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Effect of the gelatin mixed with titanium dioxide nanoparticles as active packaging on bacterial growth and some characteristics of refrigerated chicken meat

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ABSTRACT

This study was carried out to preparation of the gelatin film alone and gelatin mixed with TiO2 NPs at concentration at (2%) and (4%) as active films and determine the antibacterial effect of the active films against total bacterial count, also evaluate the chemical and physical properties of refrigerated chicken meat during 16 day. To reach the goal of the study, we counted total bacterial count, chemical parameters such as pH value and Thiobarbituric Acid (TBA) as well as physical parameters that include water holding capacity of chicken meat samples storage without coated (control) T1, coated with gelatin alone T2, gelatin with TiO2 NPs at (2%) T3 and gelatin with TiO2 NPs at (4%) T4. The results showed that The total bacterial count in samples were coated by active film was significantly decreased ($p<0.05$), compare with samples coated by gelatin alone and samples without coated. The a significant increase in the pH and TBA value with advance the storage period in all groups of chicken meat samples, while the rate increasing was significantly lowest in the T3 and T4 compared with T1 and T2 group. The water holding capacity (WHC) were significantly decrease with the increased of the storage period, and the rate decreasing was significantly lowest in the samples were coated by gelatin alone and gelatin incorporated with NPs. It was concluded from this study the gelatin mixed with TiO2 NPs helped to increased shelf life of chicken meat samples for 16 day storage in refrigerator at 4 º C..

1. Introduction

It's important to know that in most countries, the chicken meat are well consumed [1]. The chicken meat from a dietary aspect and in comparison with red meat is enriched with vitamins and minerals such as magnesium, calcium, phosphorus and sodium. In reference to vitamins content, there are distinctive vitamins such as niacin (vit B_3), A and B6 represent the most predominant vitamins in chicken meat than those in other meats [2]. Meat spoilage may be defined as a process or change which renders it undesirable for consumption[3].In addition to food and drug and other applications, there was a need to focus on nanoparticles and their role in these applications [4]. The bionanocomposite packaging (active packaging) composed of a biopolymer matrix incorporation with nanoparticles at size range (1 to 100 nm), nano composites exhibit much improve characteristics as compared with original biopolymers [5]. It is important to know that Biopolymer films act as barriers of gas and solute in nature which can be a complement for different packaging are important in imporoving and extending the quality and shelf life of food products respectively [6].

Some techniques are applied to enhance or improve the main characteristics of food packaging and this includes application of barrier properties, thermal stability, mechanical strength in addition to nanomaterials. These techniques are incorporate with the using of antioxidents, plant extracts, bacteriostatic agents and enzymes. These applications have the unique impact on extending the shelf life of food products [7]. Limited use food packaging synthesis from synthetic petroleum-based polymers which can be due to several causes such as inability to renew or biodegrade these polymers. Furthermore, some of these polymers have carcinogenic effect or could pollute the environment [8]. As a result, there is a need to produce bio polymeric packaging which is natural in source and characterize to be affordable, renewable and biodegradable as well [9]. The bio-nanocomposite packaging considered as development technique, There are many reports pointed out by researchers that indicate the main structural composition of nanocomposites are based on ZnO, gelatin, TiO2 and Ag [10].

The aim of study incorporate TiO2 NPs in edible biofilm of gelatin in order to study its effect on *Salmonella spp,* total bacterial count and total coliform count, as well as find the healthiest products in term of pH and lipid oxidation in chicken meat during different periods of refrigerated storage.

The aim of the study of gelatin polymer incorporated with TiO2 NPs in order to study, it against bacterial growth and maintain chemical and physical characteristics of chicken meat during storage period.

2. Materials and Methods

2.1 Preparation of TiO_2 NPs suspension:

In a semi-dark setting, 4g of TiO2 NPs powder were mixed well in 10 ml of deionized distilled water for nanoparticles suspension. The

mixing with Ultrasonic for 1 hrs and left overnight to fully mixed.

2.2 Gelatin film preparation:

Gelatin film was preparation according to the procedure of [11]. It was followed by weighting of 10 g of gelatin and dissolved in 80 mL of distillated water; mixed well and heating to 60 ° C for 15 mints used the Hot plate - Magnetic Stirrer, then adding the glycerol, at 30% from dry weights of gelatin. The ZnO and TiO2 NPs were adding at 2 and 4 mg/ml (0.5 and 1.0 ml from the nanoparticles suspension) and complete the volume to 100 ml used the distillated water. The pH was adjusted at 7. The 20 ml of hot gelatin solution was poured in plastic dish at 18 cm diameter, then separated at one level and dried at 30 ° C for 24 hrs by casting method.

2.3 Sample's preparation:

The poultry were collected from Al-Karkh district/Baghdad city. The preparation of the carcass was conducted under hygienic conditions, mince chicken meat was stripped from the bone of each carcass. the meat was mince by sterile mincing machine, then minced meat treatments that including control (control) (T1)samples without packaging (T1), (T2) samples coated with gelatin alone, (T3). Samples coated by gelatin mixed with TiO2NPs at 2% and (T4) samples coated by with gelatin with TiO2 NPs at 4%. Each group contain 60 samples and weight of sample 80 gm then kept in a sterile cork container, in refrigerator at 4 °C.

2.4 Determination of the total bacterial count (TBC) .

Twenty-five gram of each minced chicken samples was homogenized in 225 ml of sterile buffer peptone water (BPW) solution which was previously prepared. sequential dilutions of 10^{-1} to 10^{-9} for samples had been done in a diluent which was 0.1% (w/v) sterile peptone water, after that, the dilutions was add on plates contain nutrient agar for all dilutions. Petri dishes contain 15 ml of nutrient agar were prepared, then, in order to calculate the total bacterial counts (TBC). One ml of dilutions were transferred into petri dishes and mixed at 45°C.The mixture were aerobic incubated at 37°C and the TBC were enumerated.

2.5 Chemical tests

2.5.1 pH value

PH value of chicken meat was evaluated using Mettler Toledo Delta 320 pH Meter [12]. 10 grams of minced meat were homogenized with 50 ml of distillated water, then filtered through Whatman no. 1 filter paper. In order to calculate the Ph of the filtrate samples , a digital Ph meter was used for this procedure..

2.5.2 Thiobarbituric acid (TBA) value

50 ml of cold solution containing 20% of Trichloroacetic acid (TCA) and 2 Molars phosphoric acid for 15 min were prepared, after that, mixing 20 g of minced chicken meat with this solution for 15 mints. This mixture were transfer into 100 ml volumetric flask contain 40

ml of distilled water and shake it. Later on, 25 ml of solution war centrifuged for 30 minutes at a speed of 3000 cycle per minute. Then, 5 ml of collecting sample were filtered using filter paper no. 1. Subsequently, sample after filtration was moved into test tube and mixed with 5 ml of Thiobarbituric acid (0. 005 M) and kept at room temperature for 15 hours in a dark place. In order to evaluate color, UV spectrophotometer were used at 530 nm. TBA values were determined by multiplying the sample's absorbance value by 5.2 and converting to mg malondialdehyde (MDA)/kg meat [13].

2.5.3 Water holding capacity (WHC) :

[14] indicate an estimated water holding capacity (WHC). 8 g of minced chicken sample was placed in a tube. The addition of NaCl at a concentration of volume of 0.6 M and 12 ml, respectively. The tube was placed in a chiller set at 5°C for 15 minutes. The tube is then centrifuged for 15 minutes at a speed of 3000 revolutions per minute. The supernatant was gathered and put in a measuring cylinder, and the volume of the supernatant was then noted. Following its calculation, the WHC has been expressed as a percentage (%). The following equation describes the steps taken above:

$$\mathbf{W.H.C.} = \frac{\mathbf{initial\ volume - volume\ of\ supernatant}}{\mathbf{initial\ volume}}\ \mathbf{x\ 100}$$

3. Results and Discussion

3.1 Characterizes of Active film :

Characteristics of the active films include brightness, tasteless , odorless. Flexible, edible and environmentally friendly. The active films are possess barrier properties (retention gas oxygen, CO2 and humidity) between sample and outer surrounding.

Gelatin incorporated mix with titinum dioxide nanoparticles are called active film, the nanoparticles act as antimicrobial agent, and also improve barrier properties of the active films. Our results are agreement with mentioned [10] by study synthesis gelatin film mix with nanoparticles to improve antibacterial activity and barrier properties. The significantly decrease of the bacterial growth rate in chicken meat samples coated by the gelatin biofilm incorporated with TiO2 NPs compared with samples coated with gelatin biofilm alone and without coated , may be because the barrier properties of the active film and role of the nanoparticles for bacterial inhibition ,show in table (1).These results corresponding with mentioned [8]. the improvement antimicrobial properties of the films composed of gelatin mix nanoparticles. Thus, active films are use in food packaging.

3.2 Nanoparticles results and discussion:

3.2.1 X-ray diffraction (XRD):

The TiO2 NPs' X-ray diffraction revealed several peaks in the area 20–60, as shown in Fig1.Based on the Shearer

equation, five of the highest intensity peaks from the TiO_2 NPs' X-ray diffraction data were utilized to estimate the average size of the nanoparticles.TiO_2 nanoparticles had crystals that were 29.8 nm in size.

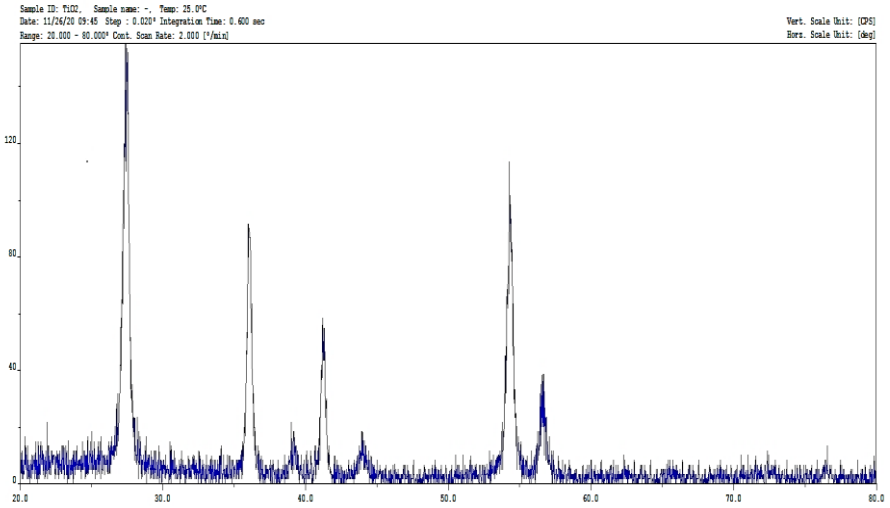

Figure:1 XRD spectrum of TiO_2 NPs

The XRD pattern of the synthesized TiO2 nanostructure figure (1) showed confirm the presence of both anatase phase of TiO_2 nanostructure and rutile forms which can be denoted at 2θ peaks. [15] indicated Similar result . Sharp diffraction patterns signify the synthesized sample's small size, high purity, and crystallinity [16].

3.2.2 Scanning Electron Microscope

The morphological information of the TiO2 nanoparticle was obtained using SEM. Figure (2) showed the SEM images of the TiO2 nanoparticles.

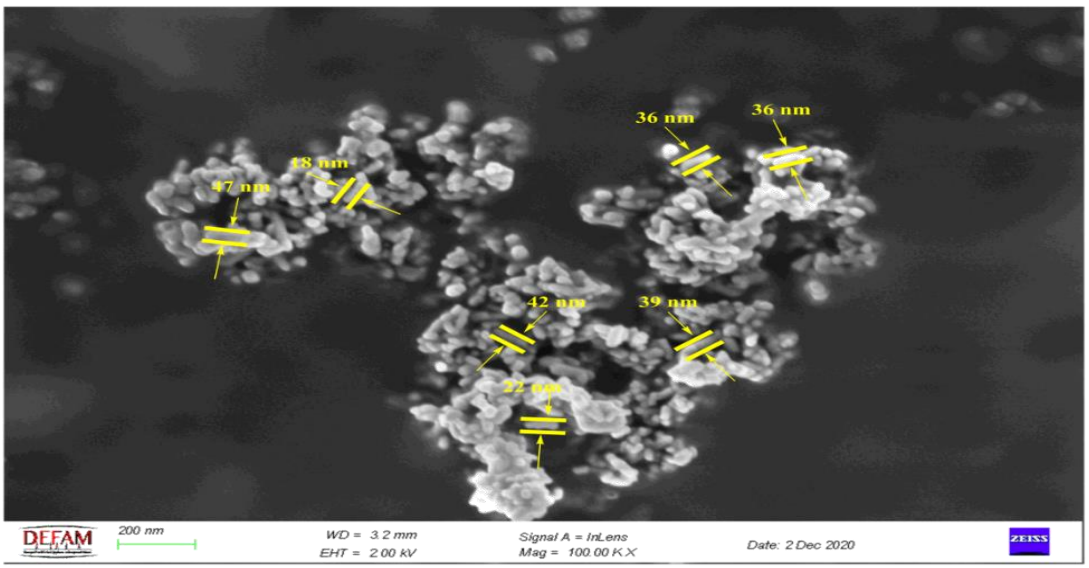

Figure:2 SEM spectrum of TiO_2 NPs, it has a nanostructure like a as merged nano-rods and nano-particles with a diameter of 18–47 nm.

The morphological information of the TiO_2 NPs was obtained using SEM. Figure (2) showed the SEM images of the TiO_2 NPs presence of a nano-particles and nano- rod with a different diameter of 18–47 nm.Our results indicated that all samples of TiO_2 nanoparticles were particles rods and rods in shape and smaller size is agreement with study by [17].

3.2.3 Energy dispersive X-ray (EDX):

The elemental analysis or chemical characterization of a material is accomplished using energy dispersive X-ray spectroscopy (EDX). It is based on the interaction of an X-ray excitation source and a sample [18]. Figure (3) show EDX pattern of the TiO2 NPs.

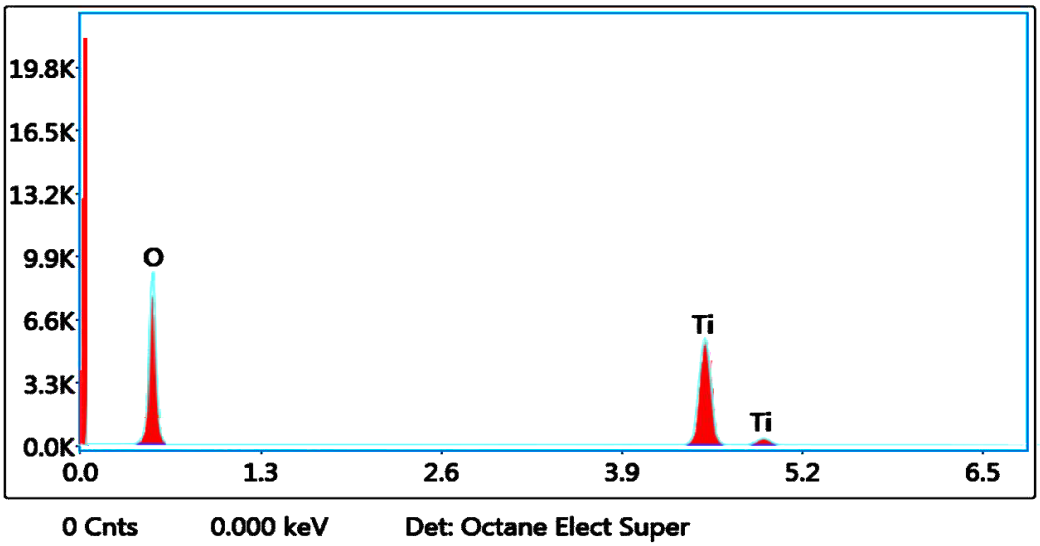

Figure: 3 EDX spectrum of the TiO_2 NPs.

the figure (3) shows EDX pattern the approximately the highest elemental percentage titanium and oxygen, our results good agreement with mentioned [19].

3.3 Bacterial part

3.3.1 The total bacterial counts (TBC):

as illustrated in Table (1) the overall bacterial population was significantly affected by gelatin biofilm alone G2, gelatin mix with TiO2 NPs (2%) G3, or gelatin mix with (4%) G4 after 4, 8, 12, and 16 days of storage at 4 C (P 0.05). The G1 samples without coating (control group) had the greatest count at 4 days of storage (6.70 log CFU/gm), while the G4 samples had the lowest count (5.57 log CFU/gm), while there was no statistically significant difference between them and the G3 samples (5.63 log CFU/gm). In 8 days of storage, highest count recorded in G1 (control) and G2 (gelatin biofilm) it was 8.60 and 6.94 log CFU/gm respectively, while lowest count recorded in G4, it was 5.63 log CFU/gm, so did not record significantly between G3. At 12 day of storage, G1 recorded highest count, it was 9.53 log CFU/gm, in contrast G4 recorded lowest count, it was 6.33 log CFU/gm. In 16 day, G1 still recorded highest count which was 11.49 log

CFU/gm, while lowest count recorded in G4, it was 6.55 log CFU/gm.

On the other hand, there is a significant difference (P0.05) between G1 and G2 in all storage periods, which was increasing gradually with increasing storage periods. The highest count which was recorded in last periods at 16 days of storage in all groups, while the lowest count recorded in first periods 0 days of storage in all groups. In addition, TBC recorded decrease in the G4 and G3 respectively when compared with the G1 and G2 counts.

Table: 1 Total bacterial count (log CFU/g) of chicken meat samples coated with gelatin biofilm mix with TiO2 NPs and storage for 16 days at 4◦ C.

Treatments	Mean ± Standard Error				
	0 day	4 days	8 days	12 day	16 day
T1	E5.46±0.05a	D6.70±0.06a	C8.60±0.08a	B9.53±0.08a	A11.49±0.01a
T2	E5.45±0.05a	D6.40±0.01b	C6.94±0.03b	B8.45±0.04b	A9.31±0.33b
T3	D5.48±0.05a	CD5.63±0.03d	C5.76±0.01cd	B6.54±0.09c	A6.72±0.02cd
T4	D5.44±0.05a	CD5.57±0.05d	C5.63±0.05d	B6.33±0.08de	A6.55±0.07d
LSD	**0.1714**				

Means with a different small letter in the same column are significantly different (P<0.05). Means with a different capital letter in the same row are significantly different (P<0.05). T1=control, T2=gelatin biofilm,T3=gelatin biofilm with TiO2NPs (2%), T4=gelatin biofilm with TiO2 NPs(4%).

The total bacterial counts (TBC) in chicken meat samples without coated (control) significantly increased (p<0.05) with increase storage time. The organoleptic sings of spoilage are started appear at five days in samples without coated by biofilms, the TBC record (8.60 log cfu/g) at eight days, that considered as indicate spoilage of the meat. In chicken meat coated by gelatin biofilm alone slowly increase in the TBC compared with control. The organoleptic sings of spoilage are started appear at nine days and the TBC record (8.45 log cfu/g) at 12 day of storage period, this indicate spoilage of the meat samples [20], may be due to the gelatin biofilms are possesses barrier properties (retention oxygen ,CO2 and humidity) which lead to inhibition for bacterial growth. Our results agreement with mentioned [21]. by study the ability of gelatin biofilm to providing unfavorable conditions for bacterial growth. Additional to ability the nanoparticles for bacterial inhibition, this results are agreement with mentioned [22]. by study ability the nanoparticles to inhibite growth of all types bacteria. The antibacterial mechanism of the TiO2 NPs that include generation of a strong oxidative force represented by the generation of free hydroxyl radicals ($OH^{\cdot}$) [23].The nanoparticles are play an important role to bacterial inhibition, when mix with gelatin films, significantly decreased TBC in samples are coated by

gelatin mix with TiO2 Nps. Also, agreement with [24]. that indicated by study increase storage time of refrigerated chicken meat coated by active films with carboxymethyl cellulose, okra mucilage and nanoparticles, the total bacterial counts in the samples coated by active films were significantly decreased.

3.4 Chemical tests

3.4.1 The pH value:

As illustrated in table 2, there were significant differences in pH value with time of storage. In that place, the pH value significantly increased along with the rise in days of storage in all groups of meat samples stored at 4 °C. The trend of increasing was significantly (P<0.05) lowest in the T3 and T4 compared with T1 and T2.

There were significant differences (P 0.05) among the groups within periods. Whereas T1 recorded the greatest PH value of 6.28 and T4 recorded the lowest PH value of 5.81 at 4 days of the period but did not differ substantially in pH value with G3..In 8 days of period,T1 and T2 highest recorded PH value 6.69 and 6.28 respectively , in contrast the G4 recorded the lowest PH value 6.01, also not recorded differ significantly with T3. At 12 day, the T1 highest recorded pH value 7.26, whereas the T4 recorded lowest pH value 6.10 , so did not recorded differ significantly in pH value with T3. In 16 day, the T1 highest recorded pH value 7.65, whereas the T4 recorded lowest pH value 6.20 .

Table: 2 The pH value of chicken meat coated by gelatin biofilm with TiO2 NPs during 16 days at 4° C.

Treatments	Mean ± Standard Error				
	0 day	4 days	8 days	12 day	16 day
T1	E5.73±0.01a	D6.28±0.02a	C6.69±0.02a	B7.26±0.07a	A7.65±0.09a
T2	E5.69±0.01a	D6.04±0.01b	C6.28±0.02 b	B6.57±0.01b	A7.06±0.01b
T3	D5.65±0.01a	C5.84±0.03c	B6.10±0.06c	B6.19±0.01dc	A6.33±0.02cd
T4	C5.72±0.01a	C5.81±0.03c	B6.05±0.08c	AB6.10±0.03c	A6.20±0.09d
LSD	0.1463				

Means with a different small letter in the same column are significantly different (P<0.05). Means with a different capital letter in the same row are significantly different (P<0.05). T1=control, T2=gelatin biofilm,T3=gelatin biofilmwithTiO2NPs(2%), T4=gelatin biofilm with TiO2 NPs(4%).

As shown in table (2), the pH value of the control T1 record significantly increased (p 0.05) throughout the period of storage; however, for the samples T4 and T3 coated with gelatin and TiO2 NPs, the rise was lower than

for T4 and T3. In general, the pH value of the control was statistically higher than the pH of the samples coated with active packing of gelatin combined with TiO2 NPs. This may be because proteolytic bacteria play a vital role in the breakdown of chicken meat's protein during an extended period of storage. Our findings are in line with those of [25]. who noticed that pH values increased to 6.12 after 14 days of refrigeration for samples coated with an active film of carboxymethylcellulose combined with nanoparticles. In contrast, after 6 days, the pH in the control samples had reached the same level. These results showed that the carboxymethylcellulose mixed with nanoparticles films delayed the increasing in the pH value of meat during refrigerated storage, may be due to antibacterial activity of the films that restricted the production of nitrogen compounds responsible to rise of pH value .Also results correspond with mentioned [26]. by study effect the edible coatings of jujube gum (4, 8 and 12% wt) mixed with nettle essential oil (2, 3.5 and 5% wt) use to preserve the fillets of beluga sturgeon during15 day in refrigerated storage.In control samples the pH value significantly increased compare with those packaged by edible coatings.

3.4.2 The Thiobarbituric acid (TBA) value :

The effects of gelatin biofilm with NPs on the TBA value of chicken samples are illustrated in table (3). The TBA value was significantly impacted by all groups (P 0.05) at 4, 8, 12, and 16 days of storage at 4 C. On day 4 of storage, T1 recorded the greatest TBA value (1.26 MDA mg/kg), whereas T4 recorded the lowest TBA value (0.70 MDA mg/kg). The greatest TBA values in T1 and T2 were 2.18 and 1.70 MDA mg/kg, respectively, on the eighth day of storage, whereas the lowest TBA value in T4 was 1.00 MDA mg/kg. At12 day of storage, T1 recorded highest TBA value , it was 2.96 MDA mg/kg, in contrast T4 recorded lowest TBA value , it was 1.29 MDA mg/kg. In 16 day, T1 recorded highest TBA value which was 3.65 MDA mg/kg, while lowest TBA value recorded in T4, it was 1.57 MDA mg/kg.

All groups were significantly affected by storage durations (P< 0.05), and the TBA value increased gradually as storage periods increased. In all groups, the maximum TBA value was recorded during the last 16 days of storage, while the lowest TBA value occurred during the opening 0 days of storage. However decreased recorded in TBA value in T4,T3 and T2 compared with T1 in all storage periods.

Table:3 The Thiobarbituric acid (TBA) value (MDA mg/kg) of chicken meat samples coated with gelatin biofilm mix TiO2 NPs storage for 16 days at 4◦ C.

Treatments	Mean ± Standard Error				
	0 day	4 days	8 days	12 day	16 day
T1	E0.43±0.003b	D1.26±0.004a	C2.18±0.004a	B2.96±0.006a	A3.65±0.008a
T2	E0.48±0.004a	D1.07±0.006b	C1.70±0.005b	B2.33±0.005b	A2.95±0.003b
T3	E0.47±0.002ab	D0.79±0.003c	C1.14±0.003c	B1.48±0.003c	A1.84±0.001d
T4	E0.46±0.004ab	D0.70±0.002e	C1.00±0.007e	B1.29±0.008e	A1.57±0.003f
LSD	0.0529				

Means with a different small letter in the same column are significantly different (P<0.05). Means with a different capital letter in the same row are significantly different (P<0.05). T1=control, T2=gelatin biofilm, T3=gelatin biofilm with TiO2NPs (2%),T4=gelatin biofilm with TiO2 NPs(4%).

The TBA value significantly (p<0.05) increased with time for all the chicken meat samples, as show in table (3), may be because increase concentration of malondialdehyde (MDA) with advance storage period that considered as one products secondary oxidation of lipid in meat [27]. While the sample without coated and meat coated with gelatin film alone showed a higher increase than the samples coated by gelatin mixed with TiO_2 NPs. Active packaging plays a crucial role in preventing oxygen from diffusing to the surface of chicken meat which led to greatly reducing lipid oxidation. [28]. Additionally, nanoparticles have an ability to reduce effect of lipolytic bacteria which convert fat into unsaturated fatty acids. this result agreement with [29]. who indicated that unsaturated fatty acids react with oxygen to create primary oxidation and secondary oxidation. Also results correspond with mentioned [30]. by study reported the antioxidant characteristic of edible coatings that composed of milk protein, oregano and pimiento .The edible coatings were ability to reduce lipid oxidation in beef meat .

3.4.3 Physical testa

Water-holding capacity (WHC):

The study's findings showed that the period had a significant (P< 0.05) impact on all groups, with an advanced period being associated with a decline in the water-holding capacity (WHC) %. The greatest WHC % was found in T4 on day 4 of storage (43.24), while T1 recorded the lowest WHC percentage (34.21). In addition, T4 had the greatest WHC percentage of 39.33 after 8 days of storage, whereas T1 had the lowest WHC percentage of 27.89. At 12 days, T4 had the greatest WHC % (34.94), whereas T1 had the lowest WHC percentage (25.05). T4 had the greatest WHC % of 31.09 throughout the 16-day storage period, whereas T1 had the lowest WHC percentage of 22.88.The WHC percentage was the highest in the T4 with means of 43.24, 39.33, 34.94,

and 31.09 at the periods of 4, 8, 12, and 16 days respectively as compared with other groups .The T3 ranked the second with corresponding means of 41.44, 37.53, 32.83, and 29.20 at 4, 8, 12, and 16 days of refrigerated storage.

Table:4 The percentage of Water holding capacity (WHC) of chicken meat samples coated with gelatin biofilm mix TiO2 NPs storage for 16 day at 4◦ C.

Treatments	Mean ± Standard Error				
	0 day	4 days	8 days	12 day	16 day
T1	A48.10±0.06a	B34.21±0.07f	C27.89±0.03f	D25.05±0.04f	E22.88±0.05e
T2	A48.12±0.06a	B38.06±0.06e	C33.65±0.05e	D27.95±0.03e	E25.48±0.06d
T3	A48.18±0.06a	B41.44±0.07c	C37.53±0.07c	D32.83±0.11c	E29.20±0.02c
T4	A48.10±0.06a	B43.24±0.09a	C39.33±0.06a	D34.94±0.10a	E31.09±0.08a
LSD= 0.1899					

Means with a different small letter in the same column are significantly different (P<0.05). Means with a different capital letter in the same row are significantly different (P<0.05).. T1=control, T2=gelatin biofilm, T3=gelatin biofilm with TiO2NPs(2%),T4=gelatin biofilm with TiO2 NPs(4%).

The water holding capacity (WHC) percentage of chicken meat samples without coated (control) significantly decreased with time as shows in table (4), although samples coated by gelatin mixed with TiO2 NPs, showed a higher increase of the WHC precentage than samples without coated and chicken meat coated with gelatin alone. The significantly decrease of the WHC percentage in control, may be because easy loss of water that attached with protein. The results we obtained were in line with those of [13]. who suggested that the activity of lysis enzymes alters the permeability of cell membranes or the structures of proteins, which may lead to water retention in the process. Chicken meat coated by gelatin film incorporated with TiO2 NPs showed a higher WHC percentage may be because ability to protect the cellular membrane from breaking, it prevent water loss, due to effect inhibition of the nanoparticles against proteolytic bacteria that secretion proteolytic enzymes. Our results agreement with [25]. by study, the higher WHC percentage of sample coated by active film of the carboxymethylcellulose incorporated with nanoparticles refrigerated storage, compare with the WHC percentage of the control samples. These results may be because the nanoparticles prevent decomposition protein, subsequently maintain the water holding capacity of meat.

Conclusion

Increasing the storage period of chicken meat sample coated by gelatin biofilm incorporated with TiO2 NPs until 16 days compared to samples without or with gelatin coating.

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تأثير استخدام الجيلاتين الممزوج مع جزيئات ثاني أكسيد التيتانيوم النانوية كمادة حفظ فعالة على نمو البكتيريا وبعض خصائص لحم الدجاج المبرد.

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الملخص

أجريت هذه الدراسة لتحضير غشاء الجيلاتين والجيلاتين الممزوج بـ TiO2 NPs بتركيز (2٪) و (4٪) كأغشية نشطة وتحديد التأثير المضاد للبكتيريا للأغشية الفعالة ضد العدد البكتيري الكلي ، وكذلك تقييم التأثير المضاد للبكتيريا للأغشية الفعالة. الخصائص الكيميائية والفيزيائية للحوم الدجاج المبردة لمدة 16 يوم. للوصول إلى هدف الدراسة ، قمنا بإحصاء العدد الإجمالي للبكتيريا ، والمعلمات الكيميائية مثل قيمة الرقم الهيدروجيني وحمض الثيوباربيتوريك (TBA) بالإضافة إلى المعلمات الفيزيائية التي تشمل سعة تخزين المياه لعينات لحوم الدجاج بدون طلاء (مجموعة السيطرة T1) ، مغلف بـ الجيلاتين T2 ، والجيلاتين مع TiO2 NPs عند (2٪) T3 والجيلاتين مع TiO2 NPs عند (4٪) T4. أظهرت النتائج أن العدد الإجمالي للبكتيريا في العينات المغلفة بغشاء نشط انخفض معنوياً ($p<0.05$) ، مقارنة مع العينات المغلفة بالجيلاتين والعينات غير المغلفة. زيادة معنوية في قيمة الأس الهيدروجيني وقيمة TBA مع تقدم فترة التخزين في جميع مجموعات عينات لحوم الدجاج ، بينما كانت الزيادة في المعدل أقل بشكل ملحوظ في T3 و T4 مقارنة بمجموعة T1 و T2. انخفضت سعة الاحتفاظ بالماء (WHC) بشكل كبير مع زيادة فترة التخزين ، وكان الانخفاض في المعدل أقل بشكل ملحوظ في العينات التي تم تغليفها بالجيلاتين وحده والجيلاتين المدمج مع NPs. استنتج من هذه الدراسة أن الجيلاتين الممزوج بـ TiO2 NPs ساعد على زيادة العمر الافتراضي لعينات لحوم الدجاج لمدة 16 يومًا للتخزين في الثلاجة عند 4 درجات مئوية