Effects of cooking methods on fatty acids, *trans* fatty acid and conjugated linoleic acid in the *longissimus dorsi* muscles of goats

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Abstract- **Heat treatment is known to accelerate lipid oxidation in meat. This study therefore examine the effects of two cooking methods (boiling and microwaving) on the fatty acid composition of *longissimus dorsi* (LD) in Kacang crossbred goats. *longissimus dorsi* muscles obtained from eight slaughtered goats were subjected to either boiling (85 ^{o}C for 60 min; core temperature 82.0±3.0 ^{o}C) or microwaving (10 min; core temperature 90.0±3.0 ^{o}C) and their fatty acid composition was determined using gas liquid chromatography. There were significantly higher (P<0.05) proportions of total saturated fatty acids (SFA) and stearic acid with no significant (P>0.05) change in total monounsaturated fatty acids (MUFA) in the microwaved chevon compared to the raw meat. Both thermal processes did not affect (P>0.05) the *c9t11*conjugated linoleic acid (CLA) isomers but decreased significantly (P<0.05) the *c12t10* CLA isomers. The microwaved chevon showed a significantly decreased PUFA: SFA ratio with no change in total *trans* fatty acids (TFA). Both cooking methods decreased significantly (P<0.05) the proportion of total PUFA *n-3.* The stearic acid, total SFA proportions were increased in microwaved samples, whereas the total *c*12, *t*10 of CLA isomers and total n-3 PUFA of the muscle were reduced. Both cooking methods decreased the proportion of total PUFA *n-3.***

Keywords- **Chevon, Fatty acids, Cooking methods.**

I. INTRODUCTION

Nutritional value and quality of the meat can be affected by the fat and fatty acid content of the meat. Saturated fatty acids (SFA) and *trans* fats which is high in ruminant meat have been shown several negative effects on human health (1). Besides the detrimental effects of SFA and *trans* fats for human health, the conjugated linoleic acid (CLA) isomers and polyunsaturated fatty acid (PUFA) in ruminant meat have received much attention for their health promoting effects (2). Meat from ruminants represents the major source of natural CLA isomers of the human diet. Two main isomer of the CLA (*cis*9, *trans*11 and *trans*10, *cis*12 have been shown to have several beneficial effects of human health (2). It is well known that cooking method can affect on the meat composition, especially its fat content and it can lead to change the meat quality (3). Many research showed that the cooking method could change the lipid composition of the meat, especially the fatty acid content, by changing the nutritional value of cooked products in compare to raw samples (4). In addition, (5) showed that heating process deteriorate the essential fatty acids, and oxidized the fats.

Despite the different studies focusing on the effect of cooking method on fatty acid composition (6 and 7), as far as we know, no data has been reported regarding the effect of cooking on fatty acid composition of chevon with focus on the CLA isomer. Thus, the aim of this study was to investigate the effect of two methods of common cooking practices (boiling and microwaving) on fatty acid composition, in goat meat.

II. MATERIALS AND METHODS

The fresh Kacang crossbred goat meat were purchased from local market and then sliced into square cuts of 5 cm. All the visible fat trimmed and the cuts were subjected to each of the cooking treatments used (boiling and microwaving), while the raw cuts were sampled directly as the control. Internal temperatures were monitored continuously using thermocouples (Hanna H145, Hanna, Italy), inserted into the centre of each cut, Boiling was conducted at 85 ^{o}C during 60 min in a water bath with core temperature 82.0±3.0 ^{o}C. For microwave cooking, the samples were placed on an aluminum foil in the centre of the microwave oven (300W, Microstar, USATech, USA),

set at 250 W for 10 minute. Final internal temperature of microwave cooking was 90.0±3.0 ^{o}C.

Determination of fatty acid composition

The total fatty acids were extracted from meat based on the method of (8) modified by (9), using chloroform: methanol 2:1 (v/v) containing butylated hydroxytoluene to prevent oxidation during sample preparation. Transmethylation of the extracted fatty acids to their fatty acid methyl esters (FAME) were carried out using KOH in methanol and 14 % methanolic boron trifluoride (BF3) (Sigma Chemical Co. St. Louis, Missouri, USA) according to methods by (10). The FAME were separated by gas chromatography (Agilent 7890N), using a Supelco SP 2560 capillary column of 100m x 0.25mm ID x 0.2 µm film thickness (Supelco, Inc., Bellefonte, PA, USA). The carrier gas was nitrogen at a flow rate of 1.2 ml/min. The split ratio was 1: 20 after injection of 1 µl of the FAME. The injector temperature was programmed at 250 ^{o}C and the detector temperature was 270 ^{o}C. The column temperature program started runs at 150 ^{o}C, for 2 min, warmed to 158 ^{o}C at 1 ^{o}C /min, held for 28 min, warmed to 220 ^{o}C at 1 oC /min, and then held for 20 min to achieve satisfactory separation. The peaks of samples were identified and concentrations calculated based on the retention time and peak area of known standards (Sigma Chemical Co., St. Louis, Missouri, USA). The fatty acid concentrations are expressed as g/100g of total identified fatty acids measured in each sample.

All data were analyzed by the least-squares means method using the GLM procedures of SAS®. Significantly different means were then further differentiated using the least significant difference (LSD) comparison procedures. All statistical tests were conducted at 95 % confidence level.

III. RESULTS AND DISCUSSIONS

Individual fatty acid composition (g/100g of total fat) in raw and cooked samples of LD muscle is showed in Table 1. In decreasing order of percentage, the major fatty acids in intramuscular fat of raw and cooked meat, were oleic (18:1*n-9*, 32.88-33.57%), palmitic (16:0, 19.32-21.93%), stearic (18:0, 17.68–19.87%) and linoleic (18:2*n-6*, 6.56-9.59%) acids. Both the cooking methods had significant effect on the some of the fatty acid profile of studied chevon ($P < 0.05$) by the thermal treatments. In addition, no new fatty acids were detected after cooking procedure. The C18:0 were significantly higher ($P < 0.05$) in both cooked meat samples than in the raw meat as a control. In contrast, the percentages all *n-3*PUFA decreased significantly ($P<0.05$) in cooked chevon compared to raw chevon. Within the 18:2 *n-6* and 20:4 *n-6*PUFA, no apparent cooking effects were observed. (4) Who observed significant differences in the fatty acid profile of beef, has already reported variations in the fatty acid composition of raw and cooked samples. According to these authors, the contents of 22:5*n-3* and total *n-3*PUFA decreased significantly after microwaving and boiling, while 18:2*n-6*, 18:3*n-3* and 22:6*n-3* did not changed significantly.

In contrast, (11) reported minor variations induced by heating in fatty acid composition of lamb fatty acids, among others. However, (12) reported great differences in fatty acid composition between raw and cooked beef. Different mechanisms, which occur during cooking, like fatty acid oxidation and water loss can relatively change some of the fatty acid (5).

Table 1: Individual fatty acid composition (g/100g total fatty acid) of raw and cooked chevon (mean ± SEM, n = 8).

	Treatment			
Fatty acids	Raw	Microwaing	Boiling	P value
C14:0	1.69±0.19	2.07±0.20	1.79±0.17	0.3596
C16:0	19.32±0.79	21.93±1.07	19.93±0.89	0.1548
C16:1	1.58±0.12	1.82±0.15	1.64±0.12	0.1215
C18:0	17.68±0.54^{b}	19.33±0.51^{a}	19.87±0.49^{a}	0.0246
C18:1 *n-9*	33.57±0.94	33.53±0.46	32.88±0.87	0.7757
C18:1 *t11*	2.72±0.15	3.63±0.39	3.79±0.47	0.1404
C18:2 *n-6*	9.59±0.66	6.56±1.05	9.27±1.24	0.1063
C18:2 *trans*	0.63±0.09	0.62±0.07	0.57±0.10	0.8828
CLA *c9 t11*	0.88±0.05	0.93±0.13	0.90±0.03	0.9349
CLA *c12 t10*	0.40±0.06^{a}	0.14±0.01^{b}	0.18±0.02^{b}	<0.0001
C18:3 *n-3*	3.75±0.32^{a}	2.90±0.25^{b}	2.60±0.21^{b}	0.0191
C20:4 *n-6*	3.08±0.19	2.78±0.14	2.93±0.12	0.3893
C20:5 *n-3*	2.42±0.17^{a}	1.84±0.34^{ab}	1.62±0.11^{b}	0.0428
C22:5 *n-3*	2.10±0.12^{a}	1.63±0.14^{b}	1.59±0.11^{b}	0.0212
C22:6 *n-3*	0.59±0.04^{a}	0.29±0.02^{c}	0.40±0.03^{b}	<0.0001

Means within the same row with different superscripts are significantly different ($P < 0.05$); SEM, standard error of mean.

The amount of individual *trans* fatty acids (TFA) remained unaffected ($P>0.05$) by the cooking treatment. *Trans*11 octadecenoic acids are the major intermediates

formed during rumen biohydrogenation of C18 PUFA (13). The effects of cooking on the CLA contents and its isomer displayed in Table 1. The *c*12*t*10 CLA was significantly lower (P<0.05) in the cooked meat in compared to the raw meat. There was no significant different in *c*9t11 CLA between cooked and raw meat. In fact, only *c*12*t*10 CLA isomers identified in chevon were changed (P<0.05), when subjected to the two cooking methods. (14) showed that the isomers of *cis* or *trans* can be determine the stability of CLA isomers but not by the double bonds position.

Data on partial sums (g/100g of total fatty acid) of intramuscular fatty acid, in both raw and cooked samples, are shown in Table 2. A significant increase (P<0.05) in the relative proportion of SFA (+2.89–4.63 g/100g), occurred after cooking. This mainly resulted from an increase in C16:0 and C18:0. Cooked chevon had lower concentrations of total *n-3* PUFA than raw meat, due to a significant loss (P<0.05) of some of *n-3* PUFA. This is consistent with the results of (4) that compared cooked and uncooked beef with different methods of cooking.

Table 2: Partial sum of fatty acid composition (g/100g total fatty acid) of raw and cooked chevon (mean ± SEM, n = 8).

	Treatments			
Partial sums	Raw	Microwaing	Boiling	P-Value
Total SFA	38.70±0.78[b]	43.33±1.30[a]	41.59±0.72[a]	0.0158
Total MUFA	37.87±0.97	38.98±0.72	38.36±0.78	0.6397
Total *n-3* PUFA	8.85±0.59[a]	6.66±0.71[b]	6.21±0.39[b]	0.0132
Total *n-6* PUFA	13.30±0.89	9.96±1.19	12.77±1.29	0.1195
Total TFA	3.34±0.22	4.25±0.38	4.36±0.43	0.1434
Total CLA	1.28±0.11	1.07±0.14	1.08±0.05	0.4654
n-6: *n-3*	1.50±0.03[b]	1.49±0.05[b]	2.10±0.25[a]	0.0192
PUFA: SFA	0.58±0.05[a]	0.39±0.06[b]	0.46±0.04[a]	0.0498

Same row with different superscripts are significantly different (P < 0.05); SEM: standard error of mean
Total SFA: sum of 14:0, 16:0,18:0; Total MUFA: sum of 16:1, 18:1*n-9*.
Total *n*-3PUFA: sum of 18:3*n-3*, 20:5*n-3*, 22:5*n-3*, 22:6*n-3*.
Total *n*-6PUFA: sum of 18:2*n-6*, 20:4*n-6*.
n-6: *n-3* : Total *n-6* PUFA (sum of 18:2*n-6*, 20:4*n-6*): Total *n*-3PUFA (sum of 18:3*n-3*, 20:5*n-3*, 22:5*n-3*, 22:6*n-3*

The changes observed in the partial sums of fatty acids in this research likely due to the higher susceptibility of *n-3*PUFA to oxidative degradation, relative to the other fatty acids. The ratios of PUFA: SFA and *n-6: n-3*, which are indicator for evaluate the nutritional value of fat for human consumption, are presented in Table 2. Total CLA content was not significantly different (P>0.05) in cooked chevon than in raw chevon. According to nutritional recommendations (15), the *n-6*: *n-3* ratio should not exceed 4.0 and the PUFA: SFA ratio in human diets should be above 0.45, in the present experiment, cooked samples showed significantly lower (P<0.05) PUFA: SFA ratios, with values around the recommended limit. In addition, the boiling method increased significantly the values of the *n-6*: *n-3* ratio in compared to raw meat. However, it was still within the recommendation level for human nutrition aspect.

IV. CONCLUTIONS

The cooking methods studied (boiling and microwaving) seem to increase the percentages of SFA and decrease the relative proportions of *n-3*PUFA in goat meat. Regarding the nutritional fatty acid ratios, the data suggest that heating decreased the chevon PUFA: SFA ratio in both cooking method and increased the *n-6*: *n-3* ratio, relative to raw meat. The *c*12*t*10 CLA content seems to be lower in cooked chevon than in raw meat, because of the effect of heat. However, minor changes in CLA profile of chevon seem to occur because of cooking, with no variation of the relative proportions of the bioactive *c*9t11 CLA isomers.

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