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The effect of addition of oyster mushroom (*Pleurotus sajor-caju*) on nutrient composition and sensory acceptation of selected wheat- and rice-based products

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Abstract

Mushroom cultivation has been more popular recently in Malaysia. They are favoured due to their delicious flavour and low calorific value. Apart from that, they also contain high amount of protein and other essential nutrients. As recommended by food pyramid, people should take in more of their calories from whole grains-based foods than any other sources. Three selected carbohydrate based products namely rice-porridge (RP), paratha flat bread (PB) and conventional cake (CC) were formulated with dried *Pleurotus sajor-caju* (PSC) powder. All three products were analyzed for proximate analysis and sensory evaluation. Result shows the percentage of moisture, ash, fat and protein of RP increased in line with the levels of PSC powder used except for carbohydrate. Whereas for PB and CCs added with 2%, 4% and 6% PSC, the percentage of all nutrients were higher than control (0%) except for fat. Mushroom-based RP had significantly higher value of odour attribute as compared to control, with RP added with 6% PSC powder received the highest score. Meanwhile, mushroom-based PB received better score on textural attribute compared the control. In CC, panels prefer the cake added with 4% PSC powder as they gave higher scores for softness and flavour attributes. In conclusion, addition of PSC powder to partially replace rice and wheat flour in RP, CC and PB enhance essential nutritional components and well accepted by consumers. Thus, PSC powder can be considered to be utilized in carbohydrate–based food products with the purpose of enhancing nutrient compositions without affecting its sensory acceptance.

Introduction

The science of nutrition has moved to understanding the physiological and genetic mechanisms by which the diet and individual food components influence health and disease (Young, 1996). A number of different terms are used to describe many natural products currently being developed for health benefit. These include nutraceutical, functional food, pharmafood, phytochemical, designer food, vitafood and foodaceutical.

Functional foods are not medicines. The term functional food is commonly used for food-based products whereas the term nutraceutical is used for a supplemented form. Both terms can be considered to be natural products which provide health benefits (Stephen, 1988). In the United Kingdom, the Ministry of Agriculture, Fisheries and Food (MAFF) has developed a definition of functional food as: A food that has a component incorporated into it to give a specific medical or physiological benefit, other than a purely nutritional benefit (Cockbill, 1994).

Foods as well as functional foods provide us proteins, carbohydrates, fat, fibre, vitamins and essential minerals as well as healthy phytochemicals needed for various body functions to keep healthy. Luckily this can meet such diverse requirements by ingesting a variety of food daily. Carbohydrates are an important source of energy in human diets comprising some 40-80% of total energy intake (Mohd *et al*., 2005). Unlike fat and protein, consumption of high levels of dietary carbohydrate, provided it is obtained from a variety of sources, is not associated with adverse health effects.

We derive energy from macronutrients which are proteins, lipids, and carbohydrates. Carbohydrates serve as the main source of energy for many communities. It should be our primary source of

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kilocalories. The primary function of flours and grains is to provide calories. They are also important in providing the basic structure and texture of a product (Shewfelt, 2009). Rice porridge (RP) or gruel is a popular breakfast dish in many Asian countries including Malaysia. Instant RP has become more popular especially at fast food restaurants. It is known as congee in cantonese or juk in mandarin. This rice porridge is eaten with pickled vegetables, with tiny bits of meat or legumes or even with the previous day's leftovers in or served with it (Newman *et al*., 1999).

World wide bread consumption accounts for one of the largest consumed foodstuffs, with over 20 billion pounds (9 billion kg) of bread being produced annually (Heenan *et al*., 2008). Water and flour are the most significant ingredients in a bread recipe, as they affect texture and crumb the most. Paratha is a griddled wheat bread prepared from ground whole wheat flour or atta flour. Whole wheat or wholemeal flour is made from the complete wheat kernel with nothing removed. This flour makes a fuller flavoured, nutritious but denser loaf than plain flour. The extra bran hinders rising (Treuille and Ferrigno, 1998).

Food stereotypes, expectations and liking/ disliking are very important personal factors in food choice. For centuries baked cereal products have been present in our diets. Bread and wheat flour derivates are consumed throughout continents and civilizations representing one of the most consumed foodstuffs. The overall quality of food can be divided into three main categories which are quantitative, hidden and sensory (Kramer, 1996).

Sensory evaluation is used to measure quality of food with human subjects. Sensory evaluation is important because it provides us with insight into how consumers react to the quality of a product (Shewfelt, 2009). Hedonics sensory analysis relates to present and unpleasant states of an organism. In hedonic scaling affective, ratings of preference or liking and disliking are measured (Land and Shepherd, 1988). Cooking induces changes in flavour, colour and texture, usually in desirable ways, but sometimes in undesirable ways.

Customers tend to avoid new foods, a phenomenon called neophobia. Some consumers are actively looking for new foods and try many new products. New products are developed for a variety of reasons, such as a new idea, a new trend, a problem confronting consumers, a new technology for food production, a new type of material for packaging or the introduction of a foreign dish. Some new products represent major changes and are truly innovative. These products may change the way the consumers eat or even think about eating.

Human have been eating different food groups such as meat and plant-based including fungi or edible mushrooms for thousands of years. Edible mushrooms have been consumed as food and medicine in many cultures (Bobek *et al*., 1997; Yang *et al*., 2001; Chocksaisawasdee *et al*., 2010; Wan Rosli *et al*., 2011). Mushrooms are fungi which commonly grown in the shady area and prolifically propagated through its spores. They are versatile and may be eaten fresh or cooked entirely. Today, mushrooms are eaten by people for their unique flavour, texture as well as for the health benefits they accord.

Mushrooms have been consumed and appreciated for their flavour, economical and ecological values and medical properties for many years (Sanchez, 2010). Mushrooms are healthy foods, low in calories and fat, but high in vegetable proteins, chitin, vitamins and minerals (Manzi *et al*., 1999). Some species of wild mushrooms are sold in the local wet markets as vegetable and many researchers focused on their therapeutic effects and cultivation methods (Tan and Wahab 1997; Pathmashini *et al*., 2008; Rashad *et al*., 2009; Beluhan and Ranogajec 2011).

The annual world production of cultivated mushrooms was 6 million metric tons in 1997, increased more than 1 million compared in 1994 (Chang, 2008). Sanchez (2010) reported that Pleurotus ostreatus is the second most cultivated edible mushroom worldwide after Agaricus bisporus which constitute about 25% of total world production of cultivated mushrooms. *Pleurotus* species of mushrooms are produced world-wide with China being the major producer. A number of different species are grown including, *Pleurotus ostreatus*, *Pleurotus sajor-caju*, *Pleurotus cystidus*, *Pleurotus cystidus*, *Pleurotus citrinopileatus* and *Pleurotus flabellatus*. The *Pleurotus* spp. is rich in medicinal values where *Pleurotus sajor-caju* has hypertensive effects through its active ingredients (Alam *et al*., 2008). Bobek *et al*. (1997) reported in-vivo studies and found that diet from oyster mushroom effectively retarded the progression of hypercholesterolemia and accumulation of cholesterol in liver.

Majority of processed foods do provide some nutritional value. Healthy developed processed foods sometimes provide an acceptable nutritional components and awesomeness in sensorial quality to consumers. Some people even prefer the flavour developed from processed foods as compared to fresh products. Therefore the aim of the present study was to investigate the proximate compositions and sensory acceptance of rice-porridge (RP), paratha bread (PB) and conventional or creaming cakes (CC)

formulated with *Pleurotus sajor-caju* (Grey Oyster Mushroom).

Materials and Methods

Sample preparation

Fresh samples of oyster mushroom (*Pleurotus sajor-caju*, PSC) were supplied by the National Kenaf and Tobacco Board of Malaysia (LKTN) from Bachok Kelantan. Samples were dried using Anjaad™ method. Anjaad™ is a unique drying technique using slow heating combined with an adjustable air breeze developed by a local small medium enterprise (SME) with established named of Anjaad Industries (M) Sdn Bhd, based in Malacca state of peninsular Malaysia.

Product development

There are three types of carbohydrate-based products which substituted with mushroom powder (PSC), namely rice-porridge (RP), paratha bread (PB) and conventional cakes (CC). There are four formulations for each product which are 0 (control), 2, 4 and 6 percent of PSC powder substituting the multipurpose flour partially.

Preparation of rice-porridge (RP)

Fresh cooking oil (palm oil) was heated with moderate flame and both onion and garlic were gently fried about one min. Meanwhile the rice were washed and added with 480 ml of water and boiled for 10 min. Other ingredients (carrot, pepper, salt and remaining water) were added and continue to boil for 30 min until rice starch become completely gelatinized. The cooked RP was then used for further analysis.

Preparation of paratha bread (PB)

Flour and water were uniformly mixed in a large bowl. The dough was then kneaded manually for one minute and the dough was then stretched using a baked roller. Margarine was spread on top of the dough and the dough were fold to make it a square shape. The dough was stretched again using baked roller and the dough was toasted it with moderate flame around two minutes each side.

Preparation of creaming cake (CC)

Exactly 120 g of both butter and castor sugar were uniformly mixed using table mixer. Eggs were then added one by one and the mixture was continually mixed. Sieved flour and PSC powder were then added and mixing process was continued. Milk and vanilla essence were poured and mixing process continued. The batter was put in a baking pan and the batter was then immediately baked with temperature 160ºC for seventy min.

Proximate analysis

All samples of PSC powder were analyzed for chemical composition (moisture, fat, ash, protein and carbohydrate) content by using the Association of Official Analytical Chemists Method (AOAC, 1996) with slight modifications. The moisture content was determined by drying in an oven at 105ºC for 24 h. The crude protein content (N x 6.25) of the samples was estimated by the macro Kjeldahl method. The crude fat was determined by extracting a known weight of samples with petroleum ether, using a Soxhlet apparatus. The ash content was determined by incineration at 500 ± 15ºC. Total carbohydrates were calculated by the difference: total carbohydrates = 100 – (g moisture + g protein + g fat + g ash).

Sensory analysis

All selected carbohydrate-based products used in the present study were added with different level of dried mushroom powders (PSC) at 2% to 6% and the acceptability attributes were analyzed using hedonic scale sensory method. Sensory panels were randomly selected from University's staff and students. Sensory forms with seven point hedonic scales (0= dislike extremely and 7=like extremely) were used to differentiate the panel preferences degree of liking. Six attributes evaluated were colour, odour, appearance, softness, chewiness, flavour and overall acceptance. Each sample was placed in a small sample container coded with random permuted three digit numbers.

Statistical analysis

All analyses were performed in triplicate. Statistical analyses were conducted using Statistical Package for Social Science for windows (SPSS), version 16. Results were analyzed by two-ways Analysis of Varians (ANOVA). Differences among means were tested by the Duncan's test. Significance level was defined using $p < 0.05$.

Results and Discussion

Proximate composition: rice-porridge (RP)

Table 1 lists the proximate composition of RP formulated with PSC at four different levels. This data shows that percentage of all mean values of moisture, ash, fat and protein increased proportionally with the level of mushroom powder except for carbohydrate. The mean values of RP sample containing 6% of mushroom powder were significantly higher ($P<0.05$) compared to control (0%). Meanwhile the mean value of ash content were significantly different ($P<0.05$) for all samples. Ash is the inorganic residue

Table 1. Proximate value of rice-porridge (RP) added with different levels of PSC powder

Proximate value	A (Control)	B (2%)	C (4%)	D (6%)
Moisture	80.42 ± 4.24^{b}	82.76 ± 4.76^{ab}	86.93 ± 0.57^{ab}	88.53 ± 2.23^{a}
Ash	0.70 ± 0.08^{d}	0.90 ± 0.10^{c}	1.08 ± 0.03^{b}	1.23 ± 0.53^{a}
Fat	0.28 ± 0.03^{b}	0.33 ± 0.09^{ab}	0.39 ± 0.13^{ab}	0.48 ± 0.07^{a}
Protein	1.12 ± 1.20^{b}	1.19 ± 0.12^{ab}	1.39 ± 0.20^{ab}	1.47 ± 0.14^{a}
Carbohydrate	97.90 ± 0.25^{a}	97.57 ± 0.29^{ab}	97.14 ± 0.31^{bc}	96.82 ± 0.48^{c}

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

Table 2. Proximate value of paratha breads (PB) added with PSC powder

Proximate value	A (Control)	B (2%)	C (4%)	D (6%)
Moisture	22.60 ± 5.13^{b}	25.66 ± 3.67^{ab}	27.01 ± 0.49^{ab}	29.50 ± 0.82^{a}
Ash	1.32 ± 0.06^{b}	1.39 ± 0.12^{ab}	1.45 ± 0.06^{ab}	1.64 ± 0.22^{a}
Fat	5.25 ± 0.25^{a}	4.43 ± 1.29^{a}	2.71 ± 0.16^{b}	1.99 ± 0.29^{b}
Protein	8.62 ± 0.13^{c}	9.16 ± 0.22^{b}	9.8 ± 0.38^{a}	10.01 ± 0.22^{a}
Carbohydrate	84.8 ± 0.43^{b}	85.02 ± 1.39^{ab}	86.04 ± 0.24^{ab}	86.36 ± 0.46^{a}

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

Table 3. Proximate value of PSC-based creaming cakes (CC)

Proximate value	A (Control)	B (2%)	C (4%)	D (6%)
Moisture	31.36 ± 0.05^{a}	32.28 ± 0.48^{a}	32.70 ± 1.49^{a}	32.82 ± 0.04^{a}
Ash	1.71 ± 0.10^{a}	1.74 ± 0.04^{a}	1.80 ± 0.18^{a}	1.89 ± 0.01^{a}
Fat	19.33 ± 0.07^{a}	15.85 ± 3.36^{ab}	15.11 ± 3.48^{ab}	13.89 ± 0.24^{b}
Protein	10.01 ± 0.51^{c}	10.32 ± 0.37^{c}	11.24 ± 0.09^{b}	12.23 ± 0.24^{a}
Carbohydrate	68.95 ± 0.54^{b}	72.47 ± 3.54^{ab}	72.93 ± 0.65^{a}	71.99 ± 0.45^{ab}

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

from the incineration of organic matter. The ash of baked products depends mainly on their salt content (Pomeranz and Meloan, 2000). Bonatti *et al*. (2004) reported 5-6% of ash in dried *Pleurotus sajor-caju* whereas Alam *et al*. (2008) reported ash value as 1.1 and 8.28 g/100g in fresh and dried Pleurotus sajor-caju respectively.

The RP sample formulated with 6% PSC powder recorded the highest content of ash (1.23%) and significantly higher than the other treatments (0.70-1.08%). The RP added with 6% PSC powder recorded protein content at 1.47% and significantly higher than control (1.12%). On the other nutrient, all RP samples recorded lower fat content ranging from 0.28-0.48%. Meanwhile, all PSC-based RP recorded higher moisture content ranging from 82.76-88.53% compared to control (80.42%).

Proximate composition: paratha bread (PB)

Flat bread or unleavened bread is a staple food for many ethnics groups of people (Huang, 1996). It is particularly important and routinely consumed by people in the Middle East region and Indian subcontinent. Paratha bread (PB) is one of the popular flat bread consumed especially among Indians. Whole wheat flour or atta flour is the main raw ingredient used for PB preparation baked on flat griddles. Pai *et al*. (2005) reported the PB had higher satiety value compared to leaven bread may be attributed to the higher fibre content. The feeling of fullness that relates to a state of inhibition over eating is referred to as satiety.

Table 2 shows the proximate composition of mushroom-based PB with four different formulations. It shows that the percentage of all proximate values increased in line with PSC powder used in PB formulations except for fat. The PBs formulated with 6% PSC powder recorded the highest composition of protein (10.01%), ash (1.64%) and carbohydrate (86.36%). These values were significantly different (P<0.05) compared to control (0%). On contrary, the fat content was inversely proportional with the levels of PSC powder. In typical white flour, approximately 0.55% of flour weight is ash, 71.00% is carbohydrate, 13.00% is protein, 1.00% is lipid and 14.00% is water (Scanlon and Zghal, 2001).

Proximate composition: creaming cakes (CC)

The proximate composition of creaming cake added with four different levels of PSC powder was shown in Table 3. It shows that the percentage of all mean values of mushroom cakes added with 2,4,and 6% were higher than control sample (0%) except for fat. Only the value of ash and moisture content were not significantly different (P<0.05) for all samples.

Proteins are important components of muscle tissue. Enzymes are also proteins and are needed to catalyze metabolic processes in our bodies (Shewfelt, 2009). Percentage of protein value for cake formulated with 6% PSC powder was significantly higher (12.23%) compared to the control samples (10.01%). Contradictory, fat content of cake formulated with 6% PSC powder was significantly lower (13.89%) compared to control sample (19.33%). This might be due to the fact that PSC powder used in the present study had significant amount of protein at 23.30% and low fat content at 3.00% (unpublished data). Dried Pleurotus sajor-caju contained 4.99 and 5.26% of fat cultivated in banana straw and rice straw respectively (Bonatti *et al*., 2004).

The cakes formulated with 6% PSC powder recorded the highest content of ash (1.89%) but not significant compared to the other treatments which had ash content ranging from 1.71 to 1.80%. Meanwhile, all PSC-based cakes recorded moisture content ranging from 32.28-32.82% and not significant compared to control (31.36%).

Sensory evaluation of rice-porridge (RP)

Overall, for PSC-based RP, panels prefer RP added with 4% PSC powder (Table 4). For odour attribute, control RP was significantly differed with the PSC-based samples. It shows that panels prefer PSC-based RP compared to control product. In fact, the highest percentage of PSC powder used (6%) in the RP, had the highest score as perceived by the

Table 4. Sensory analysis value of rice-porridge (RP) added with different levels of PSC powder

Attribute	Samples			
	A (0%)	B (2%)	C (4%)	D (6%)
Colour	4.11 ± 1.65[a]	4.49 ± 0.99[a]	4.43 ± 1.28[a]	4.57 ± 1.26[a]
Odour	3.81 ± 1.27[b]	4.49 ± 1.19[a]	4.46 ± 1.17[a]	4.68 ± 1.36[a]
Appearance	4.05 ± 1.65[a]	4.32 ± 1.16[a]	4.49 ± 1.15[a]	4.32 ± 1.27[a]
Chewiness	4.78 ± 1.34[a]	4.24 ± 1.28[a]	4.49 ± 1.19[a]	4.46 ± 1.24[a]
Flavour	3.95 ± 1.22[a]	3.73 ± 1.24[a]	4.05 ± 1.43[a]	3.70 ± 1.29[a]
Overall	4.05 ± 1.37[a]	4.19 ± 1.02[a]	4.41 ± 1.34[a]	4.39 ± 1.2[a]

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

Table 5. Sensory analysis value of *paratha* bread (PB) added with different levels of PSC powder

Attribute	Samples			
	A (0%)	B (2%)	C (4%)	D (6%)
Colour	4.63 ± 1.21[a]	5.22 ± 1.10[a]	4.63 ± 1.48[a]	4.69 ± 1.23[a]
Odour	4.63 ± 1.16[a]	5.06 ± 1.34[a]	4.72 ± 1.30[a]	4.97 ± 1.18[a]
Appearance	4.50 ± 1.37[a]	4.94 ± 1.22[a]	4.56 ± 1.44[a]	4.78 ± 1.29[a]
Chewiness	3.72 ± 1.59[b]	4.59 ± 1.21[a]	3.94±1.44[ab]	4.56 ± 1.54[a]
Flavour	4.09 ± 1.40[ab]	4.81 ± 1.26[a]	4.03 ± 1.40[b]	4.47 ± 1.46[ab]
Overall	4.13 ± 1.41[b]	4.84 ± 1.08[a]	4.22±1.31[ab]	4.53 ± 1.24[ab]

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

Table 6. Sensory analysis value of creaming cake (CC) added with different levels of PSC powder

Attribute	A (Control)	B (2%)	C (4%)	D (6%)
Colour	5.82 ± 1.34[a]	4.85 ± 1.34[b]	4.79 ± 1.43[b]	4.21 ± 1.59[c]
Odour	5.72 ± 6.60[a]	4.85 ± 1.34[a]	5.13 ± 1.50[a]	5.18 ± 1.31[a]
Appearance	5.59 ± 1.24[a]	4.67 ± 1.26[bc]	5.02 ± 1.31[b]	4.42 ± 1.66[c]
Softness	4.75 ± 1.59[a]	4.67 ± 1.75[a]	4.77 ± 1.62[a]	4.16 ± 1.62[a]
Flavour	4.62 ± 1.28[a]	4.57 ± 1.64[a]	4.80 ± 1.47[a]	4.41 ± 1.50[a]
Overall	5.23 ± 1.26[a]	4.75 ± 1.42[ab]	5.13 ± 1.27[a]	4.44 ± 1.37[b]

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

panels for odour attribute. For odour attribute, all PSC-based PR received higher score as compared to control. It indicated that RP containing PSC powder give better odour attribute compared to normal RP.

Other attributes show not significantly different among all samples. The result shows that consumer accept porridges prepared with PSC powder. The RP containing 6% PSC powder received the highest value for both colour (4.57) and odour (4.68) attributes. It is indicated that consumers prefer higher percentage of PSC powder to be used in RP formulation. Addition of 4% PSC powder in the RP had received the highest value for appearance (4.49), flavour (4.05) and overall (4.41) attributes. However, control RP had the lowest value for colour, odour, appearance and overall attributes.

Sensory evaluation of paratha bread (PB)

Water and flour are the most significant ingredients in a bread recipe, as they affect texture and crumb the most. Table 5 shows the values for all attributes used for mushroom-based PB as perceived by the panels of sensory analysis done in Universiti Sains Malaysia. There were no significant difference for attribute colour, odour and appearance for all samples. Chewiness attribute for mushroom-based PB were significantly higher than the control sample. The present result shows that panels prefer PB formulated with PSC powder in enhancing chewiness attribute. For flavour and overall acceptance attributes, panels prefer 2% of PSC powder added in the product compared to the other treatments. This is may be due to the atta flour which has its own unpleasant odour. In fact, sample PB which contains 2% of PSC powder, received the highest value for all attributes. The score values were ranging from 4.81 to 5.22.

Sensory evaluation of creaming cake (CC)

Acceptance of a food by consumers is generally affected by its various attributes. There are three significant attributes and three not significant attributes among the four samples in sensory analysis for mushroom cakes (Table 6). The former are overall acceptance, colour and appearance whereas the latter are odour, softness and flavour. Four basic taste modalities which are sweet, sour, salt and bitter are perceived by receptors on the tongue.

In the present study, mean value of all PSC-based CC sample received lower score values for colour, appearance and overall acceptance. Among all PSC-based CC, cakes prepared with 4% PSC powder received the highest scores for odour (5.13), appearance (5.02), softness (4.77), flavour (4.80) and overall acceptance (5.13). Even though CC containing 4% recorded higher softness and flavour attributes among all PSC-based cakes, but it was not significant with other treatments.

Conclusion

The present study has revealed that the percentage of moisture, ash, fat and protein of RP increased in line with the levels of PSC powder used except for carbohydrate. Meanwhile the percentage of protein, ash and carbohydrate of both PB and CC prepared with PSC powder up to 6% had higher values than control except for fat. In sensory analysis, RP added with PSC powder had significantly higher value for odour attribute as compared to the control sample, with 6% treatment received the highest scores. Meanwhile, mushroom-based PB showed better texture compared the control sample and for CC, panels prefer sample containing 4% for softness and flavour attributes. In conclusion, these selected carbohydrate-based products formulated with PSC contained essential nutritional components and well accepted by consumers. Thus, PSC powder can be considered to be applied in other food items with the purpose of enhancing nutrient compositions without

jeopardizing it sensorial characteristics.

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References

Alam, N., Amin, R., Khan, A., Ara I., Shim, M.J., Lee, M.W. and Lee, T.S. 2008. Nutritional analysis of cultivated mushrooms in Bangladesh - *Pleurotus ostreatus*, *Pleurotus sajor-caju*, *Pleurotus florida* and *Calocybe indica*. Mycobiology 36(4): 228-232.

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

Beluhan S. and Ranogajec A. 2011. Chemical composition and non-volatile components of Croatian wild edible mushrooms. Food Chemistry 124:1076–1082.

Bobek, P., Ozdín, L. and Kuniak, L. 1997. Effect of oyster mushroom and isolated β-glucan on lipid peroxidation and on the activities of antioxidative enzymes in rats fed the cholesterol diet. The Journal of Nutritional Biochemistry 8(8): 469-471.

Bonatti, M., Karnopp, P., Soares, H.M. and Furlan, S.A. 2004. Evaluation of *Pleurotus ostreatus* and *Pleurotus sajor-caju* nutritional characteristics when cultivated in different lignocellulosic waste. Food Chemistry 8: 425-428.

Chang S.T. 2008. Overview of mushroom cultivation and utilization as functional foods. In Cheung P.C.K. Mushrooms as functional foods. p.1-30. Canada. John Wiley & Sons.

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(1): 35-43.

Cockbill, C.A. 1994. Food law and functional foods. British Food Journal 96(3): 3-4.

Heenan, S.P., Dufour, J.P., Hamid, N., Harvey, W. and Delahunty, C.M. 2008. The sensory quality of fresh bread: Descriptive attributes and consumer perceptions. Food Research International 41(10): 989-997.

Huang, S. 1996. Wheat products: breads, cakes, cookies, pastries, and dumplings. In Ang Y.W., Liu K.S. and Huang Y.W. Asian foods: science and technology. p.453-463. United States of America. Technomic.

Kramer, A. 1996. Parameters of quality. Food Technology 20: 1147-1148.

Land D.G. and Shepherd, S. 1988. Scaling and ranking Methods. In Piggot J.R. Sensory analysis of foods. United States of America. Elsevier Science.

Manzi, P., Gambelli, L., Marconi, S., Vivanti, V. and Pizzoferrato, L. 1999. Nutrients in edible mushrooms: an inter-species comparative study. Food Chemistry 65(4): 477-482.

Mohd I.N., Khor G.L. and Tee E.S. 2005. Recommended nutrient intakes for Malaysia. A report of the technical working group on nutritional guidelines. Putrajaya : National Coordinating Committee on Food and Nutrition.

Newman J.M. 1999. Cultural aspects of Asian dietary habits. In Ang Y.W., Liu K.S. and Huang Y.W. Asian Foods: science and technology. p.453-463. United States of America. Technomic.

Pai, S., Ghugre, P.S. and Udipi, S.A. 2005. Satiety from rice-based, wheat-based and rice-pulse combination preparations. Appetite 44(3): 263-271.

Pathmashini L., Arulnandhy V. and Wijeratnam R.S.W. 2008. Cultivation of oyster mushroom (*Pleurotus ostreatus*) on sawdust. Ceylon Journal of Science (Biological Sciences) 37(2):177-182.

Pomeranz Y. and Meloan C.E. 2000. Food Analysis: Theory and practice. United States of America. Aspen.

Rashad M.M., Abdou H.M., Mahmoud A.E. and Nooman M.U. 2009. Nutritional analysis and enzyme activities of *Pleurotus ostreatus* cultivated on citrus limonium and carica papaya wastes. Australian Journal of Basic and Applied Sciences 3(4): 3352-3360.

Sanchez C. 2010. Cultivation of Pleurotus ostreatus and other edible mushrooms. Applied Microbiology and Biotechnology 85: 1321-1337.

Scanlon, M.G. and Zghal, M. C. 2001. Bread properties and crumb structure. Food Research International 34(10): 841-864.

Shewfelt R.L. 2009. Introducing Food Science. Great Britain. CRC Press.

Stephen A.M. 1988. Regulatory aspects of functional products. In Mazza G. Functional foods: biochemical and processing aspects. p. 403-433.U.S.A. Technomic.

Tan, Y.H. and Wahab, M.N. 1997. Extracellular enzyme production during anamorphic growth in the edible mushroom, *Pleurotus sajor-caju*. World Journal of Microbiology and Biotechnology 13(6): 613-617.

Treuille E. and Ferrigno U. 1998. Bread. London. Dorling Kindersley.

Wan Rosli, W.I., Solihah, M.A., Aishah, M., Nik Fakurudin, N.A. and Mohsin, S.S.J. 2011. 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.

Yang, J.H., Lin, H.C. and Mau, J.L. 2001. Non-volatile taste components of several commercial mushrooms. Food Chemistry 72(4): 465-471.

Young J. 1996. A perspective on functional foods. Food Science and Technology Today, 10: 1-18.