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EFFECT OF VARYING RATIOS OF OYSTER MUSHROOM POWDER TO TAPIOCA FLOUR ON THE PHYSICOCHEMICAL PROPERTIES AND SENSORY ACCEPTABILITY OF FRIED MUSHROOM CRACKERS

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ABSTRACT

The objective of this study was to determine the effect of different ratios of powder prepared from oyster mushroom to tapioca flour on the physicochemical properties and sensory acceptability of fried mushroom crackers. Four recipes for crackers were formulated with varying ratios of oyster mushroom powder to tapioca flour, i.e. 5:95; 10:90; 15:85 and 20:80. The control sample comprised 100% tapioca flour. Sensory acceptability was performed using an affective test on a 7-point hedonic scale. Fried mushroom crackers showed significant decreases ($p<0.05$) in the L* value, oil absorption and hardness, while the b* value, linear expansion, ash and protein contents increased when the content of oyster mushroom powder was increased in the crackers. Sensory acceptability of the crackers was significantly improved ($p<0.05$) with the addition of oyster mushroom powder as compared with the control. Crackers made with 15% of oyster mushroom powder and 85% of tapioca flour gave the highest mean score in all the evaluated sensory attributes; they were not significantly different ($p>0.05$) in these respects from crackers containing 20% oyster mushroom powder. These results can be useful in the development of vegetarian fried mushroom crackers that may serve as an alternative to crackers more commonly based on fish or other seafood.

Key words: Oyster mushroom powder, tapioca flour, physicochemical properties, sensory acceptability, fried mushroom cracker

INTRODUCTION

Grey oyster mushroom *(Pleurotus sajor-caju)* is a popular mushroom species commonly used in the kitchen and in the food industry. It has a meaty texture, an intense umami taste (Tsai *et al.*, 2009), subtle flavour as well as high nutritional value (Fernandes *et al.*, 2015). The mushroom contains carbohydrates (70–76 g/100 g), protein (19–35 g/100 g), fibre (4–20 g/100 g), minerals (Ca, K, Mg, Na, P, Cu, Fe and Mn), vitamins such as B_1, B_2, B_{12}, niacin, folate and ascorbic acid; it is low in fat (Rabinovich *et al.*, 2007). The shelf life of fresh mushroom is about 24 h after harvesting owing to its high moisture content coupled with generally high rates of metabolism, respiration and dehydration (Villaescusa & Gil, 2003; Zhang *et al.*, 2012). Nevertheless, oyster mushroom can be stored for periods of between 4 to 7 days at 4°C (Ares *et al.*, 2007). Recent attempts have been made to dry oyster mushroom under the sun or in ovens for conversion into a powder (Muyanja *et al.*, 2012; Zhang *et al.*, 2012). Food products in which mushroom powder can be used include soup (Henna & Norziah, 2011), wheat bread (Mahedy *et al.*, 2012), paratha bread, conventional cake and rice porridge (Aishah & Rosli, 2013), as well as snack foods (Parab *et al.*, 2012).

Crackers fried in oil are popular snack foods in Malaysia and other Asian countries. They are commonly prepared with fresh seafood like fish, prawn, squid and crab for a source of protein and for flavour. To date, only a few studies have been carried out on crackers made with the incorporation of alternative protein sources such as fish protein hydrolysate powder (Yu & Tan, 2007) and surimi powder (Huda *et al.*, 2001). The use of powdered dry oyster mushroom, a non-seafood ingredient and

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flavouring, is a novel step in the production of fried crackers for the market. The mushroom powder offers many advantages in commercial food production such as ease of handling and storage as well as low cost of transportation in distribution. In addition, mushroom crackers are suitable for vegetarian consumers and those who are allergic to fish or other seafood used in commonly available crackers.

During manufacture, the flour used in the crackers expands when fried in oil. The type of flour used in cracker production is important as it affects the colour, oil absorption capacity, linear expansion as well as proximate composition and sensory characteristics of the cracker. In these respects, sago and tapioca flours, which are low in protein and lipids, are especially suited for cracker production (Noranizan *et al.*, 2010). To date, there is no available publishing data reporting on cracker formulation incorporated with oyster mushroom powder. Therefore, the objective of this study was to determine the effect of different ratios of oyster mushroom powder (OMP) to tapioca flour on the physicochemical properties and sensory acceptability of fried mushroom crackers.

MATERIALS AND METHODS

Preparation of oyster mushroom powder

Fresh grey oyster mushrooms *(Pleurotus sajor-caju)* were obtained from Wafa Spora Enterprise, Marang, Kuala Terengganu while tapioca flour, salt, and sugar were purchased from the local market in Kuala Terengganu, Malaysia. The mushrooms were washed in tap water and rinsed prior to soaking with 1% of sodium metabisulphite (Food Grade) for 10 min. Excess water was removed and the mushrooms were oven dried at 60°C for 7 h. The dried mushroom was ground in an electric blender (Ika®-Werke, type M20, Germany) for 10 min and sieved through a vibrator sieve shaker (Retsch AS 200, Germany) to obtain particle sizes of 0.125 to 0.490 mm. The resulting oyster mushroom powder (OMP) was then sealed in a high-density polypropylene (HDPE) bag, wrapped with aluminium foil and stored at a temperature of 4.0±1.0°C for further analysis. OMP prepared in this manner was light brownish-yellow and contained 12.05±0.02% moisture and 23.18±0.24% fibre.

Preparation of fried mushroom crackers

Crackers were prepared using OMP and tapioca flour in the following ratios: 0:100, 5:95, 10:90, 15:85 and 20:80. OMP and tapioca flour constituted 250 g out of the total weight of 287.3 g of the cracker dough mixture. The other ingredients, *viz.* salt (2%), sugar (1%) and iced water (10%), were unchanged in the different cracker formulations. The OMP was mixed with half of required amount of tapioca flour, sugar and salt, and then blended for 1 min using a food processor (MK-5087 M, Panasonic, Malaysia). The remaining tapioca flour, sugar and salt were added to food processor and blended for another 4 min. Then iced water was added and mixing continued for another 30 s until all the ingredients were well homogenized. The dough was kneaded to the shape of a cylinder 5 cm in diameter and steamed at 100°C for 90 min. After cooling for about 10 min to room temperature (27.0 ± 2.0°C), the dough was kept in the chiller at 4.0 ± 1.0°C overnight. The following day, the cracker dough was removed from the chiller and left at room temperature for 5 to 10 min, before being sliced mechanically to a thickness of 1 mm using a meat slicer. The dough slices were dried for 4 h in a drying cabinet at 60°C and the resulting unfried crackers were then packed and sealed in high-density polypropylene plastic bags and kept at room temperature (27.0 ± 2.0°C) for further analysis. Samples were deep fried in palm cooking oil at 150.0 ± 1.0°C for 1 min prior to analysis.

Physicochemical analysis

Physical properties of the fried crackers were carried out in triplicate for the determination of colour, linear expansion, oil absorption, and hardness. Colour profile of lightness (L*) redness (a*) and yellowness (b*) values were determined using a colorimeter (Minolta Chroma Meter CR 300, Japan) while linear expansion (%) was calculated according to Kyaw *et al* (2001) as follows:

$$\frac{\text{Length after frying (cm)} - \text{Length before frying (cm)}}{\text{Length before frying (cm)}} \times 100$$

Oil absorption of the fried crackers was measured according to Huda *et al* (2009). The crackers were weighed before and after frying, after which they were ground and dried in the oven at 105°C overnight. Oil absorption (%) was calculated as follows:

$$\frac{\text{Weight of dried fried sample (g)} - \text{Weight of dried unfried sample (g)}}{\text{Weight of dried unfried sample (g)}} \times 100$$

Hardness of the fried crackers was analysed using a Texture Analyzer (TA.XT Plus Stable Micro, USA). A 5 kg weight was used to calibrate the 30 kg load cell prior to analysis. A constant pre-test speed was set at 1.0 mm/s, test speed at 5 mm/s and post-test speed at 5 mm/s for a distance of 5.0 mm, with data acquisition rate of 500 pps. The test cracker was placed above a support rig and penetrated using ball probes (p/0.25 s stainless steel ball probe).

Chemical analyses for moisture, ash, protein, and fat content were performed in triplicate. Moisture content of fried mushroom cracker was determined by oven drying (AOAC, 2000) at 105.0 ± 2.0°C for 24 h. The determination of ash was carried out using a muffle furnace at 550 ±2.0°C overnight. A 2100 Kjeltec Distillation Unit (Gerhardt Vapodest, Germany) and Soxtec® Avanti 2055 extraction unit were used to determine the protein content and fat content, respectively.

Sensory evaluation

An affective test on a 7-point hedonic scale was carried out to determine the sensory acceptability of five different formulations of fried mushroom crackers. Thirty randomly selected Universiti Malaysia Terengganu students were recruited as panellists to evaluate the fried mushroom cracker attributes (colour, odour, crispness, taste, and overall acceptability). Score 1 indicated extremely dislike while score 7 indicated extremely like. All the samples were deep fried in palm cooking oil at 150.0 ± 2.0°C for 1 min, cooled and packed immediately in transparent plastic packaging that were labelled with 3-digit random codes prior to serving to the panellists.

Statistical analysis

Statistical Software (Minitab Statistical Software version 14.0) was used for statistical analyses. All data were presented as mean ± standard deviation. Significant differences between means were determined by a one-way Analysis of Variance (ANOVA) followed by post hoc Fisher's Least Significant Difference (LSD) test at $p<0.05$.

RESULTS AND DISCUSSION

Physicochemical properties of fried mushroom crackers

The physical properties of fried mushroom crackers are presented in Table 1. The control sample (100% of tapioca flour) showed the highest L* value (75.57 ± 3.40) as well as the lowest a* (0.26 ± 0.16) and b* (9.69 ± 1.60) values in which represent light in colour due to usage of white tapioca flour base. Increasing the percentage of OMP and decreasing the percentage of tapioca flour will contribute to darker products, which is shown by the lower L* value (Table 1). This might be due to the dark colour of fresh grey oyster mushroom (Roshita *et al.*, 2015) and promotes to the light brownish-yellow colour of OMP used. The increase in OMP from 10-20% might have contributed to the darkening after frying due to high temperature used, lead the denaturation and oxidation of OMP protein as well as non-enzymatic browning of Maillard reaction (Herbach *et al.*, 2006; Lee *et al.*, 2007).

In Table 1, the oil absorption value of tapioca flour cracker was 35.92 ± 1.42% and this value decreased by up to 5 times (7.65 ± 0.80%) when used of 20% OMP and 80% tapioca flour in the formulation. The higher protein content contributed by increased OMP together with the reduction in tapioca flour might have inhibited the starch-lipid interaction, resulting in decreased oil absorption during frying. Fibre in OMP that swelled during the frying process might also have played a role in reducing oil absorption of the cracker. This finding was in line with that in the study by Yadav and Rajan (2012) on deep fat fried *poori*. It was also interesting to note that with higher contents of OMP, the hardness of the fried cracker decreased with linear expansion (Table 1). These results were in agreement with similar results obtained with fish crackers (Huda *et al.*, 2009) and cassava-cuttlefish crackers (Chang & Chen, 2013). Fried cracker with 100% tapioca flour obtained 15.45 ±5.47% of linear expansion (Table 1). In contrast with oil absorption trend, the linear expansion value was increased significantly by up to 2.6 times (40.79 ± 8.78%) when 20% OMP and 80% tapioca flour used. High linear expansion of the cracker gave rise to increased porosity due to the full expansion of starch granules, and this is also resulted in their low density (Cheow *et al.*, 2004). The outcome may be influenced by the OMP/tapioca flour ratio, gel

Table 1. Physical properties of fried mushroom crackers with different ratios of osyter mushroom powder to tapioca flour (n=3)

Fried mushroom cracker	L*	a*	b*	Linear expansion	Oil absorption (%)	Hardness (N/cm^2) (%)
A	75.57 ± 3.40^a	0.26 ± 0.16^b	9.69 ± 1.60^d	15.45 ± 5.47^b	35.92 ± 1.42^a	2437.40 ± 516.00^a
B	71.22 ± 0.71^a	2.22 ± 0.66^b	19.79 ± 0.30^c	25.32 ± 8.14^{ab}	12.41 ± 1.15^b	1703.10 ± 282.40^a
C	67.52 ± 0.80^b	2.94 ± 1.15^{ab}	23.39 ± 1.85^{ab}	28.33 ± 4.46^{ab}	9.71 ± 0.59^c	1269.10 ± 252.20^a
D	65.84 ± 0.40^b	1.15 ± 0.06^b	22.59 ± 0.18^b	39.43 ± 9.45^a	8.69 ± 0.46^{cd}	1019.90 ± 206.00^b
E	63.75 ± 1.84^b	3.86 ± 0.57^a	25.89 ± 0.14^a	40.79 ± 8.78^a	7.65 ± 0.80^d	1099.00 ± 301.70^b

Values are means ± standard deviation. Means with different superscript letters in the same column are significantly different ($p<0.05$).
A: Cracker made from 100% tapioca flour (control sample); B: Cracker made from 5% osyter mushroom powder and 95% tapioca flour; C: Cracker made from 10% osyter mushroom powder and 90% tapioca flour; D: Cracker made from 15% osyter mushroom powder and 85% tapioca flour and E: Cracker made from 20% osyter mushroom powder and 80% tapioca flour.

formation in the dough during the steaming process, as well as the protein content which significantly affects gel formation and strength. This development could interfere with vacuole formation or degradation during water evaporation.

Table 2 shows the chemical properties of fried mushroom crackers, *viz.* moisture, ash, fat, and protein content. Moisture (4.51–6.00%) and fat content (18.11–24.82%) of crackers were not significantly affected (p>0.05) by different ratios of OMP to tapioca flour. The control sample prepared with 100% tapioca flour obtained significantly lower (p<0.05) ash content (1.67 ± 0.18%) when compared with crackers incorporated with OMP. However, addition of 5 to 20% of OMP in the formulation similarly did not contribute significantly (p>0.05) to the ash content of cracker. Mahedy *et al* (2012) reported that mushroom powder contains only 1.80% of ash. As can be seen in Table 2, the protein content of fried mushroom crackers was significantly altered (p<0.05) by different ratios of OMP to tapioca flour. The higher the percentage of OMP used, the higher was the protein content of fried mushroom cracker. It was interesting to note that incorporation of 20% OMP increased by up to 8 times the protein content of the cracker as compared to the control. However, protein was denatured due to high temperature used during deep frying process resulted low protein content obtained in fried cracker (0.47–3.88%) when compared to other products incorporated with OMP as previously reported in bread (Mahedy *et al.*, 2012), paratha bread and rice porridge (Aishah & Rosli, 2013).

Sensory acceptability of fried mushroom crackers

As shown in Table 3, fried mushroom cracker incorporated with OMP secured higher mean scores for all sensory attributes, *viz.* colour, odour, crispness, taste, and overall acceptability, when compared to the control sample (without addition of OMP). Fried crackers of 100% tapioca flour were lighter in colour, had less odour and taste and were less crisp; these characteristics reduced the level of consumer acceptability. In contrast, the higher the percentages of OMP used, the higher were the mean scores of sensory attributes, although there was no significant difference (p>0.05) between 15% and

Table 2. Chemical properties of fried mushroom crackers with different ratios of osyter mushroom powder and tapioca flour (n=3)

Fried mushroom cracker	Moisture (%)	Ash (%)	Fat (%)	Protein (%)
A	6.00 ± 0.47^{a}	1.67 ± 0.18^{b}	23.97 ± 1.75^{a}	0.47 ± 0.14^{d}
B	4.51 ± 1.47^{a}	2.22 ± 0.56^{ab}	20.62 ± 2.69^{a}	1.08 ± 0.44^{cd}
C	5.80 ± 0.63^{a}	2.78 ± 0.64^{a}	18.11 ± 4.19^{a}	1.88 ± 0.57^{c}
D	5.57 ± 1.17^{a}	2.54 ± 0.14^{ab}	24.82 ± 2.18^{a}	3.00 ± 0.44^{b}
E	4.92 ± 0.13^{a}	2.87 ± 0.30^{a}	21.80 ± 4.35^{a}	3.88 ± 0.07^{a}

Values are means value ± standard deviation. Means with different superscript letters in the same column are significantly different (p<0.05).
A: Cracker made with 100% tapioca flour (control sample); B: Cracker made from 5% osyter mushroom powder and 95% tapioca flour; C: Cracker made from 10% osyter mushroom powder and 90% tapioca flour; D: Cracker made from 15% osyter mushroom powder and 85% tapioca flour and E: Cracker made from 20% osyter mushroom powder and 80% tapioca flour.

Table 3. Mean score of sensory acceptability of fried mushroom crackers with different ratios of osyter mushroom powder to tapioca flour (n=30)

Fried mushroom cracker	Colour	Odour	Crispiness	Taste	Overall acceptability
A	3.30 ± 1.82^{c}	3.30 ± 1.73^{b}	3.10 ± 1.77^{c}	2.33 ± 1.12^{c}	2.70 ± 1.34^{c}
B	3.97 ± 1.40^{b}	4.13 ± 1.36^{b}	3.80 ± 1.47^{b}	4.30 ± 1.29^{b}	4.20 ± 1.22^{b}
C	4.20 ± 1.24^{b}	3.87 ± 1.28^{b}	4.30 ± 1.82^{b}	4.03 ± 1.47^{b}	3.97 ± 1.33^{b}
D	5.57 ± 1.07^{a}	5.10 ± 1.24^{a}	6.13 ± 0.78^{a}	5.23 ± 1.31^{a}	5.40 ± 1.07^{a}
E	5.40 ± 1.13^{a}	5.07 ± 1.39^{a}	6.07 ± 1.05^{a}	5.07 ± 1.48^{a}	5.47 ± 1.11^{a}

Values are means score ± standard deviation. Means with different superscript letters in the same column are significantly different (p<0.05).
Score 1 – dislike extremely; score 7 – like extremely.
A: Cracker made from 100% tapioca flour (control sample); B: Cracker made from 5% osyter mushroom powder and 95% tapioca flour; C: Cracker made from 10% osyter mushroom powder and 90% tapioca flour; D: Cracker made from 15% osyter mushroom powder and 85% tapioca flour and E: Cracker made from 20% osyter mushroom powder and 80% tapioca flour.

20% OMP for all the sensory attributes evaluated. Crackers that underwent higher linear expansion tended to be less hard and crispier (Table 1); they were the most well-accepted by the tasting panel. This finding is in agreement with the observations of Noorakmar *et al* (2012). High percentage of OMP also enhanced the odour and taste of fried mushroom crackers.

CONCLUSION

The physicochemical properties and sensory acceptability of fried mushroom crackers were significantly affected by the ratio of OMP to tapioca flour base. An increase in the percentage of OMP in the formulation, decreased the L* value, oil absorption and hardness. At the same time, there were increases in the b* value, linear expansion, ash and protein contents of the crackers. These results suggested that fried mushroom crackers containing OMP was more acceptable when it attained a dark brownish-yellow colour, had higher in mushroom odour and taste and when they expanded more to become crispier with less frying oil absorbed.

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