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EFFECT OF SPRAY DRYING CONDITIONS ON THE CHARACTERISTICS OF SERICIN POWDER FROM ERI SILK BOILING WATER

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Abstract

Sericin is a soluble protein extracted from Erik silk cocoon (Samia ricini) which is antioxidant and antimicrobial which can be applied in foods, drugs, cosmetics and apparels. In the apparel industry, the boiling water contained silk sericin component which need to be treated to save the environment. Therefore, this research will recover the sericin from the Eri boiling waste water. Eri silk cocoon was boiled in water at 95 °C (cocoon 800 g: water 10 l) for 90 min. The boiling water was concentrated to 2 °brix prior to spray drying. The inlet air temperature (130, 150 °C) and outlet air temperature (70, 80 °C) affected the moisture content of the sericin powder. The experimental results showed that moisture content of the sericin powder decreased with *increasing inlet and outlet air temperature. The inlet air temperature of 150 °C and outlet air temperature of 80 °C gave lowest moisture content of 4.2% and water activity of 0.3. However, product yields obtained from different drying conditions were not significantly different (P>0.05). The composition of sericin powder was 70.63% protein, 23.51% ash, 5.79% moisture and 0.07% fat. Properties of sericin protein prepared by spray drying with different spray drying conditions had similar characteristics. This knowledge can be applied in the commercial production.*

Keywords
Sericin, Eri Silk, Cocoon, Spray Drying, Boiling Water

1. Introduction

Sericin is a kind of hot water-soluble macromolecular globular protein that envelops the fibroin fiber with successive sticky layers. The glue-like protein secreted from the mid-region of the silk gland, functions as a binder of the fiber (Aramwit et al., 2012). It helps in the formation of cocoon and contributes about 20–30% of the total cocoon weight. It is made of 18 amino acids most of which have strongly polar side groups such as hydroxyl, carboxyl, and amino groups. Sericin is being used in cosmetics because it inhibits the tyrosinase activity and this enzyme is responsible for biosynthesis. Masahiro et al., 2000 reported that consumption of sericin enhances bioavailability of Zn et al., in rats & suggested that sericin is a valuable natural ingredient for food industry. Use of sericin as a finishing agent for natural and synthetic textiles enhances their moisture absorption, antistatic, softness, and comfort properties. Filters made of polyamide or polyester fibers coated with sericin gave ant oxidation and antimicrobial activity, suggesting their potential of use as indoor air filters to reduce free radicals and fungi and bacteria contamination. Sericin can be cross linked, copolymerized, or blended with other polymers to produce a new range of biodegradable materials with improved properties. Thus because of its varied properties, sericin can be used as an additive in food, cosmetics, textiles, and pharmaceutical products (Gulrajani et al., 2009). In Thailand, Eri silk (Samia ricini) is a kind of wild silk that has been cultured in Northeastern Thailand, eat cassava leaves for food. Among their properties, sericin protein has little information, especially the properties of different varieties (Srihanam, 2011). The commercial production of Eri silk is now available in Thailand.

The degumming of silk is usually carried out by using chemical or biochemical systems or with hot water alone. The processing of raw silk produces about 50,000 tons of sericin worldwide each year (Gulrajani et al., 2009). Major part of it is discarded into the waste water stream which leads to high chemical oxygen demand (COD), biological oxygen demand (BOD) and nitrogen level (Kruapongsak et al., 2011). Therefore, the waste water released by silk industry leads to contamination of water and environment. Water treatment of this waste water consumes a lot of money (Vaithanomas & Kitpreechavanich, 2008). Likewise, it also indicated that the high nitrogen content in such wastewater could be sericin-derived products which therefore could be recovered and applied for various purposes. The aim of this work was thus to recover sericin protein for further applications.

2. Materials and Methods

2.1 Eri Silk Cocoons

The Eri silk cocoons (Samia ricini) were kindly supplied by Prof. Dr. Thipvadee Attatham, Department of Entomology, Faculty of Agriculture, Kasetsart University, & Nakhonpathom Thailand.

2.2 Preparation of Eri Silk Boiling Water

Eri silk cocoon of 800 g was weighed and put in a pot containing 10 L of distilled water and then boiled for about 90 min to obtain the Eri silk boiling water with a concentration of 2°brix. After removing the cocoons from the pot, the wastewater was left for cooling. In this way, approximately 3 L of sample was obtained. Then the Eri silk boiling water was spray dried.

2.3 Spray Drying

The Eri silk boiling water was spray dried with a laboratory-scale mini spray dryer (Büchi B-290, Flawil, & Switzerland). The inlet air temperature was 150 and 130 °C, outlet air temperature was 80 and 70 °C. The air flow rate was fixed to 35 m3/h. Feed solutions were pneumatically atomized through a nozzle using compressed air at fixed pressure of 3 bar. The powders were collected and stored in an aluminum foil bag and sealed. Analysis of variance was conducted and significant difference was conducted at the level of 95% ($P<0.05$) using the SPSS 16.0 software package (SPSS Inc., Chicago, IL., USA)

2.4 Properties of the Sericin Powder

The moisture content measurements of the spray dried sericin powder were conducted in the oven according to AOAC, 1995. The water activity was measured by using a water activity meter (Aqualab, Decagon devices Inc., Pullman, Washington, USA). Characterization of sericin protein at different drying conditions using a UV-Vis spectrophotometer by scanning over a wavelength of 190-350 nm (Wu et al., 2007).

3. Results and Discussion

3.1 The Influences of the Inlet and Outlet Air Temperatures on Moisture Contents of Sericin Powder

The influences of inlet air temperature and the outlet air temperature on the moisture contents of sericin powder were shown in Figure 1.When Eri silk boiling water with concentrations of 2 ° brix was spray dried at the increased temperature of the air inlet and outlet, the moisture content of sericin powder was decreased. Because the increased inlet air temperature results in a difference of medium temperature, heat transfer rate and drying rate were increased. The outlet air temperature was correlated with the feed rate of Eri silk boiling water. The lower feed rate of Eri silk boiling water, the higher outlet air temperature made sericin powder with lower moisture content. The drying conditions trial period was in the range of 4-13 hours. The lowest moisture content was at the inlet air temperature of 150°C and outlet air temperature of 80 °C, moisture content was 4.26 %. The highest moisture content was at the inlet air temperature of 130 ° C and outlet air temperature 70 °C, the moisture content was 6.49%.

It was found that inlet air temperature and outlet air temperature influenced the moisture content of sericin powder significantly ($P < 0.05$). Spray drying conditions at a temperature of inlet air temperature of 130 °C and outlet air temperature of 80 ° C and inlet air temperature 130° C outlet air temperature 70 ° C was statistical different ($P < 0.05$). For inlet air temperature of 150 ° C and outlet air temperature 80 ° C, inlet air temperature 150 ° C and outlet air temperature 70 ° C, there was no significant difference in moisture content ($P > 0.05$).

Generally, standard of spray-dried products required low moisture content less than 5% wet basis (Yan et al., 2008). Therefore, the sericin dry powder is safe for storage except the powder of inlet air temperature of 130 and outlet air temperature of 70 has a moisture content of 6.49% db (6.1%wb) which is prone to become sticky.

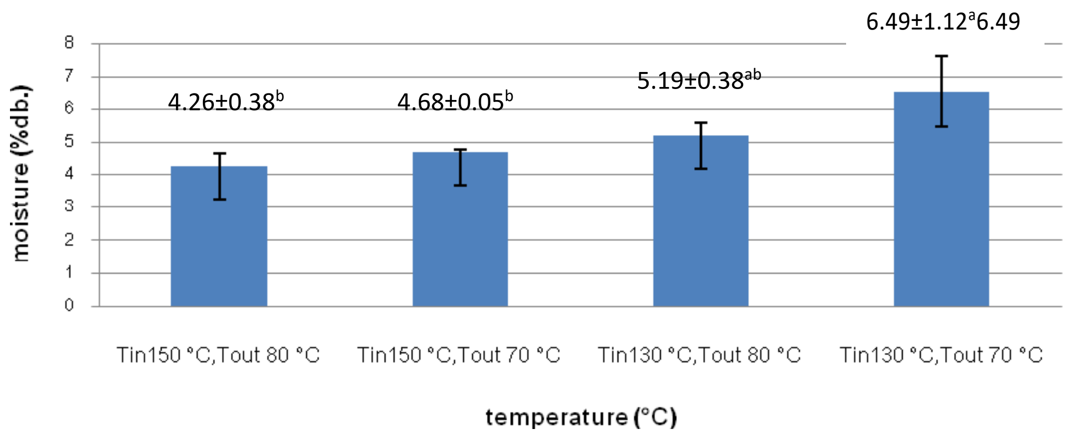

Figure 1: *Influences of inlet and outlet temperatures that affect the moisture content of sericin Powder from Eri silk boiling water Tin = inlet air temperature, Tout = outlet air Temperature*

3.2 The Water Activity and Yield

In addition, the water activities of sericin powder obtained from different spray drying conditions were in the range of 0.33 to 0.52 which was safe for storage of powder products (Quek et al., 2007). The inlet air temperature and the outlet air temperature are variables that influence the water activity. When the inlet air temperature and the outlet air temperature was higher, sericin powder would have significant lower water activity ($P < 0.05$).

Table 1: *Moisture Content, Water Activity and Yield of Sericin Powder Obtained from the Spray Drying of Erik Silk Boiling Water in Various Conditions*

Inlet temperature (°C)	Outlet temperature (°C)	Feed rate (ml/min)	Moisture (% db.)	water activity	Yield $_{dry}$ (g/ml)	Drying time (hour)
150	80	22	$4.2611^{b} \pm 0.38$	$0.3389^{d} \pm 0.0087$	$9.0800^{a} \pm 0.50$	6.56
150	70	33	$4.6884^{b} \pm 0.05$	$0.4507^{c} \pm 0.0036$	$7.4350^{a} \pm 1.33$	4.58
130	80	11	5.1962ab ± 0.38	0.4757b ± 0.0030	9.0550a ± 1.84	13.75
130	70	14	6.4945a ± 1.12	0.5236a ± 0.0005	9.8850a ± 0.04	10.40

Values are expressed as means ± standard deviation (n=2).

a, b Values in the same column followed by different letters are significantly different (P<0.05)

The yield of sericin powder from Eri silk boiling water will depend on the outlet air temperature. The higher outlet air temperature will result in higher yield due to less stickiness to the cyclone. However, statistical tests showed that the yield of sericin powder by spray drying at different conditions were not significantly different (P > 0.05).

3.3 The Chemical Composition of Eri Silk Cocoon and Sericin Powder

The analysis of the chemical composition of Eri silk cocoon and sericin powder is needed for starting the process of silk protein extraction and utilization in the future. The chemical composition of Eri silk cocoon and sericin powder were shown in Table 2. The result showed that the moisture content of cocoon was 2.63%, the protein content in the cocoon was 94.51%, the fat content was 0.46% and ash content which was the inorganic substances such as minerals was 2.35%. When comparing these values with Nuchadomrong et al., 2009, it was found that the chemical composition of the Eri silk cocoon was similar (108.40% fat, 1.04% protein and 5.48% ash content dry weight).

Table 2: *Composition of Eri Silk Cocoon and Sericin Powder*

Composition	Eri silk cocoon	Sericin powder
Moisture (%)	2.63	5.79
Protein (%),(factor 6.25)	94.56	70.63
Fat (%)	0.46	0.07
Ash (%)	2.35	23.51
Fiber (%)	-	-
Carbohydrate (%)	-	-

The sericin protein extract from Eri silk cocoon by boiling in distilled water at a temperature of 95 °C for 1.5 hours and then spray drying. It was found that the moisture content was 5.79%, protein content was 70.63%, fat content was 0.07% and ash content was 23.51% which was very high. When comparing these values with Vaithanomas & Kitpreechavanich

2008, who studied the chemical composition of sericin powder by freeze drying. It was found that the protein content of 76.10% and ash content of 21.68% which was similar. The spray drying process will require heat to dry the powder; it may affect some protein denaturation depending on the drying conditions. However, spray drying gave the appearance of a fine powder and it took very short time to dry.

3.4 The Absorption of UV light of sericin powder with a UV-Vis spectrophotometer

Measurement of the UV absorption of sericin powder from Eri silk boiling water and spray drying process at various conditions was made by using a UV-Vis spectrophotometer. Figure 2. Show the results of spectral absorbance of the sericin solutions spray drying at various conditions. It was found that the absorption of UV light at a maximum wavelength of 205 and 280 nm. These results correlated with the general structure of the protein. The structure of the protein absorbs UV light at a wavelength of 205 and 280 nm. Amino acids with aromatic ring structure absorbs UV light maximum at 280 nm and peptide bond of protein absorbs light maximum at about 205 nm (John et al., 2002), which is a characteristic of the normal protein. The structure of sericin protein is composed of serine and aspartic acid (Zhang, 2002). Wu et al., 2007 had a wavelength scan of sericin solution by UV-Visible spectrophotometer in a wide wavelength range and found a maximum wavelength of 214 and 280 nm which provided similar results.

The absorbance spectrums were slightly different from sericin powder spray drying at various conditions. The positions of 205 and 280 nm is caused by the absorption spectrum of the peptide bond and amino acids among the ring (aromatic ring), respectively. This peptide bond absorbs UV light at a wavelength of 180 -230 nm formed by amino acids are Gly, Ala, Ser, Asp, Glu, Thr, Ile, Leu, Arg, Cys, Lys, Met, Val, Pro and His. Amino acids among the rings are Tyrosine, Phenylalanine and Tryptophan can absorb UV light at 260-280 nm.

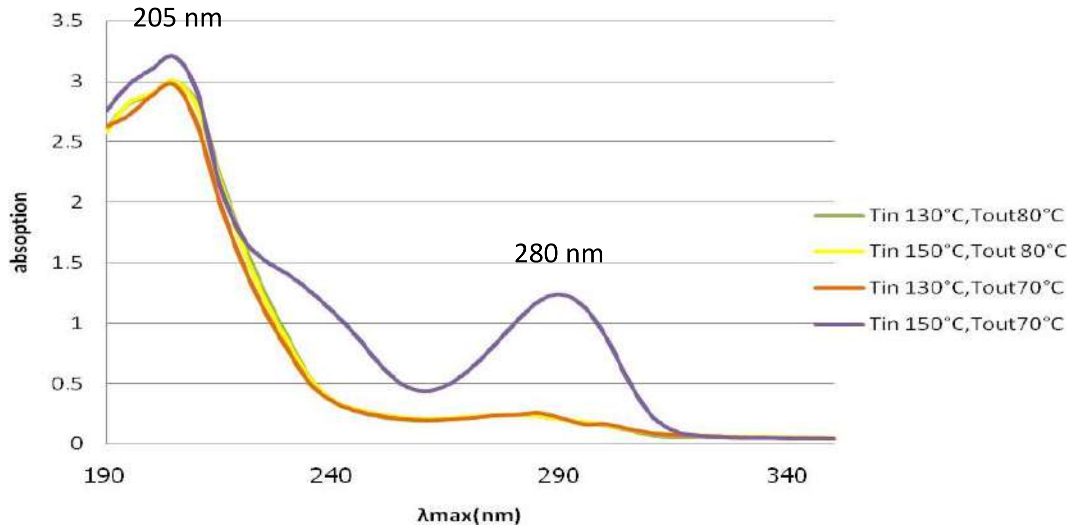

Figure 2: *UV spectrum of sericin powder extracted from Eri silk boiling water with Different spray drying conditions*

4. Conclusion

The influences of spray drying conditions on properties of sericin powder from Eri silk boiling water were investigated. It was found that increasing the temperature of the hot air inlet and outlet, sericin powder will have lower moisture content and lower water activity. Moisture contents of sericin powder obtained by spray drying in all conditions were in the range of 4.26-6.49% db. Corresponding to the amount of water activity in the range of 0.33 to 0.52 which was considered safe for powder products Product yields obtained from different drying conditions were not significantly different ($P > 0.05$). Sericin powder obtained from the spray drying process contains high protein about 70%. Sericin protein prepared by different spray drying conditions has similar characteristics due to the functional groups in the amino acid component in the structure of sericin protein. The research can be used in the cosmetic and pharmaceutical industries. In the future, which has resulted in a more acceptable material for biological applications?

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