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Free Glucose, Fructose, Sucrose and Total Fructan Contents of Some Commonly Consumed Vegetables in Maiduguri Metropolis, North East Nigeria

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Abstract
Vegetables are a rich source of carbohydrates such as the free sugars (glucose fructose, sucrose) and their polymers (fructans, starch and non-starch polysacharides) that have both beneficial and detrimental impact on health when consumed. The objective of this work is to estimate the contents of free glucose, fructose, sucrose and fructans in commonly consumed vegetables in Maiduguri metropolis of North East Nigeria. The Megazyme assay kits were used to extract and quantify the free sugar and the fructan contents of the vegetables. All the vegetables with the exception of Garlic contained varying amounts of free glucose ranging from 0.1 – 9.34 g/100g of the samples. Free fructose was not detected in Sesame leaves (*Sesamum indica*), coffee senna (*Senna occidentalis*), baobab leaves, *Mormodica charantia*, *Moringa oleifera* leaves and pumpkin. Garlic (*Allium sativum*), coffee senna (*Senna occidentalis*) and kenaf leaves (*hibiscus cannabinus*) had sucrose ranging between 1.06 – 2.1 g/100g. Garlic (*Allium sativum*) contained the highest fructan content measuring 8.97±0.19% and the least estimated concentration was seen in red pepper (*Capsicum spp*). Tomato (*Lycopesicon esculenta*) and pumpkin (*Curcubita pepo*) from this study had no detectable fructans.The results have suggested that the vegetables consumed in Maiduguri metropolis have a wide distribution of free sugars and fructans. Thus, the information from this study can be used for the development of food composition table of vegetables within the region.
Keywords: Free sugars (Glucose and Fructose); Fructans; Serving size; Vegetables.

1.0. Introduction

Carbohydrates are a major source of energy in the human diet providing the vital amount of the body's total energy requirements (Muir *et al.,* 2009). Often monosaccharide like glucose, fructose and disaccharides like sucrose and lactose are the metabolizable source of the energy which are often found in varying amount in diets like the vegetables. A side providing energy, these classes of carbohydrates modulates the physiology of the body such as control of blood glucose, insulin metabolism, and serum cholesterol (FAO, 1998).Research in the area of fermentable oligo-, di-, monosaccharides and polyols is also receiving a lot of interest in the field of nutritional science today because of its importance in improving the health of the GIT.

Fruits and vegetables are rich sources of these fermentable oligo, di- and monosaccharides. Fructan is a general name for any carbohydrate in which one or more fructosyl fructose links constitute the majority of glycosidic bonds (Roberfroid and Delzenne, 1998; Sivieri *et al.*, 2014). They can be short chains (2 – 9 unit length) fructooligosaccharides (present in fruits, vegetables, rye, wheat and other cereals) or long chains (>10 units) polysaccharide (Roberfroid, 2005) called inulin (present in bananas, onions, garlic, chicory, Jerusalem artichokes (Sabater-Molina *et al.,* 2009; Anadon *et al.,* 2016). They are synthesized in plants from sucrose by repeated fructosyl transfer and therefore usually exhibit terminal glucose unit. Presence of the terminal glucose unit linked by beta 2,1 glycosidic bonds in the chain of fructose units made this compound non digestible by the glycosidases present in the stomach (Teitelbaum and Walker, 2002). Fructooligosaccharides are non-digestible by the intestinal glycosidases and so reach the cecum structurally unchanged (Sabater-Molina *et al.,* 2009). They are hydrolysed through fermentation by colonic microflora such as bifidobacteria and lactobacilli generating gases such as carbondioxide, hydrogen, methane and reducing colonic pH by the production of lactate and short chain fatty acids like acetate, propionate, methylmalonyl-coA, succinyl-coA and butyrate which are rapidly absorbed by the colonic mucosa (Costa *et al.,* 2015).

Fructans are classified as prebiotics and dietary fibres by CODEX Alimentarius (2010). As prebiotics/dietary fibres the daily intake of FOS is reported to be about 3-11g in Europe and 1- 4g in the U.S. (Saeed *et al.,* 2015). However, there are no reports or data specifying the intake of such beneficial functional foods in Nigeria and other Sub Saharan Africa. Dietary fibres have the ability to modify cephalic-, gastric-, and intestinal – phase processes of ingestions, digestion and absorption providing numerous opportunities to influence satiation and satiety (Burton –Freeman, 2000). The recommended daily intake of dietary fibre for healthy adults is between 20 and 35g/day (Pilch, 1987; Burton-Freeman, 2000). Fructans are known to contain numerous functional ingredients including dietary fibre, oligosaccharides, sugar alcohols, peptides, proteins,

prebiotics, antioxidants and polyunsaturated fatty acids (Stark and Madar, 1994; Butt and Sultan, 2011).

Prebiotics are non-digestible food ingredients that promote the growth of beneficial microorganisms in the intestines. Foods classified as prebiotics help nourish the microflora of the gastrointestinal tract and offer many health benefits to humans and animals. The beneficial effects of FOS include prebiotic effect (Fuller and Gibson, 1997; Sivieri *et al.,* 2014), improved mineral absorption (Lopez et al., 2000; Yu Wang et al., 2010), and decreased serum cholesterol, triglycerides and phospholipids (Roberfoid, 2000; Ricci *et al.,* 2011 and Pachikian *et al.,* 2013).

Consumption of fruits and vegetables reduces the risk of several chronic ailments. Experts recommend daily intake of atleast 400g of fruit and vegetables in order to maintain a healthy status (WHO Technical Report Series, 2003) and many countries have since adopted this recommendation in their dietary guidelines. In defining the average serving size of foods, fruits and vegetables, the lack of a common definition for the collective term 'fruits and vegetables' still remain a challenge such that giving a valid measure of fruits and vegetable intake in less developed countries become a herculean task (Agudo, 2004). According to Part 101.9(4)(b)(1) the term serving size or serving means an amount of food customarily consumed per eating occasion by persons 4 years of age or older which is expressed in both common household and metric measure in brackets.

Information about the free fructose, glucose, sucrose, fructans and galactooligosaccharide contents of a wide range of foods in the western world is available in the literature; however, there is little or no data about these compositions in our commonly consumed foods in Nigeria. Knowledge of the free fructose, glucose, fructan contents of our commonly consumed foods, fruits and vegetables will provide useful information in generating a food composition table. A comprehensive food composition table is a very important tool in public health in the assessment of dietary quality of foods during nutritional management of metabolic disorders.

This study is aimed at estimating the free glucose, fructose and fructan contents of some commonly consumed vegetables in Maiduguri metropolis North east Nigeria.

2.0 MATERIALS AND METHODS

2.1 Study Location

Maiduguri also called Yerwa by locals is the capital and the largest city of Borno State in north-eastern Nigeria, located on latitude: 11°51'N; and longitude: 013°05'E (Wikipedia). It has an estimated population of over two million. Because the town is the principal trading hub for north-eastern Nigeria, its population is mostly traders and civil servants. The economy is largely based on services and trade with a small share of manufacturing (figure 1).

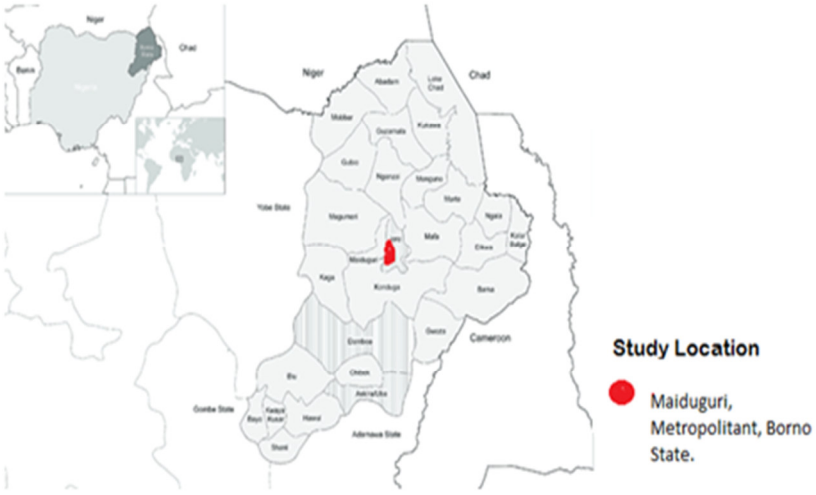

Figure 1 A global map showing the location of Maiduguri

2.2 Sample collection and Processing

The foods chosen for analyses were twenty (20) fresh vegetable samples that are consumed within the locality and purchased from the local fruits and vegetable markets. For each vegetable used, Ten grams (10g) purchased from the three different markets, were cleaned of dirt, cut into small pieces, mixed together grind or blend, from which 0.5g each was used for analyses.

2.3 Estimation of Free Sugars

Free glucose, fructose and sucrose contents of the samples was estimated by method described by Kunst *et al.,* 1988; and Beutler, 1988 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 extract sample was added to the sucrose sample and the free sugar sample cuvettes, mixed and allowed to stand for 5 minutes at 30^{o}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. 0.1 ml of buffer and 0.1 ml of NADP/ATP solutions were added, mixed and incubated for another 3 minutes and absorbance (A_1) was read at 340 nm. To all the cuvettes 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/100g weight.

2.4 Fructan Extraction and Removal of Starch and Free Sugars

The Megazyme procedure for extraction and analysis was followed (Megazyme International Ireland Ltd, Wicklow, Ireland). The first step was the extraction of the fructan from 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**

2.4.1 Hydrolysis and Measurement of Fructan

Fructans present in the samples were analysed by accurate and careful transfer of 0.2 mL aliquots of Solution S into the bottom of three (3) glass test-tubes (16 x 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 5.0 mL of PAHBAH working reagent was dispensed to all tubes [samples, sample blanks, the D-fructose standard (Controls andPrecautions adhered), reagent blank (Controls and Precautions) and the extract of the fructan/cellulose control sample] and incubated in a boiling water bath for exactly 6 minutes. The tubes were removed from the boiling water bath and immediately placed in cold water (18-20°C) for approx. 5 minutes. The absorbance of all solutions was measured at 410 nm against the reagent blank.

= ΔA x F x 5 x V x 1.1/0.2 x 100/W x 1/1000 x 162/180

= ΔA x F x V/W x 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.

3.0 RESULTS

3.1 D –Glucose, D – Fructose and Sucrose Contents in Commonly Consumed Vegetables in Maiduguri metropolis

The free glucose and free fructose contents of twenty commonly consumed vegetables in Maiduguri metropolis North east Nigeria is presented in Table 1. *Moringa oleifera* recorded the highest estimated free glucose (9.34 g/100g) with value 2 folds more than 'mambui' (*Mormodica charantia).* Onion leaves contained the most free fructose content with values close to Bell paper and African locust bean. Sorel leaves had the lowest estimated free glucose contents (0.08 g/100g), while sorrel leaves, balsam apple and garlic had the least determined free fructose content with (0.10 g/100g) each amongst all the vegetables studied. Balsam apple is the vegetable with the most sucrose content (2.34 g/100g) followed by Coffee senna (2.10 g/100g) and Onion (2.29 g/100g) whilstsorrel leaveshad (0.07 g/100g) being the least estimated sucrose contents in all the vegetables analysed.Expressing this in terms of serving size, Table 2 shows some of the free sugars, sucrose and fructans present per vegetable servings. Results were obtained by extrapolation from the average serving size provided such that a vegetable serving size is considered 80g and a recommended total of 400g is achieved by daily consumption about five portions of such vegetable. However, for foods like garlic which is a vegetable but generally put as a spice, the serving size is taken as described by the table of food composition of McCarty and Beerman, (2013). A serving size of garlic consists of about 4 pieces which weighs approximately 3g, so consuming foods containing these amounts for about three times daily will provide a total of 9g/day.

3.2 Fructan Contents in Commonly Consumed Vegetables

The total amount of fructans present in twenty commonly consumed vegetables studied is presented in Table 1. The vegetable with the highest amount of fructans (%) is *Allium sativum* (8.97 ± 0.19 %) while the least was observed in *Capsicum spp* (0.01 ± 0.00%). *Lycopesicon esculentum, Curcubita pepo* and *Moringa oleifera* in this study are vegetables with no detectable fructan content. No correlation was observed between the amount of free sugars, sucrose and fructans in the studied vegetables however majority of the vegetables presented values less than 2g of detectable fructan.

Table 1: Free Glucose, Free Fructose, Sucrose and Fructan Contents of Some Commonly Consumed Vegetables in Maiduguri Metropolis, North East Nigeria.

Sno.	Common Name	Scientific Names	Local Name	Free Glucose g/100g	Free fructose g/100g	Sucrose g/100g	Fructan (%)
1.	Sesame leaves (Dried)	*Sesamumindica*	'Karkashi' (Hausa)'Kawulu' (Kanuri)	1.28±0.37	ND	ND	0.48±0.02
2.	Pepper (Red)	*Capsicum spp*	'Atarugu' (Hausa)	1.59±0.20	0.65±0.03	ND	0.01±0.00
3.	Pepper (Bell)	*Capsicum frutensce*	'Tattasai' (Hausa)	**3.42±0.28**	1.10±0.13	ND	0.02±0.00
4.	Spinach	*Amaranthuscaudatus*	'Alayyafo' (Hausa)	0.10±0.00	ND	ND	0.08±0.02
5.	Tomato (UTC)	*Lycopesiconesculentum*	'Tumatur' (Hausa)	1.02±0.25	0.44±0.09	0.00	ND
6.	Garlic	*Allium sativum*	'Tafarnuwa' (Hausa)	ND	0.10±0.06	1.06±0.37	**8.97±0.19**
7.	Coffee senna	*Sennaoccidantalis*	'Tafasa' (Hausa)	0.97±0.02	ND	**2.10±0.59**	1.23±0.04
8.	Baobab leaves	*Adansoniadigitata*	'Kuka' (Hausa) 'Kwalukuwa' (Kanuri)	0.34±0.03	ND	ND	3.32±0.50
9.	Kenaf leaves	*Hibiscus cannabinus*	'Rama' (Hausa) 'Ngabi' (Babur)	0.72±0.17	0.58±0.03	1.46±0.09	0.73±0.06
10.	Jute leaves	*Corchorusolitorius L.*	'Lalo' (Hausa) Ngamzaino (Kanuri)	1.30±0.16	0.43±0.15	ND	0.47±0.25
11.	Pumpkin	*Cucurbitapepo*	'Kabewa' (Hausa)'Suudu' (Kanuri)	1.29±0.75	ND	ND	ND
12.	Carrot	*Dautuscarota*	'karas' (Hausa)	1.96±0.44	0.62±0.45	ND	0.16±0.00
13.	Mambui	*Mormodicacharantia*	'Mambui' (Kanuri)	**4.84±0.83**	ND	ND	**5.40± 0.19**
14.	Sorrel leaves	*Hibiscussabdariffa*	'Yakuwa' (Hausa), 'Karasu' (Kanuri)	0.08±0.04	0.10±0.03	0.07±0.07	0.13±0.04
15.	Sorrel calyxes(white)	*Hibiscussabdariffa*	'Farinsobo' (Hausa)	1.21±0.09	0.11±0.06	0.65±0.05	3.31±0.88
16.	Onion	*Alliumcepa*	'Albasa' (Hausa), 'Lowosar' (Kanuri)	1.06±0.19	0.30±0.01	**2.29±0.21**	**7.49±0.17**
17.	Onion leaves	*Alliumcepa*	'Lawashi' (Hausa),	1.47±0.20	**1.41±0.06**	0.90±0.33	0.14±0.01
18.	Balsam apple	*Mormodicabalsamina*	'Daddawu' (Kanuri)	3.04±0.11	0.10±0.04	**2.34±0.34**	3.84±0.14
19.	Moringa leaves	*Moringaoleifera*	'Zogale' (Hausa), 'Allam' (Kanuri)	**9.34±0.72**	ND	1.93±0.10	ND
20.	African locust bean	*Parkiabiglobosa*	'Dorawa' (Hausa)	0.85±0.17	**1.09±0.27**	1.44±0.43	0.64±0.01

Values are means of three individual determinations ± standard deviation. ND: not detected.

Table 2: Average Serving Size of Free Glucose, Free Fructose, Sucrose and Fructan Contents of Some Commonly Consumed Vegetables in Maiduguri Metropolis, North East Nigeria.

Sno.	Common Name	Scientific Names	Average Serving Size (mg)			
			Free Glucose	Free fructose	Sucrose	Fructan
1.	Sesame leaves (Dried)	*Sesamumindica*	1020	NI	NI	380
2.	Pepper (Red)	*Capsicum spp*	1270	520	NI	**8**
3.	Pepper (Bell)	*Capsicum frutensce*	2740	880	NI	16
4.	Spinach	*Amaranthuscaudatus*	**80**	**16**	**8**	60
5.	Tomato (UTC)	*Lycopesiconesculentum*	802	350	NI	NI
6.	Garlic	*Allium sativum*	NI	3	31.8	269.1
7.	Coffee senna	*Sennaoccidantalis*	780	NI	1680	980
8.	Baobab leaves	*Adansoniadigitata*	272	NI	NI	2660
9.	Kenaf leaves	*Hibiscus cannabinus*	560	460	1170	580
10.	Jute leaves	*Corchorusolitorius L.*	1040	340	NI	380
11.	Pumpkin	*Cucurbitapepo*	1030	NI	NI	NI
12.	Carrot	*Dautuscarota*	1570	496	NI	130
13.	Mambui	*Mormodicacharantia*	3870	NI	NI	**4320**
14.	Sorrel leaves	*Hibiscussabdariffa*	64	8	6	100
15.	Sorrel calyxes(white)	*Hibiscussabdariffa*	970	90	520	2640
16.	Onion	*Alliumcepa*	848	240	1832	**5990**
17.	Onion leaves	*Alliumcepa*	1180	1130	720	110
18.	Balsam apple	*Mormodicabalsamina*	2430	80	1872	3070
19.	Moringa leaves	*Moringaoleifera*	**7470**	NI	1544	2500
20.	African locust bean	*Parkiabiglobosa*	680	870	1150	510

NI = Not indicated, (no serving size was extrapolated because the parameters are not detected in the study).

4.0 DISCUSSION

Fruits and vegetables are low energy – dense foods that are relatively rich in vitamins, minerals and other bioactive compounds as well as being good sources of fibre (WHO, 1997). A high intake of fruits and vegetables in the diet is positively associated with the prevention of cardiovascular diseases, cancer, diabetes and osteoporosis among many others (Safefood, 2007).

This study provides useful information about the free glucose, fructose, sucrose and fructan contents of commonly consumed vegetables within Maiduguri metropolis North east Nigeria.The information herein provides for the first time an attempt towards generating a food composition table which shows the quantities of these useful carbohydrates in our commonly consumed vegetables. Knowledge of the free glucose, fructose, sucrose and fructan contents present in our commonly consumed foods forms an important tool for research and development in meal planning for dietary related diseases, assessment of energy and nutrient intake, assessment of diet quality, development and application of food - based dietary guidelines.

The Megazyme assay is a suitable method of choice in determining the free sugars and fructan contents of naturally occurring foods, fruits and vegetables but not processed foods (Muir *et al.,* 2007). Assay on the free glucose contents of the vegetables in this study showed *Moringa oleifera* as the richest source of that free sugar with values two folds more than the next source in the study *Mormodica charantia*. On the free fructose and sucrose contents of the studied vegetables, no sucrose was observed in a number of the vegetables as seen in Table 1.Coffeesenna (*Senna occidantalis*) which is a common soup vegetable in the area had a substantial amount of sucrose in the leaves assayed followed by balsam apple leaves and onions. Major sources of fructans in the diet come from plants and vegetables rather than animal sources. Muir et al. (2007), Delgado et al., (2013) and Koruri et al., (2014) similarly reported *Allium sativum* (garlic) to be among the vegetables with highest quantity of fructans. *Allium sativum* with no estimated free glucose in the present study appears to be the richest vegetable with about 3 folds more fructan when compared to the leaves of the highly medicinal baobab (*Adansonia digitata*). An earlier study documented that tomatoes and tomato products do not contain fructans (fructooligosaccharides) (Tashiro et al, 1992 and Campbell et al., 1997) and findings from this present study is not exceptional about the fructan content of tomatoes. Sucrose, a non - reducing disaccharide was found in quantities less than 2.5 g/100g in all vegetables studied and it was observed that majority of vegetables do not contain this sugar probably due to the fact that sucrose is predominantly found in fruits.

Most African countries do not have food-based dietary guidelines and the few that do have the guidelines are not explicit on how much fruits and vegetables should be consumed (Fed Min. of Health Nigeria, 2006; Min. of Health Malawi, 2007; Naude, 2013). One of the challenges of this study is the unavailability of literature on average serving sizes of many foods, fruits and vegetables consumed in Nigeria. In order to come up with a more comprehensive food composition list, data needs to be generated about food portion sizes such that the average serving sizes of foods consumed can be deduced. Doing so will help in meal planning for dietary related health issues. Mosby's medical dictionary (2009) defined food exchange list as a grouping of foods in which the carbohydrates, fats, proteins and calories are similar for the serving sizes listed. These lists are widely used by healthcare professionals in managing various dietary related issues.

More than 75% of the global population do not consume sufficient amounts of fruits and vegetables (Hall et al., 2009; Msambichaka et al., 2018). Developing countries consume low amounts of fruits and vegetables due to lack of knowledge on the importance attached to its health benefits (Banwat et al., 2012). Nigeria is the largest consumer of vegetables in sub-saharan Africa with about 61.31g/capita/day (Safefood, 2007). Inspite of this value, consumption in the country is still below the dietary recommendation of atleast five serving a day which is equivalent to 400g/capita/day global recommendation. This is because consumption of fruits and vegetables is tied down to socioeconomic status of individuals. Fresh vegetables consumption is considered to be luxury for a high income class and a necessity in the lower class (Ogundari and Arifalo, 2013).

There is a widespread consumption within the study area of various fresh vegetables when in season or dried usually as a reserve to serve the needs during out of season periods. Vegetables like onions, garlic, tomatoes, bell pepper, red pepper and spinach form part of the daily freshly consumed vegetables either in the form of stew or as part of a green leafy vegetable soup. An average serving size of garlic which is about 3g (4 average sized cloves) provides approximately 3mg, 31.8 mg and 269.1 mg of free fructose, sucrose and fructans respectively. Consuming this serving size thrice will provide a total of 9mg, 95.4mg and 807.3mg of free fructose, sucrose and fructans respectively per day. A half cup of tomatoes (125 g), half cup of bell pepper (125 g), half cup of chopped onions (125 g) and a quarter cup of red pepper (62.5 g) is sufficient to make a portion size of stew for the day for an adult. A serving size of tomatoes which is approximately 80g contributes 802mg and 350mg of free glucose and fructose respectively. It doesn't contribute any value to the dietary fibre content.

In respect of these values, a portion size of stew by extrapolation will provide 1253 mg (1.25 g) free glucose and 546.9 mg (0.55 g) free fructose (both values from tomatoes). In the same vein, bell pepper will contribute 4281 mg (4.28 g), 1375 mg (1.375 g) and 25mg (0.025 g) of free glucose, free fructose and fructans respectively whereas onions add 1325mg (1.325 g), 375 mg (0.375 g), 2863 mg (2.863 g) and 5990 mg (5.99 g) of free glucose, free fructose, sucrose and fructans respectively and red pepper adds 992.2 mg (0.992 g), 406.3 mg (0.406 g) and 6.25 mg (0.006 g) of free glucose, free fructose and fructans respectively to the sugar content of the stew. This therefore means that stew made comprising these amounts of ingredients will contribute an average total of 7.85g free glucose, 2.72 g free fructose and 9.39 g fructans per portion. Adding two serving sizes of garlic (538.2 mg/0.54g fructan) as a spice to the stew will further increase the fructan content of the stew to 9.93g.

Other green leafy vegetables consumed more such as spinach (used in soups together with tomatoes, onions, red and bell peppers) singly contributes 250mg (0.250 g), 50mg (0.05 g), 25 mg (0.025 g) and 187.5 mg (0.188 g) free glucose, free fructose, sucrose and fructan respectively per cup size of 250 g. Baobab leaves are widely consumed dry as a soup accompanying starchy foods like 'tuwo' (from rice, wheat, maize, sorghum or millet) and 'biski' (cereal grits). Findings from this study shows that an average serving size of baobab leaves soup (made without stew) will contribute approximately 272 mg (0.272 g) and 2660 mg (2.66 g) of free glucose and fructan respectively. Adding a little stew to the soup will further increase the sugar content. *Hibiscus cannabinus* and coffee senna are two vegetables studied with atleast 1g of sucrose and contribute 580mg and 980mg of fructans respectively to the average serving size of the vegetables.

Food measuring scales and standard measuring cups for food quantification is still scarce in majority of homes in Nigeria. Fadupin et al (2009) published some work on some commonly eaten foods in South west Nigeria in an attempt to generate a food exchange list. They reported serving size for ewedu soup which is similar to *Sesamum indica* leaves used in soups as 254.8g equivalent to 3.5 serving spoons (or 13.5 table spoons) in easily recognizable measure.The values reported by Fadupin et al (2009) however are in no way related to those reported in this study because their finding do not reflect the sugar/fructooligosaccharide contents of any of the vegetables. Standardly, a cup full of fresh vegetable is considered to be 250ml (250g dw) and a serving size of fruit and vegetable is 80g (WHO, Technical Report Series, 2003; Agudo, 2004).

Vegetables contain substantially less fructose and glucose than fruits (Johnson and Conforti, 2003). Presence of free sugars and sucrose in the diet has been linked to the induction of metabolic syndrome and diabetes (Havel, 2005; Johnson et al., 2007). Free sugars have been defined as all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer plus sugars naturally present in honey, syrups and unsweetened fruit juices (SACN, 2015). Under this definition, lactose when naturally present in milk

and milk products and sugars contained within the cellular structure of foods (particularly fruits and vegetables) are excluded. The Scientific Advisory Committee on Nutrition (2015) reviewed intakes of free sugars and came up with a new dietary intake recommendation of 5% or less of the total energy per day in order to remain healthy, prevent obesity, dental caries and other related diseases. Balancing the consumption of the free sugar-rich Moringa leaves, *Mormodica charantia* leaves and *Capsicum frutensce* with other sources of fructans from vegetables may help counteract the negative impact of free sugars even though this sugar may not be considered harmful since it is found within the vegetable cellular structure. Issues however on the consumption of free sugars may arise when sugar rich vegetables are made into a vegetable juices or puree to serve other culinary purposes. Sanchez – Lozada et al. (2010) compared the ability of free sugars and sucrose to cause fatty liver in rats and concluded that both diets induce hepatic alterations thus increasing hepatic triglycerides accumulation and fatty livers.

Increasing the bulk of dietary fibres by consumption of the required serving of these beneficial vegetables daily will offer the desired health benefits. The recommended dietary intake of fibre is about 30g/day for adults, this dietary fibre includes all non-digestible carbohydrates with fructans being inclusive. Garlic (*Allium sativum L.*) which is devoid of any free sugars and baobab leaves (*Adansonia digitata*) are very rich sources of fructans. Both vegetables are known to possess several medicinal values like reduction in the risk of cardiovascular diseases and cancers, have antioxidant and antimicrobial effect (Colin-Gonzalez, 2012; Aviello, 2009) and have a long history of use in culinary in northern Nigeria. The use of garlic in food preparation and as medicines to combat cold is common practice among people in the study area no doubt this is of immense health benefits.

In spite of all the immense benefits of fruits and vegetables consumption, a low consumption level is still observed especially in developing countries, therefore there is need for a widespread awareness to the general populace on the right consumption and preparation of the abundant vegetables within the local communities by health workers in Nigeria and Africa. Eating right and staying healthy in any society starts from the household. The government should also try to support researches on dietary intakes of fruits and vegetables with a view to establishing the free sugars and fructan contents of not just raw but processed foods that we consume daily with a view of coming up with a detailed/comprehensive fruit and vegetable compositional table.

Conflict of Interest: None

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