

Effects of Deboning Methods on Chemical Composition and Some Properties of Beef and Turkey Meat

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Abstract: The objective of this research was to compare some chemical and physical characteristics of mechanically deboned and hand deboned turkey meat and beef. Samples were analyzed for proximate composition, cholesterol, TBA, calcium and iron contents, hunter colour parameters and fatty acid composition. Deboning method affected chemical composition of beef and turkey meat. Mechanical deboning resulted higher cholesterol values and calcium and iron content. In hand deboned turkey meat the most abundant fatty acids were C16:0, C18:1 and C18:2. Mechanical deboning process was increased the percent of C18:1, C18:2 and C18:3 in turkey meat. C16:0, C18:0 and C18:1 were the major fatty acids in mechanically deboned and hand deboned beef.

Key Words: Mechanical deboning, turkey, beef, cholesterol, iron, calcium

Kemik Ayırma Tekniklerinin Dana ve Hindi Etinin Kimyasal Kompozisyonu ve Bazı Özellikleri Üzerine Etkileri

Özet: Bu çalışmada mekanik olarak ve elle kemiklerinden ayrılan daha ve hindi etlerinin bazı kimsyal ve fiziksel özelliklerinin karşılaştırılması amaçlanmıştır. Örneklerin kimyasal kompozisyonu, TBA değerleri, kolesterol, kalsiyum ve demir içerikleri saptanmış, hunter renk parametreleri ve yağ asitleri kompozisyonları belirlenmiştir. Kemik ayırma yöntemi hindi ve dana etinin kimyasal kompozisyonu üzerine etkili bulunmuştur. Mekanik olarak kemiklerin ayrılması örneklerin kolesterol, demir ve kalsiyum içeriklerinin artmasına neden olmuştur. Elle ayıklanan hindi etinde bazı yağ asitleri (C16:0, C18:1 ve C18:2) oranları yüksek bulunmuştur. Mekaniksel ayıklama işlemi C18:1, C18:2 ve C18:3 oranlarının artmasına neden olmuştur. Mekaniksel olarak ve elle ayıklanan dana etinde C18:1, C16:0 ve C18:0 oranlarının yüksek olduğu saptanmıştır.

Anahtar Sözcükler: Mekaniksel ayırma, hindi eti, dana eti, kolesterol, demir, kalsiyum

Introduction

Mechanically deboned meat (MDM) or mechanically separated meat are generic terms used to describe residual meat which has been recovered or separated using mechanical equipment from animal bones or poultry carcasses from which the bulk of the meat has been previously manually removed (1). Mechanical deboning involves grinding meat and bone together and forcing the mix through a fine screen or slotted surface to remove bone particles (2). This permits the recovery of most of the residual meat, which would otherwise be difficult or uneconomical to acquire. The resultant MDM has the appearance of finally comminuted meat. MDP is frequently used in the formulation of comminuted meat

products due to its fine consistency and relatively low cost. The composition and storage stability of the final product is affected by the raw materials and conditions used for mechanical deboning (3). Mechanical deboning results in cellular disruption, protein denaturation and increased lipid and haem oxidation (1).

Many differences have been documented for various types of mechanically deboned meat such as colour stability (4), mineral and vitamin content (5-7) cholesterol content (7) and lipid oxidation (8). Comparison of bone content in hand deboned meat (HDM) and MDM by Demos and Mandigo (9) revealed that MDM has a higher ash and Ca content, signifying greater bone content than HDM (7).

Ang and Hamm (6) reported higher levels of cholesterol in MDM broiler meat than HDM meat. Thus, the colour of MDM is a dull brownish red if pigment oxidation has occurred, which may affect the color of mechanical deboned meat-containing meat products. As a result of inclusion of bone marrow in MDM, there is a greater variation in the fatty acid content and a higher percentage of cholesterol and phospholipid in MDM. During mechanical deboning, some bone marrow and flour enter the meat and as with hand deboning techniques, may leave small amounts of powered bone (6,10). Mechanically deboned poultry meat has good nutritional and functional properties and is suitable for the formulation of many meat products (10,11). Yields of mechanically deboned poultry meat (MDP) range from 55 to 80% depending on the part deboned and deboner settings. Turkey is one of the leanest types of poultry and a good source of protein and minerals such as sodium, potassium and iron (12). The purpose of this study was to determine some chemical and physical characteristics of mechanically deboned turkey and beef from the Turkish market and compared with the characteristics of hand deboned turkey and beef.

Material and Methods

Material

Mechanically and hand deboned meat samples (turkey and beef) were produced in a commercial meat processing plant. Hand deboned frames including necks, vertebrae and ribs of beef and hand deboned whole turkey carcasses were processed through a AM² C Smooth Deboner, Model: SD 615/629 (Britt Food Equipment Inc. Cambridge UK). Hand deboned meat samples were used as controls and prepared by dissecting meat (with sharp knives) from close to the bone from the same source material used in mechanically deboned meat production. After hand deboning each sample was ground two times with a meat grinder. The deboned material immediately transported to the laboratory.

Measurements

Samples were evaluated for moisture (13), fat (14), ash (13), protein (15) and pH (16). Oxidative rancidity of samples was quantified using thiobarbituric acid (TBA) values determined spectrophotometrically. TBA number was expressed as mg malonaldehyde/kg (ma/kg) sample (17). The calcium and iron contents were determined on

previously ashed samples by dissolution in HCl and H₂SO₄ followed by atomic absorption spectroscopy (13). Cholesterol content of samples was determined according to the method of Naeemi et al. (18). Samples were hydrolyzed with saturated methanolic KOH. Cyclohexane was added to the mixture and the upper layer was analyzed. Analyses were performed using a gas chromatography (HP 5890) fitted with a column (Ultra performance capillary column, cross linked methyl silicone gum; 25 m x 0.32 mm x 0.52 µm. film thickness, HP 5080-8853), under the following operating conditions; carrier gas, helium with flow rate of 1.5 ml/min.; oven temperature, 180° to 280°, 20 °C/min, hold at 280 °C for 10 min; injector, splitter, 20ml/min; temperature 290 °C; flame ionization detector at 300 °C. Cholesterol standard was used to determine the amount of cholesterol in samples.

The colour of deboned meat samples was measured using a color meter. An automated Minolta Chroma Meter CR-300 (Minolta, Osaka, Japan) using light source with 8 mm measuring cell was used to register the L*(lightness), a*(redness), b*(yellowness). Before each measurement, the apparatus was standardized against a white tile (L = 90.7; a = -0.9 and b = -0.1). L*, a* and b* values is a meaning of six measurements. Lipids were extracted from duplicate 10 g samples with chloroform: methanol (2:1, v/v) (19) and methylated (20). Fatty acid methyl esters (FAME) were analyzed using a gas chromatography (HP 5890) fitted with a fused silica capillary column (CP-SIL-88; 50 m x 0.25 mm i.d., 0.20 µm film thickness of polyethylene glycol) (Chrompack, Ltd., London, UK). The column temperature programmed 170 °C to 205 °C in 1 °C/min, and 15 min. at 205 °C. The injector temperature was set at 250 °C and the detector (FID) temperature was set at 270 °C. The carrier gas was hydrogen at a flow rate of 2.25 ml/min. The fatty acids were identified by comparison of the retention times of the sample with those of standards. Data were analyzed using the general linear model (GLM) procedure of SPSS V.8 (21).

Results

Proximate composition and pH values of hand and mechanically deboned meat samples were given in Table 1. The moisture contents of HDB and HDT were 63.4% and 74.4% while significantly lower levels were found in

Table 1. Mean values for proximate composition and pH of hand and mechanically deboned meat samples (n:5).

Treatments	Moisture (%)	Protein(%)	Fat (%)	Ash (%)	pH
HDB	63.4 ± 1.2	14.7 ± 1.52	9.6 ± 0.57	0.7 ± 0.06	6.0 ± 0.01
MDB	54.9 ± 1.2	12.7 ± 1.59	31.8 ± 3.62	4.3 ± 0.46	6.8 ± 0.13
HDT	74.4 ± 0.12	20.1 ± 0.21	4.8 ± 0.21	1.0 ± 0.02	5.8 ± 0.05
MDT	69.2 ± 2.38	15.5 ± 0.54	14.0 ± 1.19	0.9 ± 0.02	6.0 ± 0.15

MDB and MDT (54.9% and 69.2%). MDB and MDT had the higher fat content (31.8% and 14.0%) than HDB and HDT (19.6% and 4.8%) respectively. Mechanical deboning resulted in beef of significantly higher ash content. Treatment MDB had ash content 4.3% compared with 0.7% in treatment HDB. Mechanical deboning resulted higher pH values for both beef and turkey as seen in Table 1.

Table 2 shows significantly higher values of cholesterol in beef and turkey meat for mechanical deboning. The cholesterol content was 89.6 mg/100g in MDB and 63.6 mg/100g in MDT, while significantly lower levels were recorded for HDB and HDT (50.3 and 56.9 mg/100g) respectively. Calcium and iron contents of meat samples were seen in Table 2. Calcium content of beef and turkey samples was significantly affected by deboning method. Calcium content of HDB and HDT were 53.9 mg/kg and 17.2 mg/kg while significantly higher levels were recorded for MDB and MDT (1360.9 mg/kg and 202.9 mg/kg). Deboning process significantly affected iron content of beef but had no effect on iron content of turkey meat. MDB had higher iron content (35.0 mg/kg) than HDB (27.0 mg/kg).

Table 3 shows the TBA (mg ma/kg) and colour parameters of samples. No significant effect of deboning methods on TBA values was recorded. Deboning method significantly affected colour parameters of meat samples.

Table 2. Cholesterol, Ca and Fe contents of hand and mechanically deboned meat samples (n:5).

Treatments	Cholesterol (mg/100g)	Ca (mg/kg)	Fe (mg/kg)
HDB	50.3 ± 1.31	53.9 ± 1.04	27.0 ± 0.13
MDB	89.6 ± 3.31	1360.9 ± 2.3	35.0 ± 2.92
HDT	56.9 ± 1.69	17.2 ± 0.68	13.5 ± 0.52
MDT	63.6 ± 0.28	202.9 ± 1.07	13.0 ± 2.1

The higher L* and a* values were found in mechanically deboned turkey meat than hand deboned turkey meat. L* values which reflects lightness were 43.4 for HDB, 40.3 for MDB, 43.5 for HDT and 46.3 for MDT.

Total saturated, monounsaturated and polyunsaturated fatty acid contents of mechanically and hand deboned turkey meat and beef samples are given in Table 4. In HDB the most abundant fatty acids were C16:0, C18:0 and C18:1. Similar fatty acid profile was obtained in MDB samples. The main fatty acids of HDT samples were C16:0, C18:0, C18:1, C18:2 and C20:4. Mechanical deboning process was increased the percent of C18:1, C18:2 and C18:3 in turkey meat. Saturated fatty acids (C16:0, C18:0 and C14:0) were higher in hand-deboned samples. Mechanically deboning resulted increment in MUFA percent in beef and turkey meat samples. The percent of total PUFA was 2.94 and 33.89 in MDB and MDT. MDB showed lower percentages of polyunsaturated fatty acids. MDT had higher linoleic acid (C18:2) and PUFA/SFA ratio than HDT. Fatty acid contents of samples didn't show a wide range as in deboned turkey meat. MUFA/SFA ratio was 0.74 and 0.53 in MDB and HDB, respectively. The ratio of the polyunsaturated to the saturated fatty acids (PUFA/SFA) found in this study showed a wide range among the samples analyzed, showing a mean of 0.04 for HDB, 0.05 for MDB and 0.93 for MDT, 0.77 for HDT.

Table 3. TBA and colour parameters of hand and mechanically deboned samples (n:5).

Treatment	TBA mg ma/kg	Hunter values		
		L *	a*	b*
HDB	0.9 ± 0.61	43.4 ± 0.16	14.6 ± 1.75	5.6 ± 2.3
MDB	1.0 ± 0.29	40.3 ± 0.26	23.7 ± 0.92	8.6 ± 0.75
HDT	0.5 ± 0.15	43.5 ± 0.4	11.3 ± 0.80	2.9 ± 0.87
MDT	0.5 ± 0.19	46.3 ± 0.62	22.1 ± 0.78	7.8 ± 0.42

Table 4. Fatty acids composition of meat samples (n:5)

Fatty acids	HDB	MDB	HDT	MDT
14:0	3.41	2.72	1.07	0.97
16:0	31.45	29.32	25.08	24.36
16:1	2.88	3.00	2.62	3.22
16:2	-	-	0.51	0.40
17:0	1.56	1.57	0.28	0.38
18:0	26.8	21.59	15.94	10.20
18:1	30.42	37.80	21.58	26.61
18:2	2.19	2.57	24.30	27.80
18:3	0.31	0.38	1.68	2.43
20:0	0.29	0.30	0.35	0.40
20:1	0.39	0.40	-	-
20:4	-	-	6.00	2.60
22:0	0.33	0.34	-	-
22:6	-	-	0.62	0.68
SFA *	63.82	55.84	42.71	36.28
MUFA **	33.68	41.22	24.20	29.83
PUFA ***	2.5	2.94	33.09	33.89
MUFA/SFA	0.53	0.74	0.57	0.82
PUFA/SFA	0.04	0.05	0.77	0.93

* SFA: Saturated Fatty Acids

** MUFA: Monounsaturated Fatty Acids

***PUFA: Polyunsaturated Fatty Acids

Discussion

It could be concluded from the chemical composition of hand and mechanically deboned samples, that hand deboning resulted higher moisture and protein content and lower fat content than mechanical deboning for both beef and turkey. In contrast to our results, some researchers reported that mechanically deboned lean (whole shoulder and neck ground prior to lean recovery) contained more moisture than hand deboned lean from the same carcass parts (22). In our research mechanically deboned beef and turkey samples had high fat contents, this was probably the reason of the low moisture content. Mechanical deboning resulted in increased lipid concentration because of the high fat content from bone marrow, which is a rich source of fat. Lipid content for mechanically deboned turkey obtained in this research was similar that reported by Essary (5) for meat from turkey backs, frames and necks (average of 15.7%). Satterlee et al. (23) reported that inclusion of skin with parts to be deboned would significantly increase the

percentage of fat in the separated product. With no skin, they found about 15% fat, with 40% skin, they obtained a 35% fat in deboned product. Higher ash contents of mechanically deboned samples are likely to be a result of bone particles incorporated into the meat. When mechanical pressure is used to force lean away from vertebrae and through small apertures, some components probably occur in different proportions than found in hand trim.

Higher pH values for mechanically deboned meat than hand-deboned meat can be attributed to the presence of marrow in the product. Demos and Mandigo (4) found that bone marrow had a pH of 7.7. The advantage of rising pH to determine the presence of marrow in mechanically deboned meat is a simple method (24).

In the present study cholesterol released from bone marrow by mechanical deboning process increased cholesterol concentration of beef and turkey samples. Bone marrow, fat and skin are the factors, which affect

cholesterol level in meat (9). In a similar study with chicken Al- Najdawi and Abdullah (7) found that mechanically deboned chicken with skin contained more cholesterol than hand deboned chicken with skin. Ang and Hamm (6) reported higher levels of cholesterol (94.6 mg/100 g) in mechanically deboned broiler meat than hand deboned broiler meat (81 mg/100 g).

Calcium content is an indicator of the amount of bone in meat. Higher calcium content of mechanically deboned samples indicates that higher bone particles were in mechanically deboned samples. Calcium content of MDB in our study was lower than the 3091 mg/kg reported by Strmiskova et al. (25) but it was higher than the 206.2 mg/kg obtained by the Crosland et al. (3) Higher iron contents in mechanically deboned beef and turkey samples is a result of incorporation of red marrow during processing. Demos and Mondigo (9) reported that mechanically recovered lean contains higher amounts of iron and calcium than is found in hand deboned meat.

Mechanically deboned meat is highly susceptible to oxidative deterioration due to the extensive stress and aeration during the machine deboning process and the compositional nature (bone marrow, heme and lipids) of the product (26). In our research no significant effect of deboning method on TBA values was observed probably due to the short period of sampling and analysing.

Mechanical deboning resulted lower L* values in beef. HDB samples were lighter than MDB samples. Higher a* value in MDT probably due to the higher bone marrow

content. Hand deboned turkey samples were lighter (lower b* value) value than other meat samples. Field (27) reported that addition of heme pigments from bone marrow and elimination of connective tissue was the reason brighter red color in mechanically deboned meat compared the control of hand deboned meat. Demos and Mandigo (4) found similar results in higher a* values of mechanically deboned beef neck.

There was a wide range among fatty acid composition of samples because deboned meat is affected by the particular carcass parts used. Mechanical deboning increased monounsaturated fatty acids in both beef and turkey samples but had no effect on PUFA percent. According to Baggio et al. (28) there was no significant difference in the total lipid level of the wings, legs and breast but the skin presented the highest contents of most fatty acids, especially monounsaturated fatty acids. The PUFA percent of mechanically deboned turkey samples was similar that obtained by Wong et al. (29) for ground turkey (24.6 to 32.5%). It can be concluded from the results obtained that the chemical composition of mechanically and hand deboned beef and turkey meat was significantly different. It can also be concluded that bone content in MDM was higher than MDT. Mechanically deboned turkey meat is a low cost, underutilized by-product of fresh meat processing with high nutritive value and protein functionality. MDT and MDB is approved for use in commercially processed meat products.

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