Nutritive qualities of patties prepared with mixture of meat and oyster mushroom

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Abstract

Nutritive qualities of patties prepared from chicken, beef and oyster mushroom were determined. Three groups of rats were fed with patty diets prepared with either a combination of 75% chicken + 25% oyster mushroom (CMP) or 75% beef + 25% oyster mushroom (BMP) or 100% chicken patty + 0% oyster mushroom (CP). There was no significant difference (P < 0.05) in total tryglyceride (0.3-0.5 mmol/L), total cholesterol (1.7-1.9 mmol/L) LDL-cholesterol (0.3-0.4 mmol/L) and HDL-cholesterol (1.2-1.4 mmol/L) for all groups except for protein free. Protein efficiency ratio (PER) values of CMP and BMP groups were significantly lower than casein group but significantly higher than chicken patty (CP) group. Both CMP and BMP fed groups recorded PER values at 1.73 and 1.69 while CP had PER value at 1.52. The AD of rats fed with CMP, BMP and CP diets were closely ranged from 98.3-98.9% but not significant as compared to casein diet group (98.5%). The close AD values between CMP, BMP and CP indicated that the mixture of patty protein from either chicken or beef with protein of oyster mushroom did not affect digestibility aspect. In summary, addition of oyster mushroom into either chicken or beef patties did not changed AD but improved PER value, thus proving that oyster mushroom could be used as an alternative ingredient to replace meat partially in the making of patties.

Introduction

Globally, meat-based patty has long been reported to be the most popular processed meat product including Malaysia. Generally, processed meat products such as burgers and sausages are often containing high calorie mainly, saturated fats (Baggio and Bragagnolo, 2006) and sodium while low in dietary fibres. The saturated fat can cause high cholesterol levels and may cause health problems such as hypercholesterolemia and hypertension (Jimenez-Colmenero et al., 2001). Both beef and chicken patties are categorized as one of the 10 most frequent consumed foods weekly (Norimah et al., 2012). The increase demand of beef and chicken as main ingredient in the production of burger/patty has increased it price. Rapid increment of beef and chicken meat price has resulted in rising of production cost thus impacting food manufacturer’s survival and profitability. In long run, this situation confers negative impact on quality of products and therefore affecting sustainability of business and entrepreneurial activities. This situation become worsen since most of the main ingredients such as beef and chicken are imported especially from India and other countries (Nam et al., 2010). The dependency of importation of raw materials in long run is not healthy since it cost will be skyrocketing when the shortage of raw materials’ supply occured.

Generally, meat provides caloric value in the range from 10 to 20% of total calories in most developed countries (Valsta et al., 2005). In parallel, world food supplies seem to be growing at a slower rate than the needs. Present inadequate food consumption levels are made even more dramatic by rapidly growing populations (Valsta et al., 2005). The pressure of the continuously expanding populations and limited energy supply have led many to search for new and better methods, through which more and higher quality food can be provided.

The linked between health and diet has been comprehensively studied and rising numbers of consumers have been advised to change and improve their eating habits. Energy-dense food utilization, especially saturated fat, is still considered to be surplus. According to the Nutritional guidelines recommended by WHO and other health professional groups such as dietician and medical experts, dietary fat should provide between 15 and 30% of total calories, and that saturated fats should be limited to between 0 and 10% of calorie intake and cholesterol intake below 300 mg/day (Chizzolini et al., 1999).

Edible mushrooms are valued for their various pharma-nutritional functions that offer multiple...
benefits to consumers. Besides it pharmacological features, mushrooms are becoming more important due to their nutritional value, related to high protein, low fat and energy contents (Barros et al., 2007). Several studies have been carried out on the chemical composition and nutritional quality of edible mushrooms from different countries (Al-Enazi et al., 2012; Ibrahim and Hamed, 2002; Manzi et al., 2004; Yaovadee et al., 2010). However, the nutritional quality of patties prepared from chicken or beef and oyster mushroom are never been highlighted. The investigation on nutritive value of patties incorporated with oyster mushroom is also scanty. Thus, this study focuses on the nutritive qualities of chicken and beef patties incorporated with oyster mushroom by evaluating lipid profile, protein efficiency ratio (PER) and apparent digestibility (AD) of Sprague-Dawley rats fed with these diets.

Materials and Methods

Preparation of oyster mushroom

Oyster mushroom (Pleurotus sajor caju) was purchased from local wet market in Kota Bharu city, Kelantan state of Malaysia. Fully-grown mushrooms with the pileus cap diameters between 9 to 11 cm were used throughout the study. The mushroom was prepared by rinsing with clean water and ground for 30 seconds. The prepared mushroom was then incorporated partially to replace beef and chicken in patty formulations.

Beef burger formulation

The patties were prepared according to formulations described by Wan Rosli et al. (2011) with slight modification. Three patty formulations were prepared. The patties were prepared with either a combination of 75% chicken + 25% oyster mushroom (CMP) or 75% beef + 25% oyster mushroom (BMP) or 100% chicken + 0% oyster mushroom patty (CP). Addition of 25% oyster mushroom in both chicken and beef patties incorporated with oyster mushroom by evaluating lipid profile, protein efficiency ratio (PER) and apparent digestibility (AD) of Sprague-Dawley rats fed with these diets.

Materials and Methods

Rat feeding protocol

Fifty male weanling Sprague-Dawley rats between 27-28 days old weighing between 85-100 g were obtained from the Animal Research And Service Centre (ARASC) Universiti Sains Malaysia. The rats were placed in individual cages and distributed into five treatment groups namely casein, protein free, CMP, BMP and CP. After 4 days of adaptation, the rats were subjected to a feeding trial for 28 days. During the feeding period, water was provided ad libitum and the diets were restricted to 15 g/day. The diet was replaced daily, while the spilled and leftover food was collected and weighed to determine total food intake. The food intake was recorded daily and the weight of the rats was recorded individually every two days. Faeces were collected from the 10th day to the 18th day of the experiment, and kept in an open container after which they were dried overnight at 100°C and analysed for nitrogen content (AOAC, 2000).

Nutritive value calculation

The apparent digestibility (AD)

The AD was determined using a formula (Acton and Ruud, 1987). Food consumption and fecal output data were recorded daily for eight days (10-18) of the 28-day study to determine the in vivo apparent protein digestibility.

\[
AD = \frac{(N \text{ in diet (g)} - N \text{ in feces (g)}) \times 100}{N \text{ in diet (g)}}
\]

Protein efficiency ratio (PER)

The PER was also determined using the method
established by Acton and Ruud (1987). The PER was calculated using a formula:

$$\text{PER} = \frac{\text{Increase in body weight (gram)}}{\text{Weight of protein consumed (gram)}}$$

**Lipid profile of rats**

Total, low density lipoprotein-cholesterol (LDL-C), high density lipoprotein–cholesterol (HDL-C) and triglycerides (TG) of rat blood serum were measured enzymatically according to Artiss and Zak (1997). Cholesterol is measured enzymatically in serum in a series of coupled reactions that hydrolyze hydroxysterol esters and oxidize the 3-OH group of cholesterol. One of the reaction byproducts, $\text{H}_2\text{O}_2$, is measured quantitatively in a peroxidase catalyzed reaction that produces a color. At the end of the experimental period, rats were weighed and deeply sedated with a barbiturate. Blood samples were obtained from the abdominal aorta and centrifuged at 1500 rpm for 15 min. Rats blood serum were then stored at -80°C before analysis. Serum samples were sent to BP Laboratory Sdn Bhd for analyses of total, low density lipoprotein-cholesterol (LDL-C), high density lipoprotein–cholesterol (HDL-C) and triglycerides (TG).

**Results and Discussion**

**Proximate composition of dried patties used for rat diets**

The proximate content of different formulations of dried patties used for rat diets is shown in Table 1. Dried CP contained 44.8% protein followed by CMP (38.0%) and BMP (34.8%). Although these levels were vary but the final protein and fat content of all rat diets were kept at 10 and 8% (AOAC, 2000). Higher level of protein content in CP dried patties than other patties required lower amount of its source (200 g) used for rat diet formulation (Table 2). Contrarily, lower concentration of protein content in dried BMP than other patties required higher amount to be added in rat diet formulation (292g). The final protein content in all rat diets except for protein free was achieved 10% (Table 3) and comply with requirement set by AOAC (2000). On the other nutrient, fat content of dried CMP (29.2%) was significantly higher ($P < 0.05$) than BMP (26.6%) and CP (24.6%). There was significant difference in moisture and ash content between all dried patties (Table 1).

All patties recorded moisture content ranging from 41.0-56.7%. In addition, all patties prepared with chicken, beef and mushroom recorded ash content ranging from 1.9-2.3%. However, after all ingredients being mixed for rat diets it proximate composition was comply with requirement set by AOCS (1992). Both fat and ash content in the diet for protein quality study must be prepared isocaloric at the levels of 8.0% and 5%, respectively (AOAC, 2000). There was no significant difference in proximate composition between all rat diets (Table 3). The level of protein found in the present study was comparable to Johnsy et al. (2011). They reported that the highest protein contents (39.1%) was obtained from *Pleurotus sajor-caju*. The concentration of dried patty containing chicken was in accord to our previous study (Wan Rosli et al., 2007).

**Serum lipid profile of rats**

The results of serum lipid profile are summarized in Table 4. Rat groups fed with either CMP or BMP or CP diets resulted in no significant difference in triglyceride (TG) value ranging from 0.3-0.5 mmol/L compared to control (casein) group (0.4 mmol/L). There was also no significant difference in total cholesterol content between all groups including casein with values ranging from 1.7-1.9 mmol/L. This indicated that addition of mushroom into chicken and beef patty formulations did not affect total cholesterol content in rats’ blood serum. In addition, there was no significant difference ($P < 0.05$) in HDL-cholesterol content between all treatments (1.2-1.4 mmol/L). Both groups fed with CMP and BMP diets recorded LDL-cholesterol content ranging from 0.3-0.4 mmol/L and not significantly difference compared

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**Table 1. Proximate analyses of different formulations of dried patties used for rat diets**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Moisture (%)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>44.8±0.1</td>
<td>24.0±1</td>
<td>41.1±0.5</td>
<td>2.3±0.1</td>
</tr>
<tr>
<td>CMP</td>
<td>38.0±0.3</td>
<td>36.5±0.8</td>
<td>51.6±0.4</td>
<td>4.4±0.2</td>
</tr>
<tr>
<td>BMP</td>
<td>34.8±0.3</td>
<td>36.5±0.8</td>
<td>51.6±0.4</td>
<td>4.7±0.2</td>
</tr>
</tbody>
</table>

* Mean values within the same column bearing different superscripts differ significantly ($P < 0.05$)

**Table 2. Formulation of Diets from different Protein Sources**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Casein (g)</th>
<th>Control Protein (g)</th>
<th>CP (g)</th>
<th>CMP (g)</th>
<th>BMP (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casein</td>
<td>135</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Protein</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>280</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMP</td>
<td>292</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn-oil (5 %)</td>
<td>76</td>
<td>78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starch + sucrose (1:1)</td>
<td>7/9</td>
<td>8/5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral (5 %)</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Ash (1 %)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

**Table 3. Proximate composition of rat diets**

<table>
<thead>
<tr>
<th>Rat Diet</th>
<th>Treatment</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Moisture (%)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Casein</td>
<td>10.1±0.1</td>
<td>8.1±0.1</td>
<td>50.6±0.1</td>
<td>4.9±0.1</td>
</tr>
<tr>
<td>2</td>
<td>Protein/ice</td>
<td>2.3±0.1</td>
<td>8.0±0.1</td>
<td>50.6±0.1</td>
<td>4.9±0.1</td>
</tr>
<tr>
<td>3</td>
<td>CP</td>
<td>10.1±0.4</td>
<td>8.1±0.1</td>
<td>4.9±0.3</td>
<td>4.8±0.1</td>
</tr>
<tr>
<td>4</td>
<td>BMP</td>
<td>8.9±0.9</td>
<td>8.1±0.1</td>
<td>3.1±0.4</td>
<td>4.9±0.1</td>
</tr>
<tr>
<td>5</td>
<td>BMP</td>
<td>8.9±0.9</td>
<td>8.1±0.1</td>
<td>3.1±0.4</td>
<td>4.9±0.1</td>
</tr>
</tbody>
</table>

* Mean values within the same column bearing different superscripts differ significantly ($P < 0.05$)

**Table 4. Serum lipid profile of rats**

The results of serum lipid profile are summarized in Table 4. Rat groups fed with either CMP or BMP or CP diets resulted in no significant difference in triglyceride (TG) value ranging from 0.3-0.5 mmol/L compared to control (casein) group (0.4 mmol/L). There was also no significant difference in total cholesterol content between all groups including casein with values ranging from 1.7-1.9 mmol/L. This indicated that addition of mushroom into chicken and beef patty formulations did not affect total cholesterol content in rats’ blood serum. In addition, there was no significant difference ($P < 0.05$) in HDL-cholesterol content between all treatments (1.2-1.4 mmol/L). Both groups fed with CMP and BMP diets recorded LDL-cholesterol content ranging from 0.3-0.4 mmol/L and not significantly difference compared
to casein group (0.4 mmol/L). The dietary fiber (14 g/1000 kcal) has shown remedial effects on serum lipid levels, reducing total cholesterol and LDL-cholesterol amounts (Erkkila and Lichtenstein, 2006; Anderson et al., 2009). The viscous properties of gels from soluble dietary fiber such as glucans contribute to inhibition of cholesterol and triglyceride absorption (Marlett et al., 2002). The viscous properties of gels are related to an increase in the fecal excretion of bile acids and short-chain fatty acids (Marlett et al., 2002). Results of some reports suggest that the hypocholesterolemic effects of some fruiting bodies of edible mushroom could be attributed to the dietary fiber (Guillamón et al., 2010). Besides, mushrooms are also containing large amounts of β-glucans polysaccharides, which exhibit hypocholesterolemic and anticoagulant functions (Vetvicka and Vetvickova, 2009).

**Protein efficiency ratio (PER)**

PER bioassay reflects the capacity of a protein to uphold body weight gain of animals. Results of PER are shown in Table 5. PER values of CMP and BMP fed groups were significantly lower than casein group but significantly higher than CP group. Both CMP and BMP fed groups recorded PER values of 1.73 and 1.69 while casein and CM had PER values of 2.05 and 1.52, respectively. This finding is in close agreement with results of Al-Enazi et al. (2012), which concluded that diets containing 10% mushroom protein resulted in Protein Efficiency Ratio (PER) of 1.50 compared with value for casein of 2.40. There was no significant difference (P < 0.05) in diet intake and body weight gain between rats fed with either CMP or BMP or CP. However, both diet intake and body weight gain of these groups were significantly lower than Casein group.

Higher amounts of diet intake which recorded during the 28 days of study has increased rat body weight gain. All groups except casein and protein free groups recorded higher total diet intake ranging from 404.9-405.3 g compared to casein (390.7 g) and protein free (242.3 g) during the 28 days of study. These results indicate that protein present in chicken, beef and mushroom play an important roles in enhancing the satiety and growth of rats. Significant intake of isocaloric protein sources from CMP, BMP and CP diets over 28 days have resulted in increment of rats’ body weight thus promoted their growth. Edible mushroom has been reported rich in glutamic acid, aspartic acid and arginine but deficient in methionine and lysine (Guillamon et al., 2010). In addition, two uncommon amino acids namely γ-amino butyric acid (GABA) and ornithine found in edible mushroom have shown important physiological activities as reported by Guillamon et al. (2010). Eventhough the group of rats treated with CMP (91.0 g) and BMP (87.4 g) recorded higher weight gain values than CP diet (80.0 g) but not significant. The present result also shows that the weight gain of rats fed the non-protein diet (protein free) decreased during the entire feeding period, resulting in average weight loss of -32.0 g. This finding accords with those of Al-Enazi et al. (2012) who found lower body weight gain (45.1 g) and PER value (1.5) for casein group. The decrease in body weight gain was also reported by other study. Al-Enazi et al. (2012) and (Huda et al., 2000) who decommented that the weight gain of rats fed with non-protein diet was -17.1(g) and -17.7(g), respectively. The reduction in body weight non-protein diet (protein free) may due to the insufficient essential amino acids to promote weight gain and rat

### Table 5. PER Values of Patties Containing Oyster Mushroom (OM) and Casein Reference

<table>
<thead>
<tr>
<th>Diet</th>
<th>Protein consumed (g/rat/8 days)</th>
<th>PER&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Corrected PER&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casein</td>
<td>375.7±12.1</td>
<td>255.0±8.4</td>
<td>2.60</td>
</tr>
<tr>
<td>Protein free</td>
<td>242.3±10.8</td>
<td>231.5±8.1</td>
<td>-</td>
</tr>
<tr>
<td>CP</td>
<td>405.0±13.5</td>
<td>415.2±0.2</td>
<td>1.85&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>CMP</td>
<td>404.5±12.9</td>
<td>404.5±0.2</td>
<td>2.11</td>
</tr>
<tr>
<td>BMP</td>
<td>405.0±12.9</td>
<td>404.5±0.2</td>
<td>2.06</td>
</tr>
</tbody>
</table>

<sup>a</sup>Mean values within the same column bearing different superscripts differ significantly (P < 0.05)

<sup>b</sup>PER = protein efficiency ratio = (increase in body weight, g / weight of protein consumed, g)

<sup>c</sup>Corrected PER = (2.502.05) x PER

CP: 100% chicken patty + 0% oyster mushroom

CMP: 75% chicken + 25% oyster mushroom

BMP: 75% beef + 25% oyster mushroom

### Table 6. Percent In vivo Apparent Digestibility (AD) of Beef Burgers Containing Palm Based Fats and Casein Reference

<table>
<thead>
<tr>
<th>Rat diet</th>
<th>DI</th>
<th>TNC</th>
<th>DF</th>
<th>NCF</th>
<th>TNF</th>
<th>TD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef patty</td>
<td>375.7±12.1</td>
<td>350.0±10.5</td>
<td>255.0±8.4</td>
<td>2.60</td>
<td>19.0±0.5</td>
<td>18.9±0.5</td>
</tr>
<tr>
<td>Protein free</td>
<td>242.3±10.8</td>
<td>231.5±8.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CP</td>
<td>405.0±13.5</td>
<td>415.2±0.2</td>
<td>1.85&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.83&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.52±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.50±0.08&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>CMP</td>
<td>404.5±12.9</td>
<td>404.5±0.2</td>
<td>2.11</td>
<td>2.08</td>
<td>1.73±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.69±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>BMP</td>
<td>405.0±12.9</td>
<td>404.5±0.2</td>
<td>2.06</td>
<td>2.02</td>
<td>1.40±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.36±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Mean values within the same column bearing different superscripts differ significantly (P < 0.05)

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Marlett, J. A., et al. (2002). In vivo


Guillamon, Y., et al. (2010). In vivo

Al-Enazi, A. S., et al. (2012). In vivo

Huda, O., et al. (2000). In vivo
growth. The growth of the animals recorded in the present study was proportional to the intake of diet. As the results indicate, the oyster mushroom protein combined with both chicken and beef protein was able to promote growth in the rats comparable to the growth in the rats fed with chicken protein alone.

**Apparent digestibility**

Apparent digestibility (AD) was calculated based on the amount of diet intake and nitrogen content from rat faeces accumulated from day 10 until day 28. The results show that AD of rats fed with CMP, BMP and CP diets were closely ranged from 98.3-98.9% (Table 6) but not significant as compared to casein diet group (98.5%). The close AD values between CMP, BMP and CP indicated that the mixture of protein from either chicken or beef with protein of oyster mushroom did not affect digestibility aspect. However, the AD values determined from the present study were slightly higher than the study done by Hernandez et al. (1996). They reported that AD of rats fed with casein diet was the highest (91.4%) compared to the group fed with the other sources of beef cuts (sirloin, liver, round and mixture of round cut with rice, corn, wheat and beans) (Hernandez et al., 1996).

In addition, true digestibility value (TD) of rats fed with CMP, BMP and CP diets were ranging from 72.9-86.4% slightly lower than TD of casein (86.5%). These values are considered high as compared to other study done previously. The values of TD of different mushroom species such as *Pleurotus ostreatus*, *Lentinus edodes* and *Lentinus lepидus* were recorded ranging from 47.32-52.16% (Yaovadee et al., 2010). The result of TD from the present study indicated that diet in the form of patty prepared from mixture of protein of either chicken or beef with protein from oyster mushroom were better than diet prepared from mushroom protein alone. The higher levels of TD values determined from the present study might be due to the positive integration between protein from oyster mushroom with either chicken and beef developed into patty formulations. The high percentage of digestibility may be due to the increase in solubility and the denaturation of protein molecules making them more accessible to proteolytic enzymes.

**Conclusions**

Diets prepared with patties containing mixture of either chicken or beef with oyster mushroom did not affect the total cholesterol concentrations including HDL-cholesterol concentrations in rat blood serum. In summary, addition of oyster mushroom into either chicken or beef patties did not changed AD but improved PER value, thus proving that oyster mushroom could be used as an alternative ingredient to replace chicken of beef partially in the making of patties. Therefore, the dietary importance of mushrooms is expected to grow in the future years due to the gradual demand of the increasing world population and the interest of reducing the risks related to the consumption of animal foods sources.

**Acknowledgements**

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