10.21608/avmj.2025.382885.1694 Assiut University web-site: www.aun.edu.eg

EFFECT OF EDIBLE COATING ON SHELF LIFE OF CHILLED CHICKEN FILLET

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Received: 17 May 2025; **Accepted:** 4 Jun 2025

ABSTRACT

The study investigated the effectiveness of using Black cumin (*Nigella sativa*) seeds, chitosan, as well as wheat flour for coating chicken fillets, assessing satisfaction, sensory preferences, quality, shelf life, and growth curves of foodborne pathogens. Chilled chicken fillets were treated with 0.1% Black cumin oil and varying chitosan levels (0.1%, 0.2%, 0.3%), mixed with 20% wheat flour, and refrigerated for a total of fifteen days across four groups: a control fortified with only wheat flour, one with 0.1 % chitosan, another with 0.2% chitosan, and a final group with 0.3% chitosan. Chicken fillet samples were evaluated for an array of quality factors (pH, WHC content, pickup, cooking loss, color, and tenderness). The CW0.3 group had considerably higher quality metrics ($P<0.05$) than other scales. It was the most stable treatment, lasting 12 days compared to the control's 9 days. CW0.3 fortification produced fully tender chicken with a bright red color after 15 days. The highest value of malondialdehyde (MDA) corresponds to an increase in chitosan concentration compared to the other treatments. Chitosan wheat (CW) treatments reduced TBC below 6 logs, coliform count below 4 logs, and Staphylococcus count below 2 logs after 15 days. Chitosan wheat (CW 0.3) eliminated Staphylococcus aureus and Salmonella enterica. Chitosan wheat (CW 0.3) effectively preserved chilled chicken fillets for 12 days, acting as an antimicrobial and antioxidant coating, enhancing safety and quality with Black cumin oil and wheat flour.

Keywords: Chitosan, Flour, MDA antioxidant values, physical, *Salmonella enterica* and *Staphylococcus aureus.*

INTRODUCTION

Because of its elevated hydration and protein level, chicken fillet is extremely sensitive to bacterial deterioration, which results in a reduction in its longevity (Takma *et al.,* 2019). Additionally, its lipid content can cause oxidation reactions, negatively impacting meat quality (Vaithiyanathan *et al.,* 2011).

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Dussault *et al.* (2014) reported that chitosan is classified as a generally recognized as safe food additive, and its safety and dual antioxidant and antibacterial properties in meat and poultry products as an organic agent.

Chicken meat's short shelf-life poses a significant risk to consumers and producers. Active packaging, which communicates with the food item regardless of how it interacts (Lorenzo *et al.,*2021), has been shown to protect quality and prolong the shelf life of meat (Elsabee *et al.,* 2015; Mulla *et al.,* 2017).

The most processed foods are battered and breaded, with frying enhancing their quality factors, such as sharpness, consistency, humidity, oily level, permeability, hue, manifestation, aroma, and nourishment combine to create a sharp outer and juicy inside (Dogan *et al.,* 2005; Tamsen *et al*., 2018; Takma *et al.,* 2019)

Using natural antimicrobial substances like Natural oils and botanical extracts offers consumers a healthier alternative to chemical preservatives, with an efficient approach to eliminating undesirable food quality changes in food packaging (Sung *et al.,* 2013; Bazargani *et al.,* 2015; Takma *et al.,* 2019).

Although essential oils are used to package food based on their antibacterial and antioxidant properties, their aromatic components restrict the level of essential oil according to the sensory attributes of the product (Takma *et al.,* 2019).

The protein gluten, which occurs in wheat flour, helps generate films and coatings that are consumable due to its cohesion and flexibility, crucial for food processing like dough and batter-based systems, entrapping gas, starch, and other ingredients within the viscoelastic structure (Hassan *et al.,* 2018; Girard *et al.,* 2019; Maciel *et al.,* 2020)

Higher water susceptibility and permeability in gluten wheat flour made it a substantial and potentially profitable application (Zhang and Mittal *et al.,* 2010; Maciel *et al.,* 2020)

Black cumin oil (BCO) has a low flavour and is commonly employed in flavoured meals as a seasoning. The seeds are prescribed for numerous disorders, such as rheumatism, asthma and influenza (Bourgou *et al.,* 2010).

Moreover, BCO at levels varying between 0.1 and 0.2% w/w may suppress the development of foodborne pathogens, such as *Listeria monocytogenes, Staphylococcus aureus, Escherichia coli* and *Salmonella enteritidis* (Hassanien *et al.,* 2014; Dutta *et al.,* 2021).

Because of chitosan's ability to form films and its antibacterial characteristics, it can be used in food packaging (Elsabee *et al.,* 2008). Chitosan-coated to preserve various food products, including meat, fruits, vegetables, and fish. Especially chicken breasts demonstrate diminished bacterial development and lower fatty acid oxidation levels than samples left untreated (Cazón, P *et al.,* 2019; Souza *et al.,* 2020)

The present study investigated the safety, longevity and antioxidant reliability of chicken fillets coated with black cumin seed oil (BCO) and chitosan (0.1%, 0.2%, 0.3%) and wheat flour. It aimed to determine if increased CW levels extend the fillets' shelf life or if their composition affects their antibacterial and antioxidant stability. The study also evaluated how chitosan affects the quality of refrigerated chicken fillets as well as the development curves of some experimentally implanted foodborne pathogens until the end of the treatment duration.

Materials:

Experiment management and approval

Benha University's Faculty of Veterinary Medicine (BUFVTM) Institutional Animal Care and Use Committee approved investigation protocols under BUFVM 50-11-23, affirming no life science study declarations apply due to no human or animal results.

• Chitosan (de-acetylation 93%, moisture ≤10.0%, viscosity >75.0%, and molarity 161.16 MW) used for edible coating preparation was obtained from Oxford Lab Chem., India.

•Glacial acetic acid (Alfa Aesar, Kandel, Germany) and glycerol (Alfa Aesar)

•Black seed oil (Nigella sativa L. seeds) essential oil was supplied from the National Research Centre.

- Malondialdehyde (MDA)
- XLD and Baird-Parker agar were procured from Sigma-Aldrich (St. Louis, USA)

The preparation of pathogens:

Two isolates were used: *Staphylococcus aureus* (ST62) and *Salmonella enterica* subspecies enterica (N7 from chicken liver). Isolates were previously obtained from earlier surveys, confirmed serologically by MALDI-TOF MS (VITEK®MS, BioMérieux, France), and evaluated for antibiotic resistance via the VITEK®-2 system and the Kirby-Bauer disc diffusion method at the Animal Health Research Institute (AHRI), Dokki, Egypt. For *Staphylococcus aureus* preparation, isolated colonies were cultured in sterile peptone water at 37°C for 24 h (Saeed *et al.,* 2005), diluted to 10^10, and plated on Baird Parker agar, adjusting to 10^6 cfu/ml (Kantachote *et al.,* 2008). This level corresponds to a significant enterotoxin concentration (>10^5 cfu/g) (Stewart *et al.,* 2003). *Salmonella enterica* was cultured overnight at 37°C, then diluted to 5 log CFU/mL, injecting 2 mL/100 g into a chicken fillet for a target level of 3 log CFU/g.

Chitosan coating preparation

Chitosan edible coatings were created based on Caner *et al.* (2008) with slight modifications. A 1.5% chitosan solution was made by dissolving in distilled water at 100 °C, cooled to 45 °C, and mixed with 1% acetic acid and glycerol as a plasticizer, then stirred for 15 minutes.

Methods:

Sample preparation and distribution

On the slaughter day, fresh chicken breast fillets weighing 60 ± 5 g and 1.5 cm thick were procured from a meat retailer in Qalyubia governorate and delivered to a laboratory of meat hygiene département at Benha veterinary medicine for aseptic investigation. The fillets were randomly assigned to four treatment groups: control (wheat only), CW 0.1 (0.1 ml/g chitosan), CW 0.2 (0.2 ml/g), and CW 0.3 (0.3 ml/g). Spread over six chilling days (0,3,6,9,12,15), each treatment involved 72 slices divided into three replicates of 24 pieces. Each replicate was allocated over six days. Chicken breast fillets were given 0.1 ml/g chitosan, then 100 mL of sterile distilled water (group 2) was added to achieve full dispersion across all slices, followed by a moderate rotation. After 30min., the study involved drying slices on a sterilized steel sieve and battering with wheat flour. The control group used sterile distilled water and wheat flour, while CW 0.2 (group 3) and CW 0.3 (group 4) used 0.2 ml/g,0.3 ml/g amounts of chitosan, respectively, and wheat flour treatment for chicken breast fillets. The chicken breast fillets were bagged and refrigerated in the cooling incubator (Binder KB, BINDER GmbH, Tuttlingen, Germany) at 4 ± 1 °C. The study evaluated the physicochemical quality of chicken breast fillets at 0, 3, 6, 9, 12, and 15 days, comparing water-holding capacity, pick-up, cooking loss, instrumental color, shelf life, pH, and antioxidant stability between various groups. The study evaluated the antibacterial activity and stability of wheat flour (CW) in chicken breast fillets, using bacteriological examinations, such as TBC, Coliform count, and *Staphylococcus count*, and against artificially inoculated *Staphylococcus aureus* and *Salmonella enterica* using the pipetting method.

Physicochemical evaluation of chicken breast fillets

These characteristics included color parameters (L*, Lightness; a*, Redness; b*, Yellowness; C, Chroma; and h°, Hue angle) as well as WHC, pick up, cooking loss (CL), and pH.

Instrumental color estimation.

In an analysis of raw chilled chicken fillets, three colors were evaluated using the CR-410 chromometer, calibrated with a reference white tile. Measurements utilized a 2° observer angle, 8.0 mm aperture, L*, a*, b* color space, and illuminant D,

adhering to (American Meat Science Association et al., 2012). Color assessments were performed on the cut surface after a 30-minute bloom. Color saturation was estimated using hue angle (h° = arctg b*/a*), while color intensity was calculated as (C = (a*² + b*²) ^0.5). Elevated chroma values indicated increased saturation, whereas higher hue angles indicated decreased red meat intensity, with six averaged measurements for each group. In an analysis of raw chilled chicken fillets, three colors were evaluated using the CR-410 chromometer, calibrated with a reference white tile. Measurements utilized a 2° observer angle, 8.0mm aperture, L*, a*, b* color space, and illuminant D, adhering to (American Meat Science Association *et al.,* 2012). Color assessments were performed on the cut surface after a 30-minute bloom. Color saturation was estimated using hue angle (h° = arctg b*/a*), while color intensity was calculated as (C = (a*² + b*²) ^0.5). Elevated chroma values indicated increased saturation, whereas higher hue angles indicated decreased red meat intensity, with six averaged measurements for each group.

Water-holding capacity estimation.

Minor modifications of Honikel *et al.* (1994) low-speed centrifugation techniques assessed the water-holding capacity (WHC). A 5 g sample of chicken breast fillets was centrifuged for 20 min at 10,000 × g and 5 °C, then dried and re-weighed. WHC was calculated as the percentage weight difference before and after centrifugation.

Purge loss (pick up) estimation

The purging loss at each checkpoint is measured as the percentage weight loss of chicken breast fillets from the initial weight over 15 chilling days (Honikel *et al.,* 1998).

Cooking loss estimation.

On checking days, four samples from chilled chicken fillet duplicates were analyzed for cooking loss and shear force. Shear force blocks were assigned randomly to two cooking batches. Each sample was placed in thin-walled plastic bags, heated for 15 minutes at 180 °C, then cooled and weighed again. Cooking loss (CL) is the weight difference percentage (Honikel *et al.,* 1998).

pH analysis.

Chicken breast fillet samples were analyzed for pH using a Jenway 3510 pH-meter, calibrated at room temperature with pH levels of 10, 4, and 7, employing a temperature metal probe for accurate readings per holding container.

Malondialdehyde estimation

MDA levels in homogenized chilled chicken fillets were determined using HPLC (Agilent HP 1200 series system, USA) following Abd-Elrazek *et al.* (2018). A 10% sample homogenate with ice-cold 0.1M Tris-HCl (pH 7.4) was prepared using an ice-cold homogenizer. The homogenate was centrifuged for 15 minutes at 2000 × g at 4 °C to remove debris. A 1mM MDA stock was prepared by dissolving 25 µL of tetra-ethoxy-propane (TEP) in 100 mL of water. After that, the 20 nmol/working standard was made by dissolving 1mL of TEP stock solution in 50 mL of 1% sulfuric acid for 2 h at room temperature, which was then diluted with 1% sulfuric acid to yield a final concentration of 1.25 nmol/mL for analysis, results expressed as nM/g.

Bacteriological assessment of chilled chicken fillets.

Bacteriological examination (TBC, Coliform, *Staphylococcus counts*) and experimental inoculation of *Staphylococcus aureus* and *Salmonella enterica* in chicken fillets were assessed over 15 days at 4 °C in a cooling incubator (Binder KB, BINDER GmbH, Tuttlingen, Germany).

Determination of Total Bacterial Count.

A Total Bacterial Count (TBC) in chilled chicken fillets was evaluated per ISO

4833-1:2013, using a 10% homogenate, serial dilutions, and incubation of inoculation plates at 37 °C for 24 hours.

Determination of Coliform Count.
Inoculated 1 mL serial dilutions into two sterile Violet red bile agar dishes at 37 °C for coliform enumeration in chicken fillets. (ISO, 2006).

Determination of *Staphylococcus, Staphylococcus aureus* and *Salmonella enterica* count.
Chicken fillets were tested for *Staphylococcus aureus* and *Salmonella enterica* using surface-plating methods. *Staphylococcus aureus* counts were determined on Baird Parker agar plates (ISO 6888-1:1999), with narrow white margins surrounded by a clear halo zone, but also *Salmonella enterica* counts were determined on XLD plates (ISO 6579-1:2018), with a black colony. Incubation was conducted for 30 minutes, inversion, and incubation at 37°C for 48 & 24 hours, respectively.

Biocompatible Chitosan and Wheat flour regarding antibacterial properties and their durability
Chitosan-Wheat (CW) has been evaluated for the biocompatibility of its antibacterial properties on *Staphylococcus aureus* and *Salmonella enterica* in chicken fillet samples. The samples were fortified into four treatments. The first one acted as a control, and the other three were (CW 0.1, CW 0.2, and CW 0.3), supplemented with chitosan-wheat at levels of 0.1 mL/g, 0.2 mL/g, and 0.3 mL/g, respectively. While the control was treated with wheat only. For artificial inoculation, chicken samples were immersed in a 100 ml sterile peptone water 0.1% solution containing a 24-hour-old culture of *Staphylococcus aureus* (about 10^6 CFU/ml) (Kantachote *et al.,* 2008). During half an hour at an ambient temperature (25°C), it improves bacterial adhesion and uptake of the inoculated bacteria. (Dubal *et al.,* 2004, Ibrahim *et al.,* 2018). The infected specimens were kept in sterile beakers at 30 ± 2°C where the initial bacterial load of *Staphylococcus aureus* was determined before treatment. Salmonella enterica was similarly prepared using the same protocol of Sabike *et al.* (2015) and Elsheikh, Mai *et al. (*2025). On Oxford agar, *Salmonella* was plated at 37 °C for 24 hours, and colonies in Trypticase soy broth were cultured. Cells were centrifuged and suspended in saline for bacterial solution generation, achieving approximately 9 logs CFU/mL. Each group received 2 mL of the *Salmonella* culture per 100 g of chicken cultured overnight at 37°C and sequentially diluted to 5 logs CFU/mL. After that, 10 g of each treatment was moved to a sterile glass flask (125 mL, rubber closure). Three glasses (three replicates) from every single treatment were distributed at random to the six checkpoints (0, 3, 6-, 9-, 12-, and 15-day further treatment) and then chilled at 4 ± 1 °C in the incubator (Binder, BINDER GmbH, Tuttlingen, Germany). For investigations of Biocompatible Chitosan and wheat flour antibacterial properties, 10g of the infected chicken fillet samples were blended for sixty seconds in a sterile stomacher bag with 90 mL of sterile distilled water (Stomacher 400 R, Seward, UK). After homogenization and decimal dilutions, 100 µL was applied to Baird Baird-Parker and XLD agar plates to count *Staphylococcus aureus* and *Salmonella enterica,* counting colonies throughout 37 ± 2°C after 48 and 24 hours, respectively.

Statistical analyses
The analysis of data was performed with SPSS Version 22. (SPSS Inc., Chicago, Illinois, USA). The influence of treatments (control wheat only, CW), chilling durations (0-, 3-, 6-, 9-, 12, and 15 days), and their association on the sensory parameters of chicken breast fillets was examined using general linear mixed models (GLM). Chicken breast fillets were deemed random, while treatments and chilling storage duration were regarded as fixed variables. Comparable statistical

methods were applied to cooking loss; nonetheless, the random model incorporated cooking batches. To evaluate the bacteriological, antioxidant, and pH properties of chicken breast fillets, the scales with stable effects for treatments (Control, CW 0.1, CW 0.2, and CW 0.3) and chilling periods (0, 3, 6, 9, 12, and 15 days), random terms for the chicken breast fillets, and interaction effects (treatment × chilling day). The Biocompatible of antibacterial activity of CW was assessed by employing fixed effects for treatments (control, CW 0.1, CW 0.2, and CW 0.3) and durations of chilling storage (0, 3, 6, 9, 12, and 15 days), random effects for control, CW 0.1, CW 0.2, and CW 0.3 bottles, along with an interaction term linking treatment to chilling duration. The outcomes are presented along with their averages and the overall standard errors of those averages. The statistical model utilized one-way ANOVA and a Tukey's multiple comparison test to measure the effectiveness of CW and their different scales in relation to control, as well as to evaluate distinct monitoring point averages within the same group. Notable differences were identified with a p-value below 0.05

RESULTS

Tables 1 and 2 illustrate the effectiveness of CW treatments on the physical parameters and keeping quality of chilled chicken fillets over 15 chilling days, rather than the control. Due to the interaction between treatments and storage periods, significant differences were found. The effects of CW and their levels were assessed, with a P-value of less than 0.05.

During the storage of chilled chicken fillets, a decrease in chroma was observed, while the CW 0.2 coating increased ($P<0.05$) until 9 days post-treatment. Longer storage reduced the hue (h°) of the control chicken fillets, while the high-treated chicken fillets showed an increase in hue, except on the 12th day following treatment, but they showed the lowest hue (h°) ($P<0.05$). The chroma refers to the intensity of the color (AMSA *et al.,* 2012; Shukla *et al.,* 2020), which decreased significantly ($P<0.05$) during the storage period (Table 1).

Tenderness in chilled chicken fillets was significantly increased by chilling storage, peaking at the 6th in CW 0.1& 0.2 and the 12th chilling days CW 0.3. Post-chilling treatments also affected tenderness, remaining higher than the control till the 15th chilling day ($P<0.05$) (Table 1).

So, the current study found that the physicochemical qualities of chilled chicken fillets, including WHC and drip loss, vary in control, increasing at various monitoring points of other treatments and increase with chilling duration, with chilling duration significantly impacting all estimated characteristics.

WHC was found to have no significant difference between chilled chicken fillets on zero day. However, post-treatment with CW, the third-day post-treatment, showed a significant increase in WHC values, while fillets coated with high levels showed an increase throughout the chilling storage period (Table 1).

This study found that chilling storage interval affected purge loss in all groups, with longer storage leading to an elevated loss pattern, reaching peak axis at the 12th chilling day, obviously in control. CW-post treatments slightly affected purge loss ($P>0.05$) in chilled chicken fillets, but were still lower than the control (Table 1).

Chitosan wheat (CW) post-treatments affected chicken fillet and cooking loss (CL) in an elevated manner than control, that in decreasing manner from the 6th chilling-day till 15th chilling day ($P<0.05$) (Table1).

Table 1: Shows the effect of edible coating on sensory and physical parameters of on chicken fillet stored at chilling temperature (4 °C ± 1 °C) and examined intermittently for 15 days

parameter	groups	Time (Days) 0	3	6	9	12	15
Chroma	Control	20.55±0.09^{Ba}	17.2854±0.08^{Cd}	17.94±0.25^{Bc}	18.4±0.04^{Cb}	20.39±0.07^{Aa}	18.73±0.1^{Ab}
	CW 0.1	19.922±0.07^{Ca}	18.24±0.11^{Bb}	13.18±0.02^{Dc}	18.49±0.10^{Cb}	18.62±0.23^{Bb}	19.99±0.18^{Aa}
	CW 0.2	15.95±0.13^{Df}	23.42±0.10^{Aa}	18.92±0.04^{Ac}	20.49±0.06^{Ab}	18.04±0.12^{Cd}	17.02±0.12^{Ce}
	CW 0.3	23.62±0.09^{Aa}	17.90±0.14^{Bc}	14.66±0.16^{Ce}	19.32±0.09^{Bb}	17.5±0.13^{Dc}	17.06±0.14^{Cd}
Hue (h°)	Control	46.53±0.48^{Aa}	43.07±0.42^{Ab}	34.7459±0.97560^{Ad}	33.18±0.17^{Dd}	47 ±0.29^{Aa}	38.75±0.29^{Ac}
	CW 0.1	32.28±0.31^{Bd}	34.21±0.53^{Cd}	28.4642±0.15350^{Be}	46.08±0.52^{Ba}	40.95±1.33^{Bb}	36.49±0.72^{Bc}
	CW 0.2	31.57±0.36^{Bd}	41.73±0.43^{Aa}	33.5279±0.14571^{Ac}	41.96±0.3^{Ca}	39.08±0.61^{Bb}	38.56±0.63^{Ab}
	CW 0.3	28.13±0.23^{Cd}	38.60±0.75^{Bb}	34.40±0.53437^{Ac}	49.49±0.41^{Aa}	38.27±0.57^{Bb}	38.85±0.73^{Ab}
Tenderness	Control	1.87±0.14^{Bd}	3.15±0.11 ^{Ba}	2.71±0.10 ^{Bb}	2.16±0.08 ^{Ccd}	3.37±0.15 ^{Ca}	2.39±0.07 ^{Bbc}
	CW 0.1	2.02±0.2 ^{Bd}	4.54±0.23 ^{Ab}	9.62±0.91 ^{Aa}	2.82±0.08 ^{Bcd}	4.60±0.23 ^{Bb}	3.48±0.11 ^{Bbc}
	CW 0.2	1.59±0.11 ^{Be}	4.12±0.26^{Acd}	9.07±0.62 ^{Ab}	2.94±0.07 ^{ABde}	4.41±0.11 ^{Bc}	27.07±0.91Aa
	CW 0.3	2.78±0.12 ^{Ab}	2.61±0.13 ^{Bb}	3.26±0.33 ^{Bb}	3.15±0.14 ^{Ab}	6.44±0.30 ^{Aa}	3.19±0.21 ^{Bb}
WHC %	Control	87.17±2.36^{Aa}	73.37±4.21^{Bb}	57.63±2.36^{Bc}	89.99±1.05^{Aa}	88.3±2.75^{Ba}	67.32±4.01^{Bb}
	CW 0.1	92.76±13.41^{Aa}	87.68±1.42^{Aa}	83.23±7.12^{Aa}	83.2±8.60^{Aa}	91.40±0.98^{ABa}	80.75±0.65^{Aa}
	CW 0.2	80.22±4.19^{Abc}	87.92±0.029^{Ab}	82.68±2.28^{Abc}	86.4±0.83^{Ab}	96.94±0.528^{Aa}	77.19±4.35^{ABc}
	CW 0.3	89.06±0.22^{Aa}	90.77±0.98^{Aa}	81.25±1.59^{Ab}	90.83±0.81^{Aa}	91.65±2.278^{ABa}	67.53±2.56^{Bc}
Pick Up %	Control	11.95±0.13^{Bd}	13.11±0.12^{Bc}	22.95±0.13^{Aa}	20.08±0.09^{Ab}	23.01±0.10^{Aa}	20.03±0.11^{Ab}
	CW 0.1	10.61±0.015^{Cd}	14.49±0.008^{Aa}	1.28±0.03^{Df}	14.21±0.020^{Bb}	12.6±0.02^{Cc}	5.72±0.15^{Ce}
	CW 0.2	13.54±0.12^{Aa}	12.94±0.16^{Ba}	10.12±0.32^{Cb}	13.49±0.32^{Ca}	6.44±0.27^{Dd}	8.85±0.04^{Bc}
	CW 0.3	13.49±0.08^{Ab}	12.25±0.13^{Cc}	12.98±0.27^{Bb}	13.18±0.25^{Cb}	15.09±0.25^{Ba}	8.65±0.25^{Bd}
Cooking Loss %	Control	41.05±1.56^{Aa}	42.62±0.63^{Ac}	33.48±1.47^{Ab}	28.88±1.83^{Abc}	27.74±0.60^{Bc}	15.96±2.48^{Ad}
	CW 0.1	24±2.08^{Bc}	39.94±3.89^{Aabc}	47.01±0.04^{Aab}	21.41±2.61^{Ac}	58.64±10.05^{Aa}	28.09±9.49^{Abc}
	CW 0.2	28.94±8.06^{ABa}	37.90±6.11^{Aa}	32.48±12.42^{Aa}	30.41±7.54^{Aa}	28.76±6.35^{Ba}	34.32±7.48^{Aa}
	CW 0.3	24.50±4.71^{Bcd}	31.22±3.80^{Abc}	40.6±3.38^{Aab}	29.29±7.23^{Abcd}	51.73±4.07^{Aa}	15.66±2.43^{Ad}

CW 0.1 mg/g Chitosan-Wheat level, CW 0.2 mg/g Chitosan-Wheat level and CW 0.3 mg/g Chitosan-Wheat level. SEM standard error of the mean, Chroma color intensity, h° color saturation or hue angle, Tenderness, WHC % water holding capacity, pickup (purge loss) %and cooking loss (CL) %, 2 Different small letters within the row show significant changes across chilling times (P<0.05), while different capital letters within the column indicate significant differences between treatments.

In Table (2), the control chicken fillet samples in upward grades, which spoiled at 9 days during the chilling period, in pH, chicken fillets posttreatment demonstrated an up-and-down.

The off-flavours and aromas that develop during storage are produced due to compounds formed during the second stage of its auto-oxidation (Kang *et al.,* 2015). TBARS were determined in milligrams of MDA per kilogram of meat (Stojanović-Radić *et al.,* 2018) (Table 2). The initial TBARS values were 64.06±2.06, 70.26±2.26, 78.53±2.53, and 79.56±2.5 in C, CW0.1, CW0.2 and CW0.3, then increased significantly (P<0.05) to 73±2.08, 86.33±2.33, 98.66±2.66, and 104.83±2.8 (malonalde-hyde nM/g), respectively, at 15 days, leading to spoilage. The highest increase value was in CW 0.3, compared to other treatments.

Oxidation indicators MDA (nM/g) revealed that different CW levels in chicken fillet had a fixed effect throughout the entire storage period, with a clearly rising curve. Additionally, the relationship between storage length and CW treatment did not significantly affect oxidative stability (P≥0.05). The CW coating with different concentrations of 0.1, 0.2, and 0.3, respectively, resulted in increased (P≤0.05) TBARS compared to the control

group at all points of measurement throughout the storage period.

The study revealed that three CW modulation scales (0.1, 0.2, and 0.3) significantly affected bacteriological evidence and the longevity of chicken fillets over a 15-day chilling experiment. The treatment scales, storage interval, and interaction significantly affected ($P<0.05$) all indices. The CW modulation scales also retarded bacteriological indices as (TBC) (Table 2), Coliform count, *Staphylococcus count* and experimental inoculation, as well as *Salmonella count* and *Staphylococcus aureus count* (Table 3), from day 0 to day 15 of the storage period. This was contrasted with the control group ($P<0.05$). Higher inhibition levels led to higher levels of CW, which postponed TBC and TCC growth below 6 logs and 4 logs CFU/g for 15- and 6-days post-treatment, respectively. Higher modulation levels also retarded *Staphylococcus* growth until storage ranged from 0.5 to 1 log CFU/g. The bacteriological evidences were estimated in chicken fillet and showed significant differences ($P<0.05$) in the CW-treated group compared to the control group.

Table 2: Shows the effect of edible coating on the keeping quality of chicken fillet stored at chilling temperature (4 ºC ± 1 ºC) and examined intermittently for 15 days

parameter	groups	0	3	6	9	12	15
pH	Control	6.83 ± 0.02^{Ac}	6.77 ± 0.023^{Ac}	6.91 ± 0.075^{Abc}	6.89 ± 0.02^{Abc}	7.01 ± 0.09^{Bb}	7.91 ± 0.05^{Ba}
	CW 0.1	6.63 ± 0.00^{ABc}	6.45 ± 0.02^{Bc}	6.94 ± 0.05^{Ab}	6.97 ± 0.07^{Ab}	7.09 ± 0.12^{Bb}	7.70 ± 0.00^{Ca}
	CW 0.2	6.49 ± 0.10^{Be}	6.75 ± 0.01^{Ad}	6.95 ± 0.012^{Ac}	6.65 ± 0.03^{Bde}	7.4 ± 0.07^{Ab}	8.49 ± 0.02^{Aa}
	CW 0.3	6.62 ± 0.05^{ABcd}	6.74 ± 0.02^{Abc}	7.02 ± 0.00^{Aa}	6.80 ± 0.06^{ABb}	6.58 ± 0.01^{Cd}	7.04 ± 0.06^{Da}
TBA (MDA, nM/g)	Control	64.06 ± 2.06^{Bb}	50.88 ± 1.88^{Cc}	64.21 ± 2.21^{Cb}	73.21 ± 2.21^{Cb}	107.91 ± 2.91^{Aa}	73.08 ± 2.08^{Cb}
	CW 0.1	70.26 ± 2.26^{ABb}	61.26 ± 2.26^{Bc}	75.60 ± 2.60^{Bb}	84.56 ± 2.56^{Ba}	92.5 ± 2.5^{Ba}	86.33 ± 2.33^{Ba}
	CW 0.2	78.53 ± 2.53^{Acd}	73.73 ± 2.73^{Ad}	88.03 ± 3.03^{Abc}	96.93 ± 2.93^{Aab}	103.97 ± 2.97^{Aa}	98.66 ± 2.66^{Aa}
	CW 0.3	79.56 ± 2.56^{Ad}	75.8 ± 2.8^{Ad}	93.21 ± 3.21^{Ac}	101.75 ± 2.75^{Abc}	113.23 ± 3.23^{Aa}	104.83 ± 2.83^{Aab}
TBC	Control	2.26 ± 1.17^{Ab}	3.25 ± 2.3^{Ab}	4.71 ± 3.3^{Aa}	4.62 ± 4^{Dab}	4.54 ± 3.69^{Aab}	4.74 ± 3.69^{Aab}
	CW 0.1	1.47 ± 1.00^{Bc}	2.16 ± 1.17^{Bc}	5.15 ± 3.17^{Aab}	5.322 ± 4^{Ca}	4.77 ± 4.69^{Abc}	5.02 ± 4.39^{Ab}
	CW 0.2	0.00 ± 0.00^{Bb}	2.49 ± 1.17^{Bb}	4.15 ± 2.54^{Ab}	5.67 ± 4.3^{Aa}	5.09 ± 3.69^{Aab}	5.43 ± 5.4^{Aab}
	CW 0.3	0.00 ± 0.00^{Ba}	1.30 ± 0.00^{Ba}	5.28 ± 3.6^{Aa}	5.49 ± 4.17^{Ba}	5.59 ± 5.43^{Aa}	5.54 ± 5.11^{Aa}

CW 0.1 mg/g Chitosan-Wheat level, CW 0.2 mg/g Chitosan-Wheat level and CW 0.3 mg/g Chitosan-Wheat level. SEM standard error of the mean, pH, TBA (MDA, Malondialdehyde) and TBC total bacterial count, 2 Different small letters within the row show significant changes across chilling times ($P<0.05$), while different capital letters within the column indicate significant differences between treatments. TBC not more than 10^5 cfu\g sample and TBA not more than 0.9 mg MDA\Kg sample (chicken fillet) according to (EOS, 1651, 2019).

The results also explained the antimicrobial impact of the three CW modulation scales over 15 days of chilling on experimentally inoculated chicken fillet groups with *Staphylococcus aureus and Salmonella,* compared to the control chilled chicken fillets (Table 3). Statistically, CW 0.3, the higher level of modulation scales, had a higher inhibitory antimicrobial effect ($P<0.05$) on *Staphylococcus aureus* and *Salmonella* compared to other scales and the control group (Table 3). This was due to the relationship between different modulation scales of CW and the chilling duration length, which showed significant differences ($P<0.05$) in growth patterns in infected samples. CW 0.1 and CW 0.2 inhibited the immediate growth of *Staphylococcus aureus and Salmonella* for 15 days following treatment, resulting in high levels of growth below 0.5 and 1 log CFU/g, which were noticed in *Salmonella* growth, but not in *Staphylococcus aureus.* CW 0.3 showed a higher stable inhibitory impression than other post-treatment CW.

Table 3: Shows the effect of edible coating on viability of Coliform count, *Staphylococcus count* and inoculated *Staphylococcus aureus, Salmonellae* in chicken fillet, stored at chilling temperature (4 ºC ± 1 ºC) and examined intermittently for 15 days

Bacterial spp.	groups	0	3	6	9	12	15
Coliform Count	**Control**	0.39 ± 0.00^{Bc}	2.47 ± 1.72 ^{Ac}	4.99 ± 3.31 ^{Ac}	5.81 ± 4.65 ^{Bb}	6.11 ± 5.04 ^{Aa}	6.21 ± 5.33 ^{Aa}
	CW 0.1	0.00 ± 0.00^{Bb}	2.47 ± 1.00 ^{Ab}	3.63 ± 2.47 ^{Bb}	5.96 ± 4.47 ^{Aa}	6.12 ± 5.49 ^{Aa}	6.18 ± 5.51 ^{Aa}
	CW 0.2	0.97 ± 0.00 ^{Ad}	2.33 ± 1.62 ^{Ad}	3.2 ± 2 ^{Bd}	5.81 ± 4.47 ^{Bc}	6.29 ± 4.17 ^{Ab}	6.37 ± 5.16 ^{Aa}
	CW 0.3	0.17 ± 0.00 ^{Ac}	1.64 ± 0.60 ^{Bc}	3.32 ± 2^{Bc}	5.71 ± 4.47 ^{Bc}	6.14 ± 5.38 ^{Ab}	6.35 ± 5.74 ^{Aa}
***Staphylococcus* Count**	**Control**	0.87 ± 0.39^{ABc}	2.436 ± 0.95^{Aa}	2.17 ± 1.69 ^{Ab}	2.54 ± 1.69 ^{Aa}	1.73 ± 0.9 ^{Abc}	1.85 ± 1.04^{Abc}
	CW 0.1	1.02 ± 0.54 ^{ABcd}	1.690 ± 0.84 ^{Ba}	1.39 ± 0.47^{Bb}	1.290 ± 0.39 ^{Bbc}	0.81 ± 0.39 ^{Bcd}	0.69± 0.3 ^{Ba}
	CW 0.2	0.74 ± 0.00 ^{Bab}	1.16 ± 0.54 ^{Ca}	1.00 ± 0.00 ^{Bab}	0.69 ± 0.69 ^{Bb}	0.00 ± 0.00 ^{Bb}	0.9 ± 0.00 ^{Bab}
	CW 0.3	1.19 ± 0.17 ^{Aab}	ND	0.17 ± 0.00 ^{Bbc}	1.30± 1.00 ^{Ba}	0.00 ± 0.00 ^{Bbc}	0.54 ± 0.00 ^{Bbc}
Viability of ***Staphylococcus aureus***	**Control**	ND	1.49 ± 1.27 ^{Aa}	ND	ND	ND	0.39 ± 0.17^{Ab}
	CW 0.1	ND	0.00 ± 0.00 ^{Aa}	0.47 ± 0.47 ^{Ba}	ND	ND	ND
	CW 0.2	0.00±0.00^{Bbc}	0.00 ± 0.00 ^{Ab}	1.00 ± 0.00 ^{Aa}	ND	ND	0.00 ± 0.00 ^{Abc}
	CW 0.3	1.00 ± 0.00 ^{Aa}	ND	ND	ND	ND	ND
Viability of ***Salmonellae***	**Control**	1.06 ± 0.17^{Ac}	0.30 ± 0.00 ^{Ac}	2.21 ± 1.51 ^{Aa}	1.91 ± 1.34 ^{Ab}	ND	ND
	CW 0.1	ND	0.17 ± 0.17 ^{Ab}	1.17± 0.69 ^{Ba}	ND	ND	ND
	CW 0.2	0.5 ± 0.00 ^{Dd}	ND	ND	1.0 ± 0.00 ^{Ba}	ND	ND
	CW 0.3	ND	ND	ND	0.5 ± 0.00 ^{Ba}	ND	ND

CW 0.1 mg/g Chitosan-Wheat level, CW 0.2 mg/g Chitosan-Wheat level and CW 0.3 mg/g Chitosan-Wheat level. SEM standard error of the mean; Coliform count, *Staphylococcus*, *Staphylococcus aureus and Salmonellae***,** 2 Different small letters within the row show significant changes across chilling times (P<0.05), while different capital letters within the column indicate significant differences between treatments. *S.aureus* count less than 10^2 cfu\g sample (chicken fillet) according to (EOS, 1651 and 2019).

DISCUSSION

The decision to purchase meat by consumers depends on meat freshness, which appears in external manifestations, such as color and packaging (Suman *et al.,* 2014).

The emulsion form of chitosan, accompanied by opacity and turbidity of the solution, can increase lightness (Noori *et al.,* 2018). Yaghoubi *et al.,* 2021 revealed findings that agree with our results, the mixture of chitosan with essential oil increased the L* value of coated chicken meat, due to the ability of chitosan and bamboo vinegar to chelate the metal ions transition and preserve their initial a* and b* values during storage, they are used to coat cooked pork chops, maintaining the meat's color because of their antioxidant capability (Zhang *et al.,* 2018), chicken meat discoloration was effectively inhibited during chilling by using chitosan as a coating. The results showed that the hue angle values in chitosan-treated samples increased significantly (P<0.05), compared to untreated samples. This agrees with (Pathare *et al.,* 2013), who revealed that a lesser yellow character is due to a higher hue angle.

This study agrees with Hashim *et al.* (1999), reporting that the chroma and hue angle of chicken fillets treated with a 0.2% coating significantly increased (P<0.05), compared to others, which is related to higher chitosan antioxidative activity. Additionally, Shukla *et al.,* (2020) found that a higher chroma value resulted in higher redness (a*) and yellowness (b*) values.

The highest tenderness appeared in CW 0.3% on the 12th day, while the lowest was in the other two treatments. However, in CW 0.1% and CW 0 .2%, the higher values occurred on the 6th day. According

to Liu *et al*. (2010), chicken fillet tenderness is linked to the dry matter content, with increased dry matter causing tenderness to decrease through storage periods.

Similarly, in the present study, the tenderness that appears as softness in chicken fillets is used by consumers as a guide for eating quality selection, which has been reported by Ngapo *et al.* (2005) and Mancini *et al.* (2008). Meat tenderness is linked with the presence of calcium-dependent proteases or calpains, resulting from the breakdown of myofibrillar proteins (Muchenje *et al.,* 2009).

The water retention in chicken fillet samples coated with CW increases during the storage period, which is useful to retain the freshness of the product. In the presence of CW 0.3-coated chicken fillets, which are attributed to the limit of protein oxidation, increased water-holding capacity. The elevation in WHC value showed a strong relation to rising pH values, owing to the enhanced solubility of meat proteins that escape from the isoelectric point. This agrees with this research and reflects the ability of CW 0.3 to protect the protein and maintain water retention.

The direct correlation between coating pickup and the viscosity of the batter results in an elevation in the pickup parameter with increasing CW levels of 0.2% and 0.3% on chicken fillets due to the increased viscosity of the batter affecting the coating's quantity, quality, and texture of the product.

The process yield and food quality in the food industry have a strong relationship with coating pickup (Guerrero *et al.,* 2010). This is similar to the results of this study and agrees with Kang *et al*. (2015) and Xavier *et al*. (2017), who recorded that chitosan and silica coating in fish nuggets achieved a 40% pickup rate.

All treated chicken fillet samples with chitosan exhibited a significant difference ($P<0.05$) in cooking loss compared to untreated samples, but no significance ($P>0.05$) was found between treated chitosan groups. Similarly, untreated samples display a decreasing manner in cooking loss values subsequently. The study reveals that chitosan can maintain the weight of samples without reduction, due to its moisture retention properties, resulting in a hydro polymer and non-adherent protective layers, thereby enhancing the cooking medium's resistance to material loss (Xavier *et al.,* 2017).

The study found that the pH of chilled chicken fillets coated with chitosan ranged from 6.4 to 6.8, with lower values due to acetic acid dissolution (Table 2). The lowest pH values were recorded for 0.3% chitosan-coated samples. This was also observed in a study on chilled fresh chicken meat (Hassanzadeh *et al.,* 2017). (Ikhlas *et al.,* 2012). It was reported that the increase in pH of chicken breast meat may be due to the accumulation of metabolites, such as amines and ammonia, resulting from the growth of psychro-trophic bacteria (Cortez *et al.,* 2012; Stojanović-Radić *et al*., 2018).

Plants and their extracts improve meat quality due to their antioxidant and antibacterial properties Muzolf-Panek *et al. (*2020), had been found that black cumin seed extract can help increase the longevity of fresh chicken, prevent its oxidation, and inhibit microbial growth. It also improves oxidative stability, safety, color, and pH stability.

Using wheat in powdered form, such as flour for breading meat, showed lower effectiveness on shelf life and microbial contamination of whole meat products, compared to other minced meats, because of the buffering action of meat (Anton *et al.,* 2019).

The control sample's TBARS values significantly (P<0.05) increased until the end of storage. Warriss *et al.* (2000) reported that the TBARS concentration limit in meat samples has no legislation. However, a value over 0.5 mg MDA/kg indicates a rancid flavour resulting from oxidation, and a value above 1.0 mg MDA/kg is unfit for consumers. The levels of MDA significantly (P<0.05) increased during storage, indicating decreased durability and reduced preference due to high peroxide values, and prefer to replace synthetic antioxidant materials in food with natural ones (Ikhlas *et al.,* 2012). After 10 days of storage in meatballs, the lipid oxidation showed increasing TBARS values in (control, dittany, rosemary) samples (Vosen *et al.,* 2004), which agreed with our findings. The oxidative capability of all treated chicken fillets with CW was not significantly improved (Table 2), as well as consistently increased the TBARS values during the period of storage (Troy *et al*., 2006; Azimzadeh *et al.,* 2018). The present study agreed with those reported by Lopez-Caballero *et al.* (2005) that TBARS production in fish meat didn't have any significant effect with a coat of chitosan. Also, it agrees with Jonaidi *et al.* (2018) and Bhoir *et al. (*2019), who reported that the storage period increases TBARS values in treatment groups rather than in the control group and increases lipid peroxidation levels, which were not affected in the presence of chitosan alone or in mixtures, such as with pomegranate juice or propolis extract.

The TBC count and Coliform count in fresh poultry meat may present as acceptable limitations of 6 Log CFU/g and 4 Log CFU/g, respectively (Alirezalu *et al.,* 2021). The higher TBC (P<0.05) in the untreated control group compared to other treatments persisted until the sixth day, after which it became the lowest. A lower TBC value indicates health benefits. The TBC values ranged from 4 to 5 (log CFU) during the storage period. The study found no significant (P>0.05) differences among the various chitosan treatments, suggesting that antioxidant compounds can prevent fat deterioration and lower bacterial growth in chicken fillets (Zhang *et al.,* 2010; Elgadir *et al.,* 2011).

Classification of coliform can include both pathogenic and non-pathogenic bacteria. Untreated samples increased to 4.5 logs CFU/g in coliform counts by the 9th day of storage, then elevated further until the end of the experiment. However, in CW 0.3% treated samples, the coliform count was significantly lower than 4 logs CFU/g until the 6th day, and it was the lowest compared to the other two treated groups (Bhoir *et al.,* 2019).

Chitosan (0.3%) and EO coatings significantly reduced coliforms in meat samples, enhancing food safety. The black cumin seed oil-based chitosan coating reduces TBC by 4 log CFU/g, maintaining meat quality and stability, and enhancing shelf life due to its high antimicrobial properties. Sharma *et al.* (2018) and Shukla *et al.* (2020) obtained the same result during the application of clove essential oil blended with chicken sausages in emulsion form, which extended their shelf life during frozen storage (−18 ± 2°C). Similar to our research, Bazargani-Gilani *et al.* (2015) reported the effectiveness of combining chitosan with plant essential oil extracts on the durability of meat when used as a coating on chicken breast meat, finding an extension of shelf life to 10-15 days during storage. The findings of this result agrees with those of Kanatt *et al.* (2013), who reported that ensuring safety for highly sensitive products, such as fresh chicken meat, and extending its shelf life can be achieved by using a chitosan solution as an edible coating with a concentration of 2% applied to meat products, which showed potential ability regardless of initial coliform levels of 2 log10 CFU/g. Duan *et al.* (2010) revealed that the electrostatic interaction between the NH3 group on the glucosamine monomer and the microbial

cell membrane, facilitated by the cationic property of chitosan, potentially leads to intracellular component leakage, resulting in antimicrobial properties. Additionally, Suman *et al.* (2014) found that chitosan's stability extends shelf life due to its selective permeability, which reduces oxygen transfer to meat. According to Bazargani-Gilani *et al.* (2015) and Bhoir *et al.* (2019), there was a statistically significant increase in the TBC count of chicken treated with pomegranate juice compared to chicken treated with a mixture of pomegranate juice and chitosan.

Chitosan has been suggested by some researchers to potentially prevent specific issues. Kanatt *et al.* (2008) reported that the antimicrobial properties of chitosan have the potential to prevent the growth of particular coliform bacteria, but it is not the most effective against others. In addition to this, Lopez-Caballero *et al.* (2005) found that the Gram-negative bacteria's outer membrane restricts the penetration and diffusion of hydrophobic compounds in their lipopolysaccharide layer, but it had an effect on lowering the count of Gram-negative bacteria.

Untreated samples (control) were noted to have *Staphylococcal* counts of 0.5 to 2 log CFU/g at zero and the 3rd day of trials, and these counts were reduced to 0.5 and 1 log CFU/g in treatment samples with chitosan. The high level of chitosan showed significantly higher growth inhibitory effects against the Staphylococcal count over all days of the experiments ($P<0.05$). Application of CW 0.3 resulted in a reduction of Staphylococcal count than other treatments throughout all checkpoints. According to Saucier *et al.* (2000) and Bhoir *et al.* 2019, the combination treatment observed a reduction in coliforms and Staphylococcal counts within acceptable limits of 3 log CFU/g.

These data indicate that CW0.3 exhibits the highest antibacterial activities against TBC, Coliforms, and Staphylococcal count during storage; therefore, it has potential in meat and meat products as an edible coating (Kanatt *et al.,* 2013; Radkowski *et al.,* 2002). The chitosan and black cumin seed essential oil mixture formed a natural edible coating for chicken meat, significantly ($P<0.05$) enhancing the safety of meat by extending longevity and inhibiting microbial contamination and growth during the chilling period of the trials, thereby reducing *Staphylococcus aureus* count, a foodborne pathogen that poses a public health hazard. In (Table 3), the edible coating of 0.3% chitosan completely suppressed and eliminated *Staphylococcus aureus* from the first day until the end of the chilling storage period (Shukla *et al*., 2020). Using chitosan at 1.55% was highly effective on chicken breast meat by suppressing the growth of *Staphylococcus aureus* (Jonaidi Jafari *et al.,* 2018). Also, according to Darmadji and Izumimoto *et al.* (1994), chitosan at 1% decreased *S. aureus* count to 2 log CFU/g in beef. However, Kanatt *et al.* (2008) showed results that contrast with ours, indicating that chitosan can eliminate the growth of *S. aureus* in some meat products.

Salmonella pathogen counts in chicken fillets were lower after artificial treatments, compared to control samples. Despite antibacterial interactions being equivalent, CW 0.3 showed a uniform dropping curve. Pathogenic bacteria compete for antimicrobial peptides (AMPs) due to nutritional and ecological demands. AMPs target pathogen plasma membranes and intracellular components with cytotoxicity limited to mammals, such as humans (Li *et al.,* 2021).

From the current investigation, it appears that CW treatments have potential antibacterial effects on meat and its products rather than on other chemical preservatives, due to their advantages over existing antibiotics. Our results agree with No *et al*. (2002), who revealed that the

antimicrobial activity of low concentrations of chitosan appeared very weak and ineffective against *Salmonella*, however, it was still able to suppress the growth of *E. coli* strains. The antibacterial activity of chitosan in chicken fillet corresponds to its pH and temperature throughout the storage period, so its effectiveness is enhanced by a decrease in pH and temperature (Fujimoto *et al.,* 2006). The barrier properties of the bacterial cell wall may be disrupted by chitosan, leading to the formation of a non-permeable coat around the cells that interferes with other macromolecules by binding to the outer membrane (Helander *et al*., 2001; El-Khawas *et al.,* 2020), which agrees also with the results reported by Elsabee *et al.* (2015) that a polymer membrane around bacterial cells, formed from high molecular weight chitosan, could prevent nutrient intake and potentially disrupt their physiological activities through pervasion. In addition, DNA interacts, and messenger RNA synthesis was interfered with (Rabea *et al.,* 2003). Also, many factors affect its antimicrobial activity, including molecular weight, degree of deacetylation, physical state, and pH (Kong *et al.,* 2010). Moreover, the differences in results between researchers can be explained. Chitosan, considered a highly efficient natural food preservative, owing to its Film-forming characteristics and antibacterial activity, improves the safety, quality, and durability of food (Darmadji *et al.,* 1994). Chitosan's antibacterial activity mechanism remains unclear, but various hypotheses suggest it can alter cell permeability through interactions between its positive and negative charges, making it a realistic one (No *et al.,* 2007). Others include the ability of bacterial growth inhibition due to chelation of metals and essential nutrients (Rabea *et al.,* 2003).

CONCLUSION

The present study found that the mixture of chitosan, wheat flour, and black cumin seed oil significantly improved ($P<0.05$) the sensory parameters, safety, and longevity of chilled chicken fillets compared to the untreated control. CW 0.3% has the longest shelf-life of 12^{th} days, followed by 0.2% and 0.1%. The edible coating with CW 0.3% had the lowest microbial counts, the least oxidative rancidity, and protein deterioration. With a long duration of experiment, the Hunter color parameters were found to be more desirable than those of the other treatments and the control group when evaluated. The instant method acts as a natural preservation technique by using an edible coat of 0.1% and 0.2% chitosan for meat and meat products, which could later be used with continuously changing prerequisites.

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تأثير الغلاف الصالح للاستهلاك على فترة صلاحية فيليه الدجاج المبرد

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هدفت هذه التجربة لدراسة فعالية زيت الحبة السوداء (Nigella sativa) والشيتوزان ودقيق القمح في تغليف فيليه الدجاج، من حيث تقييم الرضا والتفضيلات الحسية، والجودة، ومدة الصلاحية، ومنحنيات نمو مسببات الأمراض المنقولة بالغذاء. تم معالجة فيليه الدجاج المبرد بنسبة ٠,١٪ من زيت الحبة السوداء وتركيزات مختلفة من الشيتوزان (٠,١٪، ٠,٢٪، ٠,٣٪)، ممزوجة مع ٢٠٪ من دقيق القمح، وتم تخزينها عند درجة حرارة ٤ مئوية لمدة ١٥ يومًا ضمن أربع مجموعات: مجموعة ضابطة تحتوي فقط على دقيق القمح، وأخرى تحتوي على ٠,١٪ شيتوزان، ومجموعة ثالثة تحتوي على ٠,٢٪ شيتوزان، وأخيرًا مجموعة تحتوي على ٠,٣٪ شيتوزان.

تم تحليل المعالجات من حيث عدة مؤشرات للجودة مثل (درجة الحموضة pH، محتوى احتباس الماء WHC، الالتصاق، الفقد أثناء الطهي، اللون، والطراوة). أظهرت مجموعة (CW0.3) نتائج جودة أفضل بشكل معنوي ($P<0.05$) مقارنة بباقي المعالجات، وكانت الأكثر استقرارًا، حيث استمرت لمدة ١٢ يومًا مقارنة بـ ٩ أيام للمجموعة الضابطة. وقد أسفرت تقوية هذه المعالجة (CW0.3) عن دجاج طري تمامًا بلون أحمر زاهي بعد ١٥ يومًا. أعلى قيمة للمالونديألديهيد (MDA) سُجلت بالتزامن مع زيادة تركيز الشيتوزان مقارنةً بالمعالجات الأخرى.

قللت معالجات الشيتوزان مع دقيق القمح (CW) العدد الكلي للبكتيريا إلى أقل من ٦ لوغ، وعدد القولونيات إلى أقل من ٤ لوغ، وعدد بكتيريا المكورات العنقودية إلى أقل من ٢ لوغ بعد ١٥ يومًا. وتمكنت معالَجة (CW 0.3) من القضاء على كل من المكورات العنقودية الذهبية (*Staphylococcus aureus*) والسالمونيلا المعوية (*Salmonella enterica*).

وقد أثبتت معالَجة الشيتوزان مع دقيق القمح (CW 0.3) فعاليتها في حفظ فيليه الدجاج المبرد لمدة ١٢ يومًا، حيث عملت كطبقة تغليف مضادة للميكروبات ومضادة للأكسدة، مما حسّن من السلامة والجودة بمساهمة زيت الحبة السوداء ودقيق القمح.

الكلمات المفتاحية: الشيتوزان، الدقيق، قيم مضادات الأكسدة لمركب MDA، الخصائص الفزيائية، السالمونيلا المعوية، المكورات العنقودية الذهبية