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Optimization of Polysaccharide Extracted from the Manna by Ultrasound

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Abstract

In this study, the technology of ultrasound waves are used to extract polysaccharides from manna plant to enhance the extraction efficiency. Independent variables examined including extraction temperature, time of the waves and the ratio of solvent to dry matter were employed at three levels of response surface methodology and Box-Behnken design to optimize and studies of linear effects and interaction of process variables on polysaccharide extraction efficiency. Results showed that three variables selected have significant effect on the extraction yield of polysaccharides. Polysaccharide extraction efficiency increased with increasing extraction temperature, time of the waves and the ratio of solvent to dry matter. The optimum conditions for extraction is included extraction temperature 70 ° C, extraction time 10 min and the ratio of solvent to dry matter 20 ml per gram. Under these conditions, the extraction efficiency was obtained 15.2394% and well matched with the models predicted.

Keywords: *manna, extraction, polysaccharides, optimization, response surface methodology (RSM)*

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Introduction

Manna plants is a group of compounds that have valuable medicinal and nutritional properties and have a special place in traditional medicine. In fact, manna is sugar leachate secreted by insects that as a result, their feeding exits from host plant as fecal matter from their denominator [1] and remain on different parts of plants as crystallized and solid form. Manna have different types, each of them is as a result of an insect on their own host plant. Manna is as an important drug in traditional medicine in Iran. Sweet manna substance which sits as dew on the camel thorn plant. Polysaccharides comprise a wide range of materials used in food and drug industries. Natural polymers are polysaccharides of categories that actually are high molecular weight carbohydrates [3]. That today it has many applications in industries such as polymer, pharmaceutical, medical, food processing and packaging, textile, etc. [4]. Food polysaccharides are large hydrophilic molecules to create functional properties and microstructure control, texture, flavor and shelf life are used in the food industry. Polysaccharide compounds produced by plants, algae, marine and microbial sources are mining and extraction and also included a modified gum biopolymers derived from plant secretions, as well as chemicals or enzymes derived from starch or cellulose [5]. Polysaccharides are used in many food formulated with regard to product quality stability, texture and appearance. They can improve the rheological properties of food products and is generally used as a thickener for food, changing texture, stabilizers and emulsifiers for various applications. These compounds are extracted from plant and animal sources, these compounds are extracted from plant and animal sources, most of polysaccharide compounds extracted from plant sources, and one of these sources could be manna plant. Ultrasound-assisted extraction is one of the important methods for the extraction of valuable compounds from the plant tissue. The advantages of ultrasound-assisted extraction is increasing polarity system (including extraction, analytes and matrices) and increase the efficiency of de-mining cavities which can be similar or larger than soxhlet extraction. Extraction with the help of ultrasound provides the possibility of adding an auxiliary extractor, ultrasound can reduce operating temperature and provide the possibility of extracting heat sensitive components that soxhlet extraction changes under operating conditions. Extraction time changes to the soxhlet extraction. Extraction time is shorter than soxhlet extraction [6].

Materials and Methods

- Raw Materials Required

Manna was prepared from desert area around Isfahan. Manna manually in order to isolate all foreign material has been clean and then mill by domestic mill until the test was kept in the refrigerator. 80% ethanol, 60% atanva and deionized distilled water.

Methods

Extraction of polysaccharide from the manna

In summary, 200 grams of manna is crushed in a mill and turned into soft powder. Then for the removal of dyes, fat and oligosaccharides, 3 times with 60% ethanol at a temperature of 60 ° C were mixed and washed for 2 hours. Crushed sample was isolated by centrifugation at 3000 rpm for 10 minutes of mixing. The extraction process of polysaccharides were done 20 g sample of dried leaves in hot water at different power ultrasound (60 to 100 watts), different temperatures (60 to 90 ° C) and different times of extraction and wave (10 to 30 minutes). 80% ethanol was used to complete the extraction process and deposition of polysaccharides. Polysaccharide deposited in the vacuum oven with hot air at 50 ° C were dried and weighed and polysaccharide extraction efficiency was determined using the following equation.

$$\text{Extraction efficiency } (\%1) = \frac{\text{Weight polysaccharide obtained}}{\text{Initial dry leaf weight}} \times 100$$

Experimental design and statistical analysis

In this study, statistical analysis, response surface methodology to predict the impact on central composite design was used. Data analysis and charting was done using Design Expert 8.0.1 software. Experiments were conducted to determine the efficiency of extraction of polysaccharides from plant manna provided under the trial plan using Design Expert 8.0.1 software.

Results and Discussion

Studying the effect of the studied variables on the extraction efficiency of polysaccharide

Effect of temperature on the extraction efficiency of polysaccharide

Figure 1 shows the effect of temperature on the efficiency polysaccharide extracted at different levels of manna, while the other two variables, respectively, Solvent extraction time and solid than in the center (30 minutes, 7) are fixed. As can be seen with increasing temperature from 50 to 60 ° C decreased extraction efficiency. After a temperature of 60 ° C, extraction efficiency increased. The cause of the initial reduction in extraction efficiency of 50 to 60 ° C temperature, this was due to the increase in temperature, to the extent that can damage cell membranes and accelerate the entry of solvent into the plant tissue and cause an increase in extraction efficiency. Therefore an increase in temperature at low temperatures, the efficiency decreases. Due to increased efficiency at higher temperatures due to the fact that with increasing extraction temperature, breaks down the cell wall, increased solvent penetration into the cell and finally followed by further extraction of the polysaccharides.

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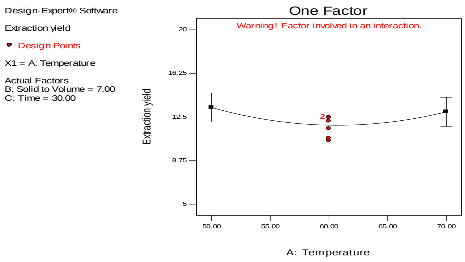

Figure 1. Effect of temperature on the extraction efficiency polysaccharide from manna plant

The effects of different material to solvent on the extraction efficiency of polysaccharide

Solid-to-solvent ratio is other factors that polysaccharides extracted. In this study the effects of different material to the solvent on the extraction efficiency of polysaccharides from plant manna studied (Fig. 2) While two variable extraction time and extraction temperature, respectively, at a central point in 30 minutes, 60 ° C were kept constant. As shown in Figure 2 can be seen. Solid ratio increases, leading to an increase in the efficiency of polysaccharide extracted with solvents to 12.5 percent. Because of the increased efficiency is to increase the amount solvent, rate of penetration into the tissue is more, it also absorbs a higher amount of polysaccharide compounds and increased efficiency. The results obtained are consistent with the results of Wang et al in 2008. Ultrasonic waves passing through the liquid medium, large bubbles and cavities are produced. Ultrasonic waves solvent penetration increases. High rates of solvent contains polysaccharides, accelerates the absorption of polysaccharide compounds. Resulting in increased performance values. The results are consistent with results of Samavati et al in 2013 [10,11].

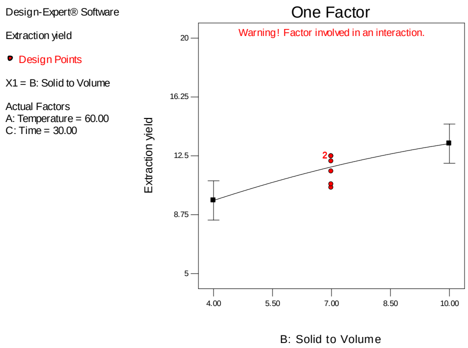

Figure 2. Effect of extraction temperature on the extraction efficiency polysaccharide from manna plant

The effect of time on the extraction efficiency of polysaccharide

Figure 3 shows the effect of extraction time at different levels on the polysaccharide extraction efficiency of manna, while two other variable temperature solvent extraction and solid ratio, respectively, in the center (60 minutes, 7) are fixed. As can be seen with increasing duration of extraction efficiency declined slightly. After 30 minutes, extraction efficiency increased. The reason for this can be explained that at first with increasing time, polysaccharide of high efficiency solids separation speed up so high, but over time, the extraction efficiency showed small declines. The results obtained are consistent with the results of Wang et al in 2014. During the extraction process, with increasing time and the presence of ultrasonic waves, holes or cavitation effect on the material increase. As a result, with increasing time, high extraction yields showed. During ultrasound operation, gradually the entire structure of plant cell decomposition and the contact surface solvent and contains extracts increase.

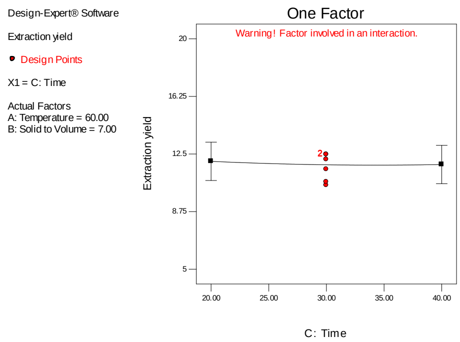

Figure 2. Effect of time on the extraction efficiency polysaccharide from manna plant

Studying the interaction of variables on the extraction efficiency of polysaccharide

The interaction of solid material to solvent and ultrasonic temperature on the extraction efficiency of polysaccharide

In order to study the interaction of the factors examined in this study, response surface shapes are used. According to figures A-4 and B-5, with increasing ultrasonic temperature of 55 to 70 ° C and increasing the ratio of solids to solvent of 4 to 10, while the other variable is fixed at a central point, extraction efficiency increases to 14.11 percent. Because of the increased efficiency by increasing both speed variable may be that increasing temperature leads to destruction of the cell wall, viscosity reduction as a result of rising temperatures, increased solvent penetration into the tissue and increase efficiency. Also, by increasing the ratio of the solid and solvent, higher solvent concentrations in the sample surface, thus increasing the extraction efficiency. Joung Guangzhou in 2012 [12], investigated the effects of various factors on the extraction of Atractylodes native hydrocolloids. The optimum extraction conditions of temperature 55 degrees and the ratio of solvent to solid 1 to 30 were reported. In fact, the highest ratio of solids to solvent treatments. In the present study the influence of temperature compared with a ratio of solids to solvent extraction efficiency was enhanced in the process.

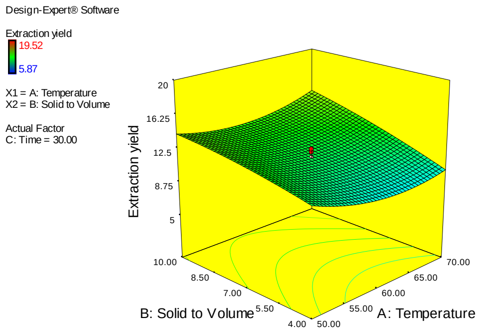

Figure A-4: Three-dimensional display of the interaction between time and temperature on the extraction efficiency of ultrasonic polysaccharides

The interaction between time and temperature of extraction on the extraction efficiency of polysaccharide

The interaction between time and temperature on the extraction efficiency polysaccharide extract has been shown in the forms of A-5 and B-5, accordingly, the extraction time on the efficiency effect, as with increasing time efficiency for nonlinear in range of changes (20 to 40 minutes) increased. With increasing temperature due to the mass transfer rate of extraction, extraction efficiency increased. Due to the significant impact quadratic effect of temperature on efficiency, it is concluded that the impact of changes polysaccharide extraction efficiency of manna plant is more dependent manna extraction temperature changes. It could be concluded that the interaction of these two factors on the efficiency polysaccharide is additive effect. The most important reason to explain this behavior, increase the speed of transfer of the solvent into the sample, using the ultrasound method synergistic effect on increasing efficiency and cavitation effects in the environment containing solvents, which corresponded with the results of Tian et al. 2012 [13,14].

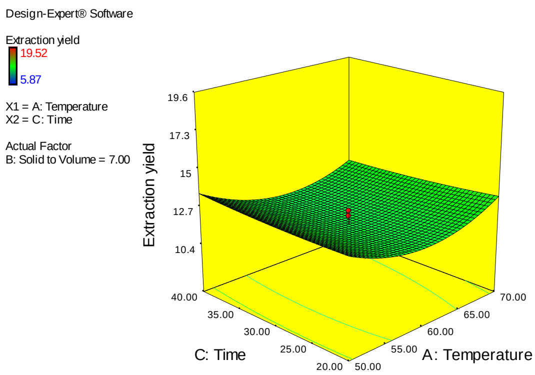

Figure A-5: Three-dimensional display of the interaction between time and temperature of extraction on the polysaccharide extraction efficiency

The interaction between time and the ratio of solids to solvent on the extraction efficiency of polysaccharide

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The interaction between time and the ratio of solids to solvent on the extraction yield of polysaccharides has been shown in Figures A-6 and B-6, accordingly, these factors had a significant effect on efficiency, as with Increased efficiency linearly increased. The results of the regression coefficients, it was found that the ratio of solid to solvent has significant effect on efficiency. It is concluded that the extraction efficiency of plant polysaccharides of manna plant is highly dependent on the ratio of solids to solvent. It could be concluded that the interaction of these two factors on the efficiency polysaccharide is additive effect. The most important reason to explain this behavior, with the ratio of solids to solvent, increase access to extraction of polysaccharide compounds. So that cavitation which is caused by the action of ultrasound, by increasing the amount of solid material to the impact of increased vehicle efficiency increases. Also by increasing the amount of solid material to solvent extract more value than less solvent is extractable. This can be attributed to increased capacity by solvent extraction of polysaccharide compounds in comparison with its smaller amounts. Time-mass and increased cavitation bubbles available in the reaction medium, which corresponded with the results of Liu et al. 2011; Tian et al. 2012.

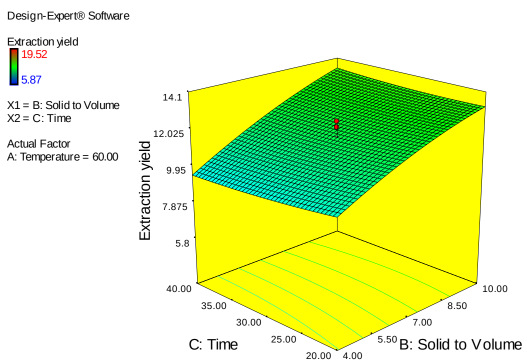

Figure A-6: Three-dimensional display of the interaction between time and the ratio of solids to solvent on the extraction efficiency of polysaccharide

Optimization of extraction process of polysaccharides

The optimum operating conditions for the extraction of polysaccharides from plant manna using numerical optimization techniques was investigated by Design Expert 8.0.1 software. For this purpose, first the optimum conditions were selected by the software. Optimum condition is included extraction time of 20 minutes, extraction temperature of 70 ° C. and the ratio of solids to solvent 9.94. To evaluate the accuracy of the results of the model, the optimal experimental conditions in points which had software, an experiment was carried out in three repeaters and the results are shown in Table 3. According to experimental efficiency table was 19.52 and predicted efficiency was 15.24. As can be seen, there is no significant difference between predicted result by model and the results obtained from the laboratory work.

Table 3. The results of the optimization process in the extraction stage

Optimum condition			Extraction efficiency	

Extraction time	Extraction temperature	Solid-to-solvent ratio	Experimental	Predicted
Minute	C			
20.00	70.00	9.94	19.52	15.24

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