

Physicochemical, nutritional, sensorial, and morphological properties of chicken frankfurters incorporated with selected vegetables

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Abstract

The physicochemical, nutritional, sensorial and morphological properties of chicken frankfurters incorporated with selected vegetables (baby corn, cabbage, and carrot) were investigated. The incorporation of selected vegetables to formulate chicken frankfurters yielded significant differences in proximate compositions among the samples; the moisture, ash, fat, protein, and carbohydrate contents were 67.16 - 66.39%, 1.90 - 2.40%, 5.33 - 7.47%, 14.53 - 15.68%, and 8.75 - 11.09%, respectively. The folding test and pH values in control frankfurter (with the score of 5.00; pH 6.84) and chicken frankfurters incorporated with baby corn (with the score of 5.00; pH 6.88) showed significant difference as compared to commercial chicken frankfurter (with the score of 3.83; pH 6.70). Chicken frankfurters incorporated with baby corn and cabbage were significantly harder than commercial frankfurter due to different levels of fat. Scanning electron microscopy (SEM) on formulated frankfurters displayed less dense microstructure and prominent presence of fat globules as compared to control and commercial chicken frankfurters. Sensory evaluation on formulated and commercial frankfurters showed almost similar result in overall acceptance score. All formulated chicken frankfurters did not show significant difference in texture profiles (adhesiveness and springiness attributes). In conclusion, the incorporation of selected vegetables in chicken frankfurters yielded nutritional product, and decreased the costs of production without affecting the sensory attributes.

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Keywords

vegetable,
chicken frankfurter,
physicochemical
properties,
nutritional properties,
morphological properties,
sensorial properties

Introduction

At present, the consumption of chicken meat and its product are gradually increasing around the world. According to Norimah *et al.* (2008), chicken meat is one of the most daily consumed foods amongst the urban and rural residents in Malaysia. Today, many types of processed meats such as burgers, hotdogs, nuggets, frankfurters, and meatballs are available locally. Chicken frankfurter is a product containing meat and fat (solid phase) dispersed into ice or water (liquid phase), thus forming a stable mass that will be subjected to moderate heat treatment (Mercadante *et al.*, 2010). Poultry products, such as chicken frankfurters, are universally popular and highly consumed because they are not subjected to cultural or religious constraints, and the meat itself is perceived as wholesome, healthy, and nutritious, being relatively low in fat, and having desirable unsaturated fatty acid content (Naveena *et al.*, 2014). Poultry products have also been found to be a good source of polyunsaturated fatty acid (PUFA) as compared to pork and beef products, which have

undesirable effects on health. Nowadays, frankfurter products have evolved into a wide variety of flavours, textures, and shapes, resulting from variations in ingredients and manufacturing processes.

Daily consumption of vegetables is essential, and plays a significant role in human nutrition, especially as sources of good phytochemicals: vitamins (C, A, B₁, B₆, B₉, and E), minerals, and dietary fibres. Both phytochemicals and antioxidants can decrease the risk of chronic diseases by protecting against free-radical damage by modifying metabolic activation and detoxification of carcinogens, or even influencing processes that alter the course of tumour cells (Dias, 2012). Data from the World Health Report 2007 found that almost 2.7 million deaths occurred annually due to unbalanced diets such as low vegetable intake, and consumption of complex carbohydrates. Hence, these factors were one of the top ten risk factors contributing to mortality (Hall *et al.*, 2009; Dias, 2012). The results from the Malaysian Adult Nutrition Survey 2003 also revealed that the intake of fruits and vegetables are still low among Malaysians (Norimah *et al.*, 2008; Chen *et al.*, 2020).

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According to the United States Department of Agriculture (Slavin and Lloyd, 2012; Izzah *et al.*, 2012), there are five subgroups of vegetables namely beans and peas (*e.g.*, lentils, red beans, and soybeans), dark green (*e.g.*, kale, broccoli, and spinach), red and orange (*e.g.*, tomato, carrot, and pumpkin), starchy (*e.g.*, potato, corn, and taro), and other vegetables (*e.g.*, cabbage, celery, and eggplant). Each group contains different and unique combination, and high amount of phytonutritional compounds. Currently, these items are considered among the popular vegetables regularly consumed by Malaysian (Norimah *et al.*, 2008).

Nowadays, people have changed their lifestyle towards healthier diet as one of the crucial factors in sustaining overall health and social well-being (Jiménez-Colmenero *et al.*, 2001). Young corn or baby corn is used as one of the samples in the present work as it is popularly consumed among Asians, and rich in dietary fibre, in which the dried young corn contains 30.4% of total dietary fibre (Jauharah *et al.*, 2014). Many previous reports showed that these vegetables provided various health goodness, and reduced the prevalence of diseases such as cancers, cardiovascular diseases, obesity, and other non-communicable diseases. Therefore, the present work was aimed to investigate the physicochemical, nutritional, sensorial, and morphological properties of chicken frankfurters incorporated with 6% of selected vegetables (baby corn, carrot, and cabbage).

Materials and methods

Sample preparation

The selected vegetables (baby corn, cabbage, and carrots), capsicum, chicken breast, and other dry ingredients (potato starch, herbs, spices, and onion powder) were purchased from a local hypermarket in Kota Bharu, Kelantan, Malaysia. The chicken breast was manually cut using a cleaver, and minced using a food processor (Panasonic, Model MK-5086M, Malaysia). The minced chicken breast meat was stored at -18°C until further processing. All vegetables were rinsed with clean water, drained, ground roughly using a food grinder, and incorporated into the chicken frankfurter formulations.

Frankfurter preparation

The procedures described by Wan Rosli *et al.* (2015) were followed with slight modification. All ingredients were carefully weighed by using a digital waterproof weighing balance (KD-200, Tanita, Japan). Three formulations of chicken

frankfurters with selected vegetables were prepared as follows: cabbage, carrot, and young corn (2.60%) mixed with phosphate, 0.40; shortening, 8.00; caseinate, 1.00; ice water, 16.00; potato starch, 3.00; onion powder, 0.20; garlic powder, 0.05; ginger powder, 0.05; HPP (chicken seasoning), 1.60; soy protein isolate, 2.50; salt, 1.10; herbs and spices, 0.10; capsicum, 1.00; and 61.10 and 65.00 minced chicken breast meat for formulation and control samples, respectively. Chicken frankfurters were thawed at 4°C for 12 h. The samples were then cooked on a pan-fried with electric skillet (Model KX-11K1, Sharp Corporation, Japan) for 7 - 8 min until an internal temperature of $72 \pm 1^\circ\text{C}$ was achieved.

Physicochemical analysis of frankfurter

pH, cooking yield, folding test, and texture profile analysis

The physicochemical analysis on the formulated chicken frankfurters was performed following the procedures described by Fernandez-Gines *et al.* (2004). Briefly, 15 g of sample and 150 mL of deionised water were blended for 2 min. Then, the pH of the resultant suspension was measured. We modified the method by using 10 g of sample and homogenised with 90 mL of distilled water for 30 s (T25B, IKA Sdn. Bhd., Malaysia). The readings were taken with a pH meter (8603, Metrohm, Swiss), and the cooking yield of the formulated chicken frankfurters was determined following the procedures described by El-Magoli *et al.* (1996). The cooking yield was then calculated using Eq. 1:

$$\text{Cooking yield (\%)} = (\text{cooked weight} / \text{raw weight}) \times 100 \quad (\text{Eq. 1})$$

The folding test on the formulated chicken frankfurters was performed according to Lanier as reported by Huda *et al.* (2010). The texture profile analysis on the formulated chicken frankfurters was performed following the procedures described by Wan Rosli *et al.* (2015) using a texture analyser (TA-XTPLUS; Stable Micro Systems, Surrey, UK).

Nutritional analysis of frankfurter

Proximate analysis

The proximate composition analyses on the formulated chicken frankfurters were performed following the method of AOAC (2000).

Morphological analysis of frankfurter

The morphological analysis on the

formulated chicken frankfurters was performed at the Laboratory of Scanning Electron Microscopy (SEM), School of Health Sciences, Universiti Sains Malaysia. The microstructure of all chicken frankfurters was examined by scanning electron microscope (SEM) at high magnification. Five micrographs of each sample were captured using SEM at 20 kV (JEOL, mod. JSM-6400, Jeol, Japan) at different magnifications, and the representative was selected (Cáceres *et al.*, 2008). The microstructures of the chicken frankfurters were then viewed and interpreted.

Sensory evaluation of frankfurter

A sensory evaluation on the formulated chicken frankfurters was performed using a seven-point hedonic scale (1 = dislike very much, and 7 = like very much; Zin *et al.*, 2014). Sensory attributes such as colour, aroma, texture, taste, flavour, after-taste, and overall acceptability of the formulated chicken frankfurters were evaluated. Each formulation was independently judged by 60 volunteer panellists. Every formulation was assigned with a random three-digit code. The code was generated from a table of random three digits numbers. The random numbers were recorded on a master sheet indicating the actual sample and the panellists.

Statistical analysis

All measurements were performed in triplicates ($n = 3$), and the results were expressed as mean \pm standard deviation. All data were analysed by one-way ANOVA using SPSS 22.0 (USA) software, and the significant differences were determined using Duncan's Multiple Range Test at $p < 0.05$.

Results and discussion

Physicochemical property

pH

The pH of chicken frankfurters incorporated with vegetables showed a significant difference in the range of 6.88 - 6.91, whereas the pH of control and commercial chicken frankfurters were 6.84 and 6.70, respectively. The incorporation of cabbage in the chicken frankfurter formulation resulted in the highest pH (6.91). This difference might be due to the diverse initial pH of the raw vegetables, and the percentage of vegetables used in the formulations. The initial pH of cabbage and carrot were higher, ranging from 5.50 - 6.75 and 5.88 - 6.40, respectively. The initial pH of vegetables did not reduce the pH of chicken frankfurters. Besides, the chicken

frankfurter's pH was determined after cooking. According to Schweigert as cited in Fernandez-Ginez *et al.* (2004), cooking increases meat pH, probably due to the breaking down of cellular buffer and the release of free fats. Determining the pH is crucial as it affects microbial growth as most bacteria grow optimally around pH 7, and a high pH (to near neutrality) in the final meat product leads to more spoilage and shorter shelf life (Quasem *et al.*, 2009).

Cooking yield

The cooking yield was significantly lower in chicken frankfurters incorporated with vegetables (86.84, 86.84, and 81.19% for baby corn, carrot, and cabbage, respectively) as compared to control (89.17%) and commercial (90.96%) chicken frankfurters. These findings are in line with the previous findings where the addition of *Pleurotus sajor-caju* mushroom in beef patty formulation resulted in reduction of cooking yield and moisture retention properties (Wan Rosli, 2012). These findings are inversely proportional to the addition of vegetables as non-meat ingredients (partially replacement of chicken meat). A similar pattern of results was obtained by Yadav *et al.* (2016) who found that the cooking yield increased due to the retention of water and fat by dietary fibre present in chicken frankfurters. Dietary fibres increased the cooking yield due to water- and fat-binding properties (Cofrades *et al.*, 2000). These results (Figure 1) demonstrated that the cooking yield was significantly reduced due to the inability of vegetable fibre to create a cohesive tridimensional matrix within the chicken frankfurter due to high moisture content. Choi *et al.* (2010) opined that the cooking yield of chicken frankfurter was also dependent on temperature, cooking time, ingredients, and amount of fat in the products.

Folding test

The folding test (Figure 1) shows that the control and chicken frankfurters incorporated with baby corn and carrot yielded the highest score (5.00 and 4.00, respectively). Commercial and chicken frankfurter incorporated with cabbage yielded the lowest score of 3.83. It is important to highlight that the difference in the folding scores could probably be due to the different moisture and fibre contents. Folding score plays a significant role as an indicator for the freshness of meat, source of starch, and type of ingredients used in the formulation (Muthia *et al.*, 2012; Fernández-López *et al.*, 2019). The present work showed that the range of folding scores for all chicken frankfurters produced were 3.83 to 5.00; the

score of 4.00 and above indicates "good gel strength" of chicken frankfurter. Previous study demonstrated that the folding test scores of commercial chicken sausages in Malaysia were in the range of 4.20 - 5.00 (Huda *et al.*, 2010). In the present work, the results obtained from the folding test indicated that the chicken frankfurters incorporated with baby corn and carrot had comparable gel quality with the commercial chicken frankfurter in Malaysia.

Texture profile

The texture profile analysis results are displayed in Table 1. The first attribute was hardness

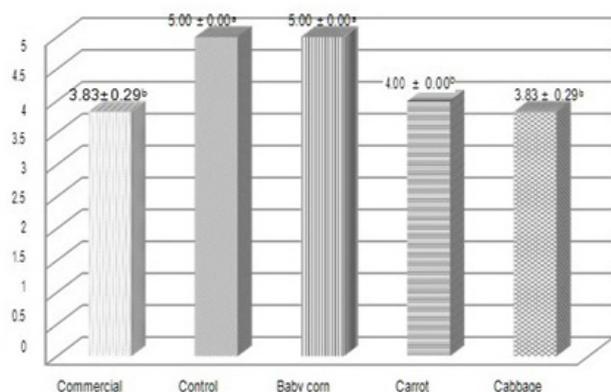


Figure 1. Folding test of commercial, control, and chicken frankfurters incorporated with selected vegetables. Values are mean \pm standard deviation. Mean with different lowercase superscripts differ significantly ($p < 0.05$).

which refers to the maximum force required when compressing the sample (Herrero *et al.*, 2008). Among all samples, control yielded the highest hardness value (0.1163 kg), followed with baby corn (0.1160 kg), cabbage (0.1137 kg), and carrot (0.0843 kg). It can thus be said that the addition of vegetables into chicken frankfurters resulted in the decrease in hardness (Ktari *et al.*, 2014). Similar findings were also reported that the hardness and shear force of sausages significantly decreased with increasing contents of bleached tomato pomace and oyster mushroom powder into the sausage batter (Savadkoochi *et al.*, 2014; Wan Rosli *et al.*, 2015). However, contradictory findings were reported for low-fat sausages incorporated with 3% cereal fibre where harder, less elastic, and less adhesive attributes were observed, particularly those with wheat fibre (Garcia and Barrett, 2002). In the present work, adhesiveness was not significantly different ($p > 0.05$) among the tested samples.

Cohesiveness measures the degree of difficulty in breaking down the internal structure of a matrix (Yang *et al.*, 2007). According to Yang *et al.* (2007), the cohesiveness scores of frankfurters depended on the types and amounts of texture-modifier. The present work showed a lower degree of cohesiveness in baby corn and cabbage chicken frankfurters as compared to the control sample. Meanwhile, chicken frankfurter incorporated with carrot resulted in higher cohesiveness value

Table 1. Textural properties and proximate composition of commercial chicken frankfurter and chicken frankfurters incorporated with selected vegetables.

Parameter	Commercial	Control	Baby corn	Carrot	Cabbage
Hardness (kg)	0.0813 \pm 0.0095 ^b	0.1163 \pm 0.0080 ^a	0.1160 \pm 0.0096 ^a	0.0843 \pm 0.0040 ^b	0.1137 \pm 0.0015 ^a
Adhesiveness (J)	-0.0150 \pm 0.0027 ^a	-0.0133 \pm 0.0023 ^a	-0.0167 \pm 0.0025 ^a	-0.0163 \pm 0.0025 ^a	-0.0143 \pm 0.0012 ^a
Cohesiveness (ratio)	0.7367 \pm 0.0593 ^a	0.6700 \pm 0.0235 ^{bc}	0.6363 \pm 0.0268 ^{bc}	0.6757 \pm 0.0076 ^b	0.6113 \pm 0.0239 ^c
Springiness (mm)	1.1313 \pm 0.7714 ^a	1.1817 \pm 1.1107 ^a	1.1767 \pm 1.1357 ^a	1.1697 \pm 1.1170 ^a	1.1673 \pm 1.1444 ^a
Moisture (%)	65.85 \pm 0.61 ^D	64.92 \pm 0.48 ^E	67.16 \pm 0.37 ^A	66.49 \pm 0.17 ^B	66.39 \pm 0.29 ^C
Ash (%)	2.36 \pm 0.44 ^B	2.30 \pm 0.17 ^C	1.90 \pm 0.52 ^D	2.40 \pm 0.21 ^A	2.07 \pm 0.15 ^{CD}
Fat (%)	5.18 \pm 0.16 ^D	7.86 \pm 0.52 ^A	5.33 \pm 0.22 ^C	6.56 \pm 0.57 ^{BC}	7.47 \pm 0.82 ^B
Protein (%)	11.89 \pm 0.33 ^D	15.95 \pm 0.61 ^A	14.53 \pm 0.24 ^C	15.68 \pm 0.02 ^{AB}	15.13 \pm 0.14 ^B
Carbohydrate (%)	14.71 \pm 0.23 ^A	9.30 \pm 1.15 ^C	11.09 \pm 0.29 ^B	8.75 \pm 0.53 ^E	8.93 \pm 0.66 ^D
pH	6.70 \pm 0.08 ^c	6.84 \pm 0.04 ^c	6.88 \pm 0.02 ^b	6.83 \pm 0.02 ^d	6.91 \pm 0.01 ^a
Yield	90.96%	89.17%	86.84%	86.84%	81.19%

Values are mean \pm standard deviation. Mean in the same row with different lowercase superscripts differ significantly ($p < 0.05$) for textural properties. Mean in the same row with different uppercase superscripts differ significantly ($p < 0.05$) for proximate composition.

(0.6757 J) as compared to the control sample. However, the cohesiveness value of control was significantly lower than the commercial chicken frankfurter.

For springiness, there was non-significant difference between all samples, thus suggesting that the addition of vegetables in chicken frankfurter formulations did not affect their springiness. Similar finding was reported in a previous study where frankfurters incorporated with soybean tofu powder yielded non-significant differences between cohesiveness, springiness, gumminess, and chewiness (Biswas *et al.*, 2011).

Nutritional property

Proximate composition

Based on Table 1, the moisture content was significantly higher for all chicken frankfurters incorporated with vegetables (67.16 - 66.39%) as compared to commercial (65.85%) and control (64.92%) chicken frankfurters. This could be due to the incorporation of vegetables in chicken frankfurter formulation which provided a significant amount of fibre to the products. According to previous studies, the addition of dietary fibre increases the moisture content of meat emulsion systems, thus providing higher water retention, and improving emulsion stability (Garcia and Barrett 2002; Choi *et al.*, 2012). These results are also in line with those reported by another study which showed a significant increase in moisture content of chicken sausage added with pumpkin fibre. Hughes *et al.* (1997) indicated similar results for chicken sausage added with oat fibre (Hughes *et al.*, 1997; Choi *et al.*, 2012). Similarly, Lee *et al.* (2009) showed that the addition of kimchi fibre also increased the moisture content of chicken sausage. Besides, the moisture content in chicken frankfurters was also influenced by the water content of the raw vegetables. A study conducted by Wan Rosli (2012) found that high moisture content of *P. sajor-caju* increased the moisture content in sausage. Fresh baby corn also contained high moisture content (90.64%) (Jauharah *et al.*, 2014). According to the United States Department of Agriculture (2016), the moisture contents of cabbage and carrot are 33.12 g and 31.79 g, in 36 g of vegetables, respectively.

For fat content, control chicken frankfurter yielded the highest (7.86%), while chicken frankfurter incorporated with baby corn the lowest (5.33%). The fat contents of chicken frankfurters incorporated with carrot, cabbage, and commercial were 6.56%, 7.47%, and 5.18%, respectively. This demonstrated that chicken frankfurters incorporated with vegetables have lower fat content. These

findings are parallel with a previous study which reported that replacing pork loin with hydrated oatmeal and tofu (15%) showed significantly lower amount of fat content (Yang *et al.*, 2007). A similar result was also reported by Wan Rosli *et al.* (2015) on the incorporation of selected vegetables into chicken meat.

Table 1 also displays the protein contents of the formulated chicken frankfurters which was found to be significantly higher in control chicken frankfurter (15.95%) as compared to the other chicken frankfurter formulations [carrot (15.68%), cabbage (15.13%), and baby corn (14.53%)], and commercial. Similar trend of protein content reduction has been reported following the incorporation of *P. sajor-caju* into chicken patty (Wan Rosli *et al.*, 2015). Thus, the present work confirmed that the partial replacement of selected vegetables in formulated frankfurters affected the reduction of protein content. Also, increasing ash content in chicken frankfurters formulated with selected vegetables directly affecting the decreased protein and increased fibre contents. This result is confirmed by a previous study which indicated that the ash content increased the dietary fibre such as albedo in low-fat chicken frankfurter (Fernandez-Gines *et al.*, 2004). Another report also confirmed that the fibre content of makgeolli in pork back fat sausage formulation reduced the fat content (Choi *et al.*, 2012).

The carbohydrate content in all chicken frankfurter formulations ranged from 8.75 to 11.09%. The highest carbohydrate content was recorded by chicken frankfurter incorporated with baby corn (11.09%). This result is confirmed by a previous study which showed that the highest carbohydrate in both biscuit and muffin products were formulated with baby corn. The researchers also indicated that the different levels of carbohydrate may be due to the difference in fat and ash contents. Another study found that the dietary fibre contents significantly increased by the addition of baby corn powder in the new formulation of cookies (Jauharah *et al.*, 2014).

Morphological property

Scanning electron microscopy

Photomicrographs A, B, C, D, and E show the microstructures of chicken frankfurters formulated with selected vegetables observed by scanning electron microscope (SEM) at two magnifications (140× and 2,000×) (Figures 2 and 3). Generally, all chicken frankfurters had similar feature of microstructure which consisted of fat

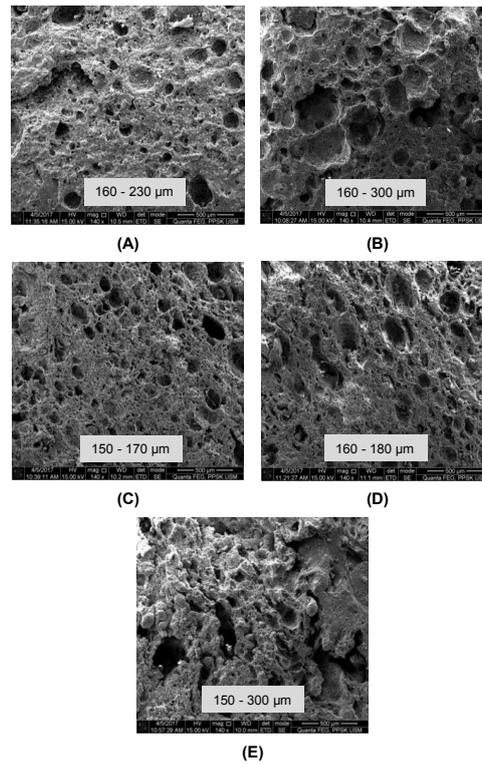


Figure 2. SEM photomicrograph images at 140 \times magnification for surface matrix of chicken frankfurters. (A) Commercial chicken frankfurter: more compact and denser matrix with the presence of numerous small air spaces and few large air spaces; (B) control chicken frankfurter: more compact and denser matrix with prominent presence of small and large air spaces; (C) baby corn: less denser matrix with more numerous small air spaces (honeycomb-like appearance); (D) carrot: less denser matrix with few large air spaces and numerous small air spaces (honeycomb-like appearance); and (E) cabbage: less denser matrix with large air spaces having fat globules inside them.

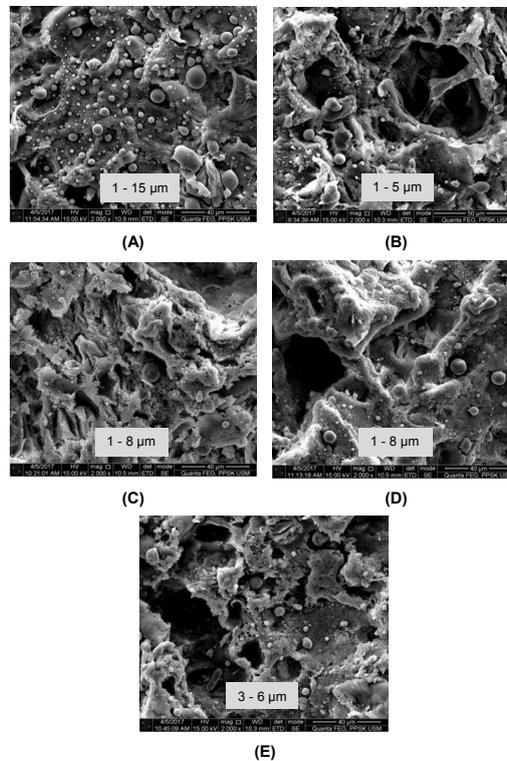


Figure 3. SEM photomicrograph images at 2,000 \times magnification for fat globules of chicken frankfurters. (A) Commercial chicken frankfurter: prominent presence of fat globules with various sizes and uneven distribution; (B) control chicken frankfurter: presence of fat globules with irregular shapes and different sizes. Insoluble fibre network was observed in the air space; (C) baby corn: unnoticeable presence of small fat globules; (D) carrot: presence of numerous small fat globules with various size and irregular distribution; and (E) cabbage: presence of numerous small fat globules with uneven distribution.

globules with numerous air spaces, thus forming a porous network structure. As shown in Figures 2A and 2B, the surface matrix of chicken frankfurters incorporated with baby corn and carrot presented spongy and denser network structures of a honeycomb-like appearance. Similar appearances of cooked meat product were also observed by Carballo *et al.* (1996), Ayo *et al.* (2008), Cáceres *et al.* (2008), and Delgado-Pando *et al.* (2011). A spongy structure was observed revealing the presence of air space of 150 - 170 μm diameter approximately; the holes were identified as the spaces where fat was placed in the gel matrix. It is also possible to observe a whitish film that delimits the space taken up by the fat. In the control chicken frankfurter, the microstructure showed a more continuous and compact structure with the presence of large air spaces. According to a previous study, a more compact matrix confers greater consistency to the product, and promotes textural changes, mainly having greater hardness and requiring more mastication work (Delgado-Pando *et al.*, 2011). This is parallel to hardness values of the control chicken frankfurter (Figure 3), where the control chicken frankfurter was harder than the other chicken frankfurters. Photomicrographs B, C, and D (vegetable-based chicken frankfurters) show less dense matrix microstructure than the control chicken frankfurter.

The shape and appearance of air spaces in photomicrographs B, C, and D were quite similar to A (control), but the microstructures of B and C had more numerous small air spaces. In contrast, microstructure of D was irregular in shape with large and small air spaces. According to an earlier study, a less dense matrix microstructure, softer, and chewy texture formation was due to the reduction of fat content, protein density, and increased water (moisture) content which causes the lowering of the concentration of protein involved in forming the

gel/emulsion matrix (Carballo *et al.*, 1996). Figure 3E is characterised as homogenous, and there was a prominent presence of fat globules with different sizes and shapes. The fat globules with an uneven size were also observed in Figures 3A, 3C, and 3D.

The fat globules in Figure 3B were in small sizes, and a bit difficult to capture at the same magnification as the other samples. Similar finding of different sizes of fat globules in low-fat chicken frankfurter has been reported (Andres *et al.*, 2006; Polizer Rocha *et al.*, 2019; Firuzi *et al.*, 2019). Greater presence of pores as characterised by higher water content in low-fat formulations has also been reported (Totosaus and Perez-Chabela, 2009). Results also showed that the fine strand of fibres were prominently featured in Figures C, D, and E which might indicate the microfibrillar fibre content in the meat. The control and chicken frankfurters incorporated with vegetables were high in protein content (Table 1). It is likely that the fibre from the vegetables was too fine and dispersed in the mix, and could not be viewed in the microstructure. The presence of protein fibre strands indicated that the processing of the grinding is not homogenous to emulsify the emulsion. Thus, the protein was unable to capture water in the batter, thus causing high water loss during cooking.

Sensorial property

Table 2 shows the sensory evaluation of chicken frankfurter formulations on their colour, texture, aroma, flavour, taste, after-taste, and overall acceptance. Colour, aroma, taste, and flavour attributes showed no significant difference in all samples. The colour of chicken frankfurter incorporated with carrot showed the highest score. Previous study also reported a higher colour score of sausage incorporated with tomato paste as compared to avocado paste (Valenzuela-Melendres *et al.*, 2014).

Table 2. Sensory attributes of commercial chicken frankfurter and chicken frankfurters incorporated with selected vegetables.

Sample	Colour	Texture	Aroma	Taste	Flavour	After-taste	Overall acceptance
Commercial	4.97 \pm 1.14 ^a	4.92 \pm 1.14 ^b	4.95 \pm 1.27 ^a	5.02 \pm 1.24 ^a	4.93 \pm 1.29 ^a	4.98 \pm 1.21 ^a	5.07 \pm 1.13 ^b
Control	4.78 \pm 1.20 ^a	5.45 \pm 0.93 ^a	5.37 \pm 0.94 ^a	5.37 \pm 0.92 ^a	5.22 \pm 0.90 ^a	5.28 \pm 0.90 ^a	5.43 \pm 0.81 ^{ab}
Baby corn	4.58 \pm 1.24 ^a	5.13 \pm 1.10 ^{ab}	4.92 \pm 1.09 ^a	5.13 \pm 1.02 ^a	5.00 \pm 1.04 ^a	5.00 \pm 0.90 ^a	5.27 \pm 0.88 ^{ab}
Carrot	4.92 \pm 1.15 ^a	5.30 \pm 1.11 ^{ab}	5.38 \pm 1.20 ^a	5.43 \pm 0.98 ^a	5.32 \pm 1.03 ^a	5.37 \pm 0.94 ^a	5.58 \pm 0.96 ^a
Cabbage	4.58 \pm 1.24 ^a	5.45 \pm 1.03 ^a	5.33 \pm 0.95 ^a	5.35 \pm 0.99 ^a	5.33 \pm 1.02 ^a	5.25 \pm 0.95 ^a	5.38 \pm 0.80 ^{ab}

Values are mean \pm standard deviation. Mean in the same row with different lowercase superscripts differ significantly ($p < 0.05$).

The texture of the chicken frankfurter incorporated with cabbage (5.45) was significantly higher than those with carrot (5.30) and baby corn (5.13), while commercial chicken frankfurter recorded the lowest score (4.92).

Chicken frankfurter incorporated with carrot showed a lower score in hardness. Moreover, the taste, flavour, and after-taste scores of chicken frankfurter incorporated with carrot were quite similar in the range of 5.02 - 5.43, 5.33 - 4.93, and 5.37 - 4.98, respectively. Commercial chicken frankfurter had the lowest score in these attributes as compared to the other chicken frankfurter formulations. Previous study reported that the addition of lemon albedo in bologna sausage and oyster mushroom in chicken patties did not show any difference in aroma, colour, springiness, juiciness, flavour, and overall acceptance (Fernandez-Gines *et al.*, 2004).

Overall, chicken frankfurter incorporated with carrot recorded significantly higher score (5.58) for overall acceptability, and the commercial chicken frankfurter the lowest (5.07). This finding is in line with a previous study on the sensory properties of chicken patties incorporated with *P. sajor-caju* (Wan Rosli, 2012). The present work demonstrated that the panellists accepted the chicken frankfurters incorporated with selected vegetables.

Conclusion

Chicken frankfurters incorporated with selected vegetables showed potential as a good source of nutritious and palatable food based on the results of proximate analysis and sensory evaluation. The highest level of protein content was recorded for chicken frankfurter incorporated with carrot, which also showed the highest yield as compared to the other formulations. The highest level of fat content was recorded for chicken frankfurter incorporated with cabbage. The incorporation of selected vegetables to replace chicken breast is suitable for chicken frankfurter commercial production. In conclusion, the overall acceptance of chicken frankfurter incorporated with vegetables as a healthy product yielded a comparable result with commercial frankfurter.

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