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Free Sugars and Fructan Contents of Commonly Consumed Fruits of Maiduguri Metropolis North East Nigeria

Abubakar Gidado*, Aliyu Daja, Zainab Mohammed Kassim, Aisha Idris and Mohammed Audu

Department of Biochemistry University of Maiduguri, Maiduguri, Nigeria

Abstract

Rationale: Free sugars are dietary monosaccharide (glucose, fructose, galactose etc.) that are absorbed directly into the bloodstream during digestion. The fructans are however not easily absorbed. Both types have a wide range of health benefits. Fruit is known to be a rich source of these classes of carbohydrates.

Objective: The objective of this study is to estimate free sugars and fructans in commonly consumed fruits in Maiduguri metropolis of North East Nigeria with a view to developing for the first time a food compositional table which reflects the presence and amounts of specific free sugars and fermentable oligosaccharides (fructans) in fruits within the study area.

Methodology: Twenty-two (22) fruits samples were collected and processed. Free sugars and fructan contents in the fruits were determined using the Megazyme K-SUFRG and K-FRUC assay kits.

Results: All the twenty-two fruits analyzed showed the presence of free glucose with tamarind (*Tamarindus indica*) showing the highest concentration, followed by sweet melon (*Curcumas melon*) and desert palm (*Balanite aegyptiaca*) respectively. Sweet detar (*Detarium microcapum)* had the lowest free glucose content of 0.01 g/100 g. On the contrary, only 50% of the total fruits studied had some detectable free fructose and sucrose. Free fructose content in oranges>African locust bean>desert date (3.34 g/100 g>1.09 g/100 g>0.82 g/100 g). The amount of sucrose in plantain (*Musa paradisiaca*) was 20.01 g/100 g which is 2-folds higher than its contents in Chris thorn (*Zizipus spinacristi*). Daleb Palm (*Borassus aethiopum*) was found to be rich in fructans followed closely by bananas and plantains. All other fruits studied showed less than 0.9% of fructan contents.

Conclusion: Information from this study provides a useful document for the development of food composition table that is reflective of the free sugars and fructan contents of fruits consumed within the region.

Keywords: Free sugars (glucose and fructose); Fructans; Fruits; Serving size

Introduction

The rising awareness of childhood obesity and its associated diseases, the risk of diabetes, cardiovascular diseases and a host of many others has generated a lot of researches in the area of foods, fruits, and vegetables as a source of nutraceuticals and functional foods. There is evidence on the link between consumption of added sugars, free sugars and sugar-sweetened beverages with many undesirable health side effects like dental caries [1], insulin resistance [2], type 2 diabetes, metabolic syndrome [3], cardiovascular diseases [4] and fatty livers [5]. In respect of these, the WHO in 2015 recommended a reduction in free sugar intake for children and adults to less than 10% of total energy intake with a further reduction of 5% more of total energy in order to maintain additional health benefits.

The daily consumption of fruits and vegetables has been associated with a reduced risk of various diseases all over the world. Fruits are known to contain vitamins, minerals, fibres, and many phytochemicals that help in maintaining a healthy body. Fruits are also a good source of prebiotics [6-8]. The prebiotics is functional foods that offer beneficial effects to the individuals by assisting the gut microbiota in maintaining a healthy environment. They are non-digestible part of food that reaches the caecum structurally unchanged [9]. They are, however, hydrolyzed through fermentation by colonic microflora such as bifidobacteria and lactobacilli, generating gases which are rapidly absorbed by the colonic mucosa [10]. Many studies have shown the presence of prebiotics in the form of fructooligosaccharides in various fruits and vegetables consumed daily.

As part of a healthy diet low in fat, sugars and sodium and rich in many other benefits, WHO recommends consumption of more than 400 g of fruits and vegetables per day (which translates to 5 portions per day) to improve overall health and reduce the risk of certain non-communicable diseases including cardiovascular diseases and certain types of cancers [11].

Information on the amounts of free sugars and fructans in fruits consumed in Nigeria and many other African countries is lacking. Knowledge about the free sugars and fermentable oligo-, di-, monosaccharides and polyols (FODMAP) composition of foods may be useful to both healthy individuals or to patients with gastrointestinal disorders who may want to limit their intake due to undesirable gastrointestinal symptoms. In addition, a comprehensive food composition table is a necessary tool for policymakers in public health sector in the assessment of the dietary quality of foods during nutritional management and in the management of metabolic disorders such as diabetes, obesity, osteoporosis, and cardiovascular diseases.

This study is aimed at detection and estimation of free sugars and fructan contents in commonly consumed fruits in Maiduguri metropolis of North East Nigeria with a view to developing for the first time a food compositional table which reflects the presence and amounts of specific

***Corresponding author:** Abubakar Gidado, Department of Biochemistry University of Maiduguri, Maiduguri, Nigeria, Tel: +2348032828098; E-mail: abugidado@unimaid.edu.ng

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free sugars and fermentable oligosaccharides (fructans) in fruits within the study area.

Materials and Methods

Samples collection and processing

The fruits selected for analyses were twenty-two (22) fresh fruit samples that are consumed within the locality and purchased from the local fruits and vegetable markets. All the samples were sourced from at least three (3) different locations and were successfully analyzed for free glucose, fructose, sucrose and fructan contents using the Megazyme K-FRUC/K-SUFRG Assay kits. All other chemicals were purchased from Sigma Aldrich. All analyses were performed on the raw (unprocessed) form and data were generated in triplicates.

Estimation of free sugars

Free glucose, fructose and sucrose contents of the samples were estimated by the method described by [12,13] using megazyme K-SUFRG assay kit (Megazyme International Ireland Ltd, Wicklow, Ireland). Briefly, into four cuvettes labelled as blank sucrose sample, sucrose sample, blank free sugar and free sugar sample, 0.20 ml of β-fructosidase reagent was added to the blank sucrose sample and sucrose sample cuvettes and 0.10 ml of the extracted sample was added to the sucrose sample and the free sugar sample cuvettes mixed and allowed to stand for 5 minutes at 30°C. To the entire cuvettes, blank sucrose sample, sucrose sample, blank free sugar and free sugar sample, 2.0 ml, 1.9 ml, 2.2 ml and 2.1 ml of distilled water was added respectively followed by the addition of 0.1 ml of buffer and 0.1 ml of NADP/ATP solution mixed and incubated for another 3 minutes. Absorbance (A_1) was read at 340 nm. To all the cuvettes again, 0.02 ml of HK/G6P-DH solution was added and the absorbance (A_2) was read. Finally, to the blank free sugar and free sugar sample cuvettes, 0.02 ml of PGI solution was added and the absorbance (A_3) was read at same 340 nm. The free sugar contents were expressed as g/100 g weight.

Fructan extraction

Fructans were extracted from the milled sample by the warm (~80°C) aqueous method. Starch and free interfering sugars were removed using enzymatic (Sucrase/Amylase) alkaline borohydride treatment to produce "pure" fructan solution termed Solution S.

Hydrolysis and measurement of fructans

Hydrolysis and measurement of the fructans were done using the Megazyme K-FRUC assay kit ((Megazyme International Ireland Ltd, Wicklow, Ireland)) procedure. Briefly, 0.2 mL aliquots of Solution S were placed into the bottom of three (3) glass test-tubes (16 nm × 100 mm). To that 0.1 mL of fructanase solution (Enzyme Solution B) was added to two of these tubes (samples) and 0.1 mL of 0.1 M sodium acetate buffer to the third (sample blank). The tubes were incubated at 40°C for 30 min to effect complete hydrolysis of fructan to D-fructose and D-glucose. The tubes were sealed with Parafilm during incubation. To the overall mixture of 5.0 mL of PAHBAH working reagent was dispensed to all the tubes (Controls and Precautions adhered), and incubated in a boiling water bath for exactly 6 minutes. The tubes were removed from the boiling water bath and immediately placed them in cold water (18-20°C) for 5 minutes. The absorbance of all solutions was measured at 410 nm against the reagent blank.

$$=\Delta A \times F \times 5 \times V \times 1.1/0.2 \times 100/W \times 1/1000 \times 162/180$$

$$=\Delta A \times F \times V/W \times 2.48$$

Where:

ΔA=sample absorbance-sample blank absorbance (both read against the reagent blank)

F=factor to convert absorbance values to µg of D-fructose

=(54.5 µg D-fructose)/(absorbance for 54.5 µg D-fructose)

5=factor to convert from 0.2 mL as assayed to 1.0 mL

V=volume (mL) of extractant used (i.e. 50 or 100 mL)

1.1/0.2=0.2 mL was taken from 1.1 mL of enzyme digest for analysis

W=weight (mg) of sample extracted

100/W=factor to express fructan as a percentage of flour weight

1/1000=factor to convert from µg to mg

162/180=factor to convert from free D-fructose, as determined to anhydrofructose (and anhydroglucose), as occurs in fructan.

Results

Twenty-two edible fruits commonly consumed in Maiduguri and environs were analyzed for free glucose, fructose, and sucrose and fructan contents. All the fruits analyzed showed the presence of free glucose, tamarind (*Tamarindus indica*) had the highest free glucose content of 16.92 g/100 g, followed by sweet melon (*Cucumis melon*) with 16.11 g/100 g and desert date (*Balanite egyptiaca*) with 12.30 g/100 g. Sweet detar (*Detarium microcapum)* showed the lowest free glucose content of 0.01 g/100 g. On the contrary, not all fruits (only about 50%) had a varying concentration of free fructose, while the remaining 50% of the fruits analyzed did not show the presence of free fructose. Orange (*Citrus senensis*) presented the highest free fructose content with a value up to 3.34 g/100 g, then African locust bean (*Parkia biglobosa*) which showed 1.09 g/100 g and Daleb Palm (*Borassus aethiopum*) with 0.82 g/100 g of free fructose. Similarly, just above 50% of the fruits had indicated the presence of the sugar in sucrose form. Plantain (*Musa paradisiaca*) had the highest sucrose content of 20.01 g/100 g and Bananas (*Musa sapientum*) 15.47 g/100 g was second and then Chris thorn (*Zizipus spinacristi*) with 9.84 g/100 g sucrose was third. Daleb Palm (*Borassus aethiopum*) was the fruit found to be rich in fructan content 2.33% while Bananas (*Musa sapientum*) and Plantain (*Musa paradisiaca*) followed with 1.42% and 1.29% respectively, as important as it is all the other fruit showed less than 0.90 % of fructan.

Discussion and Conclusion

Fruits are sugar-rich edible portions of a plant, most containing D-glucose, fructose, and sucrose in addition to many vitamins, minerals and phytochemicals in varying proportions depending on the ripeness/maturity of the fruit. Glucose as a high glycemic index substance, its presence in fruit or any food type is capable of modifying the glycemic status of individuals that consumed them either positively or negatively depending on the energy requirement of that person. Out of the 22 fruits analyzed, tamarind was found to have the highest free glucose content, while the lowest was sweet deter. Tamarind is a fruit largely used in the study area in making local pap called 'kunungyada', 'kununtsamiya' and as a soft drink called 'ardep' when mixed together with ginger, cloves and burnt sugar (added sugar). Although the high glucose content of tamarind may look a bit worrisome, the presence of free glucose and other free sugars in the fruit avails the individuals that consume them with more natural micronutrients than those with added sugar [14] hence beneficial, even though there are schools of

thought that believe both added and natural sugars in food have the same effect [15].

The monosaccharide, fructose, is also one of the free sugars found in high concentration in fruits, fruit juices, honey, and high-fructose corn syrup [16]. Orange (*Citrus senensis*) was the fruit that showed the highest free fructose with an amount similar to what was reported by [17]. Fructose is poorly absorbed across the villous epithelium which can result in gastrointestinal discomfort such as bloating, flatulence, and altered bowel habit [18-20], however, fructose often exists alongside glucose and hence absorption is enhanced [21], thus knowing the excess of free fructose of food is imperative to avoid the aforementioned complication. All the fruits except Desert date and Black plum had detectable fructans in the range of 0.01 g-2.33 g/100 with Daleb palm having the highest value while cashew had the least.

As observed from Table 1, fruits with higher free glucose contents showed very low fructans. Considering the fact that fructans and free sugars consumption both pose beneficial and non-beneficial outcomes, careful planning of diet by dieticians managing individuals with dietary related problems is very important. Therefore, information provided in this study will assist in achieving the goal. For example, in order to meet up and maintain the five a day (400 g/day) servings of fruits and vegetables recommended by WHO for a healthy well-being, it is important to note the amount of free sugars and fructans each serving of fruits will provide when consumed alone or as a composite in salads or with other foods. A serving size of fresh fruits is taken to be approximately 80 g, however, fruits tend to be consumed more than vegetables in people of higher socioeconomic status [22] therefore individuals may consume fruits in cupful sizes of 250 ml volume of juices or 250 g weight of a cupful. A juice made out of tamarind pulp which is used in the preparation of 'kunungyada', 'kununtsamiya' or 'ardep' will by extrapolation contain 13.54 g and 0.02 g of free glucose and fructan respectively per serving size of 80 g. A serving size of oranges provides approximately 7.58 g free glucose, 2.67 g fructose and <0.1 g fructan contents. Watermelon which is popular and mostly sold as sliced fruit by its vendors at an affordable price within the city especially when in season contain 2.53 g, 0.48 g and 0.26 g of free glucose, sucrose and fructans respectively per recommended serving size. Desert palm fruits are medicinal in nature and are used in the preparation of foods such as 'kununadua' in the study area. These fruits are rich in sugars and many phytochemicals and are claimed to have anti-diabetic effect in streptozotocin induced diabetic mice [23]. This study showed the fruits to provide per serving size approximately 9.84 g free glucose, 0.66 g free fructose and 1.38 g sucrose with no detectable fructans and therefore gives an idea of sugar contents in desert palm fruits to individuals who consume them and are interested in watching their glucose and sucrose intake. All fruits studied are low in fructans when compared with those from vegetables [24] with serving size ranging between 0.01 g-1.86 g. The amount of fruits one chooses to eat at any given time is called a portion size. This quantity may be more or less than a serving size. Therefore, a portion size of fruit salad made up of a quarter cup (62.5 g) each of oranges, pawpaw, pineapple, mango, watermelon, sweet melon and banana by extrapolation contributes an approximate total of 27.96 g free glucose, 2.87 g fructose, 11.24 g sucrose, and 0.91 g fructans (Table 2).

In order to meet up with the recommended daily dietary intake of fruits and vegetables, and the 5% total energy intake in terms of sugars to maintain health, it is important to understand the quantities of various sugars and FODMAP present in our commonly consumed fruits.

S. No.	Common Name	Scientific Name	Local Name	Free Glucose g/100 g	Free fructose g/100 g	Sucrose g/100 g	Fructan (%)
	West African ebony	*Diospyros mespiliformis*	'Kanya' (Hausa),'Burum' (Kanuri)	3.07 ± 0.89	0.62 ± 0.28	ND	0.17 ± 0.02
	Bananas	*Musa sapientum*	'Ayaba' (Hausa)	5.02 ± 0.14	ND	15.47 ± 0.31	1.42 ± 0.09
	Plantain	*Musa paradisiaca*	'Ayabaagada' (Hausa)	7.94 ± 0.14	ND	20.01 ± 0.65	1.29 ± 0.05
	Apple (Red)	*Malus sylvestris*	'Tufa' (Hausa)	3.64 ± 0.15	ND	ND	0.34 ± 0.03
	Apple (Green)	*Malusdomestica var.*	'Tufa' (Hausa)	4.07 ± 0.17	ND	ND	0.32 ± 0.01
	Jujube	*Zizipus mauritiana*	'Magariya' (Hausa), 'Kusulu' (Kanuri)	2.19 ± 0.03	ND	8.72 ± 0.13	0.49 ± 0.18
	Chris thorn	*Zizipus spinacristi*	'Kurna' (Hausa)	0.59 ± 0.16	ND	9.80 ± 0.26	0.54 ± 0.06
	Lime	*Citrus aurantifolia*	'Lemuntsami' (Hausa), 'Lemunchomchom'(Kanuri)	0.62 ± 0.09	ND	0.93 ± 0.13	0.86 ± 0.09
	Water melon	*Citrullus lanatus*	'Kankana' (Hausa), 'Fari' (Kanuri)	3.16 ± 0.24	ND	0.60 ± 0.09	0.33 ± 0.08
	Baobab fruit	*Adansonia digitata*	'Kuka' (Hausa), 'Kuwa' (Kanuri)	0.45 ± 0.04	0.08 ± 0.03	2.00 ± 0.36	0.22 ± 0.19
	Sweet detar	*Detarium microcapum*	'Taura' (Hausa), 'Gatafo' (Kanuri)	0.01 ± 0.00	ND	7.64 ± 0.16	0.12 ± 0.06
	Tamarind	*Tamarindus indica*	'Tsamiya' (Hausa), 'Tomsuu' (Kanuri)	16.92 ± 0.29	ND	ND	0.03 ± 0.00
	African locust bean	*Parkia biglobosa*	'Dorawa' (Hausa), 'Runo' (Kanuri)	11.53 ± 0.89	1.09 ± 0.27	0.52 ± 0.16	0.64 ± 0.01
	Orange	*Citrus senensis*	'Lemunzaki' (Hausa),'Lemun' (Kanuri)	9.48 ± 0.33	3.34 ± 0.46	ND	0.06 ± 0.09
	Desert date	*Balanite egyptiaca*	'Adua' (Hausa), 'Betto' (Kanuri)	12.30 ± 0.02	0.82 ± 0.04	1.72 ± 1.10	ND
	Pawpaw	*Carica papaya*	'Gwanda' (Hausa)	4.85 ± 0.11	0.63 ± 0.48	ND	0.02 ± 0.09
	Pineapple	*Ananas comosus*	'Abarba' (Hausa),	8.11 ± 0.39	0.44 ± 0.07	1.90 ± 0.62	0.03 ± 0.08
	Black plum	*Vitex doniana*	'Dinya' (Hausa), 'Ngarimi' (Kanuri)	0.38 ± 0.07	0.20 ± 0.16	ND	ND
	Daleb Palm	*Borassus aethiopum*	'Giginya' (Hausa), 'Ganagaa' (Kanuri)	4.88 ± 0.00	ND	ND	2.33 ± 0.03
	Cashew	*Annacardium occidentale*	'yazawa' (Hausa), 'Kashut' (Kanuri)	8.60 ± 1.63	0.48 ± 0.08	ND	0.01 ± 0.00
	Mango	*Mangifera indica*	'Mangwaro' (Hausa), 'Mongoro' (Kanuri)	0.67 ± 0.02	0.17 ± 0.06	ND	0.70 ± 0.03
	Sweet Melon	*Cucumis melo*		16.11 ± 0.06	ND	ND	0.03 ± 0.00
Values are means of three individual determinations ± standard deviation. ND=not detected							

Table 1: Free glucose, free fructose, sucrose and fructan contents of some commonly consumed fruits in Maiduguri Metropolis, North East Nigeria.

SNo.	Common Name	Scientific Name	Average Serving Size (g)			
			Free Glucose	Free fructose	Sucrose	Fructan
	West African ebony	*Diospyrosmespiliformis*	2.46	0.496	NI	0.14
	Bananas	*Musa sapientum*	4.02	NI	12.38	1.14
	Plantain	*Musa paradisiaca*	6.35	NI	16.01	1.03
	Apple (Red)	*Malus sylvestris*	2.91	NI	NI	0.27
	Apple (Green)	*Malus domestica var.*	3.26	NI	NI	0.26
	Jujube	*Zizipus mauritiana*	1.75	NI	6.98	0.39
	Chris thorn	*Zizipus spinacristi*	0.47	NI	7.84	0.43
	Lime	*Citrus aurantifolia*	0.50	NI	0.74	0.71
	Water melon	*Citrullus Lanatus*	2.53	NI	0.48	0.26
	Baobab fruit	*Adansonia digitata*	0.36	0.06	1.6	0.18
	Sweet detar	*Detarium microcapum*	0.01	NI	6.11	0.10
	Tamarind	*Tamarindus indica*	13.54	NI	NI	0.02
	African locust bean	*Parkia biglobosa*	9.22	0.87	0.42	0.51
	Orange	*Citrus senensis*	7.58	2.67	NI	0.05
	Desert date	*Balanite egyptiaca*	9.84	0.66	1.38	NI
	Pawpaw	*Carica papaya*	3.88	0.50	0.00	NI
	Pineapple	*Ananas comosus*	6.49	0.35	1.52	NI
	Black plum	*Vitex doniana*	0.30	0.16	NI	NI
	Daleb Palm	*Borassus aethiopum*	3.90	1.92	0.00	1.86
	Cashew	*Annacardium occidentale*	6.88	0.38	1.48	0.01
	Mango	*Mangifera indica*	0.54	0.14	NI	0.56
	Sweet Melon	*Cucumis melo*	12.89	NI	NI	0.24
NI=Not indicated, (no serving size was extrapolated because the parameters are not detected in the study)						

Table 2: Average serving size of free glucose, free fructose, sucrose and fructan contents of some Commonly consumed fruits in Maiduguri Metropolis, North East Nigeria.

Despite the availability of fruits in abundance during its peak harvest seasons and dried fruits all-round the year, the recommended daily intake of fruits in the study area is still below the least required for the maintenance of a healthy status. This is due to the lack of vital knowledge on the importance of consumption of fruits in fighting diseases. This study has provided information for the first time on the free sugars and fructans contents of commonly consumed fruits within the study area. No doubt this information may help policymakers in formulating regulations pertaining dietary related issues within the society.

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