World Applied Sciences Journal 17 (Towards the Traceability of Halal and Thoyyiban Application): 29-33, 2012
ISSN 1818-4952

Effect of Grilling and Roasting on the Fatty Acids Profile of Chicken and Mutton

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Abstract: The effect of grilling and roasting using a microwave oven on fatty acid profile of chicken and mutton meat was investigated. The lipid content (gravimetric method) and fatty acids composition (gas chromatography) were analyzed in three different treatments and applied on these meats in four replicates and two batches. Cooking losses, internal temperature reached by meat and, consequently, total lipids, increased directly with the cooking time and temperature used. Cooked chicken meat had a lower proportion of monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and saturated fatty acids (SFA) than cooked mutton meat. PUFA/SFA ratio decreased in chicken meat and increased in mutton meat by heating. Chicken meat presents more favorable fatty acids profile than in mutton meat. This study implies the great choice for consumer to choose the healthier meat in a better way of cooking. It is recommended that other researchers should study on the nutritional value of chicken and mutton with other different cooking methods to obtain a better comparison data.

Key words: Grilling · Roasting · Fatty acids profile · Chicken · Mutton

INTRODUCTION

Meat is the muscles of animals, including the organ and glands. Meat also includes the flesh of poultry and fish [1]. In general, meat contains 60-80% of water, 15-25% of protein and other components. Meat also contains high cholesterol, fat and SFA and less unsaturated fatty acid [2]. The fatty acids in meat are located mainly in adipose tissue, commonly termed as "fat". This has a role in providing volatile degradation products during cooking and contributing toward texture and juiciness in meat. The softness/hardness of fat, which is greatly influenced by fatty acid composition, affects various properties [3]. Changes in fatty acid composition can affect all these aspects of meat quality [4]. Fat content and fatty acid composition of meat famous are of concern among consumers because of their link towards the nutritional value and health. SFA and *trans* fats have been recognized by the international dietary authorities as primary targets for diet reduction [5]. Ruminant meat provides a valuable amount of PUFA, namely n-3 fatty acids, for the human diet [6]. Nutrition-wise the low PUFA/SFA and high n-6/n-3 ratios of some meats contribute towards the imbalance in the fatty acid intake of today's consumers [7]. Many fatty acids are lost during the cooking process. Thus, the objective of this study is to identify fatty acid profiles in chicken and mutton with different cooking methods.

MATERIALS AND METHODS

Sample Preparation: Chicken and mutton meat were purchased from a local shop.

Cooking Treatments: Grilling and roasting was done using a microwave oven. Grilling was performed at 230 °C for 20 minutes. Roasting was performed at 190 °C for 25 minutes.

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Determination of Fatty Acid Methyl Ester (FAME) Lipid Extraction: Lipid was extracted using the Hara and Radin [8] method with minor modifications. For each treatment, 3 g of sample (raw, grilled and roasted) with four replicates for chicken and mutton were weighed into 50 ml of screw-on cap plastic centrifuge bottles. 18 ml of a 3:2 mixture (vol/vol) of hexane and isopropanol were added into the centrifuge bottle and were homogenized vigorously using a vortex for 2 mins. Then, 12 ml of 6.67% (w/v) aqueous solution of sodium sulphate (freshly prepared) was added to the raw sample and cooked samples homogenate respectively. After that, the tubes were gently shaken for 30 s and centrifuged at 4000 rpm for 3 mins at 10 °C. The supernatant organic layer was siphoned off and collected in a beaker. The lipid extraction procedure was repeated for three times to the residue for complete lipid extraction. Hexane was evaporated. Then, the total lipid content was weighed and subsequently derivatized by using 5.4 M sodium methoxide with 30 % of methanol.

Derivatization of Fatty Acid to FAME: Lipid samples were converted to their constituent fatty acid methyl esters according to the method of Timm [9] and Bakar *et al*. [10]. Extracted lipid sample was diluted in 4 ml of hexane followed by the addition of sodium methoxide based on the weight of lipid. The mixture was shaken by vortex for 10 seconds and left for 30 minutes until separation of two phases occurred. The top layer which was FAME was filtered through a 0.45ìm syringe filter, centrifuged for 3 mins at 13,000 rpm and the supernatant was transferred into 2 ml vial before proceeding to the gas chromatography (GC) analysis.

Determination of FAME by GC: Analysis of FAME was analyzed with a GC (Agilent technologies 7890A), equipped split injector (50:1), HP-88 column and quantified by flame ionization detector. The GC conditions were as follows: injection port temperature was 250 °C; flame ionization detector temperature will be 280 °C. Oven temperature program was set at an initial temperature of 120°C for 1 min, then raised to 175 °C at 10 °C/min and held for 10 min, raised to 210 °C at 5 °C/min and held at 210 °C for 5 min and again the temperature was raised to 230 °C at 5°C/ min and held for 5 min. The carrier gas or mobile phase was helium. The column flow rate was 1.9 ml/min. In the detector, helium gas flowed at 30 ml/min. The sample size inject for each analysis was 1 ìL. Compounds were identified by comparison with the retention times of known standards, Supelco™ 37 component FAME [11].

Statistical Analysis: A one-way analysis of variance (ANOVA) was applied on the data. The software that was used was Statistical Analysis Software (SAS) Enterprise Guide 4.3.

RESULTS AND DISCUSSION

Physical Analysis

Total Lipid, Cook Loss and Internal Temperature: The result of total lipid (TL), cook loss (CL) and internal temperature (IT) for chicken meat are shown in Table 1 above. Total lipid of all samples showed significant differences ($p < 0.05$) among all the treatments. The cook loss indicated significant differences among the treatments (raw < roasting < grilling). The final internal temperatures reached were significantly different ($p < 0.05$) among the cooking processes (raw < roasting < grilling).

Total lipids of all samples were significantly different ($p < 0.05$) among all the treatments in mutton. The cook loss show very significant different among the treatments (raw < roasting < grilling). The final internal temperatures reached were significantly different ($p < 0.05$) among the cooking processes.

Alfaia *et al.* [12] reported there were significant differences ($p < 0.05$) of total lipid content in treatments. Sainsbury *et al.* [13] reported that fat content increased during cooking. This fact seems to be correct for all two cooking methods applied in this study although there no significant different between method of cooking for mutton meat. When using microwave, the water and cook losses tend to be high due to no crust formation occurs during microwave cooking [14]. According to Sa´nchez-Muniz and Bastida [15], proper crust formation prevents excessive dryness and fattening during cooking. Cooking losses were mainly due to water and fat loss during heating of food. These losses depend on the mass transfer process during thermal treatment [14, 16, 17], which in turn is influenced by the characteristics of the cooking procedure and of the meat systems.

Some authors have reported increased cooking loss as the fat content increases [18, 19], but others have reported no such findings [20, 21]. Garcia-Segovia *et al.* [22] observed that changes in cooking losses tended to be linear with time, with an increasing final temperature. That the increasing final internal temperature where grilling more higher than roasting may resulted in greater cooking losses, as more moisture had been lost by evaporation, during processing.

Table 1: Scores Mean (mean ± SDE) for Total Lipid, Cook Loss and Internal Temperature for Chicken and Mutton

	Chicken			Mutton		
Treatment	TL (%)	CL (g)	IT (°C)	TL (%)	CL (g)	IT (°C)
Raw	5.533 ± 1.407^{b}	0^{c}	25 ± 0^{c}	2.751 ± 0.248^{b}	0^{c}	25 ± 0^{c}
Grill	8.875 ± 1.538^{a}	16.8 ± 1.711^{a}	91 ± 1.069^{a}	10.410 ± 1.163^{a}	20.292 ± 1.809^{a}	80.5 ± 1.604^{a}
Roast	4.701 ± 1.623^{b}	8.6 ± 1.78^{b}	85.5 ± 1.604^{b}	7.494 ± 1.111^{a}	14.102 ± 1.419^{b}	75 ± 1.069^{b}

a-c: different superscript letter indicate the significant different ($p<0.05$) mean within row. (n=8 for each treatments)

Physical analysis analyzed: TL, total lipid; CL, cook loss; IT, internal temperature

Table 2: Scores Mean (mean ± SDE) for Different Treatment (R, G, RT) and Fatty Acids for Chicken and Mutton Meat

	Chicken			Mutton		
Fatty acid	Raw	Grill	Roast	Raw	Grill	Roast
DHA	0^{b}	0.10 ± 0.05^{a}	0^{b}	0^{a}	0.14 ± 0.20^{ab}	0.29 ± 0.33^{a}
EPA	0^{a}	0^{a}	0^{a}	0^{b}	0.25 ± 0.27^{ab}	0.42 ± 0.47^{a}
Erucic	1.05 ± 0.03^{a}	0.58 ± 0.06^{ab}	0.37 ± 0.01^{b}	0.18 ± 0.16^{b}	1.31 ± 0.25^{ab}	1.08 ± 0.09^{a}
LA	0.99 ± 0.08^{a}	0.45 ± 0.02^{a}	0.72 ± 0.07^{a}	3.87 ± 0.34^{a}	5.72 ± 0.94^{a}	3.26 ± 0.82^{a}
GLA	0.24 ± 0.05^{a}	0.04 ± 0.07^{b}	0.02 ± 0.06^{b}	0^{a}	0^{a}	0^{a}
ALA	1.58 ± 0.43^{a}	0.29 ± 0.27^{b}	0.24 ± 0.08^{b}	0.26 ± 0.20^{a}	1.31 ± 0.40^{a}	0.93 ± 0.97^{a}
DGLA	0.18 ± 0.01^{a}	0.03 ± 0.08^{b}	0^{b}	0^{b}	0.12 ± 0.13^{a}	0.01 ± 0.03^{b}
OA	0^{b}	0.16 ± 0.09^{ab}	0.36 ± 0.05^{a}	1.00 ± 0.77^{a}	0.34 ± 0.97^{ab}	0^{b}
MUFA	3.37 ± 0.27^{a}	2.52 ± 0.03^{a}	2.25 ± 0.59^{a}	3.92 ± 0.33^{b}	13.82 ± 1.38^{a}	4.14 ± 0.39^{b}
PUFA	3.18 ± 0.43^{a}	0.88 ± 0.09^{b}	0.98 ± 0.11^{b}	4.13 ± 0.53^{a}	7.71 ± 1.59^{a}	4.93 ± 0.45^{a}
SFA	2.33 ± 0.88^{a}	1.31 ± 0.06^{a}	1.31 ± 0.90^{a}	3.13 ± 0.11^{b}	13.88 ± 1.81^{a}	2.39 ±0.82^{b}
PUFA/SFA	1.61 ± 0.04^{a}	1.24 ± 0.17^{a}	0.96 ± 0.05^{a}	1.24 ± 0.21^{ab}	0.76 ± 0.05^{b}	2.27 ± 0.73^{a}
Cis	1.25 ± 0.73^{a}	0.61 ± 0.07^{a}	1.10 ± 0.26^{a}	4.87 ± 0.45^{b}	15.04 ± 1.33^{b}	4.29 ± 0.26^{a}
Trans	0^{a}	0^{a}	0^{a}	0^{b}	0.17 ± 0.19^{b}	1.99 ± 0.36^{a}
n-6/n-3	0^{a}	0^{a}	0^{a}	0^{b}	0.04 ± 0.04^{b}	0.50 ± 0.54^{a}

a-b: different superscript letter indicate the significant different ($p < 0.05$) mean within row. (n=8 for each treatments)

Abbreviation used for fatty acid: DHA-docosahexanoic acid; EPA-eicosapentanoic acid; LA-linoleic acid; GLA-γ-linolenic acid; ALA-α-linolenic acid; DGLA-dihomo-γ-linolenic acid; OA-oleic acid; MUFA-monounsaturated fatty acid; PUFA-polyunsaturated fatty acid; SFA-saturated fatty acid

The Effect of Treatments and Type of Meats on Fatty Acid Profile the Effect of Treatments on Chicken Meat: Fatty acid composition in raw and cooked samples of thigh cut from chicken meat is listed in Table 2. There is no *trans* fatty acid in meat for all treatments in this study.

The major FAs in grilling and roasting treatments, were MUFA > SFA > PUFA respectively. All the cooking methods had a moderate impact on the fatty acid profile of chicken, with the content of 6 of the 8 FA analyzed affected ($p < 0.05$) by the thermal treatments. Some FA, namely DHA and OA, were significantly higher ($p < 0.05$) in cooked meat samples than in the raw meat.

In contrast, the percentages of erucic, GLA, LA, ALA and DGLA decreased significantly ($p < 0.05$) in cooked compared to raw chicken. There is no EPA in all treatments which was opposite with study that had been done by de Almeida *et al.* [23].

PUFA to SFA ratio was not that significantly affected by heat processing. These results agreed with other authors who quantified some FA of thighs and observed similar reduction in FA [24, 25].

The Effect of Treatments on Mutton Meats: Fatty acid composition in raw and cooked samples of shoulder cut from mutton meat is listed in Table 2. In summarize all fatty acids shown significant differences ($p < 0.05$) among treatments except for PUFA. There is more *cis* fatty acid than *trans* fatty acid in mutton meat for all treatments. Grilling treatment gave higher results in all fatty acids. High temperature enhance the oxidation process and this can been seen in PUFA having the lowest result than MUFA and SFA.

The major Fas in roasting treatment for overall FAs, were PUFA > MUFA > SFA. All the cooking methods had a moderate impact on the fatty acid profiles of chicken, with the content of 5 of the 8 FA analyzed affected ($p < 0.05$) by the thermal treatments. Some FAs, namely DHA, EPA, erucic acid, LA, ALA and DGLA, were significantly higher ($p < 0.05$) in cooked meat samples than in the uncooked meat control. In contrast, the percentages of OA decreased significantly ($p < 0.05$) in cooked chicken compared to raw meat.

The effect of cooking on the meat fatty acid composition of meat varies among studies involving different animal species and meat cuts or product [26, 27, 28]. Variations in the fatty acid composition of raw and cooked samples have already been reported by Alfaia *et al.* [8], Sainsbury *et al.* [13], Gerber *et al.* [17] and Echarte *et al.* [29], who observed significant differences in the fatty acid profile in various meats.

According to Echarte *et al.* [29], the contents of only 8 out of 18 FAs did not change after microwave heating where microwave heating hardly modified the fatty acid profiles of both chicken and beef patties. In contrast, in this study, the meat samples that has been grilled and roasted in microwave oven with different time, temperature and internal temperatures had shown the changes in fatty acid compositions. Gerber *et al.* [16] observed that the different cooking processes affected the fatty acid composition by the decreasing of total SFA, MUFA and PUFA due to the melting of fat during cooking.

In addition, Scheeder *et al.* [28] found in fatty acid composition during grilling of beef patties. Minor variations induced by heating in fatty acid composition of beef lipids were reported, among others, by Harris *et al.* [30].

CONCLUSION

Regarding the nutritional fatty acid ratios, heating decreases PUFA/SFA ratio for grilling and increases PUFA/SFA ratio for roasting in mutton and change its n-6/n-3 ratio, relative to raw meat. The fact that cooking seems to affect the different families of FAs in a similar way may indicate that this reduction is due to alteration of the samples during cooking. More effort should be directed to expanding food composition tables to additionally include values for different degree of heating process. This is particularly important in view of the recommendation for cooking methods suitable for the meat, given by a number of health organizations.

ACKNOWLEDGEMENT

This work has been supported by the Faculty of Science and Technology, Universiti Sains Islam Malaysia and IHRAM.

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