

Research Article

Sensory Evaluation and Textural Properties of Mushroom Sausages

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Abstract: Fresh mushroom was used as primary material to produce mushroom sausages and their qualities was assessed by sensory evaluation and textural analysis. The processing procedures include clean, slice, blanch, crush and pulp, add accessories, stuff, heat and cool. Ingredients for mushroom sausage are mushroom 100, chicken 0~10, soybean protein isolate 10, corn starch 10, oil 2, spice 2.4, salt 1, sugar 1 and carrageenan 0.8. The optimal mushroom for sausage processing is *Pleurotus nebrodensis* and the following is *Pleurotus ostreatus* and other white or light color mushrooms. Mushroom sausages possess many advantages as far as nutrition, safety, cost and processing compared to normal sausages. This study shows that sausage is a potential and effective method for mushroom processing.

Keywords: Mushroom, *Pleurotus nebrodensis*, *Pleurotus ostreatus*, sausage, sensory, texture

INTRODUCTION

Edible fungi, also called mushroom, is rich in protein, amino acid, polysaccharide, dietary fiber and other nutrients. Many studies show mushroom has various biological activities, such as antitumor, antioxidant, decreasing blood sugar and lipid, etc., (Guillamón *et al.*, 2010; Kalac, 2009; Zhang *et al.*, 2007). The mushroom yield of China in 2013 exceeds 25 million tons, accounting for 70% of total world production. However, the storage period of fresh mushroom is very short for its high moisture content and rich nutrients. If mushroom can't be eaten or processed as soon as possible after harvest, it will be spoilage quickly. The present situation in China is the technology and level of mushroom processing far behind the increasing speed of mushroom production. As a result, the conflict between production and marketing becomes more and more serious during the harvest season. This restricts the sustainable development of mushroom industry. Therefore, exploitation of new technology and method for mushroom processing is necessary for healthy development of mushroom industry.

Ham sausage is a popular convenience food. However, long term and large amount of consumption of ham sausage would produce health hazards for its high animal lipid content and some unsafe additives (such as nitrite and phosphate). Mushroom has crisp texture and rich endo-biopolymers (polysaccharides and proteins), so it is easily processed into gel-like food. Several reports have been published on adding mushroom to substitute part meat when preparing ham

sausage (Sun and Ding, 2006; Li and Li, 2008; Wei *et al.*, 2005; Jin, 2009). However, the mushroom addition in these studies was low, generally being 10% and maximum being 25%. So these "mushroom sausages" are still meat sausage with a few mushroom additions in nature. The objective of this study was to develop a kind of sausage using mushroom as the primary material and compare the suitability of different kinds of mushroom for sausage processing.

MATERIALS AND METHODS

Materials: Fresh fruit bodies of *Pleurotus ostreatus*, *Lentinus edodes* and *Pleurotus nebrodensis* were obtained from local market of Xinxiang City, Henan Province, China. Chicken, pork, spice, oil, salt and sugar were purchased from local market. Corn starch, carrageenan, soybean protein isolate and nylon casing are food grades. XA-1 tissue pound crusher: Jiangsu Jintan Puxi Scientific Instrument Factory, China. C12 meat grinder: Shaoguan Xintongli Food Machine Ltd., China. JCW-46B sausage stuffer: Lianyungang Chaoyang Machine Factory, China. TA.XT Plus texture analyzer: SMS Company, UK.

Preparation of mushroom sausage: The technical flow for mushroom sausage was: fresh mushroom → clean → slice → blanch → crush and pulp → add soaked soybean protein and mix → add accessories (spice, meat, starch, carageenan, oil, etc.) and mix → stuff mixture into casing → heat → cool → product. Fresh fruit body of mushroom was cleaned and selected to remove inedible part. The mushroom was sliced and

blanched in boiled water for 3 min. Blanched slices were crushed into pulp using tissue pound crusher. Soybean protein was soaked in 30°C water for 25 min and mixed thoroughly with mushroom pulp. Other accessories including sugar, salt, oil, spice, meat paste, corn starch and carrageenan were added and mixed thoroughly. The mixture was stuffed into nylon casing and sealed. The sausage was heated in 100°C water for 30 min and cooled at room temperature.

Group design and formula: Experimental groups were designed as follow: group 1: *P. ostreatus* 100, chicken 0; group 2: *P. ostreatus* 100, chicken 10; group 3: *P. ostreatus* 75, *L. edodes* 25, chicken 0; group 4: *P. ostreatus* 75, *L. edodes* 25, chicken 5; group 5: *P. ostreatus* 75, *L. edodes* 25, chicken 10; group 6: *P. ostreatus* 75, *L. edodes* 25, pork 10; group 7: *P. ostreatus* 50, *L. edodes* 50, chicken 10; group 8: *P. nebrodensis* 100, chicken 0; group 9: *P. nebrodensis* 100, chicken 10; group 10: using a common ham sausage as control. Other accessories were fixed as: soybean protein 10, corn starch 10, oil 2, spice 2.4, salt 1, sugar 1 and carrageenan 0.8.

Sensory evaluation: Thirty students including male and female were chosen to compose sensory evaluation panel. Evaluation indexes include hardness, elasticity, cohesiveness, chewiness, taste, smoothness of cut surface, color. Evaluation score uses seven points: 1 is the lowest and 7 is the best.

Textural analysis: Physical properties of sausage were determined by TA.XT Plus textural analyzer. Test parameters were as follow: velocity before test: 2.0 mm/s; test velocity: 1.0 mm/sec; velocity after test: 1.0 mm/sec; sample deformation: 40%; pause time between twice compress: 5.0 sec; probe head: P100; sample standard: cylinder of 10 mm high; environmental temperature: 25°C. Test indexes include hardness, elasticity, cohesiveness and chewiness.

Environmental Scanning Electron Microscope (ESEM) observation: The central part of *P. nebrodensis* sausage was cut into slice of 1×1×0.1 cm. The slice was frozen-dried and stuck on sample

stage with silver conductive adhesive. The powder on sample surface was blown away and observed with Quanta 200 ESEM (FEI Co., USA).

RESULTS AND DISCUSSION

Effects of mushroom variety and meat kinds on sensory quality of mushroom sausages: *L. edodes* and *P. ostreatus* are the most two popular mushrooms in China. *P. nebrodensis* is a fast developing mushroom in recent years for its tender tissue and delicious taste. So the above three mushrooms were selected for this study. Sensory evaluation results of mushroom sausages prepared by different ingredient formula were shown in Table 1. It can be seen that *P. nebrodensis* is the best mushroom for sausage preparation because of its white or light yellow color, fine and smooth tissue and delicious taste. *P. ostreatus* is also a suitable raw material for making mushroom sausage because of its large production and low price though its color and taste are slightly inferior to *P. nebrodensis*. *L. edodes* is not suitable for processing sausage because its deep color and special flavor make the sausage hardly acceptable to some extent. As far as meat, chicken is better than pork because chicken is easily ground and can be blended with mushroom completely. However, chicken taste is slightly weaker than pork. With the enhancement of meat addition, hardness, elasticity, chewiness, taste and color of sausages increase gradually, while cohesiveness and smoothness of cut surface decrease. Overall considering, group 9 (*P. nebrodensis* 100, chicken 10) is the optimal formula for mushroom sausage. The following is group 8, 2, 5 and 1, respectively. There is no significant difference between group 9 and control group in taste, color, texture and acceptance.

Effects of mushroom variety and meat kinds on textural quality of mushroom sausages: Textural analysis results of mushroom sausages prepared by different ingredient formula were shown in Table 2. It can be seen that with the enhancement of meat addition, hardness, elasticity and chewiness increase gradually, while cohesiveness decreases slightly. The effects of

Table 1: Sensory evaluation results of mushroom sausages

Group	Hardness	Elasticity	Cohesiveness	Chewiness	Taste	Smoothness	Color
1	5.01	4.72	5.51	4.38	4.87	5.57	5.05
2	5.36	4.89	5.25	5.15	5.12	5.51	5.13
3	4.84	4.75	5.47	4.45	4.83	5.41	4.67
4	5.04	4.81	5.40	4.96	4.92	5.43	4.84
5	5.27	4.93	5.32	5.24	5.03	5.39	5.02
6	5.39	5.02	5.12	5.02	5.14	5.02	4.95
7	5.22	4.94	5.28	5.37	5.10	5.14	4.54
8	5.06	4.85	5.62	4.62	4.98	5.68	5.36
9	5.35	5.13	5.45	5.43	5.23	5.71	5.46
10	5.43	5.26	5.41	5.52	5.27	5.65	5.58

Group 1: *P. ostreatus* 100, chicken 0; Group 2: *P. ostreatus* 100, chicken 10; Group 3: *P. ostreatus* 75, *L. edodes* 25, chicken 0; Group 4: *P. ostreatus* 75, *L. edodes* 25, chicken 5; Group 5: *P. ostreatus* 75, *L. edodes* 25, chicken 10; Group 6: *P. ostreatus* 75, *L. edodes* 25, pork 10; Group 7: *P. ostreatus* 50, *L. edodes* 50, chicken 10; Group 8: *P. nebrodensis* 100, chicken 0; Group 9: *P. nebrodensis* 100, chicken 10; Group 10: Using a common sausage as control

Table 2: Textural analysis results of mushroom sausages

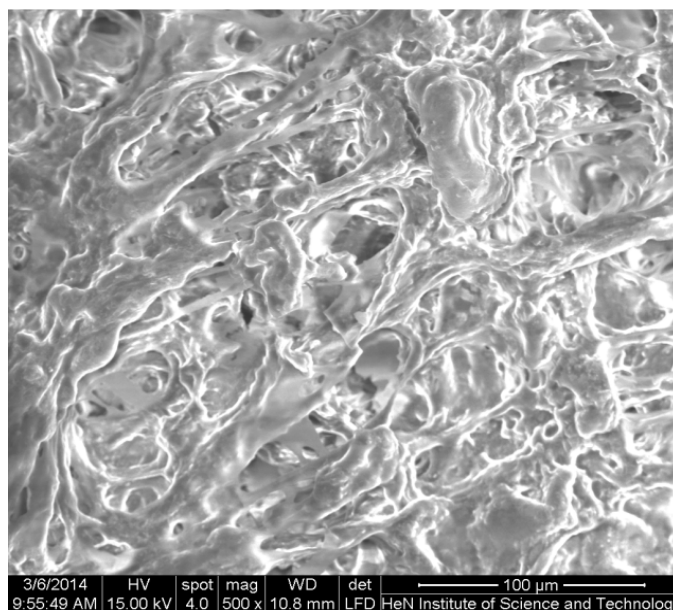
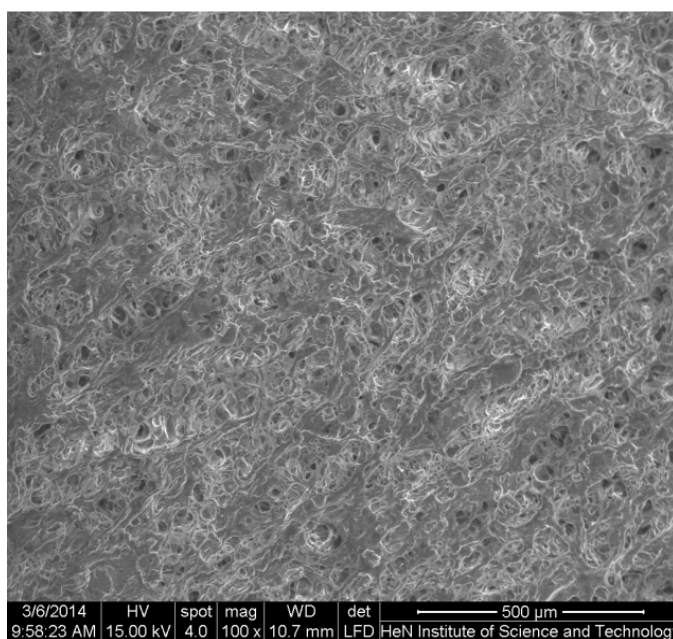
Group	Hardness	Elasticity	Cohesiveness	Chewiness
1	93.61	0.87	0.76	55.43
2	96.02	0.90	0.74	61.91
3	93.13	0.86	0.75	52.72
4	94.35	0.88	0.74	58.06
5	96.53	0.90	0.73	61.17
6	96.74	0.91	0.69	59.75
7	95.17	0.90	0.71	59.32
8	93.69	0.89	0.76	61.39
9	96.48	0.92	0.74	62.27
10	98.25	0.93	0.73	63.14

mushroom variety and meat kinds on textural quality of sausage have the similar trend to sensory evaluation. Combining the analytical results of sensory and texture, the best formula is *P. nebrodensis* 100 and chicken 10.

Effects of protein, starch, gum and oil on the quality of mushroom sausages:

Mushroom sausage can be seen as a gel that is composed of protein, starch, polysaccharide, carrageenan, water, oil, salt, sugar and spice. Protein and polysaccharide form the network frame of sausage gel (Fig. 1). Because protein content in fresh mushroom is lower than meat, adding enough soybean protein is necessary in preparing mushroom sausage. Protein can also increase water holding capacity, emulsibility and chewiness of sausage. Addition amount of soybean protein isolate is from 6 to 12% of mushroom pulp depending on mushroom variety and meat amount.

Adding starch can raise water holding capacity of sausage and make the tissue of sausage fine and



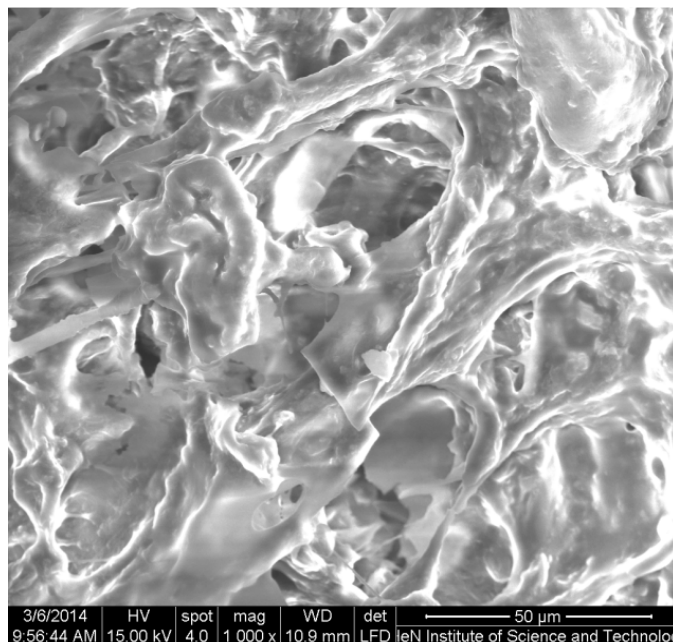


Fig. 1: ESEM photographs of *P. nebrodensis* sausage at magnification rates of 100, 500 and 1000, respectively. The ingredient is mushroom 100%, soybean protein 10%, corn starch 10%, oil 2%, spice 2.4%, salt 1%, sugar 1% and carrageenan 0.8%

Table 3: Comparison of mushroom sausages with normal sausages

Characteristics	Mushroom sausage	Normal sausage
Nutrition	Antitumor, antioxidant, decreasing blood sugar and lipid, etc	Meat protein: health promotion
Safety	Free of nitrite and phosphate	Adding nitrite and phosphate
Taste	Mushroom taste	Meat taste
Cost	Cheap	Expensive
Process	Simple	Complex
Equipment	Simple	Complex

smooth. However, overmuch starch fades the taste and chewiness. Adding 10~15% corn starch (based on mushroom weight) is suitable.

Food gum can increase water holding capacity of sausage, enhance gel strength, delay retrogradation of starch. The influence of 0.6, 0.8 and 1.0%, respectively carrageenan (based on mushroom weight) on the quality of mushroom sausage were investigated. The result showed that 0.8% carrageenan or 0.8% compound gum (carrageenan/xanthan gum = 1/1) was optimal.

Adding oil can remedy the lipid shortage of mushroom and improve the taste and smooth of sausage. The suitable amount of oil is 2~4% of mushroom weight.

Comparison of mushroom sausage with ham sausage: The comparison between mushroom sausage and normal ham sausage (i.e., meat sausage) was shown in Table 3. It can be seen that nutritional value of mushroom sausage is higher than normal sausage.

Furthermore, mushroom sausage is very safe for health because it has no nitrite, a potential carcinogen but common used in ham sausage preparation for color retention and preservation. In addition, mushroom sausage has lower materials cost and equipment invest and simpler machining process than normal ham sausage. However, the taste and color of mushroom sausage is not so attractive compared with normal sausage to some extent. This is probably because most people have been accustomed to the taste and color of normal sausage.

CONCLUSION

This study showed that using mushroom as primary material to produce sausage is feasible. Mushroom sausages possess many advantages as far as nutrition, safety, cost and processing compared to normal ham sausages. The optimal mushroom for sausage preparation is *P. nebrodensis* and the following is *P. ostreatus* and other white or light color mushrooms, such as *Coprinus comatus*, *P. eryngii* and *Flammulia velutiper*. Adding suitable chicken (10% of mushroom weight) can improve the taste and texture of mushroom sausage. This study provides a potential and effective method for mushroom processing.

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