International Food Research Journal 18: 621-627 (2011)

Colour, textural properties, cooking characteristics and fibre content of chicken patty added with oyster mushroom (*Pleurotus sajor-caju*)

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Abstract: The optical and textural properties of chicken patty formulated with different level of grey oyster mushroom (*Pleurotus sajor-caju*) at 0, 25 or 50% to replace chicken meat were investigated. The addition of up to 50% oyster mushroom to chicken patty formulations did not change colour a* (redness), compared with the control patty. Chicken patties containing oyster mushroom had lower L* value ranging from 51.02 – 52.65 compared to that of the control patty (57.86). All oyster mushroom-based patties had lower colour b* (yellowness) value compared to chicken patty without mushroom. The hardness of chicken patty decreased proportionally with the level of oyster mushroom. On the other hand, oyster mushroom-based patties were springier than the control patty. Chicken which was replaced with 25% of fresh mushroom, recorded the highest moisture retention (77.19%) and cooking yield (80.71%), respectively. However, replacement of 25% of oyster mushroom with chicken breast in chicken patty formulation was not change the moisture retention, fat retention and cooking yield compared to control patty. Chicken patty added with 50% ground oyster mushroom the highest concentration of total dietary fibre (TDF) at 4.90 g/100 g compared to chicken patty containing 25% of mushroom (3.40 g/100 g) and control (1.90 g/100 g). In summary, the addition of oyster mushroom in chicken patties has decreased the lightness, yellowness, hardness and chewiness while no changes were noted in the redness of the patties.

Keywords: Textural, optical characteristics, chicken patty

Introduction

Mushrooms have been broadly used as food or food ingredients in various food products for a long time. This fungus is cultivates on a decayed organic material and produce edible portion on the surface of the substrate. Dry matters of mushrooms contain more than 25% protein, less than 3% crude fat and almost 50% of total carbohydrate (Kotwaliwale *et al*., 2007). Mushrooms are considered to be healthy because they are low in calories, sodium, fat and cholesterol level. Therefore, they form an important constituent of a diet for a population suffering from atherosclerosis (Dunkwal *et al*., 2007). It also contain appreciable amount of dietary fibre and β-glucan, vitamin B groups, D and other useful nutrients.

β-Glucans, also a components of soluble or insoluble dietary fibre (SDF, IDF) is present in appreciable amounts in mushrooms and are linked to the ability to lower blood cholesterol levels and glycemic response (Manzi and Pizzoferrato, 2000). β-glucans are also linked with it ability to show significant immonumodulative properties, possess better antioxidant activities and exhibits scavenging capacities against free radicals (Ragunathan *et al*., 1996; Synytsya *et al*., 2008).

The dietary fibres present in the mushroom are associated with the speeding up of the transit time of bowel contents, increases bulk, frequency and ease of faecal voiding. They are also said to protect the body from irritable bowel syndrome and colon cancer. Carbohydrates and fibre from plant based materials have been used in reducing formulation cost, enhancing texture while reducing formulation cost (Colmenero, 1996; Keeton, 1994; Pinero *et al*., 2008). Various types of dietary fibres from cereal and legumes have been utilized in an attempt to improving nutritional quality and at the same time reducing production cost of meat based patties. These included the usage of oat (Aleson-Carbonella *et al*., 2005; Inglett *et al*., 2005; Steenblock *et al*., 2001; Yilmaz and Daglioglu, 2003) Palm based fats (Babji *et al*., 2001; Wan Rosli *et al*., 2006). Recently oyster mushrooms (*Pleurotus ostreatus*) were used as a substitute for pork meat in the development of the Thai glutinous fermented sausage (Chockchaisawasdee *et al*., 2010).

Extensive studies have been done in the use of various types of fat replacer and plant dietary fibre in processed meat and poultry products in attempts at increasing dietary fibre and lowering of fat content. The effect of utilization of tapioca starch, oat fibre (El-Magoli *et al*., 1996; Desmond *et al*., 1998; Dongowski *et al*., 2003; Inglett *et al*., 2005; Yilmaz

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Table 1. Chicken patty formulated with different level of ground oyster mushroom

	Mushroom level (%)		
Ingredients (%)	**Control (0)**	**25**	**50**
Chicken breast	54.0	40.5	27.0
Fat	9.0	9.0	9.0
Water	26.0	26.0	26.0
Potato starch	6.0	6.0	6.0
Ground mushroom	0.0	13.5	27.0
Isolated soy protein	3.0	3.0	3.0
Salt	1.0	1.0	1.0
Spices and seasoning	1.0	1.0	1.0
Total	100	100	100

and Daglioglu, 2003), cereal and fruit fibres (García *et al*., 2002; Hecker *et al*., 1998; Mansour and Khalil, 1999) and whey protein (El-Magoli *et al*., 1996) on the physical characteristics and sensory properties of low-fat beef patties has been studied previously. The addition of pea fiber concentrate (PFC) and wheat fiber concentrate (WFC) in beef burger formulation improves their cooking properties, i.e., increases the cooking yield and decreases the shrinkage, and minimizes production cost without ruin of sensory properties (Besbes *et al*., 2008). Recently, researchers found that dietary grape pomace concentrate and grape antioxidant dietary fibre could be successful in retarding lipid oxidation of chilled and long-term frozen stored of raw and cooked chicken patties (Sáyago-Ayerdi *et al*., 2009).

The incorporation of *Pleuratus sajor-caju* as non-meat ingredient is intended to enhance the nutritional value, physico-chemical characteristics and sensory qualities in meat based patties. The present study was focuses on the colour, textural properties, cooking characteristics and fibre content of chicken patty added with oyster mushroom (*Pleurotus sajor-caju*).

Materials and Methods

Sample preparation

Oyster mushroom (*Pleurotus sajor-caju*) was supplied by the National Kenaf and Tobacco Board of Malaysia (NKTB) from Bachok Kelantan, Malaysia. Fully-grown mushrooms with the pileus cap diameters between 9 to11 cm were used throughout the study. The mushroom was prepared by rinsing with clean water, blanched and chopped coarsely until the uniform sizes ranged from 2-5 mm is obtained . Excess water was drained to avoid patty become mushy. The prepared mushroom was then incorporated partially to replace chicken breast in patty formulations.

Chicken patty formulation

Three chicken patty formulations were compared. Each of them contains either 0 (control), 25 and 50% of ground oyster mushroom. The percentages of other ingredients are unchanged compared to the control sample, whereas the percentage of chicken breast decreases with the increase of ground oyster mushroom content. The ground oyster mushroom was incorporated into the chicken patties using the formulations described in Table 1. The finished chicken patties were directly stored in a freezer at -18°C while waiting for further analysis. Oyster mushroom was prepared in the Nutrition Laboratory of the School of Health Sciences, Universiti Sains Malaysia Health Campus. Chicken breast was purchased from local wet market. Other dry materials were purchased from local suppliers.

Processing

The chicken breast was manually cut using a cleaver and minced through a food processor (Panasonic, Model MK-5086M, Malaysia). The minced chicken flesh was stored at –18°C until processing time. Isolated soy protein was blended with water and shortening at a ratio of 1:5:5 using a Hobart mixer (N-50 Canada). The emulsion prepared (called pre-emulsion) was kept in a chiller (2-5°C) until ready for use. Salt was added to the frozen minced chicken and mixing was carried out using a Hobart mixer for 3 minutes. Water mixed with spices, potato starch and oyster mushroom were added and mixed for another 2 min. The pre-emulsion was then added and mixing continued for another 2 min. The finished chicken batters were then weighed into 70 g portions, and then manually moulded to produce a uniform patty with the diameter and thickness of 100 mm and 10mm, respectively. The raw chicken patties were then frozen in a freezer at –18°C until further analyses.

Cooking procedure

Chicken patties were thawed at 4°C for 12 h. Chicken patties were then cooked on a pan-fried electric skillet (Model KX-11K1, Sharp Corporation, Japan) for 7-8 min until an internal temperature of 72 ± 1°C was achieved.

Cooking characteristics

All cooking characteristics of chicken patties added with oyster mushroom were determined by measuring the weight of six patties for each treatment/batch and calculations of weight differences for patties before and after cooking according to El-Magoli *et al*. (1996). The cooking characteristics determined were cooking yield, moisture and fat retention, moisture retention, fat retention and diameter reduction. The detail procedures are described below:

Cooking yield

Cooking yield of chicken patties were determined by measuring the weight of six patties for each treatment/batch and calculations of weight differences for patties before and after cooking, were as follows (El-Magoli *et al*. 1996) :

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

Moisture and fat retention (percent)

The moisture and fat retention values represent the amount of moisture and fat retained in the cooked product per 100 g of raw sample. These values were calculated according to the following equations (El-Magoli *et al*. 1996).

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

$$\text{Fat retention (\%)} = \frac{(\text{cooked weight x percent fat in cooked chicken patties}) \text{ x } 100}{(\text{raw weight x percent fat in raw chicken patties})}$$

Diameter reduction (%)

Change in chicken patties' diameter was determined using the following equation:

$$\text{Diameter reduction (\%)} = \frac{\text{raw chicken patties diameter} - \text{cooked chicken patties diameter x 100}}{\text{raw chicken patties diameter}}$$

Effect of oyster mushroom addition on colour (L^*, a^* and b^*)

Colorimetric measurements of cooked chicken patties were determined in triplicate using a Colorimeter (Minolta model 3500, Minolta Camera Co., Ltd., Osaka, Japan). The instrument was calibrated with a yellow CR-A47Y standard tile: $L^* = 85.46$, $a^* = -0.13$, and $b^* = 54.58$. Five replicate measurements were taken for each sample, following the guidelines for color measurements from American Meat Science Association (Hunt and Kropf, 1987). Inner color was determined in each sample. For inner color determination the burgers were sliced through the center parallel to the surface.

Determination of calorific value

The calorific value (kJ/g dry weight or cal/g) of each sample was determined following the method described by Gopalakrishnan & Vijayavel (2009) using the bomb calorimetric technique.

Texture profile analysis (TPA)

Texture profile analysis (TPA) of chicken patties incorporated with oyster mushroom was performed with a Texture Analyser TA-XT2 (Stable Micro Systems, Surrey, UK) following (Bourne, 1978) procedures. After cooking, the patty samples were cut into uniform cubic size (2×2×0.5 cm) and subjected to a texture profile analyses. The samples were compressed to 70% of their original height with a cylindrical probe of 10 cm diameter at a compression load of 25 kg and a cross-head speed for 20 cm/min. Texture profile parameters were determined and interpreted following descriptions by (Bourne, 1978) as follows: hardness, cohesiveness, springiness and gumminess. The TPA was calibrated using fast calibration of 5 kg cylindrical probe.

Statistical analysis

Data obtained were tested for significance using ANOVA and Duncan Multiple Range Test with SAS version 6.12 (SAS, 1989). All measurements were carried out in triplicate (n = 3). The experiments were replicated twice.

Results and Discussion

Effect of oyster mushroom on colour (L^*, a^* and b^*) intensities

Effect of oyster mushroom on optical properties (Lightness L^*, redness a^*, yellowness b^*) in cooked chicken patties is shown in Table 2. Generally, data show that the higher the level of oyster mushroom, the darker the patties colour. Control chicken patties were significantly lighter (higher L^*) than chicken patties with added oyster mushroom. Chicken patties containing oyster mushroom had lower L^* value ranging from 51.02 – 52.65 compared to that of the control patty (57.86). This significant reduction in the lightness values, as a result of oyster mushroom addition could possibly due to the original grayish-white colour of fresh oyster mushroom used in patty formulations. This finding was in line with previous study done on other processed meat products added with different sources of plant based dietary fibre. Addition of grape antioxidant dietary fibre to chicken hamburgers for example significantly reduce lightness and yellowness (Sayago-Ayerdi *et al*., 2009).

Incorporation of fresh oyster mushroom of up to 50% to chicken patty formulations decreased colour b^* (yellowness), compared to control patties. In facts

Table 2. Colour analysis of chicken patties incorporated with oyster mushroom

	Oyster Mushroom Level (%)		
Colour analysis	**0 (control)**	**25**	**50**
L*	57.86±0.84[a]	51.02± 1.94[b]	52.65± 1.16[b]
a*	3.46±0.26[a]	3.61±0.29[a]	3.24±0.41[a]
b*	21.03±0.29[a]	18.77±0.47[b]	18.12±0.84[b]
C	21.31±0.32[a]	19.13±0.68[b]	18.42±1.0[b]
H	80.65±0.58[a]	79.29±2.0[a]	80.03±2.49[b]

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

Table 3. Texture profile analysis of chicken patties incorporated with oyster mushroom

	Oyster Mushroom Level (%)		
Colour analysis	**0 (control)**	**25**	**50**
Hardness (kg)	22.96±1.82[a]	13.20± 1.07[b]	11.20± 1.69[b]
Cohesiveness (mm/mm)	0.46±0.02[a]	0.37±0.04[b]	0.32±0.03[b]
Springiness (mm/mm)	0.35±0.06[a]	0.36±0.04[a]	0.40±0.03[a]
Gumminess (kg)	8.06±0.90[a]	4.75±0.61[b]	4.46±0.63[b]
Chewiness (kgsmm^{-1})	2.87±0.79[a]	1.72±0.41[b]	1.78±0.29[b]

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

the control patties had the highest b^* value at 21.03 compared to all mushroom-based patties which had value in the range of 18.77 to 18.12. In other study, the addition of lemon albedo at any type and concentration was also decreases the yellowness in the beef burger (Aleson-Carbonella *et al*., 2005).

Addition of oyster mushroom up to 50% to the formulation was not affected colour a^* (redness), compared with the control treatment. Cooked chicken patties containing 50% oyster mushroom had the lowest a^* value at 3.24 but not different with both patties containing 25% and 0% of oyster mushroom which had values of 3.61 and 3.46, respectively. The colour of sample with 0% of mushroom (control) considers within the range the colour of commercial chicken patty.

The colour of processed chicken product is one of the major factor by which consumers judge their acceptability. It also depends on various factors, including the concentration and chemical state of meat pigment, physical properties of the meat and the presence of non-meat ingredients (Sayago-Ayerdi *et al*., 2009). In summary, the addition of fresh oyster mushroom in chicken patties decreased the lightness and yellowness but did not change the redness of cooked chicken patties.

Effect of oyster mushroom addition on the textural properties of chicken patties

Table 3 shows the effects of oyster mushroom addition on the textural properties of chicken patties. Generally, all textural attributes investigated were influenced by oyster mushroom incorporation, except springiness attribute. The hardness of chicken patty decreased proportionally with the level of oyster mushroom. Oyster mushroom-based patties recorded hardness ranging from 11.20-13.20 kg and are significantly lower (P<0.05) than control patty which recorded 22.96 kg. The cohesiveness of chicken patties was also reduced proportionally with the level of oyster mushroom added. Chicken patty prepared without oyster mushroom (control) was more cohesive at 0.46 mm/mm compared to chicken patties prepared with 25% (0.37 mm/mm) and 50% (0.32 mm/mm) oyster mushroom. Similar trend was also recorded in gumminess. Addition of oyster mushroom in chicken patties reduces the gumminess attribute. Chicken patties formulated with 25 and 50% oyster mushroom were less gummy than control chicken patty. These patties recorded gumminess at 4.75 and 4.46 kg, respectively and significantly lower than control patty which was recorded 8.06 kg. The incorporation of oyster mushroom in chicken patties also reduced the chewiness. Chicken patties containing oyster mushroom recorded 1.72-1.78 kgsmm^{-1} of chewiness significantly lower than control patty (2.87 kgsmm^{-1}). However, the addition of oyster mushroom in chicken burger did not affect the springiness attributes. The textural properties of sample with 0% of mushroom (control) consider within the range the textural properties of commercial chicken patty.

Patties with added oyster mushroom (at any level) were less hard and more springy (P<0.05) than the control. This hardness reduction could be attributed to the higher moisture content of fresh oyster

Table 4. Cooking characteristics of chicken patties formulated with different level of oyster mushroom

Physical Traits (%)	Oyster mushroom Level (%)		
	0	25	50
Moisture Retention	77.82±2.00[a]	77.19±2.54[ab]	73.27±0.25[ab]
Fat Retention	81.11±3.12[a]	80.71±3.05[a]	79.40±1.67[a]
Diameter Reduction	28.58±1.40[a]	25.48±0.88[b]	24.62±2.10[b]
Cooking Yield	83.93±2.21[a]	83.77±2.76[a]	81.98±0.23[a]
Calorific value (cal/g)	2781± 32[c]	2633±35[b]	2325±39[c]

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

mushroom in meat protein systems (Kotwaliwale *et al*., 2007). Several authors have reported that the dilution effect of nonmeat ingredients in meat protein systems primarily accounted for soft texture (Comer and Dempster, 1981) (Tsai *et al*., 1998). The higher fat and water retention obtained in samples with added oyster mushroom (Table 4) could also contribute to hardness reduction (Aleson-Carbonella *et al*., 2005). The cooking process of patties added with oyster mushroom 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.

Effect of oyster mushroom addition on the cooking characteristics of chicken patties

Physical traits of cooked chicken patties incorporated with oyster mushroom are presented in Table 4. Generally, moisture retention and cooking yield characteristics were decreased in line with the level of mushroom in chicken patty formulations. Among all mushroom-based patties, chicken which was replaced with 25% of fresh mushroom, recorded the highest moisture retention (77.19%) and cooking yield (80.71%) respectively. Other mushroom-based treatments recorded moisture retention and cooking yield ranged from 73.27-77.19% and 81.98-83.77%, respectively. Even though chicken patty formulated with 25% ground oyster mushroom recorded lower moisture retention and cooking yield but there was not significantly different compared to control patty. Compared to control sample, chicken patties formulated with oyster mushroom showed a decrease ($P < 0.05$) in cooking yield. In fact, the high cooking loss was from the mushroom-based patty. This could be attributed to the high loss of moisture and fat during cooking. Cooking yield was significantly ($P > 0.05$) lower in chicken patty incorporated with fresh mushroom. Control chicken patty recorded the highest cooking yield (83.93%) but was not significant compared to patty formulated with 25% oyster mushroom. The cooking characteristics of sample with 0% of mushroom (control) consider within the range the cooking characteristics of commercial chicken patty.

There were an inverse relationship between moisture retention and cooking yield with the level of mushroom used in the chicken patty formulations. This is probably due to the inability of fresh oyster mushroom fibre to create a tridimensional matrix within the patties due to the high moisture content. The fresh oyster mushroom used in this work is high in moisture content (89%). In control patties, fat was easily removed during cooking, probably due a low density meat protein matrix, along with a high fat instability. This is in agreement with previous research (Suman and Sharma, 2003) who studied the effect of grind size and levels on the physico-chemical and sensory characteristics of low-fat ground buffalo meat patties.

The results of moisture retention of chicken patties formulated with fresh oyster mushroom were similar with the trend of cooking yield. The moisture retention was proportionally decreased with the increment of oyster mushroom content in patty formulations. The higher the amount of fresh mushroom, the higher the loss of moisture during cooking.

Mushroom-added chicken patties show more moisture and fat loss ($P < 0.05$) after cooking as compared to control chicken patty. Control chicken patty recorded 77.82% moisture retention and 81.11% fat retention while chicken patties added with mushroom up to 50% recorded moisture and fat retention ranging from 73.27-77.19% and 79.40-80.718%, respectively. It can be observed that, the addition of oyster mushroom up to 50% did not affect the fat retention. Dietary fibres increased cooking yield because of their high ability to keep moisture and fat in the matrix. This finding is supported by the previous work of (Aleson-Carbonella *et al*., 2005) on the incorporation of lemon albedo fibres in beef patty formulation. Similar findings were documented by (Mansour and Khalil, 1999) and (Turhan *et al*., 2005), who utilized wheat fibres and hazelnut pellicles, respectively in beef patty formulations.

Effect of oyster mushroom addition on dietary fibre content

Generally, the concentration of total dietary fibre (TDF) was increased in line with the level of ground oyster mushroom (Table 5). Chicken patty added with 50% ground oyster mushroom the highest concentration of total dietary fibre (TDF) at 4.90 g/100 g compared to chicken patty containing 25% of mushroom (3.40 g/100 g) and control (1.90 g/100

Table 5. Soluble (SDF), insoluble (IDF) and total dietary fibre (TDF) concentrations (g/100g) of chicken burger added with different level of ground oyster mushroom

	Oyster mushroom Level (g/100g)		
Dietary Components (%)	**0**	**25**	**50**
Soluble dietary fibre (SDF)	0.00 ± 0.00[a]	0.00 ± 0.00[a]	0.00 ± 0.00[a]
Insoluble dietary fibre (IDF)	1.90 ± 0.08[c]	3.40 ± 0.05[b]	4.90 ± 0.04[a]
Total dietary fibre (TDF)	1.90 ± 0.08[c]	3.40 ± 0.05[b]	4.90 ± 0.04[a]
β-glucan (%)	0.37± 0.04[b]	0.70 ± 0.03[a]	0.77± 0.06 [a]

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

g). Previous study reported that TDF value of the *Pleurotus ostreatus* at 34.5% are close to the values of *Pleurotus sajor-caju* at 33.1% (Synytsya *et al*., 2008). In the present study, there was no soluble dietary fibre (SDF) detected all chicken patties. Among samples, chicken patty containing 50% ground oyster mushroom had the highest IDF at 4.90 g/100 g while chicken containing 0% ground oyster mushroom had the lowest value at 1.9 g/100 g. All oyster mushroom-based patties had β-glucan value in the range of 0.70-0.77% and significantly (P<0.05) higher than control patty (0.37%). Even though chicken patty containing 50% ground oyster mushroom recorded higher value of β-glucan but was not different with chicken patty containing 25% ground oyster mushroom.

Conclusion

Chicken patties added with oyster mushroom were significantly darker than to those that were not added with mushroom. The addition of up to 50% oyster mushroom to chicken patty formulations did not change colour a^* (redness), compared with the control patty. All oyster mushroom-based patties had lower colour b^* (yellowness) value compared to chicken patty without mushroom. All textural attributes investigated were influenced by oyster mushroom incorporation, except springiness attribute. The hardness of chicken patty decreased proportionally with the level of oyster mushroom. Replacement of 25% of oyster mushroom with chicken breast in chicken patty formulation was not change the moisture retention, fat retention and cooking yield. Total dietary fibre (TDF) and insoluble dietary fibre (IDF) content was increase in line with oyster mushroom level in chicken patty formulation. In conclusion, the addition of oyster mushroom in chicken patties has decreased the lightness, yellowness, hardness and chewiness while no changes were noted in the redness of the patties. However, there was an increase in the springiness of chicken patties. Addition of 25% oyster mushroom to replace chicken breast is suitable for the purpose of production of chicken patties commercially.

Acknowledgements

The authors appreciate the funding from Universiti Sains Malaysia short term grant 304/PPSK/6131020, Saiful Haizad, Norazita, Rina Rizak, Roziyani and other staffs of School of Health Sciences who participated in sensory evaluation of mushroom-based chicken patty products. The authors would also like to thank National Kenaf and Tobacco Board of Malaysia and Omcorp Sdn. Bhd. for their technical assistance in the research.

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