Sugar Composition of Low Molecular Weight Carbohydrate and Dietary Fiber of Some Bangladeshi Fruits

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Abstract

Free sugar and dietary fiber (DF) are the two major nutritional constituent of all fruits and vegetables. The physiological importance of DF in human has been recognized due to its capacity of lowering glycemic responses. In the present paper, we report the free sugar content of low molecular weight (LMW) carbohydrate and DF of four different fruits, which were not reported earlier. These are: *Litchi Chinesis* (Litchi), *Mangifera indica* (Mango), *Psidium guajava* (Guava), *and Ananus comosus* (Pineapple) respectively. The amount of glucose and fructose for each fruit was found to be 6.1 and 5.2 g (Lichi), 5.6 and 4.5 g (Mango), 3.4 and 2.6 g (Guava), and 4.9 and 3.9 g (Pineapple) per 100 g of fresh edible part (EP) respectively. DF content of these fruits was estimated as neutral detergent fiber (NDF) and showed the value of 0.68 g, 1.05g, 2.11g, and 1.12g per 100g fresh EP of lichi, mango, guava, and pineapple respectively. Arabinose, galactose and glucose were found as neutral sugar constituents of the NDF of each fruit. The relative percentages of arabinose, galactose and glucose were estimated to 27.6, 12.8 and 59.6 for Lichi, 6.6, 5.4 and 88.0 for mango, 14.7, 8.9 and 76.4 for guava and 9.3, 6.6 and 84.2 for pineapple respectively. The Klason lignin content was found to be 0.22, 0.05, 0.93 and 0.08 percent, respectively, of the fresh EP of the fruits. The results obtained would, therefore, be contributory to the nutrient composition database of local foods.

Key Words: Free Sugar, Dietary Fiber, NDF, Sugar composition, and Klason Lignin.

Introduction

The difficulty in predicting glucose responses to various carbohydrate (CHO) foods led to the determination of the "Glycemic Index" (GI) of foods. GI is a classification index of CHO foods based on their effects on blood glucose response over two hours relative to a standard food such as white bread[1]. The glucose response dynamics and hence the GI depends largely on the rate of digestion and the rapidity of absorption of CHO.

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However, there are several food specific factors to influence the glycemic response potentials of CHO foods. Mentionable factors that affect the GI are: nature of sugars (glucose, fructose, galactose), nature of starch (amylose, amylopectin, RS), presence and types of DF, presence of antinutrients and non-nutrient biomolecules, cooking or processing, etc[3]. Role of content and composition of DF in the diet, in particular, has drawn attention. Numerous studies (reviewed in "Physiological effects of Dietary Fibre" in the report of FAO[3]) have shown that addition of DF containing foods in the diet can lower glycemic responses in healthy people and in people with type-2 diabetes. Fiber-rich foods may thus contribute to the prevention of many metabolic syndromes.

FAO and WHO endorsed[3] the use of the GI as a method of categorizing CHO foods, as this provides information on the likely metabolic effects of the CHO. But the local or regional food composition tables[4, 5] do not contain classification of CHO foods on their GI basis. In fact, it is a recent research area in Bangladesh with only two or three reported studies[6, 7].

The glycemic CHO fraction, which is available for absorption in the small intestine, is measured as the sum of sugars and starch, excluding resistant starch[2] (RS). The problems with local food composition tables are that they do not contain soluble free sugar content of foods. Moreover fiber content of foods in these tables is usually presented as crude fiber (CF) but not as DF[4, 5]. To overcome these difficulties with the local food composition tables a series of studies on local vegetables and fruits have been conducted in our collaborative laboratories[8-11]. In the present paper, the free sugar content of the LMW CHO fraction and sugar content and composition of DF of four different fruits (lichi, mango, guava, and pineapple) are described.

Materials and Methods

Sample Collection and Preparation

Litchi Chinesis (litchi), *Mangifera indica* (mango), *Psidium guajava* (guava), *Ananas comosus* (pineapple) samples were purchased from a local market of Dhaka city. Emphasis was given to purchase indigenous varieties, exclude hybrid types, and collect mature samples in the pick seasons. Collected samples were fresh, well shaped and free from insect bite and other deformities. They were selected at random from the stock lot of the seller. The clean fruit samples were cut into small pieces and a portion was immediately removed for moisture estimation at 105^{O} C for 5 h. The rest of the samples were died and powdered as described earlier[8]. The dried samples were kept in desiccators until use.

Extraction

Seed-free dried edible part of each fruit (20 g) was extracted with aqueous 80% ethanol (refluxing; 3 x 250 ml; 30 min each time). This aqueous 80% ethanol soluble material contained LMW carbohydrates along with other soluble materials. The extractive-free residue was air-dried and stored for DF analysis.

Gas Liquid Chromatographic Analysis

All sugar analysis was performed on GLC following Sweely et al.[12]. Evaporations of GLC samples were carried out under reduced pressure at below 40°C. For gas chromatographic analysis a PYE UNICAM 4500 (FID detector) GLC analyser connected with a LKB 2220 recording integrator was used. Separations were performed on (i) CP Sil 5 WCOT quartz capillary column at 185° - 210°C, 2°C per min for trimethylsilyl derivatives and (ii) CP Sil 88 WCOT quartz capillary column at 170°-220°C, 4°C per min for alditol acetates.

Analysis of Low Molecular Weight Carbohydrates

Isolation and purification: A portion (200 mg) of the aqueous 80% ethanol soluble material of each fruit materials was dissolved in water and passed through a cation exchanger (Dowex 50W x 8 H^+; 3 x 9 cm) followed by anion exchanger (Amberlite IR-45, OH^- ; 2.2 x 12 cm). The neutral solution was concentrated to a small volume and freeze-dried (0.65 g). This fraction is considered as neutral LMW carbohydrate.

Sugar analysis: The neutral LMW carbohydrate fraction (~5.0 mg) was dissolved in water, containing mannitol (0.5 mg) as internal standard and was evaporate to dryness with added methanol. The dried material was treated with dry pyridine (1.0 mL), ultrasonicated, flushed with nitrogen and trimethylchlorosilane (TMCS; 0.5 mL) and hexa-methyldisilazane (HMDS; 1.0 mL) were added to that. The mixture was ultrasonicated (2 min) and heated in an oven at 60°C for 20 min. The silylated material was evaporated to dryness with added toluene (until it was pyridine free). Extra *n*-Hexane was added to the dried material, filtered and the filtrate was reduced to a small volume and analysed by GLC[12].

Analysis of Dietary Fiber

NDF estimation: The extractive-free residue (~1.0 g) of each fruit was further extracted with neutral detergent solution (refluxing; 1 x 150 mL; 1h) according to the modified[8] method of van Soest[13]. The extractive free residue was washed twice with hot water followed by acetone and dried at 100°C for 2 h to obtain NDF gravimetrically as described earlier[8]. The content of NDF was considered as DF of all fruits through out this study.

Sugar analysis: To determine the sugar composition, a portion of the NDF fraction (100 mg) of each fruit was hydrolysed with 12.0 M H_2SO_4 at room temperature for 2 h followed by refluxing for 6 h after dilution to 0.36 M. Mannitol (0.5 mg) was used as internal standard. The resulting sugars in the hydrolysates were analysed for their composition by GLC as alditol acetates[14] and the insoluble residue was determined gravimetrically as Klason lignin.

Results and Discussion

In this study, all estimations though conducted on dry weight basis but for convenience and also for comparison purpose, results were transformed into fresh weight basis considering the water content of each fruit material and presented in subsequent tables accordingly.

The edible portion of the fresh fruits is juicy and the juiciness characterizes the fruits themselves. So it is very likely that the water content of the fruits should be high. It has also been reported[10] that the water content of most of the tropical and sub tropical fruits is high. In our present investigation the water content of the fruits varied from 80-90% (Table 1). Guava contained the highest amount of dry matter (15.4%) while mango contained the least amount (11.6%).

Table 1. Content of neutral LMW carbohydrate of fruits (g %)[1].

Items	Lichi	Mango	Guava	Pineapple
Water Content	87.10	88.40	84.60	85.10
NLMW Carbohydrate	9.30	6.20	3.80	5.10

[1]Results were expressed as mean of duplicated estimations of fresh weight of EP.

Glucose and fructose were the only two free sugars identified and quantified. The content of glucose was a bit more than that of fructose in all the four cases (Table 2). It is very likely in case of any fruits[11]. Sucrose was not detected in all the four cases and hence not contributed to the total. Probably invertase inactivity may be responsible[15] for the absence of sucrose in the extracted fruit materials though activity of invertase in all these fruits is difficult to conceive. Thus the total free sugar was considered to be constituted as sum of glucose and fructose and was in the range of 6.0 to 11.3%.

Table 2. Content of free sugar in neutral LMW carbohydrate of fruits (g %)[1].

Items	Litchi	Mango	Guava	Pineapple
Glucose	6.10	5.60	3.40	4.90
Fructose	5.20	4.50	2.60	3.90
Sucrose	nd[2]	nd	nd	nd
Total Free Sugar	11.30	10.10	6.00	8.80

[1]Results were expressed as mean of duplicated estimations of fresh weight of EP; [2]not detected.

It may be seen that insoluble DF estimated as NDF in this study constitutes the bulk (69.4 to 95.5%) of the total DF where Klason lignin is an integral part of insoluble DF (Table 3). When sugar composition of the NDF fraction was analysed it revealed that glucose, arabinose and galactose were the three neutral sugar constituents (Table

4) with a very high value of glucose (59.6 to 88.0%). The result thus gives an indication of the presence of cellulose materials in this fraction. The presence of cellulosic materials which are not soluble in water remained in the insoluble portion and thus constituted the bulk of the total DF.

Table 3. Composition of DF in fruits samples (g %)[1].

Items	Lichi	Mango	Guava	Pineapple
NDF	0.68	1.05	2.11	1.12
Klason Lignin	0.22	0.05	0.93	0.08

[1]Results were expressed as mean of duplicated estimations of fresh weight of EP.

Table 4. Sugar composition in NDF fractions of fruits samples (g %)[1].

Items	Litchi	Mango	Guava	Pineapple
Arabinose	27.66	6.65	14.68	9.26
Galactose	12.77	5.35	8.97	6.56
Glucose	59.57	88.00	76.35	84.18
Total	100.00	100.00	100.00	100.00

[1]Results were expressed as mean of duplicated estimations; -not detected of fresh weight of EP.

The ratio of the free sugars to total DF (here as NDF) of the fruits when calculated ranged between 2.0 to 12.6% of the fresh EP of the fruits. These results are in a good agreement with the previous results reported[10].

The results of the present study would be contributory for the nutrient composition data base of local foodstuffs. Researchers may use these results in estimating the available carbohydrate portion size needed for the determination of GI values of the respective fruit.

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