International Food Research Journal 18(4): 1463-1469 (2011)

On the ability of oyster mushroom *(Pleurotus sajor-caju)* confering changes in proximate composition and sensory evaluation of chicken patty

*Wan Rosli, W. I., Solihah, M. A. and Mohsin, S. S. J.

School of Health Sciences, Universiti Sains Malaysia Health Campus, 16150 Kubang Kerian Kelantan

Abstract: The proximate composition and sensory evaluation of chicken patties incorporated with various levels of grey oyster mushroom (*Pleurotus sajor-caju*, PSC) were studied. The chicken patties were formulated with either 0%, 25% or 50% of fresh PSC. Results show chicken patty formulated with 25% PSC had protein content of 17.46% lower than the control patty which had 18.13% but it was not significant. However, protein content reduces significantly when chicken meat being replaced with 50% PSC. Meanwhile, both cooked chicken patties containing 25% and 50% PSC significantly recorded lower concentration of fat at 10.67% and 7.15%, respectively. In addition, patty incorporated with 25% PSC had moisture content of 56.91% which is significantly lower than patty formulated with 50% which had moisture of 58.80%. In the sensory evaluation, there were no differences recorded in all sensory attributes of PSC-based patties judged by untrained panellists. The reduction of sensory scores for springiness and juiciness attributes were observed parallel with the level of PSC used in the patty formulations due to the higher moisture content of fresh PSC used in the formulation. Incorporation of ground PSC to replace partially chicken meat reduces fat and ash but increase moisture content of cooked patties. The addition of PSC at 25% to partially replace chicken meat can be recommended for the purpose of lowering production cost and fat content while unchanging the protein content. On the other hand, incorporation of 50% of PSC in chicken patties reduces all proximate composition except for moisture content but maintaining the overall acceptability of chicken patties.

Keywords: ***Pleurotus sajor-caju*** **(PSC), chicken patty, proximate composition, sensory evaluation**

Introduction

Presently, global commercial mushroom production has skyrocketing by 35.9% between 1995 and 2005. It is estimated that world production of mushroom comprises about 5 million tones of fresh weight annually (Omarini *et al*., 2010). Historically, mushrooms have been used for both medicinal and culinary properties in Asian and many parts of the world. There are approximately 5000 different species of mushrooms, of which at least 1220 are reported to be edible (Muhammad Nasir *et al*., 2006). There is significant interest in the use of edible mushrooms extracts as dietary supplements based on the facts that they have a lot of bioactive compounds. Pharmaceutically bioactive mushroom constituents continue to be the main focus of most scientists, including chemical structures, isolation and efficacy experimentations *in vivo* or *in vitro*. The lipid fraction was found to contain a compound with antitumor activity, subsequently identified as ergosterol. Other mushroom constituents may inhibit promotion or progression by exerting direct cytotoxicity, against tumor cells, interfering with tumor angiogenesis or upregulating other nonimmune tumor-suppressive mechanisms (Pan *et al*., 2006).

Mushrooms have been associated with many medicinal and pharmacological properties by both eastern and western medicine. They range from lowering blood pressure, reducing cholesterol, strengthening the immune system against diseases including viral ones, improving liver function and combating tumors (Mau *et al*., 2004; Regula and Siwulski, 2007). Until now, edible mushrooms are cultivated and consumed as food or food ingredients in various food preparation and processed food products. This fungus is cultivates on a decayed organic material and produce edible portion on the various surface of the substrate. Freshly harvested edible mushrooms were reported to contain low fat content in average ranged from 0.38% to 2.28%, indicated low calorific value (kcal) contribution of mushrooms on total daily energy intake (Chye *et al*., 2008). On the other hand, the cultivated edible mushroom normally had high moisture content at more than 80%.

Apparently, fresh edible mushrooms start to perish after 1-3 days upon harvesting, due to it high moisture content and other essential nutrients. Thus, dehydration process is a vital method that would extend the shelf life of these fungi by reducing unnecessary biochemical reaction such as enzymatic browning and lipid oxidation that may lead to quality deterioration. Dry matters of mushrooms contain

*Corresponding author.
Email: *wrosli@kck.usm.my, rosliishak@gmail.com*
Tel: +609 7677649; Fax: +609 7677515

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.

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). 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 (Desmond *et al*., 1998; Dongowski *et al*., 2003; Yilmaz and Daglioglu, 2003; Inglett *et al*., 2005), cereal and fruit fibres (Hecker *et al*., 1998; Mansour and Khalil, 1999; García *et al*., 2002) and whey protein (El-Magoli *et al*., 1996) on the physical characteristics and sensory properties of low-fat beef patties has been studied previously. 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 (Sayago-Ayerdi *et al*., 2009).

It is purported that by replacing meat based ingredients with oyster mushroom into patty formulation, a saving on ingredient cost is purportedly can be achieved. Recently, we studied the colour, textural properties and cooking characteristics of chicken patty added with *Pleuratus sajor-caju* (PSC) (Wan Rosli *et al*., 2011b). In continuation to that investigation, the incorporation of (PSC) as non-meat ingredient in the present study is conducted with the focus to enhance the nutritional composition and sensory qualities while reducing formulation cost in meat based patties. This intention therefore necessitate that a thorough study to be done to determine proximate composition and acceptability (sensory) evaluation of chicken patty added with PSC. Thus, this study was ventured.

Materials and Methods

Sample preparation

Freshly harvested PSC was supplied by the National Kenaf and Tobacco Board of Malaysia (NKTB) from Bachok district of Kelantan, Malaysia. Fully-grown PSC with the pileus cap diameters between 9 to11 cm were used throughout the study. The PSC 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 PSC was then incorporated partially to partially replace chicken breast in patty formulations at 0, 25 and 50% (weight basis), respectively.

Chicken Patty Formulation

Three chicken patty formulations were compared. Each of them contains either 0 (control), 25 and 50% of ground PSC. The percentages of other ingredients are unchanged compared to the control sample, whereas the percentage of chicken breast decreases with the increase of ground PSC content. The chicken used in the present formulation is fulfilling Malaysian Food Act 281 and Regulations 1983 (Food Act, 1983). The ground PSC 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. The PSC 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.

Table 1. Chicken patty formulated with different level of ground PSC

	PSC level (%)		
Ingredients (%)	**Control (0)**	**25**	**50**
Chicken breast	54.00	40.50	27.00
Fat	9.00	9.00	9.00
Water	26.00	26.00	26.00
Potato starch	6.00	6.00	6.00
Ground PSC	0.00	13.50	27.00
Isolated soy protein	3.00	3.00	3.00
Salt	1.00	1.00	1.00
Spices and seasoning	1.00	1.00	1.00
Total	100.00	100.00	100.00

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 PSC 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 10 mm, 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.

Proximate Composition

Proximate composition was conducted using AOAC (1996) for moisture, ash, soluble dietary fibre (SDF), insoluble dietary fibre (ISF), total dietary fiber (TDF), protein by nitrogen conversion factor of 6.25 [Kjeldahl method, (AOAC, 1996) and crude fat content using the semi-continuous extraction [Soxhlet] method (AOAC, 1996). All measurements were carried out in triplicate (n = 3). Total carbohydrates were calculated by the difference: total carbohydrates = 100 – (g moisture + g protein + g fat + g ash).

Sensory Evaluation

All samples were evaluated by each untrained consumers according to the hedonic scaling method outlined by Piggott (1988). Sensory evaluations were carried out by 60 untrained consumers consisting of students and staff of the School of Health Sciences, Universiti Sains Malaysia Health Campus. The cooked patty samples were equally divided into 6 portions. Each portion of product sample was placed in sensory cups with lids coded with 3 digit random numbers. Permutation sample presentation is applied to the patties before presented to the panellists. They evaluated samples for aroma, colour, springiness, juiciness, flavour and overall acceptance on a 7 point scale (1 = dislike extremely and 7 = like extremely). Significance was established at $P \leq 0.05$ using statistics outline below.

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

Proximate composition of oyster mushroom (PSC)

The proximate composition of dried PSC is shown in Table 2. The PSC used in this study contained protein concentration of 23.3% (dry basis). This value is close to the percentage range with those reported previously by Dikeman *et al*. (2005). They discovered that the protein content of 6 dried various selected mushroom varieties were ranging from 23.4 to 43.5%. On the other result, fat concentration in oyster mushroom used in the present study is 3.0%. This value is closely to the fat content of enokitake mushroom (*Flammulina velutipes*) which had 3.7% fat (Dikeman *et al*., 2005). Total ash content recorded in oyster mushroom used in this study is 3.2%. Apart from that, dried oyster mushroom contains 35.6 g/100 g of TDF with IDF being the highest component (35.4 g/100 g) while SDF had the lowest value (0.2 g/100 g). The present results were in agreement with the dietary fibre content of the fruiting body of other mushroom species which ranged from 30-40% dry weight (Kurasawa *et al*., 1982). In addition other study has revealed that other mushroom species such as *Poria cocos* also contain the dietary fiber content in this range (Cheung, 1997). The carbohydrate content of ground PSC (dry basis) quantified in the present study was 65.5%. This value was an agreement with the article published by Chirinang and Intarapichet (2009) who reported that carbohydrate content (dry basis) in *Pleurotus sajor-caju* was 65.14%.

In our previous article, 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. 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 (Wan Rosli *et al*., 2011b).

Table 2. Chemical compositions of ground PSC

Chemical Compositions	Concentration (%)
Moisture	90.20 ± 0.30
Protein (dry basis)	23.30 ± 0.90
Fat (dry basis)	3.00 ± 0.60
Ash (dry basis)	3.20 ± 0.01
Carbohydrate	65.50
Soluble dietary fibre	0.2 (g/100g)
Insoluble dietary fibre	35.4 (g/100g)
Total dietary fibre	35.6 (g/100g)

Proximate composition of raw chicken patties formulated with PSC

The proximate composition of raw chicken patties formulated with ground PSC is shown in Table 3. Moisture content of all raw chicken patties ranged from 56.03% to 67.79%. Among all treatments analyzed, patty formulated with 50% of PSC contained higher moisture content than patties formulated with 25% PSC and control. They had 67.79% moisture while chicken patties containing 0% PSC (control) had the lowest moisture content (56.03%). The increase of moisture content in the finished products is proportionally with the level of PSC incorporated in the patty formulations. This linear relationship may be due to the high percentage of water presented in the ground PSC. In the present study, ground PSC contained 90.20% of moisture (Table 1). Even though higher moisture content was recorded in the PSC-based patties, but the values were in the same range with other different brands of locally produced commercial patties. Eventually, the appropriate levels of moisture content in any processed meat based products should not exceeding 62%. Otherwise, the patty is difficult to be shaped during forming process. In the present study, the patty formulated with 25% PSC was easily formed compared to patty containing 50% PSC.

Table 3. Proximate analyses of raw chicken patty incorporated with PSC

Chemical	**PSC Level (%)**		
Compositions (%)	**0 (control)**	**25**	**50**
Protein	14.79 ± 0.16[a]	13.52 ± 0.39[b]	10.36 ± 0.22[c]
Fat	11.91 ± 0.14[a]	9.86 ± 0.22[b]	6.43 ± 0.56[c]
Moisture	56.03 ± 0.23 [a]	61.76 ± 0.45 [b]	67.79 ± 0.91[c]
Ash	2.29 ± 0.09[c]	1.93 ± 0.10[c]	1.65 ± 0.10[b]
Carbohydrate	14.98 ± 0.26[a]	12.93 ± 0.29[b]	13.77 ± 0.65[b]

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

Protein concentration was decreased proportionally with the levels of PSC used in raw chicken patty formulation. Chicken patty formulated without PSC (control) significantly (P<0.05) recorded the highest protein concentration (14.79%) followed by patty with 25% PSC (13.52%). Apart from that, the concentration of fat was also inversely proportional to the mushroom level in raw chicken patty. Chicken patty incorporated with 50% PSC was significantly (P<0.05) recorded the lowest concentration of fat at 6.43%. The fat content of raw chicken patty incorporated with 25% PSC (9.86%) were also significantly lower (P>0.05) than control (11.91%). The lowest fat percentage detected in chicken patty formulated with 25 and 50% PSC may due to the fact that fresh PSC containing very low fat content. On the other hand, ash content was decreased with the level of PSC fibre in chicken patties. The percentage of ash in all raw chicken patties ranged from 1.65-2.29%. Chicken patties formulated with 50% ground PSC recorded the lowest concentration of ash at 1.65%.

Proximate composition of cooked chicken patties formulated with PSC

The proximate composition of cooked chicken patties formulated with ground PSC are shown in Table 4. Moisture content of cooked chicken patties ranged from 50.74% to 61.80%. Control cooked chicken patties contained lower moisture content than patties formulated with PSC. They recorded 50.74% moisture while chicken patties containing 50% PSC recorded the highest moisture content (61.80%). Reductions in moisture content of control chicken patties during cooking were as high as 9.44% (reduce from 56.03% [Table 3] to 50.74% [Table 4]) compared to chicken patty added with 25% ground PSC which was 6.23% (from 61.76% [Table 3] to 57.91% [Table 4]). These findings are in agreement with other studies on different mushroom species. Manzi *et al*. (2004) documented that cooking process result in a loss of moisture and a subsequent concentration of nutrients.

Table 4. Proximate analyses of cooked chicken patty incorporated with PSC

Chemical	**PSC Level (%)**		
Compositions (%)	**0 (control)**	**25**	**50**
Protein	18.13 ± 0.39[a]	17.46 ± 0.47[a]	14.16 ± 0.57[b]
Fat	12.92 ± 0.02[a]	10.67 ± 0.46[b]	7.15 ± 0.02[c]
Moisture	50.74 ± 0.82 [a]	57.91 ± 0.19 [b]	61.80 ± 0.09 [c]
Ash	2.13 ± 0.09[c]	2.40 ± 0.05[a]	2.27 ± 0.08[b]
Carbohydrate	16.08 ± 0.33[a]	13.56 ± 0.30[b]	14.62 ± 0.29[b]

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

The concentration of protein was decreased proportionally with the level of PSC used in cooked chicken patty. Even though chicken patty formulated with 25% PSC had protein content of 17.46% lower than the control patty which had 18.13% but it was not significant (P>0.05). Similar to raw chicken patties, cooked chicken patties formulated with 50% PSC significantly (P<0.05) show the lowest protein concentration (14.16%). Meanwhile, both cooked chicken patties containing 25% and 50% PSC significantly (P<0.05) recorded lower concentration of fat at 10.67% and 7.15%, respectively. On the other result, the percentage of ash in all cooked chicken patties range from 2.13 to 2.40%.

Carbohydrates were among predominant macronutrients and ranged from 12.93 – 14.98% (Table 3) and 13.56 – 16.08% (Table 4), respectively in both raw and cooked chicken patty formulated with and without PSC. The present data are supported with the previous works done by other scientist. Barros *et al*. (2007) have reported that carbohydrates content of cooked parasol mushroom (*Macrolepiota procera*) was 16.40 g/100 g and 80.38 g/100 g in the corresponding dried sample. In the present study, the carbohydrate content of patty added with 25% PSC showed lower content compared to patty without PSC (0%) for both raw and cooked chicken patty. This situation may possibly due to the high moisture content (57.91-61.80% shown in Table 4) presented in cooked PSC-based patties. Cooking may promote a loss of nutrient due to interactions among constituents, chemical reactions, and solubility in cooking medium and thermal degradation (Manzi *et al*., 2004).

Sensory Evaluations of Chicken Patty Formulated with PSC

Table 5 shows the sensory evaluation scores for chicken patties incorporated with PSC. Apparently, the scores of all sensory attributes were in the range between 4.10-4.67 with the patty containing 50% PSC received the highest score as perceived by untrained panellists. The present sensory data also shows that all chicken patties formulated 25 and 50% PSC were not significantly different (P>0.05) compared to control chicken patty for all attributes. Among all PSC-based patty treatments, patties containing 50% PSC had the highest scores for all sensory attributes except for colour and springiness. Chicken patty containing 25% PSC had 4.56 and 4.30 score values of colour and springiness, respectively but was not significant (P>0.05) compared to other treatments. Even though chicken patties formulated with 25% and 50% PSC had slightly higher scores (4.63 and 4.67) for flavor attributes but were not significantly different with that of control.

Table 5. Sensory attributes of cooked chicken patties as influenced by the addition of PSC (N= 60)

Sensory Attributes	PSC Level (%)		
	0	25	50
Aroma	4.38±0.52[a]	4.30±0.87[a]	4.52±0.68[a]
Colour	4.63±0.52[a]	4.56±0.64[a]	4.40±0.77[a]
Springiness	4.50±0.53[a]	4.30±0.82[a]	4.12±1.00[a]
Juiciness	4.25±0.89[a]	4.06±1.01[a]	4.10±1.01[a]
flavour	4.50±0.53[a]	4.63±0.74[a]	4.67±0.69[a]
Overall acceptance	4.63±0.52[a]	4.48±0.85[a]	4.63±0.67[a]

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

Panelists gave the similar score for overall acceptance of the patty prepared with 50% PSC and without PSC (control). On the other parts, the reduction of scores for springiness and juiciness attributes were observed parallel with the level of PSC used in the patty formulations. This lower score could be attributed to the higher moisture content of fresh PSC in poultry or beef 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 (Tsai *et al*., 1998). The lower fat content presented in patties with added PSC (Table 4) could also contribute to the lower scores of springiness and juiciness attributes supported by the previous study (Aleson-Carbonella *et al*., 2005).

To recapitulate, cconsumers were unable to differentiate aroma, colour, springiness, juiciness, flavour and overall acceptance of chicken patties made from different levels of PSC. This data indicated that consumers accepting the patties prepared with all level of PSC level. These findings are in line to our previous study where the usage of cornsilk dietary fibre did not change the sensory properties and consumer acceptability of cornsilk-based beef patties (Wan Rosli *et al*., 2011a).

Conclusion

Chicken patty (cooked) formulated with 25% PSC had protein content of 17.46% lower than the control patty (18.13%) but it was not significant. Incorporation of ground PSC in chicken patties resulted in decreasing of fat content significantly. In the sensory evaluation, there were no differences recorded in all sensory attributes of PSC-based patties judged by untrained panelists. This novel food item for incorporation in chicken patties could permit a reduction of the formulation cost without affecting sensory descriptors of the product to which the consumer is familiarized. Addition of 25% PSC to partially replace chicken meat is suitable for the purpose of production of chicken patties commercially. The addition of PSC at 25% to partially replace chicken meat can be recommended for the purpose of lowering production cost and fat content while unchanging the protein content. On the other hand, incorporation of 50% of PSC in chicken patties reduces fat, protein and carbohydrate composition but increases moisture content while maintaining the overall acceptability of chicken patties.

Acknowledgements

The authors appreciate the funding from Universiti Sains Malaysia Delivering Excelllence APEX Budget 2011 (1002/PPSK/910314), short term grant 304/PPSK/61310056, Nik Fakurudin, Norazita, Aishah, Nurhanan, Roziyani and other staffs of School of Health Sciences who participated in sensory evaluation of PSC-based chicken patty products. The authors would also like to thank National Kenaf and Tobacco Board of Malaysia and Anjaad Manufacturing Industries for their technical assistance in the research.

References

AOAC. 1996. Official Methods of Analysis of AOAC International. 16th edition. AOAC International, Maryland USA.

Aleson-Carbonella, L., Fernández-López, J., Pérez-Alvarez, J. A. and Kuri, V. 2005. Characteristics of beef burger as influenced by various types of lemon albedo. Innovative Food Science and Emerging Technologies 6: 247-255.

Cheung, P. C. K. 1997. Dietary fibre content and composition of some edible fungi determined by two methods of analysis. Journal of Agriculture and Food Chemistry 73: 255-260.

Chirinang, P. and Intarapichet, K. O. 2009. Amino acids and antioxidant properties of the oyster mushrooms, *Pleurotus ostreatus* and *Pleurotus sajor-caju*. ScienceAsia 35: 326-331.

Chockchaisawasdee, S., Namjaidee, S., Pochana, S. and Stathopoulos, C. E. 2010. Development of fermented oyster-mushroom sausage. Asian Journal of Food and Agro-Industry 3: 35-43.

Chye, F. Y., Wong, J. Y. and Lee, J. S. 2008. Nutritional quality and antioxidant activity of selected edible wild mushrooms. Food Science and Technology International 14: 375-384.

Desmond, E., Troy, D. and Buckley, D. 1998. Comparative studies of nonmeat adjuncts used in the manufacture of low-fat beef burgers. Journal of Muscle Foods 9: 221-241.

Dikeman, C. L., Bauer, L. L., Flickinger, E. A. and Fahey, G. C. 2005. Effects of stage of maturity and cooking on the chemical composition of select mushroom varieties. Journal of Agriculture and Food Chemistry 53: 1130-1138.

Dongowski, G., Drzikova, B., Senge, B., Blochwitz, R., Gebhardt, E. and Habel, A. 2003. Rheological behaviour of β-glucan preparations from oat products. Food Chemistry 93: 279-291.

Dunkwal, V., Jood, S. and Singh, S. 2007. Physico-chemical properties and sensory evaluation of *Pleurotus sajor-caju* powder as influenced by pre-treatments and drying methods. British Food Journal 109: 749-759.

El-Magoli, S., Laroia, S. and Hansen, P. 1996. Flavor and texture characteristics of low fat ground beef patties formulated with whey protein concentrate. Meat Science 42: 179-193.

Food Act 281 and Regulations. 1983. Laws of Malaysia. International Law Book Services. 2005.

García, M., Dominguez, R., Galvez, M., Casas, C. and Selgas, M. 2002. Utilization of cereal and fruit fibres in low fat dry fermented sausages. Meat Science 60: 227-236.

Hecker, K., Marg, M., Newman, R. and Newman, W. 1998. Barley β-glucan is effective as a hypocholesterolaemic ingredient in foods. Journal of the Science of Food and Agriculture 77: 179-183.

Inglett, G., Peterson, S., Carriere, C. and Maneepun, S. 2005. Rheological, textural and sensory properties of Asian noodles containing on oat cereal hydrocolloid. Food Chemistry 90: 1-8.

Kotwaliwale, N., Bakane, P. and Verma, A. 2007. Changes in textural and optical properties of oyster mushroom during hot air drying. Journal of Food Engineering 78: 1207-1211.

Kurasawa, S. I., Sugahara, T. and Hayashi, J. 1982. Studies on dietary fibre of mushrooms and edible wild plants. Nutritional Report International 26: 167-173.

Mansour, E. H. and Khalil, A. H. 1999. Characteristics of low-fat beefburgers as influenced by various types of wheat fibres. Journal of the Science of Food and Agriculture 79: 493-498.

Manzi, P., Marconi, S., Aguzzi, A. and Pizzoferrato, L. 2004. Commercial Mushrooms: Nutritional quality and effect of cooking. Food Chemistry 84: 201-206.

Mau, J. L., Chang, C. N., Huang, S. J. and Chen, C. C. 2004. Antioxidant properties of methanolics extracts from *Grifola frondosa*, *Morchella esculenta* and *Termitomyces albuminosus* mycelia. Food Chemistry 87: 111-118.

Muhammad Nasir, S., Nadeem, A. A. and Nadia, S. 2006. Effect of Different Methods of Compost Preparation and Lime Concentration on the Yield of *Pleurotus sajor-caju*. International Journal of Agriculture and Biology 8: 129-131.

Omarini, A., Nepote, V., Grosso, N. R., Zygadlo, J. A. and Alberto, E. 2010. Sensory analysis and fruiting bodies characterization of the edible mushrooms *Pleurotus ostreatus* and *Polyporus tenuiculus* ontained on leaf waste from the essential oil production industry. International Journal of Food Science and Technology 45: 466-474.

Pan, L., Pan, H., Soccol, A. T., Pandey, A. and Soccol, C. R. 2006. Advances in Mushroom Research in the Last Decade. Food Technology and Biotechnology 44: 303-311.

Piggott, J. R. 1988. Sensory analysis of foods. 2nd Edition. Elsevier Science Publishers Limited. London.

Reguła, J. and Siwulski, M. 2007. Dried shitake (*Lentinulla edodes*) and oyster (*Pleurotus ostreatus*) mushrooms as a good source of nutrient. Acta Science Polymer Technologie Alimentarius 6: 135-142.

SAS. 1989. SAS User's Guide: Statistics. Version 6.12. SAS Institute Inc., Cary, NC.

Sayago-Ayerdi, S. G., Brenes, A. and Goñi, I. 2009. Effect of grape antioxidant dietary fiber on the lipid oxidation of raw and cooked chicken hamburgers. LWT - Food Science and Technology 42: 971-976.

Tsai, S. J., Unklesbay, N., Unklesbay, K. and Clarke, A. 1998. Textural properties of restructured beef products with five binders at four isothermal temperatures. Journal of Food Quality 21: 397-410.

Wan Rosli, W. I., Nurhanan, A. R., Solihah, M. A. and Mohsin, S. S. J. 2011a. Cornsilk improves nutrient content and physical characteristics of beef patties. Sains Malaysiana 40: 155-161.

Wan Rosli, W. I., Solihah, M. A., Aishah, M., Nik Fakurudin, N. A. and Mohsin, S. S. J. 2011b. Colour, textural properties, cooking characteristics and fibre content of chicken patty added with oyster mushroom (*Pleurotus sajor-caju*): International Food Research Journal 18: 612-618.

Yilmaz, I. and Daglioglu, O. 2003. The effect of replacing fat with oat bran on fatty acid composition and physicochemical properties of meatballs. Meat Science 65: 819-823.