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ORIGINAL PAPER

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THE EFFECT OF GOLDEN OYSTER MUSHROOM (*PLEUROTUS CITRINOPILEATUS*) POWDER ON THE PHYSIOCHEMICAL, ANTIOXIDATIVE, AND SENSORY PROPERTIES OF NOODLES

Tran Hong Quan[1✉], Giap Pham Ngoc Tram[1], Tran Tieu Yen[1], Nguyen Phung Tien[1], Pensiri Kaewthong[2,3], Supatra Karnjanapratum[4]

[1]Department of Food Technology, Faculty of Applied Biological Sciences, Vinh Long University of Technology Education Vinh Long, 85110, **Vietnam**

[2]Professional Culinary Arts Program, School of Management, Walailak University Nakhon Si Thammarat 80161, **Thailand**

[3]Food Technology and Innovation Research Centre of Excellence, Department of Agro-Industry, School of Agricultural Technology, Walailak University, Thasala, Nakhon Si Thammarat 80161, **Thailand**

[4]Food Innovation and Packaging Center, Chiang Mai University Chiang Mai, 50100, **Thailand**

ABSTRACT

Background. Golden oyster mushrooms (*Pleurotus citrinopilratus*) are widely consumed in Asian countries because they are rich in nutrition and bioactive compounds. However, this mushroom has not yet been incorporated into food products.

Materials and methods. This study aimed to investigate the effects of golden oyster mushroom powder (GOMP) on the physiochemical, antioxidative, and sensory properties of noodles by supplementing wheat flour with GOMP equivalent to 5–15% of the total wheat flour weight.

Results. The results showed that GOMP was very yellow (b^* value) and was a good source of ash, protein, and phytochemicals (flavonoid and total phenolic contents), as well as antioxidant capacity (DPPH radical scavenging activity and metal chelating activity). The incorporation of GOMP in the amount of 5–15% of total wheat flour increased the a^* value and decreased the L^* and b^* values of the resulting noodles. Supplementing the noodles with GOMP increased not only the ash, protein, flavonoid, and total phenolic contents but also antioxidant activity. However, a lower cutting force (N) was required to cut GOMP-enriched noodles compared to control noodles. The incorporation of GOMP at levels up to 10% of the wheat flour weight did not affect the sensory properties of the noodles at all attributes.

Conclusions. GOMP could be applied as a nutritional and antioxidant ingredient in noodle preparation.

Keywords: golden oyster mushroom, noodles, antioxidant activity, phytochemical, sensory properties

INTRODUCTION

Edible mushrooms are traditionally used worldwide in both food and medicine, thanks not only to their texture and flavor but also their chemical and nutritional properties (Elmastas et al., 2007). The golden

✉quanth@vlute.edu.vn, phone: +84 0978471514, https://orcid.org/0000-0002-6807-6867

oyster mushroom, also called the Yellow oyster mushroom (*Pleurotus citrinopilratus*), is one of the most popular mushrooms in Vietnam and the South East Asian countries. *Pleurotus* spp. are a rich source of protein – richer than nuts such as soybeans, peanuts, and plant-based proteins (cereal grains and seeds) (Muyanja et al., 2014). In addition, the golden oyster mushroom is appreciated for its high quantities of carbohydrates, minerals (Ca, P, Fe, Zn), and vitamins (thiamin, riboflavin, and niacin) as well as its low fat content (Mutukwa, 2014). Several *in vitro* studies have shown that *Pleurotus* spp. also possesses high antioxidant and free radical scavenging activities associated with a reduction in the risk of systemic health diseases (Barros et al., 2007; Fu et al., 2002; Selvi et al., 2007), especially reactive oxygen species (ROS), which can become important when human *in vivo* antioxidant defense and immunological repair systems are inadequate to prevent damage (Piskov et al., 2020). However, *Pleurotus* spp. has a high water content (87–95%) and a diversity of enzymes, which are responsible for the deterioration and the decrease of organoleptic value (Martínez-Soto et al., 2001; Piskov et al., 2020). Therefore, they are highly perishable and have a short storage life under atmospheric storage conditions (Barros et al., 2007). It is necessary to adopt suitable post-harvest techniques to prolong the shelf life and maintain the nutritional value of these kinds of mushrooms. The drying process is one of the most effective ways to extend the shelf life of many kinds of food products. There are various methods for the processing of mushrooms, such as sun drying, oven drying, solar drying, cabinet air drying, fluidized-bed drying, and atmospheric drying (vacuum and freeze drying) (Hassan and Medany, 2014). Dried oyster mushrooms have a longer shelf life and reduced weight and volume compared to fresh forms, thereby potentially reducing the cost of packaging, handling, preserving, and transporting products (Karimi, 2010).

Wheat flour is the main ingredient in various food products, especially bread and noodle products. However, lysine, an essential amino acid, is mostly deficient in wheat (Salehi, 2019). A deficiency in essential amino acids in the diet affects the normal growth of human tissues and organs. Hence, adding mushroom powder rich in lysine can increase the nutritional value of this raw material. Moreover, partially hydrolyzed protein components in the mushroom are fermentable by gut microbes to release branch-chain fatty acids to enhance host health. Dietary fiber in the mushrooms may reduce protein digestibility by obstructing enzymatic diffusion and limiting protein hydrolysis. This renders mushrooms suitable for consumption as part of a regular diet in typical food matrixes. Edible mushrooms have recently been used for food fortification or enrichment. Fortification helps to prevent, reduce, and control micronutrient deficiencies (Ayimbila and Keawsompong, 2023). Therefore, the incorporation of mushrooms into several baked products, such as bread, cookies, cakes, and pasta, could improve their nutritional value for customers (Salehi, 2019). In particular, the addition of golden oyster mushrooms to noodles has not been broadly studied. Noodles are one of the processed products that are consumed widely around the world, especially in Vietnam, China, and Japan. Thus, this study aimed to investigate the influence of golden oyster mushroom powder on the nutritional, antioxidant, and sensory properties of noodles.

MATERIALS AND METHODS

Materials and chemicals

Golden oyster mushrooms (*Pleurotus citrinopileatus*) were cultivated and collected in the membrane house of the Department of Biotechnology, Faculty of Applied Biological Sciences, Vinh Long University of Technology Education. The mushrooms had been cultivated for 2 weeks before the study was conducted. The selected mushrooms were 2-day fruiting bodies in which the size of the mushroom cap was 3 cm. The newly harvested mushrooms, without visible flecks, were kept in plastic bags and stored at 4°C before the experiments. All analytical grade chemicals used in the experiments were purchased from Merck KGAA Co. (Darmstadt, Germany).

Preparation of golden oyster mushroom powder (GOMP)

Fresh golden oyster mushrooms were washed under running tap water and wiped to dry. The mushrooms were then subjected to a tray drier (DRC – 16T, Viet Nam) with airflow rates of 1.5 m/s at 55°C for 8 h. The dried golden oyster mushrooms were ground

Table 1. Formulation of the control noodles and the noodles incorporating golden oyster mushroom powder (GOMP)

Main ingredients g	Formulation for 100 g ingredients			
	B_0	$GOMP_1$	$GOMP_2$	$GOMP_3$
Wheat flour	100	95	90	85
GOMP	0	5	10	15
Whole egg	70	70	70	70
Salt	2	2	2	2

B_0 = 100% wheat flour (control); $GOMP_1$ = 5:95 (%w/w) GOMP: wheat flour; $GOMP_2$ = 10:90 (%w/w) GOMP: wheat flour; $GOMP_3$ = 15:85 (%w/w) GOMP: wheat flour.

using a blender (Philips Blender HR2221, China). The powder was sieved through a size 16 mesh screen before being packed in polyethylene bags and then placed in the freezer (–18°C) until the analysis was completed.

Preparation of noodles

Golden oyster mushroom noodles were produced using the method of Parvin et al. (2020) with slight modification. The ingredients used in the production are described in Table 1. The GOMP was incorporated into the noodle mixture at levels of 5%, 10%, and 15% based on the wheat flour weight. The dough was homogeneously mixed and extruded using a noodle maker (Philips HR2382, Japan). Thereafter, the noodles were steamed at 95°C for 3 min and dried at 60°C for 1 h. The dried noodles were cooled for 10 min to room temperature and packaged in plastic bags before being subjected to analysis.

Analytical methods

Determination of color (*L, *a**, and *b** values), moisture content, and water activity (a_w) of golden oyster mushroom powder (GOMP) and noodles**

The colors of the GOMP and noodles were measured using a colorimeter (MSEZ-4500 L, HunterLab, USA) and expressed in the CIE system. L^*, b^*, and a^* values represent brightness, yellowness, and redness, respectively. The moisture content of the GOMP and noodles was determined using a moisture analyzer (MOC-63U Shimadzu, Japan). The a_w of the GOMP and noodles was recorded by a Water Activity Meter Set (Rotronic HP23-AW-40, Switzerland).

Determination of total ash and protein contents of golden oyster mushroom powder (GOMP) and noodles

The total ash content (%) of the GOMP and noodles was determined according to the dry ashing method, while the protein content of the GOMP was analyzed by the Kjeldahl method (AOAC, 1999).

Determination of total phenolic and flavonoid contents of golden oyster mushroom powder (GOMP) and noodles

The total phenolic content (TPC) and flavonoid content (FC) of the GOMP and noodles were analyzed as described by Piskov et al. (2020) and Salehi (2019), respectively. To extract phenolic and flavonoid compounds from mushrooms, 1 g of sample was mixed with 50 mL of absolute methanol. After extraction for 24 h using a shaker at 150 rpm in the dark, the mixture was centrifuged at 4000 rpm for 20 min and decanted. The liquid extract was then evaporated until dry using nitrogen gas at 40°C. The residue was dissolved again in absolute methanol to a concentration of 50 mg/mL and kept at 4°C.

For the TPC assay, the Folin-Ciocalteau reagent procedure was used. Briefly, 1.8 mL of tenfold diluted Folin-Ciocalteau reagent was mixed with 40 μL of the GOMP extract in an aluminum foil-covered test tube for 5 min. Thereafter, 1.2 mL of sodium bicarbonate solution (7.5% w/v) was added and thoroughly vortexed. The reaction was kept in the dark for 1 h, and the absorbance of the solution was measured at $\lambda = 765$ nm by a spectrophotometer (2602 Labomed, USA). The TPC of the samples was expressed as mg gallic acid equivalent (standard curve formula $y = 1.4497x + 0.00334$, $R^2 = 0.99$) per 1 g powder per dry weight (mg GAE/g). The tests were repeated three times.

For the FC procedure, the GOMP and noodle extracts (0.5 mL) were mixed with 10% $AlCl_3$ (0.1 mL), 1 mol/L CH_3COONa (0.1 mL), and distilled water (2.8 mL). Then, the mixture was kept at ambient temperature in the dark for 30 min. The absorbance measured at λ = 415 nm of the reaction mixture was recorded using a spectrophotometer. FC was presented as mg quercetin equivalent (standard curve formula $y = 0.009x + 0.00698$, $R^2 = 0.99$) per 1 g powder per dry weight (mg QE/g). The tests were repeated three times.

Determination of antioxidant activity of golden oyster mushroom powder (GOMP) and noodles

DPPH radical scavenging activity (DPPH)

The DPPH radical scavenging activity (%) of the GOMP and noodles was measured as per the protocol of Elmastas et al. (2007). For methanol extraction, the samples (10 g) were added to absolute methanol (100 mL) and shaken at 150 rpm for 24 h at room temperature. This step was repeated until the extracting solvent became uncolored. The obtained extract was filtered through filter paper Whatman no. 2 (Merck KGaA, Darmstadt, Germany). The filtrate was then removed from the methanol using a vacuum rotary evaporator (WEV-1010, Daihan, Korea) at 40°C. The dried extract was kept in an amber bottle and stored at 4°C until analysis to inhibit oxidation. To analyze DPPH radical scavenging activity, the dried extract (10 mg) was dissolved in absolute methanol (10 mL). One milliliter of 0.1 mM DPPH freshly prepared in absolute methanol was then mixed with 3 mL of the dried GOMP extract. The mixture was stirred well and kept at room temperature for 30 min. The tests were repeated three times. The absorbance measured at λ = 517 nm was recorded in a spectrophotometer. The activity was calculated using the following formula:

$$\text{DPPH radical scavenging activity (\%)} = [(A_0 - A_1)/A_0] \times 100$$

where

A_0 is the absorbance of the control (without the sample)

A_1 is the absorbance of the sample.

Metal chelating activity (MCA)

The methods used to measure the metal chelating activity (%) of the GOMP and noodles was described by Wong et al. (2014). Briefly, 0.2 mL of 0.1 mM $FeSO_4$ and 0.4 mL of 0.25 mM ferrozine were thoroughly mixed with 0.2 mL of the GOMP extract. After incubation in the dark at room temperature for 30 min, the absorbance of the mixture was recorded at λ = 562 nm using a spectrophotometer. The tests were repeated three times. The metal chelating activity was calculated according to the following formula:

$$\text{metal chelating activity (\%)} = [(A_0 - A_1)/A_0] \times 100$$

where

A_0 is absorbance of the control (without the sample)

A_1 is the absorbance of the sample.

Determinations of cutting force (N) of noodles

The cutting force (N) required to cut the noodles was monitored using a texture analyzer (TMS Pro, USA). A Light Weight Blade Set with a 1.2 mm thick stainless steel precision blade was used to measure the hardness of the noodles. The settings of the texture analyzer consisted of test mode (compression); test speed (40 mm/min); displacement (10 mm); and trigger force (50 N) using Texture Lab Pro software (version 1.18-408/15/10/13) for data acquisition. The tests were repeated three times.

Sensory evaluation of noodles

The sensory evaluation of noodle samples was performed according to the method of Martínez-Soto et al. (2001) using a 9-point hedonic scale. All noodle samples were cooked before being evaluated. All samples were prepared in plastic cups and blindly coded using 3-digit random numbers. Forty panelists aged between 20 and 35 were asked to evaluate the texture, appearance, taste, flavor, and overall appeal of the noodles.

Statistical analysis

All the experimental results of the triplicate measurements are shown as mean ± standard deviation (STD). Data were compared using variances across the means of different groups using analysis of variance (ANOVA) and Duncan's multiple range test (Steel and Torrie, 1980). Statistical analysis was conducted using the Statistical Package for Social Science for Windows (SPSS 11.0, SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSIONS

Physicochemical characteristics and antioxidant activity of golden oyster mushroom powder

Table 2 lists the physicochemical properties and antioxidant activity of the golden oyster mushroom powder (GOMP). It was observed that the GOMP possessed high yellowness (*b** value = 32.84 ±0.03) and low lightness (*L** value = 58.07 ±0.04) and *a** value (2.22 ±0.03). Thus, this powder could be used as a natural colorant to improve the color of noodle products. The GOMP had low moisture content and water activity, which were 5.29 ±0.20 and 0.28 ±0.00, respectively. The a_w was less than 0.6, which was stable with storage and appropriate for application in many kinds of food products (Engin, 2020). The total ash and protein content in the GOMP were 5.30 ±0.12% and 24.02 ±0.05%, respectively, showing higher protein content compared to wheat flour

Table 2. Physiochemical characteristics and antioxidant properties of golden oyster mushroom powder (GOMP)

Parameters	Golden oyster mushroom powder (GOMP)
Color values	
L^*	58.07 ±0.04*
a^*	2.22 ±0.03
b^*	32.84 ±0.03
Water activity (a_w)	0.28 ±0.00
Moisture content, %	5.29 ±0.20
Ash content, %, d.b.	5.30 ±0.12
Protein content, %, d.b.	24.02 ±0.05
Flavonoid content (FC), mg QE/g	55.87 ±1.97
Total phenolic content (TPC), mg GAE/g	0.47 ±0.03
DPPH radical scavenging activity, %	5.51 ±0.09
Metal chelating activity, %	1.44 ±0.05

*Data are expressed as mean ±standard deviation (n = 3).

(11%, data not shown). These results were similar to the finding of Hong et al. (2005), who reported that oyster mushroom (*Pleurotus ostreatus*) powder had notable protein (24.75%) and ash content (7.67%). Moreover, GOMP was rich in some bioactive compounds judging by flavonoid (FC) and total phenolic content (TPC), which were 55.87 ±1.97 mg QE/g and 0.47 ±0.03 mg GAE/g, respectively. Shankar et al. (2022) documented that dried oyster mushroom (*Pleurotus ostreatus*) powder contained 0.56 mg QE/g flavonoid and 2.67 mg GAE/g total polyphenol. These phytochemical compounds are known as effective antioxidants which can quench or neutralize free radicals (Elmastas et al., 2007). Thus, the GOMP showed high antioxidant activity. The DPPH radical scavenging and metal chelating activities of GOMP were 5.51 ±0.09% and 1.44 ±0.05%. Elmastas et al. (2007) revealed that edible mushrooms had strong metal-chelating ability and hydrogen-donating ability, and were good scavengers of free radicals and superoxide. Therefore, the incorporation of GOMP as an ingredient in food products could improve health benefits for consumers.

Effect of golden oyster mushroom powder on color values (*L**, *a**, and *b**), water activity, and cutting force of noodles

The color values, water activity (a_w), and cutting force (N) of noodles incorporated with different levels of GOMP are reported in Table 3. The color values of the noodles were significantly affected by GOMP levels ($p < 0.05$). The highest *L** value, which was 95.14 ±0.69, was observed in the control noodles (without added GOMP). A decrease in *L** value was noted as the GOMP was added. Higher levels of GOMP yielded a lower *L** value ($p < 0.05$). The L^* values of the noodles incorporating 5% and 10% GOMP were 91.07 ±0.59 and 85.47 ±0.57, respectively. The lowest value (72.49 ±4.41) was recorded in noodles with 15% GOMP. The decreased L^* value was in line with the increased a^* and decreased b^* values of noodles supplemented with GOMP. It was observed that the control noodles possessed the lowest a^* value (–0.84 ±0.03). The a^* values of noodles increased from 0.55 ±0.03 to 2.66 ±0.15, while the b^* values decreased from 30.61 ±0.15 to 18.84 ±0.76 when GOMP was added at the levels of 5% and 10%, respectively. The changes in the

Table 3. Effect of different golden oyster mushroom powder (GOMP) levels on color values (L^*, a^*, and b^*), water activity (a_w), and cutting force (N)

GOMP levels	L^*	a^*	b^*	Water activity (a_w)	Cutting force (N)
B_0	95.14^a ±0.69*	–0.84^d ±0.03	28.66^b ±0.08	0.61^a ±0.01	24.14^a ±0.81
$GOMP_1$	91.07^a ±0.59	0.55^c ±0.03	30.61^a ±0.15	0.61^a ±0.00	16.58^b ±1.32
$GOMP_2$	85.47^b ±0.57	2.03^b ±0.17	23.48^c ±0.58	0.54^b ±0.01	17.03^b ±1.38
$GOMP_3$	72.49^c ±4.41	2.66^a ±0.15	18.84^d ±0.76	0.52^b ±0.01	8.65^c ±0.52

B_0 = 100% wheat flour (control); $GOMP_1$ = 5:95 (%w/w) GOMP: wheat flour; $GOMP_2$ = 10:90 (%w/w) GOMP: wheat flour; $GOMP_3$ = 15:85 (%w/w) GOMP: wheat flour.
*Data are expressed as mean ±standard deviation (n = 3); different superscripts in the same column indicate significant differences of data in the same column ($p < 0.05$).

color of the GOMP-fortified noodles were due to the low lightness and the high yellowness of the GOMP (Table 2). Nordiana et al. (2019) found that pasta fortified with oyster mushroom (*Pleurotus sajor-caju*) had lower L^* and b^* values and a higher a^* value than control pasta. Thus, the changes in color could impact the sensory properties of the noodles.

Water activity (a_w) and the cutting force (N) of the noodles were also significantly affected by GOMP levels ($p < 0.05$) (Table 3). When the levels of GOMP were in the range of 5–15%, the a_w of the resulting noodles significantly decreased ($p < 0.05$). The a_w of noodles with 5% GOMP was 0.61 ±0.00, which decreased to 0.52 ±0.01 for 15% GOMP ($p < 0.05$). This is likely because the fiber in GOMP can hold and absorb a large number of water molecules in the noodle pore matrix. As a result, the amount of free water molecules decreases and the a_w decreases (Ho and Abdul Latif, 2016). Arora et al. (2018) found that water absorption increased with increasing levels of *Pleurotus* powder in noodles. The cutting force (N) of the noodles significantly decreased when the level of GOMP increased from 5% to 15% ($p < 0.05$) (Table 3). The highest cutting force was required for the control noodles without the addition of GOMP (24.14 ±0.81 N). The cutting force required for noodles with 5% GOMP was 16.58 ±1.32 N, which was approximately 1.5 times lower than that required for the control noodles. The cutting forces required for noodles with 10% and 15% GOMP were 17.03 ±1.38 N and 8.65 ±0.52 N, respectively. The reduction in the cutting force is related to the role of GOMP insoluble fibers, since these components partially replace the starch and protein of the wheat flour. As a result, the gluten matrix becomes less rigid, reducing its ability to gel and resulting in the dough becoming dry and more brittle (Aravind et al., 2012). This result was in contrast with that of Lu et al. (2016), who documented that noodles became softer when white button, shitake, and porcini mushroom powders were added.

Effect of golden oyster mushroom powder on the chemical composition and antioxidant activity of noodles

The effects of GOMP levels on the chemical composition of noodles, including ash, protein, flavonoid, and total phenolic content, are reported in Table 4. The ash content of noodles increased with the increase of GOMP levels ($p < 0.05$). The highest ash content was in the noodles consisting of 15% GOMP (2.96 ±0.02%), and the wheat flour-noodles contained the lowest ash content (1.42 ±0.04%). It should be noted that the total ash content in the GOMP was 5.3 ±0.12% (Table 2), so adding more GOMP increased the ash content of the noodles ($p < 0.05$). This result is consistent with that of Arora et al. (2018), who discovered that the ash content of the noodles increased as the level of oyster mushroom powder increased (2–10%). Along with the ash content, the protein content of the noodles increased with GOMP levels ($p < 0.05$). The highest protein content was recorded in the sample formulated with 15% GOMP (38.27 ±0.14%), which was almost twice as high as that of the control noodles (26.18 ±0.06%). The protein content of noodles with

Table 4. Effect of different golden oyster mushroom powder (GOMP) levels on ash, protein, flavonoid, total phenolic contents and antioxidant activities (DPPH radical scavenging activity and metal chelating activity) of noodles

GOMP levels	Total ash content %, d.b.	Protein content %, d.b.	Flavonoid (FC) mg QE/g	Total phenolic content (TPC) mg GAE/g)	DPPH radical scavenging activity (DPPH) %	Metal chelating activity (MCA) %
B_0	1.42[c] ±0.04*	26.18[d] ±0.06	34.62[d] ±1.39	0.35[d] ±0.01	2.66[d] ±0.09	1.22[d] ±0.03
$GOMP_1$	2.53[b] ±0.15	29.00[c] ±0.07	49.26[c] ±0.78	0.38[c] ±0.01	3.35[c] ±0.13	1.52[c] ±0.05
$GOMP_2$	2.61[b] ±0.20	35.73[b] ±0.10	62.57[b] ±0.24	0.44[b] ±0.01	4.27[b] ±0.17	1.83[b] ±0.02
$GOMP_3$	2.96[a] ±0.02	38.27[a] ±0.14	69.81[a] ±0.25	0.50[a] ±0.01	5.34[a] ±0.24	2.10[a] ±0.04

B_0 = 100% wheat flour (control); $GOMP_1$ = 5:95 (%w/w) GOMP: wheat flour; $GOMP_2$ = 10:90 (%w/w) GOMP: wheat flour; $GOMP_3$ = 15:85 (%w/w) GOMP: wheat flour.
*Data are expressed as mean ±standard deviation (n = 3); different superscripts in the same column indicate significant differences of data in the same column ($p < 0.05$).

5% and 10% GOMP was 29.00 ±0.07% and 35.73 ±0.10%, respectively. This result is due to the high protein content in GOMP (24.64%, Table 2). Nordiana et al. (2019) reported that the protein content of pasta significantly increased when oyster mushroom powder was added at levels of 5–15%. The current results are also in line with the findings of Salehi (2019), who revealed that the protein content of sponge cake increased from 6.52% to 7.66% when it was fortified with 5–15% button mushrooms (*Agaricus bisporus*). Moreover, the flavonoid content (FC, mg QE/g) and total phenolic content (TPC, mg GAE/g) also significantly increased with increasing GOMP levels in noodles compared to the control ($p < 0.05$). The wheat flour-based noodles contained 34.62 ±1.39 mg QE/g FC and 0.35 ±0.01 mg GAE/g TPC (Table 4). However, the noodles containing GOMP exhibited increased FC and TPC at all levels used. For instance, the FC and TPC in noodles almost doubled when GOMP was added at a level of 15%. This could be due to the high amount of FC (55.87 ±1.97 mg QE/g) and TPC (0.47 ±0.03 mg GAE/g) (Table 2) contained in GOMP.

The GOMP was rich in bioactive compounds including flavonoids and polyphenols, which contributed to the excellent antioxidant ability of the formulated foods. The control noodles had low DPPH radical scavenging activity (DPPH) (2.66 ±0.09%) and metal chelating activity (MCA) (1.22 ±0.03%). Nevertheless, with an increase in the GOMP levels, both the DPPH and MCA of the noodles improved remarkably ($p < 0.05$). The DPPH and MCA of the noodles were enhanced from 3.35 ±0.13% to 5.34 ±0.24% and from 1.52 ±0.05% to 2.10 ±0.04%, respectively, as the GOMP levels increased from 5% to 15%. This result was in line with previous studies that have shown that oyster mushroom powder-enriched noodles have increased antioxidant potential (% DPPH inhibition) with increasing levels of mushroom powder (Arora et al., 2018). Sławińska et al. (2022) reported that bread supplemented with 2.5–5% white and brown button mushroom powders had improved antioxidant properties (DPPH and Ferric reducing ability) and a higher TPC compared to control bread. Hence, the incorporation of GOMP could improve not only the bioactive compounds but also the antioxidant activity of enriched noodles.

Effect of golden oyster mushroom powder on the sensory properties of noodles

The sensory characteristics of noodles enriched with GOMP are reported in Table 5. In general, the scores of all the attributes of the noodles ranged between 4 and 8 (mild dislike to like very much). The appearance, color, and texture scores of the control noodles were not significantly different from those of the noodles that contained GOMP at the levels of 5% and 10% ($p > 0.05$). However, adding 15% GOMP caused decreases in the appearance, color, texture, and overall appeal scores ($p < 0.05$). It was observed that the GOMP decreased the lightness of the noodles and

Table 5. Effect of different golden oyster mushroom powder (GOMP) levels on the sensory characteristics of noodles

GOMP levels	Appearance	Color	Flavor	Taste	Texture	Overall appeal score
B_0	8.00^{a} ±1.05	7.57^{a} ±1.20	6.80^{a} ±1.16	7.00^{a} ±1.46	7.47^{a} ±1.32	7.53^{a} ±1.11
$GOMP_1$	7.53^{a} ±0.97	7.27^{ab} ±1.39	7.00^{a} ±1.29	6.83^{a} ±1.37	7.07^{a} ±1.39	7.27^{a} ±0.91
$GOMP_2$	5.63^{a}±1.27	7.60^{a} ±1.00	8.33^{a} ±1.24	7.27^{a} ±1.44	7.60^{a} ±1.40	6.43^{a} ±1.31
$GOMP_3$	4.57^{b} ±1.43	6.83^{b} ±1.34	5.87^{a} ±1.22	6.83^{a} ±1.39	6.13^{b} ±1.83	6.40^{b} ±1.13

B_0 = 100% wheat flour (control); $GOMP_1$ = 5:95 (%w/w) GOMP: wheat flour; $GOMP_2$ = 10:90 (%w/w) GOMP: wheat flour; $GOMP_3$ = 15:85 (%w/w) GOMP: wheat flour.

*Data are expressed as mean ±standard deviation (n = 3); different superscripts in the same column indicate significant differences of data in the same column ($p < 0.05$).

yielded a more brownish color (Fig. 1). Parvin et al. (2020) documented that 5% mushroom powder had the highest scores for all the sensory attributes evaluated. However, adding 8–10% mushroom powder affected the color, texture, flavor, mouthfeel, taste, and overall acceptability of the noodles. Moreover, Prodhan et al. (2015) also found that biscuits without any added *Pleurotus Sajor-caju* mushroom powder obtained the highest score for overall acceptability, followed by 10% mushroom powder biscuits and then 5% and 15% mushroom powder biscuits. Thus, GOMP could be added to noodles at levels up to 10% without adversely influencing the sensory attributes of the noodles.

CONCLUSIONS

The GOMP was rich in ash, protein, and bioactive compounds, especially those with high antioxidant activity. Therefore, the substitution of GOMP for 5–15% of the wheat flour in noodles could increase the ash, protein, flavonoid, and total phenolic content of the

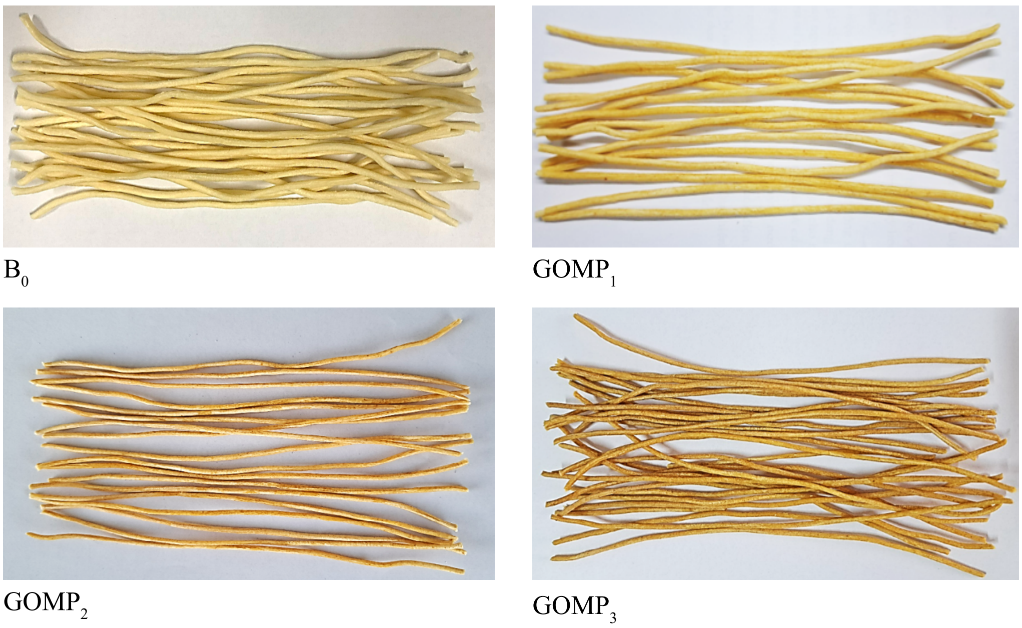

Fig. 1. The appearance of noodles incorporating different amounts of golden oyster mushroom powder

enriched noodles, compared to control noodles. Additionally, the GOMP incorporated into the noodles significantly enhanced their MCA and DPPH values. Noodles made from flour consisting of up to 10% GOMP did not have significantly different sensory qualities from the control noodles. Thus, the golden oyster mushroom could be used as a nutritional and bioactive supplement in various food products. The incorporation of golden oyster mushrooms into food products could have a positive effect on the health and safety of consumers who do not have any allergy to mushrooms.

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