The potential of Gembili (Dioscorea esculenta L.) and Dahlia (Dahlia spp L.) from Indonesia as prebiotic compound

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Abstract. Gembili (Dioscorea esculenta L) and dahlia (Dahlia L) are local plants that grow in Indonesia. This research was conducted to obtain the yield, inulin content, solubility, and white degree of gembili and dahlia by hot water, ethanol extraction, and compared by inulin commercial. This study used a completely randomized design with factorial, i.e., gembili from Gunungkidul and Sukoharjo; dahlia from Cibodas and Berastagi. The results showed that inulin extract of gembili gunungkidul, gembili sukoharjo, dahlia cibodas, and dahlia berastagi had a yield 10.84%, 10.53%, 29.00%, and 28.33%. The result showed that the inulin extract of samples was significantly different (P<0.05) on solubility and white degree. The results indicated that both gembili and dahlia contain inulin. The amount of inulin content of dahlia samples was higher in both dahlia cibodas and dahlia berastagi (21.84% and 21.14% db) than inulin gembili samples. Inulin extract from dahlia samples had higher solubility in both dahlia cibodas and dahlia berastagi (98.33% and 97.97% db) than inulin gembili models. However, the color test of inulin extract from gembili was lightness than inulin dahlia samples. It can be concluded that dahlia and gembili from Indonesia are potentially used as prebiotic sources.

1. Introduction

Food and Agriculture Organization (FAO) figures indicate that an estimated 60 million people are undernourished between 2014–2016 in South-Eastern Asia, representing almost 12.9% of the developing countries' population [1]. However, we had more significant challenges await in 2050 for feeding more than 9 billion of humankind. Also, the production of global food is expected to increase by 60%, so that alternative foods are needed in developing the local potentials of local wisdom. Food security exists when all people have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life. Today, there are also significant challenges ahead of climate change, disease virus outbreaks, and available food availability. Functional food availability is essential to provide health benefits and decrease chronic disease risk [2].

Indonesia is one of the tropical countries that have the highest potential for rich biodiversity in the world. Indonesia's people have long consumed no less than 100 types of tubers and seeds, 450 varieties of fruit, and 250 types of vegetables and mushrooms throughout Indonesia. In general, the source of

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energy intake can be obtained from twelve kinds of local food in Indonesia, eight of them came from cereals, and four others came from tubers. Apart from being a source of energy, these local foods have more functional value for health and are known as prebiotics. Today, the prebiotic concept has become an innovation opportunity to increase the value of local food in Indonesia for domestic and global market needs in developing its functional value [3].

Prebiotics are a component of functional foods that have a role in improving health and reducing the risk of digestive tract disorders. In previous studies, the prebiotic compound could increase colonization and support the growth of native microbiota in the large intestine, such as *Bifidobacterium* and *Lactobacillus* [4].

Inulin is a prebiotic compound consisting of D-fructose monomer units connected by β-(2→1) bonds and has one terminal D-glucose group linked to α-(1→2) bonds. The composition of fructose monomers makes inulin unable to be hydrolyzed in the digestive system (small intestine), and it also does not increase blood sugar levels [5]. Inulin is commercially produced from chichory roots (*Chicorium intybus*) and Jerusalem artichoke tubers (*Helianthus tuberosus*) in several western countries such as America and England. Indonesian local tubers are potentially used as a functional food. According to research conducted by [6,7], some of the primary sources of inulin in Indonesia can be found in plants such as dahlia, gembili (*Dioscorea esculenta*), and bengkuang.

The study aimed to characterize the prebiotic properties of inulin extracts from dahlia obtained from Berastagi and Cibodas and gembili, which were obtained from Gunungkidul and Sukoharjo.

2. Materials and methods

The research materials consisted of four samples and were identified as gembili (*Dioscorea esculenta* L) and dahlia (*Dahlia spp.* L) tubers. The gembili was collected from Gunungkidul Regency, Yogyakarta and Watusbonang Village, Tuwangsari District, Sukoharjo Regency, Central Java Province. The dahlia was obtained from Berastagi District, Karo Regency, North Sumatera Province, and Cibodas Botany Garden, West Java Province. Another material used was commercial inulin (*C₆H₁₀O₅*)n standard produced by industry.

The research was conducted at the Biotechnology Laboratory, Laboratory of Chemical, Biochemistry of Food and Agricultural Products, and Process Engineering Laboratory at Universitas Gadjah Mada, Yogyakarta, Indonesia.

2.1. Research methodology

Please select the best tubers of fresh gembili and dahlia to clean, peel, blanch, and blended with hot water (80°C) ratio 1:1 for each of them and then heated in a water bath shaker for 60 min 75 rpm at 80°C. The puree was filtered with double layers of cotton to get the filtrate; reheated in 1000 ml of hot water (80°C) the similar to previously; and extracted by ethanol 60% in 40% of volume. It was frozen at -20°C for 24 h and thawed. The filtrates were centrifuged for 15 min at 1500 rpm and washed by ethanol 20% (repeated three times until clean). The residue was dried in freeze-drying at -87°C for 24 hours. Then the result is grounded powder called inulin extract. The evaluation of the inulin extract of gembili and dahlia was carried out by calculating yield, analyzing moisture content, analyzing white degree, solubility, and inulin content.

2.2. Statistical analysis

A completely randomized experimental design conducted the research method with non-factorial (Gembili Gunungkidul and Sukoharjo; Dahlia Berastagi and Cibodas). 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 (%) was calculated as the weight of the dried sample extract (a) divided by the weight of the original material (b). The yield can be used to determine the depreciation or addition of weight after processing.

2.4. Measuring moisture content
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).

\[
\text{Moisture Content} = \frac{a - b}{a} \times 100\% \quad (1)
\]

2.5. Measuring white degree
The Coordinate of \(L^*\) \(a^*\) \(b^*\) is measured by chromameter CR-400 (Konica Minolta) with a visual angle of 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 a positive showed by red. While the negative \(b^*\) value showed by blue and festive colors, they were marked by yellow.

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

2.6. Solubility
Solubility analysis was performed by heating the inulin solution (1% w/v, 50 ml). Then put in the air at a temperature of 25°C, 60°C, and 90°C and stirred for 15 minutes. Solubility time is calculated using a stopwatch until it is completely dissolved. Let it stand for a while, then filter it with filter paper known its weight. The solution left in the filter paper is an oven at 105 °C for 3 hours, then weighed.

\[
\text{Solubility} = \frac{(S \times Tp) - (K_2 - K_1)}{S \times Tp} \times 100\% \quad (3)
\]

2.7. Measuring inulin content
The inulin purity test was measured using HPLC with the Aminex Ion-Exclusion HPX-87C column (250mm x 4mm), the water index refraction detector 410, and the LCHE Waters pump model M-45. Distilled water was used as a mobile phase with a speed of 0.5 ml/minute, an injection volume of 20 µl. The column temperature is set to 60°C and the detector 40°C. The standard used is inulin \((\text{C}_6\text{H}_{10}\text{O}_5)n\) obtained from sigma.

3. Results and discussions

3.1. The yield
The average yield of the inulin extract of gembili gunungkidul, gembili sukoharjo, dahlia cibodas, and dahlia berastagi was 10.84%, 10.53%, 29.00%, and 28.33%, respectively (Figure 1). The highest yield of inulin extract came from dahlia cibodas. Dahlia is known to have a high inulin content between gembili and bengkuang. Research conducted by [7] shown that the highest inulin is dahlia tubers of 78.21 mg. Simultaneously, the inulin values of bengkoang and gembili were 48.66 mg and 67.66 mg, respectively.
3.2. Measuring moisture content

The moisture content of inulin extract of gembili gunungkidul, gembili sukoharjo, dahlia cibodas, dahlia berastagi, and commercial inulin industry was 5.26%, 5.22%, 6.99%, 7.11%, and 6.89%, respectively (Figure 2). The samples of inulin extract were not significantly different ($P>0.05$) on the moisture content, according to [8] shown that the moisture content of the inulin standard was 5%.

3.3. Measuring white degree

The white degree of inulin extract of gembili gunungkidul, gembili sukoharjo, dahlia cibodas, dahlia berastagi, and commercial inulin industry was 71.13, 67.4, 67.47, 60.57, and 88.21, respectively (Figure 3). The samples of inulin extract were significantly different ($P<0.05$) on the white degree. Among the four inulin extract samples, the inulin extract of dahlia berastagi had the lowest white degree value.
It means that there are still many impurities involved in the extraction process. One of the standard physical properties and visual appearance quality of inulin is white color inulin [9].

![Figure 3](image3.png)

**Figure 3.** The white degree of inulin extract of gembili gunungkidul, gembili sukoharjo, dahlia cibodas, dahlia berastagi, and inulin commercial

### 3.4. Solubility

The solubility of inulin extract of gembili gunungkidul, gembili sukoharjo, dahlia cibodas, dahlia berastagi, and commercial inulin industry was 36.77%, 32.11%, 98.33%, 97.97%, and 98.71%, respectively (Figure 4). The level of solubility in water can measure the other quality of the physical properties of inulin, according to research conducted by [10] shown that the essential physicochemical properties of pure inulin are insoluble in cold water and highly soluble in hot water. This parameter is useful for determining materials' ability to mix when used in food products at various temperatures.

![Figure 4](image4.png)

**Figure 4.** The solubility of inulin extract of gembili gunungkidul, gembili sukoharjo, dahlia cibodas, dahlia berastagi, and inulin commercial

Among the four inulin extract samples, the inulin extract of gembili gunungkidul and sukoharjo had significantly different (P<0.05) solubility. Their value of solubility was the lowest than dahlia cibodas.
and berastagi. It means that they still need more extraction processes to increase the quality of physical property's insolubility.

3.5. Inulin content
The inulin value of inulin extract of gembili gunungkidul, gembili sukoharjo, dahlia cibodas, and dahlia berastagi was 1.39% db, 1.27% db, 21.84% db, and 21.14% db, respectively (Figure 5). In some research, the analysis of inulin purity is still used by the spectrophotometric method to read all the materials' sugars. Thus the readable inulin purity may be another component than inulin, such as polysaccharides, soluble fibers, and other carbohydrates. Therefore, it is necessary to continue a more accurate analysis of inulin purity using methods other than spectrophotometry, such as High-Performance Liquid Chromatography (HPLC).

![Figure 5. The chromatogram of inulin extract of (a) inulin commercial, (b) gembili gunungkidul, (c) gembili sukoharjo, (d) dahlia cibodas, and (e) dahlia berastagi](image)

4. Conclusions
The results indicated that both gembili and dahlia contain inulin. The amount of inulin dahlia samples were higher (21.84% db) than inulin gembili samples. Inulin extract from dahlia samples had higher solubility (98.33% db) than inulin gembili samples. However, the color test of inulin extract from gembili was lightness than inulin dahlia samples. Thus the best inulin extract from the selection based on the characteristic of solubility and inulin content is the inulin extract of dahlia cibodas. It can be concluded that dahlia and gembili from Indonesia are potentially used as prebiotic sources.

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