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Physicochemical Characteristics of *Cordyceps militaris* Influenced by Freeze-Drying Pressure

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*Cordycep smilitaris*is a well-known entamophagus fungus with wonderful health advantages. It should be dehydrated via freeze drying to retain the most valuable constituents specially cordycepin and adenosine. The characteristics of dried products such as bulk density, particle density and porosity are important indicators for design and quality management of processing, packaging, preservation. This research evaluated the influence of freeze drying pressure to some major physicochemical properties of dried *Cordyceps militaris*. Results showed that bulk density values of dried samples ranged from 862 to 913 kg/m^3 with the highest value recorded at freeze drying pressure 40 Pa. Particle density of dehydrated product increased slowly at the beginning of the process to 1094 kg/m^3 at pressure 40 Pa. Porosity of dried product at freeze drying pressure from 14 to 22 Pa initially decreased and then porosity started to increase from freeze drying pressure 22 to 80 Pa. Freeze drying pressure had a significant impact to the physicochemical properties of this valuable dehydrated fungus during processing, packaging, preservation and distribution.

Keywords: Bulk density, Cordycepsmilitaris, freeze drying pressure, particle density, porosity

INTRODUCTION

Fresh fruit and vegetable were not available all year round for their utilization and the long-term preservation could be challenging due to high moisture content, unavailability of cold-storage facilities and possibility of nutrient decomposition. Therefore, dehydration of fruit and vegetable permitted long-term consumption and manipulation, distribution and storage (Sagar et al. 2020). Freeze drying or lyophilization was a popular method for the processing of high quality food powders and solids (Ratti, 2001; Karam et al. 2016). It is commonly operated at low temperature and under high vacuum so it's a highly preferred technique for dehyration of foods containing thermallly sensitive constituents. It's the best alternative to store dried high-value fruits and vegetables with the most biocompound content in the finished products (Sagar et al., 2020). Different kinds of fruits and vegetables have successfully been executed (Shishehgarha et al. 2002; Nindo et al. 2003; Andriot et al. 2004; Hawlader et al. 2006; Ding et al., 2012; Wang et al. 2013; Ciurzynska et al. 2014; Fissore et al. 2014; Franceschinis et al. 2014; Fante et al. 2015; Gümü¸say et al. 2015; An et al. 2016).

Cordyceps militaris was one of the most highly valued staple components of the traditional Chinese and Tibetan medicine (Aarti et al. 2017).It's a well-known entamophagus fungus with wonderful health advantages by its adaptogenic, aphrodisiac, anti-oxidant, anti-aging, neuroprotective, nootropic, immunomodulatory, anti-cancer and hepatoprotective role (Lin et al., 2012; Shashidhar et al. 2013; Chen et al. 2013; Jing et al. 2014; Wan et al. 2017). It's a parasitic fungus on Lepidoptera larvae which has been used as a traditional medicine in China.

Polysaccharides and cordycepin existing in the fruiting body, mycelium or spores of *C. militaris* were responsible for the anti-inflammatory antioxidant, anti-tumor, anti-metastatic, immunomodulatory, hypoglycaemic, steroidogenic and hypolipidaemic effects (Das et al. 2010; Wang et al. 2014). It inhibited cell proliferation in tumor cells in the prevention and treatment of cancer (Wong et al. 2011). Extract of *C. militaris* possessed anti-oxidative property with capability to normalize superoxide dismutase and glutathione peroxide level (Dong et al. 2010). Cordyceps was correlated to reduction in cholesterol and triglyceride and an increase in the ratio of high density lipoprotein to LDL cholesterol (Patel and Ingalhalli, 2013). Extract of *C. militaris* included a component acting as an insulin sensitizer (Silva et al. 2012). Moreover, it also inhibited melanin synthesis relating tyrosinase, tyrosinase (Jin et al. 2012). Some remarkables studies literatured dehydration of *C. militaris*. Thitiphan (2018) determined the effect of drying methods including hot air drying and freeze drying on the quality of cordycepin production from *Cordycepsmilitaris.* The antioxidant activity and total phenolic contents of *C. militaris* extract prepared from freeze drying had higher value than that of extracted from hot air drying. Xiao-Fei et al. (2019) demonstrated the changes in moisture content and shrinkage ratio of *Cordyceps militaris* during mid-infrared-assisted convection drying. Minh (2020) concluded that acoustic drying at power 800 W in frequency 40kHz combined with vacuum drying at pressure -0.8 bar were suitable for dehydration of *Cordyceps militaris.*

The characteristics of dried products such as bulk density, particle density and porosity are important for design and quality management of processing, packaging, preservation and distribution (Martinelli et al. 2007). Various literatures mentioned to the effect of drying conditions on the physical properties of freeze dried powders such as bulk density, particle density and porosity (Que et al. 2008; Nawirska et al. 2009; Mahendran, 2010). Purpose of our study examined the influence of freeze drying pressure to some major physicochemical properties of dried *Cordyceps militaris*.

MATERIALS AND METHODS

2.1 Material

Fresh of fruiting bodies and mycelium of *C. militaris* was supplied from HauGiang province, Vietnam. After collecting, they must be quickly conveyed to laboratory for freeze drying. Chemical reagents were all analytical grade.

2.2 Researching method

Experiments were conducted in a mini scale freeze dryer. 50 g of *Ophiocordycepssinensis* was frozen in a layer of 5 mm at - 25 °C for 1.5 hours, then freeze dried under different vacuum pressure (14, 22, 40, 58, 80 Pa) at -45°C condenser temperature for 8 hours. The heating plate was set to 35°C which accelerated the sublimation process and kept constant during the drying process. The dried samples were preserved in dedicatedbags at 25±2°C for further analysis.

2.3 Physicochemical determination

Bulk density (kg/m^3) was evaluated by method described by Goula and Adamopoulos(2004), Chegini and Ghobadian (2005) and Jinapong et al. (2008).20 g of dried sample was gently loaded into a 100 ml graduated cylinder. The measured volume was used to calculate the bulk density according to the relationship: mass/volume. Particle density (kg/m^3) and porosity (%) were measured by using gas pycnometer described by Sereno et al. (2007). The volume was obtained by measuring the change in pressure experienced by an amount of compressed gas filling a constant volume reference chamber when it expands into a second chamber containing a sample of the material to be tested. From such pressure change and the knowledge of the volumes of the two chambers the volume of the sample solid matrix is determined.

2.4 Statistical analysis

The experiments were run in triplicate with different groups of samples. The data were presented as mean ±standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

RESULTS AND DISCUSSION

3.1 Bulk density

Bulk density is one of the most important variables in packaging, storage and distribution (Mayor et al., 2011). Bulk property can be highly affected during drying processes (Sablani, 2006; Sagar et al., 2020). In our research, bulk density variations of dried samples were presented in figure 1. Bulk density varied in a restricted range during dehydration. Bulk density values ranged from 862 to 913 kg/m^3 with the highest value recorded at freeze drying pressure 40 Pa. Bulk density initially increased, then reached a maximum value at 913 ankg/m^3 at pressure 40 Pa after that decreased. The benefit of dried fruit with higher density was that it could be kept in large amount into smaller bag when compared to product with lower density. Apart from that, higher bulk density implied lower amount of air occluded in the spaces between particles, which can help to avoid oxidative rancidity (Helena et al. 2013).

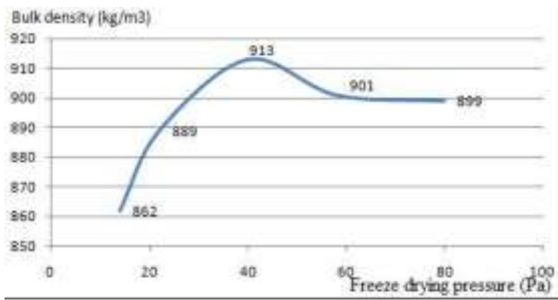

Figure 1:Effect of freeze drying pressure (Pa) to bulk density (kg/m^3) of freeze-dried *Cordyceps militaris*

3.2 Particle density

For all the treatments, particle density increased slowly at the beginning of the process (figure 2) to 1094 kg/m^3 at pressure 40 Pa. Particle density increased by the compositional change of the wet solid matrix during dehydration. Initially, moisture content was high, but during drying the content of more dense substances (sucrose, cellulose) increased leading to the increase of particle density (Mayor et al. 2011).

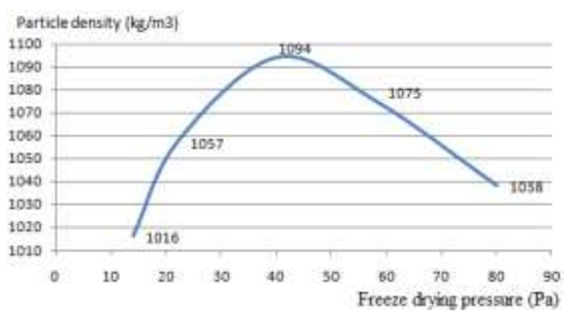

Figure 2: Effect of freeze drying pressure (Pa) to particle density (kg/m^3) of freeze-dried *Cordyceps militaris*

3.3 Porosity

In dehydration process, the heat and mass transfer flows could alter porosity (Rahman, 2001). In our research, porosity at pressure from 14 to 22 Pa initially decreased and then porosity started to increase from freeze drying pressure 22 to 80 Pa (figure 3). Textural and sensorial properties of foods were correlated to density and porosity (Rahman, 2001). Porosity was related to the chemical stability of dried products; degradation of sugars and lipid oxidation (Shimada et al. 1991; White and Bell, 1999). Low porosity lead to products with poor rehydration capability (McMinn and Magee, 1997).

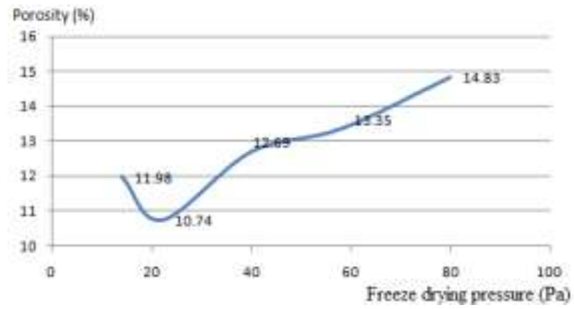

Figure 3: Effect of freeze drying pressure (Pa) to porosity (%) of freeze-dried *Cordyceps militaris*

CONCLUSION

Freeze drying technique was successfully applied to dry *C. militaris* sample. Dehydrated product was evaluated some physicochemical properties such as bulk density, particle density and porosity. Freeze drying can satisfactorily be utilized for drying of this valuable fungus to obtain the best quality product. Freeze drying pressure had a strong influence to the bulk density, particle density and porosity of dehydrated product. These variables highly contributed to processing, packaging, preservation and distribution.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript.

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