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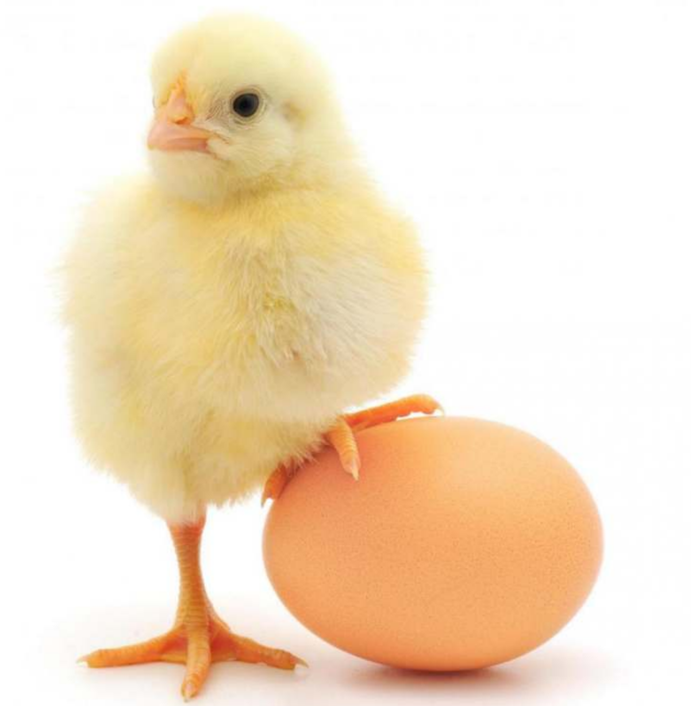

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Effect of Chicken and Duck Meat Ratio on the Properties of Sausage

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Abstract: In this study, sausages with different ratios of chicken to duck meat were produced: A (100:0), B (75:25), C (50:50), D (25:75) and E (0:100). Analyses of the physicochemical properties and chemical contents of the samples were carried out. The proximate contents were significantly different ($p<0.05$) among all samples with different formulations. In order, from samples A to E, moisture contents exhibited a decreasing trend, while protein, fat and ash contents showed increasing trends as the fraction of duck meat was increased in the formulation. Sausages having higher ratios of duck meat had a darker color, with the L* value decreasing from sample A to E. All the samples showed significant differences in the texture analysis. The texture of sausages became harder when more duck meat was incorporated in the formulation.

Key words: Processed poultry products, sausages, physico-chemical properties, sensory evaluation

INTRODUCTION

Sausages are emulsions of the oil-in-water type with protein as the emulsifier. Technically, meat emulsions can be characterized as food obtained from a homogeneous, finely triturated mixture of muscular tissue, blood, viscera and other animal products or by-products authorized for human consumption (Pereira *et al*., 2000). Although beef, veal and pork are the main meat-sausage materials, mutton and poultry are also of importance (Savic, 1985). Other than chicken, duck meat is one of the poultry meats commonly used as sausage material.

Duck (*Anas platyrhynchos*) is one of the poultry species of economic significance. Although chicken and turkey dominate the world poultry industry, about 700 million ducks are kept around the world. The majority of these, more than 500 million, are found in Asia. This means that in parts of Asia, ducks are more commercially important. It is reported that worldwide duck-meat production reached 3,583,809 tons in 2007 (FAO, 2009). Malaysia is the third-highest duck-meat producer country, with a production of approximately 111,000 tons in 2007 (FAO, 2009).

Different types of meat used for sausage raw material may yield different quality characteristics in the sausages produced. Duck is a waterfowl and has a different physiology than other poultry (Ali *et al*., 2008). The chemical and physical properties of muscle tissue and the associated connective tissue are very important when considering the usefulness of meat as food (Ahhmed *et al*., 2007). Hence, it is important to study the chemical composition and the physicochemical properties of sausages produced with duck meat. Besides these properties, the sensory properties of the sausages are also important. The main objective of this research was to evaluate the effects of the incorporation of different ratios of duck meat and chicken meat on the physicochemical and sensory properties of sausages.

MATERIALS AND METHODS

Sausage preparation: Chicken meat and duck meat were used in different ratios to produce the sausages. The ingredients involved in the sausage processing included Mechanically Deboned Chicken Meat (MDCM) (Ramli Sdn Bhd), Mechanically Deboned Duck Meat (MDDM) (Fika Food Corporation Sdn Bhd), palm oil, cold water, salt, sugar, monosodium glutamate, garlic powder and white pepper. The formulations of sausages with different ratios of chicken and duck are shown in Table 1 and the processing steps of sausage preparation are shown in Fig. 1. The prepared sausage samples were kept in the freezer at -18°C until analysis. The sausages were thawed at room temperature for about four hours and cooked in boiling water (95°C) for five minutes.

Proximate analysis: The proximate composition was determined according to the AOAC (1990) methods. Moisture content was determined by drying samples overnight at 105°C until constant weight was achieved (Memmert UL 40, Germany). Crude protein content was determined using the Kjeldahl method (Kjeltec System 1002, Sweden). Crude lipid content was determined using the Soxhlet method. Ash content was determined by ashing samples overnight at 550°C (Thermolyne Sybranm model: 6000, USA). Carbohydrate content was calculated by difference.

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Table 1: Formulations of sausages with different ratios of chicken and duck meat

Ingredients	Sample A (100:0)	B (75:25)	C (50:50)	D (25:75)	E (0:100)
	(%)				
Chicken meat	100	75	50	25	0
Duck meat	0	25	50	75	100
Cold water	10.0	10.0	10.0	10.0	10.0
Palm oil	6.0	6.0	6.0	6.0	6.0
Wheat flour	3.5	3.5	3.5	3.5	3.5
Salt	2.5	2.5	2.5	2.5	2.5
Garlic	1.0	1.0	1.0	1.0	1.0
Pepper	1.0	1.0	1.0	1.0	1.0
Sugar	1.0	1.0	1.0	1.0	1.0

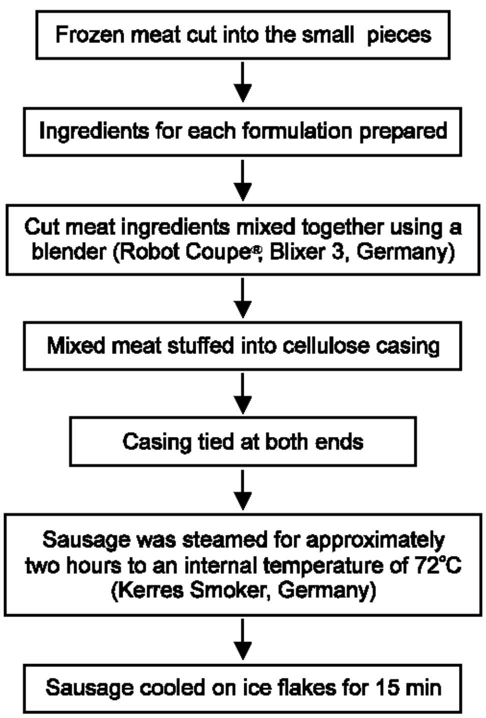

Fig. 1: Flow chart for sausage processing

Colour: The colour of sausages samples was measured using a colourimeter (Minolta spectrophotometer CM 3500d, Japan). The colour reading includes lightness (L*), redness (a*) and yellowness (b*). The equipment was standardized with a white colour standard. The mean of five measurements was taken for each L*, a* and b* values.

Cooking yield: Cooking yield was determined by measuring the difference in the sample weight before and after cooking and was calculated according to Serdaroglu and Degirmencioglu (2004).

Cooking yield (%) = (weight of cooked sausages/weight of uncooked sausages) x 100

Moisture-retention: Moisture retention value represents the amount of moisture retained in the cooked product per 100 g of sample and was determined according to equation by El-Magoli *et al.* (1996). Calculation of moisture retention is as below:

Moisture retention (%) = (% cooking yield x moisture in cooked sausage)/100

Texture profile: Texture measurement on sausages samples was conducted using a computer-assisted TA-XT2i Texture Analyzer (Stable Micro Systems, UK). Two types of test were carried out in order to compare the texture profile of the meatballs obtained from different tests. First, Texture Profile Analysis (TPA) was used to determine hardness, cohesiveness, chewiness and springiness (Bourne, 1978). This test was carried out by using compression platen with 75 mm diameter. Second, shear test which used a knife blade to determine Warner-Bratzler shear force required to cut through sample. The TA-XT2i setting for tests was load cell 25 kg; pre-test speed 2.0 mm/s; post-test speed 5.0 mm/s; distance 50% and trigger type, auto. The mean of five measurements was taken for each hardness, cohesiveness, chewiness, springiness and shear force values.

Sensory evaluation: Thirty (30) panelists among Universiti Sains Malaysia students were chosen randomly as judges to evaluate color, odor, taste, texture and overall acceptance of the sausages sample. The samples were coded using a three-digit random number. Samples were presented randomly. Seven-point hedonic scales were used for the sensory evaluation of the sausages, on which a score of one equals “dislike extremely”, while a score of seven is “like extremely” (Meilgaard *et al.*, 1999).

Statistical analysis: Data obtained from all the analysis were analyzed using the statistical one-way analysis of variance (ANOVA), followed by Duncan multiple range test of Statistical Package for Social Science version 12.0 (SPSS inc., Chicago, Illinois, U.S.A). Statistical significance was indicated at 95% confidence level.

RESULTS

Proximate composition and pH: The proximate compositions and pH values of the sausages with chicken and duck in varying ratios are given in Table 2. All of the samples were significantly different (p<0.05) for moisture, protein, fat, ash content and pH value. The moisture content was in the range of 61.51-64.86%, protein was 9.79-14.67%, fat was 14.49-18.48%, ash was 1.95-2.77%, carbohydrate was 2.64-9.39% and pH ranged from 6.02-6.27. The proximate compositions and pH values differed among samples as different ratios of chicken and duck meat were used in the preparation of the samples.

Color, cooking yield and moisture retention: Table 3 shows the color, cooking-yield and moisture-retention results for the chicken and/or duck sausages. All color measurements, taken after the sausage was cooked, were significantly different (p<0.05) for the different sausage formulations. The lightness of the sausage was in the range of 58.00-75.75, redness was 6.30-10.69 and yellowness was 22.81-34.19. There was a trend showing that the values L* and b* decreased from sample A to sample E while value a* increased from sample A to sample E.

There were no significant differences (p<0.05) among samples with respect to weight gain or weight loss (Table 3). The highest cooking yield was observed with the 100%-chicken sausage and the lowest cooking yield was for the 100%-duck sausage. The moisture retention of the sausages is shown in Table 3. There were significant differences (p<0.05) among the samples, with values ranging from 61.16-67.62%.

Texture analysis: The textural properties scores and Warner-Blatzer shear-test (WB) results are presented in Table 4. Significant differences (p<0.05) were found in hardness, springiness, cohesiveness, gumminess and chewiness. The hardness of the sausages was in the range of 1.12-4.06 kg, springiness was 7.30-11.21 mm, cohesiveness was 0.23-0.32, gumminess was 259.9-1274.37 and chewiness was 2.91-92.94. The results show that hardness, cohesiveness, gumminess and chewiness increased when more duck meat was incorporated in the formulation. The results of the Warner-Blatzer (WB) test were significantly different (p<0.05) for the different sausage formulations, ranging between 0.82 and 2.89 kg. The values were significantly higher in sausages with higher contents of duck meat. The WB is the most common shear test used to evaluate texture in meat (Honikel, 1998). Shear force increased significantly (p<0.05) with the increase of duck meat in the formulation (Table 4).

Sensory evaluation: For sensory evaluation, 30 panelists were present to evaluate the color, flavor, taste, texture and overall acceptability. Table 5 shows the ratings of sensory attributes for each formulation. The results of the sensory evaluation show that there were significant differences (p<0.05) among the five samples, A, B, C, D and E, with different ratios of chicken and duck meat. Color sensory-evaluation ratings of chicken and

Table 2: Chemical compositions and pH values of sausages with different ratios of chicken and duck meat

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	CHO (%)	pH
A	64.86^{a}±0.19	9.79^{e}±0.31	14.49^{e}±0.24	1.95^{d}±0.08	8.91^{a}±0.57	6.02^{e}±0.01
B	63.06^{c}±0.25	10.31^{d}±0.39	15.13^{d}±0.08	2.11^{c}±0.05	9.39^{a}±0.37	6.08^{d}±0.01
C	63.50^{b}±0.69	12.95^{c}±0.40	16.30^{c}±0.06	2.30^{b}±0.06	4.62^{b}±0.54	6.14^{c}±0.01
D	61.64^{d}±0.28	13.69^{b}±0.29	17.43^{b}±0.21	2.77^{a}±0.12	4.47^{b}±0.62	6.20^{b}±0.02
E	61.51^{d}±0.44	14.67^{a}±0.36	18.48^{a}±0.33	2.70^{a}±0.19	2.64^{c}±0.46	6.27^{a}±0.02

Means within a column with different letters are significantly different (p<0.05)

Table 3: Color, cooking-yield and moisture-retention measurements of sausages with different ratios of chicken and duck

Sample	Color L*	Color a*	Color b*	Cooking yield (%)	Moisture retention (%)
A	75.75^{a}±0.71	6.30^{e}±0.28	34.19^{a}±0.61	100.16^{a}±1.21	67.62^{a}±2.6
B	70.13^{b}±0.17	6.93^{d}±0.39	26.09^{b}±0.57	99.87^{b}±1.25	66.38^{b}±2.1
C	61.49^{c}±0.76	7.81^{c}±0.33	24.43^{c}±0.71	101.01^{a}±2.49	64.09^{c}±1.5
D	61.97^{c}±0.79	9.53^{b}±0.28	23.75^{d}±0.60	98.48^{b}±2.30	63.89^{d}±2.1
E	58.00^{d}±0.79	10.69^{a}±0.46	22.81^{e}±1.28	98.82^{b}±1.96	61.16^{d}±3.5

Means within a column with different letters are significantly different (p<0.05)

Table 4: Texture profile of sausages with different ratios of chicken and duck

	Hardness	Springiness	Cohesiveness	Gumminess	Chewiness	Warner-Bratzler
Sample	(kg)	(mm)	(ratio)	(kg/mm^2)	(kg/mm)	(kg)
A	1.12^{e}±0.08	11.21^{a}±0.56	0.23^{d}±0.02	0.26^{e}±0.02	2.91^{e}±0.25	0.82^{e}±0.01
B	2.36^{d}±0.08	9.75^{b}±0.34	0.24^{d}±0.01	0.56^{d}±0.02	5.45^{d}±0.25	0.09^{d}±0.01
C	3.05^{c}±0.06	8.69^{c}±0.21	0.26^{c}±0.01	0.78^{c}±0.01	6.81^{c}±0.19	1.02^{c}±0.02
D	3.53^{b}±0.08	7.98^{d}±0.19	0.28^{b}±0.01	0.98^{b}±0.02	7.85^{b}±0.29	2.12^{b}±0.02
E	4.06^{a}±0.09	7.30^{e}±0.19	0.32^{a}±0.01	1.27^{a}±0.07	9.29^{a}±0.41	2.89^{a}±0.01

Means within a column with different letters are significantly different (p<0.05)

Table 5: Sensory evaluation of sausages with different ratios of chicken and duck

Sample	Color	Flavor	Taste	Texture	Overall acceptability
A	$3.80^{c}\pm1.34$	$5.52^{a}\pm1.33$	$5.57^{a}\pm1.23$	$5.33^{a}\pm1.58$	$5.03^{a}\pm1.41$
B	$3.83^{c}\pm1.46$	$4.50^{ab}\pm1.40$	$4.67^{a}\pm1.52$	$4.52^{ab}\pm1.50$	$4.28^{b}\pm1.38$
C	$4.95^{b}\pm1.17$	$4.12^{b}\pm1.11$	$3.80^{c}\pm1.21$	$4.30^{b}\pm1.52$	$3.90^{c}\pm1.34$
D	$5.98^{a}\pm1.27$	$3.98^{bc}\pm1.49$	$3.93^{b}\pm1.48$	$3.51^{c}\pm1.43$	$4.10^{bc}\pm1.51$
E	$5.56^{ab}\pm1.35$	$3.80^{c}\pm1.16$	$3.38^{b}\pm1.52$	$3.73^{bc}\pm1.45$	$4.03^{b}\pm1.11$

Means within a column with different letters are significantly different ($p<0.05$)

duck sausage were in the range of 3.80-5.56, flavor was in the range of 3.80-5.52, taste was in the range of 3.80-5.57 and texture was in the range of 3.51-5.33, whereas overall acceptability of all the samples was in the range of 3.90-5.03.

DISCUSSION

Proximate composition and pH: Higher ratios of duck meat in the formulation decreased the moisture content of the sausage, while for fat content there was a gradual increase when the ratio of duck meat was higher in the formulation (Table 2). This was due to the fact that while duck has a lower moisture content than chicken, duck-meat fat content is higher than chicken (USDA, 2008). Serdaroglu and Degirmencioglu (2004) reported a decrement in moisture contents with increasing levels of fat in Turkish-type meatballs (koefte); similarly, Andre´s *et al*. (2004) reported that sausages with a higher fat composition contained less moisture.

According to the results, ash content increased when the ratio of duck meat was increased. Mechanically Deboned Meat (MDM) tends to have higher ash contents than Hand-deboned Meat (HDM). This is due to the MDM preparation process, which uses mechanical pressure to remove the meat from vertebrae, resulting in the incorporation of more bone into the meat produced (Serdaroglu and Degirmencioglu, 2004).

The variable amount of bone in MDM depends on many factors such as the different types of bones, their brittleness and the ratio bone to meat in the raw material used (Crosland *et al*., 1994). In this study, the ash content of the Mechanically Deboned Duck Meat (MDDM) used was likely higher than that of the Mechanically Deboned Chicken Meat (MDCM), which resulted in higher ash content at higher duck-meat ratios.

The pH values of the different sausages were significantly different ($p<0.05$). The pH of the higher-duck-ratio sausages was higher than those with more chicken. After slaughter, anaerobic glycolysis reactions occur, resulting in the decline of meat pH. This pH decline varies with species, type of muscle, antemortem factors and temperature (Haard, 1998).

As reported by Bhattacharyya *et al*. (2005), in the case of sausage emulsion and cooked sausages, the pH of cooked sausages was significantly higher than that of the emulsion. This is due to the cooking effect. In this case, cooking yielded a higher degree of oxidation resulting in a loss of free acid groups from the meat proteins. This increased the pH value of cooked meat over that of the raw material (Lawrie, 1998).

Color, cooking yield and moisture retention: The results clearly show that sausages with higher ratios of chicken were lighter, redder and less yellow in color than sausages with higher ratios of duck. This is due to the natural color of duck meat, which is fatty and red or dark compared to chicken meat (Meulen and Dikken, 2004). Serdaroglu and Degirmencioglu (2004) reported that decreasing the fat content from 20-5% significantly increased cooking yield. Weight gain or loss in sausages after cooking may be affected by several factors such as water-holding capacity, moisture and fat retention and the type of ingredients used in their formulation. The results show that the moisture retention was reduced in sausages with a higher ratio of duck meat. This may be due to the high fat content which reduced the moisture retention.

Texture analysis: As shown from the results, when the ratio of duck meat was higher, the fat content was increased as was the hardness of the product. A frankfurter formulation with a high fat content was reported to produce a harder final product (Candogan and Kolsarici, 2003). However, springiness decreased when more duck meat was incorporated into the formulation. Chang and Carpenter (1997) reported that chicken frankfurters with more water added, resulting in a lower fat content, had lower shear stress and hardness but higher springiness. This result was also confirmed by Caceres *et al*. (2005), who reported that a decrease in the hardness was observed for the reduced-fat batches in the double-compression test (TPA). The research by Andre's *et al*. (2004) on low-fat chicken sausages also reported that as fat content increased, a harder, gummier and more cohesive product was obtained, with higher chewiness and lower springiness values.

Moisture content and protein content can also influence the TPA results. According to Lin *et al*. (2002), a lower moisture content led to a harder and chewier product. A report by Pietrasik (1999) on the effects of varying contents of protein, fat and modified starch on the binding and textural characteristics of sausages also stated that higher protein contents resulted in harder sausages. This finding was correlated with the results of the proximate analysis. Gumminess and chewiness behaved similarly to hardness, mainly because it is the primary parameter which determines these secondary parameters (Caceres *et al.*, 2005). Hence, as fat content increased a harder, gummier and more cohesive product was obtained, with higher chewiness and lower springiness.

The WB technique is the instrumental method that yields the best correlation with sensory-panel scores for meat toughness. The blade knife used is similar to the human front teeth. The WB result was correlated with the hardness, showing an increasing trend of WB values when the hardness of the meat increasing with each formulation.

According to Jin *et al.* (2007), high pH, high protein content and low water content are closely related to high shear force in meats. In this study, sausages with higher contents of duck meat showed higher pH values, higher protein contents and lower moisture contents than sausages with higher contents of chicken meat. Thus, the physical structure of sausage with a higher duck-meat content should be more stable than sausage with a higher chicken-meat content; this was supported by the shear-force results.

Sensory evaluation: The variation in sensory-quality-attribute scores observed for the meats in this study was due to differences in the carcass compositions of the different meat species, especially the type and content of fatty tissues. According to Bhattacharyya *et al.* (2005), duck sausage was better in appearance owing to its darker color, which was enhanced by the smoking process. This was clearly reflected in our results, where the color of sausages which had high ratios of duck meat was scored higher by the panelists.

In terms of flavor, duck sausage was less likely to be preferred by the panelists compared to chicken sausage. This is probably because of its inherent duck aroma, very much characteristic of the duck meat, that could not be masked by the spices and condiments added during emulsion preparation. For the texture evaluation, sausage which had a high ratio of chicken meat was more preferred by the panelists. This is because chicken meat has a finer texture and is higher in moisture than duck meat. This is in accord with our results, in which the duck sausages were less preferred by the panelists due to the lower moisture content and harder texture.

Conclusion: The moisture contents of the sausages decreased when more duck meat was incorporated into the formulation, while the percentages of fat, protein and ash increased when the sausages had a higher ratio of duck meat. The color of the sausages that had higher ratios of duck meat was darker. Most sausages were also found to have a desirable texture. The increase in the amount of duck meat produced harder sausages and lower scores in sensory tests.

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