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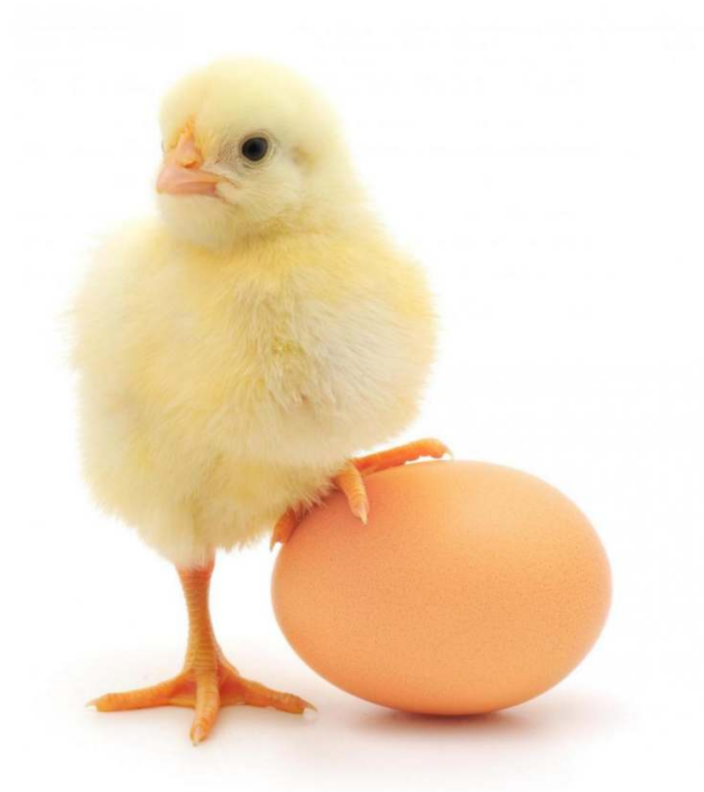

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Chemical Composition and Physicochemical Properties of Meatballs Prepared from Mechanically Deboned Quail Meat Using Various Types of Flour

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Abstract: Quail meatballs using different types of flour were analyzed for their proximate composition (moisture, protein, fat, ash and total carbohydrate) and physicochemical properties (cooking yield, moisture retention, fat retention, juiciness, folding test, color, texture profile analysis and sensory qualities). Meatballs were produced using 65% quail meat, 3% flour (cassava, corn, wheat, sago and potato flour), 3.2% soy protein isolate, 10% palm oil, 2.1% salt, 2% sugar, 0.9% mixed spices and 13.8% cool water. The proximate composition of the quail meatballs produced was comprised of 64.94-66.33% moisture, 13.43-14.47% protein, 10.32-13.77% fat, 2.30-2.95% ash and 4.80-7.67% carbohydrates. The cooking yield was highest for the quail meatball formulation using potato flour (98.97%), followed by the yields of formulations using, cassava (97.99%), sago (97.46%), corn (91.06%) and wheat flour (91.00%). Folding test scores were in the range of 3.50-4.67. Lightness (L*) was in the range of 66.06-69.10, redness (a*) was in the range of 1.79-2.25 and yellowness (b*) was in the range of 17.75-17.98. The analyzed texture profiles were significantly different ($p<0.05$). The hardness of the quail meatballs using potato flour was highest (10.08 kg), followed by the hardness of formulations using wheat (9.18 kg), corn (9.08 kg), sago (8.45) and cassava flour (7.90). The sensory evaluation of the quail meatballs generally produced a moderate score (5) on a 7-point hedonic scale. The sensory score showed that quail meat can be successfully used in the manufacture of meatballs as an alternative to other meats such as beef and chicken, using different types of flour. Cassava flour is one of the best formulations produced and is the most acceptable.

Key words: Quail meat processing, meatball, chemical composition, physicochemical

INTRODUCTION

The consumption of poultry meat and poultry meat products is growing all over the world (Mielnik *et al.*, 2002). In recent years, quail meat has gained much popularity among consumers. Quails, most commonly bred for human consumption, belong to the species *Coturnix coturnix japonica*. Their distribution in the wild spreads over large areas of Asia, Europe and Africa, but they were first domesticated in Japan (Mizutani, 2003). Meanwhile, increased production of cut-up and processed meat has provided considerable quantities of parts suitable for mechanical deboning. This process is an efficient method of harvesting meat from parts left over after hand deboning as well as from poor quality poultry. The yields of Mechanically Deboned Poultry Meat (MDPM) range from 55-80%, depending on the part deboned and deboner settings (Mielnik *et al.*, 2002). MDPM is frequently used in the formulation of comminuted meat products due to its fine consistency and relatively low cost. The use of MDPM in nuggets, sausages, comminuted sausages and restructured chicken products has been well documented (Perlo *et al.*, 2006; Daros *et al.*, 2005; Mielnik *et al.*, 2002).

Meatballs are a popular meat product in Malaysia (Huda *et al.*, 2010). This includes products such as chicken balls, fish balls, beef balls, prawn balls and squid balls. Other meat sources such as quail and duck are also potential raw materials for meatball production. Most Malaysian meatballs are manufactured by adding starch to provide desirable texture and cut down manufacturing costs.

Meats are usually used as the main ingredients in manufactured meats, including meatballs. It comprises no less than 65% of formulations according to the Food Act and Regulations of Malaysia 2009, 147(3). The essential ingredients that determine the quality of meatballs are flour (starch), water and fat or oil.

Although meatballs are a popular food among consumers, there is a rising concern about the nutritive value of meatballs. Consumers prefer real meats over processed meats. Therefore, more and more studies about the nutrition and quality of meatballs have been performed. Some studies have been done to determine the quality, chemical composition and physicochemical properties of meatballs, such as a studies on the physicochemical and sensory characteristics of low-fat

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meatballs with added wheat bran (Yilmaz, 2005), the improvement of low-fat meatball characteristics by adding whey powder (Serdaroglu, 2006), the effect of rice bran on the sensory and physicochemical properties of emulsified pork meatballs (Huang *et al.*, 2005), the quality of low-fat meatballs containing legume flour as an extender (Serdaroglu *et al.*, 2005) and the effect of ingredients on the characteristics and quality of meatballs (Hsu and Yu, 1999; Serdaroglu, 2006; Hsu and Lung-Yueh Sun, 2006).

Non-meat ingredients, such as flour, starch, soya protein, egg, whey protein and fat, play a significant role in the modification of the functional properties of a meat product, such as emulsification, water- and fat-binding capacity and textural properties (El-Magoli *et al.*, 1996; Gujral *et al.*, 2002). In particular, non-meat proteins and carbohydrates are often used to enhance the texture of meat products (Hongsprabhas and Barbut, 1999). Starch functions as a binder, stabilizer and thickening agent. Carbohydrate-based ingredients are known to be good water binders and numerous studies have focused on the effects of these nonmeat ingredients on sensory, cooking and water-binding properties in ground beef (Brewer *et al.*, 1992; Egbert *et al.*, 1992; Troutt *et al.*, 1992; Vosen *et al.*, 1993 and Desmond *et al.*, 1998). In the past, starch was added as a source of carbohydrates and to thicken the texture of meatballs (Huda *et al.*, 2009). Today, starch is extensively used as a stabilizer, texturizer, water or fat binder and emulsifier. Apart from these functions, starch can also increase the gel strength and freeze-thaw stability of meatballs if added in appropriate levels (Serdaroglu *et al.*, 2005).

The aims of this study were to investigate the suitable flour type (cassava, corn, wheat, sago and potato) and its effects on the proximate composition, physico-chemical properties and sensory qualities of quail meatballs.

MATERIALS AND METHODS

Raw material: Quail (*Coturnix coturnix japonica*) carcasses were purchased from the Institute of Poultry Development, Johor Bahru, Malaysia and transported in an ice box to FIKA Food Sdn. Bhd. Pulau Pinang, Malaysia, where they were deboned mechanically. The mean carcass weights were 299.04±30.67 g and 8 months ± 3 days old. After deboning all samples, they were processed into 20-kg blocks, frozen at -30°C and transported in an ice box to the Fish and Meat Processing Laboratory of Food Technology Program, Universiti Sains Malaysia. The blocks were sawed into portions weighing approximately 1 kg and immediately stored at -18°C for processing manufacturing. Flour and other ingredients were obtained from a local market in Penang, Malaysia.

Preparation of meatballs: Quail meatballs were formulated using 65% quail meat, 3% flour (cassava, corn, wheat, sago and potato), 3.2% soy protein isolate, 10% oil (palm oil), 2.1% salt, 2% sugar, 0.9% mixed spices and 13.8% cool water. The meat, flour and spices were mixed for 4 min (Robot Coupe, France); oil was added and the combination was mixed for another 2 min. The meatballs were formed by hand and cooked first at 40°C for 20 min and then at 90°C for an additional 20 min (Yu, 1994). The meatballs were stored and cooked before analysis at 95°C for 5 min.

Proximate analysis: Moisture, protein, fat and ash contents were determined in accordance with standard AOAC methods of (AOAC, 2000). Protein determination involved a Kjeldahl assay (Nx6.25). Fat was determined by extracting samples in a Soxhlet apparatus using petroleum ether as a solvent. Moisture was quantified by oven-drying 10 g samples at 100°C overnight. Ash was determined after incineration in a furnace at 500°C and carbohydrate content was calculated by computing the difference.

Cooking yield: Cooking yield was determined by measuring the difference in the sample weight before and after cooking and was calculated according to Murphy *et al.* (1975):

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked meatballs}}{\text{Weight of uncooked meatballs}} \times 100$$

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:

$$\text{Moisture retention (\%)} = (\text{\% cooking yield} \times \text{moisture in cooked meatballs})/100$$

Fat retention: Fat retention was calculated based on a modified method of Murphy *et al.* (1975) as follows:

$$\text{Fat retention (\%)} = (A/B) \times 100$$

A = Fat content in cooked meatballs x weight of cooked meatballs

B = Fat content in uncooked meatballs x weight of uncooked meatballs

Juiciness: Juiciness was determined as follows: the meatball sample was taken from the center and was cut into 3-mm pieces with a knife. A sample was placed between two pieces of pre-weighed Whatman (No. 41) filter paper, covered with aluminum foil and pressed for 1 min by 10 kg of force. The residue was removed and the filter paper was weighed. The extracted juice was determined as follows (Gujral *et al*., 2002):

$$\text{Juiciness (\%)} = (A/B) \times 100$$

A = Weight of filter paper after pressing-weight of filter paper before pressing
B = Weight of sample

Folding test: The folding test was determined according to Lanier (1992). Cooked samples were cut into 3 mm thick portions. The slices were held between the thumb and the forefinger and folded to observe the way that they broke. The scale used was as: (1) breaks by finger pressure, (2) cracks immediately when folded in half, (3) cracks gradually when folded in half, (4) no cracks showing after folding in half and (5) no cracks showing after folding twice.

Color measurement: Color analysis of meatballs was carried out using a Minolta Chromameter colorimeter equipped (CM 3600 d, Osaka, Japan). Color was described according to the following coordinates: lightness (L*), redness (a*, ±red-green) and yellowness (b*, ±yellow-blue).

Texture profile analysis: The Texture Profile Analyses (TPA) of meatballs were determined using a texture analyzer (Model TA-XT2 Texture analysis, England) according to Bourne (1973). The conditions of texture analyzer were as follows: pre-test speed, 2.0 mm/s; post-test speed, 5.0 mm/s; distance, 5.0 mm; time, 5.0 s; trigger type, auto and trigger force, 10 g. For TPA measurement, the meatballs were cut by two sides to get a 10 mm depth strip. Each strip was immobilized between specially constructed stainless steel plates with the cut surface oriented; the spherical probes (p/0.5 s, 1.2 cm diameter ball probe) of texture analyzer would penetrate the strip perpendicular to the muscle fiber orientation. Two separate TPA values were done per strip for a total of six measurements per group. The calculation of TPA values was obtained by graphing a curve using force and time plots.

Sensory evaluation: Panels of 30 students of Food Technology Program were participated to the study. A 7-points hedonic scale method (7 like very much and 1 dislike very much) was used to evaluate texture, colour, odour, taste, flavour and overall acceptability. The samples were coded with three digit random numbers and the order of presentation was made using random permutation. The sensory evaluation was carried out at the sensory laboratory. All necessary precautions were taken to ensure that each panelist made an independent judgment (Aminah, 2000).

Statistical analysis: The data collected were analyzed using Statistical Package Social Science (SPSS) version 15.00. Means of treatment showing significant differences ($p<0.05$) were subjected to Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The proximate compositions of uncooked and cooked quail meatballs using different types of flour are shown in Table 1. The proximate composition of uncooked quail meatball was not significantly different ($p>0.05$). Uncooked quail meatballs had a moisture, protein, fat, ash and carbohydrate content ranging from 68.12-68.35%, 13.12-13.32%, 12.15-12.41%, 2.18-2.28% and 3.89-4.23%, respectively. The quail meatballs cooked using cassava flour had the highest moisture content (66.33%), followed by those cooked using wheat (65.94%), potato (65.35%), corn (65.01) and sago flour (64.94%). These results are in accordance with the proximate composition of commercial chicken meatballs reported by Huda *et al*. (2009). The researchers found that commercial chicken meatballs have moisture, protein, fat, ash and carbohydrate contents of about 64.33-71.81%, 9.94-15.96%, 4.26-14.00%, 1.92-2.82% and 5.54-20.85%, respectively. Meanwhile, Serdaroglu (2006) found that beef meatballs with 10% fat with added whey powder (0 and 2%) have moisture, protein, fat and ash contents almost the same as those reported: 62.9 and 63.8%, 16.9 and 16.5%, 13.6 and 12% and 2.5 and 2.5%, respectively. Another study on low-fat meatball with 10% fat also found the meatballs to be composed of 67.29% moisture, 16.71% protein, 11.2% fat and 2.32% ash (Yilmaz, 2004). The meatballs prepared from quail meat using various types of flour have proximate analysis values that are not so different from those of meatballs made from other meats such as chicken. Quail meatballs have a higher protein content and lower carbohydrate content than various kinds of commercial chicken meatballs in Malaysian markets, as reported by Huda (2000) who reported protein and carbohydrate contents ranging from 12.83-13.71% and 5.23-8.25%, respectively; Huda *et al*. (2009) reported protein and carbohydrate contents ranging from 9.94-15.06% and 5.54-20.85%, respectively.

Cooking increased the protein, fat and ash content and decreased the moisture content on a percentage basis in all of the meatball formulations. Serdaroglu and Degrmencioglu (2004) also found that the cooking of Turkish meatballs had increased the fat content and decreased the moisture content on a percentage basis in all formulations. These increments in protein, fat and ash content are a result of cooking losses (Serdaroglu and Degrmencioglu, 2004). In this case, moisture was lost in the cooking of quail meatballs.

Table 1: Proximate composition of uncooked and cooked quail meatball using different types of flour (% wet basis)

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)
Uncooked meatballs					
Cassava	68.28±0.12[a]	13.12±0.17[a]	12.24±0.16[a]	2.28±0.12[a]	4.09±0.14[a]
Corn	68.12±0.11[a]	13.32±0.18[a]	12.15±0.18[a]	2.20±0.13[a]	4.20±0.21[a]
Wheat	68.35±0.22[a]	13.23±0.13[a]	12.41±0.26[a]	2.19±0.23[a]	3.89±0.23[a]
Sago	68.21±0.19[a]	13.15±0.20[a]	12.23±0.24[a]	2.18±0.14[a]	4.23±0.17[a]
Potato	68.29±0.30[a]	13.20±0.15[a]	12.34±0.13[a]	2.25±0.25[a]	3.93±0.05[a]
Cooked meatballs					
Cassava	66.33±0.08[a]	13.43±0.28[b]	10.44±0.18[c]	2.46±0.14[b]	7.33±0.15[a]
Corn	65.01±0.28[d]	14.47±0.65[a]	13.31±0.17[b]	2.41±0.15[c]	4.40±0.62[b]
Wheat	65.94±0.10[b]	13.53±0.20[b]	10.59±0.48[c]	2.30±0.13[c]	7.63±0.57[a]
Sago	64.94±0.13[d]	14.45±0.29[a]	10.32±0.22[d]	2.62±0.06[b]	7.67±0.54[a]
Potato	65.35±0.42[c]	13.68±0.40[b]	13.77±0.04[a]	2.95±0.19[a]	4.25±0.35[b]

*Value is the mean of two replicates performed in triplicate for each. Means with the same letter within the same column are significantly different ($p<0.05$)

Table 2: Cooking yield, moisture retention, fat retention, juiciness and folding test of quail meatball using different types of flour

Sample	Cooking yield (%)	Moisture retention	Fat retention (%)	Juiciness (%)	Folding test
Cassava	97.99±0.40[b]	64.99±0.08[c]	85.22±0.30[b]	15.30±0.10[c]	4.67±0.52[a]
Corn	91.06±0.62[c]	59.19±0.25[d]	82.58±0.59[d]	15.43±0.33[c]	4.50±0.55[a]
Wheat	91.00±0.44[c]	60.00±0.08[d]	84.00±0.42[c]	14.40±0.26[a]	4.17±0.41[a]
Sago	97.46±0.58[b]	63.28±0.03[b]	84.50±0.73[c]	15.74±0.07[d]	3.50±0.55[b]
Potato	98.97±0.67[a]	64.67±0.42[a]	85.91±0.49[a]	14.78±0.11[b]	4.50±0.55

[a]*Value is the mean of two replicates performed in triplicate for each. Means with the same letter within the same column are significantly different ($p<0.05$)

Table 2 shows the cooking characteristic of quail meatballs. Cooking yield results are the most important factors for the meat industry in predicting the behavior of products during cooking due to non-meat ingredients or other factors (Pietrasik and Li-Chan, 2002). The meatballs tend to shrink during the cooking process due to the denaturation of the meat proteins, with the loss of water and fat also contributing to the shrinking process. The treatment result is high cooking yield. The cooking yield of quail meatballs using potato flour was the highest (98.97%), followed by the yields of meatballs cooked using cassava (97.99%), sago (97.46%), corn (91.06%) and wheat flour (91.00%). This result indicates that during cooking, some of the moisture is lost. Moreover, this cooking yield was also the highest when compared with the cooking yields of low-fat meatballs containing legume flours as extenders: 93.2% (lentil flour), 92.8% (black eye bean flour), 88.6% (chickpea flour) and 85.2% (rusk) (Serdaroglu *et al*., 2005). This result was also highest when compared with the cooking yield of meatballs prepared using wheat flour, whey protein concentrate and soya protein isolate and their effect on the oxidative processes and textural properties of cooked meatballs, as reported by Ulu (2004); they reported a cooking yield of 41.3-49.32% after storage 4°C for 1 day. Other researchers found that cooking yields varied between 85.2% and 93.2% for meatballs using legume flours as extenders (Serdaroglu *et al*., 2005) and Ulu (2006) reported a 56.25-65.02% cooking yield for low-fat meatballs prepared from ground meat using carrageenam and guar gum formulated with 10% fat.

The moisture retention of quail meatballs using cassava flour was high (64.99%), followed by the moisture retention of meatballs prepared using potato (64.67%), sago (63.28%), wheat (60.00%) and corn flour (59.19%). This result moisture retention was also the highest compared with the values for low-fat meatballs containing legume flours as extenders: 56.4% (lentil flour), 53.9% (black eye bean flour) and 50.9% (chickpea flour and rusk) (Serdaroglu *et al*., 2005). Ulu (2004) reported a maximum moisture retention of 21.9-24.4%. Other researchers reported 30.43-35.66% moisture retention in low-fat meatball using carrageenam and guar gum formulated with 10% fat. Another study conducted by Serdaroglu and Degrmencioglu (2004) on the effects of fat content (5%, 10%, 20%) and corn flour content (0%, 2%, 4%) on some of the properties of Turkish meatballs (koefte) obtained a moisture retention value between 36.53-44.70%.

The fat retention in quail meatballs using potato flour was the highest (85.91%) followed by the fat retention in meatballs using cassava (85.22%), sago (84.50%), wheat (84.00%) and corn flour (82.58%). This result showed that very little fat was lost after cooking. This result is supported by Serdaroglu *et al*. (2005), who reported that the fat retention in low-fat meatballs containing legume flours as extenders was 95.5% (lentil flour), 95.0% (black eye bean flour), 92.8% (chickpea flour) and 82.8% (rusk). This result is different from that reported by Ulu (2004), who found that the fat retention in low-fat meatballs was low (20.7-25.3%) for meatballs stored at 4°C for 1 day; Ulu (2006) also reported low values of fat retention (24.77-42.95%) in low-fat meatball from ground meat using carrageenam and guar gum formulated with 10% fat. According to Serdaroglu and Degrmencioglu (2004), product formulation and processing methodology are key determinants of fat loss and weight loss during cooking. Shrinkage in the weight and volume of meat because of the loss of fat and moisture is appreciable (Schweigert, 1987).

Potato and cassava flour formulations produced higher cooking yields and higher fat retentions than the other treatments. Fat retention has been shown to increase with decreasing fat level (Serdaroglu and Degrmencioglu, 2004) and there is a possible connection between increasing cooking yield and higher fat retention. The formulations with corn and cassava flour produced higher cooking yields of quail meatballs probably due to their ability to retain moisture in the matrix (Serdaroglu and Degrmencioglu, 2004). However Anderson and Berry (2000) and Anderson and Berry (2001) indicate that increased cooking yield does not always result in higher fat retention. The loss of moisture and fat also affects the moisture retention, fat retention and juiciness of samples. The quail meatballs using potato, cassava and sago flours showed little weight loss compared to meatballs using corn and wheat flour; accordingly, moisture retention was highest in meatball formulations using potato flour, followed by those using cassava, sago, corn and wheat flour. The lowest cooking yield in meatballs using corn and wheat flour might be attributed to excessive fat separation and water release during cooking (Serdaroglu, 2006).

There is a possible connection between increasing cooking yield and higher fat retention, as potato and cassava flour produced higher cooking yield (98.97 and 97.99%, respectively) and higher fat retention (85.91 and 85.22%, respectively). Similar results were reported found by Serdaroglu and Degrmencioglu (2004), who also found that higher cooking yield was accompanied by higher fat retention. The addition of potato and cassava flour increased the cooking yields of meatballs probably due to their ability to retain moisture in the matrix. Retaining fat within the matrix of meat products during processing is necessary to ensure sensory quality and acceptability. Product formulation and processing methodology are key determinants of fat loss and weight loss during the cooking of products such as sausages and burgers (Sheard *et al.*, 1989). However, Anderson and Berry (2000) and Anderson and Berry (2001) indicate that increased cooking yield does not always result in higher fat retention.

The juiciness in meatballs ranged from 14.40-15.74%. Meatballs using sago flour had higher ($p<0.05$) juiciness than meatballs using other flours. Gujral *et al.* (2002) found that the juiciness of cooked patties was 12.87% with the addition of 20% textured soy protein and 12% with the addition of 10% liquid whole egg in baked goat meat patties. In this study, there was no correlation between juiciness and cooking yield, as was also reported by Berry *et al.* (1996), who found that the increased cooking yield in the non-stimulation and hot-processing of patties did not translate into improved juiciness for low-fat ground beef patties. Gujral *et al.* (2002) found that juiciness decreased with decreasing fat levels in baked patties from goat meat. Several studies have produced similar results (Berry and Wergin, 1993).

The folding test is one of the simplest methods used to measure the texture of meatballs. Differences in texture are reflected in folding tests. Folding test scores scale linearly with gel strength. Table 2 shows the folding test results for quail meatballs. Relatively, they had the best textural quality. The quail meatball using potato flour produced a lower folding test score (3.50) compared with meatballs using other flours ($p<0.05$). This may due to the suitable meat extenders or binders in its formulation.

Table 3 shows the L*, a* and b* values of quail meatball samples after being cooked. All of the color coordinates are significantly different ($p<0.05$) between the quail meatball samples. The analyses show that the quail meatball using wheat flour produced the highest value of lightness (69.10), followed by meatballs formulated with corn (68.61), sago (68.59), potato (67.69) and cassava flour (66.06). Meatballs formulated with cassava flour exhibited the highest (a) value (2.25), followed by those formulated with wheat (1.97), sago (1.88), potato (1.84) and corn flour (1.79). For yellowness (b), cassava flour produced the highest values (17.98), followed by sago (17.96), potato and wheat (17.86) and corn flour (17.75). The different types of flours resulted in different colors of quail meatballs. The lightness and yellowness (L* and b*) of low-fat meatballs increased with rye bran addition, as reported by Yilmaz (2004).

Color measurement shows the color changes in cooked samples. The color attributes of cooked meat products arise mainly from the pigmentation of the meat from which they are made and the additives that were used in their formulation (Barbut and Mittal, 1996; Bloukas and Paneras, 1996; Bloukas *et al.*, 1997; Carballo *et al.*, 1995; Hughes *et al.*, 1997). In this study, quail meatballs were produced using the same amount of oil (fat) and the same formulation; only the type of flour differed between formulations.

Table 3: Hunter color L*, a*, b* values of quail meatball using different types of flour

Sample	L*	a*	b*
Cassava	66.06±0.65^{c}	2.25±0.09^{a}	17.98±0.24^{a}
Corn	68.61±0.30^{ab}	1.79±0.04^{d}	17.75±0.04^{b}
Wheat	69.10±1.79^{a}	1.97±0.05^{b}	17.86±0.19^{ab}
Sago	68.59±0.26^{ab}	1.88±0.09^{bc}	17.96±0.16^{ab}
Potato	67.69±0.40^{b}	1.84±0.07^{cd}	17.86±0.15^{ab}

*Value is the mean of two replicates performed in triplicate for each. Means with the same letter within the same column are significantly different ($p<0.05$)

Table 4: Textural quality of quail meatball using different types of flour

	Texture profile analysis			
Sample	Hardness (kg)	Cohesiveness	Elasticity (mm)	Chewiness (kgmm)
Cassava	7.90±0.57[b]	0.34±0.01[c]	10.70±0.50[b]	24.34±2.35[b]
Corn	9.08±0.72[ab]	0.38±0.02[ab]	10.81±0.72[b]	24.50±6.20[b]
Wheat	9.18±1.32[ab]	0.40±0.02[a]	11.29±0.13[b]	30.15±5.51[ab]
Sago	8.45±0.57[b]	0.37±0.03[b]	11.03±0.47[b]	27.79±2.38[ab]
Potato	10.08±1.70[a]	0.37±0.02[b]	12.15±0.27[a]	31.38±6.29[a]

In general, the color of the quail meatballs showed lower lightness values (L*) (66.06-69.10) and higher redness values (a*) (1.79-2.25) and yellowness values (b*) (17.75-17.98) compared to the color of commercial chicken balls in Malaysian markets, as reported by Huda *et al.* (2009), which show values of 71.81-7759, -2.12-0.27 and 15.53-18.91, respectively. When compared to the color properties of Taiwanese chicken balls-72.52, 11.00 and 2.32, respectively, as reported by Tseng *et al.* (2000)-quail meatballs exhibit lower L and a values and higher b values.

Profile texture analysis revealed the hardness, cohesiveness, elasticity or springiness and chewiness of the quail meatball. Table 4 shows the texture profile of quail meatballs. The ranges of hardness, cohesiveness, elasticity and chewiness of quail meatball are 7.90-10.08, 0.34-0.40, 10.70-12.15 and 24.34-31.38, respectively. The quail meatballs using potato flour showed the highest value of hardness (10.08 kg), followed by those using wheat (9.18 kg), corn (9.08 kg), sago (8.45 kg) and cassava flour (7.09 kg). The hardness of quail meatball is higher (7.09-10.08 kg) compared with that of commercial chicken balls (3.73-5.73 kg) and shows lower cohesiveness (0.34-0.40) and chewiness (24.34-31.38 kgmm) compared with commercial chicken balls, which show values of 0.55-0.69 (cohesiveness) and 31.27-53.77 kgmm (chewiness) (Huda *et al.*, 2009). The quail meatballs using potato flour show the highest values for hardness, cohesiveness, elasticity and chewiness. Yamprayoon *et al.* (1991) reported that the hardness, cohesiveness, springiness, gumminess and chewiness of fish balls formulated with potato flour were higher than those formulated with tapioca, corn and waxy maize starch. Wheat flour, in particular, produced the highest cohesiveness compared with the other flours. The range of cohesiveness was 0.34-0.40, which is agreement with the range reported by Ulu (2004): 0.38-0.3 after storage 4°C for 1 day. The elasticity of the samples did not differ between the various types of quail meatballs. The elasticity of the potato flour formulation was higher (12.15), followed by that of the wheat (11.29), sago (11.03), corn (10.81) and cassava flour (10.70) formulations. The highest elasticity was exhibited by the potato flour formulation due to the hardness of potato starch. The chewiness ranged from 24.34-31.38 kg/mm. The chewiness of the potato flour formulation was highest (31.38 kg/mm), also due to the hardness and elasticity of potato.

Texture profile analysis is more suitable to determine the overall texture characteristics of meatballs and other manufactured meats. The factors responsible for the textural properties of comminuted meat products are the degree of myofibrillar proteins extracted, stromal protein content, degree of comminuting, type and level of non-meat ingredients. Apart from the protein content, the types and amounts of extenders used, such as starch, play a decisive role in the hardness of meatballs as well. For example, the addition of legume flour can slightly increase the toughness of meatballs (Serdaroglu *et al.*, 2005). Hsu and Chung (1998) indicated a positive correlation between hardness and overall acceptance, which means that consumers generally prefer harder textures. However, these higher values for texture (hardness) do not necessarily mean better quality. There is a cut-off point above which the texture of meatballs is unacceptable (Yu and Yeang, 1993). Therefore, the determination of good textural qualities in meatballs should be performed together with sensory tests in order to find out the most suitable range preferred by consumers.

The sensory evaluations of quail meatball are shown in Table 5. The results show there that there were no significant differences (p>0.05) in color and odor. The color and odor scores range from 4.83-5.07 and from 4.67-5.20. These scores denote moderate acceptability (score of) on a 7-point hedonic scale. With respect to taste, quail meatballs generally produced a score denoting moderate acceptability, with the cassava flour formulation producing a higher score than the others (5.17). The texture was also scored as moderately liked (4.63-5.23), with the cassava flour formulation producing the highest score, followed by the potato, sago, wheat and corn flour formulations. The score for the overall acceptability of quail meatballs produced a score indicating moderate likeability for cassava flour formulation (5.23), followed, in descending order, by the scores of the potato, sago and wheat and corn flour formulations. The cassava flour was received with overall acceptability. This acceptance was due to the suitability of cassava flour in texture and taste.

Table 5: Sensory evaluation of quail meatball using different types of flour

Sample	Colour	Odour	Taste	Texture	Overall acceptability
Cassava	5.00±0.98[a]	5.20±1.00[a]	5.17±1.21[a]	5.63±1.27[a]	5.23±0.83[a]
Corn	4.83±0.91[a]	4.93±0.93[a]	4.57±1.07[ab]	4.63±0.89[b]	4.50±0.94[b]
Wheat	5.20±0.92[a]	5.03±0.96[a]	4.87±1.04[ab]	4.70±0.95[b]	4.50±1.04[b]
Sago	5.07±0.78[a]	4.67±1.16[a]	4.77±1.27[ab]	4.77±0.89[b]	4.47±1.41[b]
Potato	4.97±0.85[a]	4.90±0.92[a]	4.23±1.59[b]	5.62±0.86[a]	4.97±1.27[ab]

*Value is the mean of scores from 30 panelists. Means with the same letter within the same column are significantly different ($p<0.05$)

In general, the sensory evaluation of quail meatballs formulated from different types of flour gave scores denoting moderate likeability (5) based on a 7-point hedonic scale. The scores assigned did not vary much among the 30 panelists. The results show that the different types of flour used did not have a great effect on the acceptability of the quail meatballs. The panelists generally gave a score denoting moderate likeability, perhaps due to the fact that the panelists were not very familiar with meatballs made from quail meat.

Conclusion: In summary, the proximate composition, color and textural properties of quail meatballs were similar to those of commercial chicken meatballs in Malaysia. These results suggest that quail meat can be used successfully for the manufacture of meatballs as an alternative to the use of other meats such as beef and chicken, using different types of flour. The sensory properties were moderately well liked for all types of flour used. The cassava flour formulation was one of the best formulations produced and was the most acceptable.

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