QUALITY EVALUATION OF IMITATION CHICKEN NUGGETS FROM GREY OYSTER MUSHROOM STEMS AND CHICKPEA FLOUR

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ABSTRACT

This study was conducted to evaluate the quality of imitation chicken nuggets or ICNs formulated with grey oyster mushroom stems and chickpea flour. Four formulation of ICNs were prepared with the percentage of mushroom stems to chickpea flour were: A (60%:10%), B (55%:15%), C (50%:20%), and D (45%:25%). A commercial brand of chicken nugget was chosen as control experiment. All nuggets were analysed for nutritional and cooking properties as well as consumer preference. Results found that protein, fat, and carbohydrate contents of all ICNs were significantly lower ($p<0.05$) than control chicken nugget. However, the moisture, and crude fibre of all ICNs were significantly higher ($p<0.05$) than control chicken nugget. Results also showed that ICNs were significantly lower ($p<0.05$) in cooking loss but were significantly higher ($p<0.05$) in cooking yield and moisture retention than control chicken nugget. Hedonic test found that consumers did significantly prefer ($p<0.05$) control chicken nugget compared to all ICNs in attributes chicken aroma, texture, juiciness, taste, and overall acceptance as expected. The ICN B which contained 55% of grey oyster mushroom stems and 15% chickpea flour was the most preferred by consumers in term of texture, juiciness, taste, and overall acceptance compared to all ICNs. This findings suggested that grey oyster mushroom stems and chickpea flour have a great potential as alternative ingredients in ICNs formulation.

Key words: Imitation chicken nugget; vegetarian nugget; mushroom nugget; chicken nugget preference

INTRODUCTION

Asian countries contribute the highest percentage of total mushroom (74.64%) worldwide (Rosmiza *et al.*, 2016). In Malaysia, the total demand for mushroom is projected to be 72,000 tonnes per year (Haimid *et al.*, 2013), and the rate of mushroom consumption is projected to be 2.4 kilograms per person in 2020 (Ministry of Agriculture, and Agro-Based Industry Malaysia, 2011). There are seventeen types of mushroom that have been cultivated and marketed in Malaysia including grey oyster, ling zhi, king oyster, black jelly, enoki, white oyster, button, shiitake, paddy straw, abalone, chestnut, red oyster, yellow oyster, fungus, shaggy mane, monkey head, and morning glory (Rosmiza *et al.*, 2016).

Mushrooms have been widely consumed by many people because of their flavour, soft texture, economic, ecological values, and medicinal properties (Sanchez, 2010). The unique flavour and tremendous benefits of nutrients in mushroom have made it as ingredient of gourmet cuisine. Mushrooms are also considered to be a good source of proteins and the fresh mushrooms are also a good source of minerals (Sadler, 2003). Furthermore, mushroom possess umami flavour which are believed to be associated with sulphur containing amino acids and it imparts meaty taste in food product (Phat *et al.*, 2016).

Several studies reported that mushroom could be applied in meat products such as in sausages and patties (Wan Rosli *et al.*, 2011; Arora *et al.*, 2016; Wang *et al.*, 2019). However, the application of mushroom have been focused only on the fruiting

bodies or cap of mushroom instead of focusing on the stems of the mushroom. The stems were usually omitted and considered as food loss which have created a problem in agro-industrial waste management (Barshteyn & Krupodorova, 2016).

Imitation meat products are currently primarily aimed and used by vegetarians and semi-vegetarians due to strong emphasis on health and ethical quality aspects (Hoek *et al.*, 2004). Indeed, imitation chicken nuggets (ICNs) that consist of plant-based ingredients (are also known as vegan nuggets) are expected to be the most popular due to commercial chicken nuggets are easily found and available in market than other type of nuggets (Grumbles, 2008). Chickpea flour which contains high protein and starch (20-28% protein, and 52-57% carbohydrate) could also be applied in ICNs as an excellent adhesive material in the products (Kılınççeker & Kurt, 2010).

The tendencies of meat-based food companies in formulating plant-based chicken nugget create demands of having nugget with high nutritional value, pleasant flavour, better taste, and texture as well as low in fats making ICN good choice for consumers. Application of mushroom stems in ICNs have not been explored in detail since it could affect nutritional, cooking and sensorial characteristics of the products. Thus, the aim of this study was to evaluate the nutritional and cooking properties as well as consumer preference of ICNs produced from different percentage of grey oyster mushroom stems in combination with chickpea flour which could be a further potential of vegetarian nuggets.

MATERIALS AND METHODS

Grey oyster mushroom stems preparation

Collection of grey oyster mushroom stems were carried out from a mushroom farm (Nas Agro Farm) at Jenderam Hulu, Selangor, Malaysia. The samples were weighed before washing and rinsing using clean tap water. Next, the samples were air-dried using a sieve to drain the excess water until the original weight before washing. Finally, the grey oyster mushroom stems were grounded in small portion for use in ICNs production.

Imitation chicken nugget preparation

Four formulations of ICNs were prepared as shown in Table 1. Ingredients such as chickpea flour, textured vegetable protein or TVP, corn starch flour, honey, salt, white pepper, chicken stock powder, wheat flour, and bread crumbs were purchased from a supermarket in Nilai, Negeri Sembilan, Malaysia. These formulations were formulated according Huda-Faujan *et al.* (2006) and Sharima-Abdullah *et al.* (2018) with modifications.

Prior to analysis, all ingredients were mixed and ground completely for approximately 10 mins and the batter was stored in the refrigerator at 4°C before coating process. Ingredients for coating were prepared by mixing 80% of soy milk (isolated soy protein-based formula) and 20% wheat flour. Next, the ICNs were shaped into the size of 4.0 cm × 3.0 cm × 0.5 cm and coated with the nugget coating before being dipped in breadcrumbs. All ICNs were then packed in a tight container and stored at –18°C before analysis. A commercial brand of nugget that was used as a control in this study contained chicken, corn starch, breadcrumb (contains wheat), vegetable protein (contains soy), spices, salt, chicken seasoning, and monosodium glutamate as stated on the packaging. The price of the chicken nugget was categorised as medium price.

Cooking procedure

All frozen nuggets were thawed at 4°C for an hour before deep-frying in the pan for three minutes in 50 mL palm oil.

Nutritional composition determination

Analysis of moisture, ash, protein, fat, carbohydrate, and crude fibre were carried out for all fried nuggets according to the methods of the

Table 1. Formulation of four imitation chicken nuggets or ICNs

Ingredients (%)	A	B	C	D
Grey oyster mushroom stem	60	55	50	45
Chickpea flour	10	15	20	25
Textured vegetable protein	5	5	5	5
Corn starch flour	6	6	6	6
Water	15	15	15	15
Honey	1	1	1	1
Salt	1	1	1	1
White pepper	1	1	1	1
Chicken stock powder	1	1	1	1

Association of Official Analytical Chemists (AOAC, 2005).

Moisture analysis

Moisture content of all fried nugget samples was determined using mechanical moisture analyser (MX-50, A&D Company, Limited) which was based on thermogravimetric analysis. The percentage of moisture content was measured by calculating difference of wet weight and dry weight of the sample. Initially, each nugget sample was weighed approximately 2.0 g and heated at temperature of 200°C (for standard drying) to maintain the temperature throughout the whole analysis.

Ash analysis

Determination of total ash content (presented mineral content) of all fried nugget samples was carried out according to AOAC (2005) Method 920.153 using conventional dry-ashing. Crucibles were pre-dried in oven at 105°C overnight and were cooled in a desiccator before adding 3.0 g of each nugget sample. Next, the samples were then charred on an electric hot plate (Favorit, HS0707V2) until it ceased smoke. After that, the crucibles containing charred samples were placed inside the furnace and temperature was set up to 550°C. The samples were ignited overnight or until a grey mass (ash) formed, and were then cooled in desiccator. The percentage of total crude ash was calculated using following equation.

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

Where W_1 = weight of samples after ashing; W_2 = weight of samples before ashing.

Protein analysis

The nitrogen content of all fried nugget samples was analysed using Kjeldahl method (AOAC, 2005) Method 928.08 which include digestion and distillation process. The percentage of crude protein was expressed as total of nitrogen percentage and multiplied by a factor of 6.25 (nitrogen-protein conversion factor for meat and grain sample) as following equation.

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

Fat analysis

Fat content of all fried nugget samples was automatically carried out using Automatic Soxhlet extraction method (Soxhterm® extractor, Gerhardt). Initially, 9.0 g of each homogenised nugget sample was weighed, and was then added to the apparatus based on the manual's instruction (Gerhardt's manual). Finally, the residue of extraction was dried in air-drying oven at 105°C for overnight, and cooled in desiccator. The fat content of nugget samples was calculated as following equation.

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

Where W_0 = weight of nugget sample after treatment; W_1 = total weight of extraction beaker with boiling stones and extracted fats; and W_2 = total weight of extraction beaker and boiling stones.

Carbohydrate analysis

Content of carbohydrate of all fried nugget samples was determined by totaling up the percentage of moisture, ash, protein, and fat, followed by deducting the result from 100%. The carbohydrate content was determined as available carbohydrate, and was calculated using following equation.

$$\text{Carbohydrates (\%)} = 100 - [\text{Moisture (\%)} + \text{Ash (\%)} + \text{Protein (\%)} + \text{Fat (\%)}]$$

Crude fibre analysis

Crude fibre of all fried nugget samples was determined using Gerhardt Method. The crude fibre which is non-soluble that remain after acid and alkali after digestion (minus the content of ash) was calculated using following equation.

$$\text{Crude fibre (\%)} = [(C - A) - (D - E)] \times 100 / B$$

Where A = Weight of FibreBag; B = Weight of sample (has to be adjusted according to dry content); C = Weight of crucible and dried FibreBag after digestion; D = Weight of crucible and ash; E = Weight of blank of the empty FibreBag (B – F); F = Weight of crucible.

Energy content

Content of energy of all nuggets was determined using Atwater general factor (Atwater & Woods, 1896) as following equation.

$$\text{Energy value (kcal/g)} = [\text{Carbohydrate (\%)} \times 4] + [\text{Fat (\%)} \times 9] + [\text{Protein (\%)} \times 4]$$

Cooking loss

Prior to cooking loss evaluation, all nuggets were weighed and measured before and after frying (Bouton *et al*., 1978). The nuggets were fried for three minutes using 50 mL palm oil at temperature 170°C and the cooking loss was then measured using following equation.

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

Where W_a = weight of nugget before frying; W_b = weight of nugget after frying.

Cooking yield

All nuggets were weighed and measured before and after frying. Next, the nuggets were fried for three minutes using 50 mL palm oil at temperature 170°C and the cooking yield was then measured using following equation described by Murphy *et al.* (1975):

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

Where W_1 = weight of nugget after frying; W_2 = weight of nugget before frying.

Moisture retention

The percentage of moisture rentention was measured using following equation (Osman & Sukru, 2012).

$$\text{Moisture retention (\%)} = [\text{Cooking yield (\%)} \times \text{Moisture of fried nugget (\%)}] / 100$$

Hedonic test

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

Statistical analysis

All data was analysed using one-way analysis of variance (ANOVA), followed by Tukey HSD Test to compare the means between samples. Data was analysed using IBM SPSS (Statistical Package for the Social Science) software version 21, and the statistical significance was established at ($p<0.05$). All experiments were replicated twice.

RESULTS AND DISCUSSION

Nutritional and cooking properties of imitation chicken nuggets

Nutritional content including moisture, ash, protein, fat, carbohydrate, and crude fibre of fried nuggets are shown in Table 2. Results showed that fried control chicken nugget was significantly higher ($p<0.05$) in protein, fat, and carbohydrate content than all fried ICNs. However, moisture and fibre content of fried control chicken nugget was significantly lower ($p<0.05$) than all ICNs.

The moisture content of all fried ICNs ranged from 55.42 to 62.90% compared to fried control chicken nugget (43.33%) (Table 2). Moisture content of ICNs in ascending order were ICN C (55.22%), ICN D (55.42%), ICN B (57.56%), and ICN A (62.90%). Moisture content of ICNs are higher than control chicken nugget and might be associated with high moisture content of grey oyster mushroom stems compared to mushroom cap. In fact, moisture content of edible mushroom *Pleurotus ostreatus* (pearl oyster mushroom) stem was 6.30% higher than in the cap part (3.50%) of the mushroom (Oluwafemi *et al.*, 2016). Hence, this could explain why the moisture content of all fried ICNs in this

Table 2. Nutritional and cooking properties of four ICNs compared to control chicken nugget

Percentage (%)	Nugget samples				
	Control	A	B	C	D
Moisture	43.33[c]	62.90[a]	57.56[b]	55.22[b]	55.42[b]
Ash	2.95[b]	2.96[b]	2.95[b]	2.93[b]	3.03[a]
Protein	9.84[a]	6.99[b]	7.78[ab]	8.63[ab]	8.74[ab]
Fat	1.30[a]	0.62[b]	0.60[b]	0.52[b]	0.47[b]
Carbohydrate	42.59[a]	26.52[b]	31.12[ab]	32.71[ab]	32.34[ab]
Crude fibre	4.09[b]	4.22[a]	4.24[a]	5.78[a]	6.28[a]
Energy content[#]	221.42[a]	139.62[b]	161.00[ab]	170.04[ab]	168.55[ab]
Cooking loss	0.59[a]	-3.18[b]	-2.29[b]	-2.55[b]	-2.79[b]
Cooking yield	99.42[b]	103.18[a]	102.29[a]	102.55[a]	102.79[a]
Moisture retention	43.07[b]	64.89[a]	58.88[a]	56.62[a]	56.97[a]

Notes:
a) Means in the same row with different lowercase letters indicate significant differences ($p<0.05$) between formulations of ICNs and control chicken nugget.
b) Control = commercial chicken nugget; A = 60% grey oyster mushroom stems and 10% chickpea flour; B = 55% grey oyster mushroom stems and 15% chickpea flour; C = 50% grey oyster mushroom stems and 20% chickpea flour; and D = 45% grey oyster mushroom stems and 25% chickpea flour.
c) [#] Energy content of all fried nuggets were expressed as kcal/g.

study was significantly higher ($p<0.05$) than fried control chicken nugget. The range of moisture content of commercial chicken nuggets in Malaysia was reported from 34.71 to 56.51% (Lukman *et al*., 2009).

Ash content of fried ICN D (formulated with 45% grey oyster mushroom stems and 25% chickpea flour) was the highest (3.03%) ($p<0.05$) compared to all fried nuggets (Table 2). Ash content of ICN A, ICN B, ICN C, and fried control chicken nugget was found to be similar (2.93 to 2.96%) to each other ($p>0.05$). Ash content of chickpea flour was between 3.00 and 3.20% (Aguilar *et al*., 2015; Ghribi *et al*., 2015) while ash content of pearl oyster mushroom stems' (*Pleurotus ostreatus*) was 5.30% (Oluwafemi *et al*., 2016). This could describe why ash content of fried ICN D was found the highest ($p<0.05$) among all fried nuggets. In fact, ash was determined to measure mineral content of chicken nuggets. In ICNs, mushroom can supply a good proportion of minerals of daily need, where the main constituents of mineral in *Pleurotus* spp. are potassium and phosphorus (Bano & Rajarathnam, 1982). Ash content of commercial chicken nuggets in Malaysian market was lower compared to this study, which was between 1.20 and 1.58% (Lukman *et al*., 2009).

Protein content of fried control chicken nugget (9.84%) was the highest ($p<0.05$). The ranged of protein content of all fried ICNs was from 6.99 to 8.74% (Table 2). Increasing amount of grey oyster mushroom stems with decreasing amount of chickpea flour in ICN formulations consistently decreased ($p<0.05$) protein content of ICNs. According to Ghribi *et al*. (2015) protein content of chickpea flour was 24.5% (Kabuli cultivar). Protein content of chickpea flour used in this study was 23.0% (labelled in the packaging). In addition, protein content of *Pleurotus ostreatus* stems' was 21.00% (Oluwafemi *et al*., 2016) and almost seemed to be similar to protein content of chickpea flour. Therefore, increasing amount of grey oyster mushroom stems with decreasing amount of chickpea flour in ICN formulations does not necessarily decrease protein content of ICNs. Protein content in fried control chicken nugget was most probably contributed by vegetable protein (contains soy) as labelled as the third major ingredient in the packaging. Furthermore, Sharima-Abdullah *et al*. (2018) reported that protein content of ICNs (formulated with combination of TVP and chickpea flour) was significantly ($p<0.05$) higher (10.80 to 11.78%) than commercial control chicken nugget (9.84%).

Fat content is one of the important nutrients to claim that the ICNs were healthier than control chicken nugget since ICNs were produced from plant-based sources (did not contain saturated fats and cholesterol). As expected, fried control chicken nugget contained the highest ($p<0.05$) fat content (1.30%), followed by a decline of ICN A (0.62%), ICN B (0.60%), ICN C (0.52%), and ICN D (0.47%) (Table 2). Results found that fat content of fried ICNs consistently decreased ($p<0.05$) when amount of grey oyster mushroom stems was decreased with increasing amount of chickpea flour. Fat content of chickpea flour used (in this study) was 4.1% as mentioned on the packaging. In contrary, fat content of mushroom stems of *Pleurotus ostreatus* was 1.50% (Oluwafemi *et al*., 2016). Even though fat content in chickpea flour is generally higher in mushroom stems, however, this finding might be related to amylose content in chickpea flour. Chickpea flour contained amylose ranging from 10.8 to 13.5% (Chung *et al*., 2008) but no starch was reported in oyster mushroom (considered no amylose) (Oei, 1996). Thus, when ICNs (from ICN A to ICN D) were fried, the amylose content in chickpea flour increased and absorbed less oil. Oil absorption was negatively correlated with amylose content in starch (Mohamed *et al*., 1998). This could explain why fat content in fried ICNs decreased when the amount of chickpea flour increased in ICN formulations. Previously, Kilinççeker and Kurt (2010) also reported that addition of chickpea flour in chicken nugget promoted reduction of oil content in fried nugget. Fat content of commercial chicken nuggets in Malaysian market was actually higher that ICNs which ranged from 18.00 to 20.00% (most probably from chicken fat) (Lukman *et al*., 2009).

Table 2 shows that fried control chicken nugget contained the highest ($p<0.05$) carbohydrate content (42.59%) compared to all fried ICNs as expected. In general, decreasing amount of grey oyster mushroom stems with increasing amount of chickpea flour in ICN formulations consistently increased ($p<0.05$) carbohydrate content in ICNs. According to Crisan and Sands (1978) mushrooms stems are high in carbohydrates as glycogen together with pentoses, hexoses, and other polymeric carbohydrates. In fact, carbohydrate content of *Pleurotus ostreatus* stem was higher (61.80%) than its cap (52.90%) (Oluwafemi *et al*., 2016). However, carbohydrate contents of chickpea flour was 70.17% (Ghribi *et al*., 2015). The highest content ($p<0.05$) of carbohydrate in fried control chicken nugget was probably due to the content of corn starch and breadcrumb containing wheat as the second and third major ingredient, respectively. Carbohydrate content of commercial chicken nuggets in Malaysian market ranged from 2.49 to 26.05% (Lukman *et al*., 2009) which depending on starch types added in nugget formulations.

Fibre content of fried control chicken nugget (4.09%) was significantly lower ($p<0.05$) than all fried ICNs (4.22 to 6.28%) (Table 2). Decreasing

amount of grey oyster mushroom stems with increasing amount of chickpea flour in ICN formulations increased fibre content of ICNs. The fibre content of ICNs in ascending order were ICN A (4.22%), ICN B (4.24%), ICN C (5.78%), and ICN D (6.28%). Previously, Oluwafemi *et al*. (2016) reported that fibre content of stalk or stem of edible mushroom *Pleurotus ostreatus* (pearl oyster mushroom) was 7.50% lower than in the cap part (30.10%) of the mushroom. Moreover, fibre content of chickpea flour (Kabuli cultivar) was 21.8% (Ghribi *et al*., 2015). This could explain why the fibre content of all fried ICNs was gradually increased when were formulated with lower amount of grey oyster mushroom stems in combination with higher amount of chickpea flour.

Energy content of fried nuggets ranged from 139.62 to 221.42 kcal/g. As expected, fried control chicken nugget was significantly higher ($p<0.05$) in energy content than all fried ICNs. Energy content of fried control chicken nugget was mainly contributed by fat content. It was observed that decreasing amount of grey oyster mushroom stem with increasing amount of chickpea flour generally increased energy content of ICNs and was line with chickpea content in the ICNs. In a recent study, El-Anany *et al*. (2020) reported that energy content of fried chicken nuggets ranged from 182.86 to 282.78 kcal/g. The energy content of fried control chicken nugget was the highest ($p<0.05$) compared to chicken nuggets formulated with frozen white cauliflower. A decreament content of chicken skin from 20 to 0% and replacing with frozen-blanched cauliflower significantly ($p<0.05$) decreased energy content of fried chicken nuggets.

The cooking properties of chicken nuggets are also shown in Table 2. Results found that fried control chicken nugget significantly ($p<0.05$) showed the highest percentage of cooking loss (0.59%) as expected due to the highest fat content in the product. Decreasing amount of grey oyster mushroom stems with increasing chickpea flour in ICN formulations increased cooking loss ranged from –2.79 to –3.18% (from ICN D to ICN A). According to Verma *et al*. (2012) higher amount of fat in a meat product causes 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. Furthermore, fat content of mushroom stems of *Pleurotus ostreatus* (1.50%) was lower (Oluwafemi *et al*., 2016) compared to chickpea flour (7.98%) (Xiao *et al*., 2015). This could explain why cooking loss in control chicken nugget was the highest compared to all ICNs formulation, and decreasing amount of grey oyster mushroom stems with increasing chickpea flour in ICN formulations increased cooking loss. Cooking loss is one of the crucial characteristics that affect juiciness of meat-based product (Sharima-Abdullah *et al*., 2018).

In the assessment of cooking yield, it was found that all fried ICNs were significantly ($p<0.05$) higher in cooking yield than fried control chicken nugget (99.42%) (Table 2). The cooking yield of ICNs seemed to be similar to each other ($p>0.05$) which ranged from 102.29 to 103.18%. Addition of dietary fibre increased cooking yield and might be related to their high ability to retain moisture and fat in food matrix (Aleson-Carbonella *et al*., 2005). Furthermore, Santhi and Kalaikannan (2014) reported that nuggets incorporated with oat flour significantly increased ($p<0.05$) cooking yield (99.46 to 99.85%) compared to chicken nugget without oat (control sample) (96.46%). The fibre content of all fried ICNs was found higher than fried control chicken in the present study. Hence, this could explain why cooking yield of all fried ICNs was higher than fried control chicken nugget.

Moisture retention of all fried ICNs (56.97 to 64.89%) was also found significantly ($p<0.05$) higher than fried control chicken nugget (43.07%) (Table 2). However, decreasing amount of grey oyster mushroom stems with increasing amount of chickpea flour in ICN formulations obtained a gradual reduction of moisture retention. The characteristic of retaining moisture in mushroom is a beneficial property including flavour concentrate in foods, improving texture, and mouthfeel (Oei, 2003). Addition of mushroom stems and legume (i.e. chickpea flour) enhance moisture retention (Jayasinghe *et al*., 2013) and might be due to high content of polysaccharides in grey oyster mushroom stems (Oluwafemi *et al*., 2016) which are able to form tridimensional matrix within the nugget.

Consumer preference of nuggets

Table 3 presents the hedonic test data of nuggets' preference by 110 panellists. Results showed that consumers' preference of sensory attributes include chicken aroma, texture, juiciness, taste, and overall acceptance were significantly higher ($p<0.05$) in control chicken nugget than all ICNs demonstrated that consumers preferred the commercial chicken nugget in market. The mean score of appearance of control chicken nugget was also the highest but did not significantly differed ($p>0.05$) compared to all ICNs. The mean score of attributes appearance, chicken aroma, texture, juiciness, taste, and overall acceptance of control chicken nugget were 6.50, 7.26, 6.56, 6.33, 6.94 and 6.69, respectively.

In the assessment of nuggets' appearance, results found that preference of panellists among ICNs was similar ($p>0.05$) to control chicken nugget (6.50) where the mean score of ICNs ranged from 6.22 to 6.31. Previously, Sharima-Abdullah *et al*. (2018)

Table 3. Mean scores of hedonic test of four ICNs compared to control chicken nugget

Attributes	Nugget samples				
	Control	A	B	C	D
Appearance	6.50[a]	6.30[a]	6.31[a]	6.22[a]	6.31[a]
Chicken aroma	7.26[a]	4.83[b]	4.85[b]	4.68[b]	4.98[b]
Texture	6.56[a]	4.36[b]	4.57[b]	4.43[b]	4.51[b]
Juiciness	6.33[a]	4.07[b]	4.17[b]	4.09[b]	4.06[b]
Taste	6.95[a]	3.72[b]	3.84[b]	3.61[b]	3.78[b]
Overall acceptance	6.99[a]	4.04[b]	4.19[b]	3.91[b]	4.05[b]

Notes:
a) Means in the row with different lowercase letters indicate significant differences ($p < 0.05$) between formulations of ICNs and control chicken nugget.
b) Control = commercial chicken nugget;
 A = 60% grey oyster mushroom stems and 10% chickpea flour;
 B = 55% grey oyster mushroom stems and 15% chickpea flour;
 C = 50% grey oyster mushroom stems and 20% chickpea flour; and
 D = 45% grey oyster mushroom stems and 25% chickpea flour.

reported that mean score of appearance of ICNs produced from chickpea flour in combination with TVP ranged from 5.44 to 5.98. Addition of chickpea flour in a food product provides better appearance and colour since chickpea flour contribute to the pleasant yellow colour (Padalino *et al*., 2014). In hamburger, addition of chickpea and lentil flour also increased ($p > 0.05$) the mean score of appearance (Motamedi *et al*., 2015).

The mean scores of 7.26 for chicken aroma was given by consumers in control chicken nugget. However, the range of mean scores of chicken aroma of ICNs was lower ($p < 0.05$) which between 4.68 and 4.83. Results found that the mean score among ICNs did not significantly differ ($p > 0.05$) among the ICNs. Previously, Sharima-Abdullah *et al*. (2018) reported that the range of mean scores of chicken aroma of ICNs produced from chickpea flour and TVP was between 4.91 and 5.25 ($p > 0.05$) and was also lower than control chicken nugget's mean score (7.80).

In term of ICNs texture, it was found that panellists' mean score were between 4.36 and 4.57 ($p > 0.05$) compared to control chicken nugget (6.56). However, Sharima-Abdullah *et al*. (2018) obtained that the mean score of texture of ICNs produced from chickpea flour and TVP ranging between 4.75 and 5.04. Decreasing amount of TVP with the increasing amount of chickpea flour generally decreased panellists' preference and might be related to the decrease of TVP which was able to provide fibrous structure in the nugget similar to the meat texture.

Meat juiciness is actually defined as amount of moisture released in the mouth when chewing the meat product. In this study, the mean score of ICNs' juiciness are similar ($p > 0.05$) which ranged from 4.07 to 4.17 and was significantly ($p < 0.05$) lower compared to control chicken nugget (6.33). Previously, Wan Rosli and Solihah (2012) reported

that the mean score of beef patties' juiciness formulated with and without combination grey oyster mushroom are similar ($p > 0.05$) for which the panellists' mean score was between 4.15 and 4.62. However, the mean score of juiciness of Malaysian commercial chicken nugget was found between 4.40 and 5.64 and might be due to different types of ingredients (starch, soy protein, and fat) in the products (Lukman *et al*., 2009).

In the context of taste attribute, it was found that panellists' mean score of ICNs ranged between 3.61 to 3.84 ($p > 0.05$) and were lower in ICNs produced from chickpea flour and TVP (4.75 to 5.04) (Sharima-Abdullah *et al*., 2018). However, the mean score of taste of Malaysian commercial chicken nugget was found between 4.12 and 5.60 (Lukman *et al*., 2009). Moreover, the mean score of overall acceptance of ICNs in this study ranged between 3.91 and 4.19 ($p > 0.05$) and were also lower in ICNs produced from chickpea flour and TVP (5.03 to 5.21) (Sharima-Abdullah *et al*., 2018). Previously, Wan Rosli and Solihah (2012) reported that the mean score of beef pattie's overall acceptance formulated with and without combination grey oyster mushroom ranged from 4.08 to 4.80 ($p > 0.05$) and was found lower than panellists' mean score of overall acceptance of Malaysian commercial chicken nugget (4.56 to 5.84) (Lukman *et al*., 2009). This might be associated to the TVP as this ingredient is always applied in commercial chicken nugget and provide familiar taste to consumer compared to mushroom in chicken nugget.

CONCLUSION

Production of ICNs from grey oyster mushroom stems and chickpea flour significantly ($p > 0.05$) changed nutritional and cooking properties of fried

chicken nuggets except in ash content. As expected, consumer preferred commercial control chicken nugget compared to all ICNs. However, among all ICNs it was found that ICN B (55% of grey oyster mushroom stems and 15% chickpea flour) was the most preferred by consumers in term of texture, juiciness, taste, and overall acceptance. These findings concluded that ICNs from mushroom stems and chickpea flour have a potential to be an alternative of chicken-based nugget in commercial market.

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