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ORIGINAL ARTICLE

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Effect of mechanically deboning of chicken on the rheological and sensory properties of chicken sausages

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Abstract

The current study was aimed to investigate the effects of different types and percentage of mechanically deboned chicken meat (MDC) on the textural and sensory properties of sausages in fried and nonfried condition. Cutting behavior, hardness, stringiness, gumminess, cohesiveness, chewiness, and resilience were evaluated on sausage with different percentage of MDC, using chicken fillet as a control. The result of the textural analysis showed that with a high percentage of MCD, the shear force, hardness, and stringiness increased in sausages. The cohesiveness and resilience often decreased with the rising of MDC percentage. Evaluation of shear force in fried products showed that the MDC percent was significantly higher after thermal processing; it means samples required more force for cutting. Sensory analysis showed that increased percentages of MDC decreased the overall acceptability.

Practical application

Mechanically deboned meat (MDM) has an important emulsifying capacity, thus, promoting nutritional and functional value, emulsion stability, and water holding capacity, which can be used in comminuted meat products. The results of the current study provides insights into the evaluation of textural and sensory properties of sausages by the inclusion of different types and percentage of MDM.

1 | INTRODUCTION

It is well known that mechanically separated meat is as an emulsifying agent with nutritional and functional values, emulsion stability, and water holding capacity which can be used in comminuted meat products (Field, 1988). The increase in the cost of meat and meat products has forced the industry to utilize all available protein sources, including MDC from spent hens and carcass trimmings (Jayathilakan et al., 2012; Babji, Chin, Sen Chempaka, & Alina, 1998; Field, 1988). The yield of MDC ranges from 55–80% depending on the body part deboned and deboning settings. Therefore, one way of producing low-cost products consists of using MDC in the formulation of comminuted meat products (Daros, Masson, & Amico, 2005; Mielnik, Aaby, Rolfsen, Ellekjær, & Nilsson, 2002). The mechanical process can cause some impact such as protein denaturation, cell breakage, and an increase in fat and heme groups of meat. These factors can lead to darker color, off-flavor, and microbial contamination (Dawson & Gartner, ; Froning, 1976, 1981). Moreover, deboning methods could affect the chemical composition of beef and turkey meat, such as iron, calcium, and cholesterol (Serdaroğlu, Yildiz, & Bağdatlioğlu, 2005). Back, neck, and thighs are the most used raw material after removal of most parts of meat from the carcass. The most suitable products of MDC which can be used to improve textural and sensorial properties are sausage and salami (not require fibrous texture) (Daros et al., 2005).

The quality of products made from deboned poultry meat depends on the raw material, a hybrid line of chickens, and the technological process of deboning (Nagy et al., 2007). Many studies evaluated physicochemical (fat, moisture, nitrogen, ash, collagen, calcium, iron, and total purines content) and functional properties (water holding capacity and emulsifying properties) of MDM and other final products which were produced using MDM (Abdullah & Al-Najdawi, 2005, Ang, 1986, Babji et al., 1998, Crosland, Patterson, Higman, Stewart, & Hargin, 1995). The addition of MDM increased the moisture, reduced fat, and protein content and increased the color of the processed formulated meat products (Pereira et al., 2011).

Sensory properties, such as color, flavor, and texture, are significant for consumer acceptance in choosing food products and, consequently, for the manufacturer. For this reason, many studies to optimize and improve these characteristics in various foods are being carried out (Yuste, Mor-Mur, Capellas, Guamis, & Pla, 1999). Daros et al. (2005) showed a reduction in tensile and compressive strength using over 60% MDM in the formulation. Savadkoohi, Shamsi, Hoogenkamp, Javadi, and Farahnaky (2013) focused their study on the physicochemical properties, rheological behaviors, and texture of raw and cooked emulsions containing different MDC produced from neck, back, and thighs of chickens. In addition, most previous studies have been focused on the evaluation of the textural and sensory effects, because these factors are essential for consumer acceptance of food products, and therefore for food producers. However, at this stage of development, there are no reports in the literature on the textural attributes of sausage containing different content of MDC extracted from various kinds of chicken carcasses.

The present study aimed to examine the textural and sensory effect of sausage by the addition of different types and percentage of MDC, also, the effect of frying was investigated.

2 | MATERIALS AND METHODS

In this study, five treatments were selected, including laying hen (a), laying hen skeleton without thigh and breast (b), broiler hen (c), broiler skeleton without thigh and breast (d), and chicken fillet (e). All tests were performed under standard conditions. Three samples were prepared from each treatment which contained 40, 55, and 70% of MDC in sausage. MDC and sausage preparation was done in the same processing plants.

2.1 | MDC preparation

MDM samples were produced in a commercial processing plant using slaughtered chickens with an average body mass of 1.5 kg and samples were collected on May 2018. The breasts and thighs were manually separated from carcasses for samples B and D. Viscera of chicken carcasses were removed by the suction system and then were processed through a Beehive RSTC separator (Beehive Machinery, Inc., Sandy, UT 84091–5002, USA) adjusted to yield about 60 (±5) % of MDC. Produced MDC kept under 4 °C until being operation.

2.2 | Preparation of sausages

Chicken sausages were made with commercial formulation commonly used by manufacturer in separate batches, including: 40, 55, and 70% of MDC from five treatments (a, Laying hen; b, Laying hen skeleton; c, Broiler hen; d, Broiler hen skeleton; e, Fillet of chicken), vegetable oil (5.82%), wheat flour (1.94%), sodium nitrite (0.01%), sodium polyphosphate (0.38%), mixed spices (0.60%; mixture of red pepper, coriander, ginger, cardamom, and onion powder), garlic powder (1.20%), ice slurry/water (17.5%), ascorbic acid (0.02%), sodium chloride (1.00%; NaCl), wheat starch (1.00%), and gluten (1.20%). The products were prepared in a pilot plant according to industrial procedures. All ingredients were added to the cutter with 120 kg capacity.

The homogenized mixture transferred to the packaging machine. In this stage, the mixture was poured in the synthetic casing (diameter of 4 cm), which was soaked in tepid water (40°C). The sausages were thermally processed without smoking for 1 hr to reach a core temperature to 75°C. After achieving the temperature, the sausages were immediately chilled with cold water (15°C) and kept in a controlled condition (4°C) until analysis.

2.3 | Textural properties analysis

The texture profile analysis was done using the Instron Texture Analyzer (Testometric, M350-10CT, Rochdale, England) attached to a Warner Bratzler shearing device according to the method described by (Bourne, Kenny, & Barnard, 1978; Pereira et al., 2011). Each sample was analyzed in two conditions, fried and not fried, for three replications. For fried condition, samples fried in a pan at 174°C for 2 min on each side until the core temperature reached 72–73°C and left at room temperature (Bengtsson, Montelius, & Tornberg, 2011). For two conditions, samples were cut in cube with dimension 20 × 20 mm, and a crosshead speed of 60 mm/min was applied. The samples were compressed twice to 50% of their original height, at room temperature, with compression flat cylindrical aluminum probe (40 mm diameter). There was no time to rest between the two compression cycles (Pereira et al., 2011). The capacity of the load cell used was 500 *N* (50 Kg).

Texture profile parameters which were measured in force–time curves, included Warner Bratzler shear force (N), hardness (N), peak force required for the first compression), stringiness (mm, distance sample recovers after the first compression), chewiness (N × mm, hardness × cohesiveness×stringiness), cohesiveness (dimensionless, ratio of the positive force area during the second compression to that during the first compression excluding the areas under the decompression portion of each cycle), gumminess (N), hardness × cohesiveness), and resilience (dimensionless, the calculation is the area during the withdrawal of the first compression, divided by the area of the first compression).

Shear force was determined by the modified method of Shackelford, Morgan, Cross, and Savell (1991) for two conditions. The samples were sheared once through the center using an Instron Texture Analyzer (Testometric, M350-10CT, Rochdale, England) equipped with a Warner-Bratzler shearing device (300 mm/min crosshead speed). Results were recorded in Wintest analysis software.

2.4 | Sensory evaluation

The sausages were analyzed after checking safety factors by the manufacturer. The hedonic sensory evaluation was performed by a panel of 10 trained panels. The panelists were selected from graduate students from National Nutrition & Food Technology Research Institute of Iran. The panelists evaluated each treatment regarding the odor, color, softness/hardness, slice ability, flavor, juiciness, and chewiness using a 9-point hedonic scale. The scales defined as "like extremely" (point 1 on the scale) and "dislike extremely" (point 9).

Two conditions of sausages (fried and nonfried) were evaluated for all samples, in fried condition samples, all samples were fried according to the procedure defined by Bengtsson et al. (2011).

2.5 | Statistical analysis

The interaction between types and percent of MDC on textural properties of samples were analyzed by SPSS 17.0 software (SPSS Inc., Chicago, IL, USA) and two-way analysis of variance ANOVA using Duncan's test with a significant level ($p < 0.05$). In cases with a significant interaction between types and percent of MDC on textural properties one-way analysis of variance (ANOVA) by SPSS 17.0 was performed for the analysis of the data. Duncan test with a significant level ($p < 0.05$) was accomplished for products.

Sensory evaluation was analyzed by complete random block design for treatments. Therefore, data were not affected by outside situations.

3 | RESULT AND DISCUSSION

3.1 | Texture profile analysis

The analysis was done both for fried and nonfried products. Figures 1–3 show the changes in textural parameters of sausages.

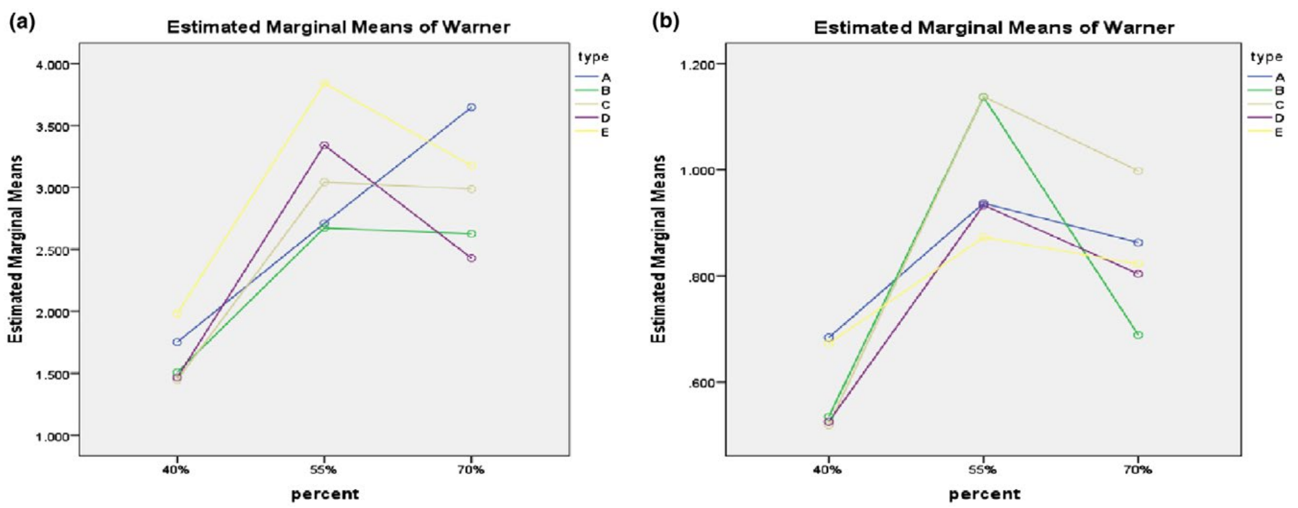

FIGURE 1 Changes in Marginal Means of Warner Bratzler (N) results in fried (a) and nonfried (b) products. Laying hen (a), laying hen skeleton without thigh and breast (b), broiler(c), broiler skeleton without thigh and breast (d), and chicken fillet (e)

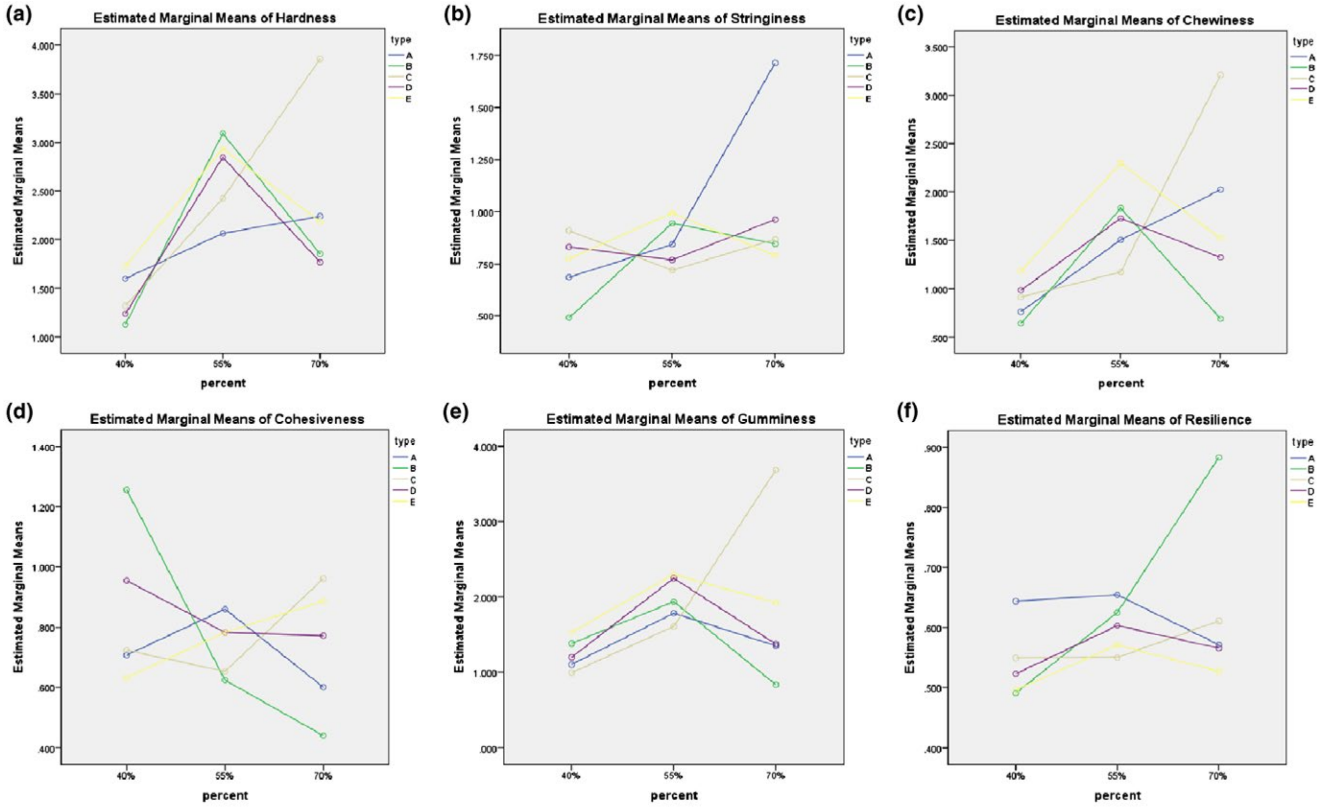

FIGURE 2 Changes in Marginal Means of fried products, a: Hardness; b: Stringiness, c: Chewiness; d: Cohesiveness; e: Gumminess; f: Resilience. Laying hen (a), laying hen skeleton without thigh and breast (b), broiler(c), broiler skeleton without thigh and breast (d), and chicken fillet (e)

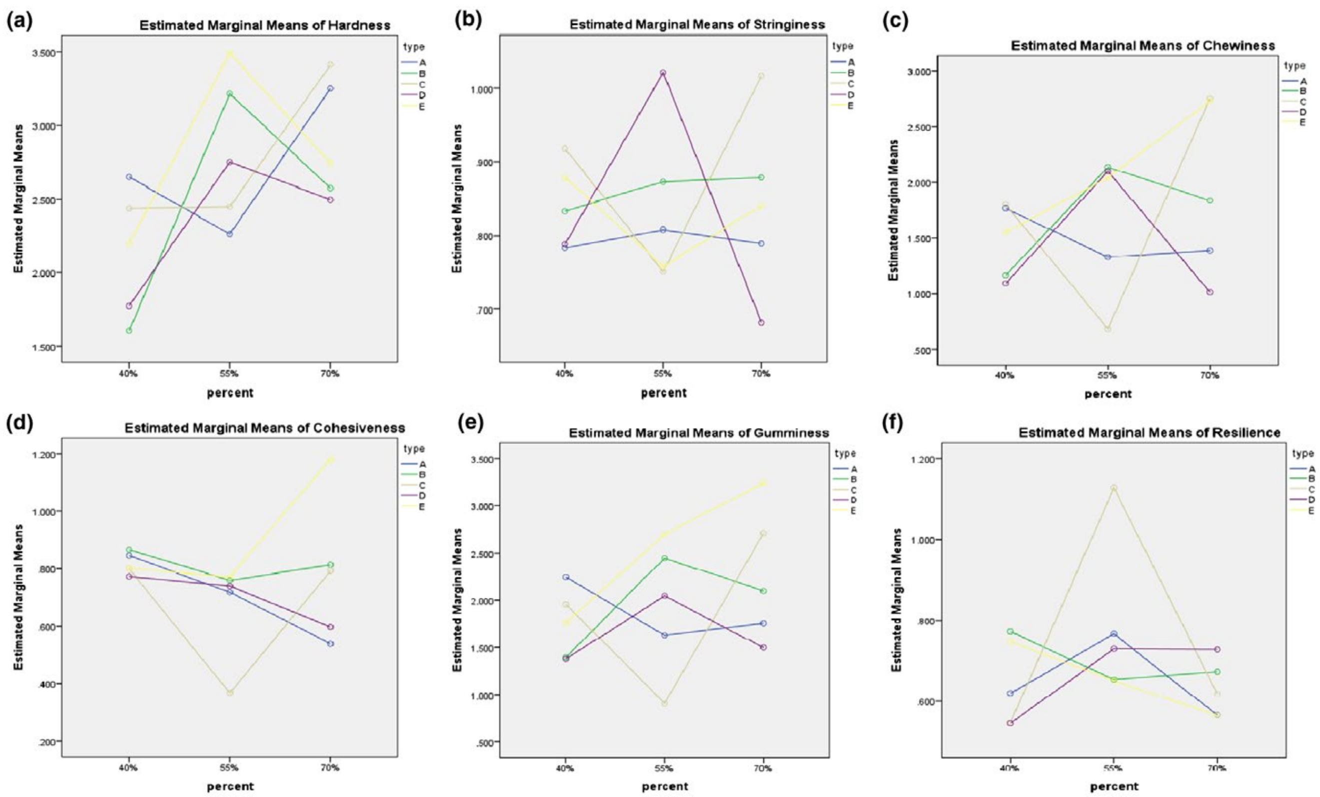

FIGURE 3 Changes in Marginal Means of nonfried products, a: Hardness; b: Stringiness, c: Chewiness; d: Cohesiveness; e: Gumminess; f: Resilience. Laying hen (a), laying hen skeleton without thigh and breast (b), broiler(c), broiler skeleton without thigh and breast (d), and chicken fillet (e)

3.2 | Textural analysis of nonfried products

Nonfried samples showed for all products interaction both between type and percent of MDC ($p < 0.001$). Accordingly, the one-way analysis of variance was used to examine differences between products groups. Figure 3 presents a textural evaluation of nonfried products. The results of the textural analysis showed that C70 and E55 had a higher amount of hardness and D55 had the maximum amount of stringiness. Warner Bratzler Evaluation of shear force for nonfried product showed that C55 and B55 showed the highest values while C40 had the lowest ones (Figure 1). The minimum amount of hardness was found for B40 sample. Moreover, samples B40 and E70 had the highest value of cohesiveness and C55 had a higher level of resilience and lower level of gumminess.

Warner Bratzler results showed in all products a particular behavior in different MDC concentrations with different forces. These procedures were observed in hardness, gumminess, and chewiness samples B and D and stringiness of sample D. (Daros et al., 2005) noticed that tensile and compressive strength decreased when mechanically deboned poultry meat content increased up to 60%, above whom the integrity of product could be lost. This behavior could be related to moisture, protein, and fat content.

Samples A and C reported a different behavior of textural parameters like gumminess and hardness. For these two samples, hardness and gumminess values decreased and subsequently increased. The same behavior was found for sample E regarding cohesiveness and stringiness. This is consistent with the fact that increased amounts of added MDC in sausages increased its cohesiveness (Daros et al., 2005; Pereira et al., 2011).

3.3 | Textural analysis of fried products

Figure 2 shows the textural parameters of fried products. Two-way analysis of variance ANOVA indicated that differences in the type and percentage of MDC were significant regarding cohesiveness, chewiness, resilience, hardness, and gumminess ($p < 0.001$).

Evaluation of shear force showed that the percentage of MDC had a significant ($p < 0.001$) effect, being higher in fried products and observing the maximum value for samples A70 and E55. During the frying process, the moisture content of the product is evaporated, and the surface will be hard, thus promoting moisture replacement by oil (Fellows, 2009). According to Sosa-Morales, Orzuna-Espíritu, and Vélez-Ruiz (2006), pork meat frying leads to an increase of penetration force and hard texture.

Hardness decreased in all samples except D55 and C70. This effect can be related to the temperature of the frying process which promotes protein denaturation and cellular damage on the surface (Min & Ahn, 2005; Tornberg, 2005).

3.3.1 | Sensory evaluations

Sensory evaluation was done for fried and nonfried products, and the results are reported in Tables 1–4. Significant differences ($p < 0.05$)

TABLE 1 Sensory evaluation for nonfried products

Types of MDC	Percent	Sliceability	Hardness	Flavor	Color	Juiciness	Chewiness	Odor	Texture
A	40	2.700(±0.675)	3.700(±0.949)	3.700(±1.418)	4.100(±0.994)	3.900(±1.663)	2.800(±1.229)	4.000(±1.699)	3.800(±1.619)
	55	4.600(±1.776)	5.400(±0.842)	4.300(±1.567)	4.700(±1.059)	5.500(±1.434)	4.300(±1.703)	4.700(±1.059)	4.400(±1.975)
	70	5.200(±1.549)	6.200(±1.398)	5.400(±1.712)	4.800(±0.789)	7.100(±0.875)	5.200(±1.619)	4.700(±1.703)	5.600(±2.118)
B	40	2.700(±1.567)	3.600(±1.265)	3.300(±1.159)	3.700(±1.337)	3.700(±1.059)	2.700(±1.337)	3.400(±0.843)	2.900(±1.791)
	55	4.000(±1.333)	5.600(±0.966)	4.500(±1.080)	5.300(±1.636)	5.500(±1.178)	4.300(±1.636)	4.500(±1.716)	4.900(±1.729)
	70	4.500(±1.716)	5.800(±1.475)	4.100(±1.593)	3.800(±1.470)	4.900(±1.286)	3.700(±1.703)	4.300(±1.636)	4.300(±1.703)
C	40	2.800(±1.229)	3.700(±1.337)	3.300(±1.494)	3.400(±1.897)	3.600(±0.966)	2.400(±0.699)	3.400(±1.174)	2.800(±1.135)
	55	4.100(±0.876)	5.100(±1.370)	3.700(±1.703)	3.800(±1.686)	4.000(±0.414)	3.100(±1.197)	3.500(±1.354)	4.000(±1.563)
	70	4.200(±1.229)	5.800(±0.632)	4.300(±1.418)	4.100(±1.523)	5.700(±0.948)	3.900(±1.100)	4.300(±1.159)	4.800(±1.751)
D	40	2.300(±0.675)	3.400(±2.221)	3.100(±1.663)	3.800(±1.229)	3.200(±1.316)	2.300(±0.948)	3.900(±1.524)	2.400(±0.966)
	55	3.700(±1.418)	4.600(±1.429)	4.200(±2.229)	4.400(±2.413)	4.300(±2.003)	3.900(±1.791)	3.900(±1.370)	4.000(±1.764)
	70	4.600(±1.505)	5.400(±0.966)	4.800(±1.813)	4.500(±1.509)	4.600(±1.265)	4.300(±1.567)	5.000(±1.330)	4.500(±1.840)
E	40	2.400(±0.699)	3.700(±1.059)	3.700(±2.003)	4.300(±1.418)	3.600(±1.975)	2.400(±0.843)	4.000(±1.333)	3.500(±1.779)
	55	3.600(±1.075)	5.100(±1.100)	4.500(±2.121)	4.500(±1.434)	4.800(±1.033)	3.700(±1.636)	4.400(±1.265)	4.500(±1.840)
	70	4.300(±1.829)	5.800(±1.229)	5.200(±1.988)	5.500(±1.509)	5.800(±1.476)	4.300(±1.636)	5.000(±1.247)	5.600(±2.065)

TABLE 2 Sensory grade for nonfried products

Types of MDC	Percent	Sliceability	Hardness	Flavor	Color	Juiciness	Chewiness	Odor	Texture	Acceptability
A	40	3	3	4	6	5	5	6	5	3
	55	14	9	9	12	11	11	13	9	9
	70	15	15	15	13	15	15	12	14	15
B	40	4	2	3	2	4	4	1	3	2
	55	8	11	11	14	12	12	11	13	11
	70	12	12	7	3	10	8	8	8	7
C	40	5	4	2	1	2	2	2	2	5
	55	9	7	6	4	6	6	3	6	4
	70	10	14	10	7	13	9	9	12	8
D	40	1	1	1	5	1	1	5	1	1
	55	7	6	8	9	7	10	4	7	10
	70	13	10	13	10	8	13	14	10	12
E	40	2	5	5	8	3	3	7	4	6
	55	6	8	12	11	9	7	10	11	13
	70	11	13	14	15	14	14	15	15	14

TABLE 3 Sensory evaluation for fried products

Types of MDC	Percent	Sliceability	Hardness	Flavor	Color	Juiciness	Chewiness	Odor	Texture	Acceptability
A	40	3.500 (±2.273)	3.900(±1.449)	3.700(±1.494)	4.30(±1.828)	4.600(±2.065)	3.000(±1.333)	4.800(±1.874)	3.900(±1.523)	4.300(±1.418)
	55	2.800(±0.632)	3.900(±0.876)	3.400(±1.349)	4.100(±0.994)	3.900(±1.370)	3.700(±1.494)	4.800(±1.475)	3.900(±1.595)	3.800(±1.032)
	70	4.400(±1.577)	5.900(±1.197)	4.600(±1.430)	4.600(±1.713)	5.800(±1.316)	4.000(±1.333)	5.500(±1.502)	5.600(±1.075)	5.100(±1.286)
B	40	2.500(±1.649)	2.900(±0.568)	4.100(±2.025)	4.600(±1.713)	3.400(±1.264)	2.400(±0.843)	4.300(±1.567)	3.700(±1.418)	4.600(±2.011)
	55	3.600(±1.174)	5.100(±0.994)	4.500(±1.269)	4.400(±1.430)	4.700(±1.337)	3.500(±1.080)	4.400(±1.173)	5.000(±1.330)	4.800(±1.032)
	70	3.900(±1.524)	5.100(±1.286)	4.400(±1.578)	4.900(±1.791)	4.600(±0.966)	4.400(±1.265)	5.400(±1.170)	5.200(±1.751)	4.800(±1.398)
C	40	2.400(±1.429)	3.400(±1.505)	3.900(±1.370)	4.400(±1.578)	3.700(±1.494)	2.600(±0.843)	4.800(±1.398)	3.300(±1.888)	4.100(±1.197)
	55	2.800(±0.632)	3.900(±0.876)	3.700(±1.337)	3.800(±1.135)	3.200(±0.788)	3.000(±1.333)	4.600(±1.712)	3.200(±1.033)	3.500(±0.972)
	70	3.300(±1.252)	4.600(±1.350)	4.000(±1.633)	4.200(±1.398)	3.900(±0.876)	3.600(±0.966)	4.100(±1.370)	4.000(±1.247)	4.400(±1.075)
D	40	2.300(±0.675)	3.000(±0.666)	3.400(±0.699)	4.400(±1.776)	3.300(±1.702)	2.100(±0.567)	4.800(±1.549)	3.500(±1.958)	3.900(±1.524)
	55	2.800(±0.632)	3.800(±0.919)	3.100(±1.595)	3.100(±0.567)	3.500(±1.178)	2.800(±1.135)	3.900(±1.197)	3.100(±0.857)	3.300(±1.159)
	70	2.600(±0.516)	3.800(±1.229)	3.800(±1.316)	4.000(±1.699)	3.100(±1.370)	2.600(±0.843)	4.100(±0.737)	3.700(±1.766)	4.200(±1.135)
E	40	3.100(±0.875)	4.500(±1.581)	4.200(±1.988)	5.100(±2.514)	4.700(±1.418)	3.500(±0.971)	4.900(±1.524)	4.900(±2.131)	4.600(±1.505)
	55	3.500(±1.080)	5.100(±1.286)	4.000(±1.054)	4.900(±1.791)	5.100(±1.370)	3.800(±1.316)	4.700(±1.567)	4.900(±1.370)	4.400(±0.966)
	70	4.500(±2.121)	4.300(±1.459)	4.700(±1.636)	5.000(±2.211)	5.700(±1.946)	4.500(±1.509)	5.300(±1.338)	4.700(±1.567)	5.300(±1.251)

TABLE 4 Sensory grade for fried products

Types of MDC	Percent	Sliceability	Hardness	Flavor	Color	Juiciness	Chewiness	Odor	Texture	Acceptability
A	40	11	6	4	6	9	6	8	7	7
	55	6	7	2	4	7	11	9	8	3
	70	14	15	14	10	15	13	15	15	14
B	40	3	1	10	11	4	2	4	5	10
	55	12	12	13	9	11	8	5	13	12
	70	13	13	12	13	10	14	14	14	13
C	40	2	3	7	7	6	3	11	3	5
	55	5	8	5	2	2	7	6	2	2
	70	9	10	8	5	8	10	2	9	8
D	40	1	2	3	8	3	1	10	4	4
	55	7	4	1	1	5	5	1	1	1
	70	4	5	6	3	1	4	3	6	6
E	40	8	9	11	15	12	9	12	12	11
	55	10	11	9	12	13	12	7	11	9
	70	15	14	15	14	14	15	13	10	15

were detected except for the two factors (flavor and odor) in fried products ($p < 0.05$). The result of nonfried products showed significant differences except for color. A70 had a lower score of hardness, sliceability, flavor, juiciness, chewiness and, while the lower score in texture, odor, and color was assigned to E70. Moreover, D40 presented a higher score in all sensorial factors except color and odor and a significant relationship between softness and hardness, other than overall acceptability previously documented by Grigelmo-Miguel, Abadías-Serós, and Martín-Belloso (1999) who reported a similar acceptability for high-fiber frankfurters and softer products. This study showed that increased percentages of MDC decreased the overall acceptability. Trindade, Eduardo, and de Felício, and Carmen Josefina Contreras Castillo. (2004) noticed that the amount of 20% of mechanically separated meat as the quantity suggested making the samples acceptable in flavor, softness, and juiciness.

In addition, the type of meat used in meat products can affect color (Froning & Johnson, 1973). It is supposed that heme pigments are the main factors affecting the color of meat products, which can be three times higher in mechanically deboned compared to hand deboning. In nonfried samples, C40 had a higher score in color and samples with a lower content of MDC were lighter and showed the low rating, such as sample E70. In the case of fried samples, D55 had a higher score in flavor, odor, color, and texture. The comparison of nonfried and fried products showed that samples with high sliceability were more acceptable.

The present research aimed to evaluate the effects of different types and percentage of mechanically deboned chicken on textural and sensory properties on sausage. Moreover, the effect of frying was investigated. With shortages of food in the world, the use of these products like MDC in the industry will increase and studies like this can help to the meat industry in order to produce new meat product with better textural and sensory properties with a lower price.

4 | CONCLUSION

The present research evaluates the effects of different types and percentage of mechanically deboned chicken (MCD) on textural and sensory properties on sausage. In addition, the effect of frying was investigated. The result of the textural analysis showed that sausages of laying hen skeleton with 40% of MCD reported the highest cohesiveness and gumminess, instead of those with 70% of broiler hen that reported the lowest. The lowest and highest shear force was found for the 55% of laying hen skeleton and broiler hen, respectively. About 55% of broiler hen skeleton showed the higher stringiness and the higher hardness was found for the sausages produced with the 70% of broiler hen. In general, it is possible to affirm that the sausages produced with 55 and 70% of MDC had more compact texture. The evaluation of shear force in fried products showed that the percentage of MDC use had a significant influence, being higher after this thermal processing method. Sensory analysis showed that increased percentages of MDC decreased the overall acceptability. Moreover, after comparing nonfried and fried products it was found that samples with higher sliceability were more acceptable.

In conclusion, the current study provided insights into the evaluation of textural and sensory properties of sausages by the inclusion of different types and percentage of MDC in fried and nonfried condition, and it can help for producing a new product with better properties.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest for this article.

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