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Quality evaluation of chicken breast marinated with encapsulation of turmeric extract

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Abstract

Turmeric is extensively used as a preservative in food because it has biological activities such as antioxidant and antibacterial activities. The quality preservation of turmeric can be applied by using microencapsulation techniques to improve the bioavailability of polyphenol substances in turmeric. This study was carried out to determine the physico-chemical, oxidative stability, antioxidant potential, pathogenic bacteria, and sensory evaluation of chicken breast marinated with microencapsulation of turmeric extract stored at refrigeration (4±1°C) on 0, 3rd, 6th, 9th, and 12th day of storage. The treatments given include control (T0), 2.5% added microencapsulated turmeric extract (T1), 5% added microencapsulated turmeric extract (T2), and 7.5% added microencapsulated turmeric extract (T3). The results showed a significant difference ($p<0.05$) in moisture, pH, free fatty acid, peroxide value, DPPH free radical scavenging activity, thiobarbituric acid reactive substances, total phenolic, and total plate count (TPC) between treatments and storage periods. In conclusion, chicken breast marinated with 7.5% microencapsulation of turmeric extract was considered to have better physico-chemical, antioxidant potential, microbiological, and sensorial properties.

1. Introduction

Chicken meat is considered for its nutritional value, as it contains high-quality digestible protein and low saturated lipids. The nutritional content of chicken meat when stored for more than two days will be easily decreased. The major threat to the quality of chicken meat has been recognized as lipid oxidation (Min *et al.,* 2008). Lipid oxidation affects the changes of aroma, colour, texture, taste, and it is responsible for reducing shelf life, which are important reasons for consumer rejection (Lima *et al.,* 2013).

The storage intervals of chicken meat are a major effect on the population of bacterial contaminants (Vihavainen *et al.,* 2007). Bacterial activity causes a decrease in chicken meat quality. The contamination of bacterial can be reduced by adding various chemical treatments. One of the methods is marination. Marination can be applied by adding the natural ingredients by soaking the marinade in food, the main purpose is to increase the shelf life (Yusop *et al.,* 2010). In all cases, marinades are associated with food preservation. Turmeric is extensively used as a preservative in food (Shahidi and Ambigaipala, 2015). Curcumin is the polyphenolic compound of turmeric and it has biological activities such as antioxidant and antibacterial activities (Gupta and Sadhana, 2005).

The quality preservation of turmeric can be applied by using microencapsulation techniques. Microencapsulation is one of the new valuable properties to improve the solubility and bioavailability of polyphenol substances in turmeric. The microencapsulation technique needs a carbohydrate matrix, and it is used for microencapsulation stability such as protecting from oxidation (Galmarini *et al.,* 2009). Freeze-drying is a process in which water is sublimed from the microencapsulation of turmeric extract after it is frozen. In the freeze-drying process, frozen material will easily evaporate without going through the liquid (Gatin *et al.,* 2008).

The basic aim of the research was to determine the quality of chicken breast marinated with microencapsulation of turmeric. Some physico-chemical, microbiological, and antioxidant parameters at different storage periods, along with the sensory attributes, were then determined.

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2. Materials and methods

2.1 Raw materials

To determine the nutritional content in the turmeric extract, 95% concentration of ethanol, 35°C extraction temperature, and 8 h time of extraction were used. A total of 10 g of turmeric were dissolved in 100 mL ethanol with a 95% concentration and extracted in a rotary evaporator (Buchi B-490). The microencapsulation process of turmeric extract used the freeze-drying method. Maltodextrin was dissolved with turmeric extract to a concentration of 10%. The mixture of turmeric extract and maltodextrin was poured into a 600 mL flask and freeze-dried using a freeze dryer (Labfreez FD-18-MTP) with a condenser temperature of -55°C, and the pressure of 235 μmHg. The drying process was held for 35 hours at room temperature. Samples resulting from the drying process were then ground and categorized as samples of turmeric microcapsule with maltodextrin as a coating material.

Live birds (Ross® 308 Broiler) were obtained from a poultry farm and were brought to Penggaron Poultry Slaughterhouse, Semarang. All materials that made contact with the surface of breast meat were sanitized each time before marinating. The chicken breast meat was marinated with microencapsulated turmeric extract by kneading for uniform distribution. The percentage of the marinate was measured by the weight of the chicken breast. The treatments given include control (T0), microencapsulated turmeric extract was added at 2.5% (T1), microencapsulated turmeric extract was added at 5% (T2), and microencapsulated turmeric extract was added at 7.5% (T3). Treated samples were packaged in silver LDPE aluminium foil packaging bags and used for analysis. The physico-chemical quality, antioxidant activity and bacterial contaminant analysis on chicken breast were determined on the 0, 3rd, 6th, 9th, and 12th day of storage.

2.2 The value of moisture

The value of moisture was evaluated from AOAC, (2005). Briefly, 10 g of treated samples were dried for 12 hrs in an oven drying (Memmert UN30) at 110°C and cooled in a desiccator to take final weights.

2.3 pH value

Determination of the pH value was using Eutech pH 700 pH meter. Aquadest was used as a sample solvent in the ratio of 5: 1. Then, the electrode on the pH meter was dipped into the sample solution and the pH value of the sample was recorded.

2.4 Total plate count

The TPC was evaluated according to the method described by Vihavainen *et al.* (2007). A total of 25 g of the treated sample was placed in an Erlenmeyer flask, then homogenized for 2 mins by using a sterile pestle to uniform the distribution of 10^{-1} dilution. This method was continued until 10^{-8} dilution was obtained. One millilitre of mixture solutions was inoculated and incubated for 24 hrs and the temperature was 38°C. The colony was counted as TPC.

2.5 Peroxide value

Peroxide value was measured from the method of Calvo *et al.* (2017) with slight modifications. Briefly, the mixture of 5 g treated sample, acetic acid–chloroform (40 mL) solution (3:2 v/v) and 0.5 mL of potassium iodide solution was mixed, then the mixture was shaken and added by thirty millilitres of aquadest and starch solution. Then, the sample was titrated in $Na_2S_2O_3$ (0.01 N) solution. The equation of peroxide value: PV(meq/kg) = [(sample-blank) x N of $Na_2S_2O_3$ x 1000) / W]

2.6 The value of thiobarbituric acid reactive substances

The TBARS was evaluated from the study of Yang *et al.* (2014). A total of 10 g of the treated sample and aquadest were homogenized. The mixture was added by TBA, trichloroacetic acid, and $C_{11}H_{16}O_2$ to the container. Then, the test tube was heated in warm water for 20 mins with Memmert WNB-10 and added in a Centrifuge (Eppendorf 5804 R) at 2500 rpm for 15 mins and counted by 10S UV-VIS spectrophotometer (532 nm).

2.7 The value of free fatty acids

The FFA were measured from the reference by Calvo *et al.* (2017) with slight modifications. A total of 20 g of treated samples and 200 mL of petroleum ether were homogenized. The mixture then was filtered and the filtrate was collected. The 20 mL filtrate was taken to measure the residual fat. Another part of the 20 mL filtrate was added to 10 mL of C_2H_5OH and added by two drops of phenolphthalein indicator (1%). Then, it was titrated with NaOH. The value of FFA was calculated from the following equation:

FFA (% oleic acid) = [(N × mL NaOH × 0.282)/(Fat weight) × 100]

2.8 The value of DPPH

The DPPH of the treated sample was evaluated by using Álvarez-Casas *et al.* (2014) as a reference with slight modifications. A total of 5 g of the treated sample and the fifteen millilitres of distilled water were homogenized. Briefly, the mixture of 200 μL treated

samples were placed in a dark room for about 15 mins. Then the absorbance samples were measured using a UV-VIS 10S spectrophotometer (517 nanometers).

DPPH (%) = [1 – (abs solution / abs control) × 100]

2.9 Total phenolic

Total phenolic in the treated sample was estimated using the reference by Çam and Hışıl, (2010). The mixture of one millilitre diluted treated sample (2:8 v/v), one millilitre of Na_2CO_3 (10%), Folin–Ciocalteu reagent (500 µL) was vortexed. The absorbance of the mixture was determined using a UV-VIS 10S spectrophotometer (700 nanometers).

2.10 Sensory analysis

The chicken breast marinated with different levels of microencapsulated turmeric extract was subjected to descriptive sensory analysis. The assessment in quality of sensory in the treated sample was determined with an 8-point descriptive scale, where 1 = undesirable and 8 = desirable (Devi and Singh, 2018). In total, thirty semi-trained panelists selected were given trial sessions for the product and their sensory attributes before final sensory analysis. The panellists were asked to score the product based on appearance, colour, aroma, texture, and overall acceptability.

2.11 Statistical analysis

Analysis of the data obtained was using SPSS 16.0. The ANOVA of a two-factorial factor was used to evaluate the significance level ($p<0.05$). The DMRT was used to compare the value of means. All parameters used three replications except in sensory, in which there were 30 semi-trained panellists.

3. Results and discussion

3.1 pH value

Turmeric has an ascorbic acid content and it is significant ($p<0.05$) on the value of pH. The data are shown in Table 1. According to Maurya *et al.* (2010), roast beef was treated with the addition of turmeric caused a decrease in the pH value. The increase of pH is related to the release of bound water to be free water and promote the growth of microorganisms. The storage periods were significant ($p<0.05$) to increase the pH. This may be due to the increasing level of the bacterial population in chicken breast. According to Sharma *et al.* (2017), the higher value of pH indicates an increase in the population of microorganisms in meat.

3.2 Moisture content

The results were significant ($p<0.05$) to treated

Table 1. Effect of microencapsulation of turmeric extract on pH, moisture, and TPC of chicken breast at different storage periods (0, 3rd, 6th, 9th, and 12th days)

Treatment	Storage period (day)					
	0	3	6	9	12	Treatment mean
pH						
T0	5.90 ± 0.04^{hij}	5.94 ± 0.02^{fg}	6.06 ± 0.01^{bc}	6.13 ± 0.02^{a}	6.16 ± 0.01^{a}	6.04 ± 0.11^{W}
T1	5.86 ± 0.01^{jk}	5.93 ± 0.02^{fghi}	5.95 ± 0.02^{f}	6.00 ± 0.03^{de}	6.07 ± 0.02^{b}	5.96 ± 0.07^{X}
T2	5.84 ± 0.02^{kl}	5.91 ± 0.04^{ghi}	5.92 ± 0.02^{fghi}	5.96 ± 0.02^{ef}	6.04 ± 0.02^{bc}	5.93 ± 0.07^{Y}
T3	5.80 ± 0.01^{l}	5.86 ± 0.01^{jk}	5.89 ± 0.01^{ij}	5.94 ± 0.03^{fgh}	6.03 ± 0.02^{cd}	5.90 ± 0.08^{Z}
Storage mean	5.85 ± 0.04^{E}	5.91 ± 0.04^{D}	5.96 ± 0.07^{C}	6.01 ± 0.08^{B}	6.08 ± 0.06^{A}	-
Moisture (%)						
T0	76.01 ± 0.03^{bcd}	75.87 ± 0.07^{cde}	75.17 ± 0.12^{g}	74.70 ± 0.13^{hi}	73.64 ± 0.50^{j}	75.07 ± 0.91^{Z}
T1	76.11 ± 0.20^{abc}	75.95 ± 0.07^{bcd}	75.58 ± 0.24^{ef}	75.08 ± 0.11^{gh}	74.32 ± 0.31^{i}	75.41 ± 0.69^{Y}
T2	76.28 ± 0.04^{abc}	76.13 ± 0.02^{abc}	75.85 ± 0.49^{cd}	75.33 ± 0.19^{fg}	74.73 ± 0.27^{h}	75.66 ± 0.63^{X}
T3	76.53 ± 0.21^{a}	76.32 ± 0.11^{ab}	76.13 ± 0.08^{ab}	76.07 ± 0.09^{bcd}	75.68 ± 0.40^{def}	76.15 ± 0.35^{W}
Storage mean	76.23 ± 0.24^{A}	76.07 ± 0.19^{A}	75.68 ± 0.44^{B}	75.30 ± 0.53^{C}	74.59 ± 0.84^{D}	-
TPC (log CFU/g)						
T0	4.20 ± 0.06^{i}	5.12 ± 0.07^{g}	6.18 ± 0.08^{cd}	6.90 ± 0.03^{ab}	7.03 ± 0.02^{a}	5.89 ± 1.12^{W}
T1	4.18 ± 0.02^{i}	5.12 ± 0.46^{g}	5.90 ± 0.01^{e}	6.74 ± 0.05^{b}	7.03 ± 0.05^{a}	5.80 ± 1.09^{X}
T2	4.11 ± 0.04^{i}	4.99 ± 0.04^{gh}	5.64 ± 0.07^{f}	6.16 ± 0.05^{cd}	6.27 ± 0.05^{c}	5.44 ± 0.83^{Y}
T3	4.07 ± 0.02^{i}	4.83 ± 0.13^{h}	5.04 ± 0.05^{g}	5.65 ± 0.41^{f}	6.05 ± 0.12^{de}	5.13 ± 0.73^{Z}
Storage mean	4.14 ± 0.06^{E}	5.02 ± 0.14^{D}	5.69 ± 0.44^{C}	6.37 ± 0.55^{B}	6.59 ± 0.46^{A}	-

Values are presented as mean±SD. Values with different superscript within the row are significantly different.
^{ABCD} Overall storage means between columns and ^{WXYZ} Overall means between rows without common letter are significantly different at $p<0.05$.

samples and storage period (Table 1). The higher value of moisture content in the treated sample was found in T3 and the lower value was found in T1. This may be due to the maltodextrin as a carbohydrate matrix was able to bind the water in the meat. According to Das *et al.* (2017), maltodextrin has the ability to increase the physical quality by binding the water content of the product. Treated samples were significantly lower because of the evaporation and drip loss in meat. Bound water can easily evaporate and be utilized for microbial growth (Chaillou *et al.,* 2015).

3.3 Bacterial contaminant

The higher treatment means of TPC was found in T0 (5.89±1.12) followed by T1 (5.80±1.09), T2 (5.44±0.83), and the minimum value was T3 (5.13±0.73) in treated samples. Turmeric contains curcumin as an antioxidant compound and it has other benefits as an antibacterial compound. Curcumin also has the function to suppress the bacterial population. According to Gul and Bakht, (2013), turmeric extract is effective in suppressing the growth of bacterial contaminants due to the influence of curcuminoid as a part of phenolic compounds. Storage intervals have a significant difference ($p<0.05$) in increasing TPC. This could be due to the increased level of bacterial contamination on chicken breasts. The storage periods and temperature can be the main factor for some bacterial populations (Chaillou *et al.,* 2015). The antimicrobial in turmeric can be the active compounds including essential oils, curcumin, curcuminoids, turmerol, and pentanoic acid.

3.4 Peroxide value

The T3 (0.37±0.42) had significantly lower PV than T2 (0.39±0.44), T1 (0.41±0.47), and T0 (0.44±0.60) samples. This could be due to the effect of curcumin which is able to inhibit lipid oxidation, curcumin is a secondary metabolite compound, and it chemically belongs to the phenolic group. The mechanism of antioxidant activity as a chain-breaking antioxidant to reduce free radicals by transferring H atoms, reducing reactive oxygen, reducing free radicals at the initiation stage and binding the transition metal catalysts (Fe^{2+} and Cu^{2+}) (Sharma *et al.,* 2017).

3.5 TBARS value

Based on Table 2, the TBARS value of chicken breast has significant effects ($p<0.05$) related to treatments and storage interval. The lowest TBARS value (0.30±0.04) was observed in (T3) treated samples on the 0 days of storage. Conversely, the highest TBARS value (0.62±0.07) was found in control (T0) on the 12th day of storage. The decrease in TBARS can be the effect of phenolic. Curcumin as a phenolic compound is a potential inhibitor to prevent lipid oxidation in chicken meat. According to Maurya *et al.* (2010) turmeric has a significant effect to reduce oxidative rancidity in processed beef products. The increase in TBARS value was perhaps due to the oxidation of lipid and volatile metabolite products. One of the lipid oxidation products is malonaldehyde (Nayak and Tanwar, 2005). A higher TBARS value indicates the increase of aldehyde compounds formed. According to Abdel-Hamied *et al*. (2009), aldehyde would be expected to cause undesirable rancid flavours, produced by lipid oxidation during storage.

3.6 Free fatty acid

The results regarding the FFA of chicken breast samples have significant effects ($p<0.05$) as listed in Table 2. Interaction between storage period and treatment was also found to be significant. Antioxidant compounds in turmeric were effective in reducing FFA value. Microencapsulation of turmeric extract indicated a positive effect in reducing FFA. According to Yetim *et al.* (2006), lipolysis by the action of lipolytic enzymes was obtained from decaying microorganisms during the storage of meat and it causes FFA formation. The FFA determination is the basic concept to control rancidity and turmeric powder effective to reduce FFA value on stored chicken mince.

3.7 The value of DPPH

Based on Table 2, The DPPH value of treated samples has a significant effect ($p<0.05$) related to treatments and storage interval. The T3 (60.04±2.03) had a significantly higher ($p<0.05$) mean than T2 (54.15±1.92), T1 (51.54±1.61), and T0 (44.51±2.88) treated samples. The higher value of DPPH radical scavenging activity could be the influence of curcumin. According to Chattopadhyay *et al.* (2004), curcumin is a strong antioxidant in turmeric. The storage intervals at refrigeration temperature (4±1°C) have a significant difference ($p<0.05$) to decrease DPPH free radical activity value. This could be due to the increased level of free radical accumulation in chicken breast.

3.8 Total phenolic content

Based on Table 2, the phenolic value of the treated sample showed a significant effect ($p<0.05$). Interaction between storage period and treatment was also significant. The highest treatment means of total phenolic was found in T3 (50.23±2.95), followed by the T2 (46.27±2.71), T1 (43.88±2.18), and T0 (39.69±2.30) treated samples. The increase in total phenolic content may be due to the effect of curcumin as a natural antioxidant compound. According to Naveena *et al.* (2008), the antioxidant can be used to prevent the auto-

Table 2. Effect of microencapsulation of turmeric extract on PV, TBARS, FFA, DPPH, and phenolic of chicken breast at different storage periods (0, 3rd, 6th, 9th, and 12th days)

Treatment	Storage period (day)					
	0	3	6	9	12	Treatment mean
PV (meq/kg)						
T0	0.37±0.05^{h}	0.39±0.05^{fg}	0.44±0.05^{c}	0.48±0.02^{b}	0.53±0.01^{a}	0.44±0.60^{W}
T1	0.35±0.03^{i}	0.38±0.03^{gh}	0.41±0.04^{e}	0.44±0.08^{c}	0.48±0.06^{b}	0.41±0.47^{X}
T2	0.33±0.03^{j}	0.35±0.08^{i}	0.39±0.81^{f}	0.43±0.09^{d}	0.45±0.03^{c}	0.39±0.44^{Y}
T3	0.32±0.06^{k}	0.34±0.07^{j}	0.37±0.09^{h}	0.41±0.04^{e}	0.42±0.06^{d}	0.37±0.42^{Z}
Storage mean	0.34±0.23^{E}	0.36±0.21^{D}	0.40±0.25^{C}	0.44±0.28^{B}	0.47±0.43^{A}	-
TBARS (mg malonaldehyde/kg)						
T0	0.32±0.01^{h}	0.38±0.04^{f}	0.42±0.06^{e}	0.50±0.07^{c}	0.62±0.07^{a}	0.45±1.09^{W}
T1	0.31±0.04^{hi}	0.37±0.08^{fg}	0.42±0.09^{e}	0.49±0.03^{c}	0.62±0.04^{a}	0.44±1.11^{X}
T2	0.31±0.10^{hi}	0.37±0.05^{fg}	0.41±0.02^{e}	0.49±0.07^{c}	0.61±0.16^{ab}	0.44±1.09^{X}
T3	0.30±0.04^{i}	0.36±0.07^{g}	0.40±0.04^{e}	0.48±0.06^{d}	0.61±0.07^{b}	0.43±1.08^{Y}
Storage mean	0.31±0.08^{E}	0.37±0.07^{D}	0.41±0.07^{C}	0.49±0.09^{B}	0.62±0.11^{A}	-
FFA (% oleic acid)						
T0	0.27±0.01^{gh}	0.28±0.02^{g}	0.33±0.06^{e}	0.37±0.06^{c}	0.42±0.02^{a}	0.33±0.58^{W}
T1	0.25±0.06^{i}	0.26±0.07^{h}	0.30±0.06^{f}	0.34±0.06^{d}	0.38±0.07^{b}	0.31±0.50^{X}
T2	0.22±0.08^{j}	0.25±0.04^{i}	0.28±0.08^{g}	0.32±0.07^{e}	0.34±0.05^{d}	0.28±0.44^{Y}
T3	0.21±0.01^{k}	0.23±0.05^{j}	0.26±0.06^{h}	0.30±0.02^{f}	0.32±0.03^{e}	0.26±0.43^{Z}
Storage mean	0.24±0.24^{E}	0.25±0.21^{D}	0.29±0.25^{C}	0.33±0.26^{B}	0.36±0.41^{A}	-
DPPH (%)						
T0	48.61±0.72^{g}	45.69±0.54^{h}	43.85±0.58^{i}	43.78±1.97^{i}	40.65±1.37^{j}	44.51±2.88^{Z}
T1	53.81±0.46^{de}	52.70±0.49^{e}	50.29±0.88^{f}	50.74±0.72^{f}	50.14±0.56^{f}	51.54±1.61^{Y}
T2	57.20±0.74^{c}	54.91±0.69^{d}	53.28±0.99^{e}	52.85±0.71^{e}	52.52±0.96^{e}	54.15±1.92^{X}
T3	62.34±0.82^{a}	61.28±0.79^{ab}	60.77±0.40^{b}	58.54±0.54^{c}	57.25±1.01^{c}	60.04±2.03^{W}
Storage mean	55.49±5.26^{A}	53.65±5.84^{B}	52.05±6.38^{C}	51.48±5.60^{C}	50.14±6.38^{D}	-
Phenolic (mg GAE/g meat)						
T0	42.47±1.09^{hi}	41.38±0.96^{i}	40.07±0.65^{j}	37.71±0.47^{k}	36.82±0.38^{k}	39.69±2.30^{Z}
T1	46.78±0.43^{de}	45.48±0.71^{f}	43.71±0.62^{g}	42.16±0.50^{i}	41.27±0.79^{i}	43.88±2.18^{Y}
T2	50.34±0.75^{c}	47.55±0.77^{d}	46.28±0.37^{ef}	43.58±0.76^{gh}	43.62±0.93^{gh}	46.27±2.71^{X}
T3	54.41±0.63^{a}	52.11±0.95^{b}	50.14±0.39^{c}	47.83±0.44^{d}	46.86±0.45^{de}	50.23±2.95^{W}
Storage mean	48.50±4.65^{A}	46.63±4.10^{B}	45.05±3.87^{C}	42.82±3.80^{D}	42.10±3.80^{E}	-

Values are presented as mean±SD. Values with different superscript within the row are significantly different.
^{ABCD}Overall means between columns and ^{WXYZ} Overall means between rows without common letter are different at $p<0.05$.

oxidation reaction at the initiation and propagation phases. Storage intervals have a significant difference ($p<0.05$) in decreasing total phenolic content. This could be due to the increased level of free radical accumulation on chicken breast. Phenolic is natural antioxidant compounds that are well-known as a free radical scavenger, and in general, the content of phenolic is positively correlated to antiradical activity (Sharma *et al.,* 2017). Polyphenols have the potential effect to reduce lipid oxidation and are related to antioxidant activity (Huang *et al.,* 2005).

3.9 Sensory evaluation

Sensory evaluation of chicken breast marinated with microencapsulation of turmeric extract based on the value of bacterial growth is in line with the standard for quality of chicken carcasses and meat by SNI (2009). The assessments made by the semi-trained panellists were concerned mainly with attributes of overall acceptability, texture, odour, taste, and appearance of the samples. Based on Table 3, it can be seen that (T0, T1, T2, T3) treated samples on 0 days of storage were significantly different ($p<0.05$) on sensory attributes. The sensory attributes on the 3rd, 6th, 9th, and 12th days of storage showed a decreased level when compared with day 0. When the storage intervals increased, scores of sensory decreased considerably in all sensory attributes, but the whole sensory score was within the acceptable range. According to Galmarini *et al.* (2009), lipid

Table 3. Effect of microencapsulation of turmeric extract on sensory of chicken breast stored at different storage periods (0, 3rd, 6th, 9th, and 12th days)

Treatment	Storage period (day)				
	0	3	6	9	12
Odor					
T0	5.93±0.25^{b}	5.56±0.67^{b}	5.36±0.72^{b}	5.07±0.87^{b}	4.70±0.79^{c}
T1	6.07±0.37^{b}	5.87±0.82^{ab}	5.73±0.78^{ab}	5.33±1.03^{ab}	4.96±0.88^{bc}
T2	6.10±0.40^{b}	5.93±0.58^{ab}	5.77±0.57^{a}	5.50±0.63^{ab}	5.27±0.58^{ab}
T3	6.33±0.55^{a}	6.07±0.69^{a}	5.80±0.81^{a}	5.60±0.62^{a}	5.40±0.62^{a}
Appearance					
T0	6.20±0.41^{ab}	6.07±0.58^{ab}	5.80±0.66^{b}	5.77±0.72^{ab}	5.50±0.86^{b}
T1	6.43±0.50^{a}	6.26±0.75^{a}	6.20±0.71^{a}	6.13±0.73^{a}	5.93±0.74^{a}
T2	6.10±0.48^{bc}	5.90±0.66^{bc}	5.83±0.65^{b}	5.80±0.71^{ab}	5.66±0.71^{ab}
T3	5.90±0.48^{c}	5.83±0.59^{c}	5.70±0.60^{b}	5.60±0.77^{b}	5.43±0.73^{b}
Texture					
T0	5.90±0.40^{a}	5.56±0.67^{ab}	5.13±0.86^{b}	4.76±0.63^{c}	4.63±0.55^{c}
T1	5.67±0.55^{b}	5.50±0.68^{ab}	5.37±0.72^{ab}	5.27±0.74^{b}	5.07±0.73^{b}
T2	5.83±0.46^{ab}	5.66±0.54^{a}	5.56±0.50^{a}	5.50±0.57^{ab}	5.27±0.64^{ab}
T3	5.80±0.55^{ab}	5.76±0.56^{a}	5.73±0.64^{a}	5.70±0.65^{a}	5.56±0.63^{a}
Taste					
K0	6.10±0.61^{a}	5.86±0.72^{ab}	5.37±0.89^{b}	5.03±0.76^{b}	4.73±0.74^{c}
K1	6.07±0.52^{ab}	5.90±0.73^{a}	5.80±0.55^{a}	5.73±0.78^{a}	5.43±0.63^{a}
K2	5.83±0.59^{ab}	5.63±0.71^{ab}	5.56±0.73^{ab}	5.42±0.67^{a}	5.17±0.59^{ab}
K3	5.77±0.43^{b}	5.60±0.77^{b}	5.53±0.57^{ab}	5.37±0.66^{ab}	5.03±0.72^{bc}
Overall acceptability					
T0	6.03±0.67^{a}	5.56±0.97^{ab}	5.16±0.87^{b}	5.03±0.72^{b}	4.83±0.59^{b}
T1	5.97±0.61^{a}	5.80±0.66^{a}	5.77±0.62^{a}	5.67±0.60^{a}	5.46±0.73^{a}
T2	5.83±0.46^{ab}	5.76±0.50^{a}	5.70±0.53^{a}	5.63±0.72^{a}	5.50±0.78^{a}
T3	5.60±0.62^{b}	5.60±0.62^{ab}	5.57±0.57^{a}	5.56±0.86^{a}	5.53±0.82^{a}

Values are presented as mean±SD. Values with different superscript within the row are significantly different.

oxidation leads to rancidity, and it is responsible for unacceptable taste and decreasing the shelf life, which is an important reason for consumer rejection. Based on the sensory result, lipid oxidation in the chicken breast can be controlled by using antioxidants. Microencapsulated turmeric extract improved the quality of chicken breast by increasing the meat flavour.

4. Conclusion

The different levels of microencapsulated turmeric extract significantly improved the quality of chicken breast during storage under refrigeration temperature (4±1°C). Chicken breast marinated with 7.5% microencapsulation of turmeric extract can be applied only up to a shelf life of 9 days in refrigeration temperatures (4±1°C), because it is able to inhibit bacterial growth <10^6 CFU/g (according to SNI 3924, 2009).

Conflict of interest

The authors declare no conflict of interest.

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