

Article

Physicochemical Properties, Nutritional Composition, and Sensory Acceptance of Chicken Meat Sausages with Chia Seed Powder Substitution

Nurhani Fatihah Mohd Hanifah¹, Hanis Nadia Yahya¹ and Norlelawati Arifin¹

¹Food Biotechnology Programme, Faculty of Science and Technology, Universiti Sains Islam Malaysia, 71800 Nilai, Negeri Sembilan, MALAYSIA

E-mail: norlela@usim.edu.my

Abstract— Chia seed has a high content of fibres and polyunsaturated fatty acids such as ω -3 α -linolenic acid. Chia seed also holds numerous amounts of minerals and vitamins, including calcium and phosphorus. Chia seed offers a great potential of gel-forming ability and good water and oil holding capacities. Therefore, this study aims to determine the effect of chia seed powder substitution in chicken meat sausage formulations on the physicochemical characteristics and sensory acceptance. In the study, the chicken meat sausages were produced in four formulations; sample A as the control (100% chicken meat), sample B (5% substitution of chia seed powder to chicken meat), sample C (10% substitution of chia seed powder to chicken meat) and sample D (15% substitution of chia seed powder to chicken meat). The sausages were analysed for colour, texture, water holding capacity, cooking loss, proximate analysis, crude fibre content, and sensory acceptability. As for the findings, the substitution of chia seed powder resulted in low 'L' values of chicken meat sausage due to the dark colour of the chia seed. On the other hand, chia seed powder's substitution decreased the hardness and cohesiveness values. However, it increased the adhesiveness, springiness, and chewiness. Water holding capacity and a cooking loss percentage of the chicken meat sausages with chia seed powder substitution were observed to improve compared to control sausage (100% chicken meat), resulting in juicier sausages. The chia seed powder substitution increased the carbohydrate, ash, fat, and fibre contents for the chemical composition. On a 9-point hedonic scale, sample B (5% chia seed powder substitution) exhibited the highest sensory scores in all attributes evaluated (colour, texture, taste, juiciness, and overall acceptance). Thus, it can be concluded that chia seed powder can be substituted in chicken meat sausage to produce better quality products.

Keywords— chicken meat sausage; chia seed powder; chicken meat substitute

I. INTRODUCTION

Consumption of highly nutritious food is crucial in a human daily diet. On the other hand, nutrients can be defined as the elements that can supply sustenance and provision, including macro and micronutrients, necessarily for complete growth, body development, and sustaining good health. A good proportion of each nutrient such as carbohydrate, protein, fibre, fat, vitamins, and minerals is crucial for the human body to ensure a complete and balanced diet. These nutritional elements are provided by many types of food such as cereal, bread, rice, meat, vegetables, fruits, etc.

Chia seed is a novel food that is reported to contain about 30-34% fibre composed of insoluble dietary fibre (85-93%) and soluble dietary fibre (7-15%) [1]. Chia seed has a high amount of polyunsaturated fatty acid such as ω -3 α -linolenic acid and ω -6 α -linoleic acid [2]. Nevertheless, this edible seed is low in saturated fatty acids such as stearic and palmitic, making it highly nutritious and healthy to consume [3]. As for the minerals and vitamin contents, chia seed is rich in riboflavin, niacin, thiamine, calcium, and phosphorus [4].

Chia seed has been a notable substance due to its property in stabilizing emulsion and has good gelling forming ability, fat binding capacity, and water binding capacity [5]. As it easily forms a gel and excellently retains water, the food system's viscosity can be reduced. Besides, chia seed is a good thickener, emulsifier, and stabilizer in frozen food products [6]. This chia seed property is very advantageous in meat products as meat products are usually stored in frozen form. During that period, the juiciness of the meat must be preserved. Chia seed is also best known for its excellent dietary fibre content, which can add value to meat products.

The trend of including some carbohydrate-based elements such as dietary fibre into meat products opens a new dimension for the consumers on various choices other than focusing on its nutritional value [7]. Moreover, dietary fibre has a neutral flavour and improves water retention, lowering cooking loss. Highly soluble fibres are used to modify texture and manage water migration in meat products [8]. Fibre is also desirable as it can increase cooking yield, reduce formulation and production cost, enhance the texture of meat products, and positively affect human health [9]. Thus, this study was conducted to determine the physicochemical properties and sensory acceptability of chicken meat sausages substituted with different percentages of chia seed powder in the formulations.

II. MATERIALS AND METHODS

A. Raw Materials

Chia seed (Health Paradise), minced chicken meat (Ramly), and isolated soy protein were purchased from Aeon Supermarket in Nilai, Negeri Sembilan. Other ingredients such as eggs, palm oil, salt, sugar, sodium tripolyphosphate, ground white pepper, and garlic powder were purchased from Tesco Supermarket in Nilai. Chia seed was blended using Waring Blender (Waring W-MX1100XTX, USA) into finely ground powder and stored in an airtight container prior to use in the sausage preparation. The minced chicken meat was stored in a freezer (-20°C) until use.

B. Formulations and Preparation of Chicken meat sausages Substituted with Chia Seed Powder

All chicken meat sausages were processed according to Yadav et al. [10]. The minced chicken meat was thawed in a refrigerator at 4°C for 3 hours. All ingredients were weighed using a weighing scale (Sartorius, German). Minced chicken meat and sodium chloride were mixed using a meat processor (Panasonic, Malaysia) for 2 minutes, followed by chia seed powder, cold water, palm oil, and egg white for another 2 minutes. Garlic powder, sugar, ground white pepper, and sodium tripolyphosphate were then added and mixed for 2 minutes. The mixture was stuffed into a cellulose casing using a stuffer. Then, the sausage was steamed under boiling water for 30 minutes. The sausage was left at room temperature until warm and soaked into cold water. The casing was removed manually, and the sausages were stored in the freezer for further study. Each sausage with different formulations was made in triplicate. The formulations are shown in Table I below.

TABLE I
FORMULATIONS OF CHICKEN MEAT SAUSAGES
SUBSTITUTED WITH CHIA SEED POWDER

Formulation	Sample A (100% chicken meat)	Sample B (5% substitution of chia seed powder in chicken meat)	Sample C (10% substitution of chia seed powder in chicken meat)	Sample D (15% substitution of chia seed powder in chicken meat)
Minced Chicken Meat (g)	75.00	71.25	67.50	63.75
Chia seed (g)	0.00	3.75	7.50	11.25
Cold water (ml)	10.00	10.00	10.00	10.00
Isolated soy protein (g)	3.00	3.00	3.00	3.00
Egg white (g)	3.00	3.00	3.00	3.00
Garlic powder (g)	2.50	2.50	2.50	2.50
Palm Oil (g)	1.80	1.80	1.80	1.80
Salt (g)	1.70	1.70	1.70	1.70

Ground white pepper (g)	1.50	1.50	1.50	1.50
Sugar (g)	1.35	1.35	1.35	1.35
Sodium Tripolyphosphate (g)	0.15	0.15	0.15	0.15

C. Colour Analysis

Hunter Lab colorimeter (LabScan XE Spectrophotometer, Hong Kong) was used to measure the sausages' colour. The parameters taken into measure were lightness, redness, and yellowness based on the L*a*b colour system. A standard white porcelain plate was calibrated. Two (2) g of minced sausage sample from each formulation were placed in the plastic Petri dish and analysed for its colour.

D. Textural Profile Analysis

The uncooked chicken meat sausage samples substituted with chia seed powder were cut (2 cm x 2 cm) and analysed for their textural properties at three different spots. Textural Profile Analysis was carried out using Texture Analyzer TA-XT Plus (Stable Micro System, London). The parameters that were taken into measure are hardness, springiness, cohesiveness, adhesiveness, and chewiness.

E. Water Holding Capacity

Water Holding Capacity (WHC) determination method was analysed according to Jayasinghe and Silva [11]. All uncooked samples were weighed (1.0 g), mixed with distilled water (10 mL), and vortexed in an agitator for 3 minutes. The samples were centrifuged at 5000 rpm for 30 minutes under room temperature (Hanil Combi, 514R, Korea). The supernatant was decanted, and the residue was weighed. The WHC percentage was calculated as follows:

$$\text{Water Holding Capacity (\%)} = [(W_3 - W_2 - W_1) / (W_1)] * 100$$

Notes: W_1 = Weight of sample, W_2 = Weight of dry tube, W_3 = the sample's weight after decanting the supernatant.

F. Cooking Loss

All uncooked chicken meat sausage samples were weighed and analysed for cooking loss, according to Sharima et al. [12]. Approximately 2.0 g of each sample was pan-fried in a preheated pan (without oil) for about 1 minute and 30 seconds on each side. The weight of each sausage was taken before and after cooking. The percentage of cooking loss was expressed through the following formula:

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

Notes: W_a = Weight of sausage after cooking, W_b = Weight of sausage before cooking

G. Proximate Analysis

Proximate analysis was used to determine the nutrient content of the uncooked chicken meat sausage substituted with chia seed powder. The standard parameters taken into measure were protein, fat, moisture, ash, and carbohydrate content in samples A, B, C, and D. This analysis was done according to AOAC (2005) nutrient determination method.

H. Fibre Content

The crude fibre content was determined under the digestion of uncooked sausage samples with sulphuric acid and sodium hydroxide in the fibre analyzer (Gerhardt Fibretherm, German) followed by an incineration process in a muffle furnace (Carbolite, England) for 4 hours at 550 °C.

I. Sensory Acceptance

Seventy untrained panellists carried out the sensory acceptance test consisted of staff and students of Islamic Science University of Malaysia (USIM). The panellists were given four cooked chicken meat sausage samples with different percentages of substituted chia seed powder (0%, 5%, 10%, and 15%). The degree of acceptability was evaluated according to few aspects such as texture, colour, juiciness, taste, and overall acceptability in a form consisting of a 9-point hedonic scale; 1: strongly dislike, 9: strongly like.

J. Data Analysis

All data were recorded and analysed using ANOVA statistical analysis on Minitab. The results were expressed in the form of (Mean value ± Standard Deviation), and a one-way analysis of variance was applied.

III. RESULTS AND DISCUSSION

A. Colour Analysis

TABLE II
COLOUR ANALYSIS OF CHICKEN MEAT SAUSAGES
SUBSTITUTED WITH CHIA SEED POWDER

Formulation	Sample A	Sample B (5% substitution of chia seed powder in chicken meat)	Sample C (10% substitution of chia seed powder in chicken meat)	Sample D (15% substitution of chia seed powder in chicken meat)
L*	62.76 ± 0.40 ^a	46.27 ± 0.77 ^b	41.65 ± 0.63 ^c	41.09 ± 0.39 ^c
a*	1.11 ± 0.15 ^d	2.88 ± 0.01 ^c	3.54 ± 0.05 ^b	3.95 ± 0.08 ^a
b*	16.14 ± 0.11 ^a	12.73 ± 0.35 ^c	13.46 ± 0.09 ^{bc}	13.53 ± 0.08 ^b

From Table II, colour analysis showed that sample A (control) had the highest lightness (L) with a value of 62.76 among all the samples. Substitution of chia seed powder at 5%, 10%, and 15% to chicken meat in sausage formulations decreased the lightness values. Chia seed powder originally has darker colour as compared to chicken meat. Oliveira et al. [13] showed similar findings when chia flour was substituted in pasta formulation. The brightness values reduced as the proportion of chia flour in pasta was increased in values of 7.5, 15, and 30 % substitution.

The substitution of chia seed powder into chicken meat sausage formulations increased the “a” value significantly ($P < 0.05$), indicating the samples become reddish as the higher percentage of chia seed powder was substituted. The redness, represented by positive ‘a’ value, noted the highest in sample D (15% substitution of chia seed powder), while

sample A (control) had the lowest values. The colour changes were basically due to chia seed powder substitution in chicken meat sausage formulation as chia seed is dark in colour.

Chicken meat sausages with chia seed powder substitution showed lower ‘b’ values than sausage made with 100% chicken meat. This indicated that sample A had high yellowness in colour, which could be explained because it was physically more yellow than other samples. Paula et al. [9] stated that chia seed addition as fat replacer produced a more intense yellowish colour of the products. This could be explained by the physical colour of the chia seed. The dark colour shown by the chia seed caused the yellow colour to be increased. Thus, greater chia seed substitution resulted in a higher ‘b’ value. Paula et al. [9] said that the increase in yellowish colour upon addition of chia seed in hamburger was probably caused by the presence of chia seed and dark colour on the surface.

B. Texture Profile Analysis

TABLE III
TEXTURAL PROPERTIES OF CHICKEN MEAT SAUSAGES
SUBSTITUTED WITH CHIA SEED POWDER

Formulation	Sample A (100% chicken meat)	Sample B (5% substitution of chia seed powder in chicken meat)	Sample C (10% substitution of chia seed powder in chicken meat)	Sample D (15% substitution of chia seed powder in chicken meat)
Hardness (N)	5.10 ± 0.66 ^a	4.52 ± 0.50 ^a	4.29 ± 0.60 ^a	3.63 ± 1.97 ^a
Cohesiveness	0.55 ± 0.02 ^a	0.46 ± 0.00 ^b	0.42 ± 0.01 ^c	0.45 ± 0.00 ^{bc}
Springiness (mm)	1.28 ± 0.30 ^a	1.39 ± 0.44 ^a	2.14 ± 0.39 ^a	2.38 ± 0.02 ^a
Chewiness (N)	3.68 ± 1.43 ^a	2.79 ± 0.43 ^a	3.35 ± 0.36 ^a	6.04 ± 0.87 ^a
Adhesiveness (g.s)	-126.77 ± 12.22 ^a	-133.01 ± 8.87 ^a	-277.15 ± 12.10 ^a	-246.05 ± 0.16 ^a

The results of texture profile analysis in chicken meat sausages substituted with chia seed powder are shown in Table III. Overall, the data showed no significant difference ($P > 0.05$) in the hardness, chewiness, springiness, and adhesiveness parameters in all samples. However, chia seed powder substitution in chicken meat sausage formulation produced softer texture of products, as shown in reducing hardness values. This data was in line with Fernández-lópez et al. [14]. Chia seed contains protein compounds such as globulin, glutelin, and albumin, allowing the gelling property to maintain the protein network and meat emulsion stability. In the present study, chia seed was ground finely, giving a greater surface area for the hydrophilic protein and soluble fibres to interact with the liquid, resulting in the sausages' soft structure. This data was also concurrent with the correlation study between water holding capacity and hardness. These two properties were highly correlated with a value of $R^2 = -0.97$. Thus, the reduction in hardness was

influenced strongly by the increasing water holding capacity of chia seed powder.

Cohesiveness can be defined as the quality of products to form together. The control sample (sample A) showed significantly ($P < 0.05$) the highest cohesiveness values in comparison to samples with chia seed powder substitution. As the percentage of chia seed powder substitution in chicken meat sausage formulations increased, cohesiveness values generally decreased. The decrease in cohesiveness values as chia seed powder substituted in chicken meat percentage may be related to the respective sausages' soft texture. This finding was supported by a study on the chia seed substitution effect to the restructured ham-like product [15]. Cohesiveness and hardness values decreased in ham-like products because of chia seed and carrageenan, forming a softer texture. It was explained that the substitution of protein and fat by water resulted in a tender and soft texture.

Similar to cohesiveness, springiness was also included as a parameter explaining visco-elastic behaviour [16]. Springiness defines a product's elasticity that can be stretched or compressed and returned to its original height. Springiness is measured by detecting the height during the second deformation after it springs back over the first deformation. Sample D (chicken meat sausage with 15% substitution of chia seed powder) had the highest springiness value among all the samples. This finding was in agreement with Fernández-lópez et al. [14]. Springiness values showed a high and positive correlation with water holding capacity ($R^2 = 0.97$). This might be due to the modification of meat muscle and fibre structural properties with chia seed powder substitution. It was stated that the springiness of meat was linked to the fibre swelling, which increased the space for water to be occupied [17]. The hydrophilic properties of soluble fibre improved water holding capacity due to the gel-forming ability. It, thus, increased springiness inside the sausages.

The substitution of chia seed powder in chicken meat sausage formulations caused the products' texture to be chewier. Chewiness is the energy needed to chew a solid food to the point that it is good enough to be swallowed. In fact, the addition of chia seed flour resulted in more chewy, springy, and softer sausage [14]. This could be the result of the gelling property of the chia seed in the sausages emulsion. Sample D with the 15% incorporation of chia seed exhibited a higher value of chewiness than sample A (Control). However, all samples had shown no difference statistically ($P > 0.05$).

Adhesiveness is the property of sticking together, which the substances inside a food product can resist and difficult to be shaken off. Excellent adhesion and cohesion of meat ensure the strength of the product and keep it remain in whole. From Table III, it is shown that the adhesiveness of chicken meat sausages with chia seed powder substitution increased insignificantly ($P > 0.05$) in comparison to the control sample. It was believed to be caused by the greater water holding capacity of chia seed powder with a high correlation between adhesiveness and water holding capacity ($R^2 = 0.95$). This data was in line with Ding et al. [15].

C. Water Holding Capacity (WHC) and Cooking Loss

TABLE IV
WATER HOLDING CAPACITY AND COOKING LOSS OF CHICKEN MEAT SAUSAGES SUBSTITUTED WITH CHIA SEED POWDER

Formulation	Sample A (100% chicken meat)	Sample B (5% substitution of chia seed powder in chicken meat)	Sample C (10% substitution of chia seed powder in chicken meat)	Sample D (15% substitution of chia seed powder in chicken meat)
Water Holding Capacity (WHC)	21.68 ± 0.52 ^d	28.70 ± 0.75 ^c	43.42 ± 0.50 ^b	60.42 ± 0.50 ^a
Cooking Loss	32.74 ± 0.17 ^a	30.32 ± 0.20 ^b	24.07 ± 0.31 ^c	22.30 ± 0.37 ^d

Water holding capacity (WHC) is defined as the total water that the sample can hold. High WHC ensures certain attributes and perceptions in meat products mainly. Moreover, WHC influences cooking yield and cooking loss. Therefore, it is somehow related to the juiciness of the meat. From the results, all samples were found to be significantly different from each other ($P < 0.05$), with sample D showing the highest WHC value (60.42%). The increase in WHC percentages is probably due to the increase in total soluble fibre inside chia seed composition. When soaked in water, assessment on chia seed showed a clear gel formed around, indicating its gel ability [18]. The gel was found to be produced by chia seed mucilages, which act as hydrocolloids. Many free hydroxyl groups in insoluble fibre interact with hydrogen bonds in water [19]. Chia seed had an abundant quantity of polysaccharides, which were found to add assistance in retaining water to sausage emulsion.

In chicken meat, protein such as myosin and actin are responsible for the WHC of comminuted meat such as sausage. Water easily binds to the charged molecules of proteins. In a 3-D structure, the immobilized water is trapped and forms a gel. It shows the same mechanism as chia seed, which also forms a gel in the presence of water. However, during processing, heating, and cooking, the protein muscle becomes stiff and less flexible. Thus, the water flows out, which is known as drip loss. Nevertheless, WHC is related to the protein content present in the chia seed itself. High protein content yields a high number of amino acids, known for the hydrophilicity and solubility in water due to its polar molecule. Grancieri et al. [4] found that aspartate and glutamine represented the two highest amounts of amino acids in chia seed. These types of amino acids have hydrophilic properties. Therefore, this explained the increase in water holding capacity of chicken meat sausage substituted with chia seed powder. This showed that chia seed powder's addition had a significant difference ($P < 0.05$) on the water holding capacity of the chicken meat sausages. It was proven that chia seed could retain the water inside the sausages.

On the other hand, the cooking loss can be defined as the total amount of dry matter lost under optimal cooking conditions. In meat products, cooking loss or degree of shrinkage defines the denaturation of protein due to heat induction. Cooking loss is undesirable, and it is the effect of

changes in the function of structural protein actomyosin complex and collagen [20]. This is because cooking loss relates closely to sensory attributes such as juiciness, toughness, or mouthfeel. All samples showed significant difference ($P < 0.05$), with sample A having the highest cooking loss percentage (32.74%), followed by sample B with 5% substitution of chia seed powder (30.32%), sample C with 10% substitution of chia seed powder (24.07%), and sample D with 15% substitution of chia seed powder (22.30%). This finding indicates that chia seed powder substitution in chicken meat sausages (5%-15%) improves cooking loss property, resulting in better water retention.

Cooking loss is closely associated with water holding capacity. It was in correlation with low WHC, which led to a large loss of drip and purge from meat products [21]. Chia seed mucilage produced high viscosity, which could be the reason for the reduction in cooking loss. It was believed that the presence of chia seed showed that the cooking loss percentage decreased consistently. This proves that chia seed is one of the dietary fibres that can retain the consistency of water. Fibre is very fit to be substituted in meat products due to its water retention ability, reduces cooking loss, and has a neutral flavour. Soluble fibres and denaturalized protein in chia seed enhanced the swelling ability and the main reasons for the high WHC.

Several studies acknowledged that chia seed could absorb water up to 10 to 12 times its corresponding volume [6]. Another research stated its water absorption ability could be up to 27 times its weight [22]. A similar result was recorded by Paula et al. [9], where the cooking loss percentage of hamburger added with chia seed decreased insignificantly ($P > 0.05$). Porras-Loaiza et al. [29] discovered a reduction in weight loss due to cooking after the addition of chia seed. The changes were due to the thickening and emulsifying chia seed's ability to trap water and fat molecules, stabilizing meat emulsion. The free water also reduced due to the chia seed's water retention property, contributing to the low drip loss. Therefore, this explains the cooking loss percentage in sample A (control), representing the highest control compared to other chicken meat sausages substituted with chia seed powder.

D. Chemical Composition

TABLE V
CHEMICAL COMPOSITION OF CHICKEN MEAT SAUSAGES
SUBSTITUTED WITH CHIA SEED POWDER

Formulation	Sample A	Sample B	Sample C	Sample D
	(100% chicken meat)	(5% substitution of chia seed powder in chicken meat)	(10% substitution of chia seed powder in chicken meat)	(15% substitution of chia seed powder in chicken meat)
Carbohydrate	9.67% ± 0.40 ^d	11.38% ± 0.17 ^c	16.59% ± 0.15 ^b	22.00% ± 0.11 ^a
Fat	2.99% ± 0.09 ^c	7.25% ± 0.08 ^b	9.39% ± 0.32 ^a	9.46% ± 0.04 ^a
Protein	22.76% ± 0.59 ^a	20.27% ± 0.04 ^{ab}	20.27% ± 0.56 ^{ab}	19.24% ± 0.04 ^b

Moisture	62.08% ± 0.25 ^a	58.31% ± 0.12 ^b	50.30% ± 0.06 ^c	45.83% ± 0.11 ^d
Ash	2.50% ± 0.03 ^c	2.80% ± 0.07 ^b	3.45% ± 0.03 ^a	3.47% ± 0.00 ^a
Fibre	6.21% ± 0.23 ^c	9.95% ± 0.26 ^b	15.27% ± 1.00 ^a	17.27% ± 0.90 ^a

The nutrient composition had been analysed through proximate analysis for raw chia seed powder. The compositions of carbohydrates, fat, and protein were 35.36%, 29.49%, and 21.21%, respectively. On the other hand, raw chia seed powder had a moisture and ash content of 9.23% and 4.72%. Raw chia seed was notably high in fibre content, which was 34.16%.

From Table V, all chicken meat sausage samples substituted with chia seed powder showed significant increases ($P < 0.05$) in carbohydrate, fat, ash, and fibre contents in comparison to control (sample A). However, protein and moisture contents of chicken meat sausages with chia seed powder substitution decreased in value, while the control sausage had the highest protein and moisture. The findings obtained were probably due to the differences in the composition of chicken meat and chia seed.

These sausage samples showed an increasing trend of carbohydrate content gradually with the increasing amount of chia seed powder substituted into chicken meat sausage formulations. All samples were statistically different ($P < 0.05$) from each other. A similar study by Cardenas et al. [24] showed that the high carbohydrate composition in chia seed cultivated in Ecuador was 31.46%. Besides, Jacqueline et al. [25] found that monosaccharides such as β -D-xylose, α -D-glucose, and α -D-glucuronic acids were obtained in chia seed through acid hydrolysis. In this study, it was believed that the high carbohydrate content in all chicken meat sausage samples substituted with chia seed powder was also contributed by the high level of fibre. Fibre is categorized as a polysaccharide, and in chia seed, lignin is the predominant insoluble fibre [26]. The same results were reported in [23] that the polysaccharides were found between 90-94%, composed with lignin, cellulose, and hemicellulose.

The chia seed added in hamburger as fat replacer also increased carbohydrate trend [14]. Animal-derived food contained very few amounts of carbohydrates, in contrast with plant-based food [27]. Results showed that the lowest carbohydrate content was in sample A (control), as there was no presence of chia seed. Moreover, the carbohydrate content in raw ground chicken meat was also at a low level (0.04%), as reported by USDA (2007) [28].

The control sample was found to have lower fat percentages than those made with chia seed powder substitutions. As the chia seed powder substitution increased in concentration, the fat content also showed increasing trends. A similar finding reported that crude fat became higher than control when chia seed amount was added into the ham restructured-like product [15]. This study also showed the same result when chia seed was used as an enrichment substance in yogurt. This rise had been reported to be justified by the high-fat content constituted in chia seed. In this research, raw chia seed powder had a fat content of 29.49%. Porras-Loaiza et al. [29] discovered that the fat content of Mexican chia seed was between 21.49-32.68%.

Chia seed has high oil content primarily consisting of α -linolenic acid, a healthy form of fat that could improve the sausage's fatty acid profiles [1][24]. The high-fat content in the sample with chia seed powder substitutions might also be caused by the oil holding capacity (OHC) of the chia seed (11.67 g/g) and its gum (25.79g/g). OHC defines the entrapment of oil physically consisted of lipid compounds. The high-fat content in chicken meat sausages with chia seed powder substitution is attributed to high good fat as chia seed contains α -linoleic acid. This could be proved by the findings in the fatty acid content in wheat bread with the chia seed addition. The fat content increased from 1.12% to 2.53%, which described the increasing content of α -linolenic acid from 2.64% to 11.52% [30]. It contrasts with the control that had the saturated fat solely due to chicken meat composition [31].

The substitution of chia seed powder into chicken meat sausage formulations decreased the protein content insignificantly ($P>0.05$) except for those made with 15% chia seed powder substitution. This happened as the chicken meat percentages were reduced, and chia seed powder was substituted to replace the meat. Raw chia seed powder had a protein content of approximately 21.21%, which was almost in line with Bilek and Turhan [3]. Also, U-Chupaj et al. [17] stated that the chia seed had a protein content of 19.78%. Romankiewicz et al. [30] found that the chicken meat contained 31.02% protein, while Edris and Ibrahim [31] reported that the composition of protein in chicken was between 23.69-23.78%. These data prove that the protein content in chicken meat was higher than the raw chia seed. The minced chicken meat was predominated in sample A (control). Therefore, it had the highest protein content among all samples. A similar study was reported by Machado [23] on the decreasing protein content when chia seed was added into pig and sheep hamburger. Therefore, it was acceptable that the low chicken meat percentages indicated the low protein content in samples with chia seed powder substitution.

Moisture content can be defined as the total moisture removal until only the dry matter is left. The moisture content of all samples was significantly different ($P<0.05$) from each other. In decreasing order, sample A (control) exhibited the highest moisture content, while sample D had the lowest moisture content with the highest chia seed powder percentage (15%). The addition of chia seed powder significantly reduced ($P<0.05$) the moisture content of the sausages and the findings were in line with Kumar [32]. The decreasing moisture content as the chia seed powder substituted in chicken meat sausage formulations might result from chia seed's low moisture content compared to chicken meat. The chicken meat had a moisture content of chicken meat between 71.14-74.31% [31].

As the chia seed powder itself was on a dry basis and not a readily gelatinized form, it reduced the moisture content. The dry chia seed's moisture content was very low (9.23%), and a similar finding is shown by Alvites-misajel et al. [33], where the chia seed on a dry basis also had low moisture content. Kibui et al. [34] claimed that chia mucilage's hydration property could explain this decreasing moisture content trend. Chia seed contained soluble fibre primarily composed of glucuronic acid and neutral sugar. These fibres

generated hydrophilic mucilages that could hold water, lower viscosity, and form gels' stability [23]. In the study conducted by Ding et al. [15], the moisture content of restructured ham-like products also decreased with the addition of chia seed.

Ash represented the total of inorganic matters after ignition or complete oxidation of organic matter. Ash content also refers to the total mineral content in the food sample. The ash content increased with the increased percentage of chia seed powder substituted into the chicken meat sausage formulation. The ash analysis result was found to be in ascending order, where the lowest inorganic matter content was found in sample A (control) (2.54%). In comparison, the highest was obtained in sample D with a 15% substitution of chia seed powder (3.48%). Based on the finding, the chia seed contained a large amount of inorganic matter, which was 4.72% and almost similar to Michele [35], which was 4.60% on a dry basis while 4.30% on a wet basis form. According to Alvites-misajel et al. [33], the dark and white type of conventional chia seed had 4.80% and 4.41% of ash content, respectively. Minerals presented in chia seed were highly constituted by magnesium, calcium, and potassium. This result also indicated that the proportion of chia seed powder substituted in chicken meat sausage increased the ash content because the chia seed itself contained a high amount of ash and minerals. The ash content in chia seed enriched cookies also showed an increasing trend along with the addition of chia seed [36].

Chia seed had been proved for its high dietary fibre content, mainly consisted of insoluble fibre such as lignin. Similar to carbohydrate, fat, and ash contents, there was an increasing trend found as the chia seed powder substitution was increased in the chicken meat sausage formulations. Raw chia seed had fibre content of 34.16% and almost close value with direct milled chia seed (33.04%) by Fernández-lópez et al. [14]. Porrás-Loaiza et al. [29] also recorded the same finding (20.10-36.15%) on the Mexican chia seed.

The chia seed's high dietary fibre allowed the substitution and dietary fibre enrichment into the meat products such as hamburger [9]. This indicated the chia seed addition in chicken meat sausage increased the fibre content of the sausage. Apart from insoluble dietary fibre composed in chia seed that increased the carbohydrate content, chia seed also has about 2.50 to 7.10% soluble fibre content. The total dietary fibre of chia seed was higher in plant-based sources such as vegetables, fruits, and grains, including corn, flaxseed, carrot, banana, and spinach [37]. Similar findings were obtained when chia seed and chia seed flour were reformulated in pork frankfurter [14]. The pork frankfurter's total dietary fibre with the addition of chia seed and chia seed flour became higher than the control. Another study showed an increase in dietary fibre in wheat bread's nutrient content due to chia seed addition [30].

E. Sensory Analysis

This study was conducted using a hedonic test in which several attributes, including colour, texture, taste, juiciness, and overall acceptance, were taken into the measure. Seventy untrained panellists had participated in this test.

Table VI showed the sensory acceptance of chicken meat sausages substituted with chia seed powder.

TABLE VI
SENSORY ANALYSIS OF CHICKEN MEAT SAUSAGES
SUBSTITUTED WITH CHIA SEED POWDER USING 9-POINT
HEDONIC SCALE

Formulation	Sample A (100% chicken meat)	Sample B (5% substitution of chia seed powder in chicken meat)	Sample C (10% substitution of chia seed powder in chicken meat)	Sample D (15% substitution of chia seed powder in chicken meat)
Colour	6.48 ± 1.76 ^a	6.65 ± 1.51 ^a	6.20 ± 1.57 ^a	6.22 ± 1.61 ^a
Texture	6.20 ± 1.69 ^a	6.68 ± 1.37 ^a	6.58 ± 1.76 ^a	6.63 ± 1.67 ^a
Taste	6.42 ± 1.90 ^b	7.18 ± 1.11 ^a	6.97 ± 1.35 ^{ab}	7.03 ± 1.25 ^{ab}
Juiciness	6.10 ± 1.75 ^a	6.75 ± 1.40 ^a	6.63 ± 1.70 ^a	6.58 ± 1.45 ^a
Overall Acceptance	6.28 ± 1.65 ^b	7.07 ± 1.23 ^a	6.95 ± 1.52 ^{ab}	6.87 ± 1.27 ^{ab}

Generally, the sensory scores for experimental chicken meat sausages (those with chia seed powder substitution) showed higher values than control sausage for all sensory attributes evaluated. This indicates that chia seed powder's substitution in chicken meat sausage formulations improves its sensory properties. High scores imply the sausages substituted with chia seed powder are accepted by the panellists. The table above showed that the mean scores for colour, texture, taste, juiciness, and overall acceptance of sample B were highest among all samples, either the control or the chicken meat sausages substituted with chia seed. Sample B had the lowest percentage of chia seed powder substituted in chicken meat sausages, which was 5%. The mean scores for taste, overall acceptance, juiciness, texture, and colour were 7.18, 7.07, 6.75, 6.68, and 6.65, respectively.

Colour is one of the main characteristics considered by the consumer in choosing and buying the product. This study recorded that chia seed powder's substitution decreased the sensory scores for colour attributes except for sample B (chicken meat sausage with 5% chia seed powder substitution). It could be due to the samples' dark colour with a higher percentage of chia seed powder substitution. Since commercial chicken meat sausage is normally light in colour, consumers might refuse to have sausage with darker colour influenced by personal perception and opinion.

In texture attribute, the highest score was recorded for sample B (5% substitution of chia seed powder), and the lowest value belonged to sample A (control). The result indicated that panellists preferred sausages with chia seed powder substitution rather than those made with 100% chicken meat. It might be related to the soft texture and high water holding capacity of chicken meat sausage with chia seed powder substitution. This assumption was confirmed by a correlation study performed between texture scores in sensory analysis and hardness and cohesiveness values obtained from texture profile analysis. The texture scores

and hardness were found to be highly correlated with a value of $R^2 = -0.74$. In addition, a high correlation was also shown between texture scores and cohesiveness values ($R^2 = -0.88$).

Similarly, the sensory scores for taste and juiciness attributes were also higher in chicken meat sausages substituted with chia seed powder than control sausage. Chicken meat sausage B (5% chia seed powder substitution) obtained the highest sensory evaluation scores for both attributes, indicating that the panellists preferred the formulation. As taste is closely related to the texture and juiciness of the product (upon mastication in the mouth), the latter attributes might influence the taste attribute scores. However, the higher percentage of chia seed powder substitution (10%-15%) was not well perceivably accepted by the panellists for texture, taste, and juiciness attributes. Though texture and juiciness are important properties to determine the sausage quality, there is a limitation in the two attributes that the panelists might prefer.

For the overall acceptance, sausage B (5% chia seed powder substitution) obtained the highest score among all the samples. Generally, chicken meat sausages with chia seed powder substitution scored higher as compared to control sausage. This finding showed that the overall acceptance attribute scores might be influenced by texture, taste, and juiciness attributes as they had similar scores. Moreover, Zaki [38] stated that the most acceptable camel burger formulation was reported in 3% addition of the chia seed extracts. Overall acceptance of the 1.0% chia seed and 0.5% carrageenan addition in the restructured ham-like product also recorded similar with extra 5% of pork fat addition [15]. Thus, it can be concluded that the panelists' substitution of chia seed in meat products was well accepted.

IV. CONCLUSIONS

In conclusion, chia seed powder (5%-15%) substitution into chicken meat sausages formulation improved the physicochemical properties, nutritional composition, and sensory acceptance of the products. Chicken meat sausages with chia seed powder substitution had greater water holding. Lower cooking loss percentages lead to a desirable effect in meat products as they can retain drippings and juiciness. The substitution of chia seed powder in chicken meat sausage produced products that are softer in texture yet more elastic. The chia seed's ability to absorb and retain the chicken-chia seed system's moisture probably contributes to the findings. Despite the improvement found in the water holding and cooking loss percentages as well as texture properties, chia seed powder's substitution in chicken meat sausage resulted in the dark colour of the product. Chicken meat sausages with chia seed powder substitution have enriched fibre and minerals. Chicken meat sausage with 5% substitution of chia seed powder (sample B) was rated as the most preferred sample as it obtained the highest scores for all attributes evaluated.

ACKNOWLEDGEMENT

This research was funded by the Faculty of Science and Technology (FST). Authors would like to thank Mrs

Rina Wahap, Mrs Normah Harun, and Mrs Norhafiza Ghafar for their kind assistance on the lab facilities.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

REFERENCES

- [1] Kobus-cisowska, J., Taczanowski, M., and Kmiecik, D., "The Chemical Composition and Nutritional Value of Chia Seeds — Current State of Knowledge," *Nutrients*, Vol. 11, pp. 1–16, 2019.
- [2] Marciniek, K., and Krejpcio, Z., "Chia seeds (*Salvia hispanica*): health-promoting properties and therapeutic applications – a review," *National Institute of Public Health*, vol. 68, pp. 123–129, 2018.
- [3] Bilek, A. E., and Turhan, S., "Enhancement of the nutritional status of beef patties by adding flaxseed flour," *Meat Science*, vol 82, pp. 472–477, 2018.
- [4] Grancieri, M., Stampini, H., Martino, D., and Mejia, E. G. De, "Chia Seed (*Salvia hispanica* L.) as a Source of Proteins and Bioactive Peptides with Health Benefits," *Institute of Food Technologists*, vol. 18, pp. 480-499, 2019.
- [5] Pintado, T., Herrero, A. M., and Cavalheiro, C. P., "Chia and oat emulsion gels as new animal fat replacers and healthy bioactive sources in fresh sausage formulation," *Meat Science*, 135(11), vol. 135, pp. 6-13, 2017.
- [6] Many, J. N., and Sarasvathi, V., "Analysis of Chia Seed – Physicochemical and Proximate Analysis," *Research Journal of Recent Science*, vol. 5, pp. 39–41, 2016.
- [7] Mehta, N., Ahlawat, S. S., Sharma, D. P., and Dabur, R. S., "Novel trends in development of dietary fibre rich meat products — a critical review," *Journal of Food Science and Technology*, vol. 52, pp. 633–647, 2015.
- [8] Biswas, A. K., Kumar, V., Bhosle, S., Sahoo, J., and Chatli, M. K., "Dietary fibres as functional ingredients in meat products and their role in human health," *International Journal of Livestock Production*, vol. 2, pp. 45–54, 2011.
- [9] M. M. de O., Silva, J. R. G., de Oliveira, K. L., Massingue, A. A., Ramos, E. M., Júnior, A. A. B., ... Silva, V. R. O., "Technological and sensory characteristics of hamburgers added with chia seed as fat replacer," *Ciencia Rural Journal*, vol. 49, pp.1–10, 2019.
- [10] Yadav, S., Pathera, A. K., Islam, R. U., Malik, A. K., and Sharma, D. P., "Effect of wheat bran and dried carrot pomace addition on quality characteristics of chicken meat sausage," *Nutrition & Food Science*, vol. 31, pp. 729–737, 2018.
- [11] Jayasinghe, C. V. L., and Silva, S. S. G., "Quality Improvement of Tilapia Fish Nuggets by Addition of Legume Flour as Extenders," *Journal of Food and Agriculture*, vol. 6, pp.32–44, 2011.
- [12] Sharima Abdullah, N., Hassan, C.Z., Arifin, N. and Huda Faujan, N., "Physicochemical Properties of Imitation Chicken Nuggets Produced from Different Ratio of Chickpeas Flour and Textured Vegetable Protein," *International Food Research Journal*, vol. 25, pp. 1016–1025, 2018.
- [13] Oliveira, M. R., Novack, M. E., Santos, C. P., Kubota, E., and Da Rosa, C. S., "Evaluation of replacing wheat flour with chia flour (*Salvia hispanica* L.) in pasta," *Semina: Ciencias Agrarias*, vol. 36, pp. 2545–2553, 2015.
- [14] Fernández-lópez, J., Lucas-gonzález, R., Viuda-martos, M., Sayas-barberá, E., Navarro, C., Haros, C. M., and Pérez-álvarez, J. A., "Chia (*Salvia hispanica* L.) products as ingredients for reformulating frankfurters: Effects on quality properties and shelf-life," *Meat Science*, vol. 156, pp. 139–145, 2019.
- [15] Ding, Y., Lin, H., Lin, Y., Yang, D., Yu, Y., Chen, J., Wang, S., and Chen, Y., "Nutritional composition in the chia seed and its processing properties on restructured ham-like products," *Journal of Food and Drug Analysis*, vol. 26, pp. 124–134, 2017.
- [16] Pandey, M. C., Harilal, P. T., and Radhakrishna, K., "Effect of processing conditions on physico-chemical and textural properties of shami kebab," *International Food Research Journal*, vol. 21, pp. 223–228, 2014.
- [17] U-Chupaj, J., Malila, Y., Gamonpilas, C., Kijroongrojana, K., Petracci, M., Benjakul, S., and Visessanguan, W., "Differences in textural properties of cooked caponized and broiler chicken breast meat," *Poultry Science*, vol. 96, pp. 2491–2500, 2017.
- [18] Ramos, S., Fradinho, P., Mata, P., and Raymundo, A., "Assessing gelling properties of chia (*Salvia hispanica* L.) flour through rheological characterization," *Journal of the Science of Food and Agriculture*, vol. 97, pp. 1753–1760, 2017.
- [19] Felisberto, M. H. F., Wahanik, A. L., Gomes-Ruffi, C. R., Clerici, M. T. P. S., Chang, Y. K., and Steel, C. J., "Use of chia (*Salvia hispanica* L.) mucilage gel to reduce fat in pound cakes," *LWT - Food Science and Technology*, vol. 63, pp. 1049–1055, 2015.
- [20] Nithyalakshmi, V., and Preetha, R., "Effect of cooking conditions on physico-chemical and textural properties of emu (*Dromaius novaehollandiae*) meat," *International Food Research Journal*, vol. 22, pp. 1924–1930, 2015.
- [21] Warner, R. D., "The Eating Quality of Meat-IV Water-Holding Capacity and Juiciness," *Lawrie's Meat Science*, vol. 8, pp. 419-459, 2017.
- [22] Rubio, O. D., Cobos, A., José, G., and Aguilera, M., "Mucilage From Chia Seeds (*Salvia Hispanica*): Microstructure, Physico-Chemical Characterization And Applications In Food Industry," Chile: Pontifical Catholic University, PhD thesis, 2012.
- [23] Machado de Melo, J., "Elaboration and Evaluation of Produced Hamburger with Meat of Old Sheep and Pig with Added of Chia Seed (*Salvia hispanica*)," *International Journal of Nutrition and Food Sciences*, vol. 4, pp. 14, 2015.
- [24] Cardenas, M., Carpio, C., Morales, D., Álvarez, M., Silva, M., and Carrillo, W., "Content of Nutrients Component and Fatty Acids in Chia Seeds (*Salvia Hispanica* L.) Cultivated In Ecuador," *Asian Journal of Pharmaceutical and Clinical Research*, vol. 11, pp. 11–14, 2018.
- [25] Jacqueline Santora Zimmerman, B., "Health Benefits of Chia-Learn About Its History, Nutrient Composition, and Current Research Regarding Its Health Benefits," 2010.
- [26] Segura-Campos, M., Acosta-Chi, Z., Rosado-Rubio, G., Chel-Guerrero, L., and Betancur-Ancona, D., "Whole and crushed nutlets of chia (*Salvia hispanica*) from Mexico as a source of functional gums," *Food Science and Technology*, vol. 34, pp. 701–709, 2015.
- [27] Marangoni, F., Corsello, G., Cricelli, C., Ferrara, N., Ghiselli, A., Lucchin, L., and Poli, A., "Role of poultry meat in a balanced diet aimed at maintaining health and wellbeing: an Italian consensus document," *Food & Nutrition Research*, vol. 59, pp. 27606, 2015.
- [28] (2019) U.S. Department of Agriculture (USDA) Website. Poultry Products: Chicken, ground, raw. [Online]. Available: <https://fdc.nal.usda.gov/fdc-app.html#/food-details/171116/nutrients>
- [29] Porras-Loaiza, P., Jiménez-Munguía, M. T., Sosa-Morales, M. E., Palou, E., and López-Malo, A., "Physical properties, chemical characterization and fatty acid composition of Mexican chia (*Salvia hispanica* L.) seeds," *International Journal of Food Science and Technology*, 49(2), pp. 571–577, 2014.
- [30] Romankiewicz, D., Hassoon, W. H., Cacak-Pietrzak, G., Sobczyk, M. B., Wirkowska-Wojdyba, M., Ceglińska, A., and Dziki, D., "The effect of chia seeds (*salvia hispanica* L.) addition on quality and nutritional value of wheat bread," *Journal of Food Quality*, pp. 1-7, 2017.
- [31] Edris, A. M., & Ibrahim, H. M., "Chemical analysis of chicken meat with relation to its quality," *Benha Veterinary Medical Journal*, vol. 23, pp. 87-93, 2012.
- [32] Kumar, S., "Comparison of Nutrient Composition of Native Chicken and Commercial Broiler Under Indian Condition," *International Journal of Applied and Pure Science and Agriculture*, vol. 2, pp. 7–11, 2016.
- [33] Alvites-misajel, K., García-gutiérrez, M., Miranda-rodríguez, C., & Ramos-escudero, F., "Organically vs conventionally-grown dark and white chia seeds (*Salvia hispanica* L.): fatty acid composition, antioxidant activity and techno-functional properties," Vol. 70, 2019.
- [34] Kibui, A. N., Owaga, E., and Mburu, M., "Proximate composition and nutritional characterization of chia enriched yoghurt," *African Journal of Food, Agriculture, Nutrition and Development*, vol. 18, pp. 13239–13253, 2018.
- [35] Michele Silveira Coelho, M. de las M. S.-M., "Chemical Characterization of CHIA (*Salvia hispanica* L.) for Use in Food Products," *Journal of Food and Nutrition Research*, Vol. 2, pp. 263-269, 2014.
- [36] Chelladurai, C., "Development of innovative bakery product chia seed enriched cookies," *International Journal of Food Science and Nutrition*, vol. 4, pp. 387-390, 2019.
- [37] Suri, S., Jain Passi, S., and Goyat, J., "Chia Seed (*Salvia Hispanica* L.) – a New Age Functional Food," *International Journal of Advanced Technology in Science and Engineering*, vol. 4, pp. 752–765, 2016.

- [38] Zaki, E.F. "Impact of Adding Chia Seeds (*Salvia hispanica*) on the Quality Properties of Camel Burger "Camburger" during Cold Storage," *International Journal of Current Microbiology and Applied Sciences*, vol. 7, pp. 1356–1363, 2018.

Received 25 June 2020; Revised 7 February 2021; Accepted 15 March 2021;
Published 1 April 2021

Academic Editor: Shahrina Ismail
USIM Press
Malaysian Journal of Science, Health & Technology
Vol. 7, No. 1 (2021), 9 pages
Copyright 2021 Fakulti of Science and Technology, Universiti Sains Islam
Malaysia.