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Effect of *Hypsizygus marmoreus* powder on cooking characteristics, color and texture of wheat noodles

Baosha TANG[1,2#], Li WU[1,2#], Minjie WENG[1,2], Junchen CHEN[1,2], Yibin LI[1,2*], Pufu LAI[1,2*]

Abstract

Hypsizygus marmoreus is a kind of edible fungus with high nutritional value. This investigation evaluated the influence of *Hypsizygus marmoreus* powder on the quality characteristics of noodles. The cooking time, cooked breaking ratio, cooking loss rate, color difference value, texture and sensory of noodles were measured. The addition of 4% to 20% mass fraction of mushroom powder had no significant effect on the cooking time and hardness of the noodles. The cooked breaking ratio of noodles increased from 0% to 13.27%, the cooking loss rate increased from 3.47% to 10.73%, the color difference value increased from 18.23 to 23.58, and the chewing hardness increased from 4569.66 g to 5888.68 g, with the mass fraction of mushroom powder increased from 0% to 20%. The sensory of noodles with 4% mushroom powder is the best. This study provides a certain theoretical basis for the further processing of *Hypsizygus marmoreus*.

Keywords: *Hypsizygus marmoreus*; wheat noodles; cooked breaking ratio; color; texture.

Practical Application: The addition of *Hypsizygus marmoreus* powder to noodles will increase the functionality and diversification of traditional Chinese food culture.

1 Introduction

Food processing and value-added are key steps in the food value chain (Alamu & Mooya, 2017). Grain is the most basic food resource of human beings, which can provide most essential nutrients for the human body (Timsina et al., 2021); Edible fungus is an edible macrofungus with high nutritional value. It also contains a lot of protein, polysaccharides, vitamins, amino acids, minerals, dietary fiber and other components and physiologically active substances. It has the physiological functions of lowering blood sugar, blood pressure, blood lipid, anti-virus, anti-fatigue and regulating immunity, and is an ideal nutritious and healthy food (Zhang et al., 2021). Noodles are the traditional foods in China. With the improvement of living standards, people put forward higher requirements for the quality of this traditional food, and pay more attention to the function and health care function of noodles (Liu et al., 2016; Shen et al., 2019). Therefore, scholars are working hard to study new nutritious noodles, adding various vegetables into noodles, such as purple yam salted noodles developed by Li et al. (2012), amaranth leaf powder instant noodles developed by Qumbisa et al. (2021), wheat germ Turkish noodles developed by Demir et al. (2021), noodles rich in citrus (grapefruit) fruit slices developed by Reshmi et al. (2020) and miscellaneous grains developed by Jing et al. (2018). Some scholars have also studied the antioxidation of *Lentinula edodes* noodles in vitro stomach digestion (Wang et al., 2020), the quality improvement of *Lentinula edodes* noodles (Parvin et al., 2020), the prevention of high-fat diet by *Auricularia polytricha* noodles (Fang et al., 2021b), the characteristics of edible fungus grain noodles (Zhang et al., 2017), and the pasta with mushroom powder (Lu et al., 2018). Relevant studies show that the dough with edible fungi will decrease its binding force and ductility due to the increase of fiber content. The research results of Li et al. (2018, 2019) show that the addition of *Pleurotus ostreatus* powder will have a certain influence on the quality characteristics of noodles, and the quality of noodles made with of 3% *Pleurotus ostreatus* powder is better, while the different addition forms of *Flammulina velutipes* will have an influence on the quality characteristics of noodles. With the increase of the addition amount of *Flammulina velutipes*, the water absorption, elongation, breakage rate and cooking loss rate of noodles will all increase. Wang et al. (2019) studied the influence of *Auricularia auricular* powder on the rheological properties of dough and noodle quality, and pointed out that adding *Auricularia auricular* powder can significantly increase the water absorption of dough and weaken the protein degree, thus shortening the dough forming time, while a certain amount of *Auricularia auricular* polysaccharide can improve the protein grid structure of gluten and increase its wrapping power to starch particles.

The fruiting body of *Hypsizygus marmoreus* is rich in nutrients and active components, including a large number of free flavoring amino acids and flavonoids (Chen et al., 2017; Mleczek et al., 2018; Lai et al., 2021a). Therefore, this experiment takes *Hypsizygus marmoreus* powder, high gluten flour and

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[1] *Institute of Agricultural Engineering Technology, Fujian Academy of Agricultural Sciences, Fuzhou, Fujian Province, China*
[2] *National R&D Center For Edible Fungi Processing, Fuzhou, Fujian Province, China*
*Corresponding author: lyb9951@163.com; laipufu@163.com
[#] *Baosha TANG and Li Wu contributed equally to this study.*

gluten powder as materials to study the effects of *Hypsizygus marmoreus* powder on the cooking and texture of noodles, so as to provide a basis for the production of functional *Hypsizygus marmoreus* noodles.

2 Materials and methods

2.1 Materials and reagent

Hypsizygus marmoreus was provided by Fujian Tongxing Fungus Industry Co., Ltd., China. The mushroom was dried at 50 °C by a heat pump dryer (ZWH-KFX-BT12, Fujian Xuefeng Refrigeration Equipment Co., Ltd., China) and was crushed by the grinder (103, Zhejiang Ruian Yongli Pharmaceutical Machinery Co., Ltd., China).

High-gluten flour, vital wheat gluten, salt used in the experiment were all food grade raw materials. Use a vertical smart noodle machine to make noodles (M4-M511XL CONY, Hangzhou Joyoung Co., Ltd., China).

2.2. Methods

Production process of Hypsizygus marmoreus noodles

Hypsizygus marmoreus powder → mix with flour and add water → stir → extrude → dry → package → test.

Cooking time

The cooking time was measured by the People's Republic of China Food Industry Standard (People's Republic of China Food Industry Standard, 2021). Drinking water with 50 times the quality of the noodles sample was boiled in 1000 mL beaker, 40 noodles were randomly selected and put into boiling water, and then kept the water was slightly boiling. After 2 min, samples were taken every 30 seconds, one root at a time, flattened with glass sheet, and the cooking time was observed when the white hard core line disappeared in the noodle.

Cooked breaking ratio

The cooked breaking ratio was measured by the People's Republic of China Food Industry Standard (LS/T 3212-2021. Dried noodle, 2021). Drinking water with 50 times the quality of the noodles sample was boiled in 1000 mL beaker. 40 21-cm-long noodles were randomly selected and put into boiling water. After cooking to the optimum cooking time, the cooked noodles were gently pick up and the cooked breakage were calculated according to the formula (Equation 1):

$$S = Ns \div 40 \times 100 \left(S,\ the\ cooked\ breaking\ ratio,\ \%;\ Ns,\ the\ number\ of\ broken\ noodles\right) \quad (1)$$

Cooking loss rate

According to the method of Chen et al. (2021), 15g noodles were added to 200 mL boiling water for 5 min, and the remaining noodle soup was mixed at 200 mL. After steaming and drying on adjustable electric furnace, 15 g noodles were dried in 105 ± 2 °C oven to constant weight, and the cooking loss rate was calculated according to the formula (Equation 2):

$$Cooking\ loss\ rate\ (\%) = dry\ matter\ in\ noodle\ soup \times 2 / called\ noodle\ mass \times 100 \quad (2)$$

Color difference value

A colorimeter (NS810, Shenzhen 3NH Technology Co., Ltd., China) is used to determine the color change of *Hypsizygus marmoreus* noodles during cooking (Lai et al., 2021b). According to the following formula (Equation 3), the chromaticity is calculated from the L^*, a^*, and b^* values obtained by the measurement.

$$\Delta E = \left[\left(L_0 - L^*\right)^2 + \left(a_0 - a^*\right)^2 + \left(b_0 - b^*\right)^2\right]^{1/2} \quad (3)$$

L^* is the luminance index, reflecting the comprehensive value of whiteness and brightness; a^*, b^* value is the chromaticity index, the positive a^* value indicates reddish, the negative a^* value indicates greenish, the positive b^* value indicates yellowish, and the negative b^* value indicates blueness; each sample is measured 60 times for taking the average value of L^*, a^*, and b^* . ΔE is the total color difference value, which represents the color difference between the sample and the control.

Texture

The toughness, hardness, and chewiness of *Hypsizygus marmoreus* noodles were determined by texture analyzer with reference to Klinmalai et al. (2017). A/LKB-F probe was selected and the measuring parameters were set as blow: trigger force 15 g, velocity before measuring 1 mm/sec, velocity during measuring 0.17 mm/sec, velocity after measuring 10 mm/sec and displacement 2 mm. Each sample was measured 10 times.

Sensory

The sensory evaluation standard (Table 1) is formulated according to the industry standard of the People's Republic of China (People's Republic of China Food Industry Standard, 1993), and 10 reviewers conduct sensory evaluation on the cooked noodles. The noodles are boiled in boiling water for 5 minutes, then taken out and placed in cold water. The noodles are evaluated after cooling to room temperature. Each assessor shall taste at least one piece of each sample and then score.

3 Results and discussion

3.1 Effect of Hypsizygus marmoreus powder addition on noodle cooking characteristics

The cooked breaking ratio and cooking loss rate are important indicators of noodle quality, the smaller the cooked breaking ratio and cooking loss rate, the better the quality of the surface. Results showed that the addition of *Hypsizygus marmoreus* powder has no significant effect on the cooking time of the noodles, and the cooking time is basically around 6 min (Table 2). The cooked breaking ratio and cooking loss rate increased with the increase of *Hypsizygus marmoreus* powder,

Table 1. Sensory Evaluation Standard for Noodles.

Project	Content	Score
Color and lustre (10)	White, milk white, milk yellow	brightness 8.5-10, general brightness 6-8.4, gray hair brightness difference 1-6
Performance state (10)	the degree of smoothness and expansion of the surface	the surface structure is fine and smooth 8.5-10, generally smooth 6-8.4, rough, serious expansion and deformation 1-6
Palatability (20)	the force required by a tooth to bite a noodle	moderate strength 17-20, slightly hard or soft, 12-17, too hard or soft, 1-12
Toughness (25)	the strength and elasticity of a noodle when chewed	bite strength is elastic 21-25, bite strength elasticity is generally 15-21, bite strength is poor, elasticity is less than 1-15
Viscosity (25)	the stickiness of the noodles during chewing	non-stick teeth 21-25, slightly more refreshing teeth 15-21, disagreeable hair sticking 1-15
Smoothness (5)	the smoothness of the palate	smooth 4.3-5, generally smooth 3-4.2, not smooth 1-3
Taste (5)	taste	fragrance no peculiar smell 4.3-5, basically no peculiar smell 3-4.2, peculiar smell 1-3

Table 2. Effect of the addition amount of *Hypsizygus marmoreus* powder on cooking characteristics of noodles.

Addition amount of *Hypsizygus marmoreus* powder (%)	Cooking time (min)	Cooked breaking ratio (%)	Cooking loss rate (%)
0	5.07 ± 0.15 b	0.00 ± 0.00 d	3.47 ± 0.25 e
4	5.60 ± 0.26 a	0.00 ± 0.00 d	4.30 ± 0.26 d
8	6.10 ± 0.36 a	3.33 ± 0.23 c	6.37 ± 0.38 c
12	6.03 ± 0.42 a	3.27 ± 0.29 c	8.43 ± 0.40 b
16	5.83 ± 0.40 a	6.70 ± 0.52 b	9.50 ± 0.78 ab
20	5.90 ± 0.52 a	13.27 ± 0.81 a	10.73 ± 0.85 a

Note: Data are presented as the mean ± SD (n = 3). Values with different letters in the same column differ significantly ($p < 0.05$).

and the cooked breaking ratio from 0% to 13.27%, and the cooking loss rate rose from 3.470% to 10.73% in the experiment. When the amount of mushroom powder added ≤4%, the cooked breaking ratio is zero; when the amount of mushroom powder is added >12%, the cooked breaking ratio increases sharply, which may be because the mushroom powder destroys the integrity of the gluten grid, resulting in the phenomenon of broken strips when the noodles are cooked. Cooking loss refers to the noodles in the cooking process dissolved in the noodle soup of the substance, seafood mushroom noodles cooking loss rate with the increase in the amount of mushroom powder added and gradually increased, which may also be related to the integrity of the gluten grid structure, the addition of seafood mushroom powder leads to the ability of noodles to wrap the contents of the noodles decreased, and mushroom powder in the dietary fiber and other substances, it is more difficult to be contained by the gluten grid, so the cooking loss rate of noodles increases. This is consistent with the findings of Szydłowska-Tutaj et al. (2021) that adding fungi reduces gluten content. In accordance with the requirements of the industry standard of People's Republic of China (LS/T 3212-2021. Dried noodle, 2021), the cooked breaking ratio (≤5.00%) and cooking loss rate (≤10.00%), the <12% mushroom powder can be added to meet the industry demand of noodles.

3.2 Effect of Hypsizygus marmoreus powder addition on noodle color

Color is one of the important indexes to judge the quality of food. Result showed that the change of noodle L^* value decreases with the increase of mushroom powder addition, and the change of color a^* and b^* increases with the increase of mushroom powder addition, but generally speaking, *Hypsizygus marmoreus* powder has little effect on noodle color, which may be due to the lighter color of *Hypsizygus marmoreus* fruiting body (Table 3). This result is consistent with Fang et al. (2021a) that the dark color of *Grifola frondosa* fruiting body leads to the high L^* value of dough color.

3.3 Effect of adding the amount of Hypsizygus marmoreus powder on the texture of noodles

The results showed that the hardness of *Hypsizygus marmoreus* noodles was not significantly affected by the amount of mushroom powder. The toughness decreased with the increase of the amount of mushroom powder (Table 4). The addition of 4-12% had little effect on the toughness and chewiness of noodles, while the addition of 12% had great effect on the toughness and chewiness of noodles, the high amount of gluten added to the noodles will reduce the protein, resulting in a sharp decline in toughness and chewiness. This may be due to the *Hypsizygus marmoreus* powder destroyed the gluten mesh structure. Lu et al. (2020) also showed that adding fungus powder to puffed wheat flour could change its microstructure.

3.4 Effect of the amount of Hypsizygus marmoreus powder on the sensory quality of noodles

Sensory evaluation plays an irreplaceable role in the food industry. The sensory evaluation results of noodles by 10 people

Table 3. Effect of the addition amount of *Hypsizygus marmoreus* powder on the color of noodles.

Addition amount of *Hypsizygus marmoreus* powder(%)	Lightness value L^*	Red and green value a^*	Blue and Yellow Value b^*	Color difference value $\triangle E$
0	81.43 ± 0.48 a	0.72 ± 0.12 c	6.79 ± 0.20 d	18.23 ± 0.16 c
4	81.89 ± 0.63 a	1.09 ± 0.16 b	10.43 ± 0.24 c	19.38 ± 1.07 bc
8	81.68 ± 0.30 a	1.38 ± 0.10 b	10.57 ± 0.19 c	19.48 ± 0.12 b
12	82.01 ± 0.60 a	1.42 ± 0.21 b	12.82 ± 0.65 ab	20.35 ± 0.88 b
16	81.31 ± 0.74 a	1.89 ± 0.17 a	12.03 ± 0.51 b	20.49 ± 0.82 b
20	79.14 ± 0.87 b	1.90 ± 0.15 a	13.86 ± 0.89 a	23.58 ± 1.04 a

Note: Data are presented as the mean ± SD (n = 3). Values with different letters in the same column differ significantly ($p < 0.05$).

Table 4. Effect of the addition amount of *Hypsizygus marmoreus* powder on the texture of noodles.

Addition amount of *Hypsizygus marmoreus* powder (%)	Toughness (g•sec)	Hardness (g)	Chewiness (g•sec)
0	49.40 ± 4.52 a	4569.66 ± 704.87 a	2219.49 ± 300.23 c
4	44.56 ± 9.67 ab	5159.82 ± 876.56 a	2488.41 ± 272.12 bc
8	40.56 ± 8.57 ab	5247.91 ± 563.41 a	2528.27 ± 396.52 abc
12	38.24 ± 3.91 b	5373.92 ± 359 a	2611.15 ± 179.67 bc
16	37.12 ± 2.49 a	5779.81 ± 292.36 a	2980.59 ± 245.14 ab
20	35.56 ± 2.54 a	5888.68 ± 559.62 a	3247.11 ± 289.26 a

Note: Data are presented as the mean ± SD (n = 3). Values with different letters in the same column differ significantly ($p < 0.05$).

Table 5. Effect of the addition amount of *Hypsizygus marmoreus* powder on the sensory quality of noodles.

Addition amount of *Hypsizygus marmoreus* powder (%)	Color and lustre	Performance state	Palatability	Toughness	Viscosity	Smoothness	Taste	Total score
0	9.07 ± 0.15 a	9.23 ± 0.12 a	18.03 ± 0.32 a	21.33 ± 0.45 a	22.60 ± 1.85 a	4.87 ± 0.21 a	4.70 ± 0.20 a	89.83 ± 1.68 a
4	8.50 ± 0.10 b	8.60 ± 0.46 ab	17.37 ± 0.80 ab	20.63 ± 1.16 ab	22.07 ± 2.04 a	4.53 ± 0.60 a	4.60 ± 0.44 a	86.30 ± 2.01 ab
8	8.17 ± 0.32 bc	7.93 ± 0.74 bc	17.47 ± 0.96 ab	20.17 ± 0.83 ab	21.83 ± 2.12 a	4.33 ± 0.70 a	4.53 ± 0.40 a	84.43 ± 3.20 abc
12	8.10 ± 0.44 bc	8.20 ± 0.50 bc	17.23 ± 0.97 ab	20.13 ± 0.76 ab	21.13 ± 1.99 a	4.30 ± 0.75a	4.50 ± 0.26 a	83.60 ± 1.61 bc
16	8.03 ± 0.25 c	7.27 ± 0.60 c	16.63 ± 0.61 b	19.63 ± 1.31 ab	20.53 ± 1.59 a	3.90 ± 0.98a	3.67 ± 0.81 a	79.67 ± 2.60 cd
20	7.77 ± 0.15 c	7.17 ± 0.61 c	15.60 ± 0.78 b	18.93 ± 1.36 b	20.10 ± 1.83 a	3.70 ± 1.31a	3.53 ± 0.75 a	76.80 ± 3.01 d

Note: Data are presented as the mean ± SD (n = 3). Values with different letters in the same column differ significantly ($p < 0.05$).

showed that *Hypsizygus marmoreus* powder had a certain effect on the sensory evaluation indexes of noodles (Table 5). Palatability, toughness, viscosity and smoothness decreased with the increase of mushroom powder dosage. The color of *Hypsizygus marmoreus* powder was yellow and had a strong seafood taste, resulting in the color, apparent state and taste score decreased with the increase of the amount of *Hypsizygus marmoreus* powder. The smoothness of the noodles is decreased due to the coarse granules of sea mushroom powder and the large amount of insoluble dietary fiber. The sensory quality score of noodles added with 4% mushroom powder was the highest, but there was no significant difference with that of noodles added with 12% mushroom powder. When the mushroom powder supplemental level was > 12%, the sensory score of noodles decreased significantly. However, Parvin et al. (2020) found that noodles added with 5% fungus powder had good taste, no peculiar smell and significant mineral content ($P < 0.05$). These results indicated that the influence on the sensory evaluation results of noodles may be related to the fineness and content of additives.

The harvesting and processing of *Hypsizygus marmoreus* will produce 5%-10% by-products. At present, most of the by-products are discarded as garbage, which wastes resources and pollutes the living environment. In the experiment, the *Hypsizygus marmoreus* powder added to the noodles was made by the by-products produced during the picking process, which not only improved the comprehensive utilization of by-products, but also reduced waste, and improved economic benefits and environmental protection.

4 Conclusion

Exogenous additives will destroy the grid structure of dough to some extent, which will lead to the decrease of hardness and elasticity of noodles, the increase of breakage rate, and the change of noodle color, which will ultimately affect the eating quality of noodles (Doblado-Maldonado et al., 2012). Color will stimulate the visual nerve and trigger the appetite, and consumers often make the initial judgment on the quality of pasta by color. The cooked breaking ratio and cooking loss

rate in the cooking process reflect the cooking characteristics of noodles, and the toughness, hardness and chewiness reflect the texture characteristics of noodles, which are important criteria for consumers to evaluate the quality of noodles. Renoldi et al. (2021) found that the cooking characteristics and texture characteristics of noodles are closely related to the grid structure of gluten. The more complete the gluten structure is, the better the noodle quality is. In this study, by analyzing the cooking characteristics, color and texture of *Hypsizygus marmoreus* noodles, it was found that the amount of *Hypsizygus marmoreus* powder was negatively correlated with the quality of noodles. Based on sensory evaluation and cooking characteristics, the best addition concentration of seafood mushroom powder is 4%.

In this study, *Hypsizygus marmoreus* noodles were developed by using *Hypsizygus marmoreus* powder. On the basis of determining the optimum amount of *Hypsizygus marmoreus* powder, the cooking characteristics, color and texture of *Hypsizygus marmoreus* noodles were also analyzed and evaluated. It is found that the sensory quality of noodles can be improved by adding proper amount of mushroom powder. Excessive addition will make the cooking characteristics of noodles worse, but the chewing hardness and chewiness will increase. The addition of 4% mushroom powder can meet the demand of consumers for the taste and nutritional quality of mushroom noodles, which provides a theoretical basis for the deep processing of mushroom noodles.

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References

Alamu, E. O., & Mooya, A. (2017). Chapter 10 - food processing technologies and value addition for improved food safety and security. In N. Nhamo, D. Chikoye & T. Gondwe (Eds.), *Smart technologies for sustainable smallholder agriculture* (pp. 201-210). Cambridge: Academic Press. https://doi.org/10.1016/B978-0-12-810521-4.00010-4.

Chen, J. L., Wang, L., Xiao, P. F., Li, C. L., Zhou, H., & Liu, D. M. (2021). Informative title: Incorporation of finger millet affects in vitro starch digestion, nutritional, antioxidative and sensory properties of rice noodles. *LWT*, 151, 112145. http://dx.doi.org/10.1016/j.lwt.2021.112145.

Chen, X. Y., Pu, P., Kang, J. Q., Duan, H., & Lan, X. J. (2017). Comparison of composition and content of free amino acids in eight kinds of edible mushrooms. *Journal of Northwest A & F University - Natural Science Edition*, 45(5), 183-190.

Demir, M. K., Bilgiçli, N., Türker, S., & Demir, B. (2021). Enriched Turkish noodles (Erişte) with stabilized wheat germ: chemical, nutritional and cooking properties. *LWT*, 149, 111819. http://dx.doi.org/10.1016/j.lwt.2021.111819.

Doblado-Maldonado, A. F., Pike, O. A., Sweley, J. C., & Rose, D. J. (2012). Key issues and challenges in whole wheat flour milling and storage. *Journal of Cereal Science*, 56(2), 119-126. http://dx.doi.org/10.1016/j.jcs.2012.02.015.

Fang, D. L., Ma, X. H., Zhao, M. W., Zheng, H. H., Chen, H., Hu, Q. H., & Zhao, L. Y. (2021a). Enzymatic modification of dough added with grifola frondosa flour and quality evaluation of noodles made from it. *Food Science*, 42(10), 23-31. http://dx.doi.org/10.7506/spkx1002-6630-20200620-272.

Fang, D. L., Wang, D., Ma, G. X., Ji, Y., Zheng, H. H., Chen, H., Zhao, M. W., Hu, Q. H., & Zhao, L. Y. (2021b). *Auricularia polytricha* noodles prevent hyperlipemia and modulate gut microbiota in high-fat diet fed mice. *Food Science and Human Wellness*, 10(4), 431-441. http://dx.doi.org/10.1016/j.fshw.2021.04.005.

Jing, Q., Yingguo, L., Yuanhui, W., Jie, C., & Panfeng, H. (2018). Formula and quality study of multigrain noodles. *Grain & Oil Science and Technology*, 1(4), 157-162. http://dx.doi.org/10.3724/SP.J.1447.GOST.2018.18051.

Klinmalai P., Hagiwara T., Sakiyama T., & Ratanasumawong S. (2017). Chitosan effects on physical properties, texture, and microstructure of flat rice noodles. *LWT-Food Science and Technology*, 76(Pt A), 117-123. http://dx.doi.org/10.1016/j.lwt.2016.10.052.

Lai, P. F., Li, Y. B., Weng, M. J., Tang, B. S., Wu, L., & Chen, J. C. (2021a). Optimization of extraction process for flavonoids from the by-products of *Hypsizygus Marmoreus* by response surface methodology. *Fujian Agricultural Science and Technology*, 51(2), 1-6. http://dx.doi.org/10.13651/j.cnki.fjnykj.2021.02.001.

Lai, P. F., Tang, B. S., Li, Y. B., Wu, L., Weng, M. J., & Chen, J. C. (2021b). Grey correlation analysis for physical and nutritional quality of hypsizygus marmoreus from different drying methods. *Journal of Nuclear Agricultural Sciences*, 35(9), 2118-2126. http://dx.doi.org/10.11869/j.issn.100-8551.2021.09.2118.

Li, B., Jin, Y. H., Nie, Y. Y., & Yang, W. (2019). Effect of adding method of *Flammunila velutipes* on the qualities of noodles. *Science and Technology of Food Industry*, 40(7), 57-63. http://dx.doi.org/10.13386/j.issn1002-0306.2019.07.011.

Li, B., Nie, Y. Y., Chang, Z. Z., Jin, Y. H., & Yang, W. (2018). Effect of adding *Pleurotus ostreatus* powder on the noodles quality. *Edible Fungi of China*, 37(6), 64-67. http://dx.doi.org/10.13629/j.cnki.53-1054.2018.06.013.

Li, P. H., Huang, C. C., Yang, M. Y., & Wang, C. C. R. (2012). Textural and sensory properties of salted noodles containing purple yam flour. *Food Research International*, 47(2), 223-228. http://dx.doi.org/10.1016/j.foodres.2011.06.035.

Liu, Y. Q., Li, M. Q., Li, C. R., & Zhou, Y. J. (2016). Effects of transglutaminase on noodles moisture status and structural basis of protein. *Journal of the Chinese Cereals and Oils Association*, 31(1), 10-16. http://dx.doi.org/10.3969/j.issn.1003-0174.2016.01.003.

Lu, X. K., Brennan, M. A., Narciso, J., Guan, W. Q., Zhang, J., Yuan, L., Serventi, L., & Brennan, C. S. (2020). Correlations between the phenolic and fibre composition of mushrooms and the glycaemic and textural characteristics of mushroom enriched extruded products. *LWT*, 118, 108730. http://dx.doi.org/10.1016/j.lwt.2019.108730.

Lu, X., Brennan, M. A., Serventi, L., Liu, J. F., Guan, W. Q., & Brennan, C. S. (2018). Addition of mushroom powder to pasta enhances the antioxidant content and modulates the predictive glycaemic response of pasta. *Food Chemistry*, 264, 199-209. http://dx.doi.org/10.1016/j.foodchem.2018.04.130. PMid:29853366.

Mleczek, M., Siwulski, M., Rzymski, P., Budka, A., Kalač, P., Jasińska, A., Gąsecka, M., Budzyńska, S., & Niedzielski, P. (2018). Comparison of elemental composition of mushroom *Hypsizygus marmoreus* originating from commercial production and experimental cultivation. *Scientia Horticulturae*, 236, 30-35. http://dx.doi.org/10.1016/j.scienta.2018.03.029.

Parvin, R., Farzana, T., Mohajan, S., Rahman, H., & Rahman, S. S. (2020). Quality improvement of noodles with mushroom fortified and its comparison with local branded noodles. *NFS Journal*, 20, 37-42. http://dx.doi.org/10.1016/j.nfs.2020.07.002.

People's Republic of China Food Industry Standard. (1993). *LS/T 3202-1993. Wheat flour for noodles*. China: People's Republic of China Food Industry Standard.

People's Republic of China Food Industry Standard. (2021). *LS/T 3212-2021. Dried noodle*. China: People's Republic of China Food Industry Standard.

Qumbisa N. D., Ngobese N. Z., Kolanisi U., Siwela M., & Cynthia G. F. (2021) Effect of *Amaranthus* leaf powder addition on the nutritional composition, physical quality and consumer acceptability of instant noodles. *South African Journal of Botany*, In press. https://doi.org/10.1016/j.sajb.2021.01.022.

Renoldi, N., Brennan, C. S., Lagazio, C., & Peressini, D. (2021). Evaluation of technological properties; microstructure and predictive glycaemic response of durum wheat pasta enriched with psyllium seed husk. *LWT*, 151, 112203. http://dx.doi.org/10.1016/j.lwt.2021.112203.

Reshmi, S. K., Sudha, M. L., & Shashirekha, M. N. (2020). Noodles fortified with Citrus maxima (pomelo) fruit segments suiting the diabetic population. *Bioactive Carbohydrates and Dietary Fibre*, 22, 100213. http://dx.doi.org/10.1016/j.bcdf.2020.100213.

Shen, L. Y., Yin, M. Q., Wu, T. T., & Jiang, Z. K. (2019). Formula optimization of coarse cereal noodle. *Cereals & Oils*, 32(6), 53-56. http://dx.doi.org/10.3969/j.issn.1008-9578.2019.06.014.

Szydłowska-Tutaj, M., Złotek, U., & Combrzyński, M. (2021). Influence of addition of mushroom powder to semolina on proximate composition, physicochemical properties and some safety parameters of material for pasta production. *LWT*, 151, 112235. http://dx.doi.org/10.1016/j.lwt.2021.112235.

Timsina, J., Dutta, S., Devkota, K. P., Chakraborty, S., Neupane, R. K., Bishta, S., Amgain, L. P., Singh, V. K., Islam, S., & Majumdar, K. (2021). Improved nutrient management in cereals using Nutrient Expert and machine learning tools: productivity, profitability and nutrient use efficiency. *Agricultural Systems*, 192, 103181. http://dx.doi.org/10.1016/j.agsy.2021.103181.

Wang, D., Zheng, H. H., Ji, Y., Fang, D. L., Zhao, L. Y., Chen, H., & Hu, Q. H. (2019). Effects of auricularia powder on dough rheological properties and noodle quality characteristics. *Food Science*, 40(21), 43-50. http://dx.doi.org/10.7506/spkx1002-6630-20190608-079.

Wang, L., Zhao, H., Brennan, M., Guan, W., Liu, J., Wang, M., Wen, X., He, J., & Brennan, C. (2020). In vitro gastric digestion antioxidant and cellular radical scavenging activities of wheat-shiitake noodles. *Food Chemistry*, 330, 127214. http://dx.doi.org/10.1016/j.foodchem.2020.127214. PMid:32521398.

Zhang, Y. R., Guo, Z., Liu, T., Gao, Y. H., & Chen, B. Y. (2017). Effect of micronization on cooking and texture properties of five-cereal noodles with edible mushroom. *Food Science*, 38(11), 110-115. http://dx.doi.org/10.7506/spkx1002-6630-201711018.

Zhang, Y. R., Wang, D. W., Chen, Y. T., Liu, T. T., Zhang, S. S., Fan, H. X., Liu, H. C., & Li, Y. (2021). Healthy function and high valued utilization of edible fungi. *Food Science and Human Wellness*, 10(4), 408-420. http://dx.doi.org/10.1016/j.fshw.2021.04.003.