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Procedia Engineering 15 (2011) 5056 – 5061

Procedia Engineering

www.elsevier.com/locate/procedia

Advanced in Control Engineering and Information Science

Ultrasound-assisted enzymatic extraction of dietary fiber from pods

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Abstract

In this paper, the hydrolysis pods before its ultrasonic treatment for the internal macromolecular substances (mainly non-soluble dietary fiber) mechanical off button and increase the water-soluble dietary fiber content and enhance the extraction of two dietary fiber Rate.It mainly check on the ultrasound factors influence the yield of SDF and IDF,The result is that the ultrasonic time is 45min, ultrasonic temperature is 45 □ and ultrasound intensity was800W,Liquid ratio of 1:60 when the maximize soluble dietary fiber is 8.9% ,and insoluble dietary fiber is 77.35%.

Key words： Ultrasonic treatment; Diet fiber; Pod

1. Introduction

Dietary fiber is one that is not by human body digest polysaccharides carbohydrates and lignin, can be divided into the floorboard of water-soluble dietary fiber and water insoluble dietary fiber, including two kinds of water-soluble dietary fiber mainly for the plant cell inside the storage matter and secretion, and also including microbial polysaccharides and synthesis of polysaccharide, its composition is mainly some

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doi:10.1016/j.proeng.2011.08.939

glue kind material and sugar substance; And insoluble dietary fiber is the main ingredient of cellulose and hemicellulose, lignin, the original pectin and chitosan[1].

At home and abroad and extraction of dietary fibre, the main method is hot water extraction, chemical extraction, enzymatic, etc. In comparison, the hot water extraction process simple, but the rate is not high, Chemical extraction is the chemical reagent separation dietary fiber, mainly has acid method, process and flocculation agent, chemical method is characteristic of the preparation with low cost, but on environmental protection has shortcomings; Enzymatic is to use all kinds of enzymes such as alpha amylase, protease and saccharifying enzyme degradation in the material as to other elements. This method efficient, no pollution, but control is poorer. At present domestic use the chemical method and chemical method of combining the owing to. The chemical separation method of the preparation of dietary fiber also contain a small amount of protein and starch, preparation of dietary fiber special pure must combine enzyme treatment. The three: alpha enzyme includes a amylase, protease papaya and cellulose enzyme [2].

Ultrasound's frequency above is 20kHz, and the elastic wave does not cause hearing.Ultrasonic extraction technology is emerging in recent years.It mainly use liquid produced by ultrasonic cavitation and it effects on the mechanical effect of substrate to achieve the mechanical properties of the molecules to effect on bond breaking[3].Ultrasound can be generated internally in the material strong vibration ,high acceleration and powerful cavitation that can damage the plant cells, decrease plant tissue between each component in the close degree of integration,and enhanced the release of cytoplasm, diffusion and dissolution, while the effect of ultrasonic vibrations generate extracts to be faster while making its way into the extract, the increase in extraction efficiency[4].

2. Methods

2.1 Materials

All trials were carried out using a single batch of pods obtained from Agricultural Sciences Academy of Hei Longjiang cultivated soybeans. Cellulase (activity 400U/mL, Japan company).Electronic balance, pH meter(pHS-25,Shanghai), muffle furnace(Tianjin), crude fiber analyzer(Shanghai), electric heated water bath, precision electric mixer, soxhlet extractor and blast oven heating temperature were used in this experiments.

2.2 Procedures

2.2.1 Ultrasonic treatment

Pods are cleaned, dried about 24 hours, smashed to ensure that the powder of pods can through the sieve of 40 meshes. Treatment with ether in order to remove fat, then cleaning again.

2.2.2 Enzyme

Putting the fat-free pods into the water to dissolve, then adding to papain and amylase respectively to react 30min at 45ºC to remove the protein and starch. Papain can decompose the macromolecules of polysaccharides. After that, using the cellulase to get the dietary fiber on different conditions.

2.2.3 Separate SDF and IDF

After the enzyme by cellulase, standing, cooling and filtering the solution.The filtrate was centrifuged at 5000r/min in order to separate the SDF from skim and IDF from the cream. SDF was extracted by 98% ethanol and IDF was extracted after cleaning the cream by acetone and ethanol.

2.3 Statistical analysis

2.3.1 Single factor experiments

(1) The parameters of the effect of enzyme additive amount on SDF and IDF single-factor experiment are as follows: ultrasonic temperatures are 60 ºC, ultrasonic power is 500W and ultrasonic time are 1:6. The selected ultrasonic time is 10, 20, 30, 40, 50min.

(2) The parameters of the effect of temperature on SDF and IDF extraction single-factor experiment are as follows: ultrasonic power is 500W, ultrasonic time is 30 and liquid ratio is 1:6. The chosen ultrasonic temperatures are 40 ºC, 50 ºC, 60 ºC, 70 ºC and 80 ºC.

(3) The parameters of the effect of time on SDF and IDF extraction single-factor experiment are as follows: ultrasonic temperatures are 60 ºC, ultrasonic time is 30 and liquid ratio is 1:6. The chosen ultrasonic power is 400,500,600,700,800 and. 900W.

(4) The parameters of the effect of pH on SDF and IDF extraction single-factor experiment are as follows: hydrolysis by cellulase temperature 50 ºC, hydrolysis by cellulase time 50min and enzyme additive amount 0.4%. The chosen liquid ratio is 1:2, 1:3, 1:4, 1:5 and1:6.

2.4.2 Response surface method analysis

The range of level values of each factors were determined based on the single-factor experiments parameters. The response surface method was employed to analysis the effects of each factors on SDF and IDF extraction rate. Four factors (ultrasonic temperature, ultrasonic power, ultrasonic time time and liquid ratio) were selected as independent variable and total SDF and IDF rate was chosen as variable.

1. **Results and discussion**

3.1 The analysis of single factor experiment

3.1.1 The effect of enzyme additive amount on SDF and IDF extraction rate

Fig.1 Shows that the SDF extraction rate increase when the ultrasonic time under 45min and decreased with the increasing ultrasonic time (beyond 45min) while the IDF extraction rate increase when the ultrasonic time under 110min and decreased with the increasing ultrasonic time (beyond 45min) which illustrates that the interaction between enzyme and substrate is totally complete. Therefore, the suitable ultrasonic time is 45min.

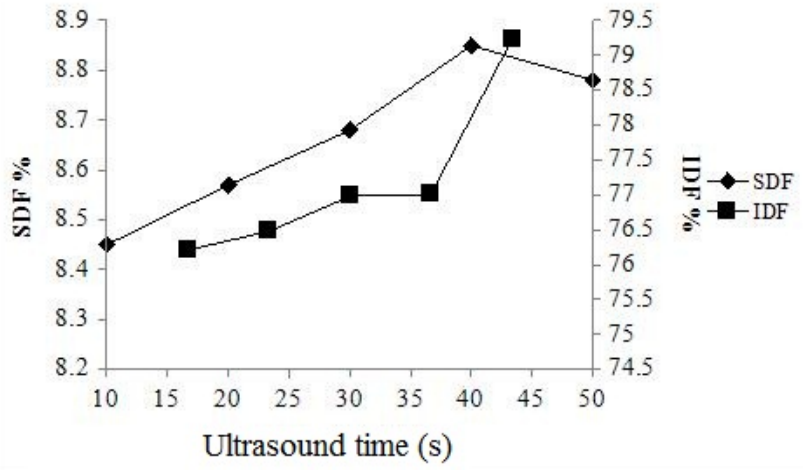

Fig.1 Effects of ultrasonic time on SDF and IDF extraction rate

3.1.2 The effect of hydrolysis temperature on oil extraction rate

Fig.2 indicates that the SDF and IDF extraction rate is increased with the increasing temperature (under 60 ºC) and decreased with the increasing temperature (beyond 60 ºC). The reason is that the suitable temperature of enzyme is below 60 ºC and the higher temperature inactivate enzyme (beyond 60 ºC). The suitable temperature is 60 ºC.

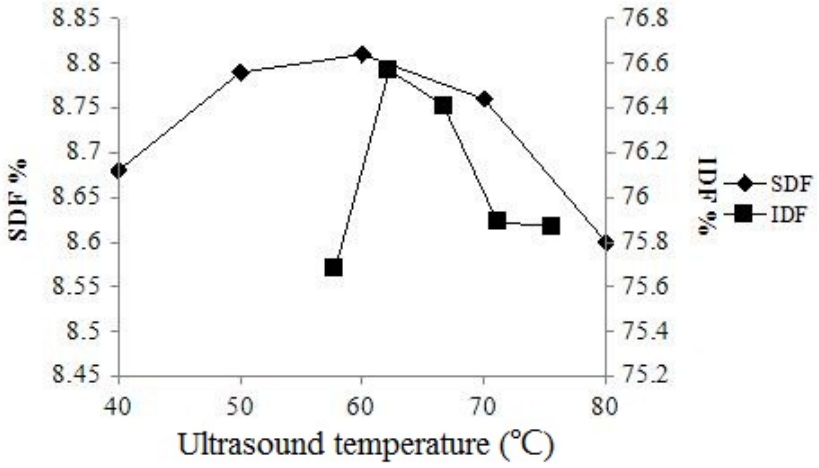

Fig.2 Effects of ultrasonic temperature on SDF and IDF extraction rate

3.1.3 The effect of hydrolysis time on SDF and IDF extraction rate

Fig. 3 shows that the SDF extraction rate increase when the ultrasonic power under 700W and decreased with the increasing ultrasonic power (beyond 700W) while the IDF extraction rate increase when the ultrasonic power under 700W and decreased with the increasing ultrasonic power (beyond

700W) which illustrates that the interaction between enzyme and substrate is totally complete. Therefore, the suitable ultrasonic power is 750W.

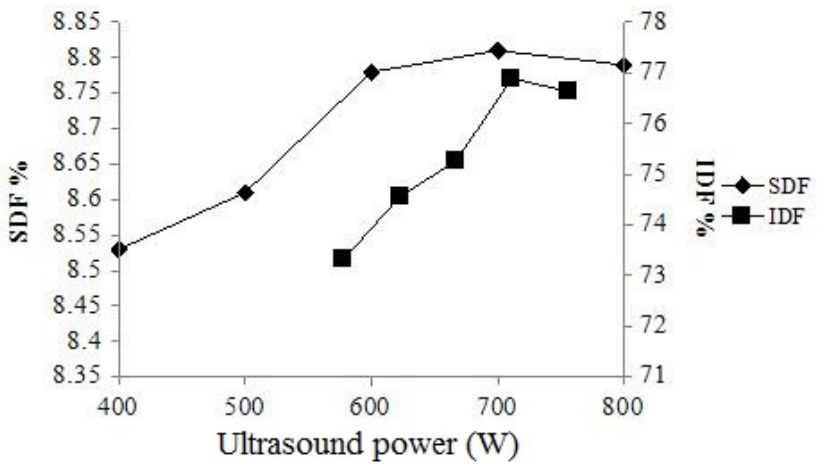

Fig.3 Effects of ultrasonic power on SDF and IDF extraction rate

3.1.4 The effect of pH on SDF and IDF extraction rate

Fig.4 shows that the SDF and IDF extraction rate is gradually increased with the increase of liquid ratio. The highest SDF and IDF extraction rate is reached when the liquid ratio is 1:5, and then the rate fell along with the decrease of pH. The main reason of this phenomenon is that the suitable liquid ratio of cellulase is 1:5.

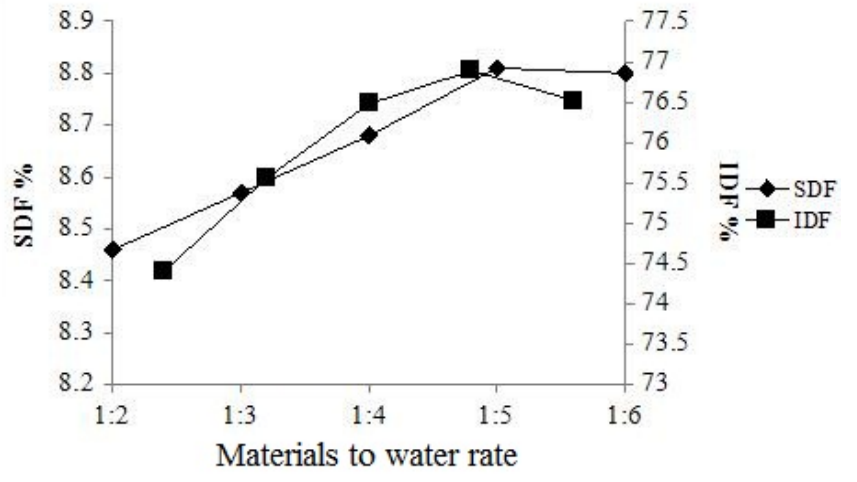

Fig.4 Effects of liquid ratio on SDF and IDF extraction rate

3.3 Verification experiment

Three parallel experiments were taken under the best conditions: ultrasonic power 800W, ultrasonic time 45min, ultrasonic temperature 45 ºC and liquid ratio1:6. The SDF average result of the three parallel experiments is 8.9% which indicates that the response value fits well with the regression predict value and the model can predict the actual condition of pods extraction. And ultrasonic power 800W, ultrasonic time 45min, ultrasonic temperature 45 ºC and liquid ratio1:6.. The IDF average result of the three parallel experiments is 77.35% which indicates that the response value fits well with the regression predict value and the model can predict the actual condition of pods extraction.

4. Conclusion

In this paper, SDF and IDF fiber enzyme extraction rate obtained in the 0.33% enzyme dosage, reaction time was 72.83min, hydrolysis temperature is 57.37 ºC, pH 8.4, we can get the maximum amount of soluble dietary fiber 6.72 %; at 0.55% enzyme dosage, reaction time for the 110.38min, hydrolysis temperature is 65 ºC, pH 8.8, we can get the maximum amount of non water-soluble dietary fiber 66.51%.

Acknowledgements

The authors would like to thank the Heilongjiang Science and Technology Agency (research grant number: GA09B401-6), National Institute of Soybean Engineering Technology and Northeast Agricultural University for funding this work. We would also like to thank other students for their assistance.

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