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Antimicrobial edible coating on poultry meat

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Abstract
The demand for the fresh meat is increasing day by day and its shelf life is important as per as the retailers point of view. The present research focused to improve self-life of fresh chicken meat by edible coating with chitosan and turmeric powder emulsion. The present study was conducted to assess the impact of chitosan coating (1%, 1.0% and 1.5%) containing turmeric powder (0.25%, 0.50%, 0.75%, 1.0% and 1.25%) as antimicrobial and antioxidant agent on the quality parameters and shelf life of poultry meat during refrigerated storage. The result showed that the incorporation of turmeric into chitosan coating significantly increase the antioxidant capacity, especially for 1% chitosan and 1.25% turmeric powder, reported 23.62% antioxidant activity. Coated poultry meat had, significantly, the highest inhibitory effects against microbial growth (*S. typhimurium*). After coating meat as well as uncoated samples were stored at refrigerated storage and evaluated for physiochemical, microbiological, and organoleptic attributes at regular interval of 2 days. The poultry meat sample without coating was spoiled within 2 days. The results revealed that applied of chitosan – turmeric powder coating had no significant effect on proximate composition among treatments. The lowest TPC count was reported in sample T2R5 (1% chitosan + 1.25% turmeric coating) i.e.1.15 × 10^3 cfu/g, however lowest yeast and mould was reported in sample T3R5 (1.5% chitosan + 1.25% turmeric coating) i.e. 2.83 cfu/g after 10 days refrigerated storage. Organoleptic attributes of coated samples also showed the highest overall acceptability scores for treatment T2R5. Therefore, the incorporation of turmeric powder into chitosan coating could be effectively used for improving stability and shelf life of poultry meat at refrigerated storage.

Keywords: Chitosan, turmeric, poultry meat, coating, antioxidant, antimicrobial

1. Introduction
Meat production in India is 6.2 MMT, with Maharashtra leading with 632.32 tonnes. Poultry meat is a good source of high-biological value proteins, Caballero (2005). Chicken meat is a good source of vitamins and minerals, with an average content of moisture 70-75%, ash 1.0%, protein 12-14%, lipid 11-13%, and carbohydrate 1-2%. The poultry meat contain higher amount of free water protein and carbohydrate which make it desirable for microbial growth. In general food spoilage is caused by biological mechanisms such as auto-degradation of tissues, viral contamination, protozoa and parasite contamination, microbial contamination, and attack by rodents and insects. Microbial spoilage is the major route for food spoilage, leading to degraded quality, shortened shelf life, and changes in natural micro flora (*E. coli, Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Lactobacillus bulgaricus*, *Bacillus cereus*), fungus (*Botrytis cinerea*, *Aspergillus fumigates*, *Botrytis cinerea*, *Candida albicans*).The poultry meat contain good amount of fat, which oxidized during storage and leads to undesirable changes in flavour, colour, and odour

Edible coatings are used to prevent moisture loss and add shine to food products, and are biodegradable in composting or biological recycling processes (Krochta, 2002) [21]. Edible coating is a thin coating or wrapping of food made from food sources that can protect food from the environment, increase shelf life, and be consumed alongside packaged food. Edible coatings are thin layers of edible materials formed directly on the surface of food products, driven by consumer demand and environmental concerns (Sanchez-Gonzalez *et al*. 2011) [29]. Antimicrobial edible coatings replace and fortify natural layers to prevent moisture losses, gas aromas, and solute movements, while selectively allowing for controlled exchange of gases. They also provide physical protection and act as both a barrier and a carrier of food additives (Embuscado and Huber, 2009) [10].

Edible films and coatings contain antimicrobial agents to extend product shelf life and improve quality and safety (Franssen and Krochta, 2003) [14].

The properties of edible films and coatings are influenced by a number of factors, including the type of film forming material composition, the film forming mechanism, such as the type of solvent, the pH of the food, the heating temperature, and the type and concentration of additives (plasticizers, antioxidants, antimicrobials and cross linking agents), and the drying method (Falguera *et al*. 2011; Erkmen and Barazi, 2018) [13, 12].

Turmeric powder is a yellow-colored nutraceutical compound extracted from the rhizomes of *Curcuma longa* L. It has light barrier properties and an antioxidant capacity to gelatin-based coatings. It is also reported as excellent antimicrobial agent. It can exist in a variety of tautomeric forms, including a 1,3-diketo form and two enol forms (Tatraaljai *et al*. 2013) [31].

In the study attempts have been made to improve the shelf life of the poultry meat by use of chitosan-based coating.

2. Material and Methodology

2.1. Edible coating preparation

Chitosan solution of different concentration i.e., 0.5, 1.0 and 1.5 per cent w/v was dissolved in 100 ml of distilled water and different concentration of turmeric powder 0.25, 0.50, 0.75, 1.0 and 1.25 per cent, respectively was added to the solution. Solution was homogenously agitated overnight. The prepared coatings were analyzed for transparency, antimicrobial activity and antioxidant activity.

2.2. Antioxidant Activity

The antioxidant activity of prepared coating was determined by DPPH method (Ozunlu, 2018) [23]. A 0.1 mM solution of DPPH was prepared in ethanol, and 2 mL of this solution was added to 1 mL of chitoan and turmeric powder solution. These solutions were thoroughly vortexed and incubated in the dark for 30 min. After 30 min, the absorbance was measured at 517 nm against a blank sample lacking scavenger in a 96-well microplate reader. The antioxidan8t capacity was calculated by using the following formula which was then used to plot the IC50:

$$\text{Scavengingactivity (\%)} = \frac{A_0 - A_s}{A_0} \times 100$$

Where A_0 is the absorbance of control (DPPH solution without chitosan and turmeric powder) and A_s is the absorbance of the sample.

2.3. Transparency of coating

The transparency of coating was determined according to Al-Hassan and Norziah by using a spectrophotometer. Transmittance was measurements at a wavelength of 550 nm.

2.4. Antimicrobial activity of coatings

Antibacterial activity assays were performed according to the method described by Vanden (1991) [33]. Coating was dissolved at 50 mg/ml in 0.1% acetic acid. The inoculum suspension (200 μL) of the tested microorganisms, containing 10 colony- forming units (cfu/mm) of bacteria cells were spread on Muller Hinton agar. The inoculums were allowed to dry for 5 min. Then, bores (3mm depth. 4mm diameter) were made using a sterile borer and were loaded with 50 μL of each sample. Well with only acetic acid (without chitosan) was used as a negative control. Gentamycin was used as positive reference. The petri dishes were kept firstly, for 1 hr at 4 °C, and then were incubated for 24 hr at 37 °C. Antibacterial activity was evaluated by measuring the diameter of the growth inhibition zones in millimeters (including well diameter of 4 mm) for the test organisms and comparing to the controls. The measurements of inhibition zones were carried out for three sample replications, and values are the average of three replicates.

2.5. Meat coating

The different concentration of chitosan and turmeric was used and these coating are termed as T1R1 = 0.50% chitosan and0.25% turmeric powder; T1R2 = 0.50% chitosan and 0.50% turmeric powder; T1R3 = 0.50% chitosan and 0.75% turmeric powder; T1R4 = 0.50% chitosan and 1.00% turmeric powder; T1R5 = 0.50% chitosan and 1.25% turmeric powder; T2R1 = 1% chitosan and 0.25% turmeric powder; T2R2 = 1% chitosan and 0.50% turmeric powder; T2R3 = 1% chitosan and 0.75% turmeric powder; T2R4 = 1% chitosan and 1.00% turmeric powder; T2R5 = 1% chitosan and 1.25% turmeric powder; T3R1 = 1.5% chitosan and 0.25% turmeric powder; T3R2 = 1.5% chitosan and 0.50% turmeric powder; T3R3 = 1.5% chitosan and 0.75% turmeric powder; T3R4 = 1.5% chitosan and 1.00% turmeric powder and T3R5 = 1.5% chitosan and 1.25% turmeric powder.

The fresh boneless meat samples were washed in potable water and surface drying was carried out. All meat samples were cut in to approximately of size 1 x 3 x 6 cmwith a sterile knife. The poultry meat divided into groups and coated with chitosan and turmeric powder coating by immersed in prepared solutions for 5 min. The excess solution was drained for 2 min and surface drying was carried out at at 40°C for 15 minutes. Then packed in low density polyethylene and stored at refrigerated condition

2.6. Colour analysis

The coated meat samples during storage were subjected to colour analysis for L* (lightness), a* (redness), and b (yellowness) by using a colour analyser.

2.7. Proximate Composition

Proximate composition of chicken was carried out by using the method described in A.O.A.C (2005) [1].

2.8. Microbiological analysis

The microbiological evaluation was performed on days 0, 2, 4, 6, 8 and 10 of the storage period. Twenty-five gram of poultry meat samples were mixed in sterile lab-blender with 225 mL of saline water for 3 min. Serial dilutions was prepared with saline water. Total plate counts (TPC) and yeast and mold counts were determined as per the procedure suggested by (APHA, 2001). The results were reported as colony forming unit/g (Log cfu/25g) of poultry meat samples.

2.9. Sensory properties

The effects of chitosan in combination turmeric powder on sensory attributes of chicken were evaluated. The coated samples were individually labeled with aleatory numbers and randomly served. Each sample was screened for the sensory parameters such as flavour, colour, texture, and overall acceptability using hedonic scale (9 point hedonic scale) (Ranganna, 1986) [27].

2.10. Statistical analysis

The statistical analysis of data collected was done by using Factorial Completely Randomized Design (FCRD) (Panse and Sukhatme 1985; Amdekar 2014) [24, 23].

3. Results and discussion

3.1. Effect of different coating combinations on Antioxidant activity

The free radical scavenging activity of chitosan and turmeric powder coating was evaluated and obtained results are shown in Table 1.The free radical scavenging activity was increased with increasing turmeric concentration. The coatings with 1% chitosan and 1.25% turmeric powder showed a higher antioxidant capacity (23.62%). Turmeric powder contains phenolic compounds, which are responsible for the antioxidant capacity of the coating. The antioxidant capacity is proportional to the concentration of antioxidant compounds present in the coating (Gomez *et al*, 2009; Tongdeesoontorn *et al*, 2020) [15, 32]. Similar observation was reported by Li *et al*. (2021) [22] in chitosan film blended with green tea extract.

Table 1: Effect of chitosan-turmeric powder coating on radical scavenging activity (%)

Turmeric powder (%)	Chitosan		
	0.5%	1.0%	1.5%
0.25	2.38	2.67	2.80
0.50	6.20	6.57	7.51
0.75	12.14	12.82	11.56
1.00	16.71	16.64	16.57
1.25	22.99	23.62	23.57

3.2. Effect of different coating combinations on Transparency

The incorporation of turmeric powder into chitosan coating significantly decreased the percentage of transmission of light (Table 2). The result showed that adding a higher concentration of turmeric powder can increase the UV / visible barrier properties of the coating. The higher values indicated lower transparency as higher values indicates lower transmission of light across the films. The higher transparency was recorded in the coating having 0.25% turmeric powder and lower was recorded in the coating having higher turmeric powder concentration (1.25%). The reduction in transparency of Turmeric ethanolic extract incorporated films is related to yellow color of turmeric (Kalaycıoğlu *et al*., 2017) [19]. However, turmeric incorporated film still allows product visibility to satisfy consumers demand. The results in present study are closely agreement with the finding of Khalaf *et al*. (2013) [20] in pullulan edible film with addition of oregano and rosemary essential oils.

Table 2: Transparency of chitosan coating incorporated with various concentrations of turmeric powder

Edible coating formulation	Transparency (%)
T1R1	74.15
T1R2	62.46
T1R3	53.37
T1R4	47.09
T1R5	40.21
T2R1	75.64
T2R2	62.81
T2R3	53.51
T2R4	49.73
T2R5	40.77
T3R1	75.86
T3R2	62.98
T3R3	54.07
T3R4	47.64
T3R5	40.66

T1R1 = 0.50% chitosan and 0.25% turmeric powder; T1R2 = 0.50% chitosan and 0.50% turmeric powder; T1R3 = 0.50% chitosan and 0.75% turmeric powder; T1R4 = 0.50% chitosan and 1.00% turmeric powder; T1R5 = 0.50% chitosan and 1.25% turmeric powder; T2R1 = 1% chitosan and 0.25% turmeric powder; T2R2 = 1% chitosan and 0.50% turmeric powder; T2R3 = 1% chitosan and 0.75% turmeric powder; T2R4 = 1% chitosan and 1.00% turmeric powder; T2R5 = 1% chitosan and 1.25% turmeric powder; T3R1 = 1.5% chitosan and 0.25% turmeric powder; T3R2 = 1.5% chitosan and 0.50% turmeric powder; T3R3 = 1.5% chitosan and 0.75% turmeric powder; T3R4 = 1.5% chitosan and 1.00% turmeric powder and T3R5 = 1.5% chitosan and 1.25% turmeric powder.

3.3. Effect of different coating combinations onantimicrobial activity

The coatings prepared with different combinations of chitosan and turmeric is subjected to screening of antimicrobial activity against some gram '-', gram '+' and yeast. The obtained results are presented in Table 3.The chitosan is already reported for its antimicrobial activity (Hosseinnejad *et al*. 2016) [17] and it was improved by the addition of turmeric powder. The data reveals that there the activity of chitosan and turmeric powder was significantly different on each type of organism. The highest inhibition zone was recorded against *S. typhimurium*by coating prepared with chitosan (1.0%) and turmeric powder (1.25%) i.e., 48.1mm whereas the lowest was recorded in against *B. Pumilis* by the coating prepared with chitosan (0.50%) and turmeric powder (1.25%). It was observed that with the increasing concentration of turmeric powder the antimicrobial effect was increasing for all the strains of bacteria and fungi as well. The inhibition is due to the fact that turmeric contain phenolic compound known as curcuminoids which is well known for its antimicrobial effect. The antibacterial properties of chitosan edible films incorporated with turmeric ethanolic extract could be related with the presence of mainly curcuminoids and also terpenoids (Kalaycıoğlu *et al*. 2017) [19]. Gul and Bakht (2015) [18] investigated that turmeric itself exhibited antimicrobial activity against *Staphylococcus aureus* in addition to *Candida albicans*, *Salmonella typhi*, and *Escherichia coli*. Also this result is in conformation with findings of Badmaev *et al*. (2004) [5] that yeasts and moulds are the most sensitive group to chitosan, followed by Gram-positive and Gram-negative bacteria. Ralston *et al*. (1964) [26] reported inhibition of Baker's yeast by chitosan.

Table 3: Inhibition zone (mm) of antimicrobial compounds for different microorganisms (mm)

Treatment	Zone of Inhibition (mm)						
	E. coli	*P. aeruginosa*	*S. typhimurium*	*S. aureus*	*S. aureus*	*B. subtilus*	*A. niger*
T1R1	6.80±0.07	5.80±0.14	6.20±0.21	11.2±0.49	9.20±0.42	5.20±0.28	8.40±0.35
T1R2	8.70±0.14	11.1±0.28	6.50±0.28	12.6±0.42	9.30±0.92	6.00±1.41	11.8±0.42
T1R3	9.40±0.07	13.4±0.35	6.80±0.49	13.5±0.07	10.0±0.71	6.7±0.78	14.5±0.21
T1R4	10.2±0.28	24.2±0.64	30.8±0.18	14.3±0.42	12.3±0.21	20.8±0.57	16.0±1.15
T1R5	18.6±0.14	26.4±0.28	30.8±0.57	17.6±0.35	14.4±0.35	25.9±0.71	28.2±0.92
T2R1	5.90±0.57	11.8±0.07	7.40±0.35	16.7±0.42	15.8±0.18	11.0±1.48	8.20±0.07
T2R2	11.6±0.00	12.6±0.14	31.6±0.21	19.2±0.78	17.2±0.78	16.8±0.35	17.5±0.28
T2R3	13.4±0.14	14.7±0.21	40.7±0.57	21.3±0.35	21.8±0.85	19.7±0.42	18.2±0.78
T2R4	17.6±0.07	15.4±0.00	47.3±0.64	24.5±0.07	32.1±0.49	28.6±0.57	19.8±0.57
T2R5	18.07±0.01	24.5±0.07	48.1±0.85	25.2±0.35	37.1±0.57	30.4±0.35	26.7±0.35
T3R1	9.60±0.14	9.80±0.21	15.6±0.14	14.9±0.71	5.98±0.44	19.8±0.42	5.80±0.21
T3R2	11.2±0.21	11.7±0.35	27.9±0.49	16.9±0.42	11.5±0.57	23.1±0.85	11.2±0.42
T3R3	12.1±0.28	13.8±0.14	29.8±0.07	18.7±0.49	13.5±0.92	26.8±0.21	14.9±0.35
T3R4	12.6±0.35	14.9±0.21	38.4±0.28	21.8±0.35	18.6±0.57	33.8±0.85	15.5±0.28
T3R5	13.5±0.07	21.3±0.42	44.8±0.64	36.5±0.21	29.7±0.49	42.4±1.41	20.3±0.35

T1R1 = 0.50% chitosan + 0.25% turmeric powder; T1R2 = 0.50% chitosan + 0.50% turmeric powder; T1R3 = 0.50% chitosan + 0.75% turmeric powder; T1R4 = 0.50% chitosan + 1.00% turmeric powder; T1R5 = 0.50% chitosan + 1.25% turmeric powder; T2R1 = 1% chitosan + 0.25% turmeric powder; T2R2 = 1% chitosan + 0.50% turmeric powder; T2R3 = 1% chitosan + 0.75% turmeric powder; T2R4 = 1% chitosan + 1.00% turmeric powder; T2R5 = 1% chitosan + 1.25% turmeric powder; T3R1 = 1.5% chitosan + 0.25% turmeric powder; T3R2 = 1.5% chitosan + 0.50% turmeric powder; T3R3 = 1.5% chitosan + 0.75% turmeric powder; T3R4 = 1.5% chitosan + 1.00% turmeric powder + T3R5 = 1.5% chitosan + 1.25% turmeric powder.

3.4. Effect of chitosan and turmeric powder coating on colour value of poultry meat during refrigerated storage

Colour is one of the most important parameters in any food and food products, since its stability could compromise the sensory properties of the product and therefore the consumer acceptance. The colour indexes (L: Lightness, a": Redness and b": Yellowness) of chicken meat samples were significantly affected by both coating and refrigerated period (Table 4).The L values of all samples decreased during refrigerated period; however, the rate of this reduction was significantly lower in coated samples. The antioxidant and antimicrobial properties of Chitosan and turmeric powder would lead to higher retaintion of L* in coated samples. At day 10, chicken samples coated with Chitosan (1.5%) and turmeric powder (1.25%) showed the highest (37.22) and lowest (37.13) values in sample coated with 0.5% chitosan and 1.25% turmeric powder. These results are in agreement with those found by Bitencourt *et al*. (2014) [6] who reported a similar trend for lightness for gelatin based films with curcuma ethanol extract.

All meat samples revealed a reduction in a value during refrigerated period. The formation of free radicals from lipid oxidation and met-myoglobin may be the main reasons for the reduction of a* values. Higher a* values were observed in coated samples may be due to the high antioxidant properties of chitosan and turmeric powder. A similar trend in the reduction of a value in lamb burgers treated with natural extracts was reported by De Carvalho *et al*. (2019) [18].

Regarding yellowness, this parameter is highly affected by the enzymatic browning reactions that occur during the refrigerated storage of meat samples. However, samples coated with chitosan and high concentration of turmeric powder showed significantly higher b* values

Table 4: Effect of edible coating on colour indexes of poultry meat during storage at refrigerated storage*

Colour code	Treatments	Storage period (Days)					
		0	2	4	6	8	10
L*	Control	41.60±0.61	37.09±0.52	SD	SD	SD	SD
	T1R5	42.04±0.49	38.90±0.01	38.52±0.30	38.51±0.27	38.12±0.69	37.13±0.60
	T2R5	41.78±0.11	40.91±0.34	40.58±0.25	38.35±0.30	38.52±0.43	37.18±0.98
	T3R5	42.01±0.34	41.09±0.01	40.57±0.82	39.78±0.36	39.09±0.54	37.22±0.24
a*	Control	11.05±0.16	10.74±0.46	SD	SD	SD	SD
	T1R5	10.22±0.25	9.33±0.44	8.97±0.40	7.21±0.38	8.61±0.50	7.36±0.62
	T2R5	10.23±0.09	8.97±0.20	8.36±0.38	7.09±0.16	7.29±0.33	6.11±0.49
	T3R5	10.11±0.99	9.15±0.09	8.45±0.29	7.66±0.24	7.69±0.40	6.77±0.29
b*	Control	39.80±0.96	39.01±0.36	SD	SD	SD	SD
	T1R5	40.95±0.14	40.11±0.14	39.22±0.11	38.75±0.20	38.92±0.14	37.79±0.19
	T2R5	41.19±0.25	40.30±0.19	39.76±0.05	38.70±0.19	39.29±0.58	38.38±0.28
	T3R5	41.33±0.46	40.96±0.16	39.80±0.49	38.95±0.05	39.33±0.33	38.35±0.22

*The readings are mean ± standard deviation (SD) of three determinations; T1R5: Chitosan (0.5%) + Turmeric powder (1.25%); T2R5: Chitosan (1.0%) + Turmeric powder (1.25%); T3R5: Chitosan (1.5%) + Turmeric powder (1.25%); SD: Sample Discarded

3.5. Effect of chitosan and turmeric powder coating on proximate composition of chicken meat during refrigerated storage

The proximate composition among treatments showed similar values for ash, fat, protein and moisture contents, which indicates that chitosan and turmeric powder had no significant effects on poultry meat composition during storage (Table 5). The results of the present research are in agreement with those observed by Alirezalu *et al*. (2019) [2]. The authors showed that the inclusion of natural antioxidants in E-polylysine, chitosan, and nisin had no significant effects on frankfurter-type sausage proximate composition. Agregan *et al*. Alsoreported similar results in the chemical composition of pork patties by applying natural antioxidants (Macroalgae *Fucusvesiculosus* extract). In the same way, de Carvalho *et al*. (2019) [18] evaluated the impact of guarana (*Paulliniacupana*) seed and pitanga (*Eugenia uniflora* L.) leaf extracts on lamb patties and reported no significant differences in chemical compositions among treatments.

Table 5: Effect of chitosan and turmeric powder coating on proximate composition of meat during storage at the 4°C (%)

Parameters (%)	Treatments	Storage period (Days)					
		0	2	4	6	8	10
Moisture	Control	74.01±1.02	73.48±1.14	SD	SD	SD	SD
	T1R5	74.79±1.07	74.46±1.05	74.43±1.12	74.30±1.02	73.85±1.45	73.34±1.21
	T2R5	74.49±1.24	74.46±1.15	74.43±1.08	74.30±1.05	73.85±1.40	73.37±1.30
	T3R5	74.49±1.12	74.47±1.08	74.44±1.11	74.36±1.21	73.83±1.51	73.39±1.05
Protein	Control	17.51±0.35	17.03±0.58	SD	SD	SD	SD
	T1R5	17.98±0.74	17.95±0.29	17.85±0.75	17.71±0.88	17.19±0.51	16.73±0.28
	T2R5	17.98±0.47	17.96±0.43	17.88±0.39	17.75±0.56	17.23±0.62	16.77±0.97
	T3R5	17.98±0.95	17.93±0.22	17.84±0.48	17.74±0.74	17.20±0.44	16.76±0.81
Fat	Control	5.51±0.14	5.12±0.06	SD	SD	SD	SD
	T1R5	5.57±0.08	5.25±0.09	5.18±0.13	5.04±0.05	4.56±0.08	3.80±0.07
	T2R5	5.57±0.01	5.24±0.12	5.17±0.01	5.02±0.01	4.55±0.03	4.20±0.09
	T3R5	5.57±0.15	5.24±0.07	5.13±0.08	5.03±0.14	4.55±0.05	4.22±0.11
Ash	Control	1.03±0.01	1.03±0.02	SD	SD	SD	SD
	T1R5	1.03±0.02	1.03±0.01	1.03±0.03	1.03±0.01	1.03±0.05	1.03±0.03
	T2R5	1.03±0.01	1.03±0.03	1.03±0.02	1.03±0.02	1.03±0.03	1.03±0.01
	T3R5	1.03±0.01	1.03±0.01	1.03±0.01	1.03±0.01	1.03±0.01	1.03±0.02
Carbohydrate	Control	1.248±0.04	1.244±0.04	SD	SD	SD	SD
	T1R5	1.250±0.09	1.248±0.01	1.246±0.01	1.244±0.04	1.234±0.02	1.228±0.04
	T2R5	1.250±0.02	1.250±0.03	1.250±0.01	1.246±0.02	1.238±0.09	1.230±0.08
	T3R5	1.250±0.03	1.250±0.02	1.250±0.03	1.250±0.03	1.240±0.01	1.230±0.03

*The readings are mean ± standard deviation (SD) of three determinations; T1R5: Chitosan (0.5%) + Turmeric powder (1.25%); T2R5: Chitosan (1.0%) + Turmeric powder (1.25%); T3R5: Chitosan (1.5%) + Turmeric powder (1.25%); SD: Sample Discarded

3.6. Microbial Quality of coated chicken meat during storage

3.6.1. Total plate count (TPC)

As regard to the storage, increasing trend for total plate count was showed during storage period. The increase in total plate count was due to the growth of bacteria (Table 6). Similar findings were observed in ground beef patties treated with essential oil by Emiroglu *et al*. (2010) [11].

As regards to the storage, increasing trend for yeast and mould was from the 6th day onwards. The rate of increase was significantly lower in coated sample showed the highest antimicrobial activities against yeast and mold (Table 6). The result of present work are in agreement with those reported by Alizezalu *et al*. (2019) [2], who support the use of chitosan (1%) in combination with plant extracts as antimicrobial ingredients in frankfurter-type sausage. Chitosan and turmeric powder coated as a coating solution act as an oxygen barrier around bacterial cell and thus prevent the growth of aerobic bacteria. The present study also confirms the results of Shahidi *et al*. (1999) [33].

3.6.2. Yeast and mould

The meat and meat products surfaces are highly susceptible for yeast and mould, which can lead to spoilage negative impacts on safety and organoleptic attributes. As regards to the storage, there was significant in the yeast and mould content was observed during 10 days of storage period. The average minimum Log value (0.33) yeast and mould count content was observed at initial stage irrespective of the treatments while average maximum Log value (3.58) yeast and mould count content was observed on 10th day of storage period. As regards to the storage, increasing trend for yeast and mould was from the 6th day onwards. The rate of increase was significantly lower in coated sample showed the highest antimicrobial activities against yeast and mould (Table 6). The result of present work are in agreement with those reported by Alizezalu *et al*. (2019) [2], who support the use of chitosan (1%) in combination with plant extracts as antimicrobial ingredients in frankfurter-type sausage.

Table 6: Effect of chitosan and turmeric coating on microbiological count (Log/cfu/g) storage at the 4°C

Parameters	Treatments	Storage period (Days)					
		0	2	4	6	8	10
Total Plate count	Control	1.21×10^3 (3.08)	2.14×10^3 (3.33)	SD	SD	SD	SD
	T1R5	1.13×10^3 (3.05)	1.57×10^3 (3.20)	1.88×10^3 (3.67)	2.05×10^3 (3.31)	2.45×10^3 (3.29)	4.01×10^3 (3.60)
	T2R5	1.13×10^3 (3.05)	1.49×10^3 (3.17)	16.8×10^3 (3.23)	1.79×10^3 (3.25)	2.01×10^3 (3.30)	3.68×10^3 (3.57)
	T3R5	1.13×10^3 (3.05)	1.61×10^3 (3.21)	1.61×10^3 (3.21)	1.89×10^3 (3.28)	2.35×10^3 (3.37)	3.83×10^3 (3.58)
Yeast and Mold	Control	1.48×10^3 (0.17)	3.59×10^3 (0.55)	SD	SD	SD	SD
	T1R5	ND	ND	ND	2.78 (0.44)	3.02 (0.48)	3.33 (0.52)
	T2R5	ND	ND	ND	2.01 (0.30)	2.17 (0.33)	2.35 (0.37)
	T3R5	ND	ND	ND	1.78 (0.25)	1.91 (0.28)	2.28 (0.35)

TPC: Total Plate Count;YAM: Yeast and Mould; ND: Not detected; T1R5: Chitosan (0.5%) + Turmeric powder (1.25%); T2R5: Chitosan (1.0%) + Turmeric powder (1.25%); T3R5: Chitosan (1.5%) + Turmeric powder (1.25%); SD: Sample Discarded; ND: Not Detected

3.7. Sensory parameters

The effects of chitosan coating with turmeric powder on organoleptic properties of meat samples are illustrated in in Table 7. The highest sensory score was observed on the initial day i.e. 0^{th} day but the score declined on the 10^{th} day for all coated samples. The overall decrease in colour, flavour score might be due to pigment and lipid oxidation whereas decrease in texture could be due to dehydration which led to hardening of product. The decrease in overall acceptability scores during refrigerated storage might be reflective of the decline in scores of colour, flavour and texture attributes. The similar observations were reported Yaghoubi *et al*. (2021) [34] on fresh chicken meat incorporated with chitosan and *Artemisia fragrans*.

Table 7: Effect of chitosan and turmeric powder coating on Sensory Properties

Sample	Colour		Flavor		Texture		Overall acceptability	
	0	10	0	10	0	10	0	10
Control	6.19	SD	6.64	SD	6.61	SD	6.48	SD
T1R5	6.26	5.78	6.69	5.60	6.60	5.70	6.06	5.82
T2R5	7.52	7.46	7.44	6.29	7.62	6.62	7.22	7.10
T3R5	6.26	6.36	6.68	5.99	6.92	6.61	6.36	6.18

T1R5: Chitosan (0.5%) + Turmeric powder (1.25%); T2R5: Chitosan (1.0%) + Turmeric powder (1.25%); T3R5: Chitosan (1.5%) + Turmeric powder (1.25%)

4. Conclusion

It was concluded from present study that using the combination of chitosan and turmeric can increase the storage time by 8 or 10 days. The fresh meat sample was spoiled within a storage period of 2 days, while the turmeric coating presented good ultraviolet and visible light barrier properties and a high antioxidant capacity. The outcomes of this study showed that coating of1.0 per cent chitosan + 1.25 per cent turmeric had the best inhibitory effects on the oxidative activity and microbial growth. It significantly prolongs the stability of poultry meat and suggested as potential coating materials in poultry meat.

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