



Technological proposal for a garlic-derived inulin extraction process

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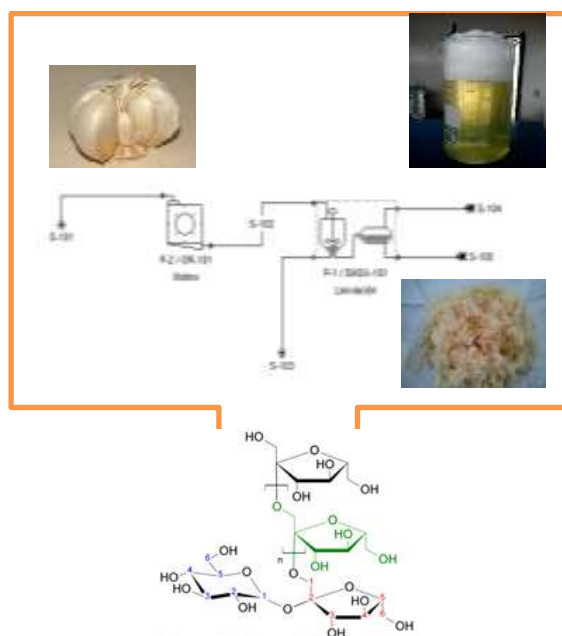
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Graphical Abstract



Abstract.

Inulin is an essential part of the family of complex carbohydrates, which actively participates in industrial applications, since it is an active ingredient of several vegetative species of tubers and roots. In developing countries, there are no inulin production industry from biomass. This carbohydrate is only imported as active ingredient of pharmaceutical drugs and quantification in already elaborated products. These are the reasons, why it is extremely important the development of inulin industrial production. This research aims to design a technological process to produce inulin from garlic biomass (*Allium sativum*), starting from the state of the art analysis of the field, which prioritizes the study of inulin extraction from garlic by solid-liquid extraction at laboratory scale, using water as solvent. The influence of the variables water / garlic ratio: 2, 3 and 4 ml water / g garlic and the temperature: 30, 55 and 80 °C on the extraction process, during 45 minutes, with constant agitation was assessed. The refining obtained from the filtration of the extract was quantified; the results indicate that garlic contains about 18% of inulin and the best extraction conditions are: temperature at 80 °C and water / garlic ratio of 4. A pilot-scale sustainable technology was designed and simulated

	<i>with SuperPro Designer software from a raw material input capacity of 10 kg/batch. A comparative analysis was made on the feasibility and possibilities of implementation of the different flow works.</i>
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Introduction

The need of new global energetic sources nowadays is a priority to humanistic and industrial development. In this context, natural energy is increasingly considered as an alternative source for a sustainable energy management. Potential vegetal natural energy might be considered. Inulin is a carbohydrate storage found in vegetables, fruits and cereals. This polysaccharide is used in daily diet as food ingredient and offers technical advantages and important health benefits (Frank, 2006). Currently, inulin could be considered as “functional food” only with its presence in low amounts in food formulation [1].

Inulin industrial production is mostly derived from chicory root [2]. Nevertheless, there are other plant species in literature that have shown to be an alternative source of inulin, as greater burdock [3], agave [4], *Dioscorea* sp. [5], and particularly from garlic (*Allium sativum*) [6]. *A. sativum*, belonging to Liliaceae family and originated from Asia, has a considerable percentage of inulin. This chemical compound has important technological benefits, primary in food and pharmaceutical industries; in food formulations it improves organoleptic properties, and is considered as fat substitute without texture modifications. Some of these products are fermented dairy products, chocolate products, beverages, frozen desserts, cereals, energetic bars, meat, low fat and sugar products due to the low calories it possesses, fruit preparations and fructose syrup [7].

In pharmaceutical field, inulin is included as drug stabilizer and excipient due to its high affinity with multiple components, as constituent element in nutritional products, as surfactant additive in cosmetology and chemical industry, as coagulant agent in wastewater treatment, alcohol production, carboxi-inulin production and anti-corrosive [8]. In Ecuador inulin industry has not developed, because there is none institution directed to inulin production. The industry in Ecuador is only oriented to importation and quantification in ready-to-use products. It is important the development of technological production industry of inulin, to strengthening the national productive matrix shift for the development of new technologies that improves the country's environment.

In concordance with the scientific issue exposed here, the aim of this study is to propose the inulin extraction from native garlic with water as solvent, based on variable evaluation process defining, mathematical modeling and pilot scale plant design simulation, to achieve a technically and economically feasible inulin production technology, as well as environmentally friendly.

Materials and Methods

The experimental study was achieved from the laboratory scale extraction allowing setting up the performance estimate, making the technology design which contemplates the dimensioning of equipment and economic evaluation.

Inulin is obtained by solid-liquid extraction process in simple contact. The extraction factors affecting the extraction are considered: solvent, particle size, solvent/garlic ratio, temperature, stirring, and extraction time. The factors that show influence in the inulin extraction were temperature and solvent/garlic ratio, which has been shown in other studies have the most influential effect into the process [9].

The solvent must be as selective as possible, with low viscosity, in order to penetrate easily through the solid pore, reasons to select water for the study. While smaller is the pore, higher is the interfacial surface and smaller the pore length, therefore the transfer speed is higher. Nevertheless, excessive smaller size, could lead the particles to compress, obstructing the extraction by nullification of the interfacial area [10]. The study was conducted with a particulate average of 4 mm and a ratio recommended by [9].

Additionally, an increase of solubility and material transfer coefficient is caused by a temperature increase, leading to a higher solute extraction. Upper temperature limit is set at 80°C, in concordance with product quality, safety and phase change of the solvent, to gradual recovery respecting with the extraction method [10].

The experimental planing study was made with the statistic software Statgraphics Centurion XV v15.1.02. The inulin amount extracted was defined as dependent variable and the temperature and water/garlic ratio were defined as independent variables. There were three levels into water/garlic ratio: 2, 3 and 4 mL of water/g of garlic and three temperature levels into extraction: 30, 55 and 80 °C, according with [9].

A central composite design was obtained, with star and central points, to obtain the empiric extraction process, from a 2^3 design to minimize the bias. A replicant was made for each assay.

The technical design was construct according [11], including the Superpro Designer software for extraction process analysis with two raw material input stream variables.

Results and Discussion

Considering the modeling calculation results, the garlic inulin extracted amount could be amplified by temperature increase because inulin percentage found in common white garlic excess by 17% that reported in literature.

The selected inulin extraction method was the batch technology, using water as dissolvent into two essential phases: raw material preparation and inulin extraction, with an equipment scaling for a 10 kg load of raw material. Inulin percentage found in common white garlic is over 17%, which is larger than literature reported (9 – 16%).

Discontinuous extraction process was the chosen inulin extraction technology, using water as solvent in two essential phases: raw material and inulin extraction.

Mill and inulin extractor for 10 kg of raw material was considered in the dimensioning of equipment.

The economic-tech evaluation of the two tech variants in the analyzed capabilities, show a favorable decision making for a 100 kg raw material capability, with VAN 210800 TIR 38.20% and recovery time of 1.91 years.

Table 1. Input and output streams

Equipment	Input Flow	Output Flow
Windmill	10 kg garlic	FLOW S-101 10 kg ground garlic
Mixer	10 kg ground garlic 40,312 kg of water	P1/SMSX-101 9.9 kg of plant (* 0.1) 40.112 kg of water (* 0.2)
Tank for decantation	9.9 kg of plant 40,112 kg of water	FLOW S-104 0.840 kg biomass 1.520 kg inulin 37,454 kg water FLOW S-105 7.560 kg biomass 0.080 kg inulin 2.859 kg water

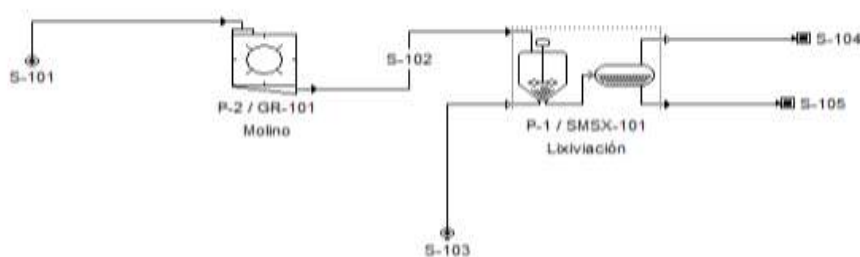


Figure 1. Proposed technological scheme for the production of inulin.

Conclusions

The optimal inulin extraction was observed in a 4 mL/g ratio of garlic, showing effective results by using this technology. Nevertheless, more studies in different regions of the country are needed, particularly with high inulin food industry. The potential use of agroindustry waste could demonstrate the feasibility of this technology.

The inulin extraction technology proposed here will stimulate the substitution of imports of inulin, strengthening the microenterprise, and aiding a positive productive matrix change.

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