Study of Inulin Content and Extractions Methods in Several Types of Tubers: Review Paper

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Abstract. Inulin is a source of fiber that can be used as a functional food. Foods that contain inulin can help overcome health problems such as obesity, colon cancer risk, lower blood sugar levels and reduce insulin resistance. The purpose of this paper is to summarize some research results on inulin content in tubers and their extraction methods. The inulin content in dahlia, gembili, uwi, potato, sweet potato, jicama, onion and garlic tubers are 74%; 15%; 12%; 7%; 13%; 41% and 33%, respectively. Extraction methods used include ethanol:water precipitation, microwave-assisted extraction, hot water extraction and ultrasound. In the future, inulin is expected to contribute to the treatment of digestive-related diseases.

1 Introduction

Inulin is a dietary fiber found in various plants and is beneficial to human health. Inulin promotes calcium absorption, increases calcium solubility, and promotes the expression of calcium-binding proteins [1]. In addition, inulin can also be utilized to make functional food products that also have beneficial effects on the gut microbiome [2]. Inulin has been studied for possible use in drug-delivery systems for the treatment of colon cancer [3]. In addition, inulin maintains gut flora, promotes weight loss, and lowers the risk of colon cancer [4]. Inulin has also been researched for its anti-diabetic properties, which include lowering blood sugar levels and reducing insulin resistance [5].

Inulin can be found in several types of tubers such as dahlias, garlic, onions and other tubers. Inulin, is natural polymer composed of fructose monomers linked by linear bonds of 2,1-fructosyl-fructose [6]. Various methods for extracting inulin include hot water extraction with ethanol as solvent [7], ethanol and water extraction as solvents [8], and flash extraction at high temperatures [9]. The inulin content can also be measured by different spectrophotometric methods, such as Roe's Resorcinol and KLT-FLD [10, 11]. Proximate testing of dahlia tubers is commonly done. Water content using the heating method, ash content using the gravimetric method, fat and crude fiber content using the Soxhlet method, determination of protein content using the Macro Kjedhal method, and carbohydrate content

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using the Gravimetric method [12]. Dahlia tubers contain crude fiber and protein, high carbohydrates and low fat so they can be used as low-calorie food ingredients.

Functional carbohydrate, which is inulin. Inulin is water-soluble and cannot be digested by digestive enzymes, but is fermented by the microflora of the colon, which are organisms located within the colon. Therefore, inulin functions as a prebiotic. Prebiotics are food ingredients that help the intestinal microflora to thrive [13]. Byzov discusses the use of inulin as a bioactive prebiotic in functional nutrition products, cosmetics, and pharmaceuticals, and notes the growing rate of inulin production worldwide [14]. The potential of inulin content, which has many health benefits, has led scientists to conduct research related to extraction methods and inulin yield from several food sources. The amount of inulin or inulin yield produced varies influenced by several factors such as the use of solvent type [15] and the extraction method used. The purpose of this paper is to review research on the content and extraction methods of inulin in several types of tubers.

2 Methods and literature research

The method used in making this review is a secondary method in the form of literature study. The literature used is research journals, books, and publications related to the scope of the topic of this journal review. Literature searches use the help of search engines such as Researchgate, Science direct, and Google. The data collected is then analyzed and discussed in the next chapter.

3 Results and discussion

3.1 Inulin from dahlia flower tubers

Dahlia tubers are known to be rich in fructooligosaccharides (FOS) and inulin [16]. Inulin is also a dietary fiber that performs various physiological functions, such as reducing blood sugar and body fat, controlling intestinal microbial flora, and increasing the absorption of calcium, minerals, and vitamins [17]. Research by [18] explore the Fe content and bioavailability of dahlia tuber syrup, and predicted high Fe bioavailability that could potentially improve the body's metabolism and reduce the risk of anemia. Inulin from dahlia tubers is obtained through several extraction methods. The extraction of inulin from types of dahlia tubers can be seen in Table 1.

Table 1. Extraction results of inulin from several dahlia species.

Dahlia Types	Extraction method	Result Yield	Reference
Dahlia variabilis	Water 80^{o}C dan Etanol 70%	48.25%	[12]
Dahlia variabilis	KLT Densitometry	73.93 ± 1.21%	[19]
Dahlia pinnata	KLT Densitometry	66.76 ± 0.57%	[19]
Dahlia tubers (*Dahlia decorative*) Glory Van Noordwijk	Microwave (MAE) and ultrasound-assisted extraction (UAE)	42% dw, 41% dw	[20]
Dahlia variabilis	HPLC 210 nm	4.53%	[21]

One of the best ways to extract inulin from dahlia tubers is through solubilization of inulin in water at 80 degrees Celsius before precipitation with 70% ethanol [12]. Another study used

microwave-assisted extraction with water as a solvent, which achieved a yield of 98.96 mol% at a temperature of 50 degrees Celsius, a charging concentration of 0.1 g/mL, and a reaction time of 50 minutes [22]. Also, keep in mind that additional research and analysis using gas chromatography (GC) may be needed to determine the degree of polymerization of inulin [23]. In addition, qualitative and quantitative tests, such as the Seliwanoff test and High Performance-Liquid Chromatography (HPLC), can be used to extract inulin from dahlia tubers. Positive identification of inulin containing fructose in a qualitative test using Seliwanoff reagent, as evidenced by the production of a red color [24]

3.2 Inulin from gembili tuber

The gembili tuber plant (Dioscorea esculenta) is a plant that grows in the plains of Indonesia which is also a potential source of inulin [25]. Not many people know that gembili tuber have a good inulin content that reduces triacylglycerol and prevents degenerative diseases such as diabetes and coronary heart disease. However, when compared to other tubers such as gembolo tubers, sweet tubers, and dahlia tubers, gembili tubers have a lower inulin content [26]. Gembili tubers have good potential to be utilized as raw materials for making biscuits, ice cream, bread, and other snacks [27].

There are many ways to obtain inulin from gembili tuber. One technique used is hot water extraction at 80-90°C before precipitation at -20°C [28] containing up to 14.77% inulin by dry weight. Another technique involves mechanically pressing the tubers to produce a rich protein juice, and then solvent extraction to extract the remaining protein and inulin retained in the solids [29]. Another method to extract inulin from gembili tuber, namely by ultrasonic technique (Ultrasound-assisted) obtained 21.13% inulin [30]. To achieve the best extraction rate, extraction conditions such as extraction time, material-to-water ratio, and pH value must be optimized [31].

Recent research on inulin from gembili bulbs has focused on several aspects. One study investigated how inulin was synthesized by using gembili as a silver ion bioreducer, with the aim of improving inulin absorption. This process produced inulin with 12-49 nm nano-particles with a spherical shape for easy absorption [32]. The physico-chemical characteristics of gembili inulin can be influenced by various factors. One of them is the drying factor. The drying methods used were foam mat drying and freeze drying which produced gembili inulin with inulin content of about 9.38% and 8.68%, respectively [33]. This study provides insight into the various techniques used to extract inulin from gembili tuber yam as well as the utilization of gembili in everyday food products.

3.3 Inulin from uwi tuber

There are many ways to obtain inulin from uwi tubers. One of the methods used is to use mesoporous material immobilized compound enzymes. The mesoporous material immobilized compound enzyme is added into the slurry, then enzymolysis and centrifugation are carried out to produce inulin enzymatic hydrolysate. Sodium alginate-chitosan microspheres were added into the hydrolysate for flocculation, and then activated carbon was used to remove color from the inulin solution [34]. Another method uses solvent extraction with hot water. Single-factor and orthogonal experiments were conducted to optimize the extraction process. The best conditions for extraction were a stock ratio of 1:15 (mass: volume), a temperature of 70 °C, a time of 90 minutes, and three extraction cycles [35]. With ideal conditions of a solid-to-liquid ratio of 1:18, extraction time of 6 minutes, and microwave power of 450 W, microwave extraction can also produce inulin levels of 12.2% [36].

Ultrasound-assisted extraction is one of the latest methods used to extract inulin [37]. In principle, this method uses acoustic cavitation to increase the extraction efficiency of

bioactive compounds to be obtained from plant tissues. The ultrasonic waves generated from this instrument will cause vacuum bubbles in the liquid material, resulting in the fragility of the plant tissue and the release of the desired bioactive compounds [38, 39]. Temperature, frequency and amplitude settings are very influential in the extraction process. In addition, the thickness and density of the plant also need to be considered so that the waves and solvent penetrate the tissue more easily [40]. The ideal conditions for inulin extraction were a temperature of 45.95 °C, extraction time of 31.44 minutes, and 100% amplitude, which gave a high inulin extraction yield of 91.26% [41].

3.4 Inulin from potatoes

The inulin content in potatoes varies depending on the isolation method used [42]. Inulin yield from white potato (*Solanum tuberosum*) that was precipitated using ethanol solvent with a ratio of 1:2 (w/v) for 12 hours was 7.72% [43]. The higher the solvent concentration, the higher the water content of the inulin extract. This is because the degree of polymerization is smaller so its solubility increases in water [44]. Transgenic potato with 5% inulin content was identified using High-performance anion exchange chromatography instrument [45]. Inulin from sweet potato (*Ipomea batatas* L.) can be produced as much as 4% [46] and 5.5% [47] from 1 kg of tubers in the wet state using the same method.

The inulin obtained can be characterized using Fourier Transform Infrared Spectroscopy (FT-IR) instrument to analyze the specific functional groups of inulin. The appearance of functional groups other than inulin can be an indication that the extracted inulin is not pure or contains unwanted compounds. Impurity compounds can come from residual solvents and other chemicals used during the extraction process [48]. There was no significant difference between the IR spectra of commercial inulin and inulin isolated from potato (*Solanum tuberosum*). The functional groups that appear are hydroxyl groups (OH) in the 3550-3220 cm^{-1} absorption band, while carbonyl groups (C=O) in the 1470-1430 cm^{-1} absorption band [43].

3.5 Inulin from jicama

Jicama (*Pachyrhizus erosus*) is a plant originating from tropical America that has potential as a source of carbohydrates [49], soluble fiber, fruktooligosaccharides [50], pectin, cellulose, xyloglucans, heteromannans and inulin [51, 52]. The inulin content of jicama measured using High-performance liquid chromatography (HPLC) was 13.4%, which decreased to 8.4% at 106 days of storage [53]. The inulin content of jicama extract was 12.3% with a degree of polymerization of 36%. This result is based on measuring using Thin-layer chromatography densitometry [54-56].

Characterization of jicama inulin using HPLC using the principle of the presence of fructooligosaccharides, glucose, sucrose and fructose. The content of these compounds is influenced by the maturity level and storage time of jicama [53]. The longer the storage, the higher the glucose content. This needs to be considered when determining the harvesting time and storage time of jicama. This is because fully ripened jicama has a higher glycemic index than jicama at lower maturity levels.

3.6 Inulin from garlic

Garlic is naturally rich in fiber, especially soluble fiber, of which inulin is the best known [57, 58]. Using ethanol solvent, the weight of inulin yield obtained from 100 g of dried onion (*Allium cepa*) is 4g [59]. Inulin from onion is characterized by being odorless, smooth, and pure white. According to [54] Garlic has the highest inulin content of 41.72% followed by

onion at 33.2%. In addition, onion extract contains inulin with a concentration of 74 g/L and a degree of polymerization of 4% [60]. The extract is resistant to gastrointestinal conditions and is therefore considered prebiotic [61]. Meanwhile, the extraction process of inulin from agro-industrial organic garlic (*Allium sativum*) wastes optimized using the Response surface method is 8% [62].

Extraction using ethanol is the most common method to obtain inulin from raw materials. This is because ethanol is a solvent that is easy and cheap to obtain. Although it requires a long extraction time, the yield that can be obtained is quite a lot. Some conditions that need to be considered during the extraction process using ethanol are temperature, pH, and extraction time. Several other extraction methods were investigated to increase the yield, without increasing the cost and extraction time. The microwave-assisted extraction, supercritical fluid extraction, and ultrasound-assisted extraction methods are considered to be faster in the extraction process and also more environmentally friendly [63]. However, its use on an industrial scale should be more massive so that the benefits of inulin can reach a wider community.

4 Conclusion

Inulin is a dietary fiber in plants that can provide health benefits for digestion. The water-soluble nature of inulin and cannot be hydrolyzed by digestive enzymes makes inulin reach the colon so that it can increase the growth of bifidobacteria in the colon. Based on the results of the review, Inulin content is found in many tubers, namely dahlia flowers, gembili, uwi, potatoes, sweet potatoes, jicama, shallots and garlic. The level of inulin content is influenced by the type of material and the extraction method used. Precipitation using ethanol is the extraction method most often used by researchers in this review.

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