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Physicochemical Properties of Low-Fat Duck Sausage Formulated with Palm Oil

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Abstract: The study was envisaged to determine the effect of washing processes (unwashing and a single washing) and addition of palm oil (0, 3 and 6%) on the proximate compositions and physicochemical properties of the duck sausages. Washing was carried out at meat to water ratio of 1:1 (w/v). Samples with higher oil levels demonstrated significantly higher fat content and at the same evidence showed lower moisture and protein contents. Treated samples were lighter after washing, while their yellowness value increased with fat content. In regards to texture profile analysis, samples with lower levels added oil had higher values for hardness and shear force and the microstructure of the samples became less porous after washing. It can be concluded that, quality characteristics of sausages were affected by washing processes and oil addition.

Key words: Duck meat, washing treatment, palm oil, sausage, physicochemical properties

INTRODUCTION

There are many varieties of frankfurters currently available in the Malaysian market; they are mainly produced from chicken, beef or fish. In the past, sausage production was performed by small family enterprises. However, increasing demand for sausage products in recent years has moved sausage manufacturing into large-scale production. Many factories have been organized in Malaysia to enhance output and to meet increasing sausage demand. Due to the increasing competition among manufacturers, more advanced technologies have been imported from other countries and fully-automated machineries have been introduced in order to produce high-quality products.

Washing techniques for mechanically deboned chicken meat have been investigated because of the advantages of removing fat, heme pigments and other water soluble compounds (Dawson *et al*., 1988; Yang and Froning, 1992). As consumers choice for white meat over dark meat so removal of heme is important from poultry meat with varying washing strategies (Yang and Froning, 1994). In addition, washing can also improve the characteristics of final products. Bhattacharyya *et al*. (2007) reported that duck sausage scored only slightly lower flavor scores with respect to sensory quality which was due to its inherent duck-like odor and dark color and that can be masked by adding spices and condiments during emulsion preparation.

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The role of fat is an important consideration in any formulation. From a physiological perspective, fats in foods serve three basic functions: as sources of essential fatty acids, carriers of fat soluble vitamins and acts as dense source of energy (Mela, 1990). Fat also plays a major role in the texture, juiciness and flavor of comminuted meat products. The sensory properties of fats make a diet flavorful, varied and rich (Drewnowski, 1992). Fat is vital to the rheological and structural properties of meat products and in the formation of a stable emulsion (Keeton, 1994).

Fat is important in determining the organoleptic properties of meat and while a variety of strategies may be applied in the development of low-fat products, the basic concern has always been to reduce fat but retain traditional flavor and texture. Simply reducing fat content leads to a product of poor organoleptic quality.

In this study, rich carotene palm oil (carotino oil) was added to the duck meat sausage formulation. Carotino oil is the richest natural plant source of carotenoids (Lietz *et al.*, 2000; Truswell *et al.*, 1992); it contains approximately 500 ppm carotene, 90% of which is present in the form of α- and β-carotene (Nagendran *et al.*, 2000). This study was carried out to observe the effect of washing (washed and unwashed samples) and the addition of oil (0, 3 and 6%) on the physicochemical properties of low-fat duck sausage.

MATERIALS AND METHODS

Raw Materials

The present study was carried out at the Fish and Meat laboratory, Food Technology Programme, School of Industrial Technology, Universiti Sains Malaysia, over the period from July 2007 to March 2008. Mechanically deboned duck meat was bought from Fika Food Sdn. Bhd. and immediately placed in the freezer to minimize the effect of thawing prior to processing. Other materials, including rich carotene palm oil (Carotino® premium cooking oil), salt, sugar, monosodium glutamate, sodium nitrite and nitrate, garlic powder, white pepper, coriander and aniseed were bought from the local market.

Sausage Preparation

The production of duck sausage was divided into two treatments: washed and unwashed. For washed samples, duck meat was washed with cold water at 1:1 ratio (v/w) of water to meat. A primary layer of water was removed and filtered through a commercial sieve. The water remaining in the washed sample was squeezed out using a cotton cloth and pressed using a screw press. Both treatments were then mixed with different amounts of carotino oil: A (80:0), B (77:3) and C (74:6). The formulation for preparing duck sausage is presented in Table 1. Other ingredients used in the formulation were water (5%), salt (2.5%), sugar (1%), monosodium glutamate (0.05%), sodium nitrite (0.01%), sodium nitrate (0.01%), wheat flour (3.43%), white pepper (2%), garlic powder (2%), coriander (2%) and aniseed (2%). All ingredients were mixed for 3 min using a high speed blender (Robot Coupe Blixer Grinder, France). The mixed meat was then stuffed into 2 cm cellulose casing then tied together and steamed until their internal temperatures reached 72°C. The samples were then immediately cooled in ice flakes for 15 min prior to being analyzed.

Proximate Analysis

Moisture was quantified by oven-drying 10 g samples at 100-105°C overnight with AOAC method 950.46 (AOAC, 2000). Protein analysis was performed using AOAC method

Table 1: Formulation information for preparing duck sausage

	Formulation		
Ingredients	1 (6% oil)	2 (3% oil)	3 (0% oil)
Grinded meat	74.00	77.00	80.00
Vegetable oil	6.00	3.00	0.00
Water	5.00	5.00	5.00
Salt	2.50	2.50	2.50
Sugar	1.00	1.00	1.00
MSG	0.05	0.05	0.05
Sodium nitrite	0.01	0.01	0.01
Sodium nitrate	0.01	0.01	0.01
Wheat flour	3.43	3.43	3.43
White pepper	2.00	2.00	2.00
Garlic powder	2.00	2.00	2.00
Coriander	2.00	2.00	2.00
Aniseed	2.00	2.00	2.00

Each value in the form of percentage

981.10 (AOAC, 2000). Fat was determined by extracting samples in a Soxhlet apparatus using petroleum ether as a solvent with AOAC method 960.39 (AOAC, 2000). Ash was determined after incineration in a furnace at 500-600°C with AOAC method 923.03 (AOAC, 2000).

Color Measurement

Samples were cooked at 90°C for 5 min and then sliced into pieces 4 mm thick (Huda *et al*., 2000). The color of cooked samples was measured using a colorimeter (Minolta CM 3500d, Japan). The color reading includes lightness (L*), redness (a*) and yellowness (b*).

Texture Analysis and Shear Test

Samples were cooked at 90°C for 5 min and were uniformly cut into 1.5 cm pieces. Texture of samples were measured by using Texture Analyzer TA-XT2 (Stable Microsystem, UK), Compression Platen (SMS P/75) with a heavy duty platform and the following settings: load cell, 25 kg; speed, 3.0 mm sec^{-1}; test speed, 1.0 mm sec^{-1}; post test speed, 3.0 mm sec^{-1}; prefixed strain, 75%; time before second compression, 2 sec. The following parameters were determined: Hardness, cohesiveness, springiness, gumminess and chewiness. Shear test of the samples were done by using a Blade Set (HDP/BSW) with a heavy duty platform and the following settings: load cell, 25 kg; pre-test speed, 2.0 mm sec^{-1}; test speed, 2.0 mm sec^{-1}; post-test speed, 10.0 mm sec^{-1}; target distance, 3.0 mm. The parameter to be determined was cutting force.

Scanning Electron Microscopy (SEM)

Microstructure of the sausages was measured according to the Andres *et al*. (2006) method. Small pieces of sausages of 0.5 cm in diameter and 0.2-0.3 cm thick were used for Scanning Electron Microscopy (SEM) analysis. Samples were dehydrated in the freeze dryer overnight. Samples were mounted on aluminium stubs using a double-sided tape and then coated with a layer of gold (40-50 nm) under vacuum (sputtering), allowing surface and cross section visualization. Micrographs of the samples were obtained with scanning electron microscope (SEM 505, Philips, Eindhoven, The Netherlands).

Statistical Analysis

The trial was performed twice. Three formulations were analyzed and the results were expressed as mean values±SD. The sausage compositions and physicochemical characteristics were compared using one-way Analysis of Variance (ANOVA) and a Tukey test for multiple mean comparisons. Data were processed using SPSS version 17.0. The level of significance was 95%, i.e., $p<0.05$.

RESULTS

In this study, six different samples with different parameters (unwashed without oil, unwashed with 3% oil, unwashed with 6% oil, washed without oil, washed with 3% oil and washed with 6% oil) were produced. The mean values of proximate analysis for duck sausage formulated with different oil added are shown in Table 2; the proximate compositions of unwashed samples were significantly different except for protein content ($p>0.05$). The range of moisture, protein, fat and ash contents were in the range of 53.94- 64.56, 12.48-12.57, 9.38-18.30 and 4.09-5.10%, respectively. While, the moisture, protein, fat and ash contents of washed samples were varied significantly in the range of 60.24-64.92, 10.77-11.81, 8.42-13.22 and 3.84-4.54%, respectively. Table 3 shows mean color values of duck sausage. A higher oil level (6%) led to significantly higher lightness (L*), redness (a*) and yellowness (b*) values. The lightness, redness and yellowness value of unwashed sample with 6% oil added was 52.68, 8.13 and 21.81, respectively. While, the lightness, redness and yellowness value of washed sample with 6% oil added was 56.62, 6.39 and 23.30, respectively. Sample lightness and redness improved significantly after washing. Table 4 shows mean values for textural properties of duck sausage, the range of hardness, springiness, cohesiveness chewiness and shear force values of duck sausage were in the range of 30.57-55.78 (N), 0.51-0.61 (cm), 0.24-0.44 (ratio), 9.47-17.06 (N), 5.76-10.16 (N-cm) and 2.10-2.67 (N), respectively. Washing and oil addition reduced sample hardness and shear force value. The cohesiveness, gumminess and chewiness values were varied significantly after washing and adding oil. Figure 1 shows the micrograph of the unwashed and washed duck sausage. From Fig. 1, washed sample with 0% oil added (Fig. 1A) shows less porous than unwashed sample with 0% oil added (Fig. 1B). Samples with oil added (3 and 6%) were not used for the microstructure comparison as a result of the difficulty of observing pore structure.

Table 2: Proximate values of duck sausage formulated with different oil level

Sample	Moisture	Protein	Fat	Ash
	----------	----------	(%)	----------
UW-0	64.56±0.28^a	12.57±0.28^a	9.38±0.24^e	5.10±0.12^a
UW-3	56.65±0.03^d	12.53±0.37^a	13.68±0.10^b	4.96±0.10^a
UW-6	53.94±0.55^e	12.48±0.97^a	18.30±0.32^a	4.09±0.04^c
W-0	64.92±0.30^a	11.81±0.08^a	8.42±0.12^f	4.54±0.09^b
W-3	61.51±0.08^b	11.63±0.14^a	10.38±0.19^d	4.18±0.03^c
W-6	60.24±0.06^c	10.77±0.08^b	13.22±0.21^c	3.84±0.16^d

Mean±SD. Value is the mean of triplicates. Means indicated with different superscript letter(s) differ significantly ($p<0.05$). UW0, unwashed-no oil; UW3: Unwashed-3% oil; UW6: Unwashed-6% oil; W0: Washed-no oil; W3: washed-3% oil; W6: Washed-6% oil

Table 3: Color values of duck sausage formulated with different oil level

Sample	Lightness (L*)	Redness (a*)	Yellowness (b*)
UW-0	51.36±1.14^f	5.52±0.23^d	17.30±0.57^e
UW-3	51.96±1.03^e	7.70±0.11^b	20.14±0.16^c
UW-6	52.68±1.41^d	8.13±0.17^a	21.81±0.41^b
W-0	52.84±1.38^c	5.75±0.43^d	18.82±0.44^d
W-3	55.15±0.49^b	6.25±0.30^c	21.56±0.71^b
W-6	56.62±0.55^a	6.39±0.39^c	23.30±0.89^a

Mean±SD. Value is the mean of 5 replicates. Means indicated with different superscript letters differ significantly ($p<0.05$). UW0, unwashed-no oil; UW3: Unwashed-3% oil; UW6: Unwashed-6% oil; W0: Washed-no oil; W3: washed-3% oil; W6: Washed-6% oil

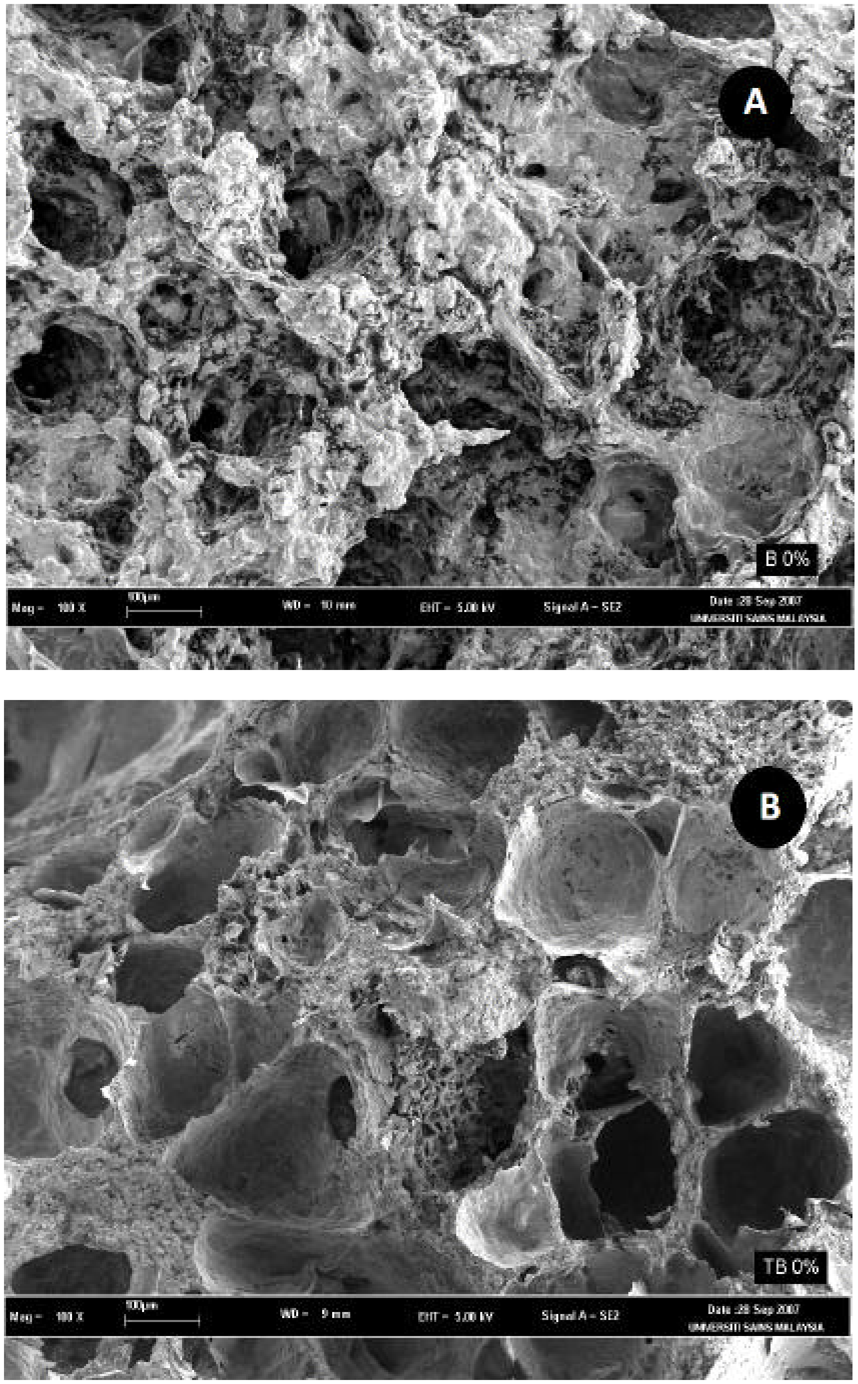

Fig. 1: Scanning electron micrographs of low-fat duck sausage: (A) W0, washed sample without oil and (B) UW0, unwashed sample without oil. Based in 100x (bars= 100 µm)

Table 4: Textural properties of duck sausage formulated with different oil level

Sample	Hardness (N)	Springiness (cm)	Cohesiveness (ratio)	Gumminess (N)	Chewiness (N-cm)	Shear force (N)
UW-0	55.78±0.78[b]	0.59±0.45[a]	0.24±0.02[c]	13.24±0.17[bc]	7.75±1.88[bc]	2.67±0.44[a]
UW-3	44.49±0.80[b]	0.60±1.74[a]	0.39±0.02[ab]	17.06±0.27[ab]	10.16±1.25[ab]	2.45±0.30[b]
UW-6	33.06±0.98[bc]	0.51±1.70[a]	0.44±0.13[a]	15.65±0.84[ab]	7.82±7.05[ab]	2.33±0.24[a]
W-0	46.17±0.49[a]	0.61±0.42[a]	0.31±0.01[bc]	14.23±0.12[a]	8.67±0.85[a]	2.44±0.19[a]
W-3	35.02±0.42[bc]	0.60±0.20[a]	0.33±0.01[bc]	11.56±0.15[bc]	6.89±1.82[bc]	2.28±0.02[c]
W-6	30.57±0.19[c]	0.61±0.07[a]	0.31±0.01[bc]	9.47±0.07[c]	5.76±0.89[c]	2.10±0.02[c]

Mean±SD. Value is the mean of 5 replicates. Means indicated with different superscript letters differ significantly ($p<0.05$). UW0, unwashed-no oil; UW3: Unwashed-3% oil; UW6: Unwashed-6% oil; W0: Washed-no oil; W3: washed-3% oil; W6: Washed-6% oil

DISCUSSION

According to Malaysian Food Regulation 1985 (Law of Malaysia, 2004), the amount of actual meat in manufactured meat products like sausages should not be less than 65%. As a major ingredient in sausage, the percentage of meat used in the three formulations in this study were within the permissible limit.

Proximate Compositions

The moisture content of the duck sausage was significantly ($p<0.05$) affected by washing and adding oil. The ranges of moisture content of unwashed and washed samples are 53.94-64.56 and 60.24-64.92%, respectively. Sausage produced with a washing treatment had significantly higher moisture content and increases in oil level were shown to decrease moisture. An increase in moisture content could be due to the water-binding capacity of added water plus moisture in the ingredients (Pouttu and Puolanne, 2004). Hamm (1960) reported that a greater amount of water could be held due to myofibrillar protein concentration in the washed meat, while fat and sarcoplasmic proteins were leached out. An increase in fat content as a result of added oil would reduce the moisture content of the samples (Yilmaz *et al*., 2002). This result was similar to the result reported by Andres ***et al.*** (2006) where sausages with higher fat composition contained lower moisture. The protein content for washed samples was lower than that of unwashed samples. These result correlated to the results reported by Perlo *et al.* (2006), who reported that the protein content of mechanically deboned chicken meat was reduced from 13.6 to 9.4% after washing. This decrease in protein content could be due to the removal of water-soluble protein (sarcoplasmic). Fat content increased significantly when the amount of oil added was high and the amount of water in the sample was low. According to Cáceres *et al*. (2004), fat content was reduced by increasing protein and/or water levels. In this study, the fat values obtained were within the permissible limit of Malaysian Food Regulations 1985 (Law of Malaysia, 2004), which specifies that fat content of all sausages shall not be more than 30%.

Color Properties

The L* (lightness) value of unwashed and washed samples were between 51.36-52.68 and 52.84-56.62, respectively. A higher L* value indicates a lighter color. The lightness of the samples was influenced by heme pigments and the meat became lighter after the pigments were removed. As consumers choice for white meat over dark meat so removal of heme is important from poultry meat with varying washing strategies (Yang and Froning, 1994). Meat redness might also be affected by washing; washing would reduce the concentration of the myoglobin that contributes to the darker color. Moreover, yellowness decreased with fat reduction (Crehan *et al.*, 2000) and the lowest ($p<0.05$) values were noted in the reduced-fat 0% samples. It can be concluded, lightness and redness values of sausage were affected by washing while yellowness values were affected by adding oil.

Textural Properties

Samples became less hard after washing and after the addition of oil. Samples with a high fat content (unwashed and washed with 6% oil) exhibited lower breaking force values. Fat in the sausages may have provided some lubrication (González-Viñas *et al.*, 2004). Mittal and Barbut (1994) also reported the same results. They noted that a decrease in fat produced an increase in sausage hardness. Different results were reported by Babji *et al.* (1998); they reported that the hardness of chicken meat frankfurters seemed to increase with fat content. This discrepancy is probably due to differences in composition and is a result of a different relationship between the components of the emulsion (fat, protein and water) and the consistency of the gel. Sample springiness showed no significant difference between samples and the results obtained seemed not to be affected by oil addition and washing ($p>0.05$). Similarly, cohesiveness, gumminess and chewiness were varied significantly ($p<0.05$) after washing and adding oil. Because sausage hardness was affected by washing and oil addition, similar results were also obtained for shear force.

Microstructure Properties

Micrographs of washed samples without oil (W-0) and unwashed samples without oil (UW-0) are shown in Fig. 1A and B, respectively. Overall, the pores of the washed samples (W-0) were smaller than those of unwashed samples (UW-0); this was probably due to excess water working with salt to help solubilise the meat myofibrillar protein that binds fat (Romans *et al.*, 1985). That is, the meat structure of washed samples was less porous than unwashed samples. During freeze drying, water droplets filling the pores would crystallize and subsequently sublimate, therefore exposing the fine protein gel matrix (Barbut *et al.*, 1996).

CONCLUSION

From this study, it is evident that different percentages of oil added to duck sausage formulations and washing treatments can influence the physicochemical properties of duck sausage. As can be observed from the analysis performed in the present study, washing improved proximate compositions by lowering fat content and concentrating myofibrillar proteins, resulting in better gelling properties. Washing also increased lightness and reduced the redness of the duck sausage and resulted in a soft gel. Addition of oil to the duck sausage contributed to the formation of a stable emulsion, recovered lost fat and acted as a lubricant in producing softer texture.

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REFERENCES

Andres, S.C., M.E. Garcia, N.E. Zaritzky and A.N. Califano, 2006. Storage stability of low-fat chicken sausages. J. Food Eng., 72: 311-319.

AOAC, 2000. Official Methods of Analysis. AOAC, Washington, DC., ISBN: 0-935584-67-6.

Babji, A.S., S.Y. Chin, M.Y. Seri-Chempaka and A.R. Alina, 1998. Quality of mechanically deboned chicken meat frankfurter incorporated with chicken skin. Int. J. Food Sci. Nutr., 49: 319-326.

Barbut, S., A. Gordon and A. Smith, 1996. Effect of cooking temperature on the microstructure of meat batters prepared with salt and phosphate. Lebensmittel-Wissenschaft und-Technologie, 29: 475-480.

Bhattacharyya, D., M. Sinhamahapatra and S. Biswas, 2007. Preparation of sausage from spent duck-an acceptability study. Int. J. Food Sci. Technol., 42: 24-29.

Cáceres, E., M.L. García, J. Toro and M.D. Selgas, 2004. The effect of fructooligosaccharides on the sensory characteristics of cooked sausages. Meat Sci., 68: 87-96.

Crehan, C.M., E. Hughes, D.J. Troy and D.J. Buckley, 2000. Effects of fat level and maltodextrin on the functional properties of frankfurters formulated with 5, 12 and 30% fat. Meat Sci., 55: 463-469.

Dawson, P., B. Sheldon and H. Ball, 1988. Extraction of lipid and pigment components from mechanically deboned chicken meat. J. Food Sci., 53: 1615-1617.

Drewnowski, A., 1992. Sensory properties of fats and fat replacement. Nutr. Rev., 50: 17-20.

González-Viñas, M.A., A.B. Caballero, I. Gallego and A.G. Ruiz, 2004. Evaluation of the physico-chemical, rheological and sensory characteristics of commercially available Frankfurters in Spain and consumer preferences. Meat Sci., 67: 633-641.

Hamm, R., 1960. Biochemistry of meat hydration. Adv. Food Res., 10: 355-463.

Huda, N., A. Abdullah and A.S. Babji, 2000. Chemical composition and quality of Malaysian fish balls. Proceedings of the Seminar Bersama ITB-UKM IV, April 12-13, Universiti Kebangsaan Malaysia, Malaysia, pp: 205-211.

Keeton, J.T., 1994. Low-fat meat products--technological problems with processing. Meat Sci., 36: 261-276.

Law of Malaysia, 2004. Food Act (Act 281) and Regulations. MDC Publisher Sdn Bhd, Kuala Lumpur, Malaysia, ISBN: 967-70-0808-0.

Lietz, G., C.J.K. Henry, G. Mulokozi, J. Mugyabuso and A. Ballart *et al*., 2000. Use of red palm oil for the promotion of maternal vitamin A status. Food Nutr. Bull., 21: 215-218.

Mela, D.J., 1990. The basis of dietary fat preferences. Trends Food Sci. Technol., 1: 71-73.

Mittal, G.S. and S. Barbut, 1994. Effects of fat reduction on frankfurters physical and sensory characteristics. Food Res. Int., 27: 425-431.

Nagendran, B., U.R. Unithan, Y.M. Choo and K. Sundram, 2000. Characteristics of red palm oil, a carotene and vitamin E-rich refined oil for food uses. Food Nutr. Bull., 21: 189-194.

Perlo, F., P. Bonato, G. Teira, R. Fabre and S. Kueider, 2006. Physicochemical and sensory properties of chicken nuggets with washed mechanically deboned chicken meat: Research note. Meat Sci., 72: 785-788.

Pouttu, P. and E. Puolanne, 2004. A procedure to determine the water-binding capacity of meat trimmings for cooked sausage formulation. Meat Sci., 66: 329-334.

Romans, J.R., K.W. Jones, W.J. Costello, C.W. Carlson and P.T. Ziegler, 1985. Sausage in the Meat We Eat. 12th Edn., The Interstate Printers and Publishers Inc., Danville, IL., pp: 779-887.

Truswell, A.S., N. Choudhury and D.C.K. Roberts, 1992. Double blind comparison of plasma lipids in healthy subjects eating potato chips fried in palm olein or canola oil. Nutr. Res., 12: S43-S52.

Yang, T. and G. Froning, 1992. Effects of pH and mixing time on protein solubility during the washing of mechanically deboned chicken meat. J. Muscle Foods, 3: 15-23.

Yang, T. and G. Froning, 1994. Evaluation of protein functionality in alkali and nonalkali surimi processed mechanically deboned chicken meat. J. Muscle Foods, 5: 221-232.

Yilmaz, I., O. Simsek and M. IsIklI, 2002. Fatty acid composition and quality characteristics of low-fat cooked sausages made with beef and chicken meat, tomato juice and sunflower oil. Meat Sci., 62: 253-258.