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Extraction Of Fructo-Oligosaccaride Components From Banana Peels

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ABSTRACT

The extraction of fructo-oligosaccharides from banana peels was aimed in this study. Experimental parameters were particle size, solvent type, temperature (40-60^{0}C) and time (10-210 minutes). 30% of yield was obtained when optimum sized peels (2*7*10 mm) were extracted with pure acetone at relatively low temperature (50^{0}C) during 90 minutes. Total fructo-oligosaccharide content was found nearly 33% of the sugar components of the extracts, and nystose was absent. The degree of polymerization was lower than those of other fructo-oligosaccharide containing plants (<6). It was concluded that GRAS-statued fructo-oligosaccharides can be produced from a solid waste, a banana peel.

Keywords: *Fructo-oligosaccharide, banana peel, extraction*

1. INTRODUCTION

Recently, a new concept called "functional foods" has been developed. They can be defined as food ingredients that affect physiological functions of the body in a targeted way so as to have positive effects that may justify health claims [1]. Among the functional components, probably the most frequently encountered classes are probiotics and prebiotics. Probiotics are known as "living microorganisms which have a positive effect on health beyond basal traditional inherent nutritional effects" [3]. A prebiotic is "a food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of prebiotic bacteria in the colon that can improve the host health" [4]. Prebiotics are non-digestible carbohydrates which increase the activity of the colonic bacteria when they are fermented. They range from small alcohols and disaccharides (lactulose and lactitol) [3], [5], to oligosaccharides (fructo-oligosaccharides (FOSs), soybean oligosaccharides, xylo-oligosaccharides etc.) [6], [7], and large polysaccharides (inulin, resistant starch, non-starch polysaccharides) [6], [8], [9], [10]. Inulin is a name given to a mixture of fructose polymers which consist of degree of polymerization (Dp) greater than 60 and it is widely available in nature in the form of stored carbohydrates in plants [11], [12].

FOSs are β(2-1)-linked fructose oligomers (Dp up to 10) either to D-fructose or to D-glucose [13]. In the FOS structure, fructosyl-glucose linkage is always β(2↔1) whereas fructosyl-fructose linkages are β(2→1) [13], [14]. FOSs have both functional and technological properties. They have approved in detailed investigated functional effects on health thus having the status of GRAS (generally-recognized-as-safe) [15], [16]. These include an increase in the absorption of calcium, magnesium, phosphorus, and iron [17], decrease in lipidemia and/or cholesterol [15], inhibition of aberrant crypt foci formation [17], prevention of osteoporosis due to increased bone strength [17], inhibition of diarrhea [17], reduction of the risk of atherosclerotic cardiovascular disease [18], reduction of the risk of

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obesity and possibly of type-2 diabetes [19]. Technologically, FOSs are highly soluble (about 80% in water at room temperature), [16], [20] and they are low-calorie carbohydrates (1.0-1.7kcal/g) (21-22). They enhance the organoleptic quality, and can be used as fiber and prebiotic instead of fat and sugar [16]. They also can extend the shelf life of the products [23]. Both functional and technological properties of FOSs depend on the degree of polymerization of the molecular structure of the compounds (the number of glucose and/or fructose unit). For example, as the degree of polymerization decreases, amount of sweetness increases [24].

Each plant has its own enzyme so as to break down or synthesize those stored carbohydrates; i.e. FOS. In order to produce the maximum amount of the most functional components of FOSs, the knowledge of the characteristics of each of the enzymes isolated from the plant species selected is required. In fact, there are two mechanisms that produce FOSs: i) deriving oligomers from sucrose, and ii) deriving oligomers from inulobiose. There are suspicious findings that confirm the oligosaccharides produced from sucrose are functional and can ensure the health effects mentioned above [17]. However, functional properties of FOSs produced via inulin hydrolyzing enzymes present in plants have been proved by studies that use both microorganism, animal, and even human subjects [15].

FOSs are especially found in plants and a large portion of vegetables, fruits and cereals such as chicory and Jerusalem artichoke, asparagus, banana, onion, garlic, tomato, etc [25]. Chicory (*Cichorium intybus*) and Jerusalem artichoke (*Helianthus tuberosus*) are the main commercial plant sources for the production of GF_n-type FOSs due to their high content [26]. In addition, a dish of leek, a small banana, and an onion and garlic consumption meets the need of daily prebiotic [27]. FOS or FOS-related components will have a magnificent future for mankind due to both nutritional and health benefits.

In this study, because of their functional and technological properties mentioned above, the availability of FOS components from banana peel was investigated. Because of its nutritional value, instead of banana that is known as one of the FOS-containing fruit, banana peel usage was aimed. There is not any study in literature concerning the FOS species and their quantities in a banana peel. The aim of the applied study was both to fill the information absence in the literature and to create alternative for production of FOS.

2. EXPERIMENTAL

In this study, the peels of banana (composition shown in Table 1) (10g) were used as a raw material and distilled water and/or acetone were used as solvents. Effects of the extraction time, solvent type, and temperature and particle size on the extraction process of FOS components from banana peels were investigated. In batch extraction experiments, the ratio of ¼ was applied in batch experiments for banana peel weight (g)/amount of solvent (ml). Batch experimental system containing the solvent and a raw material covered with paraffin was subjected to defined temperature in shaking water bath (HETO SBD 50; 150 rpm) during specified period. After filtrating of the extract analyzing procedure was performed and yield of the extraction was calculated from Equation 1. All of the experiments were repeated three times. Student's t test statistical analysis was performed on the results obtained. Experimental procedure was also summarized in Figure 1.

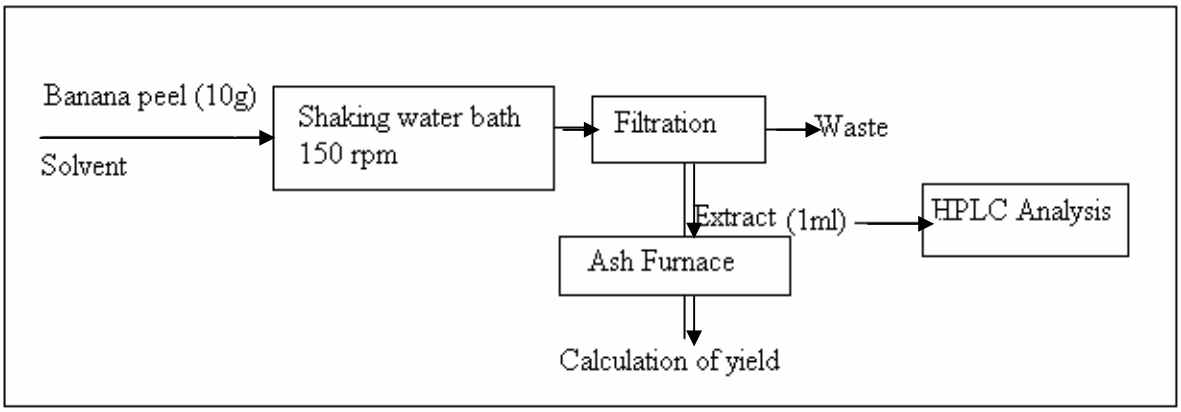

Figure 1. Experimental procedure

$$\text{Yield} = \frac{\text{Dry matter in extract of 1ml x 40 ml}}{\text{Dry matter in banana peel used (2.284 g)}} \times 100$$

Equation 1. Equation of yield based on dry matter

Table 1. Content of raw edible banana [28]

Nutritional value per 100g (One banana is 100-150 g)	
Energy	371 kj (89 kcal)
Carbohydrates	22.84
Dietary fiber	2.6 g
Fat	0.33 g
Protein	1.09 g
Vitamins (A, thiamine, riboflavin, niacin, pantothenic acid, folate etc.)	10.193 mg
Minerals (Calcium, iron, magnesium, phosphorus, potassium and zinc)	412.41 mg (15%)

In the analysis section, in order to determine the product profile of the extracts, a carbohydrate column, Aminex HPX-42C (BioRad) was used with Refractive Index detector in the Central Laboratory of METU. The column temperature was 80˚C, and mobile phase was distilled water with flow rate of 0.6 ml/min. The compounds that have a Dp up to four were accurately determined in these analyses, since the standards of only these compounds (fructose, glucose, sucrose, 1-kestose and nystose) were available. The amounts of sugar with Dp of 5 and 6 giving distinct peaks were estimated by derived equation by previous study [29]. The equation was obtained by searching the relation between the calibration constants calculated by area/concentration of the sugars to the number of fructose units.

$$A \times MW \times 10^{-6} = 47.006\ \#F^2 - 112.25\ \#F + 338.68$$

Equation 2. Derived equation for FOS components of Dp 5 and 6

3. RESULTS AND DISCUSSION

Extraction process of banana peels had been carried out at 50^{o}C for each solvent type during 10-120 seconds with ten-minute step size. As a result of the experiments the higher yield was observed with longer extraction times for all solvent types (Figure 2). Although, 140 min extraction was enough to obtain nearly the same yields for water and acetone-water mixture, higher time durations caused higher yields in pure acetone solvent. Also, as the time increased, the increase in yield had been observed in the same way for each solvent type. It was concluded that because of having higher polar property, much higher yield in lesser time was provided by acetone than the other solvent types.

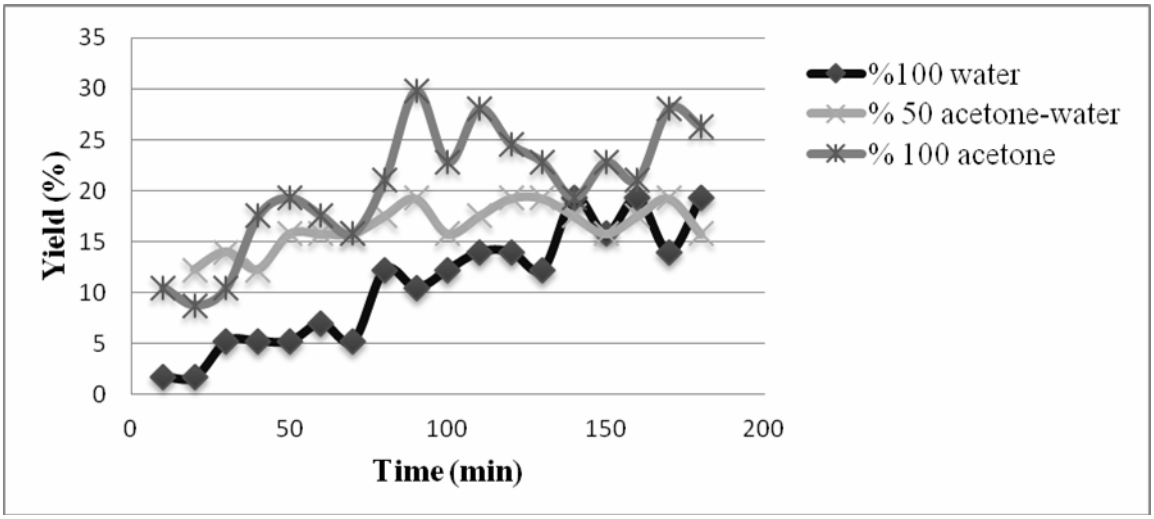

Figure 2. The change of extraction yield with time for different solvent types

Extraction processes had been performed at temperatures ranging from 40 to 60°C during optimum time of pure acetone solvent. Because boiling point of acetone in experimental conditions determined as 60°C, procedure was not continued to higher temperatures. Although, the extraction yield increased linearly between 40 and 50°C, it decreased between 50 and 60°C (Figure 3). This decrease may resulted from the optimum activity temperature of the FOS hydrolyzing enzymes, that is 50°C and also higher activities of FOS hydrolyzing enzymes than those of FOS producing ones at that temperature [29]. Thus, higher molecular weighted molecules may not diffuse through the solvent during the extraction process as effectively as before.

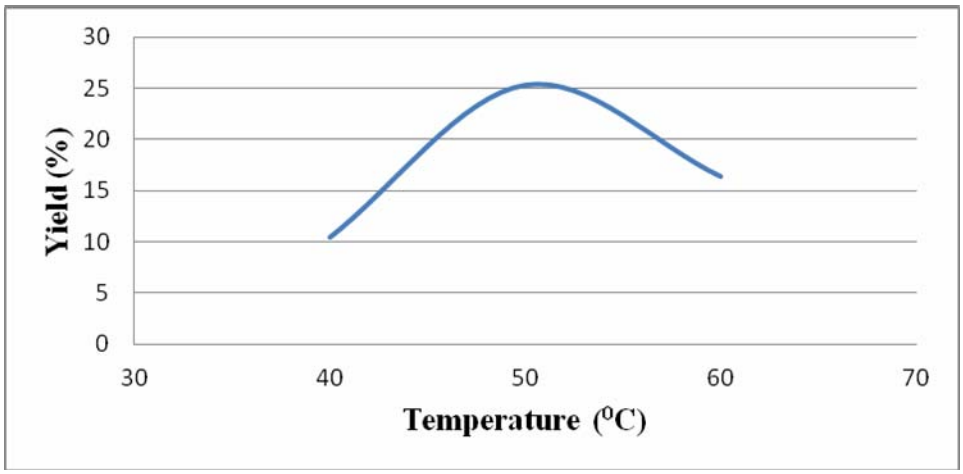

Figure 3. The change of extraction yield with temperature

In order to investigate the effect of particle size on yield of extraction process, banana peels cut into pieces in size of 2*5*8 mm (small), 2*7*10 mm (normal), and 2*21*21 mm (big). Optimum temperature and time were used in the extraction. Big sized banana peels produced the lowest yield, whereas the highest yield was obtained by using normal particle sized banana peels (Figure 4). This inconsistency of yield between normal and larger sized banana peels may be resulted from the fact that such cutting process decreased the permeability of the tissue of the banana peel. It was reported in the literature that cutting accelerates the activities of FOS hydrolyzing enzymes [29]. Thus, all of FOS components may be hydrolyzed up to glucose and fructose units. But, because of the fiber structure of the peels, permeability decreased; as a result they did not diffuse through the tissue.

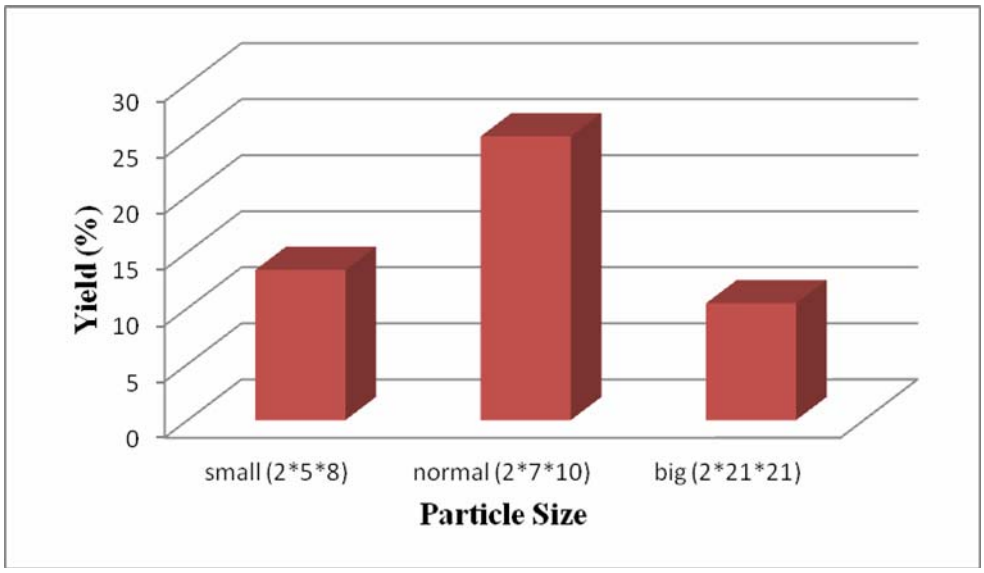

Figure 4. The effect of particle size on extraction yield

In this investigation, it was concluded that at the end of 90 minutes, FOS components could be extracted effectively from 2*7*10 mm (normal) sized banana peels by using pure acetone at 50^0C. The extract obtained at these conditions was analyzed by HPLC. FOS content of the extract was found nearly 33% of the sugar components of the extracts, and nystose was absent (1-kestose; 3.0147 mg/mL, sucrose; 6.3707 mg/mL, glucose; 7.1478 mg/mL, fructose; 6.2695 mg/mL, fructofuranosylnystose; 6.5842 mg/mL) (Figure 5). Dp of FOS compounds in banana peels was lower than those of other fructo-oligosaccharide containing plants (<6). The assumption of the extractability of 1-kestose (that is the smallest and the most functional compound of FOS noted in some investigations [30]) from a solid waste (banana peels) was confirmed by the result of this study.

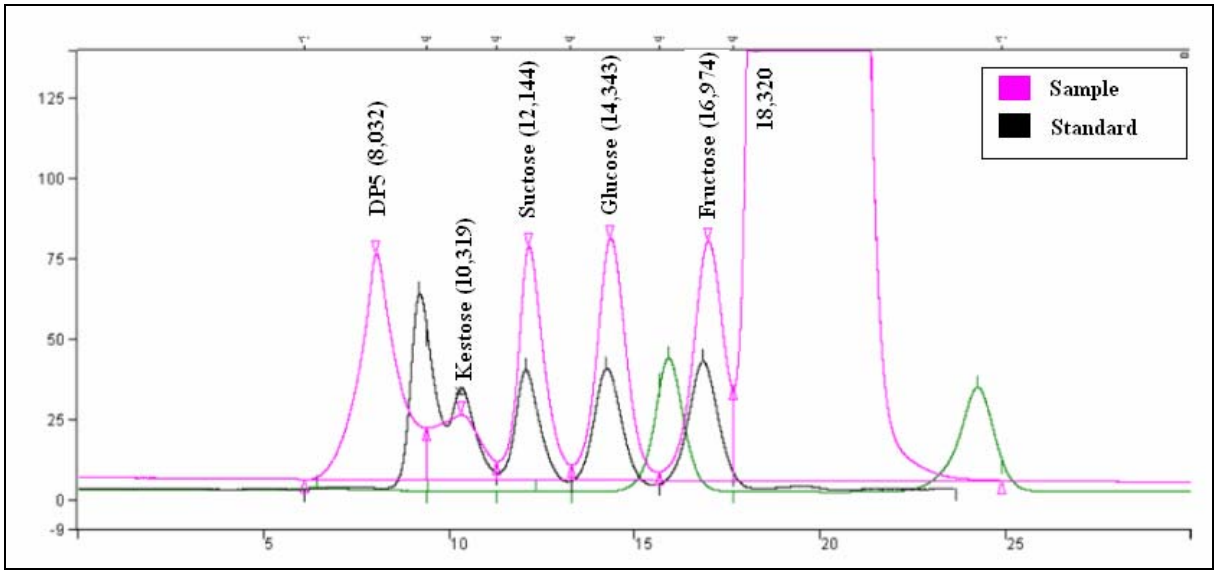

Figure 5. The result of HPLC analysis

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NOMENCLATURE, SYMBOLS AND ABBREVIATIONS

FOS: Fructo-oligosaccharide

GRAS: Generally recognized as safe

Dp: Degree of polymerization

HPLC: High Performance Liquid Chromatography

GF: Glucose Fructose Unit

METU: Middle East Technical University

MW: Molecular weight of the FOS component (either Dp 5 or Dp 6)

#F: Number of fructose units

A: Constant for the corresponding specific FOS component (either Dp 5 or Dp 6)