a]	10.96±0.3[a]	36.81±0.73[a]
0.5% of extract	0.125±0.005[a]	10.45±0.36[a]	30.2±0.38[b]
2% of extract	0.117±0.002[a]	9.07±0.31[b]	25.34±0.4[c]
8% of extract	0.12±0.003[a]	8.28±0.15[c]	21.91±0.7[d]

Each value represents as mean±SD of triplicate experiments. Different letters in the column indicate significant differences ($p<0.05$)

Table 2 Mechanical properties of chitosan-potato starch film containing celery seed extract

Film treatment	**Tensile strength** (MPa)	**Modulus of Elasticity** (MPa)	**Elongation to break** (%)
Negative control	20.69±0.9[a]	25.67±0.23[a]	29.63±0.3[d]
0.5% of extract	18.27±0.61[b]	20.26±1.11[b]	32.2±0.19[c]
2% of extract	13.23±1.57[c]	15.28±0.96[c]	45.4±1.48[b]
8% of extract	9.38±0.24[d]	8.58±0.5[d]	51.39±2.52[a]

[15]-Tensile strength

[16]-Modulus of Elasticity

[17]-Elongation to break

5-2-3 Antioxidant power of chitosan-potato starch film containing celery seed extract

Antioxidant activity of films by testDPPH Was determined. TestDPPH It provides information on the antiradical activity of the film containing plant extracts. Since this method is faster than other methods, it is widely used to evaluate antioxidant activity. Investigating the antioxidant properties by methodDPPH The ability to donate hydrogen atoms or electrons in different compounds with the degree of decolorization of the violet solution of 2,2-diphenyl-1-picrylhydrazyl (DPPH) is measured in methanol [40]. The amount of color reduction is directly related to the antioxidant power of the sample. By increasing the concentration of phenolic compounds, the radical scavenging activity of the extract also increases. Percentage of free radical inhibitionDPPH The extract is shown in Figure 1. In general, the antioxidant property of the films increased with the increase in the concentration of the extract, which was statistically significant. The antioxidant activity of films with zero, 0.5, 2 and 8% celery seed extract increased from 14.69 to 73.94%. The concentration of phenolic compounds directly increases the ability of different extracts to inhibit free radicals. At higher concentrations of phenolic compounds, due to the increase in the number of hydroxyl groups in the reaction medium, the probability of giving hydrogen to free radicals and then the inhibitory power of the extract increases. In fact, the strong antioxidant activity of the extract is related to its high amount of phenols and flavonoids. Among phenolic compounds, flavonoids are considered stronger antioxidant compounds. Flavonoids are strong inhibitors of hydroxyl and peroxide radicals, and their effect on superoxide radicals has not yet been determined. These compounds can affect free radicals even when they form complexes with metal ions. Pierce et al. (2011) stated during a research that the amount of antioxidant activity of biodegradable films is usually determined based on antioxidant additives [41].

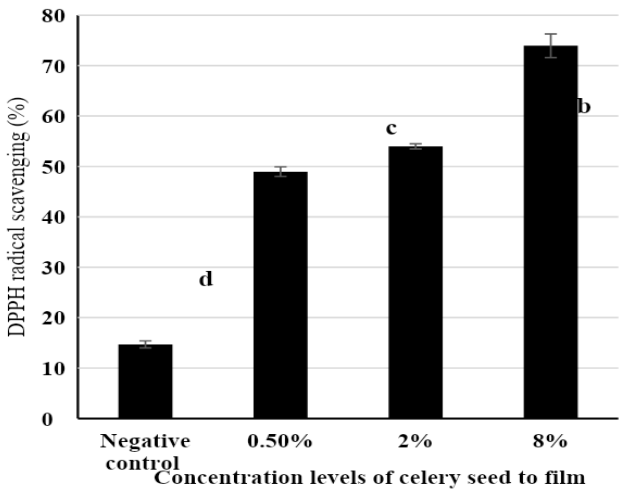


Fig 1 Antioxidant activity of chitosan-potato starch film containing different concentration levels of celery seed extract with DPPH radical inhibition assay

3-3 Qualitative evaluation of chicken fillet coated with chitosan-potato starch film containing celery seed extract during shelf life

1-3-3 Oxidative changes in chicken fillet

Fat oxidation is one of the most important reasons for reducing the shelf life of chicken, which depends on various parameters such as fat content, storage temperature, packaging method, etc.

3-3-1-1 Evaluation of primary oxidation products (peroxide index)

The peroxide index is a suitable parameter to check the oxidation process of meat fat. The sensitivity of meat to fat oxidation depends on various factors such as animal species, anatomical position of body muscles, storage time, packaging methods

and addition of antioxidants. Although free radicals are known to intensify fat oxidation in chicken meat, the amount of fat and fatty acid composition are also very important in the oxidation of chicken fat during storage. Plant extracts contain many antioxidant compounds that have the ability to control and inhibit oxidation. The peroxide index is related to the primary oxidation of fat. Changes in the peroxide index of the films kept at refrigerator temperature are shown in Table 3. The initial value of the peroxide index for the control sample was 1.92 ± 0.01 milliequivalent of oxygen per kilogram of sample. The trend of changes in peroxide value in all the examined samples is increasing, and the control sample had the highest peroxide value after the storage period. The samples coated with chitosan-pure potato starch film showed significantly less oxidation compared to the control sample, which is probably due to the antioxidant activity of chitosan and preventing the proximity of oxygen to the chicken fillet. Also, the results showed that the effect of the film containing celery seed extract on the peroxide index of chicken fillet was significant. Celery seed extract, even in low concentration, is able to prevent the spread of oxidation. The results confirmed the results of the antioxidant activity test of the film. On the last day of the storage period, the peroxide index for the samples coated with a film containing 8% celery seed extract was 3.97 ± 0.05 milliequivalents of oxygen per kilogram, which was 9.51 ± 0.12 milliequivalents of oxygen per kilogram compared to the control sample. It was significantly less. The permissible limit of peroxide number for chicken meat is 10 milliequivalents/kg, and the results were within the permissible range of peroxide. Moulai Aghaei et al. (2014) evaluated the effect of packaging with chitosan biodegradable films formulated with garlic essential oil on the chemical characteristics of chicken fillet. Based on the results of this research, the use of chitosan film in the packaging of chicken fillets prevents the increase of factors affecting its chemical spoilage, and considering the relatively similar inhibitory effect of 1% and 2% values as well as economic efficiency, the amount of essential oil of 1% can extend the life Increase the shelf life of chicken fillet [42].

Table 3 Changes in peroxide value in chicken fillet coated with chitosan-potato starch film containing celery seed extract

Storage time (days)	**Treatments**				
	Blank	Negative control	0.5%	2%	8%
1	1.92±0.1[and]	1.92±0.03[and]	1.93±0.2[and]	1.89±0.1[and]	1.83±0.19[and]
5	4.95±0.09[that]	3.13±0.07[cB]	2.72±0.04[cC]	1.81±0.3[cD]	2.03±0.07[cD]
10	7.18±0.1[not]	6.35±0.2[bB]	4.18±0.15[bC]	3.09±0.06[bD]	2.32±0.16[bE]
15	9.51±0.12[aA]	7.57±0.02[aB]	6.07±0.05[BC]	4.13±0.01[aD]	3.97±0.05[aE]

Each value represents as mean±SD of triplicate experiments. Different lowercase letters within the column and uppercase letter within the row indicate significant differences ($p<0.05$)

3-3-1-2 evaluation of secondary oxidation products (thiobarbituric acid index)

Fat oxidation is the main reason for reducing meat quality and the most important reason for not accepting the product by consumers. The thiobarbituric acid index measures the secondary products of fat oxidation and is responsible for the oxidative rancidity of chicken meat. Therefore, its measurement is important as a parameter affecting the sensory characteristics of chicken meat. The results related to changes in thiobarbituric acid index of different chicken meat samples during the storage period are shown in Table 4. It can be seen that the trend of changes in thiobarbituric acid index in all the examined samples is increasing and with the passage of time, statistically significant changes have been made. Also, the control sample had the highest amount of thiobarbituric acid. Among the coated chicken fillet samples, the samples with chitosan-potato starch film containing 2 and 8% celery seed extract had less oxidation compared to the film without extract (negative control). Vital et al. (2016) investigated the effect of alginate coating containing rosemary extract and orange peel essential oil on beef fat oxidation. The results showed that the change trend of thiobarbituric acid index is increasing and the samples containing the extract in the coating had a lower oxidation rate due to the phenolic effects of the extract and as a result the thiobarbituric acid index was lower [43]. Jaredi et al. (2018) reported similar results for beef samples coated with gelatin coating containing henna extract [44]. Deos et al. (2017) investigated the changes in thiobarbituric acid index of turkey meat samples coated with silver nanoparticles during 12 days of storage. The results indicated that the passage of storage time leads to an increase in the number of thiobarbituric acid in the samples, which is in accordance with the results obtained from the present study [45].. In fact, the reduction of thiobarbituric acid index compared to the control sample is related to the antioxidant effects of phenolic and flavonoid compounds in the extract, which was determined in the DPPH free radical inhibition test.

Table 4 Changes in thiobarbituric acid value in chicken fillet coated with chitosan-potato starch film containing celery seed extract.

Storage time (days)	**Treatments**				
	Blank	Negative control	0.5%	2%	8%
1	0.2±0.02^{and}	0.22±0.03^{and}	0.17±0.3^{and}	0.18±0.1^{and}	0.19±0.1^{and}
5	0.94±0.02^{that}	0.63±0.03^{cB}	0.59±0.02^{cB}	0.41±0.01^{cC}	0.24±0.01^{cD}
10	2.83±0.07^{not}	2.31±0.02^{bB}	2.06±0.05^{bC}	0.9±0.04^{bD}	0.76±0.03^{bE}
15	4.61±0.12^{aA}	4.01±0.02^{aB}	3.17±0.08^{BC}	1.69±0.1^{aD}	1.34±0.03^{aE}

Each value represents as mean±SD of triplicate experiments. Different lowercase letters within the column and uppercase letter within the row indicate significant differences ($p<0.05$)

2-3-3 Microbial changes of chicken fillet

In many fresh and processed foods, microbial spoilage begins at the surface of the food. Therefore, there is a need to use an effective method to control microbial growth on the surface of food products. The use of natural antimicrobial compounds in edible films leads to an increase in the shelf life of perishable foods such as chicken meat. Due to the high amount of protein and fat, chicken meat is very susceptible to spoilage and has a short shelf life. The results related to the changes in the total number of bacteria during the storage period are shown in Table 5. It can be seen that the highest number of bacteria is related to the control sample and it has a statistically significant difference with the samples coated with chitosan-potato starch film containing celery seed extract. In all treatments, until the 15th day, the number of bacteria increased and this increase in the sample containing 8% celery seed extract (5.9 ± 0.08 log CFU/g) compared to the control sample (10.71 ± 0.32 log CFU /g) was less after the maintenance period. Gómez-Staca et al. (2009) studied the effect of the application of chitosan-gelatin fish skin film containing clove essential oil on the shelf life of sardines. The results showed that this film leads to a decrease in the microbial load during the storage period (11 days) [46]. Mehdizadeh et al. (2012) investigated the antimicrobial properties of starch-chitosan edible film (50:50 ratio) containing pomegranate peel alcoholic extract. The results showed that the films containing pomegranate peel extract significantly increase the diameter of the growth inhibition halo of bacteria in the culture medium compared to films without extract [34]. Ruiz-Cruz et al. (2018) investigated the effect of chitosan coating containing tomato skin extract on the total number of bacteria in chicken meat, and it was found that the trend of changes in bacterial growth in the samples coated with the coating containing the extract was decreasing until the 4th day of storage. It increased after that [47]. Jaredi et al. (2018) investigated the effect of gelatin coating containing henna extract on increasing the shelf life of beef during 8 days of storage at 4 degrees Celsius, and it was found that the number of bacteria was lower in the samples coated with the extract containing the extract compared to the control sample. and all the samples had an increasing trend, which is in line with the results of this study [44]. Zhang et al. (2017) showed that with the passage of storage time, the total number of

bacteria in meat samples increases, and the uncoated samples had the highest total number of bacteria, which is in accordance with the results of the present study [48]. The country's veterinary organization has considered the number of critical bacteria in chicken meat to be 6 log CFU/g, which can be seen that the chicken fillet covered with a film containing 8% celery extract is in the appropriate range in terms of the number of bacteria until the end of the storage time.

Table 5 Changes in total live bacteria log (CFU/g) of different samples of chicken fillet coated with chitosan-potato starch film containing celery seed extract during the storage period.

Storage time (days)	**Treatments**				
	Blank	Negative control	0.5%	2%	8%
1	4.55±0.01^{dB}	4.92±0.01^{and}	4.91±0.03^{and}	4.59±0.05^{dB}	4.2±0.01^{cC}
5	7.15±0.09^{that}	6.03±0.07^{cB}	5.62±0.04^{cC}	5.01±0.10^{cD}	4.96±0.07^{bD}
10	8.18±0.17^{not}	7.14±0.22^{bB}	6.49±0.15^{bC}	5.9±0.06^{bD}	5.72±0.16^{aD}
15	10.71±0.32^{aA}	9.52±0.12^{aB}	8.12±0.09^{BC}	6.3±0.11^{aD}	5.9±0.08^{aE}

Each value represents as mean±SD of triplicate experiments. Different lowercase letters within the column and uppercase letter within the row indicate significant differences ($p<0.05$).

3-2-4 Counting of cold-loving bacteria

The results related to the changes in the number of cold-loving bacteria in the examined samples during the storage period are shown in Table 6. As can be seen, the general trend of changes is incremental and the amount of bacteria at the beginning and end of the storage period has a statistically significant difference. The reason for the decrease in the number of bacteria during the storage period is related to the antibacterial effects of celery seed extract. These results are consistent with the results of Hassanzadeh et al. (2016). They investigated the changes of psychrophilic and mesophilic bacteria in chicken meat samples coated with chitosan and grape seed extract at 4 degrees Celsius during 21 days[49]. The change trend of bacteria during the storage period was increasing. The phenolic compounds present in the extract, by affecting the cell wall and mitochondria of bacteria, cause changes and destruction of their structure and greater permeability, as a result of which a large amount of ions and other contents of the cell seeps out, which ultimately leads to the death of the bacteria. Another reason for the reduction of microbial growth in the coated samples is the disruption of the function of the enzymes attached to the cell membrane, which is caused by the phenolic compounds in the extract and leads to defects in the synthesis of the polysaccharide compounds of the cell wall and hinders cell growth. Mahdavi et al. (2018) discussed the effect of fennel essential oil in chitosan film on the shelf life of chicken burgers. In this research, fennel essential oil was used at concentration levels of 0.5 to 2% in chitosan film. Then the chicken burger was wrapped in the desired film and kept at 4 degrees Celsius for 12 days. The results showed that by increasing the concentration of fennel, the microbial and chemical spoilage in chicken burgers is significantly reduced [37]. Sougat et al. (2018) investigated the effect of chitosan and grape extract in edible film for packaging chicken fillet. In this study, grape extract was used at concentration levels of 5, 10 and 15%. The

results showed that grape extract inhibited the growth of bacteria*Escherichia coli* ، *Listeria monocytogenes* ،*Staphylococcus aureus* and Pseudomonas aerogenes. This film significantly inhibited the growth of mesophilic air bacteria and coliforms during the storage of chicken fillet [28]. Ajaq et al. (2010) conducted a research on the properties of chitosan film containing cinnamon essential oil. The results showed that by increasing the concentration of essential oil from 0.4% to 2%, its antimicrobial effect increases [24]. Banano et al. (2013) investigated the antimicrobial properties of celery seed extract and essential oil. The results showed that celery seed essential oil can prevent the growth of bacteria *Escherichia coli*and also from the growth of bacteria*Pseudomonas aerogenes* And*Staphylococcus aureus* also prevent it to some extent. The main compounds in its essential oil are beta-pinene[18]Campaign[19], Comin[20]is limonene [50].

Table 6 Changes of log (CFU/g) cold-loving bacteria of different samples of chicken fillet coated with chitosan-potato starch film containing celery seed extract during the storage period.

Storage time (days)	Treatments				
	Blank	**Negative control**	**0.5%**	**2%**	**8%**
1	**3.19±0.5**[and]	**3.32±0.25**[and]	**3.16±0.19**[and]	**3.11±0.2**[and]	**3.03±0.27**[and]
5	**5.58±0.09**[that]	**5.09±0.07**[cB]	**4.92±0.04**[cC]	**3.96±0.1**[cD]	**3.53±0.05**[This]
10	**7.18±0.07**[bB]	**7.88±0.32**[not]	**5.75±0.15**[bC]	**4.86±0.06**[bD]	**4.2±0.16**[bE]
15	**8.85±0.09**[aA]	**8.13±0.04**[aB]	**6.36±0.09**[BC]	**5.67±0.13**[aD]	**5.12±0.11**[aE]

Each value represents as mean±SD of triplicate experiments. Different lowercase letters within the column and uppercase letter within the row indicate significant differences ($p<0.05$)

3-3-3 Sensory evaluation results

One of the important sensory changes of chicken meat is unpleasant changes in its color, smell, texture and taste, which is due to microbial growth, chemical changes caused by oxidation and production of volatile compounds. The results of sensory evaluation of raw chicken fillet samples coated with chitosan-potato starch film containing celery seed extract are shown in Table 7. As the results showed, the use of film containing 8% celery seed extract received a significantly higher score in terms of smell, color and texture than the other treatments. The lowest score was in the control sample and the negative control sample, which was on the day Ten signs of corruption appeared in it and the quality of the product dropped significantly.

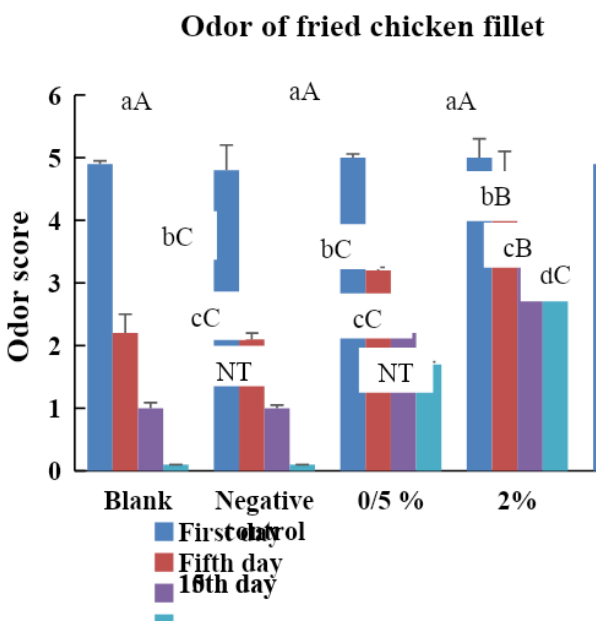
Sensory characteristics (color, smell, taste and texture) of fried chicken treatments sampled during refrigerated storage are shown in Figure 2. Sensory properties decreased during 15 days of storage period. The highest decrease in sensory attributes was observed in the control sample and then in the negative control sample. It was also observed that there is no significant statistical difference between the treatments on day zero. But from the fifth day, a statistical difference between the samples was seen, and from the tenth day, the difference between the samples increased. Thus, the taste evaluation on the 10th day and the texture, color and smell evaluation on the 15th day in the control and negative control samples were excluded due to strong inappropriate odor and slimy texture, but the rest of the samples were evaluated. On the 10th and 15th day, the samples containing celery seed extract in higher concentration were able to significantly prevent the signs of spoilage and increase the shelf life of chicken fillet from 3 days to 15 days. Sensory data correspond well with oxidative and microbiological data as well.

[18] - β-pinene
[19] - Camphene
[20] - Comene

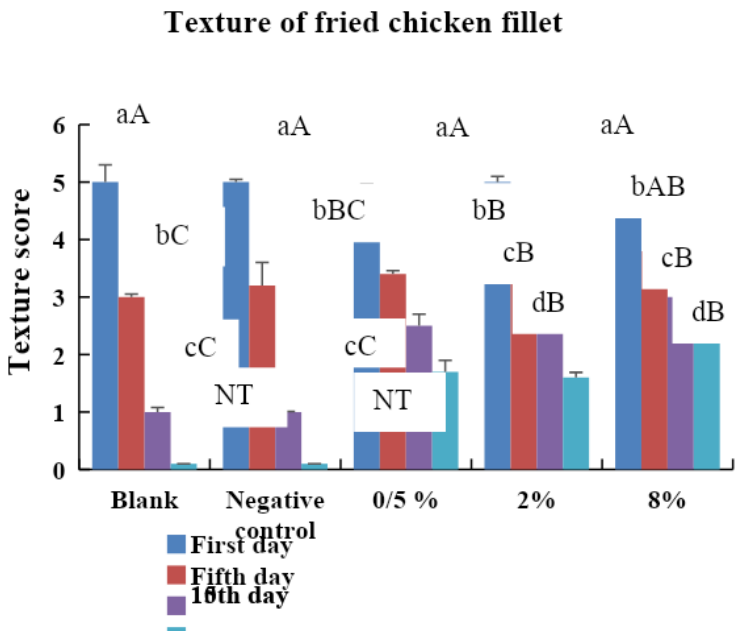
Table 7 Sensory evaluation of different samples of chicken fillet coated with chitosan-potato starch film containing celery seed extract during the storage period.

Treatments	Odor				Color				Texture			
day	1	5	10	15	1	5	10	15	1	5	10	15
Blank	$5\pm0^{a}_{A}$	3.4 ± 0.1^{bB}	1 ± 0.2^{cC}	NT	$5\pm0^{a}_{A}$	4.7 ± 0.1^{aB}	$2.1\pm0.64^{c}_{C}$	NT	$5\pm0^{a}_{A}$	$3.4\pm0.39^{b}_{B}$	$1.1\pm0.49^{c}_{C}$	NT
Negative control	$5\pm0^{a}_{A}$	3.4 ± 0.3^{bB}	1 ± 0.1^{cC}	NT	$5\pm0^{a}_{A}$	4.6 ± 0.34^{aB}	2.0 ± 0.2^{cC}	NT	$5\pm0^{a}_{A}$	3.2 ± 0.2^{bB}	$1.0\pm0.37^{c}_{C}$	NT
0.5%	$5\pm0^{a}_{A}$	4.3 ± 0.5^{aB}	$2.8\pm0.56^{b}_{C}$	1.4 ± 0.1^{cD}	$5\pm0^{a}_{A}$	4.6 ± 0.52^{aA}	3.2 ± 0.1^{bB}	$1.9\pm0.68^{B}_{C}$	$5\pm0^{a}_{A}$	$3.2\pm0.15^{b}_{B}$	1.9 ± 0.1^{bC}	$1.4\pm0.05^{b}_{D}$
2%	$5\pm0^{a}_{A}$	4.4 ± 0.37^{aB}	$3.2\pm0.21^{b}_{C}$	$1.9V0.19^{b}_{D}$	$5\pm0^{a}_{A}$	4.4 ± 0.9^{aAB}	$3.8\pm0.28^{a}_{B}$	2.2 ± 0.8^{BC}	$5\pm0^{a}_{A}$	$3.8\pm0.11^{a}_{B}$	$2.6\pm0.32^{B}_{C}$	$1.8\pm0.17^{a}_{D}$
8%	$5\pm0^{a}_{A}$	$4.5\pm0.57^{aA}_{B}$	3.9 ± 0.1^{aB}	$2.7\pm0.37^{B}_{C}$	$5\pm0^{a}_{A}$	$4.2\pm0.81^{aA}_{B}$	3.9 ± 0.1^{aB}	$2.7\pm0.27^{B}_{C}$	$5\pm0^{a}_{A}$	$3.9\pm0.17^{a}_{B}$	$2.9\pm0.18^{B}_{C}$	2.0 ± 0.1^{aD}

Each value represents as mean±SD of triplicate experiments. Different lowercase letters within the column and uppercase letter within the row indicate significant differences ($p<0.05$).



a)



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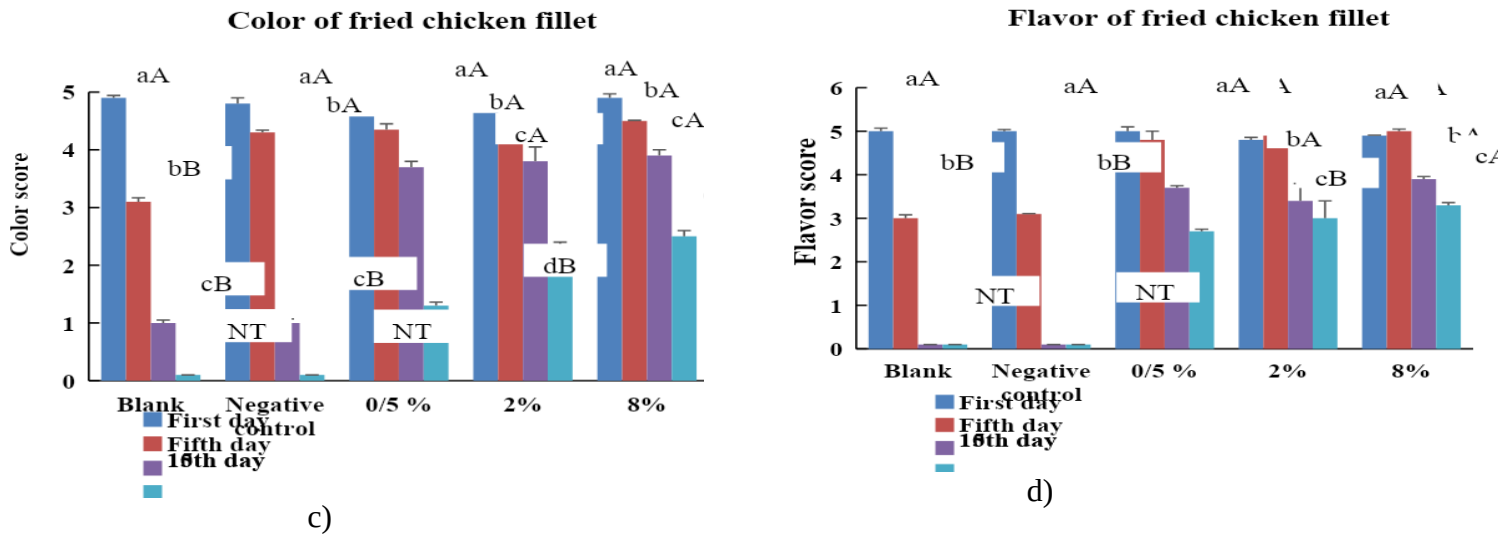

Fig 2 Sensory evaluation of fried chicken fillet coated with chitosan-potato starch film containing celery seed extract.

4- Conclusion

In this project, the antioxidant and antimicrobial effects of celery seed extract at concentrations of 0.5, 2 and 8% in chitosan-potato starch film were investigated to increase the shelf life of chicken fillet. The presence of valuable phenolic compounds (70.67 mg of gallic acid per gram of extract) and significant amounts of flavonoid compounds (62.81 mg of quercetin per gram of extract) makes the film containing celery seed extract well able to inhibit the DPPH free radical. . The properties of chitosan-potato starch film containing celery seed extract showed good antioxidant and antimicrobial properties. Coating of chicken fillet with chitosan-potato starch films containing celery seed extract increased the shelf life and maintained the quality of the fillets until the end of the storage period by preventing fat oxidation and microbial spoilage. Chitosan-potato starch film containing celery seed extract could reduce the growth of bacteria. Thus, in the coated samples, the total microbe count, the number of cold-loving bacteria was lower than the control sample. The obtained results showed that the film prepared from celery seed extract at a concentration of 8% could preserve the chicken fillet for 15 days and therefore it can be used for food packaging.

5- Resources

[1] Zhao, Y., et al.,*Development of antimicrobial films based on cassava starch, chitosan and gallic acid using subcritical water technology.* The Journal of Supercritical Fluids, 2018. 137: p. 101-110.

[2] Pineros-Hernandez, D., et al.,*Edible cassava starch films carrying rosemary antioxidant extracts for potential use as active food packaging.* Food Hydrocolloids, 2017. 63: p. 488-495.

[3] Hauser, C., et al.,*Development of an Active Packaging Film Based on a Methylcellulose Coating Containing Murta (Ugni molinae Turcz) Leaf Extract.* Food and bioprocess technology, 2016. 9(2): p. 298-307.

[4] Medina-Jaramillo, C., et al.,*Active and smart biodegradable packaging based on starch and natural extracts.* Carbohydrate polymers, 2017. 176: p. 187-194.

[5] Barbosa-Pereira, L., et al.,*Development of new active packaging films coated with natural phenolic compounds to improve the oxidative stability of beef.* Meat science, 2014. 97(2): p. 249-254.

[6] Talón, E., et al.,*Antioxidant edible films based on chitosan and starch containing polyphenols from thyme extracts.* Carbohydrate polymers, 2017. 157: p. 1153-1161.

[7] Turhan, K.N. and F. Shahbaz,*Water vapor permeability, tensile properties and solubility of methylcellulose-based edible films.* Journal of Food Engineering, 2004. 61(3): p. 459-466.

[8] Rodríguez, M., et al.,*Combined effect of plasticizers and surfactants on the physical properties of starch based edible films.* Food Research International, 2006. 39(8): p. 840-846.

[9] Ahmadi, R., et al.,*Development and characterization of a novel biodegradable edible film obtained from psyllium seed (Plantago ovata Forsk).* Journal of Food Engineering, 2012. 109(4): p. 745-751.

[10] Pelissari, F.M., et al.,*Antimicrobial, mechanical, and barrier properties of cassava starch− chitosan films incorporated with oregano essential oil.* Journal of agricultural and food chemistry, 2009. 57(16): p. 7499-7504.

[11] Vásconez, M.B., et al.,*Antimicrobial activity and physical properties of chitosan–tapioca starch based edible films and coatings.* Food Research International, 2009. 42(7): p. 762-769.

[12] Perez, C.D., et al.,*Development of a high methoxyl pectin edible film for retention of l-(+)-ascorbic acid.* Journal of agricultural and food chemistry, 2009. 57(15): p. 6844-6855.

[13] Sánchez-González, L., et al.,*Characterization of edible films based on hydroxypropylmethylcellulose and tea tree essential oil.* Food Hydrocolloids, 2009. 23(8): p. 2102-2109.

[14] Ghasemlou, M., F. Khodaiyan, and A. Oromiehie,*Physical, mechanical, barrier, and thermal properties of polyol-plasticized biodegradable edible film made from kefiran.* Carbohydrate Polymers, 2011. 84(1): p. 477-483.

[15] Shojaee-Aliabadi, S., et al.,*Characterization of antioxidant-antimicrobial κ-carrageenan films containing Satureja hortensis essential oil.* International journal of biological macromolecules, 2013. 52: p. 116-124.

[16] Jouki, M., et al.,*Effect of glycerol concentration on edible film production from cress seed carbohydrate gum.* Carbohydrate polymers, 2013. 96(1): p. 39-46.
[17] Khazaei, N., et al.,*Characterization of new biodegradable edible film made from basil seed (Ocimum basilicum L.) gum.* Carbohydrate Polymers, 2014. 102: p. 199-206.
[18] Kooti, W., et al.,*A review on medicinal plant of Apium graveolens.* Advanced Herbal Medicine, 2015. 1(1): p. 48-59.
[19] Urabe, A.A. and W.J. Aziz, *Biosynthesis of cobalt oxide (Co3O4) nanoparticles using plant extract of Camellia sinensis (L.) Kuntze and Apium graveolens L. as the antibacterial application.* World News of Natural Sciences, 2019. 24: p. 357-365.
[20] Jerman, T., P. Trebše, and B.M. water drinker,*Ultrasound-assisted solid liquid extraction (USLE) of olive fruit (Olea europaea) phenolic compounds.* Food Chemistry, 2010. 123(1): p. 175-182.
[21] Muntana, N. and S. Prasong,*Study on total phenolic contents and their antioxidant activities of Thai white, red and black rice bran extracts.* Pakistan Journal of Biological Sciences: PJBS, 2010. 13(4): p. 170-174.
[22] Shen, Y., et al.,*Total phenolics, flavonoids, antioxidant capacity in rice grain and their relations to grain color, size and weight.* Journal of Cereal Science, 2009. 49(1): p. 106-111.
[23] Silva-Pereira, M.C., et al.,*Chitosan/corn starch blend films with extract from Brassica oleraceae (red cabbage) as a visual indicator of fish deterioration.* LWT-Food Science and Technology, 2015. 61(1): p. 258-262.
[24] Ojagh, S.M., et al.,*Development and evaluation of a novel biodegradable film made from chitosan and cinnamon essential oil with low affinity toward water.* Food Chemistry, 2010. 122(1): p. 161-166.
[25] Hosseini, M., S. Razavi, and M. Mousavi,*Antimicrobial, physical and mechanical properties of chitosan-based films incorporated with thyme, clove and cinnamon essential oils.* Journal of food processing and preservation, 2009. 33(6): p. 727-743.
[26] Sánchez-González, L., J.I.Q. Saavedra, and A. Chiralt,*Antilisterial and physical properties of biopolymer films containing lactic acid bacteria.* Food control, 2014. 35(1): p. 200-206.
[27] Moradi, M., et al.,*Characterization of antioxidant chitosan film incorporated with Zataria multiflora Boiss essential oil and grape seed extract.* LWT-Food Science and Technology, 2012. 46(2): p. 477-484.
[28] Sogut, E. and A.C. Seydim, *The effects of Chitosan and grape seed extract-based edible films on the quality of vacuum packaged chicken breast fillets.* Food Packaging and Shelf Life, 2018. 18: p. 13-20.
[29] Serrano-León, J.S., et al.,*Chitosan active films containing agro-industrial residue extracts for shelf life extension of chicken restructured product.* Food Research International, 2018. 108: p. 93-100.
[30] Sharafati Chaleshtori, F., et al.,*Effect of chitosan incorporated with cumin and eucalyptus essential oils as antimicrobial agents on fresh chicken meat.* Journal of food processing and preservation, 2016. 40(3): p. 396-404.
[31] Adebo, O.A. and I. Gabriela Medina-Table,*Impact of fermentation on the phenolic compounds and antioxidant activity of whole cereal grains: A mini review.* Molecules, 2020. 25(4): p. 927.
[32] Afshari, K., et al.,*Natural flavonoids for the prevention of colon cancer: A comprehensive review of preclinical and clinical studies.* Journal of Cellular Physiology, 2019. 234(12): p. 21519-21546.
[33] Dellal, A., et al.,*Optimization of the extraction conditions of phenolic compounds from (Apium Graveolens) seeds by response surface methodology.* Advances in Environmental Biology, 2016. 10(10): p. 155-164.
[34] Mahdizade, T., Tajik, H., Razavi rouhani, S.M., Oromiehie A R. Antibacterial, antioxidant and optical properties of edible starch-chitosan composite film containing pomegranate peel extract. Studies in Medical Sciences 2012; 23 (3) :315-323. (In Persian)
[35] Hoque, M.S., S. Benjakul, and T. Prodpran, *Properties of film from cuttlefish (Sepia pharaonis) skin gelatin incorporated with cinnamon, clove and star anise extracts.* Food Hydrocolloids, 2011. 25(5): p. 1085-1097.
[36] Zinoviadou, K.G., K.P. Koutsoumanis, and C.G. Billiaderis,*Physico-chemical properties of whey protein isolate films containing oregano oil and their antimicrobial action against spoilage flora of fresh beef.* Meat Science, 2009. 82(3): p. 338-345.
[37] Mahdavi, V., S.E. Hosseini, and A. Sharifan,*Effect of edible chitosan film enriched with anise (Pimpinella anisum L.) essential oil on shelf life and quality of the chicken burger.* Food science & nutrition, 2018. 6(2): p. 269-279.
[38] Jutaporn, C., C. Suphitchaya, and W. Thawien, *Antimicrobial activity and characteristics of edible films incorporated with Phayom wood (Shorea tolura) extract.* International Food Research Journal, 2011. 18(1).
[39] Pranoto, Y., V.M. Salokhe, and S.K. Rakshit,*Physical and antibacte rial properties of alginate-based edible film incorporated with garlic oil.* Food research international, 2005. 38(3): p. 267-272.
[40] López-Caballero, M., et al.,*A chitosan–gelatin blend as a coating for fish patties.* Food hydrocolloids, 2005. 19(2): p. 303-311.
[41] Pires, C., et al.,*Characterization of biodegradable films prepared with hake proteins and thyme oil.* Journal of Food Engineering, 2011. 105(3): p. 422-428.
[42] Molaee Aghaee, E., Kamkar, A., Akhondzadeh Basti, A., Khanjari, A., Kontominas, M. Effect of packaging with Chitosan biodegradable films formulated with Garlic essential oil (Allium sativum L.) on the chemical properties of chicken fillet. Iranian Journal of Health and Invironment, 2015; 8 (3) :379-390 (In Persian).
[43] Vital, A.C.P., et al.,*Effect of edible and active coating (with rosemary and oregano essential oils) on beef characteristics and consumer acceptability.* PloS one, 2016. 11(8): p. e0160535.
[44] Jridi, M., et al.,*Physical, structural, antioxidant and antimicrobial properties of gelatin–chitosan composite edible films.* International journal of biological macromolecules, 2014. 67: p. 373-379.
[45] Deus, D., et al.,*Effect of a nano-silver coating on the quality of fresh turkey meat during storage after modified atmosphere or vacuum packaging.* Poultry science, 2017. 96(2): p. 449-457.
[46] Gómez-Estaca, J., et al.,*Antimicrobial activity of composite edible films based on fish gelatin and chitosan incorporated with clove essential oil.* Journal of Aquatic Food Product Technology, 2009. 18(1-2): p. 46-52.
[47] Ruíz-Cruz, S., et al.,*Effects of chitosan-tomato plant extract edible coatings on the quality and shelf life of chicken fillets during refrigerated storage.* Food Science and Technology, 2018. 39: p. 103-111.
[48] Zheng, W.-L., et al.,*ROS-mediated cell cycle arrest and apoptosis induced by zearalenone in mouse sertoli cells via ER stress and the ATP/AMPK pathway.* Toxins, 2018. 10(1): p. 24.
[49] Hasanzadeh, P., Tajik, H., Razavi rouhani, S.M., Application of chitosan edible coating containing grape seed extract on the quality and shelf life of refrigerated chicken meat, Journal of Food Research, 1390. 21(4): P. 467-482 (In Persian).
[50] Baananou, S., et al.,*Antiulcerogenic and antibacterial activities of Apium graveolens essential oil and extract.* Natural product research, 2013. 27(12): p. 1075-1083.

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چکیده

تمایل مردم به استفاده از نگهدارنده‌های طبیعی در فرآورده‌های غذایی به جای مواد سنتزی و ایجاد فرهنگ استفاده نکردن از مواد پلاستیکی رو به افزایش است. در این تحقیق، فیلم کیتوزان- نشاسته سیب زمینی حاوی عصاره دانه کرفس در سطوح غلظتی مختلف (۰/۵، ۲ و ۸ درصد) تهیه و خصوصیات فیزیکی فیلم از جمله ضخامت، میزان رطوبت و قابلیت انحلال آن، خصوصیات مکانیکی و آنتی اکسیدانی تعیین شد. سپس فیله مرغ پوشش دهی شده با فیلم مورد نظر در مدت ۱۵ روز در دمای یخچال نگهداری و میزان رشد میکروبی و تولید ترکیبات اولیه و ثانویه اکسایش با شاخص پراکسید و اسید تیوباربیتوریک و همچنین ارزیابی حسی طی زمان مورد پایش قرار گرفت. نتایج حاصل نشان داد که محتوی فنل و فلاونوئید کل عصاره دانه کرفس به ترتیب ۷/۸±۷۰/۶۷ میلی گرم اسید گالیک بر گرم عصاره و ۵/۶۵ ±۶۲/۸۱ میلی‌گرم کوئرستین در هر گرم از عصاره بود. افزودن عصاره دانه کرفس (۲ و ۸ درصد) میزان رطوبت و حلالیت فیلم را کاهش داد. علت آن افزایش خاصیت آب‌گریزی فیلم بود. همچنین با افزودن عصاره دانه کرفس، میزان افزایش طول تا پارگی فیلم افزایش در حالی که مقاومت در برابر کشش و مدول الاستیک آن کاهش یافت. با افزایش غلظت عصاره دانه کرفس در فیلم، میزان مهار رادیکال آزاد DPPH از ۱۴/۶۹ به ۷۳/۹۴ درصد افزایش می‌یابد. براساس آزمون اکسایشی، میکروبی و ارزیابی حسی، در صورت پوشش‌دهی شده با فیلم کیتوزان-نشاسته سیب زمینی حاوی ۸ درصد عصاره دانه کرفس می‌توان زمان ماندگاری فیله مرغ را تا ۱۵ روز در یخچال افزایش داد.