Proximate Composition and Textural Properties of Cooked Sausages Formulated from Mechanically Deboned Chicken Meat with Addition of Chicken Offal

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***Abstract*—**Proximate composition (moisture, protein, total fat, and total ash) and textural characteristics (hardness, adhesiveness, springiness, cohesiveness, chewiness and firmness and work of shear) of cooked sausages formulated from mechanically deboned chicken meat (MDCM) with addition of chicken offal (heart, gizzard or liver) were investigated. Chicken offal replaced equal weight (15 kg) of MDCM in standard sausage formulation. Regarding proximate composition sausage with heart addition was significantly ($P<0.05$) lower in moisture content (70.45%) than sausage with liver addition (71.35%), and significantly ($P<0.05$) the highest in total ash content (2.83%). Sausage with gizzard addition was significantly higher in protein content (9.77%) than sausage with liver addition (9.42%). Total fat content didn't significantly ($P>0.05$) differ among all three sausages. The effect of offal addition was more notable in Warner-Bratzler shear test results than in texture profile analysis test. Firmness and work of shear were significantly different ($P<0.05$) among all three sausages. Sausage with liver addition was significantly ($P<0.05$) lower in hardness (1672 g) and chewiness (1020 g) and numerically the lowest in springiness (0.90) and adhesiveness (–70 g*s) comparing with other two sausages. Sausage with heart addition was significantly ($P<0.05$) higher in cohesiveness (0.74) comparing with other two sausages.

***Keywords*—**Cooked sausage, mechanically deboned chicken meat, offal, proximate composition, texture

I. Introduction

CONSUMPTION of poultry meat and poultry meat products is growing all over the world [1]. The preparation of varied chicken products, such as special cuts, sausage and others, is followed by substantial increase in residues such as deboned or cut-up chicken parts with adhering meat that still generate the raw material, suitable for mechanical deboning [2], [3]. The mechanical deboning process is an efficient method of harvesting meat from parts left after hand deboning and from poor quality poultry [4]. Using this process allows recovery of most of the residual meat that is otherwise wasted and increases costs [3]. The most used raw materials for mechanically deboned poultry meat (MDPM) are back, neck and thighs either from the initial carcass or after removal of most of the meat [2]. Yield of MDPM ranges from 55 to 80% depending on the part deboned and deboner settings. MDPM has good nutritional and functional properties, of which most interested are jelly consistency, water retention and ability to emulsify fat, what makes is suitable for the formulation of many meat products [1]. Due to these good technological characteristics (fine consistency) and relatively low cost it is frequently used in the formulation of comminuted meat products [1]. The use of MDPM in the sausage formulation is considered recent in the food industry since it only started in the 60's [2]. The main applications of MDPM are in sausages and salamis, which demand emulsion stability, and also benefit from the MDPM natural color [2].

Cooked sausages are emulsion-like systems made up of a suspension of fat globules (dispersed phase) in a protein – water solution (continuous phase) where fat contributes to essential quality attributes (e.g. texture) and also plays an important role in governing the binding properties of protein molecules [5]. The structural integrity of sausage batters is governed by the strength of the interacting forces within the protein network and the binding of free water within this network on mixing and subsequent heating [5]. Protein value of the MDPM is lower than that for the meat (pork, beef) what affects the emulsification ability of the formulation, resulting in changed textural characteristics [2].

Sensory properties, such as texture and color, are important for consumer acceptance, choice of food products and, consequently, the manufacturer. Therefore, many studies were taken to optimize and improve these characteristics in various foods [2]. Beside all positive MDPM characteristics in many meat products, including good nutritional and functional properties, MDPM may have negative effects of on the texture (soft or mushy texture) of the final cooked product [2]. The poorer mechanical properties of products (cooked sausages) formulated from MDPM resulted from the fact that mechanical process of removing meat from the bone causes cell breakage, protein denaturation and increase in lipids groups [2].

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In the last few decades, the amount of available meat by-products from slaughterhouses, meat processors and wholesalers has increased considerably [6]. Many edible by-products are down-graded because of the lack of a profitable market. Since the yield of edible by-products for chickens is from 5 to 6% of the live weight; more attention should be given to edible by-products [7], especially because the majority of by-products offer a range of foods which are nutritionally attractive, with high protein content and good nutritional properties due to the presence of many essential nutrients [6], and have a wide variety of flavors and textures [8]. Also, preparation of mechanically deboned meat (MDM) enables a more economical use of animal products and reduction of the amount of biological wastes [9]. Today, economic, modern technology and industrial concern for the environment results in maximum salvage and utilization of all by-product materials [10].

Thus, the objective of this study was to investigate the effect of different chicken offal type addition (heart, gizzard or liver), as replacement of equal weight (15kg) of mechanically deboned chicken meat (MDCM) on proximate composition and textural characteristics of cooked sausages formulated from MDCM.

II. Material and Methods

A. Preparation of Sausages

MDCM was produced from breasts (30%), after removal of most meat, backs (50%), necks (10%) and thighs (10%) in a commercial processing plant. Yield of MDCM was 67%. Cooked sausages (emulsion-type product) were prepared according to standard methodology and techniques. The main mixture consisted of 45kg MDCM, 10kg vegetable fat, 25kg ice/water, 3kg maize starch, 2kg textured soy protein, 1.6kg nitrite salt, 0.1kg dextrose, 0.3kg polyphosphate, 0.05kg antioxidant and 0.5kg spice mix. Experimental sausages were prepared from main mixture and with addition of 15kg chicken heart (H sausages), gizzard (G sausage) and liver (L sausage). The emulsified materials were stuffed into artificial cellulose casings (diameter of 65mm) and were then cooked until an internal temperature of 71°C was reached. Immediately after the heating process sausages were cooled with combination of water/air cooling for 45 min (till reduced internal sausage temperature to 25°C), followed by air cooling in the chamber. The sausages were stored at +3°C until analysis.

B. Proximate Composition

Moisture [11], protein [12], total fat [13] and total ash [14] contents of cooked sausages were determined according to methods recommended by International Organization for Standardization. All analyses were performed in duplicate.

A strict analytical quality control program was applied during the study. The results of the analytical quality control program for proximate composition are presented in Table I.

TABLE I
RESULTS OF THE ANALYTICAL QUALITY PROGRAM (N=8) USED IN THE DETERMINATION OF THE PROXIMATE COMPOSITION OF COOKED SAUSAGES

Quality control	Moisture	Nitrogen	Fat	Ash
Certified concentration (g/kg)	688 ± 2.6	16.3 ± 0.6	143 ± 5.0	26.5 ±1.0
Recovery (%)	99.6	100.4	99.7	100

C. Texture Profile Analysis (TPA)

Samples for each sausage type were used to evaluate the texture. Texture profile analysis (TPA) was performed as described by Bourne [15], at room temperature, using TA.XT2 Texture Analyzer (Texture Technologies Corp., Scarsdale, NY/Stable MicroSystems, Godalming, UK) equipped with a standard cylindrical plate of 75mm in diameter. Samples, which were 2cm thick and 2.54cm in diameter, were compressed twice to 50% of their original thickness at a constant test speed of 1mm/s. The following parameters were determined; hardness (g), springiness, cohesiveness, chewiness (g) and adhesiveness (g*s). Hardness was defined by peak force during the first compression cycle. Springiness was defined as the rate at which a deformed sample goes back to its undeformed condition after the deforming force is removed. Cohesiveness was calculated as the ratio of the area under the second curve to the area under the first curve. Chewiness was obtained by multiplying hardness, cohesiveness and springiness. Finally, the adhesiveness was obtained from the negative force area under the curve obtained between cycles.

D. Warner–Bratzler Shear Test

A Warner-Bratzler (WB) shear test [16] was carried out using a WB shear V blade, using samples 1.27cm in diameter. The crosshead speed was 1.5mm/s. The following shear parameters were calculated from the force–deformation curves: maximum shear peak force (highest peak detected during the test – firmness), and total area (fitting area plus shear area) as the total amount of work required to cut through the sample.

E. Statistical Analysis

All data are presented as mean values. Analysis of variance (one-way ANOVA) was used to test the hypothesis about differences among sausage samples. The software package STATISTICA 12.0 [17] was used for analysis.

III. Results and Discussion

Proximate composition of the experimental sausages is presented in Table II. Addition of 15kg of chicken offal (heart, gizzard or liver) instead of equal weight of MDCM significantly (P<0.05) influenced proximate composition of sausages. Moisture contents ranged from 70.45% (H sausage) to 71.35% (L sausage), with significant (P<0.05) difference between these samples. Sausage G had moisture content of 70.93% and didn't differ (P>0.05) from H and L sausages. Protein content was significantly (P<0.05) higher in sausage G (9.77%) comparing to L sausage (9.42%). Protein content in sausage H was 9.66%, not different (P>0.05) from other two sausages. Type of added offal didn't affect (P>0.05) the total fat content. Moreover fat content ranged from 12.27% (L) to 12.74% (G). Sausage H was significantly (P<0.05) higher in total ash content (2.83%) than G and L sausages (2.52 and 2.62%, respectively). Results obtained for proximate composition were in agreement with results for emulsion-type sausages produced from 100% MDPM reported by Mielnik et al. [1], Daros et al. [2] and Pereira et al. [4]. Results of Daros et al. [2], and Pereira et al. [4] showed that moisture content of cooked sausages produced with different percent of MDPM addition increased with increased content of MDPM, as a consequence of the higher ability of the MDPM, than meat, to retain water. Also, same authors [2], [4] reported a decrease in protein and fat levels in cooked sausages produced with increasing addition of MDPM, comparing with sausages produced from pork.

TABLE II
PROXIMATE COMPOSITION (%) OF COOKED SAUSAGES

	Sample*		
	H	G	L
Moisture	70.45^{b}	70.93^{ab}	71.35^{a}
Protein	9.66^{ab}	9.77^{a}	9.42^{b}
Total fat	12.57	12.74	12.27
Total ash	2.83^{a}	2.52^{b}	2.62^{b}

^{ab} indicates significant difference within column at P < 0.05
H= with addition of 15kg of chicken heart in sausage formulation;
G=with addition of 15kg of chicken gizzard in sausage formulation;
L=with addition of 15kg of chicken liver in sausage formulation;

Table III provides a summary of the TPA parameters for experimental sausages. Addition of 15kg of chicken offal (heart, gizzard or liver) instead of equal weight of MDCM significantly (P<0.05) influenced textural characteristics of sausages. Hardness was significantly influenced by the liver addition, being significantly (P<0.05) lower for L sausage (1672g) comparing with H and G sausages. Hardness of H (2506g) and G sausage (2685g) didn't differ significantly (P>0.05). Higher hardness is desirable characteristic of sausages because it is an important textural attribute in final sausages acceptance [14]. In addition to the hardness, the chewiness of sausages was significantly (P<0.05) affected by the liver addition. Chewiness of L sausage was the lowest (1020g) comparing with other two groups of sausages. Chewiness of H and G sausages were 1921g and 1637g, respectively, with no significant (P>0.05) difference between them. There are several factors that can influence the texture of cooked sausage. The first aspects are protein and fat content, and other aspects to consider are the differences in fat/ moisture and protein/moisture ratios [4], [18]. Lower fat content results in a softer texture [19], also the decrease in protein content ultimately affects mechanical properties of cooked sausages [4]. Springiness represents the extent of recovery of sausage height and sometimes is referred to as "elasticity" [20]. The springiness of the sausage samples was not affected by the type of added offal. Springiness of sausages H, G and L was 1.03; 091 and 0.90, respectively. Cohesiveness is a measure of the degree of difficulty in breaking down the internal structure of the sausages [20]. The cohesiveness of H sausage (0.74) was significantly higher comparing with G (0.67) and L (0.68) sausage. Sausages G and L didn't differ significantly (P>0.05) in cohesiveness. Adhesiveness represents the work required to overcome the attractive forces between the surface of food and other materials on which food comes into contact [4]. Type of added offal didn't significantly affect adhesiveness of experimental sausages. Adhesiveness was –94 g*s for H sausage, –73 g*s for G sausage and –70 g*s for sausage L, without significant (P>0.05) differences among sausages. The adhesiveness of sausages formulated with addition of MDCM Pereira et al. [4] explained by the negative effect of MDCM on the emulsification ability of the formulation contributing to a greater loss of liquid during compression in the TPA test. This liquid contains proteins and hydrocolloids that have a sticky consistency and the adhesion of the food surface with the probe may be greater when larger amounts of exudates are released [4].

TABLE III
TEXTURE PROFILE ANALYSES OF COOKED SAUSAGES

Parameter	Sample		
	H	G	L
Hardness (g)	2506^{a}	2685^{a}	1672^{b}
Springiness	1.03	0.91	0.90
Cohesiveness	0.74^{a}	0.67^{b}	0.68^{b}
Chewiness (g)	1921^{a}	1637^{a}	1020^{b}
Adhesiveness (g *s)	–94	–73	–70

^{ab} indicates significant difference within column at P < 0.05
*H= with addition of 15kg of chicken heart in sausage formulation;
G=with addition of 15kg of chicken gizzard in sausage formulation;
L=with addition of 15kg of chicken liver in sausage formulation;

Table IV provides a summary of the Warner-Bratzler shear test parameters for experimental sausages.

TABLE IV
WARNER-BRATZLER SHEAR TEST ANALYSES OF COOKED SAUSAGES

Parameter	Sample		
	H	G	L
Firmness (N)	3.14^{a}	2.63^{b}	1.59^{c}
Work of shear (N * s)	12.35^{a}	10.52^{b}	7.00^{c}

^{abc} indicates significant difference within column at P < 0.05
*H= with addition of 15kg of chicken heart in sausage formulation;
G=with addition of 15kg of chicken gizzard in sausage formulation;
L=with addition of 15kg of chicken liver in sausage formulation;

Firmness of sausages, determined as the highest peak detected during the shear test, was significantly influenced (P<0.05) by the sausage formulation, i.e. with addition of different chicken offal type. Firmness was significantly (P<0.05) different among all three sausages. It was the highest for H sausage (3.14N) followed by G sausage (2.63), and L sausage (1.59N). The work of shear was also influenced by sausage formulation, being again significantly the highest for H (12.35 N*s) sausage comparing with G (10.52 N*s) and L (7.00 N*s) sausages. The difference in the work of shear was significant (P<0.05) between G and L sausages.

IV. Conclusion

Different type of chicken offal (heart, gizzard or liver), addition, as replacement for equal weight of MDCM, in cooked sausages formulated from MDCM, affected proximate composition and textural characteristics of final product. Regarding proximate composition only total fat content was not affected with different offal type addition. Regarding texture measurements the effect of offal addition was more notable in Warner-Bratzler shear test results than in compression-deformation TPA test. Firmness and work of shear were significantly ($P<0.05$) different among all three sausages. At the offal addition weight of 15kg, studied in this experiment, sausages with liver addition tended to be significantly ($P<0.05$) the lowest in firmness and work of shear, as well as for hardness and chewiness, comparing to other two sausages.

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