Chemical properties of Bengkuang (Pachyrhizus erosus L.) water-soluble polysaccharide by ultrasound-assisted extraction

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Abstract. A water-soluble polysaccharide is a part of the soluble food fibers in bengkuang (Pachyrhizus erosus). In previous research, it has been carried out by the methods of fermentation extraction, adding water and precipitation with ethanol on inulin extraction. A recent study was examined the effect of ultrasound-assisted extraction as a new extraction method. This research was conducted to obtain water-soluble polysaccharide of bengkuang for chemical properties by ultrasound-assisted extraction (37 kHz; 60°C; 30 min). Also, compared by Inulin and fructooligosaccharide commercial. This study uses an ultimately randomized design with non-factorial. Such as a water-soluble polysaccharide of bengkuang, Inulin, and fructooligosaccharide. The results showed that the water-soluble polysaccharide of bengkuang had a yield of 1.67%. It had a significantly different (P<0.05) on water content (11.71%); carbohydrate (98.35%); fat content (0.50%); protein content (3.62%); ash content (0.87%); pH (4.96); and white degree (85.18) compared by inulin and fructooligosaccharide commercial. Although ultrasound-assisted extraction still needs to be improved, this technique dissolves ghost particles and clumps of insoluble starch in the filtrate. Thus, it can decrease the protein, fat, and ash content and directly increase the total carbohydrate. It could be concluded that the water-soluble polysaccharide of bengkuang had potential as a prebiotic compound.

1. Introduction
Based on the Food of Agriculture Organization (FAO) report in the Sustainable Development Goals Program, the second aim of Zero Hunger is to prevent global hunger, maintain food security, and improved encourage agricultural availability. In the annual report, FAO describes depleting the number of people starving and maintaining food security, especially in the pandemic of the COVID-19. Starvation and food insecurity have been rising globally, and malnutrition like undernourishment affects millions of our children. Today, the condition becomes progressively worse due to the economic downturn and disorder by a pandemic-effect. The prevalence of undernourishment (chronic starvation) has remained virtually unchanged, below 9 percent globally. But, the total amount of people become starving has slowly increased for several years early. On the data collected, approximately 690 million
people were undernourished in 2019. It's practically close to 60 million in South-Eastern Asia from 2014 [1].

As a developing country, Indonesia needs research collaboration and development technology to generate all food crops' local food uses. The majority of Indonesia's crops are rapidly, and indigenous be generated under the local weather [2]. Food science and technology have developed rapidly by encouraging the foods to have added health value, functional food. Its goal to identify properties and potential crops as a staple food. Some prebiotics, such as Inulin and oligosaccharides, can be isolated from natural sources such as tubers. Based on [3], it is reported that bengkuang (Pachyrhizus erosus L) extracted method can encourage the hot water as solvent and ethanol as precipitation to produce water-soluble polysaccharides of bengkuang. Also, referred to as dissolved food fiber or Inulin by 48.66 mg. In other studies [4,5], bengkuang contains various bioactive compounds such as ascorbic acid, flavonoids, choline, saponins, and folic acid.

In previous studies [6] reported that bengkuang extracted by the method of water solvent extraction and fermentation produced water-soluble polysaccharides with a dextrose equivalent (DE = 4), degree of polymerization (DP = 24), and solubility (So = 83%). Besides, [7] showed that food fiber from bengkuang extracted with 80% ethanol, either soluble or not, can function as an immunomodulator in vitro and in vivo. Until now, water-soluble polysaccharides research from bengkuang still needs to be developed to get the best results.

Therefore, research is needed to improve the water-soluble polysaccharides of bengkuang on a principle research scale. The ultrasound-assisted extraction is used as a new method to extract water-soluble polysaccharides from various plant tissues [8,9]. This study aimed to determine the chemical properties of the water-soluble polysaccharides of bengkuang by ultrasound-assisted extraction.

2. Materials and methods

The primary research material was bengkuang (Pachyhrizus erosus L) by various Bengkuang Gajah with ten months harvested. They were obtained from Bhakti Karya Village, District of Binjai Selatan, North Sumatra. To compare the water-soluble polysaccharides with prebiotics, I use commercial Inulin, and Fructooligosaccharide from Sigma was used as controls. The research was established at the Integrated Research Laboratory, Universitas Sumatera Utara. Analysis of the characterization of chemical properties was carried out at the Laboratory of Chemical Properties of Foodstuffs, the Faculty of Agricultural Technology, Universitas Gadjah Mada. The reagents are composed of ethanol and distilled water.

2.1. Research methodology

Water-soluble polysaccharide extraction from fresh bengkuang was carried out by [3,6] with modifications. Fresh bengkuang was washed, peeled, and cut. The bengkuang was mashed into a puree using a blender. Then, the puree was extracted by ultrasonic water-bath at 37 kHz 60°C for 30 minutes. Furthermore, the puree was filtered with a double-layered filter to produce a filtrate.

Meanwhile, the residue from the filtering was removed. Then, the filtrate was extracted with the addition of 80% ethanol as much as 1:2 and stored at -20°C for 12 hours. The filtrate was thawed to stand apart between the fraction of supernatant and natant. The natant was dried at 4°C for 12 hours, crushed, and sieved by 100 mesh sieve-shaker to produce bengkuang water-soluble polysaccharides. The evaluation of the bengkuang water-soluble polysaccharides was carried out by calculating yield, analyzing moisture and proximate content, analyzing white degree, and measuring pH.

2.2. Statistical analysis

Ultimately Randomized Experimental Design conducted the research methodology with non-factorial. Each sample was repeated three times to minimize experimental error. The analysis was performed by analyzing variance (ANOVA) and followed by Duncan's test with a significance level of 5%. Statistical data is calculated by SPSS 21.0 software.
2.3. Calculation of the yield
The yield is the ratio between the dried bengkuang extract (a) and the bengkuang material's weight (b). The product can be used to determine the depreciation or addition of matter after processing.

2.4. Moisture content determination
The sample of 1-2 g was inserted into an aluminum foil plate that has been dried in an oven at 105°C. It was known to be constant to weight (a). The sample dried at 105°C for 3-5 h, cooled in a desiccator, and then weighed. Heated again in the oven for 30 min, chilled, and entertained. This treatment was repeated until it reaches a constant (b).

\[
\text{Moisture Content} = \frac{a - b}{a} \times 100\%
\]

2.5. Analysis of protein content
Protein content was determined by multiplying % total nitrogen by a factor of 6.25. The study of protein content using the khedjal method was as follows:

\[
\text{Protein Content} = \frac{(V_1 - V_2) \times N \times 0.014c.f \times d.f}{w}
\]

\[V_1 = \text{The HCL volume of 0.01 was used in the sample captivity}
\]
\[V_2 = \text{The HCL volume used for the blank is used}
\]
\[N = \text{HCL normality}
\]
\[c.f = \text{Conversion factor for protein from food in general; 6.25}
\]
\[d.f = \text{Dilution factor}
\]
\[w = \text{Initial weight (gr)}
\]

2.6. Analysis of fat content
The analysis of fat content using the Soxhlet method was as follows:

\[
\text{Fat Content} = \frac{w_1 - w_2}{w}
\]

\[w = \text{Initial weight (gr)}
\]
\[w_1 = \text{The weight of the measuring flask of fat after extraction (gr)}
\]
\[w_2 = \text{The weight of the measuring flask of fat before extraction (gr)}
\]

2.7. Ash content determination
The principle of determining the ash content by conditioning all organic substances at a high temperature of about 500-600°C, then the remaining combustion products are weighed. The number of samples to be ignored was weighted a certain number depending on the type of material.

2.8. Total carbohydrates by the difference
Total carbohydrate is the difference in the test results for the total ash, protein, fat, and moisture content.

2.9. Measurement of pH
The pH measurement was performed by dissolving the sample with a concentration of 10% (w/v). The pH measurement analysis aims to determine the condition of substrate acidity in the dissolved model. The pH Measurement was made in triplicate. The pH measurement was performed used by pH-meters.
2.10. White degree determination
The Coordinate of L* a* b* is measured by chromameter CR-400 (Konica Minolta) with visual angle 20. The color parameters were expressed as follows: brightness (L*), redness (a*), and yellowish (b*). The lowest L* was 0, which indicates blackness, and the highest was 100, indicated by white. A* negative value indicates by green and festive showed by red. While the negative b* value showed by blue and complementary colors, it was characterized by yellow.

\[
100 - \sqrt{(100 - L)^2 + (a^2 + b^2)}
\]  

(4)

3. Results and discussions

3.1. The yield
The average yield of the water-soluble polysaccharides of bengkuang was 1.67%. During the extraction process, many starches do not pass the filtering process because they have changed due to the temperature in the ultrasonic water-bath, according to [9] shown that during the process, ultrasonication helps to dissolve ghost particles and clumps of insoluble starch in the filtrate.

3.2. Chemical properties of the water-soluble polysaccharides of bengkuang
The chemical properties of the water-soluble polysaccharides of bengkuang are shown in Table 1.

| Samples         | Moisture (n=3, %) | Protein (n=3, % db) | Fat (n=3, % db) | Ash (n=3, % db) | Carbohydrate (n=3, % db) |
|-----------------|-------------------|--------------------|----------------|----------------|-------------------------|
| Bengkuang WSP   | 11.71 ± 0.02\(^a\) | 3.62 ± 0.06\(^a\)  | 0.50 ± 0.00\(^a\) | 0.87 ± 0.04\(^a\) | 95.01 ± 0.09\(^b\) |
| Inulin          | 6.89 ± 1.62\(^b\) | 0.12 ± 0.03\(^b\)  | 0.00 ± 0.00\(^b\) | 0.12 ± 0.00\(^b\) | 99.76 ± 0.03\(^a\) |
| Fructooligosaccarhide | 4.63 ± 0.42\(^c\) | 0.23 ± 0.10\(^b\) | 0.00 ± 0.00\(^b\) | 0.00 ± 0.00\(^b\) | 99.77 ± 0.10\(^a\) |

Description: different superscripts on the same column showed a significant difference (p<0.05)

3.2.1. Moisture content. The moisture content of the water-soluble polysaccharides of bengkuang was 11.71% (Table 1). Due to the conditions of the Covid-19 pandemic, it requires the independent drying process at home through cold drying in the refrigerator. Thus, the water-soluble polysaccharides of bengkuang were significantly different (p<0.05) on the moisture content, according to [10] shown that the standard of moisture content of Inulin was 5%. It means damage caused by microorganisms can contaminate the limited amount of water.

3.2.2. Protein, fat, and ash content. The protein, fat, and ash content of the water-soluble polysaccharides of bengkuang were 3.62%, 0.50%, and 0.87%, respectively. The ultrasound-assisted extraction has decreased the relative value of water-soluble polysaccharides of bengkuang, according to [2] shown that fat, protein, and an ash content of bengkuang flour are 0.54%, 5.68%, and 2.14%, respectively. The ultrasound-assisted extraction effectively reduced the protein, fat, and ash content [9].

3.2.3. Carbohydrate. The total carbohydrate of the water-soluble polysaccharides of bengkuang was 95.01%. The ultrasound-assisted extraction has increased the total carbohydrate of water-soluble polysaccharides of bengkuang, according to [2] shown that the available carbohydrate of bengkuang flour is 85%. The ultrasound-assisted extraction has increased the total carbohydrate above 90%.

3.2.4. pH. The pH value of the water-soluble polysaccharides of bengkuang was 4.96. During the extraction process, the pH occurs because the filtrate was not washed by distilled water after being extracted with ethanol. Even though the pH value decreases about 4.96, it is still within the normal pH range between 5 and 7 [10].
3.2.5. White degree. The white degree of the water-soluble polysaccharides of bengkuang was 85.18. Color is one of the standard physical properties of inulin quality. When the number approached a value of 100, the shade would be whiter.

4. Conclusions
The present research has shown that the ultrasound-assisted extraction has provided significantly different in each parameter of chemical properties of the water-soluble polysaccharides bengkuang analysis. Although ultrasound-assisted extraction still needs to be improved, this technique dissolves ghost particles and clumps of insoluble starch in the filtrate. Thus, it can decrease the protein, fat, and ash content and directly increase the total carbohydrate. It could be concluded that the water-soluble polysaccharide of bengkuang had potential value as a prebiotic compound.
References

[1] United Nations 2020 The Sustainable Development Goals Report 2020 (New York: United Nation) pp 26–7

[2] Buckman E S, Oduro I, Plahar W A and Tortoe C 2018 Determination of yam bean’s chemical and functional properties (Pachyrhizus erosus (L.) Urban) flour for food systems Food Sci. Nutr. 6 pp 457–63

[3] Zubaidah E and Akhadiana W 2013 Comparative study of inulin extracts from Dahlia, Yam, and Gembili tubers as prebiotic Food and Nutrition Sciences 4 pp 8-12

[4] Noman A S M, Hoque M A, Haque M M, Pervin F and Karim M R 2012 Nutritional and anti-nutritional components in Pachyrhizus erosus L. tuber Food Chem 102 pp 1112–8

[5] Nursandi F, Machmudi M, Santosu U and Indratmi D 2017 Properties of different aged jicama (Pachyrhizus erosus) plants IOP Conf Ser Earth Environ Sci 77 012003

[6] Rusmarilin H and Hilman A 2019 Physicochemical characterization of water-soluble polysaccharide of Pachyrhizus erosus L. with fermentation assisted extraction method IOP Conf Ser Earth Environ Sci 260 012096

[7] Kumalasari I D, Nishi K, Harmayani E, Raharjo S and Sugahara T 2014 Immunomodulatory activity of Bengkoang (Pachyrhizus erosus) fiber extract in vitro and in vivo Cytotechnol 66 1 pp 75–85

[8] Hilman A, Harmayani E and Cahyanto M 2018 Inulin Extraction and Characterisation of Fresh and Chip Gembili (Dioscorea esculenta) Extract by Ultrasound-assisted Extraction Proceedings of the International Conference of Science, Technology, Engineering, Environmental and Ramification Researches (ICOSTEERR) 1 pp 47-53

[9] Garcia-Hernandez A, Vernon-Carter E J and Alvarez-Ramirez J 2017 Impact of ghosts on the mechanical, optical, and barrier properties of corn starch films Starch - Stärke 69 1600308

[10] Franck A 2002 Technological functionality of Inulin and oligofructose British Journal of Nutrition 87 pp S287–S291

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