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Potential impacts of edible coatings fortified by Moringa and /or Cedar extracts on quality and shelf life of chilled turkey fillets

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ABSTRACT

Edible coatings prolong product shelf life, reduce packaging waste, and actively preserve food quality, so they have a great deal of promise to promote sustainable food production. Its application is becoming an increasing research focus with the potential to enhance meat products' quality and shelf life. Thus, the current study's goal was to evaluate the impacts of duplicated Carboxymethylcellulose (CMC) and pullulan (Pu) edible coatings fortified by natural extracts; Moringa [*Moringa oleifera* (Mo)], Cedar [*Atlantic cedar* (Cd)], and mixture of them, on quality and shelf life of chill stored turkey fillet. Bacteriological (total bacterial, psychrotrophic, coliform, and *Staphylococcus aureus* counts), physicochemical (pH, TBA, and TVB-N), and sensory analysis (color, odor, texture, and overall acceptability) of coated groups showed a significant difference ($P < 0.01$) with control uncoated group. Among the treated samples, CMC: Pu incorporated with Moringa extract showed the highest reduction in aerobic plate count, as the mean count decreased from 6.05 ± 0.1 to 2.95 ± 0.1 (log cfu/gm) at the end of the storage period while psychrotrophic count, coliform count, and *staphylococcus aureus* count not be detected at 8th, 10th and 12th day of storage, respectively followed by CMC: Pu incorporated with mixture of Moringa and cedar extracts, then CMC: Pu incorporated with cedar. Furthermore, compared to the uncoated control samples, the rate of increase in pH, TBA, TMA, and TVB for all coated treatments was lower. Additionally, according to the sensory evaluation, the covered groups showed good quality and acceptability qualities. In general, the application of edible coating enriched with natural bioactive compounds improves the quality parameters and shelf life of chilled turkey fillets.

1. INTRODUCTION

Turkey meat is a remarkable source of nutrients due to its biochemical characteristics, which include a high amount of unsaturated fatty acids despite having a low-fat content, as well as high-quality proteins, B-group vitamins, and minerals (Keykhosravi et al. 2022).

The proliferation of microorganisms and the production of free radicals lead to alterations in the products' taste, color, and texture, which in turn affects their nutritional value (Amiri et al. 2019). Using edible covering that can be strengthened with bioactive chemicals is one of the innovative methods to reduce these risks during food storage (Mansour et al. 2022). One such sustainable technology that has received a lot of attention lately to help the food sector solve its problems is edible coating (Aguirre-Joya et al. 2018; Petkoska et al. 2021; Umaraw et al. 2020). Edible coatings are thin sheets or layers of edible polymers with the proper structural integrity and barrier qualities to shield food from the outside environment and increase the product's shelf life

(Garcia et al., 2017; Yadav et al., 2021). Edible polymers, which are widely distributed in nature, eco-friendly, non-toxic, biodegradable, and suitable for consumption alongside food products, are the basis for edible coatings and formulations (Benbettaieb et al. 2019; Cheng et al. 2021). Carboxymethylcellulose (CMC) can be created by chemically altering cellulose (Miljković et al. 2021). Furthermore, *Aureobasidium pullulans* (PU) produce the polysaccharide pullulan (Haghighatpanah et al. 2020). Its water-soluble, tasteless, odorless, colorless, heat-stable, and antibacterial properties make it a helpful coating material in the food and pharmaceutical industries (Morsy et al. 2014). The native Indian plant *Moringa oleifera*, (*M. oleifera*) usually called moringa, is valued for its high medical merits because of its curative qualities (Chandrappa et al. 2015). They are also considered rich sources of several phytochemical substances, such as glucosinolates (Mgbeahuruike et al. 2017). Known by most as drumstick, *M. oleifera* contains various active ingredients, including triterpenoids, alkaloids, tannins, flavonoids, and saponins (Wansi et al., 2013). These ingredients have an intense

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antibacterial action (Jung 2014; El-Kholy et al. 2018). According to a study by Fuglie, the antioxidant power of fresh moringa leaves is seven times more than that of vitamin C (Fuglie 2001). Quercetin is one of the flavonoid groups found in moringa. According to Vergara-Jimenez et al. (2017), it has four to five times higher antioxidants than vitamins C and E. Furthermore, a total of 31 compounds, or 93.7% of all volatile substances, are present in Atlantic cedar (*Cedar atlantica*), which is known for its broad biological activity, which includes antioxidant and antimicrobial properties (Belkacem et al., 2021). The main component of this mixture is cadinene (36.35%), which is a mixture of (Z) farnesene (13.8%) and himachalene (9.4%), followed by viridiflorol (7.3%) and Himachal-2,4-diene (5.4%). So, the present investigation aimed to comprehensively determine the antioxidant and antimicrobial activity of plain CMC/pullulan edible coating and edible coating fortified with moringa and cedar to CMC/pullulan edible coating to turkey fillet.

2. MATERIAL AND METHODS

2.1. Preparation of extracts:

Ethanol leaf extracts from *Moringa oleifera* and *Cedar atlantica* leaves were prepared according to Abdel-Daim et al. (2020) at the National Research Centre, Dokki, Cairo, Egypt.

2.2. Turkey fillets

Turkey fillets were purchased from poultry markets in El Menofiya governorate and were directly packed in sterile polyethylene bags. The bags were transported instantly in an insulated ice container to the food microbiology lab, Animal Health Research Institute, Shubin Elkom, Egypt, for further treatment and analysis.

2.3. Edible coat preparation

Essential plain edible coating was prepared according to Mansour et al. (2022), with some modification in using mixture of carboxymethylcellulose (HIMEDIA, grm329, CAS Number9004-32-4) and pullulan (Jiyan Chemicals and Pharmaceuticals, Surat CAS Number, 9057-02-7) with a concentration 10% (W/V) for each with 2% (W/V) glycerol in distal water at 100 °C until complete homogenization then, cooled to 37 °C. The essential plain edible coating was used as control; another fortified coat was prepared by separately adding previously prepared plant extracts: moringa (2%), cedar (2%), and mixture (1:1) extracts.

2.4. Experimental design

Turkey fillets were divided into five groups: the first group was untreated (control), the 2nd group was coated with plain coat of CMC/ pullulan (10% for each), the 3rd group the CMC/pullulan coat fortified by 2% moringa, the 4th group was the CMC/pullulan coat fortified by 2% cedar and 5th group was the CMC/pullulan coat fortified by Mixture of moringa

and cedar extracts (1% for each). Samples were separately packed in polyethylene bags, labeled, and stored at four °C. Samples were analyzed for bacteriological, physicochemical, and sensory properties during the chill storage period (1st, 2nd, 4th, 6th, 8th, 10th, 12th, and 14th days) as The experiment was conducted in triplicate.

2.5. Bacteriological quality evaluation

Samples of turkey fillets were periodically examined at the 1st, 2nd, 4th, 6th, 8th, 10th, 12th, and 14th days of chill storage for the evaluation of the Aerobic Plate Count (APC) using the pour plate surface plate method at 35 °C by ISO 4833-1 (2013), the *Staphylococcus aureus* count on Baird Parker agar medium incubated at 37 °C for 48 hours in accordance with FDA (2001), the psychrotrophic bacterial counts on aerobic plate count at 4 °C as described by FDA (2001), and the total coliform count according to ISO 4832 (2006) on violet red bile agar media then incubated at 37°C for 24 hours.

2.6. Physicochemical evaluation

pH

In accordance with Gharibzahedi and Mohammadnabi (2017), a digital pH meter fitted with a glass pH electrode is used to measure pH. After mixing 10 grams of the sample with 100 ml of distilled water for 30 sec., the pH value at room temperature was recorded.

TVB-N

The method outlined by Shokri et al. (2015) involved two steps to determine the TVB-N content: distillation and a sulfuric acid titration step. The results were reported as mg N/100 g of sample.

TBA

The TBA value was determined using the method described by Gharibzahedi and Mohammadnabi (2017). Malondialdehyde (MDA) results were presented in milligrams per kilogram of turkey fillet.

2.2.4 Sensory evaluation performed according to Fan et al. (2008) First, panelists were trained in the methods of elementary sensory evaluation, such as color, odor, texture, and overall acceptability. Five points were used as the basis for the sensory evaluation to determine color, odor, texture, and overall acceptability.

2.7. Statistical analysis

Data was statistically examined using Graph Pad Prism 8.0.2 and two-way analysis of variance (ANOVA) with $p < 0.01$ (Geisser-Greenhouse's epsilon). The impact of coating, treatments, and storage duration on the quality of turkey fillets was investigated using statistical analysis. When the two-way ANOVA produced significant findings, post-hoc analysis used Tukey's HSD test to identify which treatments substantially varied. Greenhouse and Geisser (1959) presented all results as the mean \pm SD of three replicates.

3. RESULTS

In the challenge study, edible coating (CMC/pullulan) and herbal extracts of Moringa and cedar

were applied on turkey fillets stored at a chilling temperature (4 °C) to evaluate their impacts on physicochemical quality.

The bacteriological evaluation of tested groups is presented in Fig. (1). The mean values of aerobic plate count of control, CMC: Pu, CMC: Pu incorporated with Moringa, CMC: Pu incorporated with cedar and CMC: Pu incorporated with mixture of Moringa and cedar extracts, the treated groups changed throughout the chill storage period from 6.12 ± 0.2 , 6.08 ± 0.1 , 6.05 ± 0.1 , 6.07 ± 0.09 and 6.10 ± 0.1 to 8.45 ± 0.2 , 6.05 ± 0.07 , 2.95 ± 0.1 , 3.66 ± 0.09 and 3.66 ± 0.1 (log cfu/g) respectively, at the

end of chill storage period. The coated group count decreases continuously until the 10th day of storage then increases. Also, the mean values of total psychotropic count of control, CMC: Pu, CMC: Pu incorporated with Moringa extract, CMC: Pu incorporated with cedar extract and CMC: Pu incorporated with mixture of Moringa and cedar extracts, the treated groups changed throughout the chill storage period from 5.2 ± 0.2 , 4.90 ± 0.2 , 4.75 ± 0.1 , 4.85 ± 0.1 and 4.85 ± 0.1 to 7.25 ± 0.1 , 6.55 ± 0.1 , 0 , 1.82 ± 0.2 and 0 (log cfu/g) respectively, at the end of storage period.

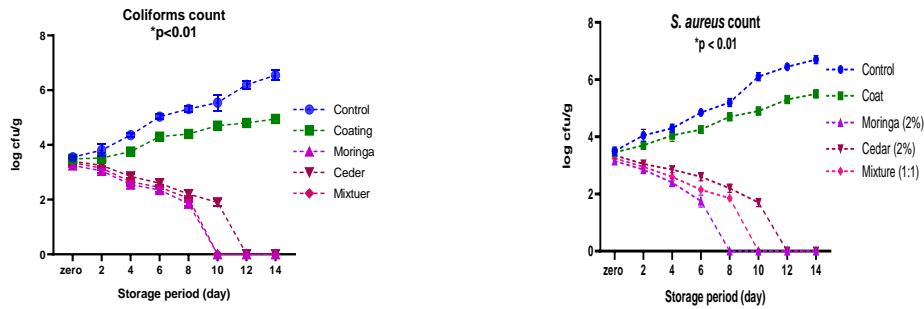


Fig (1) Impacts of CMC/pullulan bioactive coating fortified with natural extracts (*moringa oleifera* and *cedaratlantica*) on bacteriological status of chilled turkey fillets. Values are shown as the mean of triplicates ±SD. The significance at $P < 0.01$ between groups and time of storage.

The coliform count increased in the control group throughout the chill storage period, while the coliform count of the coated group decreased till the 10th of chill storage and then increased. The group treated with Moringa 2% and mixture treated group showed complete inhibition on the 10th day of chill storage. Still, the group treated with cedar 2% showed complete inhibition on the 12th day of storage.

Also, *Staph. aureus* was inhibited entirely on the 8th, 10th, and 12th day of refrigerated storage, which was treated with Moringa 2%, mixture (1:1), and cedar 2% extracts, respectively.

Results in Figure (2) showed a significant variation ($P < 0.01$) between physico-chemical characters of

chilled turkey fillet in the control group and those in treated groups with natural plant extracts. Extracts of Moringa 2% showed higher impacts on enhancing pH, TVB-N, and TBA values that reflect samples' freshness and shelf life. As the control group showed higher values of pH, TVB-N and TBA remember their incipient spoilage from day 6 of chilling storage, while the group coated with CMC/ pullulan showed spoilage on the 10th day of spoilage. Treated samples with Moringa 2% stayed within the accepted range until the 14th day of refrigerated storage. In groups treated with cedar, 2% and a mixture of cedar and moringa extracts (1%) spoiled at the end of the chilling period.

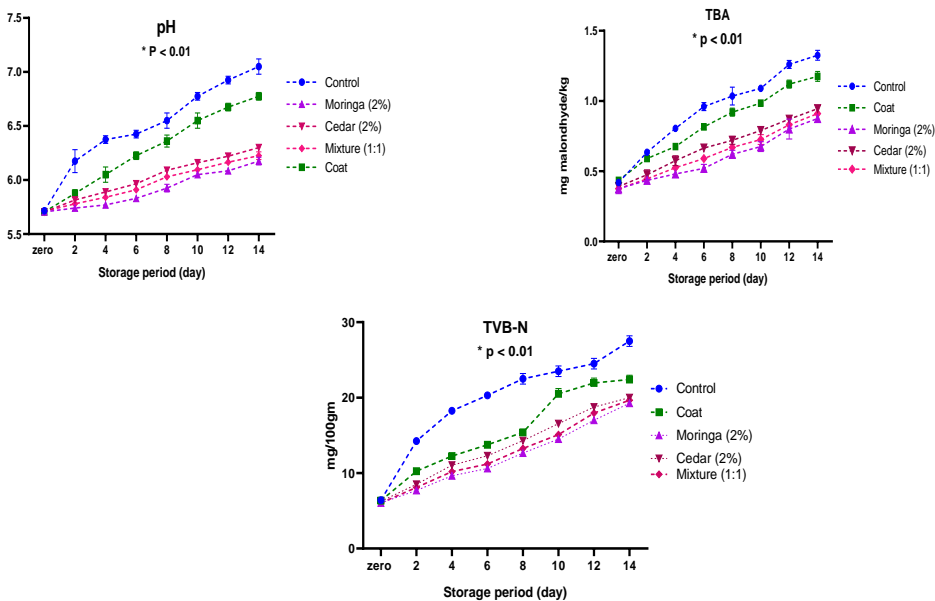


Fig (2) Impacts of CMC/pullulan bioactive coating fortified with natural extracts (*moringa oleifera* and *cedar atlantica*) on physico-chemical characteristics (pH, TBA, TVB-N) in chilled turkey fillets. Values are shown as the mean of triplicates ±SD. The significance at $P < 0.01$ between groups and time of storage.

Concerning sensory attributes of chilled turkey fillets, results in Fig. (3) showed the positive impacts of MO, cedar, and mixture extracts on sensory

characters (odor, color, texture, and overall acceptability) and shelf life of chilled turkey fillets.

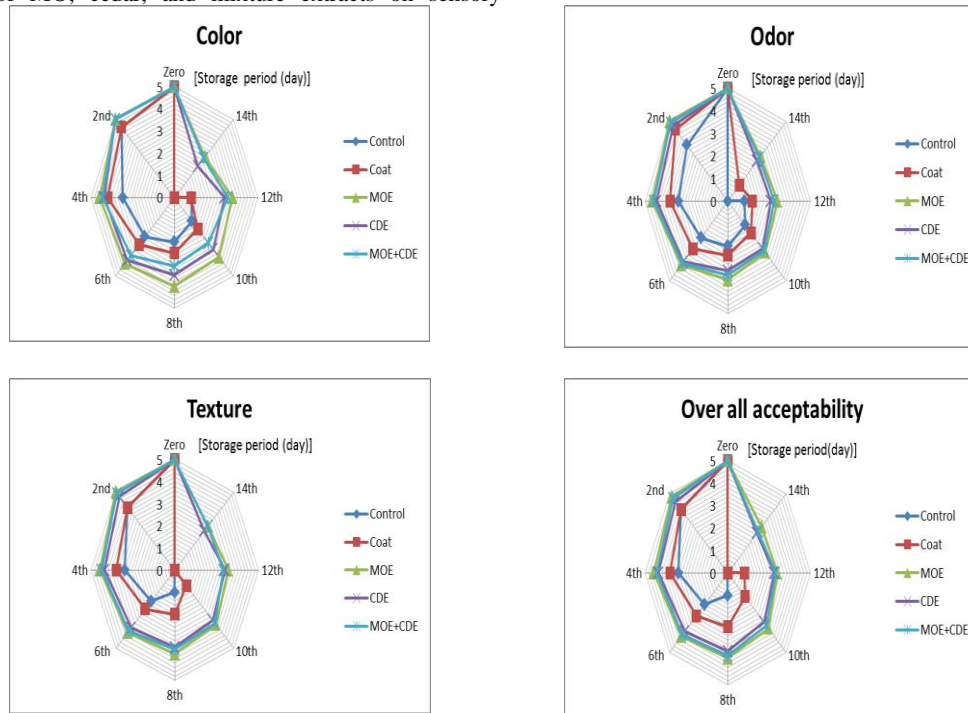


Fig (3) Impacts of CMC/pullulan bioactive coating fortified with natural extracts (*moringa oleifera* and *cedar atlantica*) on sensory attributes (color, odor, texture, over all acceptability) in chilled turkey fillets. Values are shown as the mean of triplicates \pm SD. The significance at $P < 0.01$ between groups and time of storage.

4. DISCUSSION

Food safety is a significant concern for the economy and public health. According to Lee and Yoon (2022), one in ten people gets food poisoning yearly due to contaminated food. The European Commission (2020) predicts that providing high-quality, safe, and nutritious food will get more complicated in the coming decades because food systems' health outcomes are influenced by nutrition and food safety (WHO 2022). So, nowadays, natural preservatives that have antibacterial activity find their way to food processing plants (Elsabagh et al., 2023). Moringa and cedar are two natural ingredients that have been studied for their potential use as preservatives. *M. oleifera* has been found to have great potential as a natural preservative and nutraceutical in the food industry. Upon physicochemical examination, the control sample's pH was significantly higher ($P < 0.01$) than that of the treated samples. The control sample's increased pH could result from increased volatile compounds (such as trimethylamine and ammonia) produced by microbial or endogenous enzymes during storage (Bazargani-Gilani et al. 2015). Similar to Pabast et al. (2018), delay the increase in the treated sample; this may be connected to polyphenols in the coating. The gradual rise in pH for the natural extract-containing samples may be explained by the inhibitory effects of phenolic compounds on bacterial growth and the consequent breakdown of amino complexes during the cold storage period. Amiri et al. (2019) concur with this explanation as well.

TVB-N values increased rapidly in the control group with the chill storage period till spoilage on the 6th day (20.30 mg/100g) according to (ES, 2006), as the maximum permissible limit for TVB-N in poultry is 20 mg/100g. A notable improvement ($P < 0.01$) was seen in the TVB-N content of the treatment and control groups during the chilling storage period. This increase may be attributed to specific microorganisms, such as bacteria, the activity of endogenous enzymes during metabolism, the production of alkaline metabolites during the stationary growth phase and multiplication of bacteria, and protein deamination. The primary cause of generating volatile chemicals is the bacterial breakdown that occurs in aerobic settings faster than in anaerobic conditions (Mahmoudzadeh et al., 2010). The production of anaerobic conditions in treated samples and the inhibition of the rise in TVB-N value in this group may be facilitated by edible coating.

Using TBARs, one can quantify the number of secondary metabolites created when meat oxidizes its fatty acids (Ehsani, et al. 2019). These plants have antioxidant properties due to the high concentration of phenolic and flavonoid chemicals found in moringa and cedar extracts. Additionally, lipid oxidation was suppressed in samples coated with CMC/pullulan. The volatile bases produced by enzymatic and microbiological processes are linked to the groups' elevated pH levels (Ceylan et al., 2018). Microbial growth increased in the control group and considerably decreased ($P < 0.01$) in the treated group. According to research by Mursyid et

al. (2019), the active ingredients in *M. oleifera* extract with ethanol solvent, tannin, and flavonoids can suppress the production of *S. aureus* and have antibacterial activity against *Pseudomonas aeruginosa* and *E. coli*. Additionally, a prior study (Ghanem and Olama, 2017) revealed the antibacterial and antifungal effects of aqueous and methanolic extracts of the leaves, stems, and pulp of Lebanese Cedar against *Klebsiella pneumonia*, MRSA, ESBL *E. coli*, *Listeria monocytogenes*, and *Candida albicans*. According to Hudson et al. (2011), Cedar leaf oil has antibacterial properties against *Salmonella* Enteritidis, *E. coli*, *Bacillus subtilis*, *Streptococcus pyogenes*, *Enterococcus faecalis*, *Acinetobacter baumannii*, and *Hemophilus influenzae*. Cedarwood oil was found to have antibacterial action against *Streptococcus mutans* by Chaudhari et al. (2012). Zrira and Ghanmi (2016) reported that Cedarwood essential oil exhibited bactericidal action against *Staphylococcus aureus*, *Bacillus subtilis*, and *Bacillus cereus* at 5% cedar tar concentration was added to the liquid media to sustain the bacterial growth.

Investigating the time-dependent inhibitory effect of cedar tar on tested strains showed that it successfully reduced the growth of *S. haemolyticus* and *E. coli*. This powerful effect may be associated with secondary bioactive metabolites such as β -himachalane and α -himachalane (Takci et al. 2020). The deviation in sensory attributes score decreased in the treated group while the control one spoiled rapidly on 6th day of chill storage as the formation of toxic metabolites also retarded, and the bacterial population decreased due to the antibacterial effect of CMC/pullulan fortified with natural antioxidant *M. oleifera* and *cedar atlantica*. Similar results by Elsabagh et al. (2023) and Mansour et al. (2022), who used edible coating with natural antioxidants to delay the spoilage of meat and meat products.

5. CONCLUSIONS

Food quality can be actively preserved, product shelf life can be increased, and sustainable food production may be greatly enhanced by edible coatings. The quality and shelf life of edible coatings using plant extracts, particularly those of moringa and cedar, which have antibacterial and antioxidant properties, may be improved.

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