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Effect of superheated steam cooking on fat and fatty acid composition of chicken sausage

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Abstract

The influence of superheated steam cooking on fat and fatty acid composition of chicken sausage were investigated at various temperatures (150, 200, and 250°C) with different time domains (2-6 min). It has been found that the fat content of raw sample was higher than that of all cooked samples. The total fat content of cooked sample, showed a linear decreasing with time at all investigated temperatures. Superheated steam produce changes in saturated fatty acid (SFA), monounsaturated fatty acid (MUFA), and polyunsaturated fatty acid (PUFA) in which their values were found to decrease in cooked samples. When different cooking conditions (temperature, time) were applied, the fatty acids were decreased as the time and temperature increased. The PUFA and MUFA were less prone to decrease at 150°C, while at this temperature there was a remarkable loss in SFA content. This cooking method considerably reduced the level of fat and SFA which have a positive effect on health. In addition it could imply a great choice for consumers to choose the healthier technique for cooking food.

Introduction

During the past twenty five years, the partnership between diet and health has been extensively studied and increasing numbers of consumers have been encouraged to enhance their eating habits (Juárez *et al*., 2009). Most current dietary guidelines recommended that the daily consumption of total fat for individuals with normal blood levels of cholesterol should be no more than 30% from the total calorie consumption that of saturated fat should be no in excess of 10% of the total calorie intake and cholesterol intake below 300 mg/day (Nishida *et al*., 2004; Leosdottir *et al*., 2005).

Meat and meat products are considered a vital source of vitamins and trace ingredient, which considerably contributes to the daily intakes of numerous nutrients that are essential for optimal development and growth (Gerber *et al*., 2009). However, the consumption of some meat ingredients (e.g. fat, saturated fatty acid (SFA), cholesterol, and sodium) has been related with a higher risk of major chronic diseases (e.g. ischemic heart disease, cancer, hypertension and excessive weight) (López-López *et al*., 2011; Mazaheri Tehrani, 2012). Chicken sausages considered as are very popular and highly consumed in many countries found to be a good source of polyunsaturated fatty acid (PUFA) compared to pork and beef sausage. This is because it has a great nutritional value and high level of PUFA compared to red meat, which has a remarkable effect on health (Khaksar *et al*., 2010; Issara *et al.*, 2014). In addition Poultry products are universally popular, because they are not subject to cultural or religious constraints and the meat itself is perceived as wholesome, healthy and nutritious, being relatively low in fat n fat and with more desirable unsaturated fatty acid content (Naveena *et al*., 2012).

Fat and fatty acid composition of meat are concerned among consumers due to their importance for nutritional value and health (Wood *et al*., 2004; Idrus *et al.*, 2013). The SFA and trans fat have already been identified by the international dietary authorities as major targets for diet reduction (WHO, 2003). Remarkable reductions in these particular nutrients, as well as an enhance within the PUFA content, especially n-3 PUFA at the expense of n-6 PUFA, could have a noticeable effect on public health improvement (HMSO, 1994). In fact, a valuable amount of PUFA can be provided by Ruminant meat specifically n-3 fatty acid in the human diet (Alina *et al*., 2012). On the other hand, it is renown that the low PUFA/SFA and high n-6/ n-3 ratios of some meats contribute to the imbalance in the fatty acid

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intake of today's consumers (Wood *et al*., 2004).

Chicken sausage has to be cooked before being consumed to a chief palatable, digestible and safe product. However, heat treatment can lead to undesirable change, such as a reduction in the nutritional value, alteration in fatty acid composition and production of toxic compounds mainly due to lipid oxidation and losses of vitamins and minerals (Danowska, 2009; Gerber *et al*., 2009; Cox *et al*., 2012). Various cooking methods were adapted for cooking meat including grilling, roasting, microwave oven cooking, conventional oven cooking, deep frying and boiling (Baggio and Bragagnolo, 2006; Serrano *et al.*, 2007; Juárez *et al.*, 2010; Alina *et al*., 2012). However, superheated steam may offer an alternative cooking method. Superheated steam is generated from the addition of sensible heat to water, this lead to increase its temperature over boiling point or saturation temperature at the given pressure (Zzaman *et al*., 2013a). In contrast to saturated steam, a drop in temperature will not happen in condensation of the steam as long as the temperature is still higher than the saturation temperature at the processing pressure (Cenkowski *et al*. 2007; Zzaman *et al.*, 2013b). Various products have been processed with superheated steam such as spent grains (Tang *et al*., 2005), potato chips (Kingcam *et al.*, 2008), Asian noodles (Pronyka *et al*., 2008). Sweet potato (Hatamipour *et al*., 2007), chicken meat (Nathakaranakule *et al.*, 2007), pork slices (Saadchom *et al*., 2011) and oat goat (Head *et al*., 2011). It was stated that the utilization of superheated steam doesn't cause drying only but it creates other changes in product such as protein denaturation, starch gelatinization, enzyme destruction, changes in color and texture, and deodorization. These characteristics could possibly be employed in both heating and drying food (Head *et al*., 2010; Head *et al*., 2011). Somjai *et al.* (2009) found that superheated steam could produce better quality of products, such as good colour, high porosity and high retention of vitamin C. In addition, superheated steam offered advantages such as, an oxygen free environment which lower the percentage of oxidation and nutrient loss, improve thermal degradation due to the increase in heat transfer, improve energy efficiency and accelerated drying rate (Cenkowski *et al*., 2007; Somjai *et al*., 2009).

The effect of various cooking methods on fat and fatty acid in meat products have been widely investigated in the literatures (Baggio and Bragagnolo, 2006; Alfaia *et al*., 2010; Danaé Larsen, 2010; lina *et al*., 2012).To the best of our knowledge, little information was available in the literatures on the effect of superheated steam on fat and fatty acid composition. The aim of the present work, therefore, was to determine the effect of superheated steam oven cooking on fat and fatty acid content in chicken sausage.

Materials and Methods

Sample preparation

Ready-to-cook commercial chicken sausage (chicken cocktail sausage) was supplied from a local hypermarket. The chicken sausage was packaged in polyethylene bags of 800g per pack and was transported directly to the laboratory. The chicken sausage was held under frozen conditions (-18 to -20°C) in a freezer until the cooking process. Then it taken out from the freezer and thawed for 8 hours in a chillier at 5°C prior to the cooking process. Each individually chicken sausage weighs approximately 11g and was cooked using the SHARP superheated steam oven (AX-1500) with temperatures : 150^{o}C for (4,5,6) min, 200^{o}C for (3,4,5) min and 250^{o}C for (2,3,4) min.

Determination of moisture content, total fat and cooking loss

The moisture content was determined in accordance with the standard method of AOAC (2000). Moisture was quantified by weighing 10 g of sample in aluminium dish and kept in an oven drying at 105^{o}C for overnight. Cooking loss was determined by the difference in weight before and after cooking, and it expressed as percentage of the original weight as shown in Eq. 1:

$$\text{Cooking loss (\%)} = \frac{\text{Weight of sample before cook (g)} - \text{Weight of cooked sample (g)}}{\text{Weight of sample before cook (g)}} \times 100 \quad (1)$$

The fat content of the sample was determined using soxhlet extraction with petroleum ether as a solvent (AOAC, 2000).

Fatty acid analysis

Fatty acid methyl ester (FAME) was prepared according to the method of Mondello *et al.* (2006). A twenty µL of crude oil was extracted from chicken sausage samples and trans-esterified in a Pyrex tube by using 200 µL of borontrifluoride-methanol (20% BF3) reagent then heated for 30 min at100°C. After cooling, 200 µL of n-hexane and 800 µL of distilled water were added to the mixture, which was then agitated manually for 1 min and centrifuged for 2 min. Approximately 100 µL of the upper n-hexane layer was transferred to a 150 µL glass insert for 2 ml vials after diluting the extracted hexane to obtain

a suitable chromatographic response. Fatty acids were identified by comparing the retention times of FAME mixture with the standard Myristic acid palmitic acid, stearic acid, oleic acid, linoleic acid, eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA). The results of fatty acid composition were expressed as area percentage. The fatty acid composition of chicken sausage triacyglyserol was directly analyzed using Gas Chromatography (GC) after methylesterification. One µL of each FAME sample was injected (split ratio 15:1) into a GC 17 A-SHIMADZU Gas Chromatography (Shimadzu Scientific Inc., USA) with flame ionization detector (GC-FID). A BPX 70 (SGE, Australia) column consisting of a 30 m x 0.32 mm fused silica capillary coated with 70% cyanopropyl polysilphenylene-siloxane of 0.25 µm film thickness was used, with Hydrogen as the carrier gas at constant linear velocity (28 cm/s). The injector temperature was 250°C and the detector temperature 280°C. The oven was programmed as follows: 80°C for 2 min, 5°C/min to 200°C for 10 min and 10°C/min to 230°C for a further 10 min. Fatty acid were grouped as follows : saturated (SFA) , mono (MUNA) and poly (PUFA) fatty acids.

Statistical analysis

All the analyses were carried out in triplicate for each sample and the data analysis was carried out using ANOVA followed by post hoc analysis using Duncan multiple comparison analysis. All data were analyzed using SPSS (Statistical Package for Social Science) software version 17.0 (IBM Corporation, Armonk, New York 10504-1722, United States).

Results and Discussion

Moisture content, cooking loss and fat content

In general, different heating techniques have been applied to meat products to enhance its hygienic quality by inactivation of pathogenic microorganisms to improve its taste and flavor, and increase shelf life (Juárez *et al*., 2009; Latip *et al*., 2013). The thermal processing result in thermal denaturation in which meat proteins contract leading to a considerable weight loss, and these losses primarily in the form of water and fat. Water is usually lost either by evaporation through the crust or as drip, while fat is only lost exuded from the meat as drip (Braeckman *et al.*, 2009).

The percentage of moisture content, cooking loose and fat content for chicken sausage before and after cooking are shown in Table 1. There was a significant ($p < 0.05$) reduction in moisture content for all cooked samples, in which a linear decrease ($p < 0.05$) in moisture content was observed as the cooking time increase. Thermal treatments help in decreasing the water content in meat, water might be displaced due to heat-induced protein denaturation during cooking. Consequently, causes less water being entrapped within the protein structures held by capillary forces (Juárez *et al*., 2010).

Table 1. Moisture, cooking loss and fat content of raw and cooked chicken sausage

Sample	Moisture %	Cooking loose%	Fat (%)
Raw	64.140 ±0.01^{h}	-	31.85 ± 0.02^{f}
SHS150°C-4 min	63.196 ±0.23^{g}	5.91 ± 0.19^{a}	31.51 ± 0.05^{f}
SHS150°C-5min	61.893 ±0.01^{f}	6.16 ± 0.1^{a}	31.48 ± 0.05^{f}
SHS150°C-6min	61.233 ±0.17^{e}	6.81± 0.07^{b}	30.19 ± 0.04^{e}
SHS200°C-3min	61.243 ±0.43^{ef}	6.41± 0.21^{b}	31.03 ± 0.07^{f}
SHS200°C-4min	60.666 ±0.1^{d}	7.53 ± 0.07^{c}	28.20 ±0.04^{d}
SHS200°C-5min	60.125 ±0.02^{c}	8.04 ± 0.08^{d}	27.44 ± 0.09^{bc}
SHS250°C-2 min	60.109 ± 0.21^{cd}	7.59± 0.1^{c}	31.01 ± 0.1^{f}
SHS250°C-3 min	58.433 ±0.09^{b}	9.62 ± 0.1^{e}	27.14 ± 0.1^{b}
SHS250°C-4min	57.260 ±0.10^{a}	10.06±0.1^{f}	26.35 ± 0.04^{a}

$^{a-h}$ Different letters in column indicate significant differences ($p< 0.05$)
*SHS- Superheated steam oven cooking

Cooking losses were mainly caused by water and fat loss during thermal treatment of food. These losses rely upon the mass transfer process during thermal treatment (Vittadini *et al*., 2005; Serrano *et al*., 2007; Gerber *et al*., 2009) which often is influenced by the characteristics of the cooking procedure (i.e. heating rate, final cooking temperature, time, etc.) and to the characteristics of raw meat (Alfaia *et al*., 2010). There was a gradual increase in cooking loose ($p < 0.05$) with time and temperature. Normally, this is because high temperature with longer cooking time promote the drained of juice meat. As indicated in the Table 1, there was greater cooking loss at temperature of 250°C (4 min) than those found at temperatures of 150°C and 200°C for identical cooking time. Similar finding has been observed in other similar work of Vasanthi *et al*. (2007) and Sanghoon (2011).

Fat content in chicken sausage was exhibited a significant difference ($p < 0.05$) among treatment. Compared to raw sausage, there was a considerable decrease in fat content after cooking, in which a maximum decrease in fat was found at high cooking

Table 2. Fatty acid composition (% of total fatty acids) in raw and cooked chicken sausage

		Superheated steam Cooking Temperature (°C)								
Fatty Acid	Raw	150			200			250		
		4 (min)	5 (min)	6 (min)	3 (min)	4 (min)	5 (min)	2 (min)	3 (min)	4 (min)
C14:0	1.36±0.02^{g}	1.317±0.05^{fg}	1.273±0.05^{de}	1.211±0.02^{ef}	1.305±0.05^{fg}	1.155±0.07^{d}	0.985±0.01^{a}	1.295±0.05^{fg}	0.824±0.08^{b}	0.697±0.04^{a}
C15:0	0.308±0.01^{a}	0.295±0.01^{a}	0.289±0.02^{a}	0.2886±0.02^{a}	0.2943±0.03^{a}	0.2826±0.01^{a}	0.2766±0.05^{a}	0.3026±0.05^{a}	0.299±0.03^{a}	0.2840±0.03^{a}
C16:0	23.65±0.09^{g}	22.21±0.09^{f}	21.03±0.12^{d}	20.81±0.08^{d}	22.163±0.15^{e}	20.033±0.11^{c}	19.65±0.27^{b}	21.83±0.20^{e}	20.19±0.05^{d}	19.18±0.14^{a}
C18:0	5.53±0.01^{g}	5.335±0.09^{f}	5.066±0.05^{e}	4.951±0.05^{e}	5.033±0.05^{e}	4.722±0.11^{d}	3.873±0.09^{b}	4.473±0.23^{d}	3.223±0.02^{a}	3.02±0.05^{a}
C20:0	0.25±0.32^{g}	0.204±0.07^{f}	0.199± 0.01^{df}	0.168±0.04^{ef}	0.199±0.01^{de}	0.1393±0.01^{cd}	0.1216±0.02^{bc}	0.202±0.05^{f}	0.099±0.01^{ab}	0.086±0.04^{a}
C16:1	5.14±0.06^{h}	4.773±0.02^{g}	4.303 ± 0.04^{e}	4.116±0.02^{g}	4.753±0.05^{g}	3.846±0.05^{d}	3.29±0.12^{c}	4.73±0.09^{g}	4.38±0.13^{b}	3.88±0.12^{a}
C18: 1n9	41.50±0.04^{h}	41.415±0.15^{gh}	41.137± 0.08^{g}	41.03±0.01^{gh}	39.47±0.08^{e}	38.36±0.07^{c}	38.04±0.07^{fg}	39.19±0.03^{d}	37.18±0.01^{b}	36.73±0.06^{a}
C18: 1n9 trans	0.24±0.03^{b}	0.237±0.01^{ab}	0.235±0.05^{ab}	0.228±0.01^{ab}	0.246±0.02^{ab}	0.214±0.01^{ab}	0.211±0.08^{ab}	0.232±0.023^{ab}	0.208±0.05^{ab}	0.191±0.07^{ab}
C18:3n-3	2.56±0.19^{a}	2.555±0.67^{a}	2.54±0.03^{a}	2.50±0.02^{a}	2.466±0.23^{a}	2.44±0.03^{a}	2.44±0.01^{a}	2.45±0.22^{a}	2.44±0.01^{a}	2.43±0.07^{a}
C18:2n-6	17.19±0.17^{d}	16.98±0.03^{cd}	16.35±0.04^{bc}	16.21±0.04^{b}	16.52±0.56^{bc}	15.99±0.09^{ab}	15.82±015^{ab}	16.24±0.88^{b}	15.44±0.08^{a}	15.32±0.06^{a}
C20:3n-6	0.26±0.01^{a}	0.265±0.05^{a}	0.264±0.05^{a}	0.263±0.05^{a}	0.264±0.06^{a}	0.262±0.04^{a}	0.261±0.03^{a}	0.264±0.02^{a}	0.261±0.01^{a}	0.26±0.06^{a}
C20:5(n3) EPA	0.166±0.09^{f}	0.1476±0.06^{ef}	0.133±0.03^{cd}	0.123±0.02^{b}	0.1430±0.03^{ef}	0.1313±0.06^{cd}	0.1201±0.01^{b}	0.1470±0.01^{ef}	0.11098±0.01^{a}	0.1090±0.03^{a}
C22:6(n3) DHA	0.13±0.01^{e}	0.106±0.02^{de}	0.118±0.04^{cd}	0.106±0.03^{be}	0.123±0.02^{de}	0.102±0.09^{b}	0.099±0.07^{ab}	0.121±0.0.13^{de}	0.085±0.07^{a}	0.084±0.04^{a}

$^{a-h}$ Different letters in the same row indicate significant difference ($p< 0.05$)
-Values are means ± SDs of triplicate determinations.

temperature (250°C) and long time (4 min). High cooking temperature make the meat juice run out leads to melted fat release from the surface. Similar finding has been found by Gerber *et al.* (2009) when they studied the effect of cooking temperature and time on fat content of meat. Various investigations, reported that longer cooking time at high temperature resulted in greater cooking, moisture and fat loss (Serrano *et al*., 2007; Braeckman *et al.*, 2009; Sanghoon, 2011). On the other hand, other author's Liu *et al.* (1991) and Berry (1994) reported that the fat content might be increase as the cooking loss increased. However, others have reported no such findings (Serrano *et al.*, 2007; Alina *et al*., 2012).

Fatty acid composition

The effect of heat treatment on fatty acid composition of various types of meat and their products varies among studies (Heymann *et al.*, 1990; Baggio and Bragagnolo, 2006). These variations in the fatty acid composition of raw and cooked samples have already been reported by Juárez *et al.* (2009), Alfaia *et al*.(2010), Danaé Larsen (2010), Juárez *et al*. (2010), and Alina *et al*. (2012). Fatty acid composition of raw and cooked chicken sausage are listed in Table 2.

For the illustration purpose, Figure 1,Figure 2, and Figure 3 shows the total SFA, PUFA, MUFA, n-6/n-3, and PUFA/SFA in raw as well as the cooked samples. For raw samples, MUFA was the most abundant fatty acid (48.19%) followed by SFA (31.098 %) and PUFA (20.314 %). Same trend was also apparent with cooked samples. These results are in agreement with Baggio and Bragagnolo (2006). In which, they analyzed the fatty acid composition of chicken sausage and they found that MUFA had the highest percentage of the total fatty acid followed by SFA and PUFA. The MUFA were dominated by oleic acid (C18: 1) and palmitoleic acid (C 16: 1). The PUFA was dominated by linoleic acid (C 18: 2n-6) as the most abundant omega -6 fatty acid and α- linoleic acid (C 18: 3n-3) as the most abundant omega-3 fatty acid, and the SFA was dominated by palmitic acid (C 16: 0) and stearic acid (C18: 0).

The analysis exhibited significantly ($p < 0.05$) lower SFA MUFA and PUFA than that found in the raw samples. The decrease in SFA was related to decrease in (C16:0), (C18:0), and (C14:0). While, the decrease in MUFA was related to the decrease in (C16:1), (C18:1n9c). Also, the decrease in PUFA was related to decrease in (C18:2n-6), EPA and DHA. However, there was no significant ($p > 0.05$) effects of cooking temperature on the (C20:3n-6) and (C18:3n-3) contents.

At superheated steam temperature of 150°C, the SFA were decreased from 6.02 to 13.42 % as the time

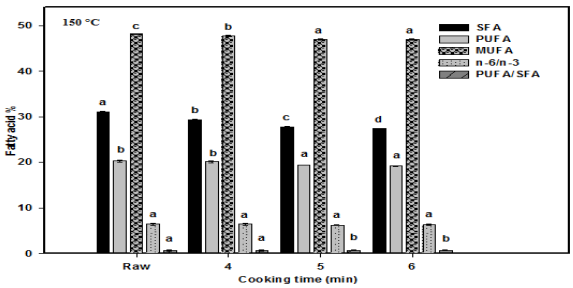

Figure 1. Effect of superheated steam oven cooking on fatty acid composition (% of total fatty acid) at 150°C. Different letter indicates significant difference ($p< 0.05$). Each value is presented as mean ± standard deviation (n = 6). Means above each bar with different letters differ significantly ($P< 0.05$). Where each abbreviation is as follows: SFA: saturated fatty acids; MUFA monounsaturated fatty acids; PUFA polyunsaturated fatty acid; n-3: omega-3 fatty acid and n-6: omega-6 fatty acid

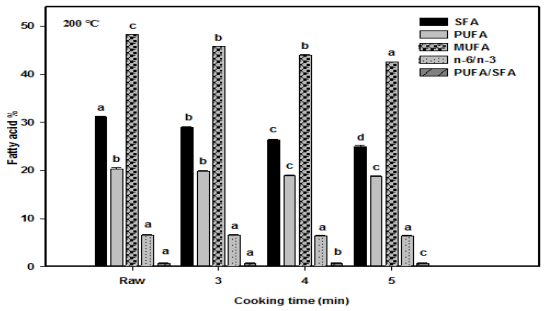

Figure 2. Effect of superheated steam oven cooking on fatty acid composition (% of total fatty acid) at 200°C. Different letter indicates significant difference ($p< 0.05$). Each value is presented as mean ± standard deviation (n = 6). Means above each bar with different letters differ significantly ($P < 0.05$). Where each abbreviation is as follows: SFA: saturated fatty acids; MUFA monounsaturated fatty acids; PUFA polyunsaturated fatty acid; n-3: omega-3 fatty acid and n-6: omega-6 fatty acid

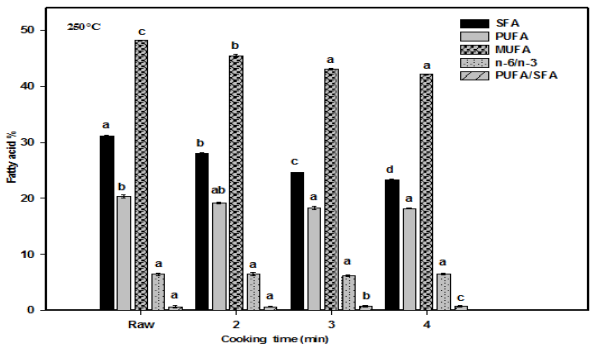

Figure 3. Effect of superheated steam oven cooking on fatty acid composition (% of total fatty acid) at 250°C. different letter indicates significant difference ($p< 0.05$). Each value is presented as mean ± standard deviation (n = 6). Means above each bar with different letters differ significantly ($P < 0.05$). Where each abbreviation is as follows: SFA: saturated fatty acids; MUFA monounsaturated fatty acids; PUFA polyunsaturated fatty acid; n-3: omega-3 fatty acid and n-6: omega-6 fatty acid

increased from 4 to 6 min. While, the content of SFA at 200°C was decreased from 7.3 to 24.89 % as the cooking time increased from 3 to 5 min. Also, their values were found to decrease at 250°C in the range of 10.7 to 33.75% at time domains from 2 to 4 min. At cooking temperature of 150°C, the MUFA were found to decrease from 0.97 to 2.59 % when cooking time increase from 4 to 5 min. However, the losses in MUFA values were slightly decreased at cooking time of 6 min. The content of MUFA at 200°C was decreased in the range of 5.33 to 13.41 % with time (3 to 5 min). At 250°C, the MUFA exhibited decreasing from 6.05 to 14.43 %. The PUFA in the cooked samples were also found to decrease in which it shows decreasing from 0.92 to 5.79% at 150°C. At superheated steam temperature of 200°C, the PUFA showed decreasing from 4.07 to 8.5%. The same trend was found at 250°C in which the decreasing percentage was from 5.97 to 12.10%. However, there is no significant difference ($p > 0.05$) in PUFA between raw sample and that cooked at 4, 5, and 6 min for 150,200, and 250°C respectively.

As indicated, the decreasing of SFA, MUFA, and PUFA were rose as the temperature of superheated steam oven increased. Also, the maximum decrease in fatty acid composition was observed at high cooking temperature of 250°C by longer residence time. This reduction in fatty acids might be due to reduction in overall fat contents of the examined samples. Similar trends were recorded by other researchers Gerber *et al*. (2009) and Alina *et al.* (2012), in which they acquired the decreasing in total SFA, MUFA and PUFA to the melting of fat during cooking process. The analysis of the results indicated that there were a great decrease in SFA and MUFA compared to PUFA. In fact, this phenomenon is expected due to an oxygen free environment of the superheated steam. In which, the absence of oxygen in superheated steam oven hinder the oxidation of PUFA. The decreasing in SFA and MUFA was also recorded by other researcher. For instance, Juárez *et al.* (2010) found that the SFA and MUFA are largely represented in neutral lipids and are more prone to migration compared to PUFA. Those authors Ono *et al.* (1985) and Gerber *et al.* (2009) found that the unsaturated fatty acids, mainly PUFA, are less affected by cooking considering they are part of the membrane structure. Thus, the relative change in fatty acid composition could be explained by lipid losses comprising especially triacylglycerols of adipose tissues with relatively more saturated than unsaturated fatty acids. Inspection of the drip (Igene *et al*., 1981) during the cooking (in the absence of phospholipid) of beef and chicken contained mainly triglycerides, indicating that the phospholipids

remained bound to the membrane. However, the conventional cooking method (Alfaia *et al.*, 2010) resulted in a higher SFA and MUFA with lower proportions of PUFA. This has been explained in light of the higher affinity of PUFA to the oxidation compared with SFA and MUFA. Additionally, Baggio and Bragagnolo (2006) found that there was no significant effect in fatty acid composition when conventional cooking (at approximately 220°C and cooking time of 25 min) was utilized to chicken sausage samples.

The ratios of PUFA/SFA and n-6/n-3, which are indices widely used to evaluate the nutritional value of fat for human consumption. According to some nutritional recommendations (HMSO, 1994), the PUFA/SFA ratio in human diets should be above 0.45 and the n-6/n-3 ratio should not exceed 4.0. In the present investigation, the cooked samples showed significantly higher ($P < 0.05$) PUFA/SFA ratio, and was over the minimum recommended value. Also, the ratio of n-6/n-3 ($p > 0.05$) was not affected by cooking of chicken sausage, which ranged between (6.47%- 6.56%) that is higher than the recommended value.

Conclusion

The influence of superheated steam oven cooking on fat and fatty acid composition of chicken sausage were investigated. Various superheated steam cooking temperatures (150, 200, and 250°C) were applied at different time domains. The results showed that the total fat content of raw sample was found to be higher than that of all cooked samples and exhibited a linear decreasing with time at all investigated temperatures. It has been found that there were a remarkable reduction in SFA, MUFA and PUFA composition after cooking. These decreases in the fatty acid were found to increase with the investigated temperatures (150 - 250°C). The highest losses were observed at superheated steam temperature of 250°C and 4 min of cooking time, in which the reduction of SFA, MUFA, and PUFA were found to be 33.75, 14.43 and 12.1%, respectively. At low residence time, the PUFA and MUFA possessed an insignificant decrease at all investigated temperatures. However, the behavior of SFA showed significant decrease at all investigated conditions. The PUFA and MUFA were less prone to decrease at 150°C, while at this temperature there was a remarkable loss in SFA content. It might be concluded that the low cooking temperature (150°C) is more preferable for preserve the unsaturated fatty acid. The analysis showed that the utilization of superheated steam in cooking had a great impact on fat reduction for chicken sausage; consequently it could lower the serum cholesterol concentration in blood and reduce the obesity. Moreover, the high reductions in SFA during cooking have positive influence on human health. Therefore, the application of superheated steam in household cooking could induce new, best, and safety method of cooking for human consumptions and health's improvement.

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