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Evaluation of the properties of sericin protein recovered from silk effluents

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Abstract: This study aims to evaluate the properties of sericin protein recovered from silk effluents of textile industry. Recovered sericin was characterized in terms of molecular weight, ash contents, elemental and amino acid compositions. The molecular weight range of recovered sericin was found as 40-176 kDa, with 86-96 kDa at the highest fraction of 79-97%. Ash content was found as 11-14%. In terms of elemental composition, C, H and N contents of recovered and dialysed sericin were determined as 43%, 7% and 14%, respectively. Properties of recovered sericin were quite similar to the reference sericin used in this study and those reported in literature. Although some amino acids were lost during processing, the amino acid composition was acceptable. With a serine content of almost 29%, sericin recovered from silk effluent holds the potential of high moisture absorption. The results suggest that recovered sericin is likely a promising raw material for potential applications in cosmetics, biomedical and textile industries.

Keywords: Sericin; silk effluents; recovery

Introduction

Our understanding of wastewater is shifting from an obligation- effluent that has to be discharged properly- towards an opportunity- renewable resource from which valuable materials can be extracted. Among them comes water, energy, nutrients and metals. Advanced technologies such as membrane separation processes are finding increasing interest for recovering these materials. Textile is one of the most polluting and water intensive industries, from which dyes, auxiliary chemicals and water can be recovered. When natural raw materials such as silk are processed, it even becomes possible to recover proteins.

Sericin is a water soluble, gummy protein secreted by the silkworm *Bombyx mori* in order to envelop the main silk fiber, namely fibroin, with sticky layers. In this way, the thin fibroin fibers are held together and the cocoon is formed. Sericin, which constitutes about 20-30% of the total cocoon weight is removed from the silk fiber and conventionally discharged together with silk processing wastewaters. These effluents cause severe environmental pollution due to their rich organic contents. However, sericin is a valuable protein with an economical value. It has a variety of end-uses in some industries including cosmetics, biomedical and textile due to its useful properties such as antioxidation, UV resistance, moisture absorption and biocompatibility.

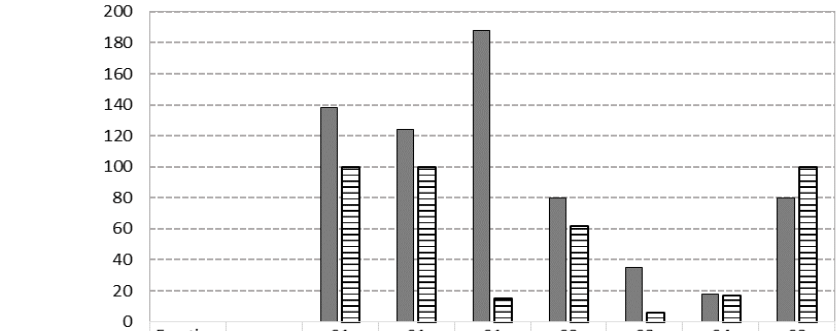
The recovery of a material from a waste stream requires that its properties are known and compatible with its original state so that it can be used safely. In this regard, characterization of sericin and determination of its properties is very important for effective end-use of this protein. To this end, this paper aims at evaluating the properties of sericin protein recovered from silk effluents generated in cocoon cooking process of textile industry. Sericin was recovered by adopting a process train consisting of nanofiltration+ethanol-induced precipitation (Capar, 2012). The characterization study covers MW, pH, moisture and ash contents, elemental composition (C, H, N) and amino acid analysis.

Material and Methods

The recovered protein was characterized in terms of molecular weight (MW), ash contents, elemental and amino acid compositions. MW distribution and sericin concentrations were determined by using an HPLC equipped with a gel permeation chromatography (GPC) column (NUCLEOGEL AQUA OH-40-8) and UV detector. The weight percents of C, H and N elements of sericin samples were determined on a dry basis using LECO CHNS-932 model elemental analyser. Amino acid analysis was performed by an UFLC with UV detection. Dialysis was adopted to purify the protein. Sericin was extracted from native cocoons via hydrothermal processing. 2-D gel electrophoresis and MALDI-TOF analyses were used for protein identification.

Results and Conclusions

Sericin is a family of proteins with a wide range of MW, i.e., 6-467 kDa (Zhang, 2002; Kundu et al., 2008; Wu et al., 2007). This is due to the fact that MW of sericin is affected by the factors such as pH, temperature and processing time. In this study, four MW fractions of sericin were detected in the source wastewater, which ranged from 10 kDa to 200 kDa at varying proportions. As shown in Figure 1.1, they were named as S_1 (average MW 188 kDa, average fraction 15%), S_2 (average MW 80 kDa, average fraction 62%), S_3 (average MW 35 kDa, average fraction 6% and S_4 (average MW 18 kDa, average fraction 17%) (Figure 1.1). On the other hand, only S_2 (average MW 80 kDa, average fraction 100%) was detected in the recovered powder. As a comparison, MW of a commercially obtained sericin powder (S_C) was determined as 138 kDa and that of sericin obtained directly from the native cocoon (S_N) was found as 124 kDa. Recovered sericin was classified as high MW-sericin, which is suitable for making biomaterials and membranes (Zhang, 2002).



Fraction		S1	S1	S1	S2	S3	S4	S2
Sample		SC	SN	SW				SR
MW (kDa)	0	138	124	188	80	35	18	80
Percentage (%)	0	100	100	15	62	6	17	100

Figure 1.1. Molecular weight comparison of sericin

MALDI-TOF spectrums of protein spots revealed that recovered protein was compatible with SER1 (O96614) and SER2 (O96615). Elemental analysis of sericin revealed that C, H and N contents of recovered sericin were 38%, 6% and 10%, respectively. Carbon and nitrogen contents were lower than those of commercial (S_C) and native sericin samples (S_N); which had 41-43% C, 6% H and 14-15% N (Figure 1.2). The reason for this was found to be the presence of another silkworm protein in the recovered sample (Capar, 2012). This impurity was removed via dialysis. The dialyzed sample (S_{RD}) had C, H, N contents of 43%, 7% and 14%, which were almost the same as S_C and S_N used as standards. The elemental composition

of recovered and dialysed sericin was also similar to the 48% C and 14% N contents of sericin reported by other researchers (Chen et al., 2011; Wu et al., 2007).

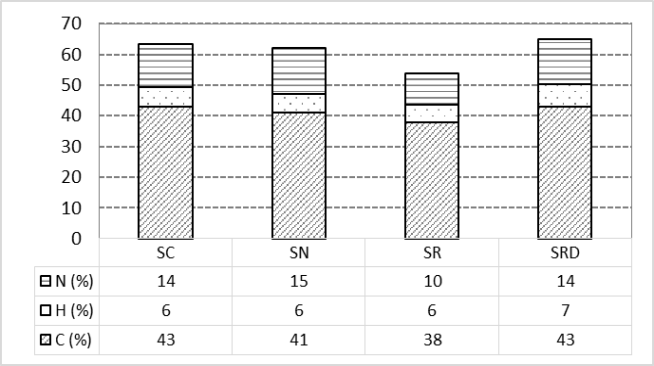


Figure 1.2. Comparison of elemental composition of sericin

Serine, aspartic acid and glycine content of sericin samples reported in literature count for more than 50% of the whole amino acid composition, i.e., 51%, 64% and 67% were determined by Takasu et al. (2002), Wu et al. (2014) and Aramwit et al. (2010). In this study, serine, aspartic acid and glycine content of commercial sericin and recovered sericin samples were determined as 56% and 49%, respectively. Serine is the dominant amino acid in sericin, which was determined as 35% and 29% for S_C and S_R, respectively. These values are quite compatible with those reported in literature, i.e., 22% (Wu et al., 2014), 34% (Aramwit et al., 2010) and 39% (Takasu et al., 2002). These results reveal that amino acid composition of recovered sericin, despite the loss of some amino acids, is quite acceptable.

The results revealed that sericin recovered from the silk wastewater has acceptable quality. Having a serine content of almost 29%, recovered sericin holds the potential of high moisture absorption and it is regarded as a promising raw material for potential applications in cosmetics, biomedical and textile industries.

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