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The Ascorbic Acid Contents of Selected Marketed Foods and Influence of Water Activity (a_w) during Storage

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ABSTRACT

Selected foods marketed in Nigeria and grated raw cassava and garri flour were analysed for their ascorbic acid contents. The effects of a_w *and length of storage on the ascorbic acid contents of the cassava and garri samples were also examined.*

Varying levels (0–184 mg/100 g, as received basis) of ascorbic acid were detected in the food samples. High levels (mg/100 g, as received basis) were observed in whole guava fruit (184·6 ± 20·7), fresh palm wine (138·4–155·2), whole red pepper (86·8 ± 10·5), commercial palm wine (70·3 ± 92·6), cashew apple juice (44·4 ± 4·2), and ripe pawpaw (42·3 ± 4·6). Based on a recommended daily allowance of 15–60 mg, and assuming high levels of bioavailabilities, most of the foods could be considered as good sources of ascorbic acid. Significant losses (between 21 and 83%) of ascorbic acid were observed after 4 and 8 weeks storage of the garri and cassava, respectively. Increasing a_w *led to increasing storage losses of the vitamin in both foods.*

INTRODUCTION

There is a need to explore as many vitamin C sources as possible, apart from traditionally known sources such as citrus fruits. Vitamin C assays of non-traditional sources are worth while, even if these sources do not constitute major sources of the vitamin because overall sources (i.e. cumulative intakes) of nutrients from different origins may be more important than single and isolated sources in the feeding habits of many people. The present studies have partly addressed this issue.

In computing and compounding food intakes aimed at meeting recommended daily allowances for various nutrients, food composition must be considered as it exists naturally and as it exists post-processing and during storage under various conditions, if reliable nutritional information is to be obtained. The ascorbic acid contents of raw, grated cassava (*Manihot* spp.) and of garri flour (a product derived from the frying of grated and fermented cassava) appear so far to have received little attention. There is a particular lack of information on the influence of water activity on the ascorbic acid contents of these foods, even when it is now generally accepted that a_w is more closely related to the physical, chemical and biological properties of foods and other natural products than is total moisture content (Rockland & Nishi, 1980).

There have been some studies on the effects of a_w on the ascorbic acid contents of some other foods (Labuza, 1972; Lee & Labuza, 1975). Nevertheless, there is a need for specific studies on specific foods because of the variability in the response of ascorbic acid to a_w in various foods (Labuza, 1980). In recognition of this and of the fact that cassava is a major food resource in many countries, this aspect was examined in stored grated cassava and garri flour.

MATERIALS AND METHODS

Most of the samples were purchased from various markets in Ibadan and Benin City, Nigeria. Cashew fruits from which the juice was extracted manually under hygienic conditions, cashew nuts, cocoa seeds and the kolanut species were from available stocks at the Cocoa Research Institute of Nigeria, Ibadan, Nigeria.

Six hundred gram triplicate samples each of the grated cassava and garri flour were weighed into plastic plates and equilibrated to a_w 0·33, 0·94 and 0·97, respectively, in desiccators (Rockland, 1960). The grated cassava samples were stored for 8 weeks while the garri flour samples were stored similarly for 4 weeks, but equilibrated to a_w of 0·11 and 0·75, respectively, as indicated in Table 2. These periods represented short-term storage periods.

The ascorbic acid contents of the samples in Table 1 and of garri (Table 2) were determined by the AOAC (1970) method as described by Joslyn (1970). However, extracts of coloured samples were treated with chloroform (Singh *et al.*, 1981) before titration with 2,6-dichlorophenol indophenol dye, as specified in the AOAC method.

The ascorbic acid contents of the grated cassava samples (Table 2) were determined spectrophotometrically, essentially after 1 ml of each of the 3% metaphosphoric acid extracts had reduced 9 ml of the 2,6-dichlorophenol

TABLE 1
The Ascorbic Acid Contents (mg/100 g, as received basis) of some Foods Marketed in Nigeria

Food	*Ascorbic acid content (Means ± SEM of six results each)*
'Akanmu' (Maize starch) (*Zea mays*)	Not detected
Kolanut (*Kola nitida*) (Skinned)	Not detected
Palm oil (*Elaeis guineensis*)	Not detected
Cocoa seeds (hulled) (*Theobroma cacao*)	0·4 ± 0·2
'Amala' (Yam flour) (*Dioscorea* spp).	0·5 ± 0·0
Cowpea (*Vigna unguiculata*) seeds	0·6 ± 0·1
Cashew nut (*Anacardium occidentale*)	0·6 ± 0·2
Hulled melon seed (*Citrullus vulgaris*)	0·8 ± 0·1
Roasted groundnut seeds (*Arachis hypogea*)	0·9 ± 0·2
Kolanut (*Kola acuminata*) (Skinned)	1·1 ± 0·3
Fresh groundnut seeds (*Arachis hypogea*)	13·0 ± 2·7
Banana (Peeled) (*Masa sapientum*)	15·8 ± 3·2
Cocoyam (Peeled) (*Colocosia esculenta*)	17·1 ± 3·4
Green Okro (*Hibiscus esculentus*)	23·2 ± 1·8
Guinea corn flour (*Sorghum vulgare*)	23·9 ± 5·0
Tangerine (Peeled, seeds removed) (*Citrus reticulata*)	29·4 ± 2·1
Whole 'Hausa' tomato (*Lycopersicum esculentum*)	30·4 ± 2·7
Sweet potato (*Ipomoea batatas*)	33·3 ± 3·2
Pineapple (Skinned) (*Ananuis comosus*)	36·2 ± 4·8
Mango Juice (ripe fruits) (*Mangifera indica*)	37·2 ± 5·9
Soybean flour (*Glycine max*)	39·8 ± 6·3
Pawpaw (Ripe peeled, seeds removed) (*Carica papaya*)	42·3 ± 4·6
Cashew apple juice (*Anacardium occidentale*)	44·4 ± 4·2
Commercial palm wine samples (3–6 h fermentation)	70·3–92·6
Whole red pepper (*Capsicum annuum*)	86·8 ± 10·5
Fresh palm wine sample (0–30 min fermentation)	138·4–155·2
Whole guava (*Psidium guajava*)	184·6 ± 20·7

indophenol dye. Absorbance values were measured at 520 nm within 15 s of the addition of the dye and the amount of ascorbic acid estimated by reference to a standard curve (Joslyn, 1970).

The results of the storage studies were subjected to an Analysis of Variance (Bhattacharyya & Johnson, 1977).

RESULTS AND DISCUSSION

The ascorbic acid contents of the various foods analysed are presented in Table 1. Ascorbic acid was not detected in the maize starch, palm oil or in the

TABLE 2

Effects of a_w and Storage on the Ascorbic Acid Contents of Grated Cassava and Garri Flour
(Means ± SEM of triplicate results μg/g, dry wt basis)

Number of weeks in storage	a_w 0·97		a_w 0·94		a_w 0·33		a_w 0·75	a_w 0·11
	A	B	A	B	A	B	C	C
0	226·67 ± 1·80	208·86 ± 0·68	226·67 ± 1·80	208·86 ± 0·68	226·67 ± 1·80	208·86 ± 0·68	4·2 ± 0·2	4·2 ± 0·2
1	186·52 ± 2·50	173·05 ± 0·83	188·43 ± 0·92	180·59 ± 0·25	190·00 ± 0·49	185·88 ± 0·45	—	—
2	147·65 ± 1·56	139·32 ± 0·70	149·46 ± 1·13	145·38 ± 0·37	155·06 ± 1·24	153·03 ± 0·34	—	—
3	118·44 ± 0·80	112·20 ± 0·054	119·05 ± 1·03	116·46 ± 0·14	120·93 ± 0·94	120·48 ± 0·29	—	—
4	89·71 ± 1·30	85·53 ± 0·53	92·76 ± 1·23	90·76 ± 0·16	93·89 ± 0·28	93·14 ± 0·14	2·6 ± 0·1	3·3 ± 0·4
5	67·75 ± 0·82	64·94 ± 0·13	71·21 ± 0·37	68·97 ± 0·19	73·15 ± 0·40	71·57 ± 0·26	—	—
6	56·06 ± 0·67	53·66 ± 0·22	57·26 ± 0·42	55·04 ± 0·11	60·36 ± 0·37	58·67 ± 0·16	—	—
7	45·48 ± 0·93	43·86 ± 0·23	46·26 ± 0·24	44·27 ± 0·15	47·98 ± 0·27	45·29 ± 0·17	—	—
8	39·36 ± 1·18	37·00 ± 0·29	40·37 ± 0·40	37·52 ± 0·12	41·55 ± 0·46	37·83 ± 0·08	—	—

A = Values for the sweet type of grated cassava (μg/g, dry wt basis).
B = Values for the bitter type of grated cassava (μg/g, dry wt basis).
C – Values for the garri flour (μg/g, dry wt basis).

Kola acuminata. Maize starch processed into a Nigerian pudding-type food ('ogi' or pap: reconstitution of starch flour in boiling water with vigorous stirring) is used as a weaning food in Nigeria. It is deficient in protein and, in accordance with the results in Table 1, it is also deficient in ascorbic acid. It is suggested therefore that, apart from fortification with milk protein which is the usual practice among Nigerian mothers who can afford milk protein, the 'ogi' should also be fortified with ascorbic acid before being dispensed as a weaning food. This is imperative in view of the not-too-high level of ascorbic acid (16·5–27·5 mg/litre) (Brunner, 1976) in cow's milk. The cashew nuts, hulled melon seed, roasted groundnut, cowpea seeds, yam flour, cocoa seeds and *K. acuminata* all had detectable but very low levels of ascorbic acid. However, melon seeds (in the form of 'egusi'), roasted peanut (as a snack food), cowpea seeds (in the form of 'moin-moin' and the cooked material), yam flour (in the form of 'ema', pounded yam, 'amala') and cocoa seeds (in the form of various cocoa-based products such as Ovaltine, Bournvita, Nescao, Pronto, Milo, etc) form important components of the daily diets of many Nigerians. The vitamin C contents of these foods, even if small as presented in Table 1, must be taken into account in any meaningful assessment of the intake of this vitamin in the population.

It is observed in Table 1 that roasted groundnut seeds had a much lower vitamin C content than the fresh seeds—an indication of the well recognised thermolability of the vitamin (Ukhun *et al.*, 1988).

Among the samples screened for ascorbic acid in Table 1, the following had high comparative values: whole guava, fresh palm wine, whole red pepper, cashew apple juice, ripe, peeled and deseeded pawpaw, soya bean flour, pineapple, mango juice and sweet potato. Fresh palm wine samples had much higher levels of ascorbic acid than the commercial palm wine samples which has undergone about 3–6 h of fermentation; oxidative and processing losses probably account for the differences. Ascorbic acid is a very unstable vitamin. Generally, the different levels of the vitamin in the food samples in Table 1 may be ascribed to intrinsic factors, post-harvest factors such as processing methods and marketing conditions. Stage of maturity (Ogunmodede & Ukhun, 1976) can also affect ascorbic acid levels. In many developing countries, where marketing conditions for foods are unstandardised and, for the most part, inadequate, there is a need to do regular analyses of foods for important nutrients (such as ascorbic acid), pre- and post-harvest, including the point of marketing. This way, dangerously low levels of nutrients can be detected and a useful data base will then be available for institutional and home dietary formulations.

The recommended daily allowances of ascorbic acid for humans range from 15 to 60 mg, depending on age, sex and physiological status (Pyke, 1979). The results in Tables 1 and 2 can, therefore, be used to estimate how much of these allowances can be met by the consumption of various amounts of the food items examined in the present studies. With that level of recommended daily allowance (i.e. 15–60 mg), it is obvious that most of the foods examined in Table 1 can, in fact, be considered good sources of ascorbic acid; 100 g of most of them (assuming a high level of bioavailability), will supply the recommended daily levels of ascorbic acid intake. It is emphasised, once more, that the practice of looking only at the so-called important sources of the various nutrients has to give way to one that considers intakes of nutrients from various sources. Orange juice, for example, though high in ascorbic acid, cannot be the only source of ascorbic acid for people. The small amounts of ascorbic acid in foods such as cassava starch, garri, and others (Tables 1 and 2) will be cumulatively important.

The ascorbic acid-lowering effect of elevated a_w in the cassava and garri samples, as is observed in Table 2, might be explained thus: increasing levels of available water led to increasing solubilisation of the water-soluble ascorbic acid which then led to higher rates of destruction. Increased levels of available water could also have promoted increased oxygen dissolution in the food materials, leading to increased oxidative loss of ascorbic acid. Additionally, increased levels of available water could have caused disintegration of the crystalline regions of the starch granules in the samples, leading to a corresponding accentuation of oxygen diffusion into them and to increasing ascorbic acid-degrading reactions. Labuza (1972) has suggested that elevated a_w may act to lower the activation energy for ascorbic acid destruction.

The reported storage losses of ascorbic acid in the food samples (Table 2) which were statistically significant ($P < 0{\cdot}01$), possibly, were due to the action of ascorbic acid oxidase in the grated raw cassava (Birch *et al.*, 1977), catalysed aerobic degradation, uncatalysed aerobic degradation and anaerobic degradation, all of which can be influenced by factors such as time, temperature, pH sugar levels, amino acids, redox substances, oxygen and salts (Tannenbaum, 1976).

CONCLUSIONS

Most (17 out of the 29) of the foods assayed for ascorbic acid in these studies can be considered good sources of the vitamin, based on a recommended daily intake of 15–16 mg, and assuming a high level of bioavailability. High storage water activities (0·75, 0·94, 0·97) lower the ascorbic acid contents of cassava mash and its product, garri, both of which are popular foods in Nigeria.

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