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Liquefaction of Porcine Hoof Shell via Steam Explosion (#361)

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Introduction

Porcine hoof shell (PHS), as a keratin-rich animal byproducts, is characterized by plenty of intermolecular and intramolecular cystine cross-links and formed disulfide bonds between cross-linking protein chains and hard to be degraded in nature [1-2]. Most of PHS is discarded, which causes environmental negative impacts and is against the strategy of sustainable development. Steam explosion (SE) is developed from conventional extrusion or steam spout or swollen technologies. Now, SE mainly devoted for the lignocellulosic biomass such as cellulose, hemicellulose and lignin [3]. After SE pretreatment, the constitutive components of biomass are released. For instance, oligosaccharides produced from the sugarcane bagasse, and the enzyme and solvent accessibility of cellulose are increased. In terms of the animal byproducts, duck feather treated with SE has been reported that the disulfide cross-links and hydrogen bonds could be broken by SE [4]. In the present study, SE was proposed to liquefy the PHS. The liquefied rate was investigated at specific pressure and maintaining time via SE. The chemical composition change of the SE samples was analyzed.

Methods

Experiments were carried out with the SE apparatus. SE process was shown in Figure 1. About 55 g of PHS were loaded into the chamber and pressurized at 0.5, 1, 1.5, 2 and 2.3 MPa. Each pressure was kept for 5, 10, 15, 20, 25 and 30 min, respectively. The liquefied rate was measured as weight loss of sample during SE process and expressed as a percentage of initial sample weight (Liquefied rate = $(1-m_1/m_0) \times 100$. Where m_0 and m_1 represents the weight of the initial sample before SE treatment, and the weight of the solid residual after SE treatment, respectively).

Moisture content in raw PHS (about 50 g) was determined by drying at 105±1 °C in the oven until constant weight. After that, the dry basis of PHS was smashed into powder to estimate the content of protein, fat, ash and mineral elements. The contents of protein, fat and ash were determined by AOAC methods. The molecular weight distribution of polypeptides in the liquid fractions of SE samples were determined via HPLC. Statistical analysis was performed using SPSS 17.0 software. Data were subjected to one-way analysis of variance followed by Duncan's multiple range tests. Significance was set at $p<0.05$. All experiments were carried out in triplicate and the data were shown as mean ± standard deviation.

Results

The moisture content in the raw PHS was 50.36±0.32%. For the dry basis, PHS powder was characterized by a 97.36±1.41% protein content. The contents of ash and fat were 1.13±0.27% and 0.91±0.11%, respectively. Forty-eight minerals were detected, which accounted for 0.53±0.05% in the dry basis (Fig. 2A). The contents of total amino acids determined in PHS were shown in Figure 2B. The results suggested that PHS contained organic and inorganic substances, which may be required for microbial activities. Therefore, PHS has the great potential to prepare peptone.

With the increase in pressure (from 0.5 to 2.3 MPa) and maintaining time (from 5 to 15 min), liquefied rate was improved dramatically ($P<0.05$). Especially, when pressure and time was more than 0.5 MPa and 10 min, respectively, debris (insoluble) was not observed. The highest liquefied rate reached about 96% at 2.0 MPa for 15 min (Figure 3A). In order to investigate the constituents of liquid fraction SE samples, the distribution of peptides was analyzed (Figure 3B). Under the same pressure, the fraction of the molecular weight > 10 kDa was decreased significantly ($P<0.05$) with the maintaining time increasing, and the counterpart < 2 kDa was increased dramatically ($P<0.05$). SE could induce the PHS liquefaction at the specific pressure and maintaining time. During the SE conditions, PHS was likely subjected hydrolysis reaction and then converted into an aqueous product. Based on the results of distribution of peptides, the liquefied PHS can be made into short peptides product.

Conclusion

In the present study, SE was proposed to liquefy degradation-resistant keratin from animal byproducts with co-friendly. PHS can be liquefied by SE. The liquefied PHS has a great potential to prepare the peptone for fermentation industry in the future.

Notes

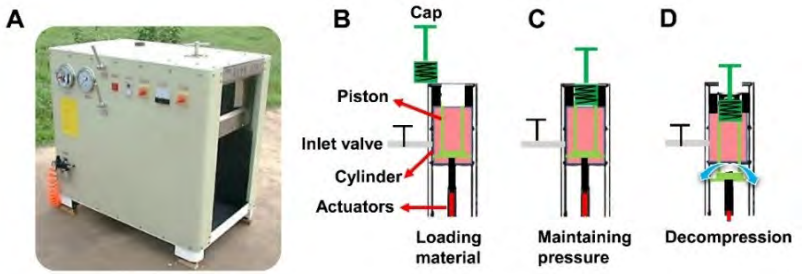

Figure 1. The diagram of the SE process.
(A) The SE apparatus. (B) Raw material was loaded in the cylinder. (C) Steam pressurization phase, cylinder and piston were tightly coupled. (D) Instant catapult explosion phase, the piston was catapulted out of the cylinder, which was driven by the actuators and the kinetic energy of the steam and material.

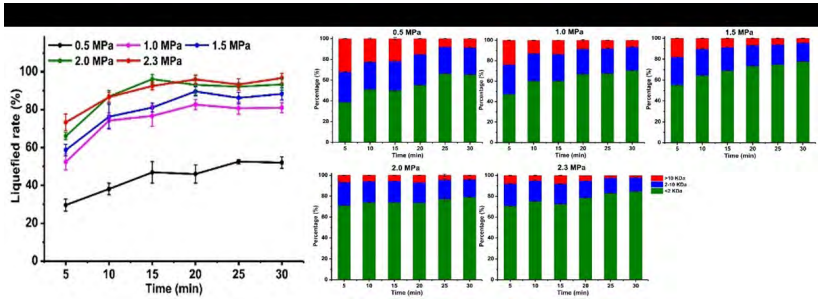

Figure 3. Liquefaction of PHS by SE and the distribution of peptides in liquid fraction of PHS.
(A) The liquefied rate of different SE samples. (B) The distribution of peptides in liquid fraction of PHS

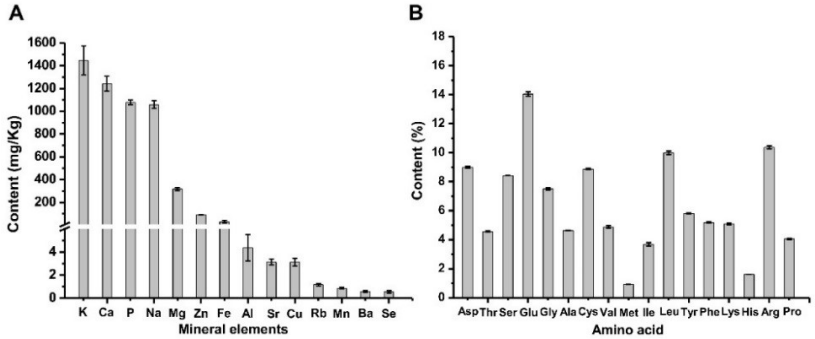

Figure 2.
Contents of main mineral elements and amino acids in PHS.

Notes