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Assessment of the Nutritional Value of Plant-Based Diets in Relation to Human Carbohydrates: A Preliminary Study

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Abstract: The aim of the study is to evaluate which plant foods are suitable for high temperature food processes. Plant foods are the only sources of dietary fiber. Carbohydrates are the major nutrients of fruits and vegetables and human nutrition. Sugars are determined in the combined extracts using high-performance liquid chromatography (HPLC) with a universal evaporative light scattering detector. Results showed that that fructose, glucose, sucrose contents were high in *Cordia myxa* (9.38, 12.75, 29.09%) respectively and the starch content was high in *Alocacia indica* (60.41%). *Alocacia* has high calorie and nutritional value because it contains high carbohydrates contents (72.66%) and *Cordia* was the sweetest fruits because it contains the maximum amounts of sucrose, glucose and fructose. The TDF content was low in *Portulaca oleracia* (dried) (8g %) and was high in *Cordia myxa* (27.7g %). It is observed that vegetables of *Portulaca, Asparagus, Momordica* and *Eulophia* can be recommended in plant-based diets in Iran and India. These vegetables are relatively good carbohydrates sources.

Key words: Carbohydrates, Edible plants, Fiber, India, Iran and nutritional values

INTRODUCTION

Dietary Fiber (DF) plays an important role in decreasing the risks of many disorders such as constipation, diabetes, Cardiovascular Diseases (CVD), diverticulosis and obesity (Bassi *et al*., 1994). Plant foods are the only sources of DF. All the fractions (cellulose, lignin, hemicellulose, pectins, gums and mucilages) of DF are the major constituents of plant cell wall (Douet *et al*., 2004). FAO/WHO discussion document on carbohydrates recommended dropping the terms soluble and insoluble fiber (Charro and Barreiro, 1957). The physiological effects of Total Dietary Fiber (TDF), in the forms of insoluble and soluble fractions of foods, have a significant role in human nutrition (Desmaison and Adrian, 1986).

Indian diets predominantly consist of a variety of plant foods such as cereals, pulses, Green Leafy Vegetables (GLV), roots, tubers, other vegetables, fruits, oil seeds, spices and condiments. Fruits are consumed in various forms like fresh, dried, frozen or canned (FAO, 1998). The polysaccharides comprising a major part of DF in fruits and vegetables are beneficial to healthy human volunteers, since the consumption of fiber lowers plasma cholesterol levels (Food and Nutrition Board, 2002).

Reported protective effect of fruits and vegetables against the development of stroke in men. Addition of fruits and vegetables to the regular diet of infarcted survivors resulted in a decreased mortality and subsequent infarctions (Gopalan *et al*., 2000). Therefore, the dietary fiber may play a major role in determining the health and disease conditions of different population groups.

The data on DF content and its components in fruits are not available in India. The dietary reference value (DRV) for the DF has not been prescribed so far, either in India (Herausgegeben, 2000), or in most other countries. Some organizations suggested 10 g DF/1000 kcal as an interim recommendation (George *et al*., 1993; Marlett, 1992), Institute of Medicine, USA recommended approximately 14 g TF/1000 Kcal. No systematic studies are available so far in this regard. Presently, the food composition tables give Crude Fiber (CF) content but not DF content of foods in India (Mori *et al*., 1996). Moreover, the methodology for the determination of fiber content of foods has changed from time to time from a chemical method (Truswell and Beynen, 1992) to chemical and gravimetric method (Selvendran, 1984).

Carbohydrates are the major nutrients of fruits and vegetables, with sucrose representing one third of total sugars (Singh *et al*., 1993). This disaccharide is one of the important parameters for the assessment of the commercial quality of the fruit, since consumers prefer the sweetest fruits.

Spiller (2001) followed Scales technique (quoted by these authors) in which the Feehling reagent is used, for carrying out one of the first studies on the nutritional composition of fruits, where they found a sucrose content of 5.7% in fresh matter. French investigators published a study on the nutritional composition of fruits from different varieties in their country, and found values for

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this disaccharide ranging from 7.6 to 16.7% of dry matter, whilst reducing sugars ranged between 4.5 and 9.6% of dry matter. These authors however do not specify the method of determination used. Southgate (2006) determined the content of soluble carbohydrates in Italian varieties of fruits, using chromatographic determination with antrone and obtained values then from 7.4 to 8.4 % of dry matter. Senter *et al.* (1994) studied sugars and nonvolatile acid contents in fruits from different varieties of fruits, using gas chromatography, and obtained values of 9.2 g of sucrose% of dry matter and traces of glucose and fructose.

Adverse influence of plant- based diets on BMD: The nutritional intakes of populations are known to vary considerably because of the availability and consumption of different foods. For example, in Asian nations, total energy and protein intakes have traditionally been lower than in Western nations, and lower intakes of these nutrients before the late 1940s, and not hereditary differences, were largely responsible for the reduced growth acceleration in height during the first 2 decades of life. A comparison of typical nutrient intake patterns between Asians, as illustrated by Japanese data, and Western populations, such as in the United States, is shown in Table 1 (Lacey and Anderson, 1990). Some of the same concepts are presented in a different way (Fujita and Fukase, 1992) in relation to osteoporotic fractures among Japanese.

In summary, of the risk factors cited above that contribute to low BMD, Asian women have a more favorable status with respect to balanced dietary intakes from plant foods than do Western women, and possibly with respect to vitamin D status from fish consumption and sunlight exposure as well. Western women, however, have greater intakes of calcium and other nutrients from dairy foods than do Asian women. In addition, Western women have greater intakes of animal proteins and fats, but lower intakes of sodium. Compared with Western women, Asian women have a lower lifetime estrogen exposure and lower BMIs, which increase their risk of osteoporosis, particularly their BMI status.

Table 1: Comparative nutritional intakes of Asian and Western populations*I*

Nutrient	Asian	Western
Total energy	Lower	Higher
Protein		
Total	Lower	Higher
Percentage from plant-food sources	Higher	Lower
Total fat	Lower	Higher
Calcium	Lower	Higher
Phytoestrogens	Higher	Lower

Adapted from reference 10.

MATERIALS AND METHODS

Collection of samples: This study were conducted in Department of Botany, Pune University, India, at 2007.

Eight different types of fruits and vegetables (*Alocacia indica* Sch., *Asparagus officinalis* DC., *Chlorophytum comosum* Linn., *Cordia myxa* Roxb., *Eulophia Ochreata* Lindl., *Momordica dioicia* Roxb., *Portulaca oleracia* Linn. and *Solanum indicum* Linn.) were purchased from were collected from various localities of Maharashtra (India) and Iran. Five wild edible plants were collected from Iran viz *Asparagus officinalis*, *Chlorophytum comosum, Codia myxa, Portulaca oleracia* and *Solanum indicum* were collected from Iran. Efforts made to collect these plants in flowering and fruiting conditions for the correct botanical identification. Healthy and disease free edible plant part/s selected Each variety of fruit and vegetables was collected to assess the variation in their TDF, simple sugars and starch contents.

Samples preparation: Fresh fruits and vegetables were cleaned with water and external moisture wiped out with a dry cloth. The edible portion of the individual fruits was separated, dried in a hot air oven at 50ºC for 1 h. The dried samples were then powdered in blander for further study. Some of the plants dried under shade so as to prevent the decomposition of chemical compounds present in them.

Chemical and Instruments:

Chemicals: 1.25% (w/v) H_2SO_4 and 1.25% (w/v) NaOH solutions, hydro alcoholic solution at 80% (v/v), ethanol solution at exactly 80% (v/v), solution of acetonitrile and water-in a ratio 80/20, standard solutions of different sugars: sucrose, glucose and fructose.

Instruments: Erlenmeyer flask of 250 ml, ultrasound bath, centrifuge, volumetric flask of 50 ml, Erlenmeyer, filters of 0.2 µm, high-performance liquid chromatography (HPLC).

Determination of TDF: Crude fiber is loss on ignition of dried residue remaining after digestion of sample with 1.25% (w/v) H_2SO_4 and 1.25% (w/v) NaOH solutions under specific conditions. Method is applicable to materials from which the fat can be and is extracted to obtain a workable residue, including grains, meals, flours, feeds, fibrous materials, and pet foods (Soest *et al*., 1967).

Extraction of sugars using an ultrasound bath: We weighed 3 g of dry plants and introduced them in a Erlenmeyer flask of 250 ml, adding a hydro alcoholic solution at 80% (v/v), before putting the top on and introducing it in an ultrasound bath for half an hour at 60ºC. Then it was centrifuged at 2500 rpm for 15 min. The supernatant, which contains the sugars of this first extraction, was transferred to a volumetric flask of 50 ml and the residue introduced in a new Erlenmeyer to carry out the second extraction in the same conditions as mentioned above. The floating material was again

transferred to a flask of 50 ml which contained the previous floating material and this was diluted in an ethanol solution at exactly 80% (v/v). This solution contained the sugars from the initial samples and once filtered-filters of 0.2 µm and degasified it was utilized for analysis using liquid chromatography.

Determination of sugars using Advanced HPLC: Sugars are determined in the combined extracts using high-performance liquid chromatography (HPLC) with a universal evaporative light scattering detector. In the mobile phase we used a solution of acetonitrile and water- in a ratio 80/20-previously filtered and degasified, like the sample. The column used was of the amino kind (Teknokroma, kromasil 100 NH_2 5 µm 25×0.46 cm^2), thermostatized at 30ºC in order to avoid fluctuations in detector responses. Working conditions were: flow rate of 1.5 ml/min, detector temperature 130ºC and pressure 40 mmHg. The analyses were performed in triplicate batches (Southgate, 2006).

Before the quantitative and qualitative determination of sugars in the sample, we prepared standard solutions of different sugars: sucrose, glucose and fructose. With those standard solutions of different sugars we made calibration lines for each one of the sugars, which were later used for assessing the concentrations corresponding to the different peaks in the chromatograms.

Statistical methods: For the statistical analysis of our sampling we have used the Windows SPSS 10.0. Comparisons were carried out at 95% confidence by application of the Anova and Dunnet Test, which establishes a comparison of means of sucrose and glucose contents between the plants varieties.

RESULTS AND DISCUSSION

Fig. 1 showed the CF, IDF and SDF expressed as % of TDF, contents of common vegetables and fruits. Among the vegetables, the TDF content was low in *Portulaca oleracia* (dried) (8g %), and high in *Cordia myxa* (27.7g %). The TDF contents of the fruits ranged between 23.9 and 25.7g % in *Solanum indicum* Linn and *Cordia myxa* respectively. The SDF content of vegetables ranged from 22.9 g % in *Eulophia ochreata* to 8g % in *P. oleracia* The TDF % was minimum in *P. oleracia* (8%) and maximum in *C. myxa* (25.7%). The TDF % was moderate in *Chlorophytum comosum* (17.24%). The TDF % was high in *Momordica dioicia* (21.3%), *Eulophia ochreata* (22.9%) and *S. indicum* (23.9%). The TDF % was low in *Alocacia indica* (11.05%) and was relatively high in *Asparagus officinalis* (18.5%).

Fig. 2-5 gives that fructose, glucose, sucrose contents were high in *C. myxa* (9.38, 12.75, 29.09%) respectively and the starch content was high in *Alocacia indica* (60.41%) and fructose and glucose contents were low in *P. oleracia* (0.86, 0.01%) respectively and sucrose content

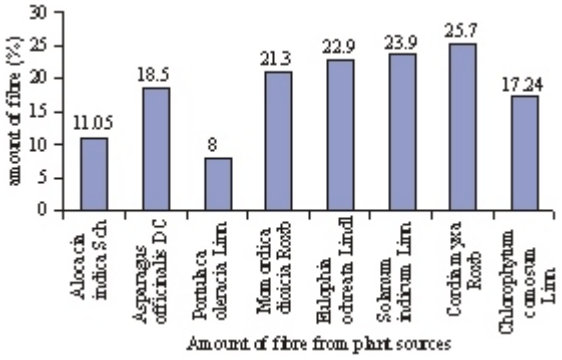

Fig. 1: Fiber contents of plants sources

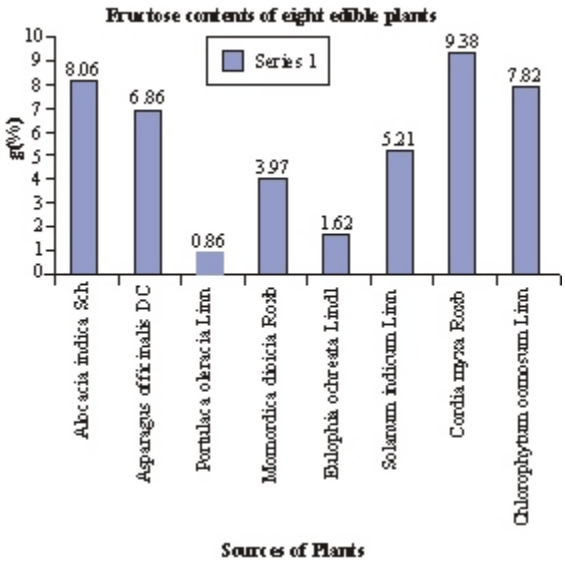

Fig. 2: Fructose contents of plants sources

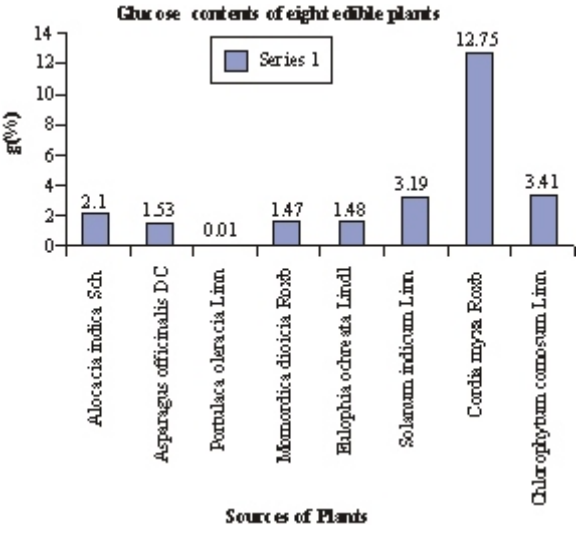

Fig. 3: Glucose contents of plants sources

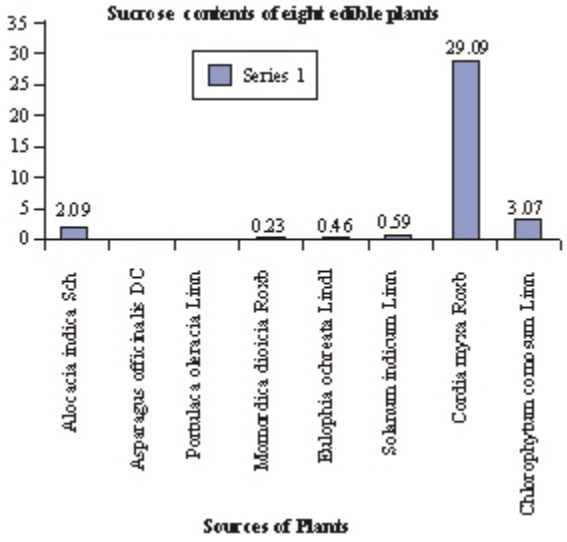

Fig. 4: Sucrose contents of plants sources

was not detected in *A. officinalis* and *P. oleracia*, starch content was low in *C. myxa* (5.86%).

Intervarietal comparison of results showed that the sucrose variables were not significantly different between *Eulophia*, *Solanum* and *Asparagus*, *Portulaca* and also the glucose variables were not significantly different between *Asparagus*, *Momordica* and *Momordica, Eulophia*,and *Solanum*, *Chlorophytum*.

The vegetables of *Asparagus*, *Portulaca, Momordica eulophia*, *Solanum* contain lowest content of the disaccharide, whilst *Cordia* was the sweetest fruits because it has the maximum amounts of sucrose, glucose and fructose.

The values for sucrose in other plants was very low, which may be due to a partial hydrolysis of sucrose.

Therefore, *Alocacia* have high calorie and nutritional value because it contain high starch and total carbohydrates contents but because it contains high Antinutrients is not suitable for consumption (Fig. 6).

Parmar, *et al.* (1982), carbohydrates contents of *Cordia myxa* Roxb. reported in below:

The fruit contains total sugars, 3.55g; reducing sugars, 3.41g; non-reducing sugars, 0.08g, and pectin, 4.5g; all per 100g of the edible portion.

Duke and Ayensu (1985), carbohydrates contents of *Asparagus officinalis* DC. Reported in below: In grammes per 100 g stem fresh weight of food : Carbohydrate: 5 Fibre: 0.7. Carbohydres contents of *Portulaca oleracia Linn* reported by Ezekwem *et al.* (1999) in below: Leaves (Dry weight) in grammes per 100 g weight of food : Carbohydrate:50 Fibre:11.5.

Carbohydrates contents of *Chlorophytum comosum Linn* has been showed by Becker (1983), in below: Carbohydrates: 35-42%.

Comparison of obtained results from this study with other workers results showed that carbohydrates amounts

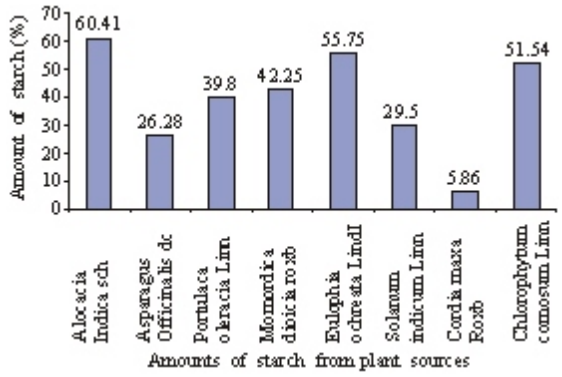

Fig. 5: Starch contents of plants sources

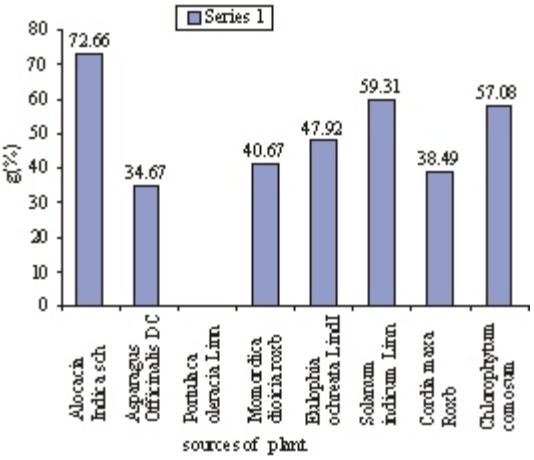

Fig. 6: Total carbohydrates contents of plants sources

of studied edible plants in this research except *Portulaca* were higher than obtained results from other workers.

It is observed the edible plants of *Portulaca, Asparagus, Momordica* and *Eulophia* are relatively good carbohydrates sources in plant -based diets.

Concluding Remarks: The nutrition parameters, such as water, starch and free sugars, in the edible plants studied, are in accordance with the literature data. The free sugars concentrations appear to be high in the *Solanum indicum*, Cordia myxa, and *Chlorophytum comosum* plants. The starch concentration is low in the *Cordia myxa* plant.

Three plants, *Momordica dioicia*, *Eulophia ochreata* and *Portulaca oleracia,* as new Plant Foods, are suitable for high temperature food processes, because they have very low free sugars concentrations; thereby reducing the possibility of Maillard reaction and then acrylamide formation.

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