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Monitoring of Changes in the Quality Characteristics of Cooked Chicken Döner Kebabs Formulated from Mechanically Deboned Chicken Meat Subject to Refrigerated Storage

Ayşe Öney[1,*], Mustafa Karakaya[1], Ali Samet Babaoğlu[1]

[1] Selçuk University, Faculty of Agriculture, Department of Food Engineering, Konya, Türkiye

HIGHLIGHTS

- The use of MDCM increased the pH values of the chicken döner kebabs.
- MDCM had no negative effect on the TBARS values of the samples.
- The redness values increased with increasing MDCM addition.
- MDCM increased the flavour scores of the sample on day 0.

Abstract

This study aimed to evaluate the effects of mechanically deboned chicken meat (MDCM) on the physicochemical and sensory properties of chicken döner kebab during 28 days of storage. Five different groups of chicken döner kebab were produced: C1: Control 1 including chicken breast meat, C2: Control 2 including ground chicken breast + transglutaminase, M1: 95% ground chicken breast + 5% MDCM + transglutaminase, M2: 90% ground chicken breast + 10% MDCM + transglutaminase and M3: 85% ground chicken breast + 15% MDCM + transglutaminase. The addition of MDCM to chicken döner kebab samples increased the pH value of the samples ($P < 0.05$). The TBARS values of the chicken döner kebabs increased during the storage period, especially on the 21st and 28th day. Groups M1, M2 and M3 had lower lightness (L^*) and higher redness (a^*) values than the control groups ($P < 0.05$). The addition of MDCM had no negative influence on the sensory parameters of the samples ($P > 0.05$).

Keywords: Colour; Lipid oxidation; MDCM; Poultry product

1. Introduction

Döner kebab, often referred to as "gyros," "donair," "kebab," "chawarma," and "shawirma," is a traditional meat product from Turkey and the Middle East that is eaten throughout the world. The döner kebab has gained popularity in the fast food industry in recent years and has taken on a role in the human diet due to its nutrient density and taste (Barthaloma et al. 1997; Kayışoğlu et al. 2003; Kılıç 2003). Döner kebab is prepared in three ways: as a leaf, minced meat or mixed (leaf-minced meat), depending on how it is offered in the market (TGK 2018). Lamb, beef or poultry can be used for döner kebab production. To prepare döner kebab, the meat is marinated with a marinade sauce containing salt, spices, onions, tomatoes and yoghurt. A certain amount

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*Correspondence: oney.ayse@hotmail.com

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of beef or sheep tallow is also added to the marinated meat and prepared into a cone shape. Then the mass is cooled so that the meat and fat particles stick together. After cooling, the raw döner kebab is placed on a vertical skewer and slowly rotated to cook evenly using gas, charcoal or an electric heating equipment. The cooked döner kebab is cut into thin slices and served (Ergönül and Kundakcı 2007; Kayışoğlu et al. 2002; Moeller et al. 1994). Recently, chicken döner kebab has become very popular. This is because poultry meat is easy to digest, contains less fat and cholesterol and is more affordable (Kılıç et al. 2001). It is also an important source of protein, as it is of animal origin and contains many nutrients necessary for the human body, such as essential amino acids, fatty acids and large quantities of minerals (Kaya et al. 2018).

Mechanically deboned meat (MDM) is obtained by the decomposition of the meat remaining on the bones after the meat of the carcass has been removed by mechanical means such as pressure and grinding, and is referred to as mechanically deboned poultry meat (MDPM) or mechanically deboned chicken meat (MDCM) depending on the species from which it is derived (Navarro-Rodriguez et al. 2010; Püssa et al. 2009; Serdaroğlu et al. 2005).

MDPM is often used in the formulation of meat products due to its smooth consistency, good nutritional and functional characteristics, and low cost. The use of MDPM in nuggets, sausages, fermented sausages and restructured chicken products has been well documented (Perlo et al. 2006; Serdaroğlu et al. 2005; Hassan and Fan 2005). This valuable by-product of poultry meat processing is commonly used in restructured meat products such as frankfurters, fermented sausages and restructured chicken products as a substitute for the meat raw material because of its smooth texture, good nutritional and functional properties and low cost. In contrast to these benefits, MDCM has a negative impact on sensory properties (e.g. unpleasant taste and odour in the final product (Mielnik et al. 2002), which has undesirable textural properties and is susceptible to lipid oxidation (Jin et al. 2014).

Song et al. (2014) reported on the effects on quality characteristics of semi-dry dehydrated chicken meat that the use of mechanically deboned chicken meat (MDCM) and collagen can be useful components to reduce production costs and improve processing efficiency. Pereira et al. (2011) found that the added MDPM content affects the proximate composition and textural properties (cohesion and stickiness) of Frankfurter-type sausages, negatively affecting the cooking performance and colour of the final product.

Although there are studies on the use of MDCM in chicken products such as sausages and nuggets (Perlo et al. 2006; Jin et al. 2015; Mohamed et al. 2016; Pindi et al. 2017), there are no studies on the use of MDCM in chicken döner kebab. As far as we know, this was the first study to investigate the use of MDCM in the production of chicken döner kebab. Therefore, the aim of this study was to evaluate the effects of MDCM on lipid oxidation, colour properties and sensory characteristics of cooked chicken döner kebabs during refrigerated storage over 28 days.

2. Materials and Methods

2.1. Materials

The chicken breast used for the study was obtained from a poultry plant (Şen Piliç, Adana, Türkiye). Mechanically deboned chicken meat was supplied by Gedik Piliç in Uşak, Türkiye. The animal fats used in the production of chicken döner kebab were provided by a local butcher in Konya, Türkiye. The transglutaminase (Benosen Food, Tegen 220 DM, China) and the salt (Salina, Ankara, Türkiye) were purchased from a company.

2.2. Production of chicken döner kebab döner samples

The chicken döner kebab production was carried out at the Selçuk University Food Engineering Department. As outlined in Table 1, five groups of chicken döner kebabs were prepared as follows: C1

(produced with chicken breast fillets and no added MDCM, transglutaminase), C2 (produced with ground chicken breast and no added MDCM), M1 (produced with 5% MDCM + 95% ground chicken breast + transglutaminase), M2 (produced with 10% MDCM + 90% ground chicken breast + transglutaminase) and M3 (produced with 15% MDCM + 85% ground chicken breast + transglutaminase). In the formulation of the chicken döner kebab samples, the ground chicken breast was partially replaced by MDCM in groups M1, M2 and M3.

Table 1. Formulations of chicken döner kebab samples

Formulation (g)	Sample Groups				
	C1	**C2**	**M1**	**M2**	**M3**
Chicken breast meat	3500	-	-	-	-
Ground chicken meat	-	3500	3325	3150	2975
Mechanically deboned chicken meat	-	-	175	350	525
Animal fat	875	875	875	875	875
Salt	52.5	52.5	52.5	52.5	52.5
Transglutaminase enzyme	-	87.5	87.5	87.5	87.5

C1: Control 1 including chicken breast meat; C2: Control 2 including ground chicken breast + transglutaminase; M1: 95% ground chicken breast + 5% MDCM + transglutaminase; M2: 90% ground chicken breast + 10% MDCM + transglutaminase; M3: 85% ground chicken breast + 15% MDCM + transglutaminase.

In the production of C1, the chicken breasts were cut into leaf-shaped slices (chicken breast fillets) with a slicer (parallel to the direction of the fibres). The salt and animal fat were added and mixed. Then the chicken breast fillets were skewered on kebab döner skewers and these skewers were tightly wrapped with stretch film and stored at -20 °C for 24 hours.

In the production of C2, M1, M2 and M3, the chicken breasts were ground twice in a meat grinder. The ingredients in the formulation for these groups given in Table 1 were prepared by mixing them with minced chicken for 10 minutes and then placing them in a transparent cylindrical package around the döner skewers. Raw chicken döner kebab is stored at -20°C for 24 hours.

All groups of raw chicken döner kebab blocks were placed 10 cm apart in front of the open vertical gas kebab cooker (oven, burner). Each surface of the kebab block was cooked for 6 minutes. After 6 minutes, the cooked surfaces were cut with a thickness of 5 mm, the meat block was turned over and the cooking process of the other surfaces was continued. During the cooking process, the temperature of the heat source was controlled by the gas valve. This process was continued until the entire kebab block was cooked. The cooked kebab slices were cooled to 20°C at room temperature for about 30 minutes. Then 300 g of the chicken döner kebab samples were vacuum packed and stored at 4°C for 28 days.

pH, TBARS and colour properties of all samples were analysed on the 0th, 7th, 14th, 21st and 28th day during storage and sensory evaluation was performed on the 0th, 14th and 28th day.

2.3. pH determination

The pH values of the chicken döner kebab döner samples were measured with a pH meter (WTW series pH 720, Weilheim, Germany) according to AOAC (2000).

2.4. Determination of TBARS number

The method described by Gökalp et al (2012) was used to determine the lipid oxidation of the samples during the storage periods. The TBA number was expressed as milligrammes of malonaldehyde per kilogramme of the sample (mg MA /kg sample).

2.5. Colour measurement

The colour parameters of the samples were determined with a colourimeter (CR -400 Minolta, Osaka, Japan) with illuminant D65, observer angle of 2°, diffuse/O mode and aperture of 8 mm for illumination. The colour properties (L*: lightness, a*: redness, b*: yellowness) were determined on the inner surface of the chicken döner kebab samples.

2.6. Sensory evaluation

Sensory analyses of the chicken döner kebab samples were conducted by a group of 11 semi-trained panellists from the Department of Food Engineering at Selçuk University. The panellists evaluated the colour, taste, smell, texture and general assessment of the samples using a 9-point hedonic scale. The scale ranged from 1, disliked, to 9, liked very much. Samples were microwaved for 20 seconds and chicken döner kebab slices from each treatment were randomly selected, presented in bowls with random three-digit numbers and served to the panellists with water and bread to avoid a quality carryover effect between samples.

2.7. Statistical analysis

A completely randomised factorial design was used to compare the five treatments (C1, C2, M1, M2 and M3). For the statistical analysis of pH, TBARS, colour and sensory results, a one-way analysis of variance (ANOVA) was performed using the generalised linear mixed model. MINITAB for Windows Release 16.0 was used to estimate the results. Tukey multiple comparison tests were used to determine differences between means at a 5% significance level.

3. Results and Discussion

3.1. pH and TBARS number

The pH values and TBARS numbers of chicken döner kebab döner samples during storage are given in Table 2. When examining the pH values of the chicken döner kebab samples in relation to the storage, there was no significant change in the C1 group ($P > 0.05$), while in the C2, M1, M2, and M3 groups there was a decrease was observed as the storage period progressed. The lowest pH values were determined on day 28 in the C2, M1, M2 and M3 groups. This decrease in pH could be due to microbial growth (especially lactic acid bacteria) in kebabs during storage. Since no microbiological analyses were carried out in our study, it is difficult to draw a definitive conclusion in this regard. On the other hand, previous studies are showing that the pH of meat products decreases due to microbial growth during storage. Lactic acid bacteria (LAB) have been described as the predominant bacteria in vacuum-packed meat products (Sakala et al. 2002). In addition, Nowak and Krysiak (2005) reported that storage of frankfurters in cold storage led to an increase in LAB, so the pH value decreased during storage.

The use of MDCM for each storage period had significant effects on the pH values of the samples ($P < 0.05$). The addition of MDCM in each storage period increased the pH values of the samples compared to the C2 group, except for Day 21. ($P < 0.05$). The reason for this increase in the pH values of the samples containing MDCM could be attributed to the high pH value of MDCM.

Similarly, Perlo et al. (2006) indicated that mechanically deboned poultry meat (MDPM) significantly increased the final pH values of chicken nuggets. Mohamed and Mansour (2012) also reported higher pH values of beef patties with MDPM compared to the control. A similar increase in pH was also reported by Song et al. (2014), who evaluated the effect of collagen and MDCM on the production of semi-dried chicken jerky.

Table 2. pH and TBARS number of chicken döner kebab samples

Analyses	Storage period (Day)	Samples				
		C1	C2	M1	M2	M3
pH	Day 0	6.51 ± 0.00^{ABa}	6.44 ± 0.02^{Ca}	6.47 ± 0.00^{BCa}	6.50 ± 0.01^{ABa}	6.54 ± 0.02^{Aa}
	Day 7	6.48 ± 0.00^{ABa}	6.42 ± 0.00^{Ba}	6.45 ± 0.03^{ABab}	6.45 ± 0.01^{ABab}	6.50 ± 0.03^{Aab}
	Day 14	6.47 ± 0.00^{ABa}	6.42 ± 0.00^{Ca}	6.45 ± 0.00^{BCab}	6.46 ± 0.00^{ABab}	6.50 ± 0.02^{Aab}
	Day 21	6.44 ± 0.06^{Aa}	6.36 ± 0.03^{Aab}	6.42 ± 0.01^{Aab}	6.40 ± 0.00^{Abc}	6.45 ± 0.02^{Aab}
	Day 28	6.42 ± 0.00^{Aa}	6.28 ± 0.05^{Bb}	6.38 ± 0.03^{ABb}	6.35 ± 0.04^{ABc}	6.43 ± 0.02^{Ab}
TBARS number (mg MA / kg sample)	Day 0	0.32 ± 0.06^{Ab}	0.43 ± 0.11^{Aa}	0.41 ± 0.03^{Ab}	0.39 ± 0.06^{Ab}	0.33 ± 0.05^{Ab}
	Day 7	0.66 ± 0.01^{Aab}	0.50 ± 0.18^{Aa}	0.52 ± 0.08^{Aab}	0.53 ± 0.10^{Aab}	0.40 ± 0.04^{Ab}
	Day 14	0.77 ± 0.04^{Aa}	0.62 ± 0.04^{Ba}	0.66 ± 0.04^{ABab}	0.65 ± 0.01^{ABab}	0.44 ± 0.01^{Cb}
	Day 21	0.90 ± 0.04^{Aa}	0.57 ± 0.07^{ABa}	0.70 ± 0.16^{ABab}	0.71 ± 0.09^{ABa}	0.52 ± 0.04^{Bab}
	Day 28	0.80 ± 0.21^{Aa}	0.75 ± 0.08^{Aa}	0.83 ± 0.04^{Aa}	0.73 ± 0.03^{Aa}	0.69 ± 0.08^{Aa}

Within the same row, values with different uppercase superscript letters indicate significant differences ($p<0.05$) Within the same column, values with different lowercase superscript letters indicate significant differences ($p<0.05$). C1: Control 1 including chicken breast meat; C2: Control 2 including ground chicken breast + transglutaminase; M1: 95% ground chicken breast + 5% MDCM + transglutaminase; M2: 90% ground chicken breast + 10% MDCM + transglutaminase; M3: 85% ground chicken breast + 15% MDCM + transglutaminase.

As shown in Table 2, the TBARS numbers of the samples, except the C2 group, increased with increasing storage time. During the 28-day storage period, the change in TBARS levels in the C2 group was insignificant ($P > 0.05$). The lowest TBARS numbers for the C1, M1 and M2 groups were obtained on day 0 ($P < 0.05$). Although the TBARS values for the other storage periods gradually increased, this increase was not statistically significant ($P > 0.05$). In the M3 group, the lowest TBARS values were found on days 0, 7 and 14. When the TBARS numbers for the MDCM treatment were examined, the use of MDCM did not affect the TBARS numbers of samples on days 0, 7 and 28 ($P > 0.05$). However, on days 14 and 21, the lowest TBARS numbers were determined in the M3 group ($P < 0.05$). In summary, the use of MDCM in this study had no negative effect on the TBARS values of the samples. On the contrary, Mohamed and Mansour (2012) found that the TBARS values of beef patties formulated with MDPM (200 g/kg) were significantly higher than the TBARS values of beef patties formulated without MDPM. In contrast to our results, studies on mechanically separated meat have generally reported negative effects on the number of TBARS in the literature (Kılıç and Richards 2003; Pindi et al. 2017; Püssa et al. 2008).

3.2. Colour properties

Colour properties were measured to determine the effects of different levels of MDCM on the colour characteristics of chicken döner kebab samples. Table 3 indicates the L^*, a^* and b^* values of chicken döner samples during storage for 28 days. The storage period did not affect the L^* values of C1 and C2 ($P > 0.05$), while the L^* values of M1, M2 and M3 decreased with increasing storage period ($P < 0.05$). There is a negative correlation between lightness and TBARS values (Hernández-Hernández et al. 2009). In other words, as oxidation increased, lightness decreased (the samples became darker). This relationship was observed in groups M1, M2 and M3, which had the lowest L^* values. The a^* values of the samples, except the C2 and M2 group, increased with increasing storage time ($P < 0.05$). The storage period and the MDCM treatment for the individual storage periods did not affect the b^* values of the samples during the entire storage ($P > 0.05$).

When the L^* values of the samples were examined in terms of MDCM addition for each storage period, it was found that the L^* value decreased with increasing MDCM addition ($P < 0.05$). The highest L^* values for all storage periods were found in group C1 ($P < 0.05$), while the highest value was in group M3 ($P < 0.05$). The

reason for the increase in *L** values in our study could be that MDCM has been reported to have a higher content of haem pigments, resulting in a darker colouration (Perlo et al. 2006). Similarly, Song et al. (2014) reported that the addition of MDCM in amounts greater than 10% significantly reduced the *L** value of semi-dry chicken.

When the *a** values of the samples were examined about the MDCM addition for each storage period, the highest ($P < 0.05$) *a** value was determined in the M2 and M3 groups in all storage periods except on the 21st day. In other words, MDCM addition increased the redness values of samples. This situation could be explained by the fact that the characteristic colour of MDCM is generally reddish, which is due to the admixture of hemoglobin deposited from the bone marrow during the manufacturing process (Ockerman and Hansen 2000). Similarly, Pereira et al. (2011) reported that the *a** values increased by up to 50% with the addition of MDPM to the sausage formulation. Jin et al. (2015) also found that the redness of pork sausages containing MDCM hydrolysates increased significantly after 4 weeks of storage due to the addition of MDCM hydrolysates, ascorbate and sodium erythorbate.

Table 3. Colour characteristics of chicken döner kebab samples

Analyses	Storage period (Day)	Samples				
		C1	**C2**	**M1**	**M2**	**M3**
*L**	Day 0	75.24 ± 0.84^{Aa}	72.23 ± 0.86^{Ba}	71.26 ± 0.16^{Ba}	67.20 ± 0.01^{Cab}	65.75 ± 0.10^{Ca}
	Day 7	77.40 ± 1.05^{Aa}	72.54 ± 0.97^{Ba}	68.86 ± 0.04^{Cc}	68.25 ± 0.12^{Ca}	63.93 ± 0.09^{Dab}
	Day 14	77.81 ± 0.45^{Aa}	71.34 ± 0.35^{Ba}	69.84 ± 0.30^{Bbc}	65.57 ± 0.53^{Cb}	63.37 ± 1.27^{Cab}
	Day 21	77.17 ± 0.13^{Aa}	70.81 ± 0.45^{Ba}	70.24 ± 0.70^{Babc}	66.04 ± 0.60^{Cb}	61.21 ± 0.20^{Db}
	Day 28	75.65 ± 0.69^{Aa}	70.57 ± 0.38^{Ba}	70.54 ± 0.09^{Bab}	66.29 ± 0.85^{Cab}	63.61 ± 0.13^{Dab}
*a**	Day 0	1.46 ± 0.11^{Eab}	2.45 ± 0.03^{Da}	3.61 ± 0.01^{Cab}	4.82 ± 0.26^{Ba}	5.40 ± 0.13^{Abc}
	Day 7	1.08 ± 0.42^{Db}	2.84 ± 0.18^{Ca}	4.14 ± 0.23^{Bab}	4.41 ± 0.32^{ABa}	5.52 ± 0.22^{Aabc}
	Day 14	1.34 ± 0.21^{Cb}	3.51 ± 0.52^{Ba}	3.85 ± 0.45^{Bab}	4.62 ± 0.30^{ABa}	5.81 ± 0.13^{Aab}
	Day 21	1.15 ± 0.08^{Bb}	3.81 ± 0.76^{Aa}	3.34 ± 0.20^{Ab}	4.47 ± 0.30^{Aa}	4.92 ± 0.28^{Ac}
	Day 28	2.41 ± 0.23^{Ca}	3.53 ± 0.77^{BCa}	4.44 ± 0.22^{Ba}	4.79 ± 0.50^{ABa}	6.20 ± 0.14^{Aa}
*b**	Day 0	13.49 ± 0.95^{Aa}	10.44 ± 1.12^{Aa}	10.83 ± 1.34^{Aa}	10.59 ± 0.37^{Aa}	10.54 ± 1.06^{Aa}
	Day 7	11.90 ± 0.51^{Aa}	10.71 ± 0.40^{Aa}	12.44 ± 1.08^{Aa}	10.93 ± 0.13^{Aa}	11.95 ± 1.23^{Aa}
	Day 14	10.98 ± 0.27^{Aa}	11.55 ± 0.42^{Aa}	12.13 ± 0.40^{Aa}	11.47 ± 0.86^{Aa}	11.86 ± 0.16^{Aa}
	Day 21	13.00 ± 0.12^{Aa}	14.79 ± 1.28^{Aa}	11.61 ± 1.21^{Aa}	11.63 ± 1.30^{Aa}	12.48 ± 1.80^{Aa}
	Day 28	10.50 ± 1.48^{Aa}	13.20 ± 0.43^{Aa}	10.52 ± 0.15^{Aa}	12.29 ± 0.01^{Aa}	12.69 ± 0.81^{Aa}

Within the same row, values with different uppercase superscript letters indicate significant differences ($p<0.05$) Within the same column, values with different lowercase superscript letters indicate significant differences ($p<0.05$). C1: Control 1 including chicken breast meat; C2: Control 2 including ground chicken breast + transglutaminase; M1: 95% ground chicken breast + 5% MDCM + transglutaminase; M2: 90% ground chicken breast + 10% MDCM + transglutaminase; M3: 85% ground chicken breast + 15% MDCM + transglutaminase.

3.3. Sensory properties

The odour, colour, flavour, texture and general acceptance scores of chicken döner kebab samples on days 0, 14 and 28 are shown in Table 4. As storage progressed, the differences in the colour, odour and texture scores of the samples were insignificant ($P > 0.05$). For the flavour parameter, the effect of storage time was significant only in the C1 group and the lowest score was obtained on 28th day ($P < 0.05$). Among the general acceptancee, only the C2 group was affected by the storage period and the lowest score was obtained on days 14 and 28 ($P < 0.05$).

The use of MDCM for each storage period had no significant effects on the colour, odour and general acceptance scores of the samples ($P < 0.05$). In the flavour assessment, the differences between the scores of the groups on day 14 and 28 were insignificant ($P > 0.05$), while the use of MDCM on day 0 increased the flavour scores of the samples ($P < 0.05$). It is well known that MDCM leads to a deterioration of sensory properties such as colour, flavour and texture, which could be mainly due to the denaturation of proteins during mechanical separation and the entrapment of lipids and free haem groups from the bone. In contrast to our study, Song et al (2014) observed a significant decrease in satisfaction with colour, taste, tenderness and juiciness with increasing substitution rates of chicken breast with MDCM in semi-dried chicken jerkies. The reason for this discrepancy between our study and the literature could be differences in formulation and manufacturing methods.

Table 4. Sensory evaluation of chicken döner kebab samples

Sensory parameters	Storage period (Day)	Samples				
		C1	C2	M1	M2	M3
Colour	Day 0	7.02 ± 0.26^{Aa}	7.09 ± 0.12^{Aa}	8.25 ± 0.35^{Aa}	7.87 ± 0.66^{Aa}	8.14 ± 0.66^{Aa}
	Day 14	6.20 ± 1.13^{Aa}	5.25 ± 0.35^{Aa}	6.65 ± 1.20^{Aa}	7.14 ± 0.76^{Aa}	7.35 ± 1.63^{Aa}
	Day 28	6.04 ± 0.90^{Aa}	7.45 ± 0.07^{Aa}	7.55 ± 0.07^{Aa}	7.17 ± 0.23^{Aa}	7.49 ± 0.45^{Aa}
Odour	Day 0	7.85 ± 0.50^{Aa}	7.82 ± 0.02^{Aa}	8.84 ± 0.23^{Aa}	8.50 ± 0.71^{Aa}	8.65 ± 0.21^{Aa}
	Day 14	7.22 ± 0.87^{Aa}	6.49 ± 0.97^{Aa}	7.24 ± 0.62^{Aa}	7.05 ± 0.64^{Aa}	6.57 ± 2.50^{Aa}
	Day 28	6.20 ± 0.28^{Aa}	7.24 ± 0.80^{Aa}	7.82 ± 0.02^{Aa}	6.29 ± 0.16^{Aa}	7.29 ± 0.16^{Aa}
Texture	Day 0	7.57 ± 0.33^{Aa}	7.59 ± 0.59^{Aa}	7.85 ± 0.50^{Aa}	7.50 ± 0.00^{Aa}	7.50 ± 0.00^{Aa}
	Day 14	7.50 ± 0.00^{Aa}	7.50 ± 0.00^{Aa}	7.50 ± 0.00^{Aa}	7.50 ± 0.00^{Aa}	7.50 ± 0.00^{Aa}
	Day 28	7.50 ± 0.00^{Aa}	7.50 ± 0.00^{Aa}	7.50 ± 0.00^{Aa}	7.50 ± 0.00^{Aa}	7.50 ± 0.00^{Aa}
Flavour	Day 0	7.20 ± 0.28^{Ba}	8.17 ± 0.23^{ABa}	8.54 ± 0.19^{Aa}	8.10 ± 0.14^{ABa}	8.30 ± 0.42^{Aa}
	Day 14	8.10 ± 0.14^{Aa}	6.34 ± 0.94^{Aa}	7.39 ± 0.30^{Aa}	7.62 ± 1.11^{Aa}	7.39 ± 1.11^{Aa}
	Day 28	6.07 ± 0.37^{Ab}	7.45 ± 0.07^{Aa}	8.02 ± 0.26^{Aa}	7.52 ± 0.45^{Aa}	7.62 ± 1.11^{Aa}
General Acceptance	Day 0	7.39 ± 0.30^{Aa}	7.70 ± 0.42^{Aa}	8.15 ± 0.50^{Aa}	8.35 ± 0.21^{Aa}	8.40 ± 0.57^{Aa}
	Day 14	7.15 ± 0.50^{Aa}	6.02 ± 0.26^{Ab}	6.80 ± 0.28^{Aa}	7.49 ± 0.45^{Aa}	7.44 ± 1.75^{Aa}
	Day 28	6.32 ± 0.73^{Aa}	7.49 ± 0.45^{Ab}	7.82 ± 0.02^{Aa}	7.54 ± 0.19^{Aa}	7.87 ± 0.76^{Aa}

Within the same row, values with different uppercase superscript letters indicate significant differences ($p<0.05$) Within the same column, values with different lowercase superscript letters indicate significant differences ($p<0.05$). C1: Control 1 including chicken breast meat; C2: Control 2 including ground chicken breast + transglutaminase; M1: 95% ground chicken breast + 5% MDCM + transglutaminase; M2: 90% ground chicken breast + 10% MDCM + transglutaminase; M3: 85% ground chicken breast + 15% MDCM + transglutaminase.

4. Conclusions

In this study, the use of MDCM in the formulation of chicken döner kebab was found to be comparable to that of control groups produced with chicken breast and ground chicken breast. The addition of MDCM in each storage period increased the pH values of the samples compared to the C2 group. MDCM had no negative effect on the TBARS values of the samples. The L^* values decreased with increasing MDCM addition, while the a^* values increased. The use of MDCM for each storage period had no significant effect on the colour, odour and general acceptance scores of the samples. In addition, on day 0, MDCM increased the flavour scores of the samples.

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