Development of Microwave Puffed *Hericium* Rice Cookie

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Abstract

Hericium erinaceus is well known as a traditional and valuable mushroom in China. It has immunomodulatory effect and remarkable ability at gastric cancer and gastric ulcer. The objectives of this study were (1) to analyze polysaccharide contents and physical properties of different rice concentrations (5%, 7% and 9%) with 3% glucose in shake flasks by 5-day *Hericium erinaceus* submerged fermentation at 25℃, 150 rpm, and (2) to develop microwave puffed *Hericium* rice cookie as a functional food. The increasing rice concentration in *Hericium erinaceus* submerged fermentation had higher °Brix, polysaccharide, L* and b* values. The viscosity of 7% and 9% rice media were too high and difficult to operate; therefore, the 5% rice milk by *Hericium* submerged fermentation was chosen for the following rice cookie production. The *Hericium erinaceus* fermented rice milk, cassava starch and rice were mixed, homogenized, and then filled into an artificial casing. It was cooked, cooled, and then cut to small pieces of rice pellets. The rice pellets were dried in a 85℃ oven for 2~3 hours to decrease moisture content below 15%. Finally, they were puffed in a 1000W microwave oven for 20 sec instead of frying to avoid high oil content and high calories. The puffing ratios of *Hericium* rice cookies by microwave were 480%~730%, and they are higher than the commercial puffed cookies and the control. The breaking force of *Hericium* rice cookies were 0.6~3.1 kg, especially for 1:1 of the ratio of rice to cassava starch formula having the lowest value. Therefore, the new functional food "*Hericium* rice cookie" containing *Hericium* fermented rice milk can be developed for the three generation snacks by puffing in a microwave oven and have great potential application for nutraceutical food industry.

Introduction

Hericium erinaceus is well known as a traditional Chinese medicine and functional food. This *Hericium erinaceus* contains polysaccharides, which exhibit immunomodulating activity, antitumor effects and antioxidant activity etc. The objectives of this study were (1) to investigate the effects of different rice media and operation conditions on the production of polysaccharide by *Hericium erinaceus* submerged fermentation in a shake flask, and (2) to develop microwave puffed *Hericium* rice cookie as a functional food. The cultivation variables for *Hericium erinaceus* , including temperature (25°C), pH (6~7), rpm (150) and media composition significantly influenced mycelia and metabolite production. The *Hericium* fermented rice milk was added and made rice cookie with high nutraceutical function. The developed *Hericium* rice cookie are low fat and high nutrition instead of high oil, high sugar and high calorie. The rice pellets needed to be pre-gelatinized, and dried to low moisture content. The glass types of rice pellets were stable, and low volume to reduce package and cost. The dried rice pellets can be developed as the third generation snack foods, because they can be puffed by microwave heating or frying at home.

Materials and Methods

Phenol-sulfuric method

Hericium erinaceus (BCRC 36470)

↓

5% rice medium with 3% glucose ← Polysaccharide

↓

5%, 7% and 9% rice medium with 3% glucose for 5 days liquid fermentation

Plate culture

Liquid fermentation in a shaking flask

↓

Moisture, Polysaccharide, Protein, Solid, pH, Viscosity, Color

No.	rice	:	cassava starch	:	water
A	Commercial rice pellet				
B	Commercial shrimp pellet				
C	1		1		1.2
D	2		1		1.7
E	3		1		2.2
F	1		2		2.0
G	1		3		2.7

5% rice medium → Rice cookie formula

Antioxidant properties

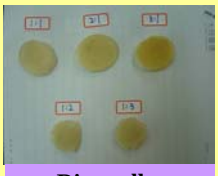
- Scavenging DPPH ability
- Ferrous ion-chelating ability
- Reducing power
- Flavonoid contents
- Total phenolics

↓

Homogenized mix

↓

Fitting into a casing



Rice pellet

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Pre-gelatinization (100°C 60min)

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Cooling (0°C 120min) and cut into 2~3 mm slice

↓

Drying (85°C oven 2.5hr) to pellet (M. C. 10~12%)

↓

Microwave puffing rice cookie (1000 W 20 sec in a microwave oven)

↓

Puffing ratio, Texture, Color

Microwave-puffed rice cookie

Fig.1 Flow chart of *Hericium erinaceus* rice cookie process

Results and Discussion

The polysaccharide content increased through 7 days *Hericium erinaceus* liquid fermentation (Fig. 2). The antioxidant activities of 7% fermented rice milk were higher than unfermented rice medium (Table 1). Increase rice concentration in media had higher L* and b* values in the 5-days fermented rice milk (Table 2). Increasing rice concentration in media had higher polysaccharide, solid contents and viscosity in the 5-days fermented rice milk (Table 3). When the 5% *Hericium erinaceus* fermented rice milk was mixed with different ratios of rice powder, cassava starch and water to make pellets. The different formula of pellets were further puffed by microwave to obtain rice cookies. Comparing puffing ratios of fermented rice and commercial cookies, the formula D rice cookie had significantly higher puffing ratio (Fig. 3). The texture profile analyses of commercial and D rice cookies were shown in Fig. 4. The D rice cookie had higher breaking force and higher deformation; so it had crispness texture (Table 4). The colors of microwave puffed rice cookie was shown in Table 5. The pictures of pellets and microwave puffed rice cookie were shown in Fig. 5. Overall, the formula D containing *Hericium erinaceus* fermented rice milk had better puffy texture and could be developed as a functional snack.

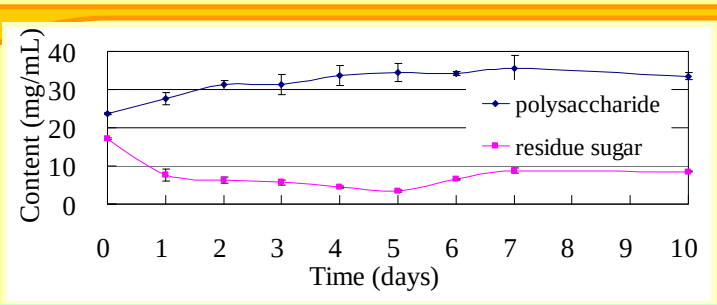

Fig. 2 The polysaccharide and sugar contents during *H. erinaceus* liquid fermentation

Table 2 The color of *H. erinaceus* fermented rice milks

Rice concentration	L*	a*	b*
5%	65.1±0.57^{c}	-1.75±0.23^{a}	1.42±0.61^{b}
7%	66.6±0.76^{b}	-1.72±0.26^{a}	1.66±0.32^{b}
9%	68.1±1.18^{a}	-1.79±0.26^{a}	3.77±0.58^{a}

Table 1 The antioxidant activities of 7% *H. erinaceus* fermented rice milk

Rice milk	Total phenol (mg/g HWE)		Flavonoid (mg/g HWE)		Reducing power (Abs)		Scavenging DPPH ability (%)		Chelating Fe^{2+} ability (%)	
	Initial	Fermented	Initial	Fermented	Initial	Fermented	Initial	Fermented	Initial	Fermented
7%	1.78 ± 0.20	2.58 ± 0.09	1.35 ± 0.04	1.64 ± 0.06	0.56 ± 0.01	0.59 ± 0.01	52.01 ± 0.07	89.63 ± 0.14	25.01 ± 0.44	41.25± 0.66

Table 3 The analyses of *H. erinaceus* fermented rice milks

Rice concentration	Moisture (%)	Polysaccharide (%)	Protein (%)	Solid (˚Brix)	pH	Viscosity (cP)
5%	94.38±0.07^{a}	3.03±0.09^{b}	1.19±0.14^{a}	4.88±0.18^{c}	6.15±0.01^{a}	2588.30±4.16^{c}
7%	92.69±0.10^{b}	3.34±0.10^{a}	1.65±0.44^{a}	6.30±0.11^{b}	6. 06±0.03^{b}	6089.99±15.81^{b}
9%	90.99±0.13^{c}	3.41±0.22^{a}	1.88±0.54^{a}	8.13±0.16^{a}	6.01±0.01^{b}	13786.80±8.87^{a}

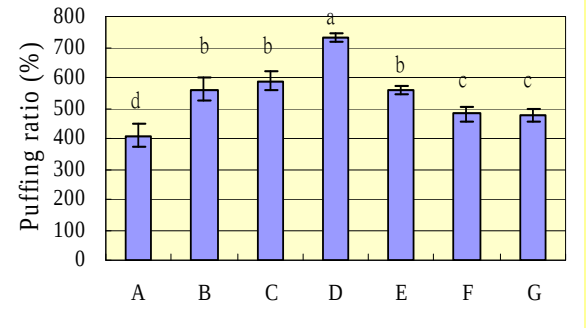

Fig. 3 The puffing ratios of different formula rice cookies (C~G; and A: commercial rice cookie, B: shrimp cookie)

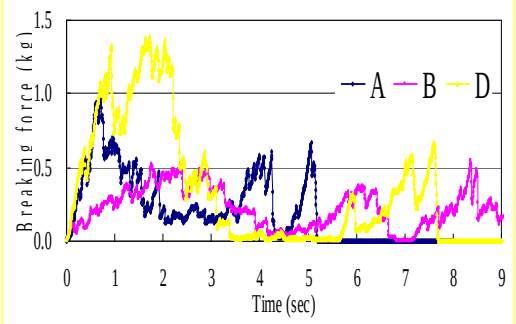

Fig. 4 The texture profile analysis (TRA) of commercial cookies and F formula rice cookie

Table 4 The texture analysis of commercial and rice cookies by microwave puffing

Rice cookies	Breaking force (kg)	Deformation (mm)
A	1.006	55
B	0.546	135
C	0.619	97
D	3.081	127
E	2.370	146
F	1.384	74
G	2.388	68

Table 5 The color of microwave puffed rice cookie

Cookie	L*	a*	b*
C	59.15±0.61	-3.63±0.12	14.51±0.26
D	62.74±3.64	-0.80±0.39	9.87±0.38
E	62.74±3.64	-6.54±0.09	21.62±0.14
F	56.51±1.80	-0.40±0.14	7.96±0.31
G	73.26±5.49	-0.61±0.27	8.78±0.28

Fig. 5 Pictures of pellets and microwave puffed rice cookie

Conclusions

The 150 mL 5% rice medium with 3% glucose in shake flasks was operated at 25℃, 150 rpm by 5-day *Hericium erinaceus* fermentation for adding rice cookie formula, because the viscosity of 7% and 9% rice media were too high and difficult to operate. The antioxidant activity of rice milk increased after *Hericium erinaceus liquid* fermentation. The ratio of rice powder, cassava starch and water was 2:1:1.7 for formula D had larger puffing ratio and crisper texture. The functional foods "*Hericium* rice cookie" containing *Hericium* fermented rice milk were developed for the three generation snacks by puffing in a microwave oven at home.