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Research Article

Effect of wheat flour on physico-chemical, textural and sensory qualities of duck meat nuggets

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Abstract

The functional properties of five wheat flour levels, 10%, 15%, 20%, 25% and 30% were evaluated to improve the quality of processed duck meat nuggets. Incorporation of 30% wheat flour in duck meat nuggets showed that moisture, fat and protein content decreased significantly while the carbohydrate content increased. Lightness (L*), redness (a) and yellowness (b) values did not vary significantly between the products with different levels of wheat flour ranging from 56.97 – 60.33, 4.19 – 4.66 and 19.19 - 19.98, respectively. Cooking loss value was significantly lower for the product with 30% wheat flour level (13.57%). Texture profile indicated that products made by combining different levels of wheat flour had a significant effect on toughness value of duck meat nuggets ranging from 13.57 - 21.86 kg-s. Sensory qualities (colour, odour, taste, gumminess, hardness, juiciness and overall acceptability), showed that generally all samples were acceptable to the panelists. Products containing different levels of wheat flour showed no significant effect on odour, taste and gumminess. The 30% wheat flour level gave greater gumminess (5.64±0.49) to the products, resulting in higher sensory scores for texture and overall acceptability. The results indicated that 30% wheat flour level is the better binder concentration for developing duck meat nuggets when compared to all other levels based on physico-chemical, textural and sensory attributes.

Keywords: poultry, additives, cooking loss value, functional properties, Indonesia.

Introduction

In recent years, several studies have been conducted in many countries in the world on how to increase the per capita consumption of poultry meat. The studies revealed that the production of value added products and poultry meat-based fast food is the best way to achieve this aim. Duck nuggets is one type of value added product produced from chopped or ground duck meat and a number of other ingredients.

Duck raising, once a small sideline occupation, is gradually growing in importance to the poultry meat industry. With the growing demand for poultry meat, the duck industry has commenced to follow the same pattern of the broiler industry. This could be seen in the establishment of more specialized business ventures with modern poultry slaughterhouses, processing for better packaging and presentation to consumers. About 10 million meat ducks are raised annually for slaughter in Malaysia. Duck meat production per annum is about 2.0 kg. This low consumption of duck meat could be attributed to lack of awareness and promotion and the poor demand by the other communities [1].

With the encouragement of the Malaysian Government for duck production under its National Agriculture Policy, the demand for duck meat need to be further increased in tandem with the population increase of the future [1]. The Department of Veterinary Services has organized a campaign to encourage people to eat duck meat, especially among the non-Chinese population [2]. Duck meat provides protein in similar amounts to other poultry meat. Hopefully duck meat will become more popular as a regular meal even though the current market for duck meat is smaller compared to chicken [3].

The development of value added products, such as duck nuggets, has been identified as the best way to increase poultry meat consumption. This research describes the methodology and process involved in the production of nuggets from duck meat.

Although large numbers of ducks are available in Malaysia, this poultry has a low economic value because of flavour and colour characteristics of the species. It is therefore desirable to develop a duck product with increased acceptability.

In this study, a nugget-type product was developed in an attempt to increase the acceptability and marketability of duck meat. The meat does not have wide acceptability because of the unfamiliar smell and the colour is darker than chicken meat. Since visibly non-homogenous particles are typical to a nuggets product, the dark colour is not detrimental to acceptability. A nugget-type product has the further advantage of a relatively high level of spices which can mask the typical off-flavour in the formulation which may develop. Another advantage of nuggets is consumer convenience, an important marketing consideration [4]. The nuggets described in this research require no special equipment and could easily be prepared at home. A final advantage of the nuggets product is their potential to become a commercial product in the future. The nuggets described in this research are incorporated with wheat flour with different concentrations. The effect of wheat flour in different concentration to physicochemical and sensory properties of duck nuggets was studied.

Materials and Methods

Flour and duck nugget preparation

Food-grade wheat flours were prepared under sanitary conditions. Deboned duck meat (MDDM) was stored in a deep-freeze at -15^{o}C. MDDM was ground in a meat mincer (Rheninghaus, Torino-Italy). Wheat flour and seasonings (garlic powder, salt and black pepper) were weighed and added to the formulations. They were hydrated with tap water and thoroughly mixed with ground duck meat in a mixer (Robot Coupe Blixer 3, France) equipped with a flat beater and operated at a low speed for 2 min. The duck mixture was then transferred to a steam machine (Pau Cabinet MSM-2001, Malaysia) at 90^{o}C for 30 min. The mixture from each formulation was weighed to provide individual nugget pieces (25±1g per piece), shaped into discs about 1.5 cm thick and deep-fat fried in palm oil at 193^{o}C for 2 min using an electric fryer (Anvi FFA 3001, South Africa). Fried nuggets were drained on absorbent paper, kept warm by covering with aluminum foil and served to consumers within 30 min for acceptability evaluation.

Proximate composition analysis

The proximate composition (moisture, fat, protein and ash content) was determined according to standard procedures [5]. Carbohydrate content was calculated by difference.

Colour analysis

Lightness L^*, redness a^* and yellowness b^* [6], of cooked nugget samples were evaluated on a Minolta spectrophotometer (CM 3500d Japan). The equipment was standardized with a white colour standard.

Texture analysis

Texture Analysis (TA) for measurement of the toughness of chicken nuggets was made using a texture analyzer model TA-XT2 (Stable Microsystems Ltd. Surrey, England, UK). 5-bladed Kramer Shear Cell was used to compress the nuggets to 35% of original height. The test speed was 3.0 mm/s. The average of ten samples is reported as toughness.

Sensory evaluation

Twenty five members of the panel were trained in product and terminology. The sensory evaluation test was performed on a seven point scale [7]. For the test the chicken nuggets were shallow pan fried in cooking oil until golden brown and served warm to an experienced panel of scientists and postgraduate students in the discipline of food technology to determine their sensory characteristics. The sensory attributes evaluated were: colour, appearance, odour, taste, gumminess, hardness, juiciness and overall acceptability, using a 7 hedonic scale, where 7=like extremely and 1=dislike extremely.

Statistical analysis

Data obtained from all the analyses were analysed by using One-Way Analysis of Variance (ANOVA), followed by Duncan's Multiple Range Test, using the statistical package for social science version 15.0 (SPSS Inc., Chicago, Illinois, U.S.A). Statistical significance was indicated at 95% confidence level.

Results and Discussion

As shown in Table 1, the proximate composition for chicken nuggets was significantly different ($P<0.05$). Sample E had the lowest moisture content, that is 53.12%, while sample A had the highest moisture content of 58.32%. The protein value ranged from 14.18% to 19.79%. The difference in protein content depends on the duck meat that is used in the formulation of nuggets. In short, protein content in duck nuggets comes mainly from meat so a higher amount of duck meat used in the formulation will result in higher protein content.

According to Dean and Sandhu [8], duck meat is a good dietary source of high quality protein, energy and several minerals and vitamins. Proteins have a high biological value due to their quantity and quality, containing different types and ratios of amino acids, very similar to those required for maintenance and growth of human tissue. Fat content was highest in Sample A (16.46%) and lowest in Sample E (11.01%). Reduction in fat can significantly affect the acceptability of a product and increase the toughness of meat product. It is of such importance that several studies have attempted to maintain sensory and texture attributes through the use of fat replacers [9]. From a physiological standpoint, fat is a source of energy in the diet (9 Kcal/g). However, fat intake is associated with increased risk of obesity, some types of cancer, high blood cholesterol and coronary heart disease. For these reasons, several health-related organizations (American Heart Association, American Cancer Society and World Health Organization) have proposed limiting total fat intake to no more than 30% of total calories [9]. The fat content of chicken nuggets analyzed was in accordance to Malaysian Food Act 1983 [10], which must below 30%. Carbohydrate content in chicken nuggets ranged from 4.26% - 19.46%. The increase of carbohydrate content in duck nuggets could be due to the increase of wheat flour content (acting as an extender) to substitute for meat in the formulation. The main reason behind this is to reduce processing cost to increase the marginal profit.

The ash content in duck nuggets varied from 1.05-1.16%. According to Field [11], the ash content for mechanically deboned chicken meat is higher compared to traditional deboned chicken meat (deboned chicken meat by using hand). This is because during the process of mechanical deboning, the bones of the meat were crushed and mixed into the mince causing higher ash content.

Table 1. Proximate composition of duck nuggets (%wb).

Sample	Moisture	Fat	Protein	Ash	Carbohydrate
A	58.32 ± 0.54^{d}	16.46 ± 1.01^{e}	19.79 ± 0.48^{e}	1.16 ± 0.01^{e}	4.26 ± 1.42^{a}
B	57.42 ± 0.37^{c}	15.35 ± 0.46^{d}	18.45 ± 0.27^{d}	1.13 ± 0.03^{d}	6.13 ± 0.75^{b}
C	56.96 ± 0.32^{c}	13.61 ± 0.68^{c}	16.41 ± 0.26^{c}	1.11 ± 0.01^{c}	10.44 ± 0.61^{c}
D	55.33 ± 0.80^{b}	12.78 ± 0.32^{b}	15.28 ± 0.35^{b}	1.09 ± 0.04^{b}	14.01 ± 0.85^{d}
E	53.12 ± 0.56^{a}	11.01 ± 0.43^{a}	14.18 ± 0.66^{a}	1.05 ± 0.06^{a}	19.46 ± 1.18^{e}

* Means within a column with different letters are significantly different ($p<0.05$) n = 6

In Table 2, it can be seen that Sample E shows the highest L* value at 60.33 compared to other samples. The lowest L* value is found in Sample A at 56.97. Honikel [12] reported that the content of pigment (myoglobin) is intrinsic to the muscle, being dependent on primary production factors such as species breed, age of animal and nutritional status. Myoglobin varies according to species, being the lowest in chicken and highest in beef. The pre-slaughter period, the slaughter process and

subsequent processing also affect colour by influencing the rate and extent of pH and temperature decline during storage, distribution and display, the processes of oxygenation and oxidation of myoglobin influence colour. These changes include discolouration of the meat, due to the oxidization of pigment heme groups [13]. According to Cross *et al*. [14], heat applied on meat was responsible for converting myoglobin and haemoglobin to metmyoglobin which is brown in colour.

Table 2. Colour properties of duck nuggets.

Sample	Lightness (*L**)	Redness (*a*)	Yellowness (*b*)
A	56.97±0.62^{a}	4.19±0.14^{a}	19.63±0.19^{ab}
B	57.59±0.17^{b}	4.65±0.27^{c}	19.19±0.38^{a}
C	58.89±0.34^{c}	4.59±0.21^{bc}	19.59±0.42^{ab}
D	59.58±0.18^{d}	4.30±0.37^{ab}	19.98±0.41^{b}
E	60.33±0.20^{e}	4.66±0.18^{c}	19.52±0.33^{ab}

*Means within a column with different letters are significantly different ($p<0.05$) n = 6

Texture analysis results for duck nuggets are shown in Table 3. The samples showed results in toughness ranging from 12.66 – 18.55. Some of the factors responsible for textural properties in comminute meat proteins are degree of myofibril proteins extracted, stored protein content, degree of comminution and type and level of non-meat ingredients. The amount of protein content, types and amount of extenders such as starch will play a decisive role in hardness of nuggets as well. As an example, addition of legume flour can slightly increase toughness of chicken nuggets. According to Ngadi *et al*., [15] the changes in the textural properties of chicken nuggets could be attributed to the physical and chemical changes taking place during the frying process, particularly in the batter or breading portion. There is a cut-off point above which the texture of chicken nuggets would be unacceptable. Therefore, determination of good textural qualities of duck nuggets should be done together with sensory testing in order to find out the most suitable range preferred by consumers.

Table 3. Textural, weight and cooking loss of duck nuggets.

Sample	A	B	C	D	E
Weight	21.50±0.93	20.57±0.68	20.99±1.62	21.34±1.47	21.66±1.36
Cooking loss	21.86±0.85^{d}	20.95±0.19^{d}	19.18±0.41^{c}	16.98±0.62^{b}	13.57±1.05^{a}
Toughness	21.86±0.85^{d}	20.95±0.19^{d}	19.18±0.41^{c}	16.98±0.62^{b}	13.57±1.05^{a}

*Means within a column with different letters are significantly different ($p<0.05$) n = 10

Based on Table 3, better cooking scores were demonstrated by Sample E, that is 13.57%, whereby lower percentages of cooking loss were obtained. Cooking loss is synonymous with emulsion stability. It is an important parameter for assessing the quality of meat products. Breakdown of emulsion occurs with increasing comminution temperature and will increase cooking losses [16].

Table 4. Sensory evaluation test of duck nuggets.

Sample	A	B	C	D	E
Colour	4.64±1.55^{ab}	4.92±1.47^{ab}	5.48±1.48^{b}	4.80±1.12^{ab}	4.56±1.36^{a}
Odour	5.16±1.14^{a}	5.20±0.96^{a}	5.00±1.00^{a}	5.12±0.78^{a}	5.20±1.08^{a}
Taste	5.28±1.21^{a}	5.36±0.95^{a}	5.24±0.66^{a}	5.64±0.70^{a}	5.72±1.06^{a}
Gumminess	5.40±1.00^{ab}	5.48±0.82^{ab}	5.04±1.40^{a}	5.40±0.71^{ab}	5.64±0.49^{b}
Hardness	5.16±0.94^{abc}	5.52±0.82^{c}	4.52±1.50^{a}	4.72±1.37^{ab}	5.32±1.49^{bc}
Juiciness	4.88±1.33^{a}	5.32±0.69^{ab}	5.16±1.43^{ab}	5.56±0.87^{b}	5.56±0.51^{b}
Overall	5.32±1.22^{a}	5.60±0.82^{a}	5.52±1.00^{a}	5.52±1.42^{a}	6.24±0.66^{b}

*Means within a column with different letters are significantly different ($p<0.05$) n = 30

Based on the 7-hedonic scale (1=dislike extremely, 7=like extremely) sensory scores (Table 4) showed that the acceptability of duck nuggets did not differ significantly ($p<0.05$), depending on the percentage of wheat flour added to the formulation. Panelists had significantly higher preference for the colour of duck nuggets found in Sample E at 6.24 and lower preference for the colour in Sample A at 5.32. This indicated that panelists preferred duck nuggets with light colour.

Conclusions

Based on the analysis results, the proximate composition, colour, textural properties and sensory evaluation test of duck nuggets were quite different in several cases. The differences in duck nuggets were mainly due to the concentration of wheat flour and duck meat added. The analysis results obtained in this study show that the sample with 30% added wheat flour in the formulation of duck nuggets is optimal compared with other formulations.

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