Study on processing and antioxidant properties of *Tuber magnatum* solid-state fermented grains

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Abstract

Tuber magnatum is the famous Italian white truffles, due to fascinating aroma, it has a high economic values. Truffle fruiting bodies require 4-7 years cultivation; however, truffle mycelia require only several weeks solid-state fermentation to obtain a good amount of bioactive metabolites. Mixed grain medium (soy bean: red adlay =1: 3) shortened the fermentation time from 4 to 3 weeks and obtained more uniform bioactive components and higher antioxidant activity. RF pasteurization with 15 cm gap and RF cold air drying significantly reduced the downstream process time, and had no differences of bioactive compounds among these pasteurization and drying methods. Therefore, RF saved processing time and operation energy.

Keywords: Truffles, solid-state fermentation, antioxidant, RF

Introduction

There were studies on truffle liquid fermentation. The optimum medium was sucrose, yeast extract, peptone, and Mg^{2+} to get the optimal maximal biomass, production of extracellular (EPS) and intracellular (IPS) polysaccharides (Liu & Tang, 2010). But so far there are no studies about the mixed medium for truffle solid-state fermentation. The radio frequencies (RF) reserved for industrial use by the Federal Communications Commission of USA are 13.56, 27.12, and 40.68 MHz. The polar water or ionic molecules can vibrate to generate heat by RF; therefore, RF can overcome heat resistance to reduce processing time. Application of RF heating foods includes pasteurization, sterilization, disinfestation, cooking, and drying (Orsat & Raghavan,2014). RF can be further developed for pasteurization and drying downstream processes of *Tuber magnatum* solid-state fermented grains.

Experimental design

Tuber magnatum

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Pre-activation (25℃, 120 rpm, 3days) → Lethal conditional

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Media: soy bean (S) & red adlay (A)

4: 0 (S4A0), 3: 1 (S3A1), 2: 2 (S2A2) 1: 3 (S3A1), 0: 4 (S0A4)

(25 ℃ cultivation, 0~5 weeks)

↓ ↓

Bioactive components (Polysaccharide, triterpenoids, total phenol, flavonoids)

Antioxidant Activity (Scavenging DPPH radicals, chelating ferrous ions, reducing power)

↓ ↓

RF pasteurization (Gap: 13, 15 and 17 cm)

Autoclave (121℃)

↓ ↓ ↓

RF-cold air drying (Gap: 13, 15 and 17 cm)

45℃ air drying

Freeze drying

↓

Water or 95% ethanol, 300 W microwave extraction 5 min

↓ ↓ ↓

Color Bioactive components Antioxidant Activity

Table 1. Effect of different pasteurization with drying methods on the drying rate of *Tuber magnatum* solid-state fermented products

Drying methods	Linear regression equation	R^2	Drying rate (g/min)	Drying time (min)
RFP15-CD	y = -1.5650x + 591.9	0.987	1.5650	120
RFP13-RFD13	y = -39.220x + 2910.1	0.977	39.220	19
RFP15-RFD15	y = -50.626x + 2759.5	0.977	50.626	14
RFP17-RFD17	y = -44.695x + 3026.2	0.973	44.695	18

RFP: RF pasteurization, RFD: RF drying, CD: cold air drying, No.: gap (cm)

Results and discussion

The polysaccharide contents of *Tuber magnatum* by different ratio of soybean and red adlay medium during solid-state fermentation were shown in Fig. 1. The mixed medium (soy bean: red adlay = 1: 3) obtained more uniform bioactive components and higher antioxidant activity (Fig.2). The survival condition of *Tuber magnatum* in 2 mL PDB heating at 80 ℃ water bath was in Fig. 3. The temperature profiles of 3 kg *Tuber magnatum* solid-state fermented products during RF heating at 13, 15 and 17 cm electrode gaps were shown in Fig. 4, and their powers were 2.52, 2.42 and 2.36 kW, respectively. *Tuber magnatum* solid-state fermented products were pasteurized after RF heating with 15 cm gap for 180 s (Fig. 5). The temperature and drying curves of *Tuber magnatum* solid-state fermented products (Fig. 6) during RF-cold air drying with 15 cm gap had the fastest rate (50.626 g/min) (Table 1). Polysaccharides, triterpenoids and DPPH free radical scavenging capacity of four kinds dried *Tuber magnatum* solid-state fermented grains of had no significant difference (P>0.05) (Table 2). But the autoclaved with cold dried samples had the darkest color.

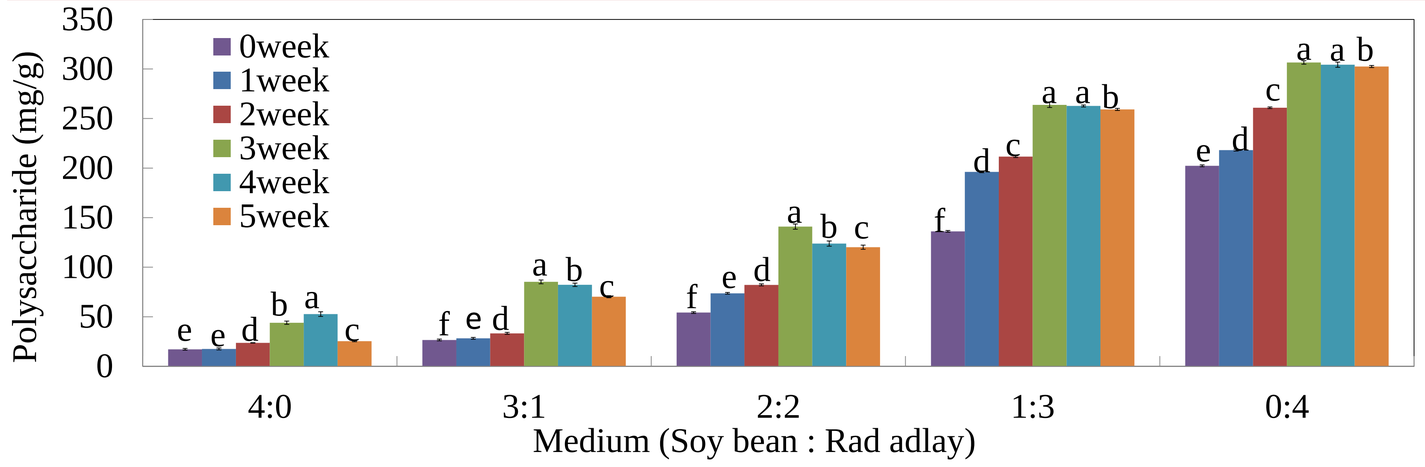

Fig. 1. Effect of different medium on polysaccharide contents in *Tuber magnatum* solid-state fermented grain products.

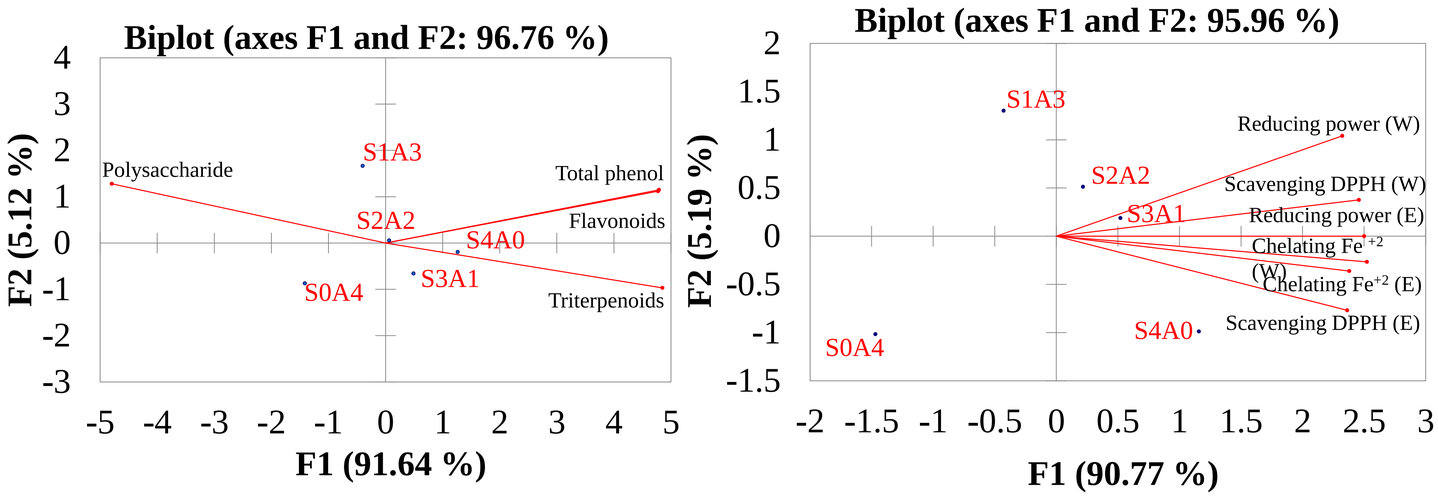

Fig. 2. Principal components analysis of bioactive components and antioxidant activity in different *Tuber magnatum* solid-state fermented products. (W: water, E: ethanol)

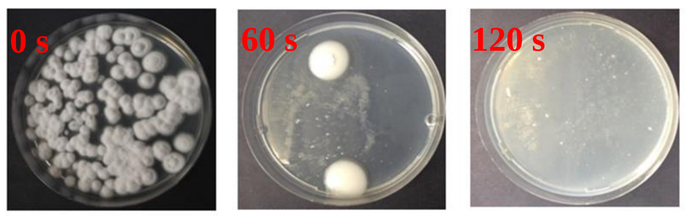

Fig. 3. The survival condition of *Tuber magnatum* in 2 mL PDB heating at 80℃ water bath after 7-days cultivation.

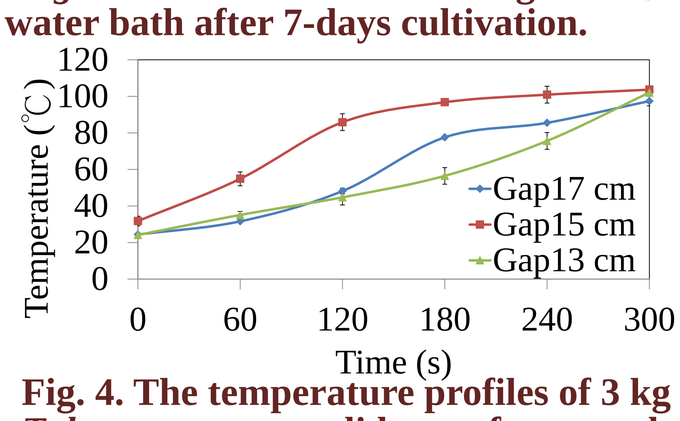

Fig. 4. The temperature profiles of 3 kg *Tuber magnatum* solid-state fermented products during RF heating at different electrode gaps.

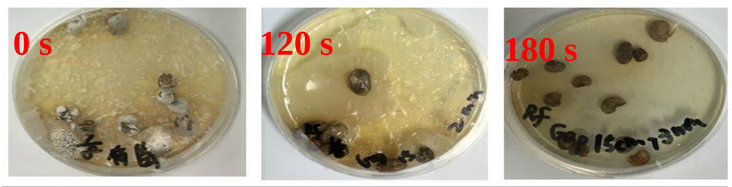

Fig. 5. The survival condition of *Tuber magnatum* solid-state fermented products during RF with 15 cm electrode gap heating after 7-days cultivation.

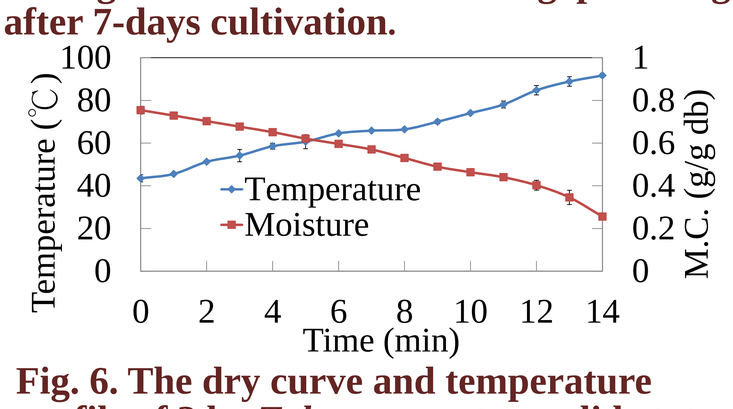

Fig. 6. The dry curve and temperature profile of 3 kg *Tuber magnatum* solid-state fermented products during RF heating with a 15 cm electrode gap.

Table 2. Effect of different pasteurization methods with different drying methods on yields, polysaccharide, triterpenoids and scavenging DPPH radicals of hot water and ethanol extracts from *Tuber magnatum* solid-state fermented products

Sample treatments	Color			Water extracts		Ethanol extracts	
	L*	a*	b*	Polysaccharide (mg/g)	Scavenging DPPH (%)	Triterpenoids (mg/g)	Scavenging DPPH (%)
RFP15-FD	31.60 ± 0.16^{a}	6.32 ± 0.32^{b}	14.25 ± 0.20^{b}	271.56 ± 3.70^{a}	90.77 ± 0.18^{ab}	16.98 ± 0.09^{a}	92.85 ± 0.40^{ab}
RFP15-CD	30.68 ± 0.25^{b}	7.51 ± 0.08^{ab}	14.55 ± 0.13^{ab}	270.99 ± 1.78^{a}	89.95 ± 0.10^{b}	16.91 ± 0.09^{a}	91.64 ± 0.45^{b}
RFP15-RFD15	28.56 ± 0.17^{c}	7.98 ± 0.36^{ab}	15.54 ± 0.42^{a}	269.61 ± 4.47^{a}	89.43 ± 0.22^{b}	16.83 ± 0.05^{a}	90.98 ± 0.28^{b}
A121-CD	23.22 ± 0.24^{d}	5.67 ± 0.09^{c}	9.11 ± 0.22^{c}	268.11 ± 3.70^{a}	89.16 ± 0.11^{b}	16.42 ± 0.06^{a}	90.33 ± 0.28^{b}

$^{a-d}$ Means within each row with followed by different letters are significantly different (P<0.05). Data are expressed as mean ± S.D. (n=3).

Different pasteurization and drying condition: **RFP15-FD** (RF 15 cm gap 3 min pasteurization with freeze-drying), **RFP15-CD** (RF 15 cm gap 3 min pasteurization with 45℃ cold air drying), **RFP15-RFD15** (RF 15 cm gap 3 min pasteurization with RF 15 cm gap 14 min drying), **A121-CD (121℃** Autoclaving 50 min with 45℃ cold air drying)

Conclusions

Mixed medium (soy bean: red adlay =1: 3) shortened the solid-state fermentation time to 3 weeks and obtained more uniform bioactive components and higher antioxidant activity. *Tuber magnatum* solid-state fermented products during RF with 15 cm electrode gap heating 180 s can be pasteurized. RF pasteurization with 15 cm gap and RF-cold air drying significantly reduced the downstream process time, drying speed is eight times than cold air drying. There were no differences of color, polysaccharide, triterpenoids, scavenging DPPH radicals among these RF pasteurization and drying methods.

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