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The ability of oyster mushroom in improving nutritional composition, β-glucan and textural properties of chicken frankfurter

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Abstract

This study was focused on the effect of incorporation of oyster mushroom, *Pleurotus sajor-caju* (PSC) powder to partially replace chicken meat in frankfurters on nutritional composition, β-glucan content and textural properties. The frankfurters were formulated with either 0 (control), 2, 4 or 6% of PSC powder. The results show control chicken frankfurter had the highest fat content (11.60%) while 6% PSC frankfurter had the lowest value (10.74%). In other nutrient, ash, moisture and carbohydrate content in all samples ranged from 1.55 to 1.92%, 59.36 to 61.98% and 8.84 to 13.09%, respectively. Apparently, total dietary fiber of chicken frankfurter was increased in line with the levels of PSC powder (0.08 - 6.20%). All samples recorded β-glucan in the range from 0.16 to 1.43%, except for control sample. The texture profile showed that both adhesiveness and cohesiveness attributes were not significantly different among all mushroom-based frankfurters. However, frankfurter added with 6% mushroom was more cohesive and springier than the control formulation. In summary, partial replacement of chicken meat with PSC powder resulted in enhancement of dietary fibres up to 6.20% and β-glucan up to 14.30% significantly, lowering fat content but unchanged adhesiveness and cohesiveness attributes. Therefore, PSC powder can be considered to be used as an alternative functional ingredient to improve nutritional values of processed food products.

Introduction

Presently, consumption of meat product is increasing rapidly and it is expected that the demand for meat is exponentially skyroketting every year. Continually eating processed meat products like sausages/frankfurters will affect health status and at the same time will increase cancer risk (Chan *et al*., 2011). Malaysia also confront with the increase prevalence of atherosclerosis, heart disease, diabetes and other non communicable diseases. In addition, the prevalence of hypertension among Malays is high and blood pressure control is poor especially in rural residents in Malaysia (Rashid and Azizah, 2011). Malnutrition resulting in obesity will increase the rate of hypertension (Rahmouni *et al*., 2005). So, diet modification with less sodium and fat will decrease the prevalence of the above mentioned factors. According to Norimah *et al*. (2008) in food consumption pattern among Malaysian, chicken meat is consumed almost every day but there is no such report on consumption of beef as well as processed meat product.

By eating variety of food, choosing plenty of fruit and vegetable and use sparingly fat and oils in food preparation can give us a better health condition. Edible mushrooms are one of the popular fungi consumed as vegetable by consumers globally. It has been utilized a long time ago for both food and medicinal use (Cheung, 2010). Beside of it nutritive values, appeal for taste and flavor makes the mushroom itself become popular in culinary purposes. It is characterized by two parts namely; fruiting body and mycelia. According to Babu *et al*. (2010), mushroom can be defined as a macro fungus with a distinctive fruiting bodies which can be either epigeous or hypogenous. The fruiting body of this macro fungus is large enough to be seen by naked eyes and pick-up by hand. Oyster mushrooms have been reported to contain many valuable benefits such as rich in dietary fiber, protein, vitamin and mineral while having low in fat and calorific value. Besides this facts, bioactive functional component of cell wall known as β-glucan is also found in edible mushroom. The unique functionality of β-glucan is its contribution towards healthy characteristics in edible mushroom (Manzi and Pizzoferrato 2000).

Sausage-type products grew in popularity of meat products from a few decades ago until up to the present. This meat product basically cylindrical

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Table 1. The formulation of frankfurters added with PSC powder

	Oyster mushroom (PSC) powder level (%)			
Ingredient (g)	0 % (control)	2 %	4 %	6 %
Chicken breast	520	509.6	499.2	488.8
Fat	100	100	100	100
Water	250	250	250	250
Potato starch	75	75	75	75
Isolated soy protein	30	30	30	30
Salt	12	12	12	12
Herbs and spices	13	13	13	13
PSC powder	0	10.4	20.8	31.2
TOTAL	100	100	100	100

in shape, made from finely minced meat either beef, pork, lamb or chicken and seasoned with herbs, spices, salt, preservatives, fillers and other ingredients to make the sausage become more appeal for taste. The ingredient is then stuffed in tube-shaped casing made from either animal intestine or synthetic casing. The sausages are differs depending on their shape, length, ingredients, additives and curing techniques. It can be freshly processed or cured. The objective of the present study was to determine the nutritional compositions, β-glucan and textural properties of chicken frankfurters added with oyster mushroom.

Materials and Methods

Sample preparation

Sample of oyster mushroom (*Pleurotus sajor-caju*, PSC) was obtained from the National Kenaf and Tobacco Board (NKTB) located in Bachok, Kelantan, Malaysia. Fully grown mushroom was used in this study with cap is 9 to 11 cm in diameter. Oyster mushroom with smaller or bigger than this sizes range was discarded to maintain the quality of end product. Sample preparation begins with the cleaning process of the oyster mushroom. Sample was rinsed with clean water and chopped coarsely into size of 2 to 5 mm. Then, the oyster mushroom was tossed to drain excessive water and to avoid it from becoming too watery. Mushroom was then oven dried at 55°C until the creamy color obtained. The dried oyster mushroom will then ground manually for 60 seconds by using food grinder and stored in air-tight container for further usage. It was then incorporated into sausage/frankfurter formulation by the ratio set at 2, 4 and 6%. Chicken meat was used as main ingredient in the present study. The muscle tissue of chicken meat was selected from the breast part because this section has the lesser fat content compared to the other part of chicken. The other ingredients for frankfurter formulation were obtained from local suppliers. Chicken breast was purchased from local hypermarket and other dry materials such as potato starch and herbs were purchased from local market.

Frankfurter formulation

The formulation of frankfurter was following the method of Wan Rosli *et al*. (2010) with slight modification (Table 1). There are four different treatments consisting of control and three formulations of sausages added with oyster mushroom. The percentage of salt, spices and fat remain unchanged with the control sample, whereas the percentage of meat decreases with the increases of oyster mushroom powder content. The finished chicken sausages were kept in freezer (-18°C) until further analysis.

Nutrient analysis

All samples prepared with different levels of oyster mushroom powder were analyzed for moisture (air-oven method), protein (semi-micro Kjeldhal method), crude fat (Soxhlet method) and total ash content (dry-ashing method) according to standard method as described in AOAC (2000). All measurements were carried out in triplicate (n=3). Available carbohydrates were calculated by difference: available carbohydrates = 100 – (g moisture + g protein + g fat + g ash).

Total dietary fibre and β-glucan analyses

Total dietary fiber (TDF) which covers both soluble and insoluble dietary fibre was determined by enzymatic gravimetric method, based on the AOAC (1990). To determine β-glucan, mixed-linkage β-glucan procedure was used. This assay procedure adapted from Megazyme International Ireland Limited. In this method, samples were suspended and hydrated in buffer solution with pH 6.5. Then, they were incubated with lichenase enzyme and were centrifuged (Hettich–Universal 32R). The aliquot from centrifuged sample was then hydrolysed with beta-glucosidase. After that, Glucose Determination Reagent (GOPOD Reagent) was added and the samples were incubated again in water bath (Memmert – WB29) before measuring the

Table 2. Nutrient composition of chicken frankfurters incorporated with different levels of PSC powder

Chemical compositions (%)	PSC powder level (%)			
	0 (control)	2	4	6
Protein	18.41±0.18^{a}	16.22±0.13^{b}	15.32± 0.15^{c}	14.29±0.31^{d}
Fat	11.60±0.10^{a}	11.41±0.648^{ab}	11.12±0.16^{ab}	10.74±0.10^{b}
Moisture	59.36±0.68^{b}	61.98±0.19^{a}	59.83±0.91^{b}	60.13±0.15^{b}
Ash	1.79±0.04^{b}	1.55±0.04^{c}	1.92±0.01^{a}	1.750±0.01^{b}
Carbohydrate	9.46±0.75^{b}	8.84±0.67^{b}	11.82±1.03^{a}	13.90±0.37^{a}

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

absorbance using spectrophotometer (Perkin Elmer – Lamda EZ150). The absorbance was measured at 510 nm for each reaction against the reagent blank. The calculation of β-glucan in four chicken sausages was using the Mega-Calc^{TM}.

Texture profile analysis (TPA)

The texture profile attributes such as hardness, adhesiveness, cohesiveness and springiness of the all samples were analysed by using Texture Analyser TA-XT.PLUS (Stable Micro Systems, Surrey, UK) that applies mechanical compression on the foodstuff and generates a deformation curve of it response. Texture profile parameters were determined following descriptions by (Bourne, 1978). The texture analyzer was equipped with a 36mm radius cylinder probe (P/36). The operating condition included pre-test speed (2.0 mm/s), test speed (2.0 mm/s), post-test speed (2.0 mm/s), trigger force (20 g) and distance (10 mm). Three measurements per sample for a replication were recorded and three replications were done per batch.

Data analysis

Result was expressed as the mean ± standard deviation. Data obtained was analyzed using analysis of variance (ANOVA) and the Duncan Multiple range test by SPSS Predictive Analytics Software Statistics (PASW) version 18.0 (SPSS Inc, Chicago, Illinois) (SPSS Inc. 2009). All the measurement was carried out in triplicate (n= 3) analysis. Significant level established at $P \leq 0.05$.

Results and Discussion

Nutrient analysis

The nutritional composition of chicken franfurters formulated with different concentration of PSC powder is shown in Table 2. The concentration of protein in four samples was reduced with the increment levels of PSC powder. Control (0% PSC) chicken frankfurter recorded the highest protein content (18.41%) as compared to chicken frankfurters containing PSC powder at 2% (16.22%), 4% (15.32%) and 6% (14.29%). This decreasing pattern was also in line with the earlier study done on the partially replacement of fresh PSC into chicken patty (Wan Rosli *et al*., 2011b). This may be due to the original high protein content in chicken. Even though mushroom was known to have slightly higher amount of protein (Chinirang and Intarapichet 2009; Wan Rosli *et al.*, 2011a), however the amount of protein in chicken is higher than other fungi (Tee *et al.*, 1997). Thus, by partially replacing chicken meat with PSC powder, the protein level in chicken sausage containing PSC powder was slightly affected.

Apart from that, the concentration of fat was inversely proportional to the percentage of PSC powder added to partially replace chicken meat. Control chicken frankfurter (0% PSC powder) showed significantly (P<0.05) the highest fat content (11.60%) while frankfurter added with 6% of PSC powder to partially replacing chicken meat had the lowest fat content (10.74%). But, there was no significant difference (P>0.05) in fat content between 2 and 4% treatments. This reduction could be mainly because of the original grey oyster mushroom used in the present study has lower fat content (Wan Rosli *et al*., 2011b). The other type of edible mushrooms has also been previously reported to have low fat content (Pavel 2009; Mattilla *et al*., 2001; Cheung 2010). On the other hand, the significant reduction of fat in 6% treatment could explained that, with less percentage of chicken meat utilized in the frankfurter formulation, the lower fat content detected in finished frankfurter products.

Besides that, the moisture content in all chicken sausages range from 59.36% to 61.98% (Table 2). Among all samples, chicken frankfurter without PSC powder (0%) shows the lowest moisture content (59.36%). Replacement of 4 and 6% of PSC powder in chicken frankfurter formulations showed

Table 3. Calorific value, dietary fibre and β-glucan of chicken frankfurter incorporated with different levels of PSC powder

Dietary component	PSC powder level (%)			
	0 % (control)	2 %	4 %	6 %
Calorific values (kcal/100g)	511±4[a]	519±12[a]	532±15[a]	510±6[a]
Total dietary fiber (%)	0.08±0.01[d]	0.80±0.13[c]	3.03±0.15[b]	6.20±0.30[a]
β- glucan (g/100g)	0.00±0.00[b]	0.16±0.23[b]	1.33±0.27[a]	1.43±0.51[a]

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

no significant different (P>0.05) between them and control group. However, there was slightly increase in moisture retention between control chicken frankfurter and chicken frankfurter added with 2% PSC powder.

On the other result, ash content ranged from 1.55% to 1.92% was observed as shown in Table 2. Ash refers to the inorganic residue remaining after complete combustion of organic matter in food sample. Since total mineral contents can be obtained from ashing procedure, it is important in nutritional analysis to estimate the amount of mineral contents in certain foodstuff. Ash content in all four formulations did not show any patterns either decreasing or increasing trends with the different levels of PSC powder used in sausages formulation. Similar pattern was also reported in previous studies on the addition of inulin, oat fiber and wheat fiber in the sausages (Mendoza *et al*., 2001). Ash content in control Chinese sausage was 2.74%, while sausage formulated with 3.5% wheat was 2.55% of ash and 7% wheat sausage was 2.64% of ash contents. This findings also matched with the study conducted on chicken patty with grey oyster mushroom documented that with the increase of 25% to 50% of mushroom, ash content shows 2.40% and 2.27% respectively compare to control chicken patty (2.13 %) (Wan Rosli *et al*., 2011b).

Carbohydrate contents in all formulations of chicken frankfurters were increased in line with the levels of PSC used (Table 2). However, there were no significant changes (P>0.05) of carbohydrate content between control (9.46%) and 2% chicken meat replaced with PSC powder (8.84%). The highest concentration of carbohydrate (13.09%) was recorded in 6% chicken frankfurter added with PSC powder while the lowest carbohydrate content was recorded in 2% PSC powder (8.84%).

Calorific value, dietary fibre and β-glucan

Calorie is a unit of heat used to express energy values in foodstuff. It could be defined as the energy needed to raise the temperature of one gram of water by one degree Celsius. One calorie is equal to 4.187 joules. Table 3 shows the calorific value of chicken frankfurters incorporated with different PSC powder levels. The addition of 2%, 4% and 6% of PSC powder into chicken frankfurters did not alter the calorific values of the finished chicken frankfurters. Control chicken frankfurter had calorific values of 511 kcal/100g while 2%, 4% and 6% of partial replacement of PSC into chicken frankfurters had 519 kcal/100 g, 532 kcal/100 g and 510 kcal/100g respectively. However, the addition of PSC into chicken frankfurter formulations resulted in insignificant (P>0.05) content of calorific values. This finding was remarkably in contrast with the other study which documented that the replacement of meat with other natural product decreases the calorie in certain foods like chicken patty (Wan Rosli *et al*., 2011c). These variations possibly due to the difference conditions in processing procedures of frankfurter and patty. The energy values of food decreased with the decrement of fat contents in food. Frankfurter-type sausages with reduced-fat and containing fat replacer were lower in energy and cholesterol contents (Cengiz and Gokoglu 2005). There were no significant differences for calorific values for all treatments and control. The trend of increment and decrement of caloric values among all treatments were also not much differences.

Generally, the concentration of total dietary fibre (TDF) was increased proportionally with the levels of PSC powder used to replace chicken meat in frankfurter formulations (Table 3). Addition of 6% PSC powder in chicken frankfurters resulted in an increases in TDF concentration at the highest value of 6.20% compared to 4% (3.03%), 2% (0.80%) and control (0.08%). This increasing trend might contributed by the high dietary fiber concentration in PSC powder used during the preparation of processed products as reported before (Wan Rosli *et al*., 2011c). Based on findings by Chinirang and Intarapichet (2009), PSC contain about 42.5% of dietary fiber. Meanwhile, Synystsya *et al*. (2008) reported total

Table 4. Texture profiles analyses of chicken frankfurters incorporated with different levels of oyster mushroom

Texture attribute	PSC powder level (%)			
	0 (control)	2	4	6
Hardness (Kg)	0.13 ± 0.01^{a}	0.06 ± 0.01^{c}	0.08 ± 0.01^{b}	0.06 ± 0.00^{c}
Adhesiveness (Kg.sec)	-0.03 ± 0.00^{a}	-0.03 ± 0.00^{a}	-0.04 ± 0.00^{b}	-0.03 ± 0.00^{a}
Cohesiveness (Kg.sec)	0.68 ± 0.04^{b}	0.74 ± 0.48^{ab}	0.74 ± 0.03^{ab}	0.77 ± 0.01^{a}
Springiness (mm)	1.39 ± 0.01^{b}	1.41 ± 0.00^{ab}	1.43 ± 0.01^{a}	1.42 ± 0.01^{a}

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

dietary fiber of PSC is 33.1% and another finding reported that PSC has 35.6% of total dietary fiber in dry basis (Wan Rosli *et al.*, 2011c). Chicken patty incorporated with fresh PSC up to 50% shows the increasing pattern of TDF (Wan Rosli *et al*., 2011c). Incorporation of dietary fiber into processed meat products becomes a trend among food developers. A few studies have proven that addition of plant–based into processed meat product increase the dietary fiber level in the final product and indeed at the same time raised the nutritional quality of the food (Verma and Banerjee, 2003; Huang *et al*., 2011).

On the other result, the concentration of β-glucan could be observed increasing in line with the levels of PSC powder (Table 3). Control sample had 0.00% β-glucans followed by 0.16%, 1.33% and 1.43% respectively in 2, 4 and 6% of frankfurters incorporated with different levels of PSC powder. There was no significant different between control and frankfurters formulated with 2% PSC. The frankfurters containing 4 and 6% PSC powder was also showed no significant difference in β-glucans content. Partial replacement of PSC with chicken meat up to 2% reported to has a significant different with the 4 and 6% of chicken frankfurters. An increasing pattern of β-glucan concentration observed and this finding have similar pattern as compared to the previous study (Wan Rosli *et al*., 2011c). Mushroom has been shown to have a distinctive amount of β-glucan (Manzi and Pizzoferrato, 2000; Synytsya *et al*., 2008; Kim *et al.*, 2011). Thus, with the partial replacement of mushroom with chicken meat will subsequently increase the amount of β-glucan in processed meat-based product.

Texture profile analysis (TPA)

The textural characteristics of the frankfurter samples added with different levels of PSC powder are presented in Table 4. The hardness attribute of frankfurters added with PSC powder were ranging from 0.06 kg - 0.08 kg significantly lower ($P<0.05$) than control (0.124 kg). The same finding was in line with the study done by Szczepaniak *et al*. (2007). They found that shear force and hardness sausages were significantly reduced along with an increase in the amount of potato fiber and bran preparation introduced to sausage batter. However the present data was contradictory to Garcıa *et al*. (2002). Low fat sausages with added cereal fibre showed that sausages with 3% addition were harder, less elastic and less adhesive, particularly those with wheat fibre (Garcıa *et al*., 2002).

The present results also showed that the adhesiveness attribute was not significantly different ($P>0.05$) among all mushroom-based frankfurters (-0.03 kg.sec-0.04 kg) but quite significant ($P<0.05$) compared with control (-0.03 kg.sec). Cohesiveness value was also not significantly different among all mushroom-based frankfurters (0.74 kg.sec - 0.77 kg.sec). However, frankfurter added with 6% (0.77 kg.sec) mushroom was more cohesive than the control treatment (0.68 kg.sec). According to Ho *et al*. (1997) frankfurters incorporated with soybean tofu powder had showed non-significant differences between cohesiveness, springiness, gumminess, and chewiness. On the other attribute, all mushroom-based frankfurters recorded significantly higher value ($P<0.05$) of springiness (1.41 - 1.43 mm) as compared to control frankfurter (1.39mm). The cooking process of frankfurters added with oyster mushroom powder could lead to some modifications in their structure, which could cause an increase in the springiness of the patties when it is added at high concentrations (Wan Rosli *et al*., 2011c). The present result however was opposite with Mendoza *et al*. (2001) who reported that inclusion of dietary inulin in low-fat sausage resulted in decreased in adhesiveness, springiness and cohesiveness. Other study revealed that patties containing textured soya protein showed greatest effect on cohesiveness, back extrusion force and hardness of both raw and baked patties (Biswas *et al*., 2011).

Conclusion

Partial replacement of chicken meat with PSC powder was shown to affect the nutritional composition, total dietary fiber and β-glucan of chicken frankfurter. Partial replacement of PSC powder with chicken in frankfurters has resulted in increment in the total dietary fiber and parallel with the concentration of β-glucan. Besides, the concentration of fat content in all chicken frankfurters manifests the decrease pattern. Frankfurter formulated with 6% PSC being the best formulation which gave the highest nutritional compositions including total dietary fiber and β-glucan except for protein. The texture profile showed that both adhesiveness and cohesiveness attributes were not significantly different among all mushroom-based frankfurters. However, frankfurter added with 6% mushroom was more cohesive and springier than the control formulation. Therefore, PSC powder can be considered to become an alternative functional food in improving nutritional aspect of processed meat products.

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