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The effects of egg white powder addition with tapioca and sago flours on physicochemical and sensory properties of duck sausage

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Abstract

The objective of this study was to evaluate the effects of using tapioca and sago flours with or without egg white powder (EWP) on the physicochemical and sensory properties of duck sausages. There was significant increase ($P<0.05$) in protein content, folding test, cooking yield, water holding capacity (WHC), lightness, moisture retention and fat retention in duck sausages prepared using flours combined with EWP. However, the ash and carbohydrate contents of duck sausages prepared using flours and EWP decrease significantly compared to their counterparts without EWP. There was no significant difference ($P>0.05$) in hardness and cohesiveness attributes among all the samples examined but significant differences ($P<0.05$) occurred in springiness, chewiness and gumminess attributes. Overall acceptability was higher for duck sausages prepared using sago flour and EWP compared to duck sausages prepared with tapioca flour and EWP.

Introduction

Duck meat production and the number of stocks from 1991 to 2008 increased by 185.06% and 92.69%, respectively (FAOSTAT, 2010). Worldwide duck meat production was about 3.95 million tonnes in 2007 and Asia accounted for 84% of the world output (Poultry Hub, 2009). Duck meat production has also increased continuously for the past twenty years around the world and most of this increase occurred in Asian countries.

In recent times, there has been an increased demand for duck meat and products. This demand has been necessitated by the increase consumption of duck meat, and the rapid development and wide acceptance of value added duck meat products among consumers. This has also generated interest to research into the development and production of more varieties of value added duck meat products (Bhattacharyya *et al*., 2005; Lukman *et al*., 2009; Nurul *et al*., 2010; Huda *et al*., 2010a; Muthia *et al*., 2010; Ramadhan *et al*., 2010). The supply of food is largely constituted by ready-to-cook and ready-to-eat food products.

Polysaccharides and non-meat protein ingredients are important in sausage formulation. They act as binding agents and contribute to better final product. The use of polysaccharides and non-meat protein ingredients such as tapioca starch, potato starch, cereal flours and whey protein in sausage formulations have been studied (Hughest *et al*., 1998; Hsu and Sun, 2006; Serdaroğlu, 2006; Yetim *et al*., 2006; Ruban *et al*., 2008; Yang *et al*., 2009; Ayadi *et al*., 2009). Muthia *et al*. (2010) found that tapioca, wheat, sago, and potato flours improved the physicochemical properties of duck sausages but were lower in sensory attributes compared with commercial chicken sausages.

Egg white powder is known to have high source of protein and fat, and it is produced from fresh egg with or without separating the yolk and albumen, and further dried by spray drying. The whole white powder or yolk powder is used in many food products such as bakery, confectionary, and also meat products for different purposes such as emulsifier, and texture and nutrient enhancers especially to increase protein and fat contents (Lu and Chen, 1999; Hsu and Sun, 2006).The objective of this study was to evaluate the use of tapioca and sago flours with or without egg white powder (EWP) on the quality of duck meat sausage in terms of physicochemical, textural, and sensory attributes.

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Materials and Methods

Raw materials

Mechanically deboned duck meat (MDDM) was purchased from Fika Food Sdn Bhd in Penang, Malaysia. MDDM was immediately transported under frozen condition to the laboratory and was stored at -18°C until further used. Before being used, the MDDM was thawed at 5°C for 1 hr in a chiller and cut into small pieces (3 x 3 x 3 cm) using a cutting machine (Cutting Blade Model P79, USA). Tapioca flour, sago flour, palm oil, spices, salt sugar, and monosodium glutamate (MSG) were purchased from Tesco (Penang, Malaysia) whereas egg white powder (EWP) was purchased from Dimeters Choice Trading (Penang, Malaysia).

Duck sausages were processed as: T sample (containing 4% tapioca flour), S sample (containing 4% sago flour), TEWP sample (containing 3% tapioca flour and 1% EWP), and SEWP sample (containing 3% sago flour and 1% EWP). Each sample also contained 65% MDDM. MDDM was chopped using a mixer (Robot Coupe Blixer 3B, France) for 2 min, and then 14.5% cold water, 7% palm oil, 2.5% salt, 1% sugar, 0.5% MSG, and 5.5% spices were added into the mixer and chopped for further 3 min. The final product obtained were stuffed into a synthetic casing (15 mm diameters) using a mechanical sausage-stuffer and tied manually into 15 cm lengths. The sausages were steamed at 65°C for 30 min in a steamer (Smoke Air Kerres) and the temperature was gradually raised to 85 - 90°C for 2 hrs. Afterwards, duck sausages were soaked in shuttered ice for 2 min and stored in a refrigerator at ±4°C for further analyses.

Proximate analyses

Analysis for moisture, protein, fat, ash and carbohydrate were carried out according to AOAC (2000) standard method. All samples were done in triplicate.

Folding test

Folding test was conducted to determine the gel strength of the cooked duck sausages and was done according to Lanier (1992).

Cooking yield

Cooking yield was determined according to Serdaroğlu (2006). Duck sausages were boiled using water bath (WB-22 DAIHAN, Korea) at a temperature of 90°C for 5 min, and the weights of duck sausages cooked before and after cooking were taken.

Moisture retention and fat retention

Sausages were cooked in a preheated electric grill for 4 min. Percentage cooking yield was determined by calculating the weight differences for samples before and after cooking. Measurements were done in three replicates per treatment. Cooking yield, moisture and fat retention were done according to Serdaroğlu (2006).

Colour

The colour of cooked duck sausages (sliced into pieces 4 mm) were measured using a colorimeter (Minolta Spectrophotometer CM-3500d CM, Japan). The colour reading includes lightness (L*), redness (a*) and yellowness (b*).

pH

Determination of the pH was performed according to Sallam *et al*. (2004) with slight modification.

Texture profile analyses

Texture profile analyses were carried out according to Yetim *et al*. (2006). Cooked duck sausages were uniformly cut into a length of 2 cm pieces. The following parameters were determined: hardness (kg/mm^2), springiness (mm), cohesiveness (ratio), gumminess (kg), and chewiness (kg mm) for the textural analysis.

Sensory evaluation

Sensory evaluation of duck sausages were conducted by 25 panellists using a seven point hedonic scale according to Abdullah (2000). Cooked duck sausages were served on a plate (cube of approximately 1.5 cm^3) in six coded different sausage samples of the same internal end-point temperature presented in a random order. The sensory attributes evaluated were colour, odour, texture, juiciness, oiliness, taste, and overall acceptability.

Statistical analysis

The data obtained from the experiments were analyzed using one way ANOVA test and the SPSS software version 16.0 (SPSS Inc. Illinois, USA). Duncan's multiple-range test was employed to determine the differences between mean values at a significant level of $P<0.05$.

Results and Discussion

Proximate composition

The results of proximate composition analyses are shown in Table 1. Generally, the addition of egg white powder (EWP) increased the protein and fat content of duck sausages. Egg white powder is usually

Table 1. Proximate composition (% wb) of duck sausages prepared using flours with or without EWP

Samples	Moisture	Protein	Fat	Ash	Carbohydrate
T	65.17^{a}±1.17	12.27^{a}±0.27	12.81^{ab}±0.19	2.97^{b}±0.18	6.78^{b}±1.04
S	65.22^{a}±0.12	12.36^{a}±0.31	12.46^{a}±0.23	2.71^{ab}±0.20	7.25^{b}±0.94
TEWP	64.93^{a}±0.22	13.66^{b}±0.24	12.83^{ab}±0.06	2.35^{a}±0.29	6.23^{ab}±0.94
SEWP	65.22^{a}±0.26	14.32^{c}±0.17	12.95^{b}±0.31	2.36^{a}±0.30	5.29^{a}±0.00

T= Tapioca flour; S=Sago flour; TEWP: Tapioca flour and Egg White Powder; SEWP= Sago flour and Egg White Powder. Data presented in means ± standard deviation (n = 3). Means with different letters in the same column are significantly different at a significant level of 5%.

Table 2. Folding test, cooking yield, moisture retention, and fat retention of duck sausages prepared using flours with or without EWP

Samples	Folding test (score)	Cooking Yield (%)	Moisture Retention (%)	Fat Retention (%)
T	4.00^{a}±0.00	91.36^{a}±0.65	59.53^{a}±0.66	77.2^{a}±0.57
S	4.00^{a}±0.00	94.86^{b}±0.25	61.86^{b}±0.28	94.34^{b}±0.25
TEWP	5.00^{b}±0.00	98.92^{c}±0.54	64.23^{c}±0.57	104.36^{c}±0.57
SEWP	5.00^{b}±0.00	98.95^{c}±0.48	64.12^{c}±0.35	104.56^{c}±0.52

T= Tapioca flour; S=Sago flour; TEWP: Tapioca flour and Egg White Powder; SEWP= Sago flour and Egg White Powder. Data presented in means ± standard deviation (n = 5). Means with different letters in the same column are significantly different at a significant level of 5%.

produced from fresh egg albumen using spray drying and it is known to be a rich source of protein and fat.

The powder; whole or egg white powder has been used in many food products such as bakery products, confectionaries and meat products for different purposes such as emulsifier, and texture and nutrition enhancers to increase protein and fat content. Commercial EWP contains 82% protein (Turabi *et al*., 2008). Ndife et al. (2010) reported that egg white powder contains high proportion of protein (62.04%) and fat (7.17%). Owing to the high protein content of EWP, different percentage of EWP has been used in other products such as fish crackers. Julianty *et al*. (1994) showed that increasing the EWP percentage in crackers increased the protein content. Yang *et al*. (2009) produced duck sausages supplemented with cereal flour. Their proximate composition was slightly different from our study (72% moisture, 14.3% protein, 4.8% fat, and 2.5% ash).

Folding test, cooking yield, moisture retention and fat retention

The results of folding test, cooking yield, moisture retention and fat retention are shown in Table 2. There were significant differences (P<0.05) in folding test, cooking yield, moisture retention and fat retention between duck sausages incorporated with EWP compared to sausages without EWP incorporation. In general, duck sausages prepared from flours with the addition of EWP gave better result for folding test, cooking yield, moisture and fat retention.

Folding test is an indicative of the freshness of meat, sources of starch, storage method and ingredients used for sausage formulation. The folding test score for TEWP and SEWP samples were 5, respectively which means that there were no cracks seen after folding the duck sausage samples twice. The folding test score for T and S samples were 4, respectively which mean that there were no cracks seen only after folding the duck sausage half way. EWP may act as an emulsifier in sausage formulation in order to make more equitable distribution of particles from the ingredients used. It influences texture development of sausages and finally gives better result in folding test. EWP has been used in some meat product as binding agent (Lu and Chen, 1999). Hsu and Sun (2005) reported that EWP has been used to replace pork fat in developing low-fat Kung-wans meatball with success.

Cooking yield is one of the most important tests for the meat industry to predict the behaviour of products during cooking (Pietrasik and Li-Chan, 2002). Cooking yield was higher for TEWP (98.92%) and SEWP samples (98.95%) compared to T (91.36%) and S samples (94.86%). Keeton (1994) stated that carbohydrates such as starches and hydrocolloids are added to meat products to improve cooking yield, increase moisture retention and modify product texture.

The moisture and fat retentions were high in sausages incorporated with EWP. The addition of EWP increased the cooking yield of duck sausages probably due to its ability of keep the moisture in duck meat matrix. As noted by Kato *et al*. (1999), the utilization of EWP has been applied in many food products due to its nutritional content. Besides, good functional properties of EWP make it suitable as gelling and emulsifying agents.

pH, WHC and colour properties

The results for pH, water holding capacity and colour properties are shown in Table 3. The pH value of sausages incorporated with EWP was found to be higher than samples without EWP. Ahmed *et al*. (2007) reported that there was a slight and gradual increase in pH of buffalo meat cutlet and product yield with increasing levels of EWP. Yang *et al*. (2009) also produced duck meat sausages with the addition of beef fat and cereal flours, and found that the pH value ranged from 6.6 to 6.7.

Water holding capacity (WHC) was conducted to measure how well juices are retained in duck sausages and it is one of the important attributes of sausages and other meat products. Thus WHC measures the ability of a product to hold moisture and other juices in the product both before and after treatment (Yang *et al*., 2007; Brewe, 2010). In this study, WHC was higher for sausages containing flours and EWP. Puolanne (1999) reported that the water-binding capacity of ingredients is related to the ingredients

Table 3. pH, WHC and colour properties of duck sausages prepared using flours with or without EWP

Samples	pH	WHC	Colour		
			L*	a*	b*
T	$6.45^{c} \pm 0.02$	$57.80^{b} \pm 0.44$	$58.55^{a} \pm 0.62$	$3.87^{ab} \pm 0.15$	$28.23^{a} \pm 0.23$
S	$6.33^{a} \pm 0.04$	$56.40^{a} \pm 0.54$	$58.38^{a} \pm 0.39$	$3.69^{a} \pm 0.12$	$29.15^{b} \pm 0.27$
TEWP	$6.37^{b} \pm 0.01$	$60.00^{d} \pm 0.94$	$59.64^{c} \pm 0.21$	$4.85^{c} \pm 0.07$	$28.39^{a} \pm 0.22$
SEWP	$6.31^{a} \pm 0.01$	$58.80^{c} \pm 0.44$	$59.10^{b} \pm 0.09$	$4.03^{b} \pm 0.24$	$29.78^{c} \pm 0.94$

T= Tapioca flour; S=Sago flour; TEWP: Tapioca flour and Egg White Powder; SEWP= Sago flour and Egg White Powder. Data presented in means ± standard deviation (n = 5). Means with different letters in the same column are significantly different at a significant level of 5%.

Table 4. Texture profile analysis of duck sausages prepared using flours with or without EWP

Samples	Hardness (kg)	Springiness (mm)	Cohesiveness (ratio)	Gumminess (kg/mm^2)	Chewiness (kg mm)
T	$3.77^{a} \pm 0.60$	$6.20^{a} \pm 0.09$	$0.27^{a} \pm 0.02$	$1.02^{a} \pm 0.02$	$6.32^{a} \pm 0.45$
S	$3.63^{a} \pm 0.66$	$6.50^{b} \pm 0.02$	$0.29^{a} \pm 0.02$	$1.05^{ab} \pm 0.28$	$6.83^{a} \pm 0.72$
TEWP	$4.05^{a} \pm 0.84$	$6.31^{a} \pm 0.06$	$0.27^{a} \pm 0.05$	$1.13^{ab} \pm 0.23$	$7.12^{ab} \pm 0.70$
SEWP	$4.47^{a} \pm 0.62$	$6.60^{b} \pm 0.03$	$0.28^{a} \pm 0.00$	$1.26^{b} \pm 0.01$	$8.32^{b} \pm 0.78$

T= Tapioca flour; S=Sago flour; TEWP: Tapioca flour and Egg White Powder; SEWP= Sago flour and Egg White Powder . Data presented in means ± standard deviation (n = 5). Means with different letters in the same column are significantly different at a significant level of 5%.

composition and ingredient-ingredient interactions. This is particularly true with non-meat ingredients. The addition of suitable binder such as EWP also enhanced the water binding capacity of sausages. The increment of the WHC of duck sausage was higher with the addition of EWP. This result is consistent with that reported by other researchers. Hughes *et al*. (1996) obtained similar results in frankfurters with the addition of carrageenan or oat fiber; which reduced cooking losses and increased WHC. Yang *et al*. (2007) also reported that when oatmeal and tofu were added to sausages, the sausages exhibited higher water-holding capacity (± 94 - 95%) and produced less cooking loss.

The addition of EWP increased the WHC (TEWP was 60.00% and EWP was 58.80%) compared to flours without EWP (T was 57.80% and S was 56.40%). Generally, when the fat content of processed meat product is gradually reduced, the water content is increased, and the product's WHC becomes the critical factor in production. WHC is the ratio of moisture retained in the sample to the initial moisture content, so higher WHC percentage indicates release of less moisture (Pietrasik and Duda, 2000).

In general colour of duck sausages are slightly darker than the commercial chicken sausages. Huda *et al*. (2010b) reported that the colour of chicken meat is lighter than duck meat. This is due to the natural colour of duck meat, which is fatty and red or dark compared to chicken meat (Meulen and Dikken, 2004). In addition, duck is a flight poultry and has darker breast meat and muscles because more oxygen is delivered to those muscles by the red cells. Myoglobin (one of the proteins in meat), carries oxygen in the muscle, and gives meat a darker colour (USDA, 2010). Heinz and Haurzinger (2007) also stated that myoglobin concentration in muscles differs among animal species.

Texture profile analysis

Texture profile analysis results are shown in Table 4. There was no significant difference ($P>0.05$) in hardness, springiness, cohesiveness, gumminess and chewiness attributes in both sausages incorporated with EWP and without addition of EWP. However, chewiness attributes differed significantly between S and SEWP samples. On the other attribute, springiness of TEWP was lower ($P<0.05$) compared to SEWP sample.

In general, the addition of EWP had a minimal effect on textural development although some textural attributes such as springiness and cohesiveness differed significantly. Total moisture content of the final product as affected by the function of EWP in the duck sausages influenced textural attributes such as springiness and cohesiveness. In this study, S and SEWP samples were higher in springiness. This is similar to previous study using tapioca, wheat, sago, and potato flours in duck sausages preparation (Muthia *et al*., 2010). Textural determination equipments (including Textural Profiles Analyzer) can be used to determine differences in texture among different treatment samples, whereas textural determination based on the sensorial test is preferred by consumers (Nurul *et al*., 2010).

Duck sausages prepared from EWP and sago flour (SEWP) showed higher hardness, springiness, gumminess and chewiness values compared to the duck sausages prepared using EWP and tapioca flour (TEWP). Addition of EWP increased hardness from 37.72 (Tapioca) to 40.49 (TEWP) and 36.30 (Sago) to 44.73 (SEWP), respectively. These findings were in agreement with Ahmed *et al*. (2007), who observed desirable textural attributes up to 2% inclusive level of EWP in buffalo meat cutlets. The addition of EWP significantly increased the hardness of the duck sausages. Reducing fat level can increase the hardness and firmness of sausages (Mugueza *et al*., 2002). Kato *et al*. (1990) stated that heating egg white powder would exposed a greater number of functional hydrophobic group available for cross-link formation to stabilize the gel network, which involves intermolecular hydrogen bonding and hydrophobic interactions. EWP has been used in some meat products as binding agents. Lu and Chen (1999) reported that the addition of EWP in poultry meat increased the tensile strength of poultry meat ($P<0.01$) and a linear relationship between the quantity of EWP applied and the resulting tensile strength.

Table 5. Sensory evaluation of duck sausages prepared using flours with or without EWP

	Texture	Elasticity	Colour	Flavour	Taste	Juiciness	Overall Acceptability
T	$4.12^{a} \pm 1.48$	$4.04^{a} \pm 1.20$	$4.68^{a} \pm 1.10$	$5.2^{a} \pm 0.91$	$5.00^{a} \pm 1.00$	$4.32^{a} \pm 1.03$	$4.76^{a} \pm 0.66$
S	$4.48^{ab} \pm 1.12$	$4.32^{ab} \pm 0.90$	$4.96^{ab} \pm 0.93$	$5.2^{a} \pm 0.95$	$5.04^{a} \pm 0.88$	$4.24^{a} \pm 1.05$	$5.02^{ab} \pm 0.73$
TEWP	$5.00^{bc} \pm 1.00$	$4.48^{ab} \pm 1.04$	$5.16^{ab} \pm 0.74$	$4.76^{a} \pm 1.30$	$5.04^{a} \pm 0.67$	$5.20^{a} \pm 0.95$	$5.12^{ab} \pm 0.60$
SEWP	$5.40^{bc} \pm 0.71$	$4.64^{b} \pm 0.75$	$5.32^{b} \pm 0.98$	$4.96^{a} \pm 0.78$	$5.12^{a} \pm 0.78$	$5.24^{a} \pm 0.97$	$5.36^{b} \pm 0.70$

T= Tapioca flour; S=Sago flour; TEWP: Tapioca flour and Egg White Powder; SEWP= Sago flour and Egg White Powder . Data presented in means ± standard deviation (n = 25). Means with different letters in the same column are significantly different at a significant level of 5%. Score 1 = Dislike very much; 2 = Dislike moderately; 3 = Dislike slightly; 4 = Neither like nor dislike; 5 = Like slightly; 6 = Like moderately; 7 = Like very much.

Sensory evaluation

The results of sensory evaluation are shown in Table 5. The results show that significant differences ($P<0.05$) occurred among T, S, TEWP and SEWP duck sausages. The scores for sensory evaluation for duck sausages range were; texture (4.1-5.4), elasticity (4.0-4.6), colour (4.7-5.2), flavour (4.8-5.2), taste (5.0-5.1), juiciness (3.6-4.4) and overall acceptability (4.8-5.4). In general, sensory evaluation aimed at determining consumers' acceptability for food products, and it is applied when developing new food products, substituting food formula, or to study the shelf life of food products during storage (Hutchings, 1999).

The panelists gave better score for TEWP and SEWP duck sausages compared to T and S sample. The higher moisture and fat retention of TEWP and SEWP duck sausages resulted in improved flavour, texture and juiciness of duck sausages. Colour is one of the main physical attributes of processed meat products, which determines the acceptability of a product by consumers. Kalaikannan *et al*. (2007) reported a high sensory score for chicken patties prepared with egg white powder. The score range for overall acceptability of duck sausages was 4.8-5.4 which means that the panellist slightly liked the product. This may be due to the fact that duck sausage is a newly developed product and panellist may not be familiar with the taste of this product.

In particular, duck sausages prepared using tapioca or sago flours together with EWP increased overall acceptability and improvement in texture, elasticity, and colour. However, the treatments had no significant effect ($P>0.05$) on flavour, taste, and juiciness. Sensory scores were under six that means panellists slightly liked the duck sausages. This may also be due to the fact that duck sausage is a new processed meat product and duck meat product intake is very low compared to chicken meat products (Oteku *et al*., 2006). The higher lightness may have been caused by the higher concentration of fat in sausages and this parameter is an important factor that influences the choice of sausages by consumers (Nurul *et al*., 2010).

Similarly to our results, Yang *et al*. (2009) reported lower sensory scores for duck meat sausage produced with the addition of beef fat and cereal flours. Their scores ranged from 4.6 to 6.9 for colour, 4.2 to 4.9 for flavour, 3.9 to 4.6 for juiciness, 3.8 to 5.6 for tenderness, and 3.9 to 5.4, respectively for overall acceptability. Responds from our respondents pointed out that there are definite constraints limiting the consumption of duck meat products. Therefore, there is a need to develop appropriate duck meat products to improve consumers' acceptance and consumption of duck meat products. Presumably, providing training in the methods of cooking and preparing duck meat products, and substantial advertisement of duck meat products is more likely to improve consumers acceptance and consumption rates.

Conclusion

The use of flours and EWP (TEWP and SEWP samples) increased the moisture, protein, and fat contents but reduced the ash and carbohydrate contents. It also decreased the pH value of duck sausages. WHC, moisture retention and fat retention were increased in sausages incorporated with EWP. Lightness and redness of TEWP and SEWP were significantly higher ($P<0.05$) than T and S. SEWP sample showed higher hardness, springiness, gumminess and chewiness values compared to the other duck sausages. Panelists gave better sensory marks to TEWP and SEWP.

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