International Food Research Journal 25(3): 1016-1025 (June 2018)

Journal homepage: *http://www.ifrj.upm.edu.my*

Physicochemical properties and consumer preference of imitation chicken nuggets produced from chickpea flour and textured vegetable protein

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Article history

Received: 3 February 2017
Received in revised form: 1 April 2017
Accepted: 3 April 2017

Keywords

Imitation chicken nugget
Textured vegetable protein
Chickpeas nugget
Vegetarian nugget

Abstract

In recent years, consumers' demand increases for healthier foods with nutritional benefits and similar taste to the origin. Thus, this study was conducted to evaluate the physicochemical properties and proximate composition as well as consumer preference of imitation chicken nuggets or ICNs formulated with different percentage of chickpea flour and textured vegetable protein (TVP). A commercial brand of chicken nugget was chosen as control experiment to compare its characteristics with ICNs. Five formulation of ICNs were prepared with the percentage of chickpea flour to TVP of ICNs were: A (30:10), B (25:15), C (20:20), D (15:25), and E (10:30). Results found that all ICNs were found significantly lower ($P<0.05$) in cooking loss, lightness, hardness, chewiness, springiness, cohesiveness, and water activity than in control nugget. However, all ICNs were higher ($P<0.05$) in yellow colour than in control nugget. The ash, protein, and carbohydrate contents of ICNs were higher ($P<0.05$) than in control nugget but were lower ($P<0.05$) in moisture and fat content. However, hedonic test found that consumers preferred ($P<0.05$) control nugget compared to all ICNs. The ICN E which contained percentage of chickpea flour to TVP (10:30) was the most preferred by consumers in term of texture, taste, and overall acceptance compared to all ICNs. This findings showed that formulation of ICNs with chickpea flour with TVP could be accepted by consumers but further research should be focused on the optimised amounts of the chickpea flour in the ICNs. Thus, the sensory characteristics with these proteins and the nutritional values should be improved similar to those with chicken.

Introduction

In recent years, the global situation on food and nutrition consumption has changed to healthier and convenience foods. Consumers are becoming more health conscious of the foods they consume. In fact, nutritional facts and labeling information on packaging are now being read concisely by consumers before making their food choice. These market trend derived towards convenient foods since consumers due to the busy lifestyle. Consumers demand foods that provide high in proteins but low in fat contents and calories but provide sweet taste, fat mimic, or fat analogue as well as convenient to be consumed. Beside health benefits, consumers also demand fat mimic food due to some reasons such as religious beliefs, environmental concerns, and animal rights (Lim *et al.*, 2010). Hence, food manufacturers need to initiate and offer meat analogues products with provide health and nutrition benefits, convenience, and provide similar flavour and texture to actual meat.

Food such as nugget is an example of convenience food that is preferred by consumers. Nuggets are restructured meat product with batter and coater to retain the quality (Lukman *et al.*, 2009). Restructured meat is one of the meat processing technologies which utilise the relatively small size and irregular shape of meat to be processed into a wholesomeness meat product which could add of those small meat pieces (Evaruarini and Purnamo, 2011). Chicken nuggets increased in popularity in food industry since it invented in 1950's by Robert Baker of Cornell University (Meat, 2006). Grumbles (2008) reported that chicken nugget was the only nugget accepted worldwide that has reached high level of popularity compared to other meat. In fact, until now, the most common nuggets that can be found and available in the market is chicken nugget.

According to Pulver (2010), many consumers want products with high nutrition and sensory characteristic similar to meat products but with little or no actual meat. Either the reason for related to personal perception or health, consumers prefer product that can accurately mimic what it is being replaced and, if possible, add nutritional values to the meat products. Hence, non-meat ingredients

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especially from soys, beans, peas, and lentils have been used as imitation meat as well as binders and extenders in comminuted meat products because of their high nutritional value and acceptable functional properties and in some cases reduce product cost (Riaz, 2005; Unatrakarn, 2014).

Chickpea is a type of legume that has been consumed by humans since ancient times due to its good nutritional composition. Several studies have well described on the physicochemical and nutritional characteristics of chickpeas and found that it was possible to replace meat in products such as nuggets and sausages (Verma *et al*., 1984; Kilinççeker and Kurt, 2010; Verma *et al*., 2012). Indeed, chickpeas have been processed into flour in order to increase its functionality in food application. However, the application of chickpea flour in food ingredient was limitedly use only as meat binders and extenders even though it could be chosen as meat replacer due to the high protein content (Jukantil *et al.*, 2012).

Combination of chickpea flour and textured vegetable protein (TVP) was believed to be potential meat analogue ingredients in developing imitation chicken nugget (ICN). Chickpea flour contains high protein which is believed to imitate meat characteristics. In fact, chickpea flour contains 20.3 to 24.5% protein and TVP have more than 50% protein (Sadler, 2004; IFRPD, 2013). The protein content of five commercial chicken nuggets from different brands or manufacturers in Malaysia ranged from 12.52 to 16.62% (Lukman *et al*., 2009). By considering the protein content and other benefits of chickpea flour and TVP, the combination of these two ingredients could give effects on the physical, chemical, and sensorial characteristics of ICN formulations. Thus, the purposes of the study were to evaluate the physicochemical properties and nutritional composition of ICNs produced from different percentage of chickpea flour and TVP as well as to determine its preference by consumers.

Materials and Methods

Formulations and preparation of nuggets

Five formulations of ICNs with different percentage of chickpea flour and TVP have been formulated in this study were: A(30:10), B(25:15), C(20:20), D(15:25), and E(10:30). Other ingredients were gelatinised rolled oat (34.0%) (prepared by heating rolled oat with boiled water (100°C) at ratio of 1:4.5 and was heated approximately for 18 to 20 mins), palm stearin (11.5%), wheat flour (4.0%), chicken seasoning (4.0%), honey (2.5%), isolated soy protein (2.0%), onion powder (1.0%), salt (0.5%), and sodium tripolyphoshate (STPP) (0.5%). These formulations were formulated according to Mona *et al.* (2011) and Huda-Faujan *et al*. (2006) with modification. A commercial brand of chicken nugget that mimics to the appearance of formulated nuggets was chosen as reference and control sample.

Nuggets preparation were started by mixing all dry ingredients include chickpea flour, wheat flour, isolated soy protein, salt, STPP, onion powder, and chicken seasoning. After that, palm stearin was added to the mixture and mixed for 3 mins. Subsequently, TVP and gelatinised oat were well mixed together for 3 mins. Next, honey was mixed to the batter and mixed for 5 mins in order to ensure that all the ingredients were smoothly mixed together. Finally, the mixture was refrigerated at 4°C before coating process. The nugget coating was prepared by mixing 80% soy milk and 20% wheat flour.

Cooking Loss

The difference in weight of samples before and after cooking were recorded as total cooking loss and it was expressed as a percentage of weight before cooking (Bouton *et al.,* 1978). The percentage of cooking loss was calculated using the following equation.

$$\text{Cooking loss (\%)} = [(W_1 - W_2)/W_1] \times 100$$

Where:

W_1 = weight of sample before frying;

W_2 = weight of sample after frying.

Colour

Determination of colour of fried nuggets was analysed using colorimeter (LabScan® XE Spectrophotometer Model, HunterLab). Approximately, 15 g of nugget sample was placed within a plastic Petri dish with the lid on and the colour was measured according to manufacturer's instruction.

Texture

The texture profile analysis of fried nuggets was determined using texture analyzer (TA-XT Plus Model, Stable Micro System) according to manufacturer's instruction. All nuggets were cut into cube sized (1 cm × 1 cm × 0.5 cm) and was placed into a 36 mm diameter cylindrical probe 75 (P.75) during analysis.

pH

Sample of raw nuggets were weighed approximately for 10 g at 20°C and followed by addition of 50 mL of distilled water (Nopianti *et al*., 2012). Then, the samples were homogenised using homogeniser (Model Stomacher® 400 Circulator) at 300 rpm for 1 min. Finally, the pH of homogenised nuggets were measured using pH meter (Model Aqua Lab).

Water activity

The water activity (A_w) of raw nuggets was determined at 25°C using an Aqualab Series 4TE water activity meter (Decagon, Pullman, WA, USA) according to manufacturer's instruction.

Moisture content

Moisture content of fried nuggets was analysed using mechanical moisture analyser (MX-50, A&D Company, Limited). Initially, each nugget was weighed at 2.0 g and was heated at 200°C. Heating pattern in this apparatus was used the standard drying where the temperature was maintained throughout the whole analysis. The percentage of moisture content was measured by calculating difference of wet weight and dry weight of sample according to manufacturer's instruction.

Ash content

The total ash content of fried nuggets was determined according to the AOAC (1990) Method 923.03 using conventional dry-ashing according to manufacturer's instruction. The percentage of crude ash was calculated using the following equation.

$$\text{Crude ash (Dry basis) (\%)} = [W_1 / W_2] \times 100$$

Where:
W_1 = weight after ashing;
W_2 = weight before ashing.

Protein content

The nitrogen content of fried nuggets was analysed using Kjeldahl method (AACCI, 1995) Method 46-11.02. The percentage of crude protein was expressed as total of nitrogen percentage and was multiplied by a factor of 6.25, which was the nitrogen-protein conversion factor for meat and grain sample. The measurement of crude protein was calculated using the following equation.

$$\text{Crude protein (\%)} = \text{Nitrogen (\%) in samples} \times 6.25$$

Fat content

Fat analysis was done using Automatic Soxhlet extraction method (Soxhterm® extractor, Gerhardt). Prior to analysis, each 9.0 g of homogenised fried nugget was weighed on a filter paper and folded into a pre-dried extraction thimble which plugged in lightly with cotton wool. After that, the thimble was put into the extraction beaker that contained three boiling stones, and subsequently was added with 140.0 mL of petroleum ether. Next, the equipment was programmed based on the manual's instruction (Gerhardt's manual). Finally, the residue of extracted was dried in air drying oven at 105°C for overnight, and cooled in desiccator. The percentage of fat content of samples was calculated using following equation.

$$\text{Fat (\%)} = [(W_1 – W_2)/ W_0] \times 100$$

Where:
W_0 = weight of nugget sample;
W_1 = Total weight of extraction beaker with boiling stones and extracted fats;
W_2 = Total weight of extraction beaker and boiling stones.

Carbohydrate content

The carbohydrate content of fried nugget was determined as available carbohydrate and was calculated using following equation.

$$\text{Carbohydrates (\%)} = 100 – [\text{moisture (\%)} + \text{ash (\%)} + \text{protein (\%)} + \text{fat (\%)}]$$

Hedonic test

Sensory test of nuggets was conducted in individual booths at Sensory Laboratory, Universiti Sains Islam Malaysia, Nilai, Malaysia. The hedonic test was done according to Meilgaard *et al*. (2007) to evaluate consumers' preference all ICNs compared to control nugget. A total of 110 panellists were participated in this test to evaluate the products. In this study, a hedonic scale of 9-points was used and the attributes were appearance, colour, texture, chicken aroma, taste, and overall acceptance. All nuggets were cut into rectangle shape and it was presented to panellists in a plate with three-random-digit coded number to avoid bias. The score was based on a 9-point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like).

Statistical analysis

All data were analysed with one-way analysis of variance or ANOVA, followed by Tukey's test to compare the means between samples. Data was analysed using Minitab® software, Release 16 (McKenzie *et al.*, 1995) and the statistical significance was established at ($P<0.05$). All experiments was done in triplicate.

Table 1. Physical properties of five fried ICNs compared to fried control nugget

Nugget samples	Cooking loss (%)	Colour			Texture profile analysis			
		L^*	a^*	b^*	Hardness (N)	Chewiness (N/cm)	Springiness (cm)	Cohesiveness (ratio)
Control	14.94[a]	66.35[a]	3.23[c]	21.93[f]	6.43[a]	3.99[a]	0.95[a]	0.64[a]
A	6.06[d]	64.70[b]	2.76[c]	40.26[a]	5.86[a]	1.52[b]	0.73[b]	0.36[c]
B	7.43[cd]	62.54[c]	3.12[c]	37.62[b]	6.09[a]	2.36[b]	0.78[b]	0.43[bc]
C	7.73[c]	61.32[c]	3.33[c]	31.89[c]	6.04[a]	2.22[b]	0.85[ab]	0.45[b]
D	9.51[b]	58.93[d]	4.59[b]	29.60[d]	6.28[a]	2.33[b]	0.88[ab]	0.50[b]
E	9.67[b]	56.61[e]	6.21[a]	27.56[e]	6.25[a]	2.39[b]	0.88[ab]	0.51[b]

Notes:
a) Means in same column with different lowercase letters indicate significant difference (P<0.05) between formulations of ICNs and control nugget.
b) Formulations: Control = Commercial chicken nugget;
A = 30 % chickpea flour and 10 % TVP;
B = 25 % chickpea flour and 15 % TVP;
C = 20 % chickpea flour and 20 % TVP;
D = 15 % chickpea flour and 25 % TVP;
E = 10 % chickpea flour and 30 % TVP.

Results and Discussion

Physicochemical properties of imitation chicken nuggets

Data of physical characteristics of all fried nuggets include percentage of cooking loss, colour, and texture are shown in Table 1. From the Table, results found that the highest percentage (P<0.05) of cooking loss was found in control nugget (14.94%). Among ICN, sample of ICN E obtained the highest percentage of cooking loss (9.67%), and followed by ICN D (9.51%), ICN C (7.73%), ICN B (7.43%), and ICN A (6.06%). The cooking loss of ICN E was significantly higher (P<0.05) than all ICNs except with ICN D. This finding found that as the percentage of chickpea flour to TVP decreased in ICNs formulation, the cooking loss of ICNs consistently increased as shown in Table 1.

In food system, cooking loss was one of the main properties that being considered in production of high fat content food such as in meat product since it would affect the juiciness of the final product. Several studies reported that higher amount of fat in meat products cause higher moisture loss during frying and might be associated with the loss of emulsion stability of hydrophobic interaction between fats and moisture in the product (Pinthus *et al.*, 1993; Verma *et al.,* 2012). Chickpea flour contains abundance of polysaccharides (starches) and were found to assist in retaining the water molecule in nugget system. Hence, chickpea flour has a good water holding and emulsifying capacities (Kohajdová *et al.*, 2011). Thus, this study explained why the cooking loss in control nugget was significantly higher than all sample of ICNs (P<0.05).

Analysis of colour for fried nuggets was only done for internal nugget colour. Results found that the highest lightness *(L^*)* was obtained in control nugget (66.35) and was significantly higher (P<0.05) with all ICNs. Among all ICNs, the ICN A obtained the highest lightness *(L^*)* with the value of 64.70 (P<0.05). The L^* value of ICN B, ICN C, ICN D, and ICN E was 64.70, 62.54, 61.32, 58.93, and 56.61, respectively. These results found that the L^* value (darkness to whiteness) of ICNs decreased as the percentage of chickpea flour to TVP decreased as shown in Table 1. Previously, Verma *et al.* (1984) reported that beef skinless sausages containing chickpea flour were lighter in colour compared to control beef sausages (did not contain chickpea flour), and this finding was similar to this study. However, in this study, the control nugget use chicken as the main ingredient which was grouped as white meat compared to beef meat (red meat) and this could be explained why the L^* value of control sample was significantly higher (P<0.05) than all ICNs.

Results of a^* value (green to red) found that ICN E obtained the highest value (6.21) and was significantly different (P<0.05) compared to all nuggets (Table 1). Results also exhibited that as the percentage of chickpea flour to TVP decreased in ICNs formulation, the a^* value increased. The a^* value of ICN D, ICN C, ICN B, and ICN A was 4.59, 3.33, 3.12, and 2.76, respectively. Interestingly, the a^* value of control nugget obtained value of 3.23 which between the ranged of a^* value of ICN B (3.12) and ICN C (3.33) which contained the percentage of chickpea flour to TVP B(25:15), and C(20:20), respectively. The a^* value of control nugget was not significantly different (P>0.05) from ICN A, ICN B, and ICN C. Kitcharoenthawornchai and Harnsilawat (2015) reported that increasing TVP content in meat analogue nuggets would increase the a^* value. The a^* value of meat analogue nugget containing 10 to 70% TVP ranged between 3.38 and 4.95 and this was probably due to the colour of TVP after rehydrated was meaty-brown. Nevertheless, in this study, the a^* value of ICN containing 30% TVP was 6.21 and this could be due to the combination of TVP and chickpea flour (green-yellowish in colour).

The b^* value (blue to yellow) of ICN A had the highest value (P<0.05) compared to all ICNs. As the percentage of chickpea flour to TVP decreased in ICNs formulation, the b^* value was consistently decreased as show in Table 1. The b^* value of ICNs in descending order were ICN A (40.26), ICN B (37.62), ICN C (31.89), ICN D (29.60), and ICN E (27.56). It was also found that control nugget exhibited significantly (P<0.05) the lowest b^* value (21.93) compared to all ICNs. This finding was similar to the study done by Kitcharoenthawornchai and Harnsilawat (2015) who reported that addition of 10%, 30%, 50%, and 70% TVP in meat analogue nugget the b^* value was 20.46, 19.81, 19.02, and 18.96, respectively. In addition, this study obtained the highest b^* value (40.26) in ICN A (10%TVP and 30% chickpea flour) since the chickpea flour contributed the yellowish colour in ICN samples.

Result of nugget's texture is also shown in Table 1. It is showed that the hardness, chewiness, springiness, and cohesiveness of control nugget was the highest compared to all ICNs. It was also found that the hardness, springiness, and cohesiveness of ICNs would increase when the ratio of chickpea flour to TVP decreased in ICN formulation. The hardness of control nugget was 6.23 N (P>0.05) while the hardness of ICNs samples in ascending order was ICN A (5.86 N), ICN C (6.04 N), ICN B (6.09 N), ICN E (6.25 N), and ICN D (6.28 N).

According to Ziegler *et al.* (1987) hardness of dried and non-dried sausages would increase when the moisture content was decreased. Table 1 found that the hardness of all nuggets was directly proportional to cooking loss during frying. Hardness of control nugget was also related to the toughness of chicken meat in the ingredient. In this study, the hardness of ICNs increased with increasing amount of TVP and decreasing amount of chickpea flour. Previously, El-Magoli *et al*. (1996) reported that addition of whey protein concentrate at certain concentration was able to increase the hardness of low-fat burger. Addition of textured soy protein increased the hardness of burger patties (Kassama *et al*., 2003). Furthermore, decreasing amount of chickpea flour in ICNs promoted an increase hardness in ICNs and consistent with Verma *et al.* (1984) who reported that beef sausages containing chickpea flour were harder in texture with decreasing levels of chickpea flour.

Chewiness was defined as the energy required to chew the beef burger (Sarıçoban *et al.,* 2009). Previously, Riaz (2005) reported that TVP is commonly used together with meat to provide desired quality of meat in term of texture, desired amount of chewiness, or to make a product firmer and softer. However, springiness was defined as how well a product physically springs back to the initial condition during the first compression (Yılmaz and Dağlıoğlu, 2003), and was mostly related to fat (Horita *et al*., 2011). In this study, the highest chewiness and springiness were found in control nugget and the values was 3.99 N/cm and 0.95 cm, respectively. The ranged of chewiness of all ICNs was between 1.52 and 2.39 N/cm (P>0.05). The springiness of ICNs in this study in ascending order were ICN A (0.73 cm), ICN B (0.78 cm), ICN C (0.85 cm), ICN D and ICN E (0.88 cm). Decreasing percentage of TVP to chickpea flour would affect the springiness (P<0.05) of ICNs and could due to the capability of TVP to mimic the meat character to retain fats in ICN sample. According to Kumar *et al.* (2013) the springiness of nuggets with soybean hulls flour was significantly higher (P<0.05) compared to nuggets without addition of soybean hulls flour.

Other characteristic that important in meat product is the cohesiveness. Cohesiveness is related to the extent to which food can be deformed before it ruptures (Sarıçoban *et al*., 2009). Cohesiveness of control nugget was the significantly higher (P<0.05) than all ICNs, and this obtained that the sample had high tendency to cohere or stick together even it was being compressed. Furthermore, cohesiveness was also related to the intermolecular attraction by which the elements of ingredients are held together. This study found that chickpea flour and TVP provided weaker interaction with other ingredients than chicken meat. Thus, other ingredients is suggested to be added together in ICN formulation to increase the cohesiveness of ICNs. The cohesiveness of all ICN samples in ascending order were ICN A (0.36), ICN B (0.43), ICN C (0.45), ICN D (0.50), and ICN E (0.51) compared to 0.64 in control nugget (P<0.05).

A study by Kitcharoenthawornchai and Harnsilawat (2015) found that an increase of TVP from 10 to 70% in meat analogue nugget formulations decreased the hardness, cohesiveness, springiness, and chewiness (P<0.05) of nugget and this finding was different compared to this study. This probably due to the formulation only use TVP and ISP as the main ingredient rather other starch source ingredient. In contradict, in this study, increase amount of TVP in ICNs, increased the hardness, chewiness, springiness, and cohesiveness of ICNs, and this might be associated with the combination of chickpea flour in ICN formulation which contain starch. Previously, Ramadhan *et al.* (2011) reported that hardness of chicken burger in Malaysian market was positively correlated with cohesiveness attribute but was negatively correlated with springiness and might be associated with addition of different types and amount of ingredients into different chicken burger brands. However, TVP is the most popular ingredient to be used in vegetarian food because can provide a fibrous structure similar in meat texture (Kitcharoenthawornchai and Harnsilawat, 2015).

Table 2 shows the pH and water activity of raw nuggets. It was found that the highest pH (P<0.05) of ICN was obtained in both ICN D and ICN E (pH 6.70). In this study, it was obtained that the higher the concentration of TVP in ICN, the higher the pH values (less acidic pH). This most probably due to the slightly alkalinity of TVP (pH 7.42 to 7.43) (Anjum *et al.*, 2011) compared to the slightly acidity of chickpea flour (pH 6.93) (Verma *et al.*, 2012). In this study, the control nugget also contain soy protein and this could explain the less acidic pH compared to other previous studies. Indeed, Abd-El-Qader (2003) reported that pH value in meat product is an important chemical factor because its will influence other characteristics include shelf-life, colour, water holding capacity, and texture of meat and meat products.

The ranged of pH values of nuggets were between pH 6.52 to pH 6.70. It was found that the pH of ICN B (pH 6.61) and ICN C (pH 6.62) were not significantly different (P<0.05) from the control nugget (pH 6.59). This indicated that the percentage of chickpea flour to TVP at 25:15 and 20:20 produced similar pH to control nugget, and both ICN formulations were possibly provide similar chemical characteristic to control nugget. The pH of meat product were slightly acidic as raw beef patties formulated with different starch types ranged between pH 5.78 and 5.80 (Mbougueng *et al.*, 2015). Furthermore, chicken nuggets with partial replacement of meat, and fat by pea fibre ranged between pH 5.48 and 5.81 (Polizer *et al.*, 2015).

Table 2. Chemical properties of five raw ICNs compared to raw control nugget

Nugget samples	pH values	Water activity (A_w)
Control	6.59[b]	0.98[a]
A	6.52[c]	0.91[d]
B	6.61[b]	0.93[c]
C	6.62[b]	0.95[b]
D	6.70[a]	0.95[b]
E	6.70[a]	0.95[b]

Notes:
a) Means in same column with different lowercase letters indicate significant difference (P<0.05) between formulations of ICNs and control nugget.
b) Formulations: Control = Commercial chicken nugget;
A = 30 % chickpea flour and 10 % TVP;
B = 25 % chickpea flour and 15 % TVP;
C = 20 % chickpea flour and 20 % TVP;
D = 15 % chickpea flour and 25 % TVP;
E = 10 % chickpea flour and 30 % TVP.

The water activity of control nugget was the highest (A_w=0.98) and was significantly differed (P<0.05) from other raw ICNs. The water activity of ICNs ranged between 0.91 and 0.95. In general, water activity of ICNs increased with increasing percentage of TVP to chickpea flour. The percentage of starch in chickpea flour was 51% (Idriss *et al.*, 2012), and could function as binder as well as water binding capacity of free water in food system and at the same time reduce water activity. This might clarify the high water activity in ICN that contained lower chickpea flour. Addition of chickpea flour at 10%, 15%, and 20% in ICN formulation did not give any significant different (P>0.05) to the value of water activity (A_w=0.95).

Proximate composition of fried nuggets

The moisture, ash, protein, fat, and carbohydrate contents of fried nuggets are shown in Table 3. It is found that the control nugget was significantly higher (P<0.05) percentage in moisture, and fat content than all ICNs. However, the content of ash, protein, and carbohydrate in the control nugget was significantly lower (P<0.05) than all ICNs.

Moisture content of all nuggets were significantly differed (P<0.05) to each other. Moisture content of control nugget was 57.93% (P<0.05) compared to all ICNs. Results obtained that as the percentage of chickpea flour to TVP decreased, the moisture content decreased (P<0.05). The ranged of moisture content for all ICNs was between 39.77 and 48.69%. This was probably due to higher water retention of chickpea flour compared to TVP and might be related to the high content of amylose in chickpea flour which able to absorb high water molecule. Idriss *et al.* (2012) reported that chickpea flour contained almost 51% of total starch which consisted of 30 to

Table 3. Proximate composition of five fried ICNs compared to fried control nugget

Nugget samples	Proximate analysis (%)				
	Moisture	Ash	Protein	Fat	Carbohydrates
Control	57.93[a]	1.62[b]	9.84[b]	7.50[a]	23.12[e]
A	39.77[f]	3.23[a]	10.85[ab]	3.83[c]	42.32[a]
B	43.20[e]	3.24[a]	10.98[a]	4.22[c]	37.69[b]
C	44.98[d]	3.36[a]	10.80[ab]	4.51[bc]	36.35[b]
D	46.93[c]	3.11[a]	11.06[a]	5.35[b]	33.55[c]
E	48.69[b]	3.12[a]	11.78[a]	5.45[b]	30.95[d]

Notes:
a) Means in same column with different lowercase letters indicate significant difference (P<0.05) between formulations of ICNs and control nugget.
b) Formulations: Control = Commercial chicken nugget;
A = 30 % chickpea flour and 10 % TVP;
B = 25 % chickpea flour and 15 % TVP;
C = 20 % chickpea flour and 20 % TVP;
D = 15 % chickpea flour and 25 % TVP;
E = 10 % chickpea flour and 30 % TVP.

40% amylose (Guillon and Champ, 2002).

Ash of nuggets was determined to measure total amount of minerals presented after removing water and organic matters in the nugget system. Results found that the ash content of all ICNs were between 3.11 and 3.36% (P>0.05). The ash content of fried ICNs, in ascending order were ICN D (3.11%), ICN E (3.12%), ICN A (3.23%), ICN B (3.24%), and ICN C (3.36%). The ash content of chickpea flour ranged between 3.00 and 3.20% (Aguilar *et al*., 2015; Ghribi *et al.,* 2015). However, the ash content of TVP ranged between 3.29 to 3.30% (Anjum *et al*., 2011) and was slightly similar to the ash content in chickpea flour. This could explain why the ash content of cooked ICN samples in this study were found similar (P>0.05) among them.

The protein content of fried control nugget (9.84%) was significantly lower (P<0.05) than all fried ICNs. The protein content of fried ICNs in ascending order was ICN C, (10.80%), ICN A (10.85%), ICN B (10.98%), ICN D (11.06%), and ICN E (11.78%). A recent study done by Ghribi *et al.* (2015) reported that the protein content of chickpea flour was 20.3% (Desi cultivar), and 24.5% (Kabuli cultivar). Indeed, the protein content of chickpea flour used in this study was 23.0% as labelled in the packaging. However, the protein content of TVP was more 50% as reported by Sadler (2004) and IFRPD (2013). This could explain why the protein content in cooked ICN E which contained 30% of TVP and 10% chickpea flour had the highest (P<0.05).

Fat content is one of the important nutrients to claim the ICN product was healthier than control nugget. In fact, ICN was developed using vegetable fats (palm stearin) which could provide mouthfeel sensation for better consumption. Fat content of fried control nugget had the highest (P<0.05) compared to all fried ICNs samples (Table 3). The fat content of fried ICNs were consistently increased (P<0.05) with increasing percentage of TVP to chickpea flour. Indeed, TVP was made from defatted soy flour and fat content of TVP ranged from 3.00 to 4.60% (Cuptapun *et al*., 2013) and was lower than in chickpea flour (4.8 to 7.98) (Sreerama *et al*., 2012; Desalegn, 2015; Ghribi *et al*., 2015; Xiao *et al*., 2015). In this study, the fat content of chickpea flour used was 4.1% as mentioned in packaging. In fact, when the ICNs (from ICN A to ICN E) were cooked, the amylose content in chickpea flour decreased and absorbed more oil. Previously, Mohamed *et al.* (1998) reported that oil absorption was negatively correlated with amylose content in starch. This could explain why the fat content in fried ICNs increased when percentage of chickpea flour decreased in ICN formulations.

Carbohydrate contents of fried nuggets ranged from 23.12 to 42.32% (Table 3). Results exhibited that carbohydrate contents of fried control nugget had the lowest (P<0.05) compared to all fried ICNs. Higher amount of chickpea flour in ICN (from ICN E to A) increased carbohydrates contents. Carbohydrate contents of chickpea flour ranged from 61.0 to 70.17% (Sreerama *et al*., 2012; Desalegn, 2015; Ghribi *et al*., 2015; Xiao *et al*., 2015) compared to TVP (31.8%) (Cuptapun *et al*., 2013). This would also related to higher starch content of chickpea flour compared to TVP. Sanjeewa (2008) found that chickpea flour contained almost 45.10% of total starch from 69.5% of carbohydrate (Pearson and Gillett, 1999).

Table 4. Mean scores of hedonic test of five ICNs compared to control nugget

Nugget samples	Appearance	Colour	Chicken aroma	Texture	Taste	Overall acceptance
Control	7.65^{a}	7.64^{a}	7.80^{a}	7.73^{a}	7.73^{a}	7.97^{a}
A	5.98^{b}	5.68^{b}	5.24^{b}	4.75^{b}	4.57^{b}	5.06^{b}
B	5.88^{b}	5.79^{b}	5.25^{b}	4.99^{b}	4.66^{b}	5.03^{b}
C	5.44^{b}	5.03^{c}	5.09^{b}	4.98^{b}	4.96^{b}	5.14^{b}
D	5.62^{b}	5.52^{bc}	4.91^{b}	5.00^{b}	4.83^{b}	5.08^{b}
E	5.53^{b}	5.43^{bc}	5.11^{b}	5.04^{b}	4.96^{b}	5.21^{b}

Notes:
a) Means in same column with different lowercase letters indicate significant difference (P<0.05) between formulations of ICNs and control nugget.
b) Formulations: Control = Commercial chicken nugget;
A = 30 % chickpea flour and 10 % TVP;
B = 25 % chickpea flour and 15 % TVP;
C = 20 % chickpea flour and 20 % TVP;
D = 15 % chickpea flour and 25 % TVP;
E = 10 % chickpea flour and 30 % TVP.

Carbohydrate contents of chickpea flour used in formulation of ICNs was 62.1% as stated in the food label.

Consumer preference of nuggets

Table 4 presents the data of hedonic test of nuggets by consumers. Results obtained that the preference of nuggets in terms of the appearance, colour, chicken aroma, texture, taste, and overall acceptance had the highest mean scores (P<0.05) for control nugget compared to all ICNs demonstrating that consumers preferred the chicken nugget in market. The mean score of attributes appearance, colour, chicken aroma, texture, taste, and overall acceptance of control nugget were 7.65, 7.64, 7.80, 7.73, 7.73, and 7.97, respectively. Previously, Motamedi *et al.* (2015) reported that the control hamburgers which was prepared based on a commercial formulation had the highest mean scores (P<0.05) of overall acceptability compared to other formulation with chickpea and lentil flour. Indeed, the lowest acceptability of the hamburgers was found in the formulation with 12% chickpea and lentil flour.

Generally, the mean scores of attribute of texture, taste, and overall acceptance increased with the decreasing amount of chickpea flour. The mean score of these attributes decreased in ICNs with decrease percentage of chickpea flour to TVP. This might be due to the functionality of TVP that able to provide fibrous structure in the nugget similar to the meat texture. Recently, Malav *et al.* (2016) reported that addition of red kidney bean powder in mutton patties affected preference of consumers. The mean scores of overall acceptability of the mutton patties were significantly increased (P<0.05) with decreasing level of black bean in the patties. As expected, the mutton patties without addition of black bean was found as the highest acceptability (P<0.05) compared to other mutton patties with red kidney bean flour. Decrease of mean score of the overall acceptability of the patties could be due to the development of beany taste and flavour.

In the assessment of appearance, and colour of ICNs, panellists preferred ICN that contained higher amount of chickpea flour compared to TVP. High amount of chickpea flour provide better appearance and colour since chickpea flour contribute to the pleasant of yellow colour (Padalino *et al.*, 2014). The yellow colour of ICNs with chickpea flour affected the appearance of ICNs. Addition of chickpea and lentil flour increased (P>0.05) the mean score of appearance in hamburger (Motamedi *et al.*, 2015). However, in the assessment of chicken aroma, the mean scores given by consumers were not significantly different (P>0.05) among the ICNs. The ranged of mean scores of the chicken aroma of ICNs was between 4.91 and 5.25. In fact, Malav *et al.* (2016) found that addition of 5% red kidney beans powder in mutton patties was obtained to be comparable to the mutton patties without addition of red kidney beans powder.

Conclusion

This study concluded that the physicochemical properties of ICNs produced from chickpea flour and TVP significantly (P<0.05) changed the physical and chemical characteristics of nuggets compared to control nugget. However, ICNs provide better ash, protein, and carbohydrate (P<0.05) but lower in moisture and fat content (P<0.05) compared to control nugget. In the overall acceptability of ICNs, ICN E (10% chickpea flour and 30% TVP) was the most acceptable and might be due to the lowest amount of chickpea flour. Thus, it is suggested that the optimised use of amount chickpea flour should be formulated with other ingredients. Addition of other ingredients such as mushroom, carrageenan, and seitan could be used in formulating nugget with better meat texture. Hence, the preference of ICNs product could be also increased and comparable to the commercial nugget.

Acknowledgements

The authors are grateful to Faculty Science and Technology, Universiti Sains Islam Malaysia, Malaysia for the use of all laboratory facilities, apparatus, and financial support of this entire work. Thanks and appreciation also to all laboratory assistants of Faculty Science and Technology, Universiti Sains Islam Malaysia, for their assistance in this work.

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