Research on Changes of Dietary Fiber in Bean Dregs during Extrusion Process

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Abstract: Bean Dregs contain abundant dietary fibers (DF), proteins, fats, vitamins and microelements, among which DF takes more than 50% content thus bean dregs are good raw material for extracting DF. DF is named as the seventh major nutrients since it has many important physiological functions. It can promote intestinal peristalsis to reduce the food dwelling time in gastrointestinal tract and speed up excretion. DF has powerful water absorbing swelling nature which can reduce food intake dose. Moreover, xylons in DF can combine with cholic acid to prevent calculus. Since most DF in bean dregs are insoluble and cannot be absorbed by human body, we planned to conduct extrusion process to convert some insoluble DF to soluble DF by a series of unit processes. Research showed that by adjusting heating temperature, screwing speed, water content in bean dregs, a certain portion of insoluble DF changed to soluble DF. This results greatly increased the availability of DF in bean dregs.

1. Introduction

With the improvements of human living standards, dietary habits began to change since several decades ago. Fine foods have been manufactured with larger amount which provides increasing protein, fat and calories to human daily diet while dietary fibers intake decreased contrarily leading to an imbalance of eating habit inventory and a series of modern illnesses of affluence such as diabetes, cardiovascular diseases, obesity, etc [2]. Massive researches have revealed that dietary fibers have remarkable influence on preventing and treating such diseases. As a result, dietary fiber is named as the putative seventh nutrient. Among various species of food, it has been revealed that soybean dietary fibers possess leading medical function and physiology. Since the annual production of soybean in China is around 12 million tons[3], soybean dregs which were bounded to be wasted of enormous amount during soybean industrial process is an outstanding source for manufacturing dietary fibers in order to improve human health.

Dietary fibers is defined as the constitution of indigestible polysaccharide carbohydrates and lignin. The soluble dietary fibers (SDF) is consisted of colloid compounds and saccharides, while insoluble dietary fibers (IDF) is consisted of lignin, cellulose, hemicellulose, chitosan and protopectin [4,5]. Since SDF has antidiabetics function and can be hydrolyzed in colon to prevent colon cancer, it attracts more attention in food engineering and medical science research fields. Moreover, SDF has better physiology compared with IDF, thus it can be added to food process as functional food additives.

As a by-product of soybean process, soybean dregs is mainly utilized as animal fodder because of its low solubility. However, soybean dregs is a good source of dietary fibers thus the more and more researchers have been focusing on extracting dietary fibers from soybean dregs [8]. For the purpose of extracting different dietary fibers, four classic methods are commonly utilized in the experimental process, which are chemical separation, membrane separation, fermentation method and chemical-enzyme extraction method. Chemical separation and membrane separation can not eliminate all amounts of proteins and fats in the soybean dregs and fermentation method consumes much time, the chemical-enzyme extraction method has been widely opted during dietary fiber extraction process as enzyme hydrolysis can remove residual proteins and fats after chemical separation to obtain purer dietary fibers.

The SDF extracted from soybean dregs is constituted by non-starch polysaccharide molecules with stable chemical properties. The functions of SDF are depended on its physiology which is closely related to polysaccharide chain formation and inter-chain forces. Compared with the four extracting methods listed above, extrusion is one mechanical degradation method which can integrate homogeneity, smashing, fusion, sterilization and curing unit operation and can realize the transition of macromolecule polymers to SDF directly or indirectly [9]. Meanwhile, the color and flavor of high cellulose can be changed by extrusion. Under the extrusion thermal field, mechanical energy field and high pressure, hydrogen bonds which hold the cellulose fascicular texture are broken leading to granulation of cellulose molecules [10, 11]. As a result, dietary fiber modification commonly utilizes extrusion method.

In this research, we integrated extrusion method and enzyme extraction method to obtain SDF from soybean dregs. Firstly, soybean dregs was prepared after grinding soybean milk and desiccation; Secondly, all dry soybean dregs samples were processed by extruding machine under different operating situations; Finally, extruded samples were processed by chemical-enzyme extraction method to obtain SDF in soybean dregs.

2. Methods

2.1 Materials and Instruments

Wet Soybean dregs was prepared by squeezing soybean milk (soybean: water = 1:10) and samples were filtered by 80-mesh sieve after desiccation. Neutral protease was provided by Solaribio, all the other reagents are analytically pure. Brabender twin screw extruder was selected in this study. Extruder is constituted by combined sleeved (5 joints) and screws (5 joints). The screw speed is 0~550 r/min, barrel temperature is 0~ 400℃ and die head diameter is 2×20mm. Thermostatic water bath oscillator was used of HAD-HZS-H from Beijing Heng Odd Instrument Co., Ltd, centrifuge was used of TDL-5_A from Shanghai Anting Scientific Instrument Factory.

2.2 Experiments

Single factor experiments were carried out with three factors which are water content, extruding temperature and screw rotation speed. Firstly, dry soybean dregs was prepared with different water content (20%, 22%, 24%, 26%, 28% and 30% w/w) before being extruded. The influence of water content was examined under the extruding temperature of 110℃ and screw rotation speed of 130 r/min. Then, extruding temperature was examined with the range of 90℃ to 130℃ with 10℃ interval with the settled water content of 26% and screw rotation speed of 130 r/min. Finally, screw rotation speed was examined from 110 r/min to 150 r/min with the fixed water content of 26% and extruding temperature of 110℃.

In the next step, 16 soybean dregs samples were gathered and 3g of each sample was taken to conduct alkali treatment. Distilled water was added to each sample with the amount of 45g. 1 mol/L NaOH was diluted to each sample till the pH reached 13 and all samples were put into 80℃ water bath of 80min. Samples were then washed by distilled water after water bath and the precipitates were IDF abstracted from soybean dregs. 50 mL distilled water was diluted to each IDF sample and 0.5% neutral protease was added to samples. Enzyme hydrolysis process was conducted under 40℃ for 2 hours. The supernatants of the samples were gathered after centrifugation the 4 times (v/v) absolute ethyl alcohol was added to the supernatants for alcohol precipitation process. Consequently, SDF samples were gathered after centrifugation and measured of the weights.

3. Results and Discussions

After extruding soybean dregs, the degree of polymerization, molecular weight of fiber reinforced polymers will change leading to an increase of SDF yield from soybean dregs [1]. It has been published that the SDF yield in soybean dregs after extrusion was greatly improved compared with raw soybean dregs under same alkali treatment condition. Moreover, extrusion process could also passivate some lipoxidase which brings about beany flavors. In this study, the yield of SDF was

calculated as equation 1.

$$\text{SDF Yield} = \frac{\textit{SDF weight}}{\textit{soybean dreg sample weight}} \times 100\% \quad (1)$$

Three factors related to extrusion process were observed in this study. Five extruding temperatures were determined from 90℃ to 130℃ while rotation speed was fixed at 130 r/min and water content was fixed at 26%. Five rotation speeds were determined from 110 to 150 r/min while temperature was fixed at 110℃ and water content was fixed at 26%. Also water contents were determined from 20% to 30% while temperature was fixed at 110℃ and rotation speed was fixed at 130 r/min. The factor ranges were determined according to the extruder (Brabender) properties and former experiments.

Temperature is one of the key influencing factors for extrusion process, as figure 1 illustrated, extruding temperature was investigated and the influence on SDF yield was shown. The yield was at the lowest level under 90℃ and increased to 31.27% under 110℃.When temperature exceeded 110℃, the yield of SDF started to decrease until the 130℃ point with 8.61%. As a result, high temperature will lead to the decrease of the SDF yield since it would introduce denaturation of gelatin, pectin and hemicellulose. Temperature of the materials in the extruding socket increased rapidly together with the shear force and compression, glucosidic bonds of the fiber polymers break up and are degraded to carbohydrates of low molecular weights. With the increase of temperature, chemical bonds ruptures also increase leading to more molecular degradations and exposes of water-based groups, being expressed as the increase amount of SDF yields. However, higher temperature generated a darker color of the soybean dregs due to the Mailard reaction leading to a sharp decrease of the SDF yield.

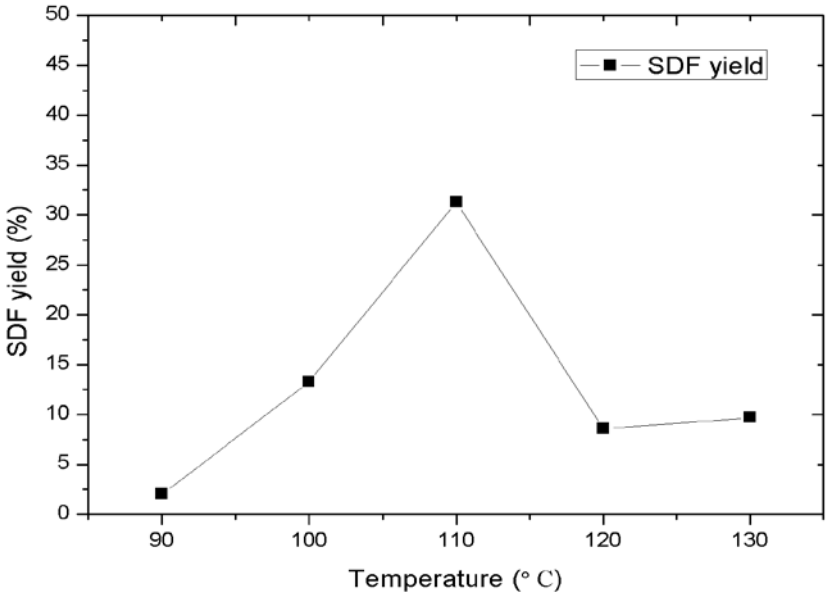

Fig.1. Temperature influence of extrusion on SDF yield from soybean dregs.

Being influenced by viscosity and friction, high mechanical energy is consumed when extruding and cutting high polymers such as protein and starch. Water, as the flexibilizer of polymers, can reduce the interaction forces of materials with lower mechanical energy. In this study, under 110℃ and 130 r/min, water content was observed to reveal the influence on SDF yield. Figure 2 shows the experimental data with water content from 20% to 30% (w/w). Firstly, the SDF yield increased from 20% to 24% with the peak value of 25.95%, and then decreased until 30% water content with SDF yield of 13.63%. Firstly, the water content was not sufficient to provide flexibilization effect to abstract SDF. However, with the increase of water content, the viscosity of soybean dregs in

extruding sleeves and screws became lower. Consequently, pressure of grinding head of extruder decreased leading to a negative influence of dietary fiber degradation.

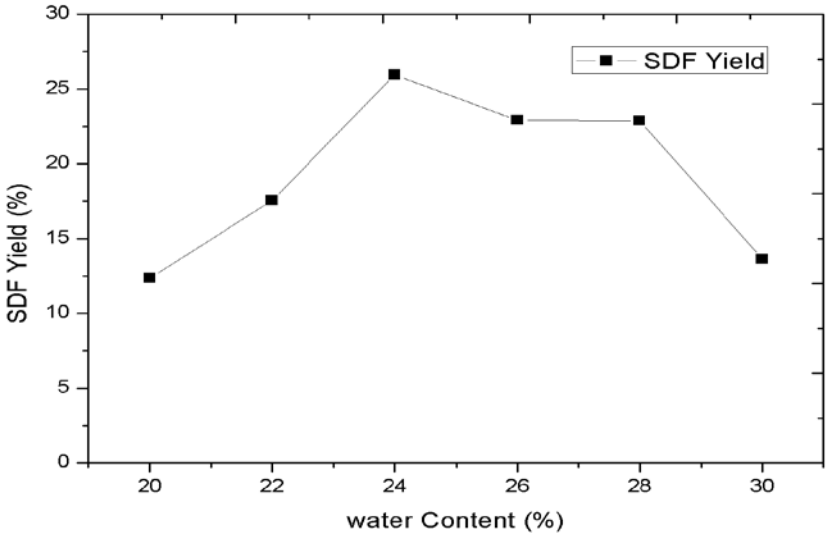

Fig.2. Water content influence of extrusion on SDF yield from soybean dregs.

In addition, screw rotation speed is another essential factor for abstracting SDF from soybean dregs. The expanding rate of soybean dregs can be affected by screw rotation speed. When the rotation speed is accelerated, the exit pressure increases simultaneously. As a result, the unit volume of material discharge also increases in unit time. The expansion decreases inside the screw because of the increasing shear force, thus the SDF yield had the highest value at 110 r/min and decreased until 150 r/min. For the reason that the optimum rotation speed of the extruder in the research lab is from 110 r/min, the low rotation speed range was not included in this study. The result is illustrated by Figure 3.

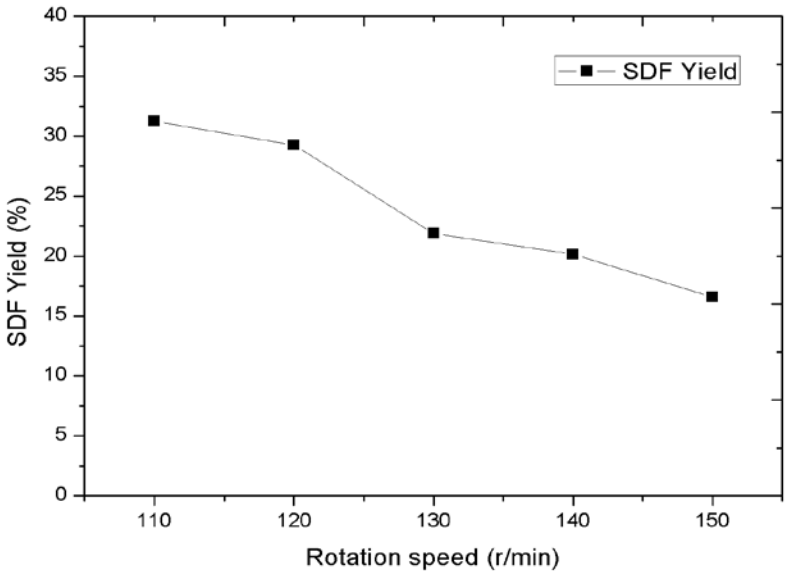

Fig.3. Rotation speed influence of extrusion on SDF yield from soybean dregs.

4. Conclusion

In this study, the extruding factors were observed to reveal the influence of SDF yield from

soybean dregs. The experimental results showed that best extruding temperature was 100℃, the optimal water content and screw rotation speed were 24% and 110 r/min respectively. After extruding, the samples were hydrolyzed by protease under optimal operating situations. Results illustrated that the optimum values of studied factors were reasonable and the results are helpful for future soybean SDF study.

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