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[Note]

Effect of enzyme treatment on the DSC and TGA behavior of silkworm powder

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Abstract

Silkworm powder's thermal property is an important factor for its storage and marketing. This study examined the effect of edible enzyme on the thermal property of silkworm powder using Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC). Results of the TGA showed that regardless of the enzyme treatment, the weight loss patterns of silkworm powders exhibited 3 step thermal property deterioration at approximately 80 °C, 280 °C, and 480 °C due to water evaporation and thermal degradation. This is similar with the DSC which also resulted in all samples two endothermic peaks attributed also to water evaporation and thermal degradation. These results indicated that the use of enzyme such as protease and cellulase might not affect significantly the thermal properties of silkworm powder.

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Introduction

Traditionally Korea and China have used silkworm and silkworm droppings as a folk remedy for diabetes (Ryu *et al.*, 2013). Recently, many researchers have elucidated the use of silkworm in production of anti-diabetic functional food (Chung *et al.,* 1997; Ryu *et al.,* 1997; Ryu *et al.*, 2002). A study of Ryu *et al.* (2002) found out that the commercial silkworm powder produced by freezing-drying method on the 3rd day of the 5th instar exhibited optimum blood-glucose lowering effect. Researchers have also proven silkworm powder's potential for blood LDL-cholesterol-lowering (Kim, 2008; Yoon *et al.*, 2005), antioxidant activity (Choi *et al*., 2000), and antihepatotoxic activity (Kim *et al*., 2008).

To this date, enzymatic modification for protein food is widely used in order to improve the functional and physiological properties such as meat tenderization, cheese-making, dehairing, baking, and brewery, among others (Singhal *et al*., 2012). Silkworm powder, a protein food, is composed of 10.6% water, 54.8% crude protein, 9.4% crude fat and 7.2% crude fiber (Kim *et al*., 2008). In addition, silkworm powder has many active components including 1-deoxynojirimycin (DNJ).

As mentioned earlier, enzyme treatment resulted in the antioxidant activity and enzymatic degradability of silkworm powder (Bae *et al.,* 2016; Kim *et al.,* 2015). However, thus far, no studies have been conducted on using enzyme treatment to modify the thermal properties of silkworm powder. Hence, this paper studied the effect of edible enzyme (alkaline protease and cellulase) treatment on the silkworm powder's thermal properties.

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Materials and methods

Preparation of silkworm powder extract

The silkworm variety, *Kumokjam*, used in this study, was reared by feeding mulberry leaves at the National Institute of Agricultural Science. The 3rd larva of the 5th instar were quickly frozen with in liquid nitrogen and lyophilized. FoodPro Alkaline Protease (endo-type protease from *Bacillus lichenformis*) and Plantase TL (cellulase from *Aspergillus niger*) obtained from Bision Corporation (SeongNam, Korea) were stored at 4 ºC until use. For the enzymatic treatment, one gram of silkworm powder was used as a substrate: 10 mL of distilled water and 10 uL of enzyme were added.

Measurement of thermal properties

TGA was operated using Rheometric Scientific TGA 1000 (USA) under the flow of nitrogen gas at a scanning speed of 20°C per minute. On the other hand, DSC measurement was performed with a Thermal Analysis Instrument (TA2910, USA) at a heating rate of 10°C per minute and a nitrogen gas flow rate of 50 mL per minute.

Results and discussion

TGA, a technique for measuring the mass of a material as a function of temperature or time, was applied to obtain information on the stability of silkworm powder. The typical thermogravimetric curve and its differential thermogravimtric curve of silkworm powders are shown in Fig. 1. Regardless of enzyme treatment, the weight loss patterns of silkworm powders showed 3 step thermal degradation behavior at approximately 80 °C, 280 °C, and 480 °C. The initial weight loss was due to the evaporation of water while the 2nd and 3rd weight loss was associated with the silkworm powder degradation. Similar patterns of thermal decomposition behavior were observed for enzyme treated and untreated silkworm powder. Although the silkworm powder treated with alkaline protease showed sharp degradation pattern at around 450 °C. Table 1 shows the values of explaining the thermogravimetric behavior of silkworm powder. The sample exhibited the 1st, 2nd, and 3rd degradation at approximately 5%, 50%, and 35%, respectively. However, SPP+ showed 3rd degradation percentage of 27.1% which was lower than the other samples. With regards to the kind of

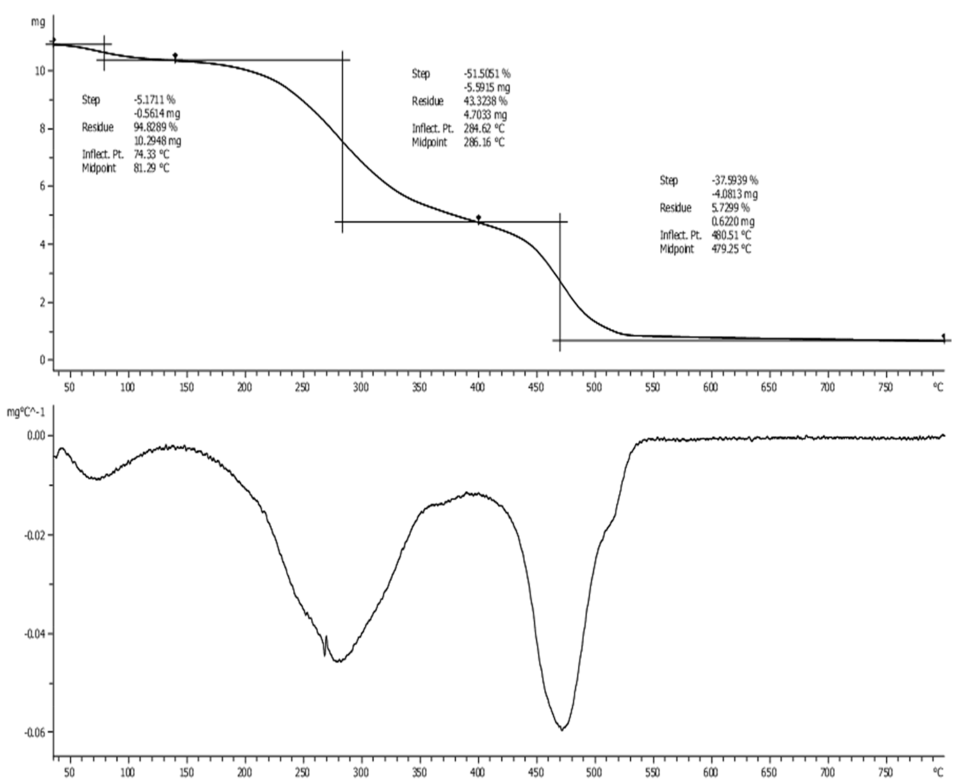

Fig. 1. Typical thermogravimetric (upper figure) and differential thermogravimetric curve (lower figure) of silkworm powder.

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Table 1. Thermogravimetric behavior of silkworm powder

Sample*	SP	SPP-	SPP+	SPC-	SPC+
1st step	5.2%	5.5%	4.5%	5.9%	5.4%
2nd step	51.5%	45.9%	46.5%	50.4%	50.1%
3rd step	37.6%	34.1%	27.1%	34.9%	38.4%

*Sample ID: silkworm powder (SP); silkworm powder treated without protease (SPP-); silkworm powder with protease (SPP+); silkworm powder without cellulase (SPC-); silkworm powder with cellulase (SPC+)

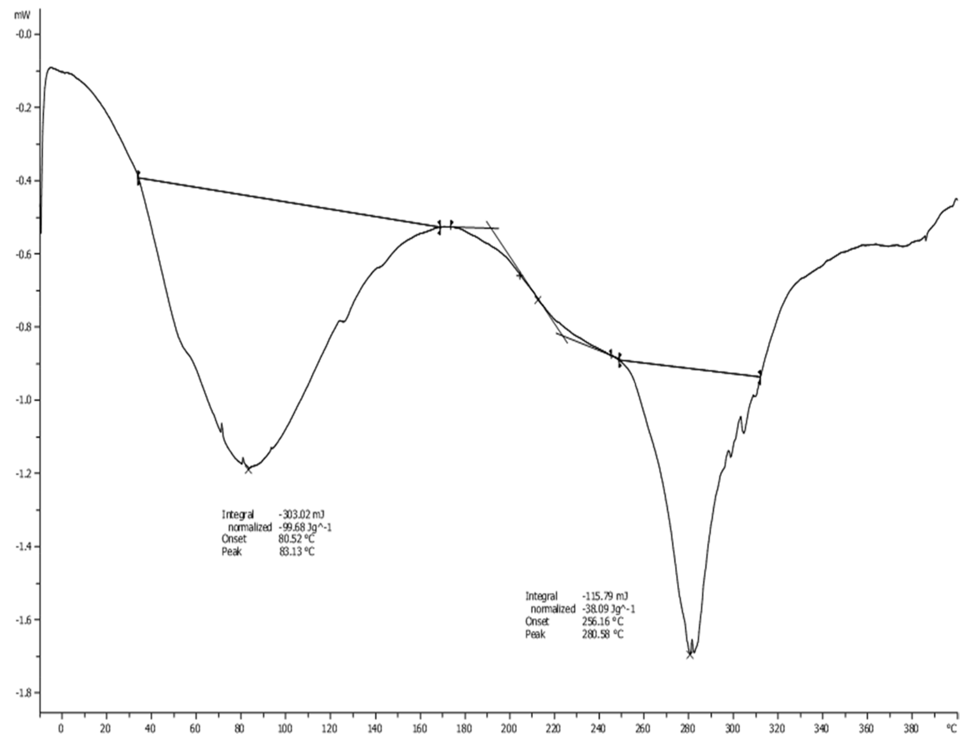

Fig. 2. Typical differential scanning calorimetric curve of silkworm powder.

Table 2. Differential scanning calorimetric characteristics of silkworm powder

Sample*	SP	SPP-	SPP+	SPC-	SPC+
1st endothermic peak	78.5	83.1	71.3	88.4	83.1
2nd endothermic peak	269.5	280.6	281.8	282.3	274.4

*Sample ID: silkworm powder (SP); silkworm powder treated without protease (SPP-); silkworm powder with protease (SPP+); silkworm powder without cellulase (SPC-); silkworm powder with cellulase (SPC+)

enzyme used (protease from *Bacillus lichenformis* and cellulase from *Aspagillus niger*), the weight loss patterns and differential thermogravimetric curves were similar to each other. Generally, the thermal combustion of organic matter occurs through two main sequences; low temperature region and high temperature region (Kristensen, 1990). Low temperature regions' degradation ranges from 100°C to 350°C which originated from dehydration, oxidative degradation of aliphatic carbohydrate, and formation of carbonaceous char, among others. Meanwhile, high temperature regions' degradation ranges from 350°C to 600°C which attributed to oxidation of aromatic groups and carbonaceous char.

Fig. 2 shows the typical DSC curve of silkworm powder. The first characteristic DSC data are summarized in Table 2. As shown in the table, all samples showed two endothermic peaks at approximately 80°C and 280°C due to water evaporation and thermal degradation. The results of the DSC thermograms were complying with TGA thermal properties. Results showed that enzymatic processing did not affect significantly the thermal properties of silkworm powder.

Acknowledgments

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