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Research Article
Effects of Vegetable Incorporation on Physical and Sensory Characteristics of Sausages

A. Syuhairah, N. Huda, Z.A. Syahariza and A. Fazilah

Food Technology Program, School of Industrial Technology, Universiti Sains Malaysia, 11800 USM, Penang, Malaysia

Abstract

Objective: The effects of incorporation of vegetables (30, 40 and 50%) in chicken sausage formulations were examined. **Methodology:** The five selected vegetables used were capsicum, carrot, spinach, purple cabbage and grey oyster mushroom. A total of 16 samples included control were prepared and analyzed for pH, cooking loss, water holding capacity, textural properties (hardness, springiness, cohesiveness, gumminess, chewiness and Warner-bratzler) color and sensory evaluation. **Results:** The results revealed that 14 samples had the range of 4.0-5.0 score for folding test. The pH, cooking loss and water holding capacity was affected significantly ($p<0.05$) by the different formulations of sausages. Samples with higher vegetable levels demonstrated significantly lower values in hardness and Warner-bratzler. The color of sausages varied significantly among samples due to the differences in the original color of vegetables. The sensorial evaluation results demonstrated that sausages with capsicum, carrot and oyster mushroom gave significant overall acceptability as compared to control. **Conclusion:** In general, the study suggested that vegetables can be valuable to the modification of sausage formulations particularly in the case of quality as well as consumer acceptability.

Key words: Chicken sausage, vegetables, physicochemical properties, sensory characteristics

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Corresponding Author: A. Fazilah, Food Technology Program, School of Industrial Technology, Universiti Sains Malaysia, 11800, USM, Penang, Malaysia Tel: +6046535208 Fax: +6046536375

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Consumers demands for fast, convenient and healthier food have been increasing rapidly in the recent years due to changes in lifestyles. The demands have initiated to an extensive research on the meat industry to develop less fat meat product and incorporate health-enhancing ingredients. In order to achieve this goal, the direct replacement of fat with non-meat ingredients such as plasma protein, vegetable oil, vegetable protein, hydrocolloid, oat and dietary fiber is a good alternative approach used to limit the detrimental effects of fat reduction as well as to improve the textural properties and emulsion stability of meat products[1-3].

Many researches have been conducted to explore the feasibility of using non-meat ingredients to promote a healthier meat sausage product, emphasizing the physicochemical properties and sensory characteristics in relation to the addition of new ingredients and the substitution of animal fat. Healthier meat-sausage formulations need to contain less saturated fat and/or promote the presence of specific healthy compounds as they affect the quality attributes of cooked meat emulsions[4-5]. A previous study by Ayo *et al.*[5] reports, an improvement in the nutritional profile after adding 25% of walnut to frankfurters. Incorporation of steamed pumpkin, chestnut peel powder and oyster mushroom powder has been shown to lower the fat content, improve emulsion stability and increase the amount of fiber[6-8]. Moreover, many researchers have also carried out studies on the addition of dietary fiber in lower fat meat product as a fat substitute to restore product's rheological properties and cooking yield due to its water-binding and fat-binding properties[9-12]. Aside that, tomato paste and avocado in pork frankfurter has been reported to improve the proportion of monounsaturated fatty acid in finish product as well as sensory acceptance[13].

Capsicum, carrot, spinach, purple cabbage and oyster mushroom can provide several health benefits in daily diet. Capsicum is a good source of vitamins C and E as well as provitamin A and carotenoids[14,15]. Carrot contains high amounts of α and β-carotene, which account for about half of the provitamin A carotenoid found in the food supply[16]. Carrot also contains other compounds, such as phenolic compounds and organic acids, which contribute not only to the sensory qualities but as an additional nutritional properties for human health[17]. Spinach contains an abundance of phenolic compounds, which may allow protection against oxidative stress mitigated by free-radical species[18]. Purple cabbage is a rich source of anthocyanins, minerals, vitamins, oligosaccharides and a number of bioactive substances that provides a positive impact on human health[19]. Apart from some nutritional benefits, purple cabbage is also valued by consumers for its taste and color, which increases the esthetic value of the food[19]. Oyster mushrooms had a unique flavor and texture and perceived as an important source of biologically active compounds of medicinal value[20]. They are also treasured health foods, since they are excellent sources of vitamins, minerals, proteins, carbohydrates, unsaturated fatty acids, high amounts of fibers and often regarded as an ideal and healthy food for people[21,22].

Therefore, to take advantage of the biological properties of capsicum, carrot, spinach, purple cabbage and oyster mushroom, the development of these selected vegetables in chicken sausage can be a fascinating combination of protein intake, additional nutritional value, unique natural color properties and helps to promote healthier sausages compared to the traditional type of meat products available in the market. However, it is essential to know the right level to which they should be added, without compromising the quality of sausage produced. In light of this consideration, the objective of this study was to evaluate the physical properties and sensory characteristics of chicken sausage incorporated with five different vegetables; capsicum, carrot, spinach, purple cabbage and oyster mushroom, respectively at 30, 40 and 50% level.

MATERIALS AND METHODS

Preparation of sausage: The present study was carried out at the Fish and Meat Laboratory, Food Technology Programme, School of Industrial Technology, Universiti Sains Malaysia over the period from May, 2014-January, 2015. Mechanically Deboned Chicken Meat (MDCM) and five types of vegetables; spinach, purple cabbage, carrot, capsicum and oyster mushroom were purchased from a local market in Penang, Malaysia. Sixteen sausage formulations were prepared using three percentage levels of vegetables (30, 40 and 50%) and control (100% chicken) as shown in Table 1. Other ingredients added in the sausage processing were tapioca flour, spices, fresh egg white, water, palm oil, salt, sugar and sodium thiosulphate. All ingredients were mixed for 5 min using a mixer (Robot Coupe®, Blixer 3, France). The batter was then stuffed manually into 2.5 cm diameter cellulose casing. Sausages were steamed in a steamer (Electric and Steamer, Model RS-6, 0881, China) until their internal temperature

Table 1: Formulations of vegetable chicken sausage preparation

	Samples/100 g			
Ingredients	Control	V30	V40	V50
Chicken meat	75	52.50	45.00	37.50
Vegetables	-	22.50	30.00	37.50
Tapioca flour	10	10.00	10.00	10.00
Spices	4	4.00	4.00	4.00
Palm oil	1.8	1.80	1.80	1.80
Fresh egg white	3	3.00	3.00	3.00
Cold water	3	3.00	3.00	3.00
Salt	1.7	1.70	1.70	1.70
Sugar	1.35	1.35	1.35	1.35
Sodium thiosulphate	0.15	0.15	0.15	0.15

V30: Ratio of vegetables: chicken meat = 30:70, V40: Ratio of vegetables: chicken meat = 40:60, V50: Ratio of vegetables: chicken meat = 50:50, Vegetables used: Capsicum, carrot, spinach, purple cabbage and oyster mushroom

reached 72±2°C (measured using a thermocouple probe) and held for approximately 30 min. The steamed sausages were promptly cooled in ice water for 15 min, the casing was peeled and vacuum-packed. The prepared sausage samples were kept in the freezer at -18°C prior to analyzes.

Folding test: Folding test was conducted according to the method described by Lanier[23]. The sausages were cut into 3 mm thick slices. The slices were folded slowly between the thumb and forefinger. A numeral score grade is given as follows: AA (5): No crack showing after folding into a quadrant, A (4): No crack showing after folding into half, B (3): Cracks gradually when folded into half, C (2): Cracks immediately when folded into half and D (1): Breaks by finger pressure.

pH: The pH was determined by the method of Jin *et al.*[24]. About 5 g of sample was homogenized with 45 mL of distilled water using a wiring blender. The pH was then measured using a digital pH meter (Microprocessor pH meter, Model pH 211, Hanna Instruments, Mauritius).

Cooking loss: Cooking Loss (CL) was determined by the method described by Ayo *et al.*[5]. The CL was measured by calculating the difference in weight of samples for each treatment before and after 3 min placement in a water bath at 90°C and the removal of remaining exudates using absorbent paper. The CL then was expressed as a percentage of initial sample weight. The mean of five measurements was taken for each sample.

Water Holding Capacity (WHC): Modified procedures of Lin and Huang[25] and Santana *et al.*[26] were followed. Approximately 5 g of a homogenized sausage was placed in a 50 mL centrifuge tube with the addition of 10 mL of distilled water. Following 15 min centrifugation at 2000 g, 5°C, the supernatant was decanted and the final sample weight was determined. The WHC was calculated as follows:

$$\text{WHC} = \frac{\text{Final sample weight} - \text{Original sample weight}}{\text{Original sample weight}}$$

Texture profile analysis: Texture Profile Analysis (TPA) was performed by using Texture Analyzer TA-XT2 (Stable Microsystem, UK) as described by De Huidobro *et al.*[27]. Sausages were cooked at 90°C for 5 min and uniformly cut into 1.5 cm, thick slices. A slice was placed horizontally on a platform. Hardness, cohesiveness, springiness, gumminess and chewiness were measured using a compression plate (P/75) with a heavy duty platform at the following settings: Load cell, 25 kg, pre-test speed and post-test speed, 3.00 mm sec^{-1}, prefixed strain and 75% time before second compression 2 sec. Hardness was defined by the peak force required for the first compression. Cohesiveness was calculated as the ratio of the area under the curve of the second compression to the area under the curve of the first compression. Springiness was defined as a ratio of the distance of the second area at second compression and the first area at first compression. Chewiness was calculated by multiplying gumminess and springiness. The TPA was measured at five-time trials.

Warner-bratzler shear test: Shear force was determined by the method of De Huidobro *et al.*[27]. The test cell consisted of a 3 mm thick steel blade with a 73°V-cut at its lower edge. The sample was cut through as the blade moved down at a constant speed at the following settings: Pre-test speed, 3.0 mm sec^{-1}; test speed, 1.0 mm sec^{-1} and post-test speed, 3.0 mm sec^{-1}. Shear value was expressed in kg.

Color: Color of the inner part of sausage was analyzed using colorimeter (Minolta Spectrophotometer CM-3500d). The medium target mask was set up and calibration was made by zero calibration box and white calibration plate before it was tested. The black empty dish (CM-A120) was used to calibrate the spectrophotometer followed by white calibration using a white opaque dish. The color reading includes lightness (L), redness (a) and yellowness (b). Measurements of the samples were made in triplicates.

Sensory evaluation: Sensory evaluation was conducted by 25 semi-trained panelists according to the criteria described by Carpenter *et al.*[28] and Muthia *et al.*[29]. The samples were cut into a uniform size (1.5 cm) and served warm (~50°C) to the panelists. All the samples were coded with a random three-digit number and presented to the panelists in a random order. The panelists were instructed to evaluate the color, odor, taste, texture and overall acceptability using a 7-point hedonic scale; 1: Dislike very much and 7: Like very much.

Statistical analysis: The results were analyzed using the two-way statistical analysis of variance (ANOVA), followed by Duncan multiple range test using SPSS package (SPSS 21.0 for Windows, SPSS Inc, Chicago, Illinois, U.S.A). All data were analyzed using two-way ANOVA to detect a significant difference between mean values of treatments with factors: Different vegetables at same percentage and different percentage of the same vegetable. Statistical significance was indicted at 95% confidence level.

RESULTS AND DISCUSSION

Folding test, pH, cooking loss and WHC: Table 2 presents the results of the folding test, pH, water holding capacity and cooking loss of the sausages produced. There were significant differences (p<0.05) in the folding test, pH, water holding capacity and cooking loss of different vegetables at the same percentage. Folding test is a simple test to determine the textural quality of gel composite products, such as sausages and meatballs. In this study, the folding test scores ranged from 3.33-5.00. Huda *et al.*[30] reported that the folding test scores of commercial chicken sausages in Malaysia were in the range of 4.2-5.0. Seven samples had a score of 5.0 in the folding test, seven samples were in the range of 4.0-4.67, while two samples were in the range of 3.33-3.67. Sausages incorporated with carrot showed the best gel strength compared to the others sample, whereas, sausages incorporated with oyster mushroom gave the lowest score. The difference in score is probably due to the different texture of vegetable added and amount of fiber content. The score of the folding test would act as an indicator of the freshness of meat, sources of starch and types of ingredients used in sausage formulation[31]. Thus, it is proven that the incorporation of 30, 40 and 50% level of vegetables in chicken sausage formulation did produce a good quality sausage as the control sausage.

Table 2: Folding test, pH, CL and WHC of sausages containing chicken and vegetables

	Parameters			
Samples	Folding test	pH	Cooking loss (%)	WHC (%)
Control	4.00 ± 0.00	6.51 ± 0.01	2.80 ± 0.08	57.33 ± 1.15
CP_{30}	5.00 ± 0.00^{aA}	6.56 ± 0.01^{aA}	2.77 ± 0.01^{aA}	54.67 ± 2.31^{aA}
CP_{40}	5.00 ± 0.00^{aA}	6.55 ± 0.01^{aA}	2.76 ± 0.01^{aB}	57.33 ± 2.31^{aA}
CP_{50}	4.33 ± 0.58^{abA}	6.52 ± 0.01^{aB}	2.76 ± 0.01^{aB}	56.00 ± 2.00^{cA}
C_{30}	5.00 ± 0.00^{aA}	6.53 ± 0.01^{abA}	2.77 ± 0.02^{abA}	58.00 ± 0.00^{aB}
C_{40}	5.00 ± 0.00^{aA}	6.52 ± 0.01^{abB}	2.74 ± 0.05^{abAB}	62.00 ± 4.00^{aAB}
C_{50}	4.67 ± 0.58^{aA}	6.49 ± 0.00^{bC}	2.67 ± 0.03^{bB}	64.00 ± 2.00^{aA}
S_{30}	5.00 ± 0.00^{aA}	6.61 ± 0.01^{cB}	2.53 ± 0.06^{cA}	54.67 ± 2.31^{aB}
S_{50}	4.67 ± 0.58^{aA}	6.64 ± 0.01^{dA}	2.48 ± 0.01^{dAB}	59.33 ± 4.16^{aAB}
S_{50}	4.33 ± 0.58^{abA}	6.64 ± 0.01^{dA}	2.43 ± 0.03^{dB}	61.33 ± 1.15^{abA}
PC_{30}	5.00 ± 0.00^{aA}	6.54 ± 0.00^{abA}	2.77 ± 0.02^{abA}	54.00 ± 3.46^{aA}
PC_{40}	5.00 ± 0.00^{aA}	6.49 ± 0.01^{bB}	2.70 ± 0.02^{bB}	57.33 ± 2.31^{aA}
PC_{50}	4.33 ± 0.58^{abA}	6.47 ± 0.01^{bC}	2.66 ± 0.02^{bC}	59.33 ± 4.16^{bcA}
OM_{30}	4.33 ± 0.58^{bA}	6.57 ± 0.01^{bB}	2.75 ± 0.02^{bA}	54.67 ± 1.15^{aB}
OM_{40}	3.67 ± 0.58^{bA}	6.58 ± 0.01^{cA}	2.61 ± 0.01^{cB}	58.67 ± 1.15^{aA}
OM_{50}	3.33 ± 0.58^{bA}	6.56 ± 0.00^{cC}	2.58 ± 0.01^{cB}	60.67 ± 1.15^{abA}

CP: Capsicum, C: Carrot, S: Spinach, PC: Purple cabbage, OM: Oyster mushroom. Mean±SD. Lowercase within the rows indicate significantly different (p<0.05) between different vegetables at the same percentage. The uppercase within the rows indicate significantly different (p<0.05) between different percentage of the same vegetable, CL: Cooking loss and WHC: Water holding capacity

The pH values of sausages incorporated with vegetables were found to have significant difference (p<0.05) in the range of 6.47-6.64, whereas, the pH of the controlled sausage was 6.51. The differences in the pH of the sausages were might due to the initial pH of raw vegetables and percentage levels of vegetables used in the formulations. Incorporation of spinach gave the highest value of pH compared to other samples (6.61-6.64), which suggested due to the high initial pH of raw spinach compared to other raw vegetables. However, Ayo *et al.*[5] reported that the pH of sausage added with walnut was 6.37, but there was no significant effect on the pH of the controlled meat batter. A study by Sallam *et al.*[32] report that the garlic in sausage gives the initial pH value ranging from 6.65 (in controlled samples) to 6.78, when using the fresh garlic and it tends to increase with storage time. The determination of pH is important for determinant of microbial growth as most bacteria grow optimally at about pH 7 and a high pH in final meat product has higher spoilage potential and shorter shelf life[33].

Cooking Loss (CL) was used to measure the amount of juices lost during cooking. Meanwhile, Water Holding Capacity (WHC) was conducted to measure how well the juices were retained in the cooked products. Based on the results, both types and percentage levels of vegetables added into the sausage formulations affects the cooking loss in the range of 2.43-2.77, which is lower than the control sausage. Previous studies showed that the results of cooking loss were in a range of around 3% is considered as acceptable for frankfurter type sausages[5,34,35]. The difference in cooking loss is probably due to varying better concentration by the percentage of fat and moisture contents Pietrasik[36]. These findings were further supported by Choi *et al.*[37,38] and Shand[39], where cooking loss occurs through the release of fat and moisture, related to the binding ability between meat protein, fat and moisture. Some studies also reported the cooking loss was affected by dietary fiber as it will decrease as the amount of dietary fiber increased[38,40]. This statement was further agreed through addition of tofu[2], wheat, oat bran[41], chestnut powder, pumpkin fiber[7,11] and apple pomace[42] in meat products, which showed the decrease in cooking loss value compared with the control.

The comparison of the WHC values (54-64%) between all the samples did not indicate substantial differences. However, at the 40% incorporation with vegetables, the sausages start to show higher WHC as compared to the controlled sample. A previous study by Hughes *et al.*[43] reported that frankfurters with the addition of carrageenan or oat fiber have the increase in WHC. Yang *et al.*[2] also obtain the similar results in low-fat pork sausages with added hydrated oatmeal and tofu as texture modifying agent.

Meanwhile, studies by Martin and Rogers[44], Bloukas and Paneras[45], Carballo *et al.*[46] and Pietrasik[36] reported an inverse relationship, whereby the amount of liquid that separates off while pressing the sausage sample is smaller as the protein content in is larger. This is because an increase in protein content causes an increase in the number of locations in the polypeptide chains capable of interacting during heating. As a result, a more stable gel matrix is formed, which leads to a smaller release of water and fat, thus improving binding properties of meat emulsions[46]. This was not found in this present study, which then suggests that the difference is due to the different methods used to determine the WHC. Also, at 40% incorporation of vegetables, the sausages would retain the moisture and juicy texture after cooked.

Texture profile analysis: Textural properties of sausages are shown in Table 3. The results from the hardness, springiness, cohesiveness, gumminess, chewiness and Warner-bratzler analysis showed significant variations ($p<0.05$), indicating a significant data dispersion for all the parameters studied. As expected, the control sausage had the highest hardness value amongst the sausage samples and the hardness of the sausage samples gradually decreased with the increasing addition of vegetables. Among the five vegetables used, incorporation of purple cabbage demonstrated the highest hardness value while incorporation of oyster mushroom showed the lowest hardness value. Huda *et al.*[30] reported that the hardness scores for commercial chicken sausages in Malaysia were in the range of 3.84-7.25 kg. In this study, the hardness scores were in the range of 3.34-10.04 kg. According to Dingstad *et al.*[47], sausages with a hardness of 4.73 kg and above will have at least 60% of consumer's purchasing power. The results obtained indicate that the

Table 3: Texture profiles analysis of sausages containing chicken and vegetables

	Parameters					
Samples	Hardness (kg)	Springiness (mm)	Cohesiveness (ratio)	Gumminess (kg mm^{-2})	Chewiness (kg mm^{-1})	Warner bratzler (kg)
Control	10.04±0.48	8.82±0.10	0.35±0.02	4.10±0.18	36.16±1.90	1.86±0.09
CP_{30}	8.30±0.08^{aA}	7.74±0.28^{bcA}	0.27±0.01^{bA}	3.67±0.23^{aA}	28.36±1.62^{bA}	1.70±0.05^{aA}
CP_{40}	6.09±0.04^{bB}	7.24±0.25^{bB}	0.26±0.02^{abA}	3.63±0.12^{aA}	26.26±0.73^{aA}	0.65±0.09^{bB}
CP_{50}	4.65±0.21^{bC}	7.73±0.07^{bA}	0.25±0.01^{aA}	2.02±0.17^{cB}	15.64±1.19^{cB}	0.52±0.05^{bC}
C_{30}	6.30±0.16^{bA}	7.55±0.30^{cA}	0.27±0.02^{bA}	3.02±0.07^{bA}	22.78±0.69^{cA}	1.08±0.03^{cA}
C_{40}	6.29±0.44^{bA}	7.54±0.28^{bA}	0.25±0.02^{abAB}	2.70±0.17^{bA}	20.39±1.88^{bA}	0.51±0.08^{cB}
C_{50}	4.12±0.20^{bB}	7.57±0.23^{bA}	0.24±0.01^{aB}	1.68±0.33^{cB}	12.72±2.82^{cB}	0.35±0.03^{cC}
S_{30}	8.31±0.22^{aA}	8.07±0.08^{abA}	0.32±0.02^{aA}	3.67±0.15^{aA}	29.58±1.35^{abA}	1.80±0.07^{aA}
S_{40}	6.51±0.06^{aB}	8.04±0.14^{aA}	0.27±0.02^{abB}	3.43±0.15^{aA}	27.54±0.78^{aB}	0.89±0.10^{aB}
S_{50}	4.61±0.14^{bC}	7.57±0.28^{bB}	0.23±0.02^{abC}	3.10±0.10^{aB}	23.41±0.26^{aC}	0.61±0.09^{abC}
PC_{30}	8.37±0.15^{aA}	8.18±0.13^{aA}	0.28±0.02^{bA}	3.81±0.11^{aA}	31.14±0.46^{aA}	1.30±0.07^{bA}
PC_{40}	6.64±0.13^{aB}	8.17±0.13^{aA}	0.28±0.01^{aA}	3.42±0.09^{aB}	27.98±1.23^{aB}	0.81±0.01^{aB}
PC_{50}	4.84±0.11^{aC}	8.14±0.20^{aA}	0.25±0.02^{aB}	2.38±0.17^{bC}	19.36±1.84^{abC}	0.64±0.07^{aC}
OM_{30}	4.36±0.04^{cA}	6.60±0.18^{dA}	0.24±0.00^{cA}	1.40±0.34^{cA}	9.26±2.22^{dA}	0.54±0.10^{dA}
OM_{40}	3.73±0.15^{cB}	6.53±0.40^{cA}	0.24±0.02^{bA}	0.92±0.10^{cB}	6.01±0.98^{cB}	0.44±0.04^{cAB}
OM_{50}	3.34±0.37^{cB}	6.54±0.03^{cA}	0.21±0.01^{bB}	0.71±0.11^{dB}	4.66±0.69^{dB}	0.36±0.04^{cB}

CP: Capsicum, C: Carrot, S: Spinach, PC: Purple cabbage, OM: Oyster mushroom, Mean±SD. Lowercase within the rows indicate significantly different ($p<0.05$) between different vegetables at the same percentage. The Uppercase within the rows indicate significantly different ($p<0.05$) between different percentage of the same vegetable

Table 4: Color analysis of sausages containing chicken and vegetables

Samples	Parameters L	a	b
Control	66.82±0.02	1.36±0.01	18.85±0.02
CP_{30}	57.62 ± 0.00^{cA}	19.66 ± 0.01^{aC}	32.20 ± 0.02^{bC}
CP_{40}	53.79 ± 0.01^{dB}	23.07 ± 0.01^{aB}	33.66 ± 0.03^{bB}
CP_{50}	52.77 ± 0.01^{dC}	24.92 ± 0.01^{aA}	34.61 ± 0.02^{bA}
C_{30}	66.50 ± 0.01^{aA}	6.99 ± 0.01^{bC}	36.37 ± 0.01^{aC}
C_{40}	65.45 ± 0.01^{aC}	8.39 ± 0.02^{bB}	37.84 ± 0.01^{aB}
C_{50}	65.76 ± 0.02^{aB}	9.35 ± 0.00^{bA}	39.26 ± 0.01^{aA}
S_{30}	49.32 ± 0.02^{eA}	0.18 ± 0.01^{eA}	24.15 ± 0.03^{cC}
S_{40}	49.06 ± 0.01^{eB}	-0.14 ± 0.01^{eB}	24.85 ± 0.01^{cA}
S_{50}	45.98 ± 0.01^{eC}	-0.10 ± 0.02^{eB}	24.54 ± 0.02^{cB}
PC_{30}	57.11 ± 0.00^{dA}	1.65 ± 0.01^{dA}	12.70 ± 0.01^{eA}
PC_{40}	55.01 ± 0.01^{cB}	0.66 ± 0.01^{dB}	8.240 ± 0.01^{eB}
PC_{50}	54.21 ± 0.01^{cC}	-0.06 ± 0.02^{dC}	1.630 ± 0.03^{eC}
OM_{30}	66.38 ± 0.01^{bA}	1.81 ± 0.02^{cC}	17.99 ± 0.01^{dB}
OM_{40}	64.56 ± 0.02^{bC}	1.89 ± 0.01^{cB}	17.69 ± 0.01^{dC}
OM_{50}	64.59 ± 0.01^{bB}	2.13 ± 0.01^{cA}	18.30 ± 0.01^{dA}

CP: Capsicum, C: Carrot, S: Spinach, PC: Purple cabbage, OM: Oyster mushroom. Mean±SD, Lowercase within the rows indicate significAntly different (p<0.05) between different vegetables at the same percentage, The uppercase within the rows indicate significantly different (p<0.05) between different percentage of the same vegetable, L: Lightness, a: Redness, b: Yellowness

incorporation of vegetables, induced a decrease in hardness presumably due to differences in composition, resulting in different protein/fat/water ratios, which is a determining factor in the consistency of the resulting gel[12]. Similar trends were obtained by Savadkoohi *et al.*[3] and Wan Rosli *et al.*[8] who found that the hardness and shear force of sausages were significantly reduced along with an increase of bleached tomato pomace and oyster mushroom powder introduced to sausage batter.

The springiness scores of sausages were in the range of (6.53-8.82 mm). Control sample had the highest score in springiness compared with the sausages added with vegetables. Previous studies by Aleson-Carbonell *et al.*[48] and Wan Rosli *et al.*[49] also showed that the lower chicken meat content would contribute to the lower scores of springiness and juiciness attributes. Cohesiveness is a measure of the degree of difficulty in breaking down the internal structure of the sausage. The cohesiveness scores of the sausages varied with the types and amount of texture-modifying agents used. In general, the addition of vegetables produced a slightly higher degree of cohesiveness except for the oyster mushroom samples. The secondary parameters of gumminess and chewiness behaved similarly to the parameters, on which they were dependent on the hardness[50]. Warner-bratzler shear force is a test to measure the force (kg) necessary to shear a piece of meat. A larger value indicates the greater shear force and therefore, the tougher the sausage[51]. Sample CP_{30} and S_{30} had a higher value of shearing compared to other samples added with vegetable ranging from of 0.36-1.80 kg. The shear force value was decreased with increased in percentage of vegetables added. This might be due to the substitution of chicken meat with vegetable as formulation in Table 1, which caused the lower amount of protein and fat contents in sausage.

Color: Color appearance is one of the primary physical attributes that determine consumer's acceptability of products. In the food industry, although visual color standards are still used, instrumental color measurements are extensively employed[52]. Table 4 shows the color attributes for all the samples. The lightness (L), redness (a) and yellowness (b) of the samples were significantly affected (p<0.05) by the addition of various vegetables with three different levels. Control sample had the highest L value and this indicates that it has a lighter color. Incorporation of vegetable had decreased the L value gradually with an increase in percentage of vegetable, which is expected in this result. Sausage with spinach exhibit the lowest L value (45.98-49.32) significantly (p<0.05). The positive values of a indicate the redness color of the samples. The sausages with the addition of capsicum gave the highest a value. Meanwhile, the negative values of a indicate the green color of the samples which were obtained with the addition of spinach. For b, the yellowness values were the highest in the sausages added with a carrot, while the lower b values indicate that the sample's color are slightly blue as in samples containing purple cabbage. Based on the color of commercial chicken sausage[30] in Malaysia, the range for L, a and b value is between 44.42-65.54, 6.51-22.11 and 16.10-31.8. However, the significant color difference in sausages produced in this study is due to the original color of the vegetables, which also varied upon formulations. Despite the significant difference in the colors of sausages (p<0.05), it had higher overall acceptability, except for the sausages added with spinach and purple cabbage for all formulations as discussed in Table 5.

Sensory evaluation: The sensory panels were convened to assess the effects of the different percentage incorporation of capsicum, carrot, spinach, purple cabbage and oyster mushroom on the color, odor, taste, texture and overall acceptability in vegetable chicken sausages (Table 5). Color is one of the main physical characteristics of processed meat products that determine the acceptability of a product for consumers including sausages. It is also a parameter that is

Table 5: Sensory analysis of sausages (n = 25) containing chicken and vegetables

	Attributes				
Samples	Color	Odor	Texture	Taste	Overall acceptability
Control	5.20 ± 1.41	4.72 ± 1.40	4.00 ± 1.53	4.28 ± 1.51	4.28 ± 1.37
CP_{30}	5.60 ± 0.87^{aA}	4.56 ± 1.29^{abA}	4.76 ± 1.09^{aA}	4.92 ± 1.15^{aA}	5.04 ± 0.89^{aA}
CP_{40}	5.44 ± 0.96^{aA}	4.88 ± 1.09^{abA}	4.72 ± 1.28^{abA}	5.04 ± 1.27^{abA}	5.04 ± 0.93^{aA}
CP_{50}	5.44 ± 0.96^{aA}	4.60 ± 1.19^{abcA}	5.24 ± 1.36^{aA}	4.80 ± 1.29^{aA}	4.92 ± 1.47^{aA}
C_{30}	5.04 ± 1.21^{aA}	5.04 ± 0.84^{aA}	5.04 ± 1.27^{aA}	4.96 ± 1.17^{aA}	5.08 ± 1.12^{aA}
C_{40}	5.32 ± 0.75^{aA}	5.12 ± 1.17^{aA}	5.12 ± 1.05^{aA}	4.92 ± 1.38^{abA}	5.04 ± 1.10^{aA}
C_{50}	5.32 ± 1.03^{aA}	4.88 ± 1.13^{aA}	4.76 ± 1.45^{abA}	4.48 ± 1.50^{abA}	4.72 ± 1.21^{abA}
S_{30}	3.08 ± 1.78^{cA}	4.36 ± 1.58^{abA}	3.72 ± 1.51^{bA}	3.92 ± 1.61^{bA}	3.56 ± 1.39^{bA}
S_{40}	3.12 ± 1.62^{cA}	4.36 ± 0.95^{bcA}	4.20 ± 1.35^{bA}	4.00 ± 1.71^{cA}	4.16 ± 1.14^{bA}
S_{50}	3.08 ± 1.61^{bA}	4.04 ± 1.27^{bcA}	4.24 ± 1.48^{bA}	3.92 ± 1.32^{bA}	4.00 ± 1.38^{bA}
PC_{30}	2.72 ± 1.24^{cA}	3.88 ± 1.39^{bA}	3.72 ± 1.43^{bB}	3.96 ± 1.37^{bA}	3.56 ± 1.33^{bA}
PC_{40}	2.28 ± 1.31^{dA}	4.08 ± 1.44^{cA}	4.20 ± 1.53^{bAB}	4.32 ± 1.44^{bcA}	3.84 ± 1.43^{bA}
PC_{50}	2.52 ± 1.53^{bA}	3.92 ± 1.22^{cA}	4.80 ± 1.26^{abA}	4.00 ± 1.08^{bA}	3.96 ± 1.02^{bA}
OM_{30}	4.80 ± 1.32^{bA}	4.88 ± 1.20^{aA}	4.80 ± 1.35^{aA}	4.88 ± 1.56^{aA}	4.76 ± 1.23^{aA}
OM_{40}	4.60 ± 1.22^{bA}	4.84 ± 1.37^{abA}	5.12 ± 1.17^{aA}	5.32 ± 1.18^{aA}	5.32 ± 1.07^{aA}
OM_{50}	4.68 ± 1.25^{aA}	4.68 ± 1.18^{abA}	4.72 ± 1.81^{abA}	4.96 ± 1.40^{aA}	4.76 ± 1.48^{abA}

CP: Capsicum, C: Carrot, S: Spinach, PC: Purple cabbage, OM: Oyster mushroom, Mean±SD. Lowercase within the rows indicate significantly different ($p<0.05$) between different vegetables at the same percentage. The Uppercase within the rows indicate significantly different ($p<0.05$) between different percentage of the same vegetable

easily altered by the proportion of non-meat ingredients in the formulation[53]. Based on the color attributes, the addition of capsicum demonstrated the highest score (5.44-5.60) followed by carrot (5.04-5.32), oyster mushroom (4.60-4.80) and spinach (3.08-3.12), while the addition of purple cabbage gave the lowest score (2.28-2.72) significantly. The high score in sausage incorporated with capsicum and carrot probably due to orange tone color of sausage produce, which is more favorable by the panelist. Valenzuela-Melendres *et al.*[13] reported that the color of sausage added with tomato paste was significantly ($p<0.05$) higher compared with addition of avocado paste.

Odor and texture scores were improved by the incorporation of the capsicum, carrot and oyster mushroom. Purple cabbage gave the lowest score in odor, while spinach gave the lowest score in texture significantly. In terms of taste and overall acceptability, the highest score was obtained with the incorporation of oyster mushroom. The overall acceptability scores ranged from 3.56-5.32, with the maximum acceptability obtained at the 40% of the oyster mushroom level. The high scores for sausage with oyster mushroom could be due to the contributions of the flavor enhancers and taste active compounds that exist within the oyster mushroom. A previous study has found that mushrooms contain considerable levels of flavor enhancer (e.g., 50-guanosine monophosphate and lenthionine) and taste active compounds (e.g., monosodium glutamate) that contribute to the umami-like taste or palatable taste[54-55].

Meanwhile, the addition of purple cabbage showed significant lowest overall acceptability score followed by spinach at all levels. These results might be influenced by the color of purple cabbage and spinach sausages produced, which was slightly purple and greenish, thus they were less preferred by the panellist as they also had the lowest scores for color and odor attributes. This signifies that color plays a significant role in influencing customer's first impression of any food product that they wish to consume[52].

CONCLUSION

The results obtained in this study show that the incorporation of sausage with capsicum, carrot, spinach, purple cabbage and oyster mushroom does alter its physicochemical properties. In general, replacement of chicken with 30 and 40% of capsicum, spinach, carrot and purple cabbage gave most desirable physicochemical properties, which is particularly important in the case of quality and economic justification of the product. However, in sensory characteristics, the replacement of chicken with purple cabbage and spinach showed the lowest acceptance of the sausage samples among the panelists. Overall, it is feasible to produce potentially functional vegetable chicken sausages as much as 40% replacement of chicken with capsicum, oyster mushroom and carrot since it has acceptable physicochemical properties and positive correlation on sensorial characteristics.

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