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Effect of cooking methods on nutritional quality of chicken meat

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Abstract
A study was carried out to evaluate the nutritional effect of *Sous vide* cooking and pressure cooking on broiler chicken meat. Broiler chicken breast meat subjected to two cooking methods (*Sous vide* cooking and pressure cooking). Fresh and cooked meat samples evaluated for the proximate composition, amino acid profile and fatty acid profile of raw and cooked broiler chicken meat under different conditions content. Results of the study revealed that there was a highly significant difference (<0.01) in moisture, protein, fat, gross energy of fresh, pressure cooked and *sous vide* cooked meat. But no significant difference (*P*>0.05) in total ash content of fresh and pressure-cooked meat. Most of the amino content increased significantly (<0.01) after cooking, except arginine, methionine in both cooking methods and lysine and glutamic acid content in *Sous vide* cooking decreased significantly. The most abundant fatty acids found in raw samples were palmitic acid (32.12%) oleic acid (28.49%), linoleic acid (14.51%), stearic acid (7.44%), Myristic acid (6.22%) and in cooked meat were oleic acid (36.52 to 37.57%), palmitic acid (21.05 to 24.77%), linoleic acid (20.17 to 23.5%), stearic acid (6.35 to 7.23%) and Palmitoleic acid (3.16 to 4.22%). Regarding total SFAs, significant reduction were found in the heat-treated chicken meat samples compared to the raw meat. In cooking methods shows significant decreases noticed in pressure cooked (32.25%) sample compared to *Sous vide* cooked (35.83%) sample. In total MUFA and PUFAs, significant increases were found in the heat-treated chicken meat samples compared to the raw meat, although between cooking methods no significant difference was noticed in MUFA. However, between the cooking methods, pressure cooked sample had a significant higher MUFA value (24.06%) than *Sous vide* cooked sample (21.96%). The PUFA/SFA ratio was determined as 0.35, 0.75 and 0.61 in the raw breast, pressure cooked and *Sous vide* cooked meat samples, respectively.

Keywords: *Sous vide* cooking, pressure cooking, broiler chicken, fatty acid profile

Introduction
Chicken meat and products are a very popular food commodity worldwide, as chicken meat is characterized by low fat, low cholesterol content and high nutritional value (Choi *et al.*, 2011) [1]. The nutritive value of meat is attributed to its high-quality protein, essential fatty acids, important minerals and B complex group of vitamins. Meat protein is superior to plant protein because of its high biological value. Biological value and net protein utility were significantly varied between chicken meat sourced from broiler, spent and desi birds (Sathishkumar, 2019) [2] as well as with the different cooking methods. *Sous vide* (SV) cooking has become one of the most preferred cooking methods because of its convenience and ability to extend the shelf-life of products (Bikiyli *et al.*, 2020) [3]. This method cooks vacuum-sealed raw foods in heat-stable pouches under precisely controlled temperatures (Baldwin, (2012) [4], Kaur *et al.*, 2020) [5]. It can make the sensory quality characteristics of various meat types more uniform and improved, especially tougher meat cuts, compared to the conventional cooking methods (Baldwin, 2012; Roldan *et al.*, 2014; Hwang *et al.*, 2019; Kim *et al.*, 2019) [4, 6-8]. *Sous vide* meat cooked at 60 °C exhibited a greater water-holding capacity and required lower initial and final force to penetrate the meat than meat cooked by conventional oven (Park *et al.*, 2020) [9]. Alfaia *et al.*, (2010) [10] found that the heating time, temperature, cooking method and muscle composition were the important variables, which may influence the final desirable characteristics of meat. Although meat changes induced by cooking have been studied for many years and extensively discussed (Tornberg, 2005) [11] but only few reports have specifically dealt with the influence of different cooking conditions on the amino acid and mineral contents (Wilkinson *et al.*, 2014; Shehab, 2016 and Kim *et al.*, 2017) [12-14]. Moreover, the nutrient composition of cooked meat available in food composition databases is quite limited.

Materials and Methods

The broilers breast used in this study were obtained from the local markets. Their live weight ranged between (1900–2100 g) and the average age 8 weeks. Chicken breast was cut into 20- to 25-mm-thick meat and cooked by *Sous vide* and pressure cooking. *Sous vide* cooked in a thermostatized water bath at 80 °C for 30 minutes, a heating treatment was completed when samples reached an internal temperature of 75 °C, which was monitored during cooking using a digital probe thermometer (Testo thermocouple, Mod. 735-1, Lenzkirch, Germany). Pressure-cooking chicken breast was placed in a pressure cooker and cooked for 10 minutes (reaching 121 °C without holding time). After cooking and cooling, samples were vacuum-packed and stored at 20 °C until laboratory analysis was carried out.

Proximate composition

The proximate composition of chicken meat was determined as per the methods recommended by AOAC (1997) [15]. The crude protein content was determined by the Kjeldahl method, and the crude fat content was determined by the Soxhlet method. The total ash content was determined by ashing the samples overnight at 550 °C. Moisture content was determined by drying the samples overnight at 105 °C.

Fatty acid estimation (%)

Lipid was extracted from the chicken meat following the method of Folch *et al.* (1957) [16]. Fatty acid profile of chicken meat was analysed in measured by gas chromatography (Chemito GC 8610, India) fitted with a SP tm-2380 capillary GC Column (LX I.D 30 m x 0.25 mm, df 0.20 um film thickness and a flame ionization detector. Fatty acid was carried out following the procedure of Wang *et al.* (2000) [17].

Amino acid composition (%)

The amino acid profile of raw and cooked meat were analysed using the standard amino acids at different concentration, provided in the kit (Hewlett Packard). The analysis was done following the procedure of Bruckner *et al.* (1991) [18] in high performance liquid chromatography and a chromatogram was obtained.

Results and discussion

Proximate composition

The mean ± S.E of proximate composition (Moisture, protein, fat, total ash content and energy value) of fresh and cooked meat were presented in Tables 1 along with test of significance.

There was a highly significant difference (<0.01) in moisture, protein, fat, total ash content and energy value of fresh and cooked chicken, except ash content of *Sous vide* cooking was similar to raw meat. The test of significance revealed a decrease in moisture content with a concomitant increase in the other constituents of cooked meat samples of both methods of cooking was noticed in this study which was in congruence with the note made by Nandini *et al.* (2017) [19]. But significantly less moisture loss was observed in *Sous vide* cooking. Moisture loss is more in *Sous vide* cooked chicken at 100 °C for 120 min as compared to chicken sausage subjected to 100 °C for 30 and 60 min (Naveena *et al.*, 2017) [20]. *Sous vide* cooked samples showed the lowest results of moisture loss compared to other cooking methods Silva *et al.* (2016) [21] and increase product yield (Soletska and Krasota, 2017) [22]. Li *et al.* (2017) [23] reported higher cooked internal temperature resulted in higher cooking losses because of the prolonged cooking time, causing extra moisture loss via evaporation and the release of excess juice inside the meat samples.

Cooking process caused an increase in the dry matter of the meat because of the reduction in the water content. This situation is seen in all kinds of meat (Heymann *et al.*, 1990; Cobos *et al.*, 2000) [24, 25]. A very significant (P<0.01) increase in the protein content of the breast meat with cooking (boiling, grilling, pan frying without fat or oil, pan frying with oil, deep-fat frying, oven and microwave) was observed (Oz and Celik, 2015) [26]. Karimian-khosroshahi *et al.* (2016) [27] observed that cooking methods (baking, boiling, microwaving, and frying) were increased protein content of fish. Bastias *et al.* (2017) [28] reported that protein content in both salmon and chilean jack mackerel significantly increased under the different cooking methods (oven cooking, canning, microwaving and steaming). Increasing protein content of pressure cooked and sous cooked chicken samples also recently reported by Nandini *et al.*, (2017) [19] and Głuchowski *et al.*, (2020) [29], respectively. Higher protein content of pressure-cooked sample might be due to higher moisture loss during cooking.

Also, a highly significant difference (<0.01) in fat content between raw and cooked sample. A higher fat content of cooked sample observed by many authors (Verma, 2012, Asmaa *et al.*, 2015, Nandini *et al.*, 2017 and Głuchowski *et al.*, 2020) [30, 31, 19, 29]. Compared to cooking methods, pressure cooked sample had significantly higher value. Higher fat content of pressure-cooked sample might be due to higher moisture loss during cooking. A highly significant difference (<0.01) in ash content between raw and pressure-cooked sample. Ash content was lower in pressure cooked sample compared to raw and *Sous vide* cooked sample. This result disagreement with Nandini *et al.* (2017) [19]. They revealed increased ash content in cooked meat. Bastias *et al.* (2017) [28] reported the ash content showed no significant changes after cooking in Salmon and Chilean jack mackerel. Verma (2012) [30] reported ash content showed no significant changes in different cooking methods on quality of broiler chicken meat. Silva *et al.* (2016) [21] concluded desalted and *Sous vide* cooked chicken charqui shown significant lower ash content.

Gross energy content of cooked meat shown significant difference (<0.01) compared to raw meat (1481 Kcal/kg). Higher gross energy value was noticed in pressure cooked (2111 Kcal/kg) chicken samples compared to *Sous vide* cooked (1635 Kcal/kg) samples. Cooked meat showed lower water contents and consequently higher energy values than raw meat (Brugiapaglia and Destefanis, 2012) [32]. Nandini *et al.* (2017) [19] also reported similar results in pressure cooked chicken breast.

Table 1: Mean (±) SE of proximate composition of raw and cooked broiler chicken meat under different conditions

Parameters	Control	Treatments		Overall treatment mean	F Value	P Value
		Pressure Cooking (T1)	*Sous vide* cooking (T2)			
Moisture (%)	73.27±0.31[c]	65.24±0.51[a]	71.01±0.09[b]	69.84±0.84	141.137	0.000
Crude Protein (%)	24.22±0.16[a]	31.83±0.57[c]	26.21±0.08[b]	27.42±0.8	132.320	0.000
Ether Extract (%)	0.65±0.01[a]	0.84±0.01[c]	0.81±0.01[b]	0.77±0.02	100.246	0.000
Total Ash (%)	1.28±0.01[b]	1.15±0.01[a]	1.28±0.01[b]	1.24±0.02	39.447	0.000
Gross Energy Kcal/kg	1481±22.59[a]	2111±15.18[c]	1635±18.63[b]	1742.33±65.85	297.350	0.000

Means bearing different superscripts between columns differ significantly.
n= 3 for each treatment.

Table 2: Mean (±) SE of amino acid profile of raw and cooked broiler chicken meat under different conditions

Amino acid profile	Control	Treatments		Overall treatment mean	F Value	P Value
		Pressure Cooking (T1)	*Sous vide* cooking (T2)			
Essential Amino acid						
Arginine	6.87±0.12[c]	3.83±0.08[a]	4.35±0.08[b]	5.02±0.33	309.118	0.000
Histidine	9.84±0.10[a]	13.95±0.14[c]	11.24±0.10[b]	11.68±0.42	320.441	0.000
Isoleucine	13.62±0.06[a]	20.76±0.03[c]	15.59±0.12[b]	16.66±0.73	2264.524	0.000
Leucine	20.89±0.15[a]	31.96±0.18[c]	24.63±0.23[b]	25.83±1.12	887.080	0.000
Lysine	24.09±0.20[b]	35.92±0.13[c]	21.54±0.16[a]	27.18±1.52	2151.883	0.000
Methionine	1.71±0.03[c]	1.64±0.07[b]	0.97±0.03[a]	1.44±0.09	75.833	0.000
Phenyl alanine	11.80±0.11[a]	16.17±0.07[c]	13.53±0.15[b]	13.83±0.44	368.448	0.000
Threonine	12.97±0.11[a]	18.56±0.05[c]	14.7±0.08[b]	15.41±0.57	1198.448	0.000
Valine	4.04±0.08[a]	6.55±0.05[c]	4.56±0.05[b]	5.05±0.26	453.824	0.000
Non-essential Amino acid						
Alanine	3.65±0.08[c]	0.27±0.00[a]	0.67±0.02[b]	1.53±0.37	1521.471	0.000
Aspartic acid	4.99±0.09[a]	36.31±0.06[c]	7.12±0.09[b]	16.14±3.47	47225.682	0.000
Glutamic acid	11.75±0.16[b]	56.94±0.07[c]	2.92±0.13[a]	23.87±5.74	52522.333	0.000
Glycine	13.99±0.05[a]	19.35±0.03[c]	15.04±0.05[b]	16.13±0.56	3915.682	0.000
Serine	11.24±0.05[a]	17.12±0.05[c]	13.6±0.12[b]	13.98±0.59	1443.788	0.000
Tyrosine	13.67±0.12[a]	22.35±0.12[c]	20.27±0.08[b]	18.76±0.90	1712.955	0.000

Means bearing different superscripts between columns differ significantly.
n= 3 for each treatment.

Amino acid profile

The differences in amino acid profile of broiler chicken before and after cooking were presented in Tables 2 and observed significant difference between pressure and *Sous vide* cooked sample. Most of the amino content increased significantly (<0.01) after cooking, except arginine, methionine in both cooking methods and lysine and glutamic acid content in *Sous vide* cooking decreased significantly. The resulting loss of moisture enhanced the contents of other nutritive components in the cooked meat (Lopes *et al.*, 2015; Tornberg, 2005) [33, 11]. In chicken breasts, arginine, histidine, methionine and valine showed differences by cooking method, and the content amount increased after cooking (Kim *et al.*, 2017) [14]. However, mentioned that amino acid content increased, reducing water retention capacity to thermal denaturation of the protein. The degree of protein denaturation was different for each cooking method temperature and chicken part, demonstrating a difference in protein and amino acid content. Some authors reported that lysine was lost due to the formation of Maillard reaction products by heating, while threonine was converted to other compounds (Sikorski, 2001; Jannat-Ali-pour *et al.*, 2010; Oduro *et al*., 2011;) [34-36]. Among the essential amino acids in chicken, the contents (g/100 g) of lysine, leucine and isoleucine are found within ranges of 21.54 to 35.92, 20.89 to 31.96, and 13.62 to 20.76, respectively. It was reported that lysine was lost by reaction with autoxidizing fat at temperatures below 100 °C, while at high temperatures (i.e. 115–130 °C) the loss was apparently in-dependent of the presence of fat (Lea *et al*., 1960) [37].

Macy *et al.* (1964) [38] found that most free amino acids increased in concentration during cooking of roasts to an internal temperature of 77 °C except for threonine, serine, glutamic acids, histidine and arginine. They attributed this general increase in amino acids content to hydrolysis of protein by photolytic enzymes. Oluwaniyi *et al.* (2010) [39] reported the reduction of total essential amino acid values was more pronounced in the fried samples comparing with the boiled and roasted samples. Histidine and taurine, in particular, have been found to show low retention rates of 69.8% and 52.4% when cooked at 75 °C (Wilkinson *et al.*, 2014) [12]. Veal showed a high retention rate of over 100% for all amino acids when cooked by microwaving, boiling, and grilling, and it has been reported that the cooking method only shows a difference in the leucine rate (Lopes *et al.*, 2015) [33]. Shehab (2016) [13] reported noticeable amounts of sulpher containing amino acids, i.e. leucine, tyrosine, phenylalanine and lysine (as essential amino acids) as well as serine, glycine, alanine, histidine and arginine (as non-essential amino acids) were destroyed, while as slight decrease was noticed in all the other amino acid contents under cooking of chicken breast or thigh meat samples.

The reduction of amino acid content might be attributed to their loss with drippings separated during cooking as well as by the heat destruction. Kim *et al.* (2017) [14] studied the retention rates of the chicken parts varied with the cooking methods, yielding a minimum value of 83% for isoleucine in a roasted wing, 91% for protein in a steamed breast, and 77% for isoleucine and lysine in a roasted leg. Therefore, the protein and amino acid contents of the roasted breast were higher than those of the other cooked (boiling, pan-cooking, pan-frying, deep-frying, steaming, and microwaving), chicken parts. Oshibanjo *et al.* (2019) [40] studied the effect of three cooking methods (frying, boiling and grilling) and three cooking temperatures (80, 90 and 100 °C) on amino acid profile of breakfast sausage. They found that the Breakfast sausage grilled at 80 °C had the highest essential amino acid scores.

Table 3: Mean (±) SE of fatty acid profile of raw and cooked broiler chicken meat under different conditions

Fatty acid profile	Control	Treatments		Overall treatment mean	F Value	P Value
		Pressure Cooking (T1)	*Sous vide* cooking (T2)			
Myristic acid	6.22±0.01[b]	1.73±0.01[a]	1.7±0.03[a]	3.22±0.75	20964.839	0.000
Palmitic acid	32.12±0.17[c]	21.05±0.47[a]	24.77±0.11[b]	25.98±1.63	370.939	0.000
Stearic acid	7.44±0.02[c]	6.35±0.06[a]	7.23±0.01[b]	7.01±0.17	226.469	0.000
Oleic acid	28.49±0.33[a]	37.57±0.16[c]	36.52±0.23[b]	34.19±1.44	391.256	0.000
Linoleic acid	14.51±0.15[a]	23.5±0.22[c]	20.17±0.00[b]	19.39±1.31	853.028	0.000
Linolenic acid	2.05±0.04[c]	0.75±0.03[b]	0.64±0.01[a]	1.15±0.23	671.036	0.000
Arachidic acid	1.43±0.06[b]	0.13±0.01[a]	0.15±0.01[a]	0.57±0.22	502.318	0.000
Behenic acid	1.73±0.00[a]	3.08±0.03[b]	2.23±0.03[c]	2.35±0.20	680.438	0.000
EPA	0.33±0.01[c]	0.08±0.01[c]	0.25±0.02[b]	0.22±0.04	95.109	0.000
DHA	0.37±0.01[a]	0.47±0.02[b]	1.35±0.01[c]	0.73±0.16	2550.806	0.000
Palmitoleic acid	3.63±0.01[b]	3.16±0.01[a]	4.22±0.08[c]	3.67±0.15	137.338	0.000
Total SFA	48.03±0.49[c]	32.25±0.20[a]	35.83±0.35[b]	38.7±2.40	513.379	0.000
Total MUFA	32.07±0.30[a]	40.06±0.33[b]	40.66±0.52[b]	37.6±1.40	148.323	0.000
Total PUFA	17.02±0.34[a]	24.06±0.21[c]	21.96±0.46[b]	21.01±1.06	104.952	0.000
Total UFA	48.98±0.86[a]	64.78±0.27[b]	62.58±0.64[b]	58.78±2.49	179.115	0.000
ω-3	2.65±0.07[c]	1.31±0.03[a]	2.29±0.05[b]	2.08±0.20	192.081	0.000
ω-6	13.99±0.28[a]	23.36±0.29[c]	20.19±0.09[b]	19.18±1.38	397.321	0.000
ω-6 / ω-3	5.29±0.11[a]	17.89±0.14[c]	8.82±0.14[b]	10.67±1.88	2501.515	0.000
PUFA/SFA	0.35±0.01[a]	0.75±0.01[c]	0.61±0.02[b]	0.57±0.06	253.887	0.000
SFA/UFA	0.98±0.01[c]	0.5±0.00[a]	0.57±0.00[b]	0.68±0.08	2096.991	0.000

Means bearing different superscripts between columns differ significantly.
n= 3 for each treatment.

The fatty acid profile of raw, pressure cooked and *Sous vide* cooked chicken meat is displayed in Table 3. The most abundant fatty acids found in raw samples were palmitic acid (32.12%) oleic acid (28.49%), linoleic acid (14.51%), stearic acid (7.44%), Myristic acid (6.22%) and in cooked meat were oleic acid (36.52 to 37.57%), palmitic acid (21.05 to 24.77%), linoleic acid (20.17 to 23.5%), stearic acid (6.35 to 7.23%) and Palmitoleic acid (3.16 to 4.22%).

Regarding total SFAs, significant decreases were found in the heat-treated chicken meat samples compared to the raw meat. In cooking methods shows significant decreases noticed in pressure cooked (32.25%) sample compared to *Sous vide* cooked (35.83%) sample. Dal Bosco *et al.* (2001) [41] reported no differences in the total SFA, total MUFA and total PUFA percentage in raw and cooked (boiled, fried, roasted) rabbit meat. Current results agreement with Gerber *et al.* (2009) [42] found an increase in PUFA/SFA ratio in cooked meat and explained it by the difference in the localization of PUFA and SFA in meat structure. The adipose tissue contains a higher proportion of SFA than PUFA and the decrease in SFA results from lipid losses during cooking (Gerber *et al.*, 2009) [43]. Asmaa *et al.*, (2014) [44] investigated fatty acid composition of chicken sausage at various temperatures (150, 200, and 250 °C) with different time domains (2-6 min). SFA showed a significant decrease in 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. The decrease in SFA in steam-cooked beef in this study corresponds with a higher cooking loss in these samples as compared with *Sous vide*. Total SFA content of the breast meat decreased with boiling, pan frying with oil and deep-fat frying, while other cooking methods caused an increase in total SFA content of the breast meat (Oz and Celik, 2015) [26]. In contrast to this Alfaia *et al.* (2010) [10] found significant differences were observed in the FAs profile in beef meat cooked with three different methods. The authors reported an increase of total SFA in grilled, boiled and microwaved meat compared to the raw samples. According to these authors, some of SFA (14:0, 16:0, 17:0, and 18:0) were significantly higher in cooked meat samples than in the uncooked meat control. They observed a significant increase in the relative proportion of total MUFA (1.9% microwaved, 2.5%-boiled, 3.4%- grilled meat), which occurred after cooking too, resulting mainly from an increase in C18:1. Geese breast muscles subjected to various methods of heat treatment, the Σ SFA percentage increased with grilling, oven cooking, pan-frying without oil, and decreased with water boiling (Oz and Celik, 2015) [26]. Silva *et al.*,2016 [21] reported that there were no differences in saturated fatty acids (SFA) between raw and cooked jerky chicken (grilling, roasting, frying and *Sous vide*). Xiong *et al.* (2020) [43] 3studied the fatty acids content in chicken meat after heating to different temperatures (50°,60°, 70°, 80°, 90°, 100 °C). They observed saturated fatty acids were increased. However Werenska *et al.* (2021) [44] studied the effect of water bath cooking (WBC), oven convection roasting (OCR), grilling (G), pan-frying (PF) on the fatty acid profile of goose meat (muscles with and without skin). The sum of SFA was significantly higher in cooked samples for both kinds of meat than in raw ones. The cooked samples with skin had a lower increase in total SFA than the skinless meat.

Regarding total MUFAs, significant increases were found in the heat-treated chicken meat samples compared to the raw meat. The total MUFA content of the raw, pressure cooked, *Sous vide* cooked breast meat were 32.07%, 40.06% and 40.66%, respectively. Cooking process caused an increase in total MUFA, although between cooking methods no significant difference was noticed. Xiong *et al.*, (2020) [43] stated that monounsaturated fatty acids decreased significantly (P<0.05) with the elevation of heating temperature. Werenska *et al.* (2021) [44] reported that boiling (meat without skin) and pan-frying (both kinds of meat) caused a slight decrease, while grilling and oven convection roasting (both kinds of meat) caused an increase of total MUFA compared to raw samples. Oz and Celik, (2015) [26] reported that cooking caused a decrease in total MUFA content of breast meat, whereas total PUFA content increased. On the other hand, total SFA content of leg meat decreased with cooking, while total MUFA content increased.

Regarding total PUFAs, significant increases were found in the heat-treated chicken meat samples compared to the raw meat. However in cooking methods, pressure cooked sample had a significant higher value (24.06%) than *Sous vide* cooked sampe (21.96%). Igene and Pearson (1979) [45] found that cooking caused a decrease in total SFA content in beef and chicken, while total MUFA and PUFA contents of the samples increased with cooking. Rodriguez-Estrada *et al.* (1997) [46] reported that cooking caused a significant increase in PUFA content, while it had no effect on MUFA and SFA content in hamburger. Scheeder *et al.* (2001) [47] found that cooking of meatballs decreased the total SFA content and increased the total MUFA and PUFA contents. On the other hand, cooked beef had lower concentrations of total PUFA (5.8% microwaved, 5.9%-boiled, 7.1%-grilled meat) than raw meat, due to a significant loss of some n-6 and n-3 PUFA (Alfaia *et al.*, 2010) [10]. PUFA, being the part of cell membrane structure (phospholipids) might remain bound to the membrane (Gerber *et al.*, 2009) [42] and therefore its relative proportion increased in the meat. Additionally, in the *Sous vide* samples, the oxidation process was limited due to the evacuation of oxygen during the vacuum- packing process. In contrast, *Sous vide* cooking technique promoted a decrease of PUFA in chicken charqui samples, which may be associated with the long heat exposure of the charqui meat (Silva *et al.*, 2016) [21]. This might prevent FA, especially PUFA, from oxidation and, therefore, their proportion after *Sous vide* treatment did not decrease. Xiong *et al.*, (2020) [43] reported PUFA decreased significantly ($P<0.05$) with the elevation of heating temperature. Moreover, the total PUFA was lower in all cooked samples than in raw meat, wherein this decline was usually higher for skinned meat. The grilled meat was the lowest and pan frying the highest total PUFA content after heat treatment (Werenska *et al.*, 2021) [44].

Hussain *et al.* (2013) [48] concluded that the cooking methods exhibited significant effect on the nutritional attributes and fatty acid compositions of chicken meat. Boiling and frying were healthy cooking practices, whereas grilling and microwave roasting showed negative effects on the protein and fat contents of chicken meat. Microwave cooking was responsible for losing essential fatty acid i.e. linoleic acid to a significant extent. The average value of each of the fatty acids composition in the meat samples with other published data vary because of the many factors which can affect fatty composition of each meat, i.e. geographical location, age, sex, diet, physiological acclimatization, part of carcass used, etc.

During cooking of meat and meat products, several mechanisms can lead to changes in fatty acid composition, such as (1) water loss; (2) lipid oxidation; (3) incorporation of cooking oil in meat pieces and (4) diffusion and exchange of fatty acids between intramuscular fat and cooking oil. During frying process, a replacement of fatty acids from the food fat with those from the cooking oil takes place, altering lipid profile of fried products (Haak *et al.*, 2007) [49].

The PUFA/SFA ratio was determined as 0.35, 0.75 and 0.61 in the raw breast, pressure cooked and *Sous vide* cooked meat samples, respectively. The ratio increased with both cooking methods. Other investigators have also observed similar results in various meat samples (Scheeder *et al.*, 2001) [47]. Dietary intake of unsaturated fatty acids (UFA) has been shown to reduce the risk of cardiovascular disease (CVD) and possibly the incidence of some cancers, asthma and diabetes among other conditions. At the same time, the recommended ratio of polyunsaturated fatty acids (PUFAs) to SFAs (P/S) should be above 0.4, with the normal P/S ratio of meat at around 0.1 (Wood *et al.*, 2003) [50]. Heat treatment caused an increase in the PUFA n-6/n-3 ratio, wherein the lowest value was shown by the *Sous vide* cooked (8.82%) samples and the highest by pressure cooked (17.89%) samples. Other investigators have also observed same trends in various meat samples and cooking methods (Juarez *et al*., 2010; Werenska *et al*., 2021) [51, 44].

Conclusion

Chicken meat is an important food item in the human diet. The increasing production of chickens and their potential use in the home and restaurant need for more detailed information regarding their quality and nutrient retention. Cooking methods have different effects on the values of nutrients of chicken. The obtained results from this study revealed a decrease in moisture content with a concomitant increase in the other constituents of cooked meat samples of both cooking methods. Cooked chicken breast meat contained more essential amino acid than fresh raw chicken meat ($P<0,05$). The recommended ratio of polyunsaturated fatty acids (PUFAs) to SFAs (P/S) should be above 0.4, with the normal P/S ratio of meat at around 0.1. The PUFA/SFA ratio was determined as 0.35, 0.75 and 0.61 in the raw breast, pressure cooked and *Sous vide* cooked meat samples, respectively. Heat treatment caused an increase in the PUFA n-6/n-3 ratio, wherein the lowest value was shown by the *Sous vide* cooked (8.82%) samples and the highest by pressure cooked (17.89%) samples.

Reference

1. Choi YS, Choi JH, Kim HY, Kim HW, Lee MA, Chung HJ, *et al*. Effect of lotus (*Nelumbo nucifera*) leaf powder on the quality characteristics of chicken patties in refrigerated storage. Korean Journal of Food and Cookery Science 2011;31:9-18.
2. Sathishkumar R. Comparison of meat quality and nutrient composition of commercial native chicken, backyard native chicken, commercial broiler and spent layer chicken. M.V.Sc thesis submitted to Tamil Nadu Veterinary and Animal Sciences University Chennai-51. 2019.
3. Bikiyli M, Akoglu A, Kurhan S, Akoglu IT. Effect of different *Sous vide* cooking temperature-time combinations on the physicochemical, microbiological, and sensory properties of turkey cutlet. International Journal of Gastronomy and Food Science 2020;20:100204.
4. Baldwin DE. *Sous vide* cooking: A review. International Journal of Gastronomy and Food Science 2012;1(1):15-30.
5. Kaur L, Hui SX, Boland M. Changes in Cathepsin Activity during Low-Temperature Storage and Sous Vide Processing of Beef Brisket. Food Science of Animal Resources 2020;40:415-425.

6. Roldan M, Antequera T, Hernandez A, Ruiz J. Physicochemical and microbiological changes during the refrigerated storage of lamb loins *Sous vide* cooked at different combinations of time and temperature. Food Science and Technology International 2014;21:512-522.
7. Hwang SI, Lee EJ, Hong GP. Effects of Temperature and Time on the Cookery Properties of Sous-vide Processed Pork Loin. Food Science of Animal Resources 2019;39(1):65-72.
8. Kim YA, Ba HV, Hwang I. Effects of Traditional Sauce Type and Storage Time on Quality Characteristics, Shelf-life and Flavor Compounds of Marinated Pork Cooked by Sous Vide Method. Food Science of Animal Resources 2019;39(3):355-370.
9. Park CH, Lee B, Oh E, Kim YS, Choi YM. Combined effects of sous-vide cooking conditions on meat and sensory quality characteristics of chicken breast meat, Poultry Science 2020;99(6):3286-3291.
10. Alfaia CM, Alves SP, Lopes AF, Fernandes MJ, Costa AS, Fontes CM, *et al*. Effect of household cooking methods on fatty acids conjugated isomers of linoleic acid and nutritional quality of beef intramuscular fat. Meat Science 2010;84:769-777.
11. Tornberg E. Effects of heat on meat proteins—implications on structure and quality of meat products. Meat Science 2005;70:493-508.
12. Wilkinson BH, Lee E, Purchas RW, Morel PC. The retention and recovery of amino acids from pork longissimus muscle following cooking to either 60 °C or 75 °C. Meat Science 2014;96:361-365.
13. Shehab T. Effect of cooking methods on amino acids composition of chicken meat. Theory and practice of meat processing 2016;1(4):11-18.
14. Kim H, Do HW, Chung H. A Comparison of the Essential Amino Acid Content and the Retention Rate by Chicken Part according to Different Cooking Methods. Korean Journal for Food Science of Animal Resources 2017;37(5):626-634.
15. AOAC, Official methods of analysis. 16th edition, 3rd revised, Association of Official Analytical Chemists. Washington, DC. 1997, 1.
16. Folch J, Lees M, Stanley SGH, A simple method for the isolation and purification of total lipids from animal tissues. The Journal of Biological Chemistry 1957;226:497-509.
17. Wang M, Xu YN, Jiang GZ, Li LB, Kuang TY. Membrane lipids and their fatty acid composition in *Nostoc flagelliforme* cells. Acta Botanica Sinica 2000;42:1263-1266
18. Bruckner H, Winter R, Godel H. Fully Automated HPLC separation of DL amino acids derivatized with OPA together with N – isobutryl – cystine – applications to food samples. Chromatographia 1991;32:383-388.
19. Nandini Devi T, Ramani R, Narendra Babu R, Appa Rao V, Ramesh J, Abraham R JJ. Effect of Cooking on Cholesterol and Proximate Composition on Breast and Thigh Muscles of Chicken and Quail Meat. International Journal of Current Microbiology and Applied Sciences 2017;6(10):3700-4703
20. Naveena BM, Khansole PS, Shashi Kumar M, Krishnaiah N, Kulkarni VV, Deepak SJ. Effect of *Sous vide* processing on physicochemical, ultrastructural, microbial and sensory changes in vacuum packaged chicken sausages. Food Science and Technology International, 2017;23(1) :75-85.
21. Silva FA, Ferreira VC, Madruga MS, Estévez M. Effect of the cooking method (Grilling, roasting, frying and sous- vide) on the oxidation of thiols, tryptophan, alkaline amino acids and protein cross-linking in jerky chicken. J Food Science Technology 2016;53(8):3137–3146.
22. Soletska A, Krasota A. Prospects of applying vacuum technology in the manufacture of culinary poultry meat products. Journal Food and Environment Safety 2017;15:3-9.
23. Li K, McKeith AG, Shen C, McKeith RA, Comparison Study of Quality Attributes of Ground Beef and Veal Patties and Thermal Inactivation of *Escherichia coli* O157:H7 after Double Pan-Broiling Under Dynamic Conditions. Foods 2018;7:1.
24. Heymann H, Hedrick HB, Karrasch M, Eggeman MK, Ellersieck MR. Sensory and chemical characteristics of fresh pork roasts cooked to different endpoint temperatures. Journal of Food Science 1990;55:613-617.
25. Cobos A, Veiga A, Diaz O. Chemical and fatty acid composition of meat and liver of wild ducks (*Anas platyrhynchos*). Food Chemistry 2000;68:77-79.
26. Oz F, Celik T. Proximate composition, color and nutritional profile of raw and cooked goose meat with different methods. Journal of Food Processing and Preservation 2015;39:2442-2454.
27. Karimian-Khosroshahi N, Hosseini H, Rezaei M, Khaksar R, Mahmoudzadeh M. Effect of Different Cooking Methods on Minerals, Vitamins, and Nutritional Quality Indices of Rainbow Trout (*Oncorhynchus mykiss*). International Journal of Food Properties 2016;19:2471-2480.
28. Bastias JM, Balladares P, Acuna S, Quevedo R, Munoz O. Determining the effect of different cooking methods on the nutritional composition of salmon (*Salmo salar*) and chilean jack mackerel (*Trachurus murphyi*) fillets. 2017. PLoS One 2017;12(7) :e0180993
29. Gluchowski A, Czarniecka-Skubina E, Buła M. The Use of the *Sous vide* Method in the Preparation of Poultry at Home and in Catering-Protection of Nutrition Value Whether High Energy Consumption. Sustainability. 2020;12:7606.
30. Verma A. Effect of different cooking methods on quality of broiler chicken meat chat. Haryana veterinary 2012;51:38-40
31. Asmaa AA, Zzaman W, Tajul AY. Effect of superheated steam cooking on fat and fatty acid composition of chicken sausage. International Food Research Journal 2015;22:598-605.
32. Brugiapaglia A, Destefanis G. Effect of cooking method on the nutritional value of Piedmontese beef. 58th International Congress of Meat Science and Technology, 12-17th August Montreal, Canada 2012.
33. Lopes AF, Alfaia CM, Partidario AM, Lemos JP, Prates JA. Influence of household cooking methods on amino acids and minerals of Barrosã-PDO veal. Meat Science, 2015;99:38-43.
34. Sikorski EZ. Chemical reactions in proteins in food systems. In: Chemical and functional properties of food protein. Sikorski Z. E. (ed) Technomic publishing company, Inc., PA 2001, 191-215.
35. Jannat-Alipour H, Shabanpoor B, Shabani A, Mahoonak AS. Effects of cooking methods on physico-chemical and

nutritional properties of Persian sturgeon *Acipenser persicus* fillet. International Aquatic Research 2010;21:5-23.
36. Oduro FA, Choi ND, Ryu HS. Effects of cooking conditions on the protein quality of chub mackerel *Scomber japonicas* Fish. Aquatic Sciences 2011;14:257-265.
37. Lea CH, Parr LJ, Carpenter RJ. Chemical and nutritional changes in stored herring meal. 2. British Journal of Nutrition 1960;4:91-113.
38. Macy RL Jr, Naurman HD, Bailey MF. Soluble flavor odor precursors of meat. 1-Qualitative study of certain amino acids, carbohydrates, non-amino acid nitrogen compound and phosphoric acid esters of beef, Pork and lamb. Journal of Food Science 1964;29:136-148.
39. Oluwaniyi, Omolara, Dosumu, Omotayo, Awolola, Victoria. Effect of local processing methods (boiling, frying and roasting) on the amino acid composition of four marine fishes commonly consumed in Nigeria. Food Chemistry 2010;123:1000-1006.
40. Oshibanjo O, Olusola O, Ogunwole O. Influence of Cooking Methods and Temperature on Essential Amino Acid Score of Breakfast Sausage. Meat and Muscle Biology 2018;1(2).
41. Dal Bosco A, Castellini C, Bernardini M. Nutritional Quality of Rabbit Meat as Affected by Cooking Procedure and Dietary Vitamin E Journal of food science 2001;6(7) :1047-1051
42. Gerber N, Scheeder MRL, Wenk C. The influence of cooking and fat trimming on the actual nutrient intake from meat. Meat Science 2009;81:148-154.
43. Xiong Q, Zhang M, Wang T, Wang D, Sun C, Bian H *et al*. Lipid oxidation induced by heating in chicken meat and the relationship with oxidants and antioxidant enzymes activities, Poultry Science 2020;99(3):1761-1767.
44. Werenska M, Haraf G, Wołoszyn J, Goluch Z, Okruszek A, Teleszko M. Fatty acid profile and health lipid indicies of goose meat in relation to various types of heat treatment. Poultry Science 2021;100(8) :101237.
45. Igene JO, Pearson AM. Role of phospholipids and triglycerides in warmed-over flavor development in meat model systems. Journal of Food Science 1979;44:1285-1290.
46. Rodriguez-Estrada MT, Penazzi G, Caboni MF, Bertacco G, Lercker G. Effect of different cooking methods on some lipid and protein components of hamburgers. Meat Science 1997;45:365-375.
47. Scheeder MRL, Casutt MM, Roulin M, Escher F, Dufey PA, Kreuzer M. Fatty acid composition, cooking loss and texture of beef patties from meat of bulls fed different fats. Meat Science, 2001;58:321-328.
48. Hussain AI, Chatha SAS, Iqbal T, Arshad MU, Zahoor AF, Afzal S. Comparative Study of Different Cooking Methods on Nutritional Attributes and Fatty Acid Profile of Chicken Meat. Journal of the Chemical Society of Pakistan 2013;35(3) :678-684.
49. Haak L. Impact of animal diet and meat preparation on fatty acid composition and oxidative stability of pork. PhD dissertation, Ghent University, Ghent 2007, 228.
50. Wood JD, Richardson RI, Nute GR, Fisher AV, Campo MM, Kasapidou E. Effect of fatty acids on meat quality: a review. Meat Science 2003;66:21-32.
51. Juarez M, Failla S, Ficco A, Pena E, Aviles C. Polvillo O. Buffalo meat composition as affect by different cooking methods. Food and Bioproducts Processing 2010, 88.