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ORIGINAL ARTICLE

Nutritional Composition and Physicochemical Properties of Sausages Developed with Non-Meat Ingredients (Tofu)

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KEYWORDS

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ABSTRACT: This study was attempted to determine the impact of different percentage of tofu on nutritional values and physicochemical properties of sausages development as a non-meat ingredient. The sausages were prepared by adding 25%, 50% and 75% of tofu. The nutritional analysis and physicochemical properties of non-sausages produced were then examined. The percent finding suggested that the 75% added tofu formulation of chicken sausage recorded the highest moisture (61.11%) and ash content. Nevertheless, 25% formulation recorded the lowest fat content (11.28%) among other formulations. The result of protein content displayed that the decrement of the protein content with the increment of tofu levels. The calorific value of the sausages did not show any linear pattern with an increase of tofu levels. Based on the result of the sensory evaluation score, 25% added tofu formulation maintain a higher score on the colour, texture, juiciness, flavour, and overall acceptance attributes as compared to the other formulations. In conclusion, the formulation of sausages with different level of tofu was shown to affect the nutritional composition (proximate value and calorific value) and physicochemical properties (cooking yield, moisture retention and fat retention).

INTRODUCTION

Different types of the sausages in the form of the frankfurters, hot dog and pepperoni are one of the most popular meat products among world consumers. As a strategy to economize and to preserve meat as consumption of meat has limitations due to its short shelf life, sausages making are evolved. Beef, pork, and poultry as a meat product and both spices and seasoning are also commonly used in the production of sausages. Non-meat ingredients including water, salt, sugar, non-fat dry milk, extenders and binders, and spices are used to impart flavour, slow bacterial growth and increase the yield of the sausage [1]. Sausages originated from the Latin word "salsus" which means preserved by salting. Greeks and Romans particularly prefer sausages in any festive and occasion. In the United States, expansion in the meat packing industry during the Civil War, along with the development of refrigeration for use in railroad cars and slaughtering facilities, provided an incentive for meat processors to create sausage products that could utilize cheaper and perishable cuts of meat [1].

In addition, migrations from different races to the United States have made a wide range of sausages with traditional ingredients due to their preference. In Malaysia, preferences towards meat and meat products increase exponentially due to rapid economic growth. Economists have determined the main factor associated with the change is the increased per capita income that makes meats more affordable [2]. The function of meats

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in supplying calories and protein intakes, culinary preferences and livestock availability also contributes to the change towards meats preferences. According to previous report before the mid-1970s, less than 20% of the total beef consumed in Malaysia was imported [2]. However, this number increased dramatically to more than 70% in 2007. On the other hand, per capita consumption of both poultry and beef has risen rapidly from 1960 to 2005. Poultry represents the major proportion of meat consumption as it has a role as the major, cheapest, and homogeneous popular meat product in multiracial Malaysian society and has seen 900% growth in per capita consumption from 1960 to 2005 while per capita consumption of beef experienced a nearly 260% increase within the same period. Sausages and patties are popularly consumed meat products due to convenience and quick to prepare. Furthermore, sausages are relatively safe product to consume because of the added effects of salt, pH, curing, drying and cooking to preserve the product and eliminate harmful bacteria [1]. However, regarding previous research, which is indicated that adding fat to making sausage to reduced cooking loos, forming meat emulsions and improving water holding capacity, hardness, juiciness and mouth feel were necessary [3]. Besides that, excessive fat intake is also concerned with health problem such as obesity, cardiovascular diseases and hypertension. In this regard also researcher was suggested the isolated of soy protein, vegetable oil and dietary fiber to replace by animal fat to product of sausage [3]. Consequently, several researchers have reported of the health-promoting benefits of fermented sausages made from beef with a focus on antioxidant and antihypertensive benefits [4]. Another research was reported that, replacement of different source of protein such as isolated soy protein and sodium caseinate, egg white powder and pork plasma protein in different values with meat to make sausage suggested that the pork plasma protein as the best replacement to make pork sausage compared to other sources of protein [5]. Due to this concern, consumers should consume vegetables to complement to meat consumption. Soybean and its products are one of the popular foods consumed as vegetables. Soybeans (Glycine max) are leguminous plants related to clover, peas, and alfalfa [6]. Soybean is greatly recognized as a great source of nutrients. On average, dry soybean contains about 40–41% protein, 8–24% oil, 35% carbohydrate, and 5% ash [7]. In particular, soy protein contains all essential amino acids; most of them are present in amounts of those required by humans or animals [8]. Soy proteins are the most comparable plant-based protein with an animal-based protein. Soybeans are often utilized in the form of soy products which includes soymilk, tofu, tempeh, soy flour, and others. Among those products, tofu is one of the most popular soybean products which are consumed all over the world. The tofu known as bean curd or soy curd was consumed over a millennium ago in China as a major source of protein which is made by coagulating soymilk [9]. Tofu is a good source of protein and contains all eight essential amino acids (isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) that are not produce naturally by the body and also an outstanding source of calcium, iron, manganese, selenium, phosphorous, vitamin B1 as well as copper, zinc and magnesium [9]. Generally, it is believed that non-fermented soy foods like non-fermented tofu can provide the human body with important health benefits [9]. Tofu can also be incorporated into sausages making as a replacement for meat protein. Due to a health concern, nowadays many people are demanding healthy food in making food choices. Sausages incorporated with protein from vegetable are more preferred due to its health benefits. Other than that, the consumption of vegetable protein in food products are also increasing due to animal diseases, shortage of animal proteins demands religious (Halal) food and economic reasons [7]. Sausages which are incorporated with tofu are believed to give better health benefit due to lower fat content as well as high nutrient content. Therefore, this study aimed to determine the nutritional composition and physicochemical properties of sausages added with soy protein from tofu.

MATERIALS AND METHODS

Raw material

The sample materials were selected based on the inclusion and exclusion criteria. Chicken breast and tofu purchased from the local wet market, and other dry

materials obtained from local supplier around Kota Bharu, Kelantan, Malaysia.

Sausages formulation

The sausages had been prepared following the formulations described by previous researcher with slight modification [7]. There were four different treatments of sausage, including control and three formulations of sausages added with tofu. The percentage of other ingredients remain unchanged with the control sample, whereas the percentage of chicken meat decreased with the increased of tofu. The tofu had been added to the sausage using the formulation described in Table 1. All samples kept in the freezer (-18°C) until further analysis.

Table1. Formulation of sausages added with tofu.

Ingredients	Percentage of tofu addition (%)			
	0 (control)	25	50	75
Chicken breast	52.0	39.0	26.0	13.0
Fat	15.0	15.0	15.0	15.0
Water	20.0	20.0	20.0	20.0
Potato starch	7.5	7.5	7.5	7.5
Isolate soy protein	3.0	3.0	3.0	3.0
Salt	1.3	1.3	1.3	1.3
Sugar	0.4	0.4	0.4	0.4
Spices and seasoning	0.8	0.8	0.8	0.8
Tofu	0.0	13.0	26.0	39.0
Total	100	100	100	100

Sausages processing

Tofu which purchased from the local supermarket, the moisture content was removed and chopped into chunk sizes (3-5 mm diameter). Chicken meat from the breast part was cut to fist-size chunk, minced with simultaneous addition of salt and 1:3 of the total amount of water needed by using a food processor (MK-5087M) for about 6 to 8 min. After that, the other ingredients, including tofu, were added, chopped for around 6 minutes. The raw sausage inserted into the casing and chilled until further use.

Cooking procedure

Sausages samples cooked about ten to fifteen minutes by using moist-heat preparation (steam) technique.

Protein determination

Proximate composition was conducted using (AOAC, 1996) for moisture, ash, fat and protein by nitrogen conversion factor of 6.25 and crude fat content using the semi-continuous extraction [Soxhlet] method [8]. All measurements were carried out in triplicate (n=3).

Determination of calorific value

Calorific value was measured by IKA calorimeter machine. 1g of samples was pelleted using pelleting press and weighed into a crucible. Decomposition vessel was prepared and introduced into the machine. The results in the unit of cal were changed into the unit of kcal/100g. The calculation was as follow:

$$\text{kcal}/100\text{g} = \frac{\text{cal}}{1000} \times 100\text{g}$$

Cooking yield

Cooking yield of sausages was determined by measuring the weight of the samples for each treatment and calculating weight differences for the samples before and after cooking. The values were calculated as follow [8]:

$$\text{Cooking yield (\%)} = \frac{(\text{cooked weight} \times 100)}{\text{Raw weight}}$$

Moisture and fat retention

The moisture and fat retained values in the cooked product per 100 g of raw sample. This values were calculated according to the following equations [8]:

$$\text{Moisture retention (\%)} = \frac{(\text{percent yield} \times \text{\% moisture in cooked sausages})}{100}$$

$$\text{Fat retention (\%)} = \frac{(\text{cooked weight} \times \text{percent fat in cooked sausages})}{(\text{raw weight} \times \text{percent fat in raw sausages})} \times 100$$

Sensory evaluation

Sensory evaluation had been carried out by 60 untrained panellists among students and staffs of the School of Health Sciences, Universiti Sains Malaysia Health Campus. All samples evaluated according to 7 hedonic scaling [8]. The samples evaluated on colour, texture, juiciness, flavour, and overall acceptance on a 7 point scale (0 = extremely dislike until 7 = extremely like).

Statistical analysis

Data obtained were analyzed and tested for significant using one-way ANOVA and Duncan Multiple Range Test with SPSS version 24. Data expressed in mean ± standard deviation. All the measurement were carried out in triplicate (n=3) ($P \leq 0.05$).

RESULTS

Proximate analysis

The proximate analyses of sausages formulated with different levels of tofu addition were shown in Table 2.

Table 2. Proximate value of sausages prepared with different levels of tofu addition.

Proximate analysis (%)	Percentage of tofu level (%)			
	0 (control)	25	50	75
Moisture	58.40 ± 0.14^{c}	59.43 ± 0.10^{b}	57.93 ± 0.35^{d}	61.11 ± 0.18^{a}
Ash	1.68 ± 0.01^{c}	1.78 ± 0.04^{b}	1.88 ± 0.02^{a}	1.88 ± 0.02^{a}
Fat	12.24 ± 0.15^{b}	11.28 ± 0.89^{b}	11.65 ± 1.79^{b}	14.99 ± 0.38^{a}
Protein	15.59 ± 0.03^{a}	14.76 ± 0.09^{b}	12.93 ± 0.06^{c}	10.77 ± 0.50^{d}
Carbohydrate	11.91 ± 0.15^{b}	12.75 ± 0.82^{b}	15.61 ± 2.11^{a}	11.26 ± 0.67^{b}

$^{a-d}$ Mean values within the same row bearing different superscripts differ significantly ($P < 0.05$)

The result of moisture content showed that sausages formulation with 75% added tofu (61.11%) was significantly higher (P<0.05) than other samples. Nevertheless, Sausages added with 50% tofu recorded the lowest moisture content (57.93%). However, this value was not significantly different (P>0.05) as compared to the control sample (0% tofu) for moisture content. The results of ash content demonstrate that the control sausages had significantly (P<0.05) lower value (1.68%) compared with other formulations. On the other hand, 50% and 75% formulations of sausages recorded the highest amount of ash content (1.88%) with significantly different (P<0.05) compared to other formulations. The result of 25% formulation of sausages displayed dramatically (P<0.05) higher ash content (1.78%) as compared to the control sample. The result of 75% and 25% of tofu formulation showed significantly the highest and lowest value (14.99%, 11.28%) for fat content (P<0.05) consequently. Meanwhile, there was no significant different (P>0.05) between 0%, 25%, and 50% formulations. The results of the protein content of control sausage (0% tofu) and highest formulation of sausage (75% tofu) displayed the highest (15.59%) and lowest value (10.77%) frequently. The protein content seems to be decreasing directly with the increment levels of tofu added in the sausages formulation. Sausage formulated with 50% tofu recorded the highest value for carbohydrate concentration (15.61%). However, this value did not differ significantly (P>0.05) with the frankfurter formulated with 25% tofu. Due to the result, it seems that 75% formulation recorded the lowest value for carbohydrate concentration (11.26%). There was no significant difference (P>0.05) observed between the formulations of 25% and 75% as compared to the control sample.

Calorific value

The calorific values of sausages formulated with different levels of tofu presented in Table 3. Calorific value for sausages showed that 75% treatment recorded the highest calorie for 100g of samples (644.30kcal/100g). Meanwhile, the 50% formulation recorded the lowest calorie for 100g of samples (592.60kcal/100g). However, both control and 50%

formulations did not show significant different (P>0.05) in calorific values.

Table 3. Calorific value of sausages prepared with different levels of tofu addition.

Dietary component	Percentage of tofu level (%)			
	0 (control)	25	50	75
Calorific value (kcal/100g)	598.37 ± 7.50[c]	630.03 ± 1.21[b]	592.60 ± 7.88[c]	644.30 ± 2.07[a]

[a-d] Mean values within the same row bearing different superscripts differ significantly (P < 0.05)

Physicochemical Properties

The results for physicochemical properties such as cooking yield, moisture retention and fat retention of sausages formulated with tofu were shown in Table 4.

Table 4. Physicochemical properties of sausages prepared with different levels of tofu

Physical traits (%)	Percentage of tofu level (%)			
	0 (control)	25	50	75
Cooking yield	91.58 ± 0.08[bc]	92.81 ± 0.99[ab]	91.07 ± 0.93[c]	94.41 ± 1.03[a]
Moisture retention	53.49 ± 0.13[c]	55.15 ± 0.09[b]	52.75 ± 0.32[d]	57.70 ± 0.17[a]
Fat retention	90.43 ± 3.75[a]	94.19 ± 2.65[a]	89.14 ± 3.89[a]	87.89 ± 3.54[a]

[a-d] Mean values within the same row bearing different superscripts differ significantly (P < 0.05)

The result of cooking yield showed that the cooking yield of 75% formulation was significantly higher (P<0.05) (94.41%) than control sample while 50% formulation did not show a significant difference (P>0.05) compared to the 25% formulation. Also, sausage developed with 50% tofu had the lowest cooking yield (91.07%) but did not show a significant difference (P>0.05) with the control and sausage developed with 25% tofu. Besides, the 25% formulation did not show any significant difference (P>005) with all samples for cooking yield. Sausages added with 75% tofu shows significantly (P<0.05) the highest value (57.70%) as compared to other samples for moisture retention. The lowest value for moisture retention (52.75%) observed for the 50% formulation, which had significantly different (P<0.05) with other samples. The 25% formulation had significantly (P<0.05) higher moisture retention (55.15%) compared to the control sample. The result indicated that the highest value of fat retention (94.19%) observed for the 25% added tofu formulation but did not show any significant difference (P>0.05) with other samples while the 75% formulation of tofu showed the lowest value for fat retention (87.89%). However, the fat retention for 50% and 75% formulation did not show any significant changes (P>0.05) with other samples.

Sensory evaluation

The results of the sensory evaluation showed that the control sample displayed the highest score (5.10) while 50% formulation recorded the lowest score (4.67) for the colour attribute (Table 5). However, there was no significant different (P>0.05) for the colour attribute between all samples. Meanwhile, texture attribute indicated the significantly different (P<0.05) between control sample and 75% formulation where the control sample had the highest score (4.65) and sausages with 75% added tofu had the lowest score (3.75). The result of the texture attribute indicated that no significant difference (P>0.05) between 25% and 50% formulations compared with the control sample. The result of juiciness showed that there was also no significant difference (P>0.05) between all the samples. However, the score for juiciness decreased with the increment of tofu level, where the control sample had the highest score (4.55), and 75% had the lowest score (3.92). The result of flavour attribute showed that the sausages with the highest formulation of tofu displayed the lowest score (3.32) and significantly different (P<0.05) from other samples. Whereas, the control sample showed the highest score for flavour attribute (4.67). However, 25% and 50% formulations did not show any significant changes for flavour attribute (P>0.05) compared with the control sample. As for overall acceptance, sausages with 75% level of tofu had the lowest score (3.77) and significantly different (P<0.05) compared with control and 25% of tofu level. However, the result of overall acceptance did not show any significant differences (P>0.05) between

75% and 50% formulation, and between the control sample and 25 %, 50% formulation.

Table 5. Sensory evaluation scores of sausages prepared with different levels of tofu addition.

Sensory attribute	Percentage of tofu level (%)			
	0 (control)	25	50	75
Colour	5.10 ± 1.15^{a}	4.97 ± 1.26^{a}	4.67 ± 1.41^{a}	4.72 ± 1.44^{a}
Texture	4.65 ± 1.38^{a}	4.47 ± 1.40^{ab}	4.27 ± 1.59^{ab}	3.75 ± 1.73^{b}
Juiciness	4.55 ± 1.36^{a}	4.52 ± 1.28^{a}	4.27 ± 1.41^{a}	3.92 ± 1.54^{a}
Flavour	4.67 ± 1.36^{a}	4.45 ± 1.43^{a}	4.00 ± 1.51^{a}	3.32 ± 1.41^{b}
Overall acceptance	4.83 ± 1.25^{a}	4.65 ± 1.29^{a}	4.30 ± 1.41^{ab}	3.77 ± 1.38^{b}

[a-d] Mean values within the same row bearing different superscripts differ significantly ($P < 0.05$)

DISCUSSION

Based on the proximate analysis, 75% tofu formulation showed that the considerably highest moisture content (61.11%) among other samples. Due to previous research, the tofu had higher moisture content than chicken breast so it could explain the high value of moisture content for sausages formulated with the highest amount of tofu. This finding is in line with the previous study which mentioned that moisture content of regular tofu was ranging from 82% to 88% [10] and chicken breast which was ranging from 73.9% to 75.92% [10]. Ash content was found to be considerably higher ($P<0.05$) when tofu incorporated in sausages this was due to the fibre content in tofu which is not available in chicken breast. Fernández-Ginés, Fernandez-Lopez, Sayas-Barbera, Sendra & Perez-Alvarez (2004) [10] showed that the ash content increased significantly with the addition of dietary fibre such as the incorporation of dietary fibre from lemon albedo in low-fat sausage. Similar results reported by the previous researcher [11, 12]. Fat content was found significantly higher in the 50% (11.65%) and 75% (14.99%) formulation compared to the control sample which could be explained by the weak emulsification properties of fat and water so emulsification breakdown observed in this formulation during cooking. This phenomenon occurred might be due to the weak emulsification properties by soy lecithin to emulsify fat and water in the frankfurter. On the other result, 25% formulation recorded the lowest value (11.28%) for fat content among all formulations. Addition of tofu might have affected the fat content as moisture content relatively increased. The result of fat content for 25% formulation of sausages was in line with Yang et al. (2007) which reported that replacing pork loin with hydrated oatmeal and tofu at 15% significantly reduced the amount of fat content [13, 14]. The concentration of protein in the frankfurter reduced with the increment levels of tofu. Protein content in control (0%) frankfurter (15.59%) was significantly ($P<0.05$) higher compared to sausages containing tofu 25% (14.76%), 50% (12.93%) and 75% (10.77%) consequently. This decreasing pattern was also similar with the study by previous research which reported that the ability of oyster mushroom in improving nutritional composition, β-glucan and textural properties of sausages [15]. This pattern might be due to the original high protein content in chicken breast. Even though tofu was known to have high protein content, however, the amount of protein in chicken is higher than in tofu. According to the USDA National Nutrient Database, tofu contains about 16% of protein while chicken contains about 25% of it. Therefore, by partially replacing chicken breast with tofu, the protein level in sausages containing tofu was slightly affected. The addition of tofu at different levels in the sausages resulted in insignificant ($P>0.05$) content of calorific values. This result was in contrasted with previous documented that showed that the replacement of meat with other natural product decreases the calorie in certain foods such as chicken patty [16]. These variations possibly caused by different conditions in processing procedures of frankfurter and patty [15]. Besides, the energy values of food decreased with the decrement content of fat in food. Physicochemical properties of sausages displayed that the cooking yield, moisture retention, and fat retention of sausages. The current result showed that similar pattern of cooking yield in the moisture content of sausages. The result of cooking yield showed the opposite of cooking loss through the cooking procedure of sausages.

Additionally, the cooking yield showed that the highest (94.41%) amount of moisture in the 75% added tofu formulation which had similar trend with the value of moisture content (61.11%) and moisture retention (57.70%). Due to previous report researcher showed that soy commonly used as meat binders due to their various functionalities such as water retention, binding and emulsifying characteristics which were results in improved binding and texture of the sausage [17]. They included in comminute meat for the enhancement of both the physical and chemical properties of processed meat products such as frankfurters and meat patties [13]. Moisture and fat retention values represent the amount of moisture and fat retained in the cooked products. The 75% formulation showed more moisture retention and more fat reduced after cooking this might due to fat reduced through cooking caused by weak binding properties between water and fat. Other reason could be due to the unsuitable type of fat used in the formulation. Regarding last research, incorporation of 2% soy protein isolate showed that level enhanced of moisture content and cooking yield while diminishing purge loss of light pork sausage and being less red and yellow by adding 1.5% soy protein isolated volume [18]. Based on the results for sensory evaluation it could be clear that 25% of added tofu showed the preferable sausages formulation with the higher score for all attributes of the sensory assessment and overall acceptance compared to the other formulations. The colour attribute did not show any significant differences among all the samples. The texture attribute for 75% added tofu formulation (3.75) compared to other samples showed the lowest score and least preferable as it was very soft and mushy. Regarding the previous report, soy protein isolate resulted in a softer texture of low-fat bologna and did not affect another

chemical parameter [19], while other researchers described that heated and enzyme hydrolyzed soy proteins affected texture properties differently, with improving hardness and reducing hardness, cohesiveness and breaking strength [20]. The 75% formulation also received the lowest score (3.92) in the juiciness attributes. Instead of juicy, the sample appeared to be too oily; this might be explained through emulsion breakdown that occurred during the cooking process. Due to the previous report, researchers indicated that incorporation of soy protein isolates slightly improved texture, juiciness, and colour of emulsion sausage [21]. Flavour attribute of 50% and 75% tofu formulations for some of the panellists was quite noticeable and unpleasant because of the tofu odour. Therefore, the formulations received a low score for flavour attribute, which was 4.00 and 3.32, respectively. Based on the overall acceptance score of the sausages, the most preferred tofu-based formulation was the 25% formulation, and the least favourite was the 75% formulation.

CONCLUSIONS

In summary, the best sausage formulation was 25% incorporation of tofu level as it demonstrated excellence nutritional composition with the highest protein content (14.76%) and the lowest fat content (11.28%) among other tofu-based formulations. This formulation also received the highest score in sensory attributes, which were colour, texture, juiciness, flavour, and overall acceptance. Both 50% and 75% tofu formulations did not recommended to be incorporated in the frankfurter due to higher fat content. The relatively high-fat content in the formulations was due to weak emulsification properties of soy lecithin to emulsify fat and water. Due to emulsion breakdown during the cooking process, the formulations became oily and thus increased the fragility of the frankfurter. Other than that, the formulations also receive a low score on sensory evaluation attributes, which represent that the formulations were less preferred compared to the 25% formulation. Finally, among all treatments, 25% addition of tofu was recommended to be incorporated in sausages.

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