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Effects of spray-drying operational parameters on the quality of freshwater mussel powder

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ABSTRACT

In this paper, the operating parameters of spray drying after a series of pre-processing were investigated and the properties and qualities of the freshwater mussel meat (FMM) powder were also analyzed. The considerable optimum conditions of spray drying were as follows: the inlet and outlet air temperature of the both deodorization were 180 °C and 80 °C, respectively; the optimum feed concentration for composite deodorization (CD) FMM powder was 30%, and for stewing deodorization (SD) FMM powder 27%; on top of all that, the feed temperature was 50 °C, 45 °C, respectively. In the later analysis, FMM powder was shown to be rich in protein and glycogen, up to 52.7%, 27.71% and 53.4%, 27.69%; meanwhile both the contents of essential amino acids (EAAs) in FMM powders were as high as 44%, which were close to the pattern of FAO/WHO. Thus the FMM powder of the both kinds, namely CD and SD FMM, were thought to be acceptably edible resources with high nutrition for human.

Keywords: Optimum conditions; Deodorization; FMM powder; Quality analysis

1. Introduction

Freshwater mussel, belonging to bivalve mollusk, because of their fast-growing ability, high reproductive capacity, and strong adaptability (Li et al., 2010), is a main source used for culturing pearls. Recently, as a result of its nutrition, advantages for human diets and edibleness as other shellfish such as shrimp, clam, scallop, lobster, crab and abalone, mussels is in growing value. Reports also showed that such shellfish food has lower fat and calories, compared with pork and beef (Caglak et al., 2008; Vernocchi et al., 2007); beyond that, marine mussel have an exceptional nutritional value such as 8 kinds of essential amino-acids (EAAs), n-3 Polyunsaturated fatty acids (PUFAs) and rare minerals such as selenium, calcium, iron, magnesium, phosphorous and vitamins (A, B1, B2, B6, B12 and C) (Li et al., 2010; Fuentes et al., 2009; Orban et al., 2002; Caglak et al., 2008; Pardo et al., 1990).

Though freshwater mussels are widespread in China, which are mainly distributed in the regions of the Mid-Lower Reaches of Yangtze River, producing higher than 0.6 million tons a year which accounted for about 40% of the total world production (about 1.5 million tons) (Wang and Wang, 2008), most farming freshwater mussels were discarded, causing either a waste of source or the environment pollution (Liu et al., 2009; Mol et al., 2007).

Recent studies were focused on the marine mussels processing and storage techniques, like deshelled refrigerated products packaged in plastic pouches or frozen in vacuum-sealed plastic pouches (Caglak et al., 2008; Fuentes et al., 2009; Goulas, 2008; Turan et al., 2007). Nevertheless, freshwater mussels were rarely commented, and processing problem existed in marine mussels like shelf-life also remained to be settled in freshwater mussel meat (FMM).

Spray drying is a unique technique which is able to produce powder of special particle size and low moisture content regardless of dryer capacity and product heat sensitivity. In many cases, spray drying is the only rational choice to dry fluid feed stocks (Hankins et al., 1985; Masters, 1985). For example, with the good properties of the powders, spray drying is widely used in tomato powder (Al-Asheh et al., 2003), whole

Abbreviations: FMM, freshwater mussel meat; EAA, essential amino acid; PUFA, polyunsaturated fatty acids; MC, moisture content; CD, composite deodorization; SD, stewing deodorization.

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milk powder (Baldwin and Truong, 2007) and other edible foods as the technology gradually matured (Chinn et al., 2011; Rocha et al., 2011; Foerst et al., 2011; Ghio et al., 2000). To make effective utilization of pearl production leftovers, powered FMM using spray drying was prepared in the study. Powered FMM had many advantages, including convenience of packing, transportation and storage, and providing an easy way to blend with other functional products. Since there were few articles about FMM powder produced by spray drying, this article was to study the effects of spray drying parameters such as inlet and outlet air temperature, feed concentration, feed temperature on the properties of FMM powder with the purpose of additional value of the product.

2. Materials and methods

2.1. Materials

The freshwater mussels were supplied by ZhenNi Daily Chemical Company (Suzhou, China). All other chemicals are analysis grade and were used without further purification.

2.2. Methods

2.2.1. Sample collection

After pearls were harvested, the freshwater mussels were immediately transported under refrigeration (4 °C) to the State Key Laboratory of Food Science and Technology of Jiangnan University, China. The stale ones were discarded and then the elected ones were stored at −18 °C for use upon arrival.

2.2.2. Sample preparation before spray drying process

The clear meat tissue was collected in the procedure as follows: after mantle, stomach and their purtenance around were discarded, FMM was washed with cold water. The obtained FMM were then subjected to deodorization treatment using two methods: (1) composite deodorization (0.3% sodium chloride, 1% citric acid and 0.1% yeast powder) for 45 min with ratio of material 1:3, with intermittent mixing; (2) stewing deodorization (1% ginger and 0.5% cooking wine) for 10 min with ratio of material 1:2, under the conditions of continuous mixing. Then the deodorized FMM were subsequently put into a meat grinder, then the little pieces were transferred to a ultrafine grinder (QDGX-18, 9000 r/min, 200–50 micrometer, China) with 20% (mass basis) water for further pulverizing. After that, the feed were concentrated to different concentrations with homogeneity.

2.2.3. The spray drying process

After the preparation for spray drying, the feed of deodorized FMM obtained were used at specific mass concentration (18%, 20%, 22%, 25%, 27%, 30%) with different feed temperatures (25 °C, 30 °C, 35 °C, 40 °C, 45 °C, 50 °C), by means of a peristaltic pump in the range 12–18 r/min. The drying air was electrically heat, controlled at the varied inlet temperature (170 °C, 180 °C, 190 °C, 200 °C), and different outlet temperatures (75 °C, 80 °C, 85 °C, 90 °C, 95 °C). By assaying the quality index of the FMM powder, the optimum parameters of spray drying process was determined. For each combination of the control variables, experiments were conducted.

2.2.4. Feed total solids

A sample of FMM feed (about 2 g) was weighed precisely and placed in an oven at 105 °C until the weight was constant (Al-Asheh et al., 2003). The total solid percentage (weight basis) was calculated as: Total solids (%) = weight of dried sample/weight of fluid sample × 100%.

2.2.5. Viscosity

The DV-II + Pro viscometer (Brookfield company, America) with its SC4-18 spindle was used directly under the spindle speed of 10–50 r/min to determine the viscosity of the FMM feed samples at different temperatures.

2.2.6. Quality analysis of the FMM powder

2.2.6.1. Solubility. The solubility of the product was measured according to the method reported by Gong et al. (2008) with some modification. 1 g (m_1) FMM powder was put into the 50 mL beaker then adding 10 mL distilled water (50 ± 1 °C), with constantly stirring for 60 s and then maintain 60 s, timing by a stopwatch. Then 1 mL was transferred into an aluminum can with constant heavy by 200 μL micropette plus (Dragon-Med company, China) for 5 times, and then dried in a oven at 105 ± 2 °C for 4 h. The samples were removed from then oven, cooled in a desiccated and weighted as m_2. The drying and weighing processes were repeated until constant weigh were obtained. The solubility was calculated as: solubility (%) = $10m_2/m_1 \times 100\%$.

2.2.6.2. Bulk density. The bulk density of the product was determined by pouring about 5 g of the powder into a 10 mL graduated cylinder. The volume occupied by the sample was recorded and bulk density was calculated (Yetismeyen and Deveci, 2000; Wade and Waller, 1994).

2.2.6.3. Proximate analyses. The FMM powder samples were analyzed in three parallel experiments for proximate composition: lipid content, moisture content, ash content, crude protein and the total sugar content determined by the method of AOAC (1997).

2.2.6.4. Dispersion time. The dispersion time of the product was determined by pouring 10 g of the powder into a 250 mL beaker with 100 mL de-ionized water in 25 °C water-bath. The time (s) was recorded immediately when the stirring began until all samples were dispersed (Quek et al., 2007; Aminlari et al., 1997).

2.2.6.5. Angle of repose. The fluidity of the product was determined by pouring 50 g of the powder from a funnel (dia. 1 cm) to the surface plate (kept the height from the funnel to the surface about 8 cm). By calculating the angle of repose, the fluidity was revealed (Aminlari et al., 1997).

2.2.6.6. Color measurement. The color measurement (CIELAB) on sample trials was carried out with the GR-400 Ultra-scan Pro1166 (Hunter lab company) directly. The color was measured on FMM powder, The FMM powder was placed in plastic Petri dishes and the color measurement was repeated three times (Quek et al., 2007; Schubring, 2002; Veazie et al., 2007).

2.2.6.7. Ratio of output. The ratio of output was calculated as:

$$\text{Ratio of output}(\%) = \frac{\text{Weight of mussel meat meal collected}}{\text{Total solids of mussel meat fluid}} \times 100\%$$

2.2.6.8. Composition and analysis of amino acids. Amino acids composition and their contents of two kinds of FMM powder were analyzed by reversed-phase high-performance