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Abstract. Oyster Mushroom is a mushroom that can be used for food and medicine. It contains highly nutritious and functional substances such as statins and beta-glucan. A comprehensive evaluation of noodle-enriched with Oyster Mushroom powder has not been performed so far. In this study, we performed a comprehensive evaluation of noodle-enriched with Oyster Mushroom powder. The aim of this study was to assess the effects of enrichment of Oyster Mushroom Powder (OMP) on the quality of noodle. The quality of noodle was evaluated based on physical, chemical and sensorial characteristics. This study was done by substituting wheat flour with OMP at the level of 0 (control); 5; 7.5; 10; 12.5; and 15%. The results showed that OMP significantly affected ($P<0.05$) the chemical, physical and sensorial quality of enriched noodles. Increased OMP level concurrently increased ash, crude fiber content and water activity (Aw) of resulting noodles. The enrichment was significantly raised the redness and yellowness of noodles, but decreased whiteness index. In addition, the enrichment of OMP significantly affected the sensorial properties of enriched noodles including color, taste, aroma and texture. OMP enrichment can be done at the level of 5% without compromising color, aroma, and texture of noodle, but 12.5% for taste attribute. Thus, OMP enrichment is feasible to enhance the nutritional values of noodle.

Keyword: Oyster mushroom powder, noodle, *Pleorotus ostreatus*, enrichment

1. Introduction

Oyster Mushroom (*Pleorotus ostreatus*), is a mushroom that can be utilized for food and supplement to maintain the body fitness. They contain protein, carbohydrate, fat, fiber, moisture, vitamins, minerals and secondary metabolites. Its statins compound is outstanding to reduce a bad plasma lipid and blood-pressure, hence it can lessen the risk of cardiovascular diseases. In addition, its beta-glucan can stimulate the body immune system. It has been reported that Oyster Mushroom effectively combat cancer, microbial infection and diabetic [1]. It has been reported that 5% of ethanolic extract of Oyster Mushroom powder can reduce the cholesterol level in serum about 52% [2]. Hence, recently, oyster mushroom have attracted much attention to be used as functional food since demonstrated its beneficial effects for well-being [3].

Noodle is a food product made from dough of wheat flour or other flour with the addition of several ingredients. Noodle can be classified as food replacement of staple food. Usually, it is consumed for breakfast or side-dishes. In 2008, total production of noodle in Indonesia is 1.6 million tons. It is increased by 2,0 million tons in 2013 and predicted to be 2,2 million tons in 2014. The production of noodle is driven by number of consumers who consume noodle daily. This affect to the high demand of imported wheat flour. The national consumption of wheat flour in 2013 is increased by 4,1% (5,35 million) compared to that in 2012. Further, in 2014, it is increased by 5,4% (2,79 million) compared to that in 2013.

The production of noodle by adding Oyster Mushroom powder will enrich its nutritious and functional compounds. However, that enrichment must deal with the sensory properties of noodle. Study in enrichment of noodle by using Oyster Mushroom powder is still limited. Desayi [4] reported that 10%

of Oyster Mushroom powder deliver the best acceptance. Suarti et al. [5] reported the use of mocaf (modified cassava) and Oyster Mushroom-mixed flour in the range of 5-20% to make noodle. They found that 5% of Oyster Mushroom powder provide the best sensory acceptance. Furthermore, the addition of 20% Oyster Mushroom powder provide the best chemical quality. However, a comprehensive evaluation of noodle-enriched Oyster Mushroom powder has not been performed yet. Therefore, in this study, we performed a comprehensive evaluation of noodle-enriched with Oyster Mushroom powder including chemical, physical and sensory properties.

2. Materials and methods

2.1 Materials

Oyster mushroom was obtained directly from farmer in Mangli, Jember. It was selected based on size, maturity, and freshness. The commercial wheat flour (Cakra, P.T. Indofood Sukses Makmur) containing 20% protein, 2% fat, and 24% carbohydrate was purchased from supermarket in Jember. Additional ingredients (salt, egg, STPP) were purchased from traditional market in Jember.

2.2 Methods

2.2.1Noodle processing

Noodle was made by substituting wheat flour with 0; 2.5; 5; 7.5; 10; 12.5; and 15% of Oyster Mushroom powder (OMP), respectively. The noodle formulation is shown in Tabel 1.

Table 1. Formula of noodle enriched with Oyster Mushroom Powder

Ingredients	P0 (0%)	P1 (2.5%)	P2 (5%)	7.5%)	10%)	12.5%)	P6 (15%)
Oyster Mushroom powder (g)	0	6.25	12.5	18.75	25	31.25	37.5
Wheat flour (g)	250	243.75	237.5	231.25	225	218.75	212.5
Egg (piece)	1	1	1	1	1	1	1
Salt	4.25	4.25	4.25	4.25	4.25	4.25	4.25
Sodium tripolyphospate (STPP) (%)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ice water (ml)	50	50	50	50	50	50	50

2.2.2 Chemical analisys of oyster mushroom noodle

Water contents

Water contents of Oyster Mushroom noodle was analized using oven drying method [6].

Ash Contents

Ash contents of Oyster Mushroom noodle was analyzed using AOAC method [7].

Water Activity

Water activity was measured using an Aw meter (Shibaura, WA-360). Previously, Aw meter was calibrated using barium chloride. After that, the grinded and homogenized sample was placed into the sample container of Aw meter. Then, the start knob was pressed for measuring Aw. The Aw value was displayed on the Aw-meter screen.

Protein Content

Protein content was analyzed using the method of AACC 46-12.

Crude Fiber
Sample (1 g) was weighed and put into conical flask. Then, 100 ml of 0.3 N H_2SO_4 was added and followed by extraction using boiling water for 30 min. A 50 ml of 1.5 N NaOH was added into the flask and was extracted again with boiling water for 30 min. After extraction, filtration was performed using filtration paper. Afterward, it was washed consecutively using 50 ml of hot water, 50 ml of 0.3 N H_2SO_4, and 50 ml of alcohol. Then, it was dried for 8 hours or overnight. Pellet was cooled down in desiccator for about 30 min and then weighed (a gram). Pellet was then burned in electrical furnace at 500 °C for 3 h. It was cooled down in desiccator for 30 min and then weighed (b gram).

2.2.3 Physical Analysis of Noodle
Cooking Loss
Cooking loss was measured by the following method. A 50 ml distilled water was heated in 200 ml glass beakers until boiling. A 10 g of noodle was weighed and boiled in the boiling water. After 5 min, the noodle was taken and drained. The remaining residue present in the cooking water was then heated using drying oven at 105 °C until reached a constant weight.

Cooking Yield
Cooking yield was measured by weighing 10 g of noodle. Then, the noodle was boiled using 50 ml of distilled water. After boiling, the noodle was drained in room temperature and then weighed.

Color
The color of noodle was analyzed using a Color Reader (Hunterlab A 60-1014-085). Six points upon surface of noodle samples were measured. Then, hunter color values of lightness (*L*), redness (*a*) and yellowness (*b*) were recorded. The whiteness index (*WI*) was calculated according to the following formula:

$$WI = 100 - [(100\text{-}L)^2 + a^2 + b^2]^{1/2}$$

Where:
WI is whiteness index, *L* is lightness, *a* is redness, and *b* is yellowness.
2.2.4 Sensory Properties
Noodle samples were prepared from a freshly cooked noodle. Sensory evaluations were conducted by semi-trained consumers who were students at Food Industrial Study Program, State Polytechnic of Jember. The sensory attributes evaluated were color, taste, aroma, and texture. The sensory attribute scale used for assessing the noodle was as follows: 1, extremely dislike; 3, neither like nor dislike; and 5, extremely like.

2.2.5 Statistical Analysis
One-way analysis of variance (ANOVA) was performed to test the significance among treatments followed by Duncan's Multiple Range Test (DMRT) at the level of significance $p < 0.05$. The analysis was carried out using SPSS for Windows ver. 20 (IBM, New York, USA).

3. Results and discussions
3.1 Chemical characteristics
Effect of OMP enrichment on the chemical characteristics of noodles are given in Table 2. It can be seen that OMP enrichment increased water content and protein content but insignificantly ($P<0.05$). On the other hand, OMP enrichment significantly ($P<0.05$) increased water activity, ash, and crude fiber content of enriched noodles. In general, increased OMP concurrently raised protein content. Thus, enrichment of noodle with OMP is reasonable to enhance the nutritional values of noodle.
The ash content of enriched noodles at the level of 12.5 and 15% was significantly ($P<0.05$) higher than that of control noodle. This can be attributed to the rich ash content of OMP than that in wheat flour.
OMP enrichment significantly ($P<0.05$) increased the crude fiber of enriched noodles. The crude fiber of enriched noodles raised coincidently with increased of OMP. The crude fiber of enriched noodles

with 15% of OMP was the highest and significantly different to that of control noodle. According to [8] crude fiber content of fresh mushroom is considerably high (17.27%). The dried oyster mushroom contains dietary fiber ranging from 33.00% to 37.50% with regard to drying techniques [9]. In addition, increased Oyster mushroom powder significantly enhanced total dietary fiber of chicken frankfurter [10]. The water activity of enriched noodles were affected significantly by OMP enrichment. Increased OMP raised the water activity of enriched noodles. The water activity increased significantly by the level of enrichment of 2.5% compared to that of control noodle and then increased coincidently with regard to the level of enrichment.

Table 2. Chemical characteristics of noodles enriched with different level of OMP

Samples	Water Content (%)	Aw	Ash (%)	Protein (%)	Crude Fiber (%)
Control	57,51 ± 3,27a	0,942 ± 0,00c	0,55 ± 0,14b	7,16± 0,99a	6,28 ± 0,68b
OMP 2,5%	54,40 ± 2,22a	0,953 ± 0,00b	0,67 ± 0,09ab	7,82± 1,99a	6,49 ± 0,60b
OMP 5%	55,67 ± 3,52a	0,958 ± 0,00ab	0,74 ± 0,10ab	8,27± 1,81a	8,10 ± 1,79ab
OMP 7,5%	55,57 ± 3,16a	0,960 ± 0,00ab	0,84 ± 0,38ab	8,75± 2,08a	7,85 ± 1,01ab
OMP 10%	55,96 ± 1,11a	0,962 ± 0,00ab	0,85 ± 0,06ab	8,61± 1,01a	7,73 ± 0,55ab
OMP 12,5%	58,19 ± 2,07a	0,963 ± 0,00a	0,97 ± 0,17a	9,27± 1,40a	8,72 ± 0,78ab
OMP 15%	58,76 ± 1,65a	0,965 ± 0,00a	0,98 ± 0,14a	9,73± 1,07a	10,84 ± 2,54a

Values are the mean of the three replicates ± SD.
Means with different letters within row indicate statistically differences ($p<0.05$), as determined by Duncan's multiple range test.

3.2 Physical Characteristics

Physical characteristics evaluated including cooking loss, cooking yield, cutting force, and elasticity. Cooking loss is indicated by the loss of solid materials contained in noodle during cooking. Cooking yield is depending on the ability of noodle to absorb water during cooking. Cutting force is a physical property of noodle that determine the quality of noodle. The cutting force measurement is based on the compression test and is represented by a peak force in compression test [11]. Elasticity is the ability of noodle to stretch from its original length during stretching test.

Effects of OMP enrichment on the physical properties of noodle have been evaluated. The evaluations included cooking loss, cooking yield, cutting force and elasticity. As shown in Table 3. OMP enrichment increased cooking loss and cooking yield, but decreased cutting force insignificantly ($P<0.05$). Elasticity of enriched noodles did not alter by the enrichment of OMP.

Table 3. Physical properties of noodles enriched with different level of OMP

Samples	*Cooking Loss* (%)	*Cooking Yield* (%)	*Cutting force* (N)	Elasticity (N)
Control	4,24 ± 0,86a	182,02 ± 15,82a	2,92 ± 0,17a	0,19 ± 0,04a
OMP 2,5%	4,75 ± 0,94a	181,94 ± 12,68a	2,27 ± 0,53a	0,11 ± 0,02a
OMP 5%	4,37 ± 1,09a	187,64 ± 20,41a	2,48 ± 0,56a	0,11 ± 0,03a
OMP 7,5%	4,61 ± 0,84a	206,69 ± 14,58a	2,73 ± 0,83a	0,21 ± 0,13a
OMP 10%	4,82 ± 1,56a	197,39 ± 21,49a	2,44 ± 1,46a	0,12 ± 0,06a
OMP 12,5%	4,85 ± 1,03a	219,25 ± 21,16a	1,89 ± 0,71a	0,18 ± 0,10a
OMP 15%	5,32 ± 1,28a	195,14 ± 26,07a	1,98 ± 1,09a	0,09 ± 0,07a

Values are the mean of the three replicates ± SD.
Means with different letters within column indicate statistically differences ($p<0.05$), as determined by Duncan's multiple range test.

Hunter's color values of OMP enriched noodles are given in Table 4. The OMP enrichment significantly increased redness and yellowness, but decreased whiteness index of enriched noodles. At a level of 2.5%, OMP enrichment altered the redness of noodle and significantly different than that in control noodle. OMP enrichment also altered the yellowness of noodle significantly at a level of 15%. On the contrary, OMP enrichment significantly decreased whiteness index of enriched noodles. The higher values of redness and yellowness of enriched noodles can be attributed to the high values of redness and yellowness of oyster mushroom powder. It has been found that OMP enrichment increased the redness and yellowness of muffins (Wahyono et al., unpublished data).

Table 4. Hunter color properties of noodles enriched with different level of OMP

Samples	*L (lightness)*	*a (redness)*	*b (yellowness)*	*WI (Whiteness Index)*
Control	63.87±10.62^{a}	1.82±0.06^{e}	25.95±2.11^{b}	55.03±7.54^{b}
OMP 2.5%	64.73±6.93^{a}	3.39±0.59^{d}	29.49±2.67^{ab}	53.60±3.73^{a}
OMP 5%	61.97±9.52^{a}	3.64±0.77^{cd}	29.49±3.34^{ab}	51.25±5.55^{a}
OMP 7.5%	60.17±10.57^{a}	4.52±0.81^{bcd}	30.38±4.32^{ab}	49.07±5.86^{a}
OMP 10%	59.52±8.62^{a}	4.88±0.37^{abc}	30.93±2.19^{ab}	48.51±5.57^{a}
OMP 12.5%	58.50±7.42^{a}	4.94±0.20^{ab}	30.63±1.66^{ab}	47.98±5.15^{a}
OMP 15%	55.62±4.67^{a}	6.03±1.22^{a}	31.47±2.43^{a}	45.13±2.75^{a}

Values are the mean of the three replicates ± SD.
Means with different letters within row indicate statistically differences ($p<0.05$), as determined by Duncan's multiple range test.

3.3 Sensory characteristics

Sensorial evaluation of OMP enriched noodles are given in Table 5. The OMP enrichment significantly decreased all sensory attributes. However, sensory attributes of enriched noodles were scored ranging from 2.72 to 3.82 indicating that the enriched noodles were acceptable. The OMP enrichment can be done at the level of 5% without compromising color, aroma, and texture of enriched noodles compared to those of control noodle. In term of taste attribute, the enrichment can be done at the level of 12.5%. It has been reported that higher level of Oyster Mushroom Powder supplementation decreased the score of sensory attributes of biscuits [12]. On the contrary, [4] reported that higher level of OMP supplementation markedly enhanced the texture, taste and overall acceptability of noodles. In addition, [13] reported that generally, OMP incorporation did not alter the sensory attributes of mushroom biscuits.

Table 5. Sensory characteristics of noodles enriched with different level of OMP

Samples	Color	Taste	Odor	Texture
Control	3.86^{a}	3.64^{a}	3.30^{a}	3.88^{a}
OMP 2.5%	3.82^{a}	3.46^{a}	3.17^{ab}	3.69^{ab}
OMP 5%	3.65^{ab}	3.34^{a}	3.26^{a}	3.44^{abc}
OMP 7.5%	3.10^{bc}	3.23^{ab}	2.87^{b}	3.08^{c}
OMP 10%	2.78^{c}	3.31^{a}	2.92^{b}	3.02^{c}
OMP 12.5%	2.84^{c}	3.23^{ab}	2.99^{ab}	3.19^{bc}
OMP 15%	2.72^{c}	2.80^{b}	2.93^{b}	2.96^{c}

Values are the mean of the three replicates.
Means with different letters within row indicate statistically differences ($p<0.05$), as determined by Duncan's multiple range test.

4. Conclusions

The use of oyster mushroom powder (OMP) significantly affected the physicochemical and sensorial qualities of noodle. The OMP enrichment significantly increased water activity, ash, and crude fiber content of enriched noodles compared to that of control noodle. But, the OMP enrichment insignificantly increased water content and protein content of enriched noodles. The redness and yellowness of OMP enriched noodles significantly higher than those of control noodle. The OMP enrichment significantly affected the sensorial properties of enriched noodles. Generally, increased OMP decreased the sensorial scores of enriched noodles. However, all sensorial scores including color, taste, odor, and texture of enriched noodles were acceptable. In conclusion, OMP enrichment is feasible to enhance the nutritional values of noodle.

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