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The contribution of flesh, placenta and seeds to the nutritional attributes of a variety of *Capsicum annum* (Bell pepper)

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ABSTRACT

The flesh, seed, placenta and the whole fruit samples of a variety of tropical chillies (peppers) commonly found in Nigeria Capsicum annum L (bell pepper), were examined in the laboratory for their proximate compositions and some nutritionally valuable minerals on wet weight basis. The results showed that the seeds have the highest concentrations of ash (2.06 g/100 g), protein (14.1 g/100 g) and fibre (32.4 g/100 g), flesh had the highest concentration of crude fat (6.66 g/100 g) while the placenta had the highest concentrations of moisture (88.2 g/100 g) and carbohydrate (3.35 g/100 g). The seeds were also the best sources of most of the nutritionally valuable minerals (Ca, Mg, Zn, P, Fe, K and Na) determined. These parameters were good in the samples: Ca/P, Ca/Mg and [K/(Ca +Mg)] but Na/K was poor. In the mineral safety index (MSI), only Zn results were seriously aggravated. Bell pepper would serve as a good source of the following minerals: Ca, Mg, Zn and Fe which are important components of bones and supporting tissue, enzymes and blood formation respectively.

Introduction

Peppers come from the fruits of the capsicum or chillie plant (*Capsicum frutescens* L and *Capsicum annum* L). They are also known as paprika, chilli, pimento, cayenne or red pepper[1].

Chillies are perennial berry which are grown worldwide and constitute a significant proportion of African diet. Many varieties of *Capsicum* species are consumed and traded in both wet and dry form in Nigeria and International markets. They differ considerably in their size, shape and pungency. They are given various botanical classifications and vernacular names[2]. The varieties of *C. annum* have been identified[3] as bell pepper and cherry pepper. Bell peppers are fleshy, the ripe fruits are almost hollow, containing only the seeds embedded on the central region of the fruit.

Chillies are widely used in the tropical countries as soup thickners, hotness inducer (pungency due to high capsaicinoid content), colour and flavour enhancer in foods, thus promoting appetite and aiding consumption. In many tropical countries the basic staple is smooth in texture and bland in flavour, and highly spiced sauce is therefore an essential accompaniment to most meals. Recently, chillies have been incorporated into some Nigerian confectionery products like biscuits, ginger soft drinks, preparation of curry powder, tobasco sauce, etc. [4, 5, 6]. Traditional and modern methods of healing cite hot chillies as a stomachic, carminative and stimulant, hence with medical properties. They have also been used in the past for preserving food before the advent of refrigeration, as colouring agents for textiles and as important constituents in cosmetics and perfume products[7]. It is said to be a good source of carotene,[8, 9].

However, despite the wide utilization of tropical chillies, little work has been reported on their nutritional composition. Szent-Györgyi was reported to have been awarded a Nobel Prize in 1937 for isolating vitamin C in paprika[5]. The previous works on tropical chillies were on chilli processing for improved colour and shelf life; the possible vitamin C contribution of tropical chillies to human diet[2]; the effect of method of grinding on the level of iron in pepper[10]; the determination of nutritionally valuable mineral composition and distribution in tropical chillies[4]; determination of amino acid and mineral compositions of some Nigerian chillies[11] and determination of proximate composition and some nutritionally valuable minerals of two varieties of *Capsicum annum* L (Bell and Cherry peppers)[12]. The mineral contents of Indian[9,13], Spanish[14] and American varieties of chillies[15] have been reported in the literature.

When some people want to use bell peppers in Nigeria in cookery, they remove and throw away the placenta (pulp) together with the seeds and use only the flesh. This is because the seeds (attached to the pulp) are considered difficult to grind or when they want to use the seeds for propagation. This work is therefore aimed at determining the proximate composition of the whole fruits, seeds, plancenta and flesh separately as well as the mineral determination of various nutritionally valuable minerals and their distribution in the various parts in order to know the nutritional loss in throwing away the placenta and the seeds of *Capsicum annum* (bell variety).

Materials and methods

Sampling

The *C. annum* (bell pepper) specie were purchased from Oba market, Akure, Nigeria.

Sample treatment

The chilli fruits were washed to remove adhering dirts and the adhering water was dried by wrapping the fruits in filter paper. The fruits were then divided into two parts. One part was processed whole while the other part was separated into flesh, placenta and seeds. Each part was ground in an all glass mortar into fine paste and packed inside plastic bottles and kept in the laboratory freezer until used.

Proximate composition analysis

The proximate analyses of the samples for moisture, crude fat, crude fibre and total ash were carried out at least in duplicate using the methods described by AOAC [16]. Nitrogen was determined by the micro-Kjeldahl method described by

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Pearson[17] and the nitrogen content was converted to crude protein by multiplying with 6.25. Carbohydrate was determined by difference.

Mineral analysis

The minerals in each chilli sample either whole fruit, seeds, placenta or flesh were analysed from solutions obtained by first dry-ashing the samples (2.33 g each) at 550 ^oC to constant weight and dissolving the ash in heated beaker with 10 % HCl, filtering into standard flasks using distilled deoinised water with addition of few drops of concentrated hydrochloric acid[18]. Ca, Mg, Zn and Fe were determined by using an atomic absorption spectrophotometer (Pye Unicam, Model Sp 9, Cambridge, UK); both Na and K were determined using the flame photometer (Corning, Model 405, Gallenkamp, London, UK) while phosphorus was determined colorimetrically using the Spectronic 20 (Gallenkamp, London, UK) using the phosphovanado molybdate method[16]. Determination from each sample was done in duplicate and the results were expressed as the mean of all determinations. All chemicals used were of analytical grade obtained from BDH (British Drug Houses, London).

Other calculated parameters

These included the followings:

1. Differences in the proximate parameters between whole fruit minus seeds, whole fruit minus placenta and whole fruit minus flesh in the bell pepper.
2. Differences in the mineral parameters between whole fruit minus seeds, whole fruit minus placenta and whole fruit minus flesh in the bell pepper.
3. Some mineral ratio quality parameters like Na/K, Ca/P, Ca/Mg and [K/(Ca + Mg)] in the bell pepper.
4. Calculation of mineral safety index (MSI) of Ca, Mg, Zn, P, Fe and Na in the bell pepper.

Statistical analysis

All data generated were analysed statistically[11]. Calculated were the grand mean, standard deviation and coefficient of variation (per cent) in the proximate and mineral results in the four samples. Subjected to further analysis were the whole fruit/seeds, whole fruit/placenta and whole fruit/flesh for the determination of linear correlation coefficient (r_{xy}), coefficient of determination (r_{xy}^2) (or degree of association), linear regression coefficient (R_{xy}), coefficient of alienation (C_A) or lack of relationship and index of forecasting efficiency (IFE) both in the proximate and mineral results. To see if any significant relationship existed in any of the parameters among the samples, the r_{xy} was compared with the table value (critical value) at $r_{=0.05}$ and n-2 degrees of freedom (df). Further analysis using the Chi-square (X^2) was carried out to see if significant differences existed among the determined parameters in both the proximate and the mineral data; setting the critical value at $\alpha_{=0.05}$ at k-l df.

Results and discussion

Proximate composition

Data on the proximate composition of the different samples are shown in Table I which indicated that the seeds were the best sources of total ash, crude protein and crude fat while placenta was the best source of moisture and carbohydrate. The ash and moisture contents were the least varied in the samples and they had lower coefficients of variation of 24.8 % and 20.4 % respectively. Protein, fibre, fat and carbohydrate were highly varied among the samples and they all had coefficient of variations greater than 50.0 %.

The moisture content varied between 50.2-87.0 g/100 g. This gave dry matter values as 15.2 g/100 g (whole fruit), 49.8 g/100 g (seeds), 11.8 g/100 g (placenta) and 13.0 g/100 g (flesh). The moisture content was close to the values of 71.3 and 84.8 g/100 g reported in Nigerian chillies by Olaofe et al.[11] They also reported a maximum dry matter content of 28.7 g/100 g in 'atawewe' samples which is much below the value in the bell pepper seeds. The dry matter content is related to the content of oleoresin which influences the quality of the product[9]. Dry matter content has been reported to vary between 20.46 and 32.00 % (mean 26.90 %) in Indian chillies[9]; 21.30 and 33.49 % and 14.24 and 21.26 % in red and green chillies respectively[20]; and 10.10 and 25.00 % in Nigerian chillies[2]. Adeyeye and Otokiti[12] reported 84.81% in bell pepper and 83.32 % in cherry pepper with corresponding dry matter of 15.19 % and 16.68 % respectively. In Olaofe et al.[11] ash varied as 0.89-1.41 g/100 g, protein varied as 11.94-13.44 g/100 g, fat varied as 0.08-0.58 g/100 g and carbohydrate varied as 0.66-13.84 g/100 g; when compared with whole fruit results in the present report: ash, fat and carbohydrate values were better concentrated. The quantity of protein is low compared with the crude protein content in protein-rich foods (soy bean, cowpea, etc), but higher than that of tuber foods (yam, cassava, etc)[21].

An adult man of 70 kg body weight requires 0.57 g/kg of protein[22], that is 39.9 g of protein daily. This means that 745.79 g, 283.38 g, 1191.04 g and 1050 g will be needed from whole fruit, seeds, placenta and flesh respectively to produce the daily requirement of protein if bell pepper is the main source of protein. All the samples were largely composed of water like leafy greens and this may result in their being sources of low contents of proteins, fat and carbohydrates. The seeds had a high percentage of fibre. The spongy mass of fibre helps to satisfy the appetite, it also assists in moving food through the alimentary canal by aiding the muscular action of the intestine, thus preventing constipation[7]. The results in Table I show that every part of bell pepper contributes nutritionally to the food quality of the pepper.

The differences in the proximate parameters between whole fruit minus seeds, whole fruit minus placenta and whole fruit minus flesh in the bell pepper are shown in Table II. Seeds were better concentrated than whole fruit in ash (28.8%), protein (163%) and fibre (584%) but whole fruit was better than seeds in fat (45.2%), moisture (40.85) and carbohydrate (81.6%). Placenta was better concentrated in fat, moisture and carbohydrate than whole fruit by values of 3.95-106% (lower than in seeds) whereas whole fruit was better in ash, protein and fibre than the placenta in value range of 28.8 – 75.9% (again lower than in the seeds comparison). Flesh was only better than whole fruit in two parameters: fat (254%) and moisture (2.63%) whereas ash, protein, fibre and carbohydrate were better concentrated in whole fruit than flesh than flesh with value range of 26.9% - 90.2%. In summary seeds were better in three parameters like placenta and just two in flesh than whole fruit.

The correlation coefficient, etc of proximate analyses of the bell pepper are shown in Table III. All the r_{xy} values for whole fruit/seeds, whole fruit/placenta and whole fruit/flesh were each significantly different and positively high. The r_{xy}^2 values were all also high. In R_{xy} values, whole fruit/seeds showed that for every 1g/100g increase in the proximate level, there was a corresponding increase of 8.25g/100g in the seeds; in the whole fruit/placenta, for every unit increase in the whole fruit, there was corresponding reduction of -0.78unit in the placenta and similar observation of negative reduction (-0.51) was observed in the relationship between whole fruit/flesh. The coefficient of alienation (C_A) was slightly high in whole fruit/seeds (0.5668) but very low in whole fruit/placenta (0.0572) and whole fruit/flesh (0.0819); showing that alienation was moderate in whole fruit/seeds but low in the other two groups. The index of forecasting efficiency (IFE) was low in whole fruit/seeds (0.4332) but very high in whole fruit/placenta (0.9428) and whole fruit/flesh (0.9181). This means that while it is slightly difficult to predict relationship between whole fruit and seeds, it is very easy to predict relationship between whole fruit and placenta and also between whole fruit and flesh. Actually IFE is a value of reduction in the error of prediction of relationship, the higher the value the easier of prediction of relationship and the lower the reverse. In this case the placenta or the flesh will easily carry out all the physiological functions of the whole fruit with ease much better than in the seeds.

In Table IV is shown the Chi-square (X^2) of the proximate parameters of the bell pepper. These values were significantly different: protein, fibre and moisture, while ash, fat and carbohydrate were not significantly different among themselves. Significant differences would be due to the seeds in protein, seeds in fibre and placenta in moisture since each contributed the highest value in its group[19].

Minerals

Table V shows the variation in mineral content of the different samples of the bell pepper. It can be seen that the seeds had the highest concentration of most of the nutritionally valuable minerals determined except potassium and sodium; hence, the seeds could be better sources of essential minerals than the other parts in bell pepper. The mineral results for the seeds are in agreement with the results of Fagbemi and Oshodi[4]. The results obtained for the whole fruit follow the trends reported for whole sweet pepper[23] and some fruits and vegetables[21]. It has been shown that the seeds are richer in minerals[4,24] than any other part of the pepper, this means that any loss in the seeds may result in lower values for some or all of the minerals. The prevailing situation is that the pepper seeds are mostly lost during drying and storage.

Bell pepper was high in (on wet weight basis) Ca (5.0 – 15. 0 mg/100g), Mg (2.0 – 18. 0 mg/100 g), Zn (63.0 – 538mg/100g) and Fe (0.48 – 1.02mg/100g) but low in P (N.D. – 12.7mg/100g), K (3.20 – 4.45mg/100g) and Na (10.0 – 31.5mg/100g) of the wet pepper.

Iron is reported to be very important for normal functioning of the central nervous system[25]. Iron also facilitates the oxidation of carbohydrates, proteins and fats. Zinc is in all tissues of the body and is a component of more than fifty enzymes[26]. Zinc dietary deficiency has been found in adolescent boys in the Middle East eating a poor diet based largely on unleavened bread[26]. Consumption of meat with vegetables enhances the absorption of both iron and zinc. Bell pepper would supply enough of the body requirement of zinc (13.0mg) per day[27]. Calcium in conjuction with phosphorus, magnesium, manganese, vitamins A, C and D, chlorine and protein, are involved in bone formation[28]. Calcium also plays important roles in blood clotting, in muscles contraction and in certain enzymes in metabolic processes. Calcium in bell pepper would serve as a food supplement of the mineral from other sources. Calcium, magnesium and potassium act as neutralizers of acids which are produced in the course of digestion of meat, cheese and other foods[7]. Magnesium serves as an activator of many enzyme systems and maintains the electrical potential in nerves[29] with a daily need of 350 mg showing that bell peppers can only serve a complimentary role in its supply in food.

The pungency or spicy taste of chillies which is due to a crystalline substance known as capsaicin ($C_{18}H_{27}NO_3$) , concentrated mainly in the spongy placental region where the seeds are attached, seems to be inversely related to the size of the fruit[30]. Bell peppers have the mildest flavour with little pungent costituent[7], and this is further reduced when the central pulp (and the seeds) are removed and discarded. The colouring matter of the ripe fruit of bell pepper is said to consist of several compounds such as capsanthin ($C_{40}H_{58}O_3$), capsorubin, zeaxanthin, cryptoxanthin, lutein, α –and β-carotenes and a few xanthophylls[7]. The aesthetic look of soups prepared with bell peppers are enhanced by these colouring materials which come majorly from the flesh and the placenta.

To compare with literature results, the whole fruits of bell pepper mineral data was further converted from wet weight to dry extract values using the formula: wet weight value x 100/100- moisture content; the values were (mg/100 g dry extract): Ca(46.1), Mg (59.2), Zn (889), P (19.7), Fe (4.34), K (29.3) and Na (207). The Ca value was higher than any value (13.54-32.04 mg/100 g dry sample) in four different pepper samples (including bell pepper) reported by Olaofe et al.[11] and Zn having their values as 0.66-3.99 mg/100 g but their results in Mg, K, Na and Fe were much higher than the present results.

The range of concentration of a particular element varies widely between different plants and is also affected by the conditions under which the plants are grown, but all plant ash is similar in certain respects. The main constituent is usually K, which often comprises nearly 50 % of the total weight of ash. Animal tissues, in general, are much less rich in K, but on the other hand, they usually contain more Na[31]. It is possibly related to the preferential accumulation of K in the large vacuoles which are a prominent feature of many plant cells, but meristematic cells, which only have small vacuoles, show an even greater preference for K over Na[32]. After K, Ca is often the most abundant element in plant ash, although its concentration ranges widely from trace amounts in maize (*Zea mays*) grains to over 7 % of the dry weight in mature sunflower (*Helianthus annuus*) leaves. In contrast to K, Ca occurs mainly in combined forms either associated with cell walls or as crystalline deposits of insoluble Ca salts, such as calcium oxalate, in the cytoplasm[31]. Plant ash is also rich in magnesium, which is a constituent of some organic molecules, including cholorophyll, and also occurs as free ions in the cell sap. Individual plant species differ markedly in their salt content even when they are grown under the same conditions. Sometimes these differences can be traced to differences in the size and form of the root system which enables the plants to exploit different characteristics of absorption[33]. Grasses tend to have lower amounts of Ca than leguminous plants, both in the field and when grown in solution culture[33]. In the whole fruit of bell pepper, this trend was observed (mg/100 g dry extract): K (29.3) < Ca (46.1) < Mg (59.2) < Na (207). In the report of Olaofe et al.[11], K was found to be the most abundant mineral present, with an average content of 2181.4 mg/100 g dry sample. This is in close agreement with the observation of Olaofe and Sanni[34], that K was the most predominant mineral in Nigerian agricultural products. Bajaj and Kaur[9] have also reported that K is the most predominant mineral in Indian chillies with a mean of 3820 mg/100 g dry sample, which is much higher than the present value. The mean Na value in Olaofe et al.[11] result was 646.8 mg/100 g dry sample, but the present report (whole fruit = 207 mg/100 g dry sample) is higher than the Na content of 36.62 mg/100 g dry sample reported for Indian chillies[9] and 19 mg/100 g dry sample for American red chillies[15]. Iron, magnesium and calcium deficiencies in foods can lead to abnormal bone developmet and anaemia [35]. The average Fe, Mg and Ca contents in the chillies examined by Olaofe et al. [11] showed a wide variation, with means of 41.76, 130 and 25.71 mg/100 g dry sample, respectively. The Fe content in Nigerian chillies was higher than reported for Indian chillies (11.7 mg/100 g dry sample)[13] as for the case of Olaofe et al.[11] but the present level of 4.34 mg/100 g dry sample was lower than the Indian literature value; Ramasastri[36] also reported 12.9 mg/100 g dry sample for Fe in Indian chillies and Spanish chilli varieties (7.3 mg/100 g dry sample)[14]. The Mg content is much lower to the one reported for American red chillies (140-180 mg/100 g dry sample)[15]. The Ca content is much lower when compared with the Indian chillies' average content of 270 mg/100 g dry sample[9]. One of the major factors influencing macro and micro mineral uptake in plants is the composition of the soil on which the plant is grown[37, 38, 39].

Sodium is not said to be universally essential in plant growth but its soluble compounds may increase crop growth[40]. It has been known for many years that this element will in part replace K and that common salt will at times increase crop yield[40]. Such seems to be the situation with respect to mangels, sugar beets, Swiss chard, table beets, celery and turnips grown on peat soils[40]. That Na is essential with certain crops under certain conditions is highly probable [41, 42, 43]. Sodium is an activator of transport ATP-ases in animals and possibly also in plants. There is evidence that Na can replace K partly in some of its functions. Sodium effects are particularly evident when K is deficient. There is now good evidence that Na is an essential micro-nutrient for *Atriplex vesicara* and some other plants notably those showing the C_4 photosynthetic pathway[44]. In the report of Adeyeye[39] on some Fadama farm crops in three major towns in Ekiti State, Nigeria, the followings were observed: Ifaki-Ekiti, Na in *Celosia argentea* fruit was 45.3 mg/100 g dry sample, *Hibiscus esculentus* 36.3 mg/100 g dry fruit sample, *Zea mays* leaves 53.1 mg/100 g dry sample and *Corchorus olitorius* leaves 44.4 mg/100 g dry sample; Ado-Ekiti, Na in *Hibiscus esculentus* fruit 45.3 mg/100 g dry sample, *Celosia argentea* seeds 49.3 mg/100 g dry matter, *Zea mays* grain 51.6 mg/100 g dry sample and *Lycopersicon esculenyum* fruit 45.4 mg/100 g dry sample; Ikere-Ekiti, Na in *Zea mays* grain 57.6 mg/100 g dry sample, *Hibiscus esculentus* fruit 44.6 mg/100 g dry sample, *Celosia argentea* fruit 54.3 mg/100 dry sample and *Lycopersicon esculentum* fruit 36.9 mg/100 g dry sample; all these results were lower than the present Na concentration in the whole fruit of bell pepper. It is evident that during evolution animals have maintained an internal environment more similar to that of the sea than have most plants. One consequence of this is that the diet of domesticated herbivorous animals such as cattle must be supplemented with common salt[31]. Calcium is an element for all higher plants and is found in relatively large quantities in plant leaves but plants differ widely in the amounts of Ca they need. Calcium, in the form of calcium pectate, is an important component of plant cell walls. Calcium salts of phosphatidic acid occur in membranes and are essential to the maintenance of their structure and properties. Amylase is activated specifically by calcium[31]. Calcium deficiency results in early death of meristematic regions of stem and root; malformation of the young leaves, causing the tips to be hooked back. Once it is deposited in leaves, calcium like sulphur is immobilized[31]. It is observed in the present report that the bulk of Ca is present in the seeds and the placenta (Table V). In the absence of Ca roots do not grow well and often appear brown in colour and stunted. Degeneration at the apex of young fruits ('blossom end rot') is a common symptom of Ca deficiency in tomatoes.

Magnesium is a constituent of every chlorophyll molecule, and therefore essential for photosynthesis, green plants cannot do without it. Magnesium is also found in plant seeds. (It is 118 mg/100 g in the seeds but 59.2 mg/100 g dry sample in whole fruit of bell pepper.) It is also associated with many plant proteins[31]. It appears to be connected with phosphorus metabolism in the plant, with the activation of enzymes affecting carbohydrate metabolism, and also (in association with sulphur) in the synthesis of plant oils[45]. It is mobile in the plant, being transferred from old leaves to young ones if necessary, and deficiency symptoms, usually a chlorosis or whitening of the tissue between the veins appears first on the older leaves. Leafy crops such as tobacco are particularly sensitive to Mg deficiency, and deficiencies have been observed in West Africa in oil palms where they have been thought to be responsible for orange frond disease[45].

Potassium is lower in very many respects to Mg in the samples because it is possible that the K is concentrated solely in the cytoplasm where K requirement of plants would presumably be much lower. K, the third of the so-called primary or major nutrients in plants is essential for the formation and transfer of carbohydrates in plants, and for photosynthesis and protein synthesis. K occurs particularly in the growing points, fruits and seeds of plants. This information is particularly true for fruits, buds, flowers, seeds, efflorescence and roots [39]. Plants such as cassava which synthesise and store relatively large amounts of starch usually have particularly high K needs[46]. By increasing crop resistance to certain diseases and by encouraging strong root systems, K tends to prevent the undesirable "lodging" of plants and to counteract the damaging effects of excessive nitrogen. In delaying maturity, K works against undue ripening influences of phosphorus. In a general way, K excerts a balancing effect on both N_2 and P, and consequently is especially important to cereals in grain formation, as it aids in the development of plump and heavy kernels[47]. Abundant available K is also absolutely necessary for tuber development. Therefore, the percentage of K usually is comparatively high in mixed fertilizers recommended for potatoes[47]. All root crops respond to liberal applications of K. The leaves of crops suffering from a K deficiency [48] appear dry and scorched at the edges, and the surfaces are irregularly chlorotic. As a result of deterioration, photosynthesis is much impaired and the synthesis of starch is practically brought to a standstill[48]. The results of Adeyeye and Otokiti[12] on the mineral composition of cherry and bell peppers (wet samples calculated on dry extract basis) had generally good correlation with present results as follows (present/literature, mg/100 g): bell pepper Ca(46.1/32.92), Mg (59.2/59.25), Zn (889/888.74), P(19.7/19064), Fe (4.34/3.16), K (29.3/29.30) and Na (207/207.37); cherry pepper Ca (46.1/29.98), Mg (59.2/53.97), Zn (889/479.62), P (19.7/23.74), Fe (4.34/3.54), K (29.3/62.95) and Na (207/188.85).

In Table VI, the differences in the mineral parameters between whole fruit minus seeds, whole fruit minus placenta and whole fruit minus flesh in the bell pepper are shown. Negative value indicates that the whole fruit value was less than the reverse. In the table it is seen that negative differences were observed for Ca, Mg, Zn, P and Fe (54.5-325 %) between whole fruit-seeds whereas positive differences were observed in K and Na (28.1 -49.2 %) for the same sample. In the whole fruit-placenta, Ca, Fe and Na had negative values (1.59-28.6 %) whereas Mg, Zn and K had positive values (18.0-77.8 %). In the whole fruit-flesh, all values were positive showing the minerals were more positively shifted to the whole fruit with change value of 15.7-99.7 %.

Table I. The proximate composition (g/100g)[a] of bell pepper

Sample	**Ash**	**Crude protein**	**Crude fibre**	**Crude fat**	**Moisture**	**Carbohydrate**
Whole fruit	1.60	5.35	4.73	1.88	84.8	1.63
Seeds	2.06	14.1	32.4	1.03	50.2	0.30
Placenta	1.14	3.35	1.14	2.86	88.2	3.35
Flesh	1.17	3.80	1.17	6.66	87.0	0.16
Mean	1.49	6.65	9.85	3.11	77.6	1.36
SD[b]	0.37	4.36	13.1	2.15	15.9	1.28
CV (%)[c]	24.8	65.6	133	69.1	20.4	94.1

[a]Determinations were in duplicate; [b]Standard deviation; [c]Coefficient of variation.

Table II. Differences in the proximate parameters between whole fruit minus seeds, whole fruit minus placenta and whole fruit minus flesh in the bell pepper

Sample difference	Ash	Protein	Fibre	Fat	Moisture	Carbohydrate
Whole fruit-seeds	-0.46	-8.73	-27.6	+0.85	+34.6	+1.33 (81.6 %)
	(28.8 %)	(163 %)	(584 %)	(45.2 %)	(40.8 %)	
Whole fruit-placenta	+0.46	+2.0	+3.59	-0.98	-3.35	-1.72 (106 %)
	(28.8 %)	(37.4 %)	(75.9 %)	(52.1 %)	(3.95 %)	
Whole fruit-flesh	+0.43	+1.55	+3.56	-4.78	-2.23	+1.47 (90.2 %)
	(26.9 %)	(29.0 %)	(75.3 %)	(254 %)	(2.63 %)	

Note: 1. Negative sign (-) indicates that whole fruit is less concentrated in that parameter than the other sample;
2. Positive sign (+) indicates that whole fruit is more concentrated in that parameter than the other sample;
3. The percentage value carries similar arithmetical sign as the figure within the same box.

Table III. Correlation analysis of the proximate results of bell pepper

Statistics	Whole fruit/Seeds	Whole fruit/Placenta	Whole fruit/Flesh
Correlation coefficient (r_{xy})	0.8238*	0.9984*	0.9966*
Coefficient of determination (r_{xy}^2)	0.6787	0.9967	0.9933
Coefficient of regression (R_{xy})	8.25	-0.78	-0.51
Mean of whole fruit and its SD	16.7±33.4	16.7±33.4	16.7±33.4
Mean of corresponding sample and its SD	16.7±20.5 16.7±35.0 16.7±34.6	16.7±35.0 16.7±34.6	16.7±34.6
Coefficient of alienation (C_A)	0.5668	0.0572	0.0819
Index of forecasting efficiency (IFE)	0.4332	0.9428	0.9181

*r_{xy} values significantly different at $r_{=0.05}$ at df of (6-2) = 4; $r_{=0.05}$ = 0.811 (from critical values).

Table IV. Chi-square (X^2) values of the proximate parameters of the bell pepper

Parameter	**Chi-square value**	**Remark ($X^2_{table=7.815}$)[+]**
Ash	0.3771	Not significant
Protein	11.4	Significant
Fibre	69.5	Significant
Fat	5.95	Not significant
Moisture	13.0	Significant
Carbohydrate	4.85	Not significant

[+]df = 4-1 = 3 and critical level was set at $\alpha_{=0.05}$.

Table V. Some mineral contents (mg/100 g) of bell pepper

Sample	**Ca**	**Mg**	**Zn**	**P**	**Fe**	**K**	**Na**
Whole fruit	7.00	9.00	135	2.99	0.66	4.45	31.5
Seeds	15.0	18.0	538	12.7	1.02	3.20	16.0
Placenta	9.00	2.00	63.0	N.D.	0.84	3.65	32.0
Flesh	5.00	4.00	80.0	0.01	0.48	3.75	10.0
Mean	9.00	8.25	204	3.93	0.75	3.76	22.4
SD	3.74	6.18	195	5.22	0.20	0.45	9.61
CV (%)	41.6	74.9	95.4	133	26.8	11.9	43.0

N.D. = not detected.

Table VI. Differences in the mineral parameters between whole fruit minus seeds, whole fruit minus placenta and whole fruit minus flesh in the bell pepper

Mineral	Whole fruit-seeds	Whole fruit-placenta	Whole fruit-flesh
Ca	-8.0(114 %)	-2.0 (28.6 %)	+2.0 (28.6 %)
Mg	-9.0 (100 %)	+7.0 (77.8 %)	+5.0 (55.6 %)
Zn	-403 (299 %)	+72.0 (53.3 %)	+55.0 (40.7 %)
P	-9.73 (325 %)	n.d.	+2.98 (99.7 %)
Fe	-0.36 (54.5 %)	-0.18 (27.3 %)	+0.18 (27.3 %)
K	+1.25 (28.1 %)	+0.80 (18.0 %)	+0.70 (15.7 %)
Na	+15.5 (49.2 %)	-0.50 (1.59 %)	+21.5 (68.3 %)

n.d. = determined.

Table VII. Correlation analysis of mineral results of bell pepper

Statistics[+]	Whole fruit/Seeds	Whole fruit/Placenta	Whole fruit/Flesh
r_{xy}	0.9805*	0.9580*	0.9932*
r_{xy}^2	0.9613	0.9177	0.9864
Rxy	-23.1	3.11	-1.36
X±SD	27.2±48.6	27.2±48.6	27.2±48.6
Y±SD	86.3±199	15.8±23.6	14.7±29.0
C_A	0.1967	0.2868	0.1167
IFE	0.8033	0.7132	0.8833

[+]See Table III for interpretation of symbols; r_{xy} values significantly different at $r_{=0.05}$ at df of (7-2) = 5; $r_{=0.05} = 0.754$ (from Critical values).

Table VIII. Chi-square (X^2) values of the mineral parameters of the bell pepper

Parameter	Chi-square value	Remark ($X^2_{table = 12.59}$)[+]
Ca	6.22	Not significant
Mg	18.5	Significant
Zn	743	Significant
P	27.7	Significant
Fe	0.216	Not significant
K	0.213	Not significant
Na	16.5	Significant

[+]df = 7-1 = 6 and critical level was set at $\alpha_{=0.05}$.

Table IX. Some mineral ratio quality parameters in the bell pepper

Parameter	Whole fruit	Seeds	Placenta	Flesh	Standard
Na/K	7.08	5.0	8.77	2.67	0.60
Ca/P	2.34	1.18	-	500	≥ 1
Ca/Mg	0.78	0.83	4.50	1.25	1.0
[K/(Ca+Mg)]	0.56	0.19	0.66	0.83	< 2.2

Table X. Mineral safety index of Ca, Mg, Zn, P, Fe and Na for the bell pepper sub-samples

Sample	Ca			Mg			Zn			P			Fe			Na		
	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D
Whole/fruit	10	0.06	9.94	15	0.34	14.7	33	297	-264	10	0.02	9.98	6.7	0.29	641	4.8	0.30	4.50
Seeds	10	0.13	9.87	15	0.68	14.3	33	1184	-1151	10	0.10	9.9	6.7	0.46	6.24	4.8	0.15	4.65
Placenta	10	0.08	9.92	15	0.08	14.9	33	139	-106	10	-	-	6.7	0.38	6.32	4.8	0.31	4.49
Flesh	10	0.04	9.96	15	0.15	14.9	33	176	-143	10	0.00	10	6.7	0.21	6.49	4.8	0.10	4.70

Table VII depicts the correlation analysis of the mineral results of bell pepper. All the corelational samples had high positive and significant values of r_{xy} being 0.9580-0.9932. The r_{xy}^2 values were also high (0.9177-0.9864). The R_{xy} showed that for each unit rise in whole fruit, there were different corresponding behaviour in the seeds, placenta and flesh, hence, R_{xy} varied from -23.1 to +3.11. The C_A was low at 0.1167-0.2868 with corresponding high values of IFE having value range of 0.7132-0.8833 thereby making prediction of relationship between whole fruit and other bell pepper components much easier. In Table VIII, the chi-square calculated results in the minerals for the samples are shown. Ca, Fe and K do not have significant differences among the samples but Mg, Zn and P had significantly different and high positive values in the samples with significant value being due to the seeds[19] among the samples.

Some quality and health important parameters are shown in Table IX. The ratio of Na/K ranged from 2.67-8.77. The two minerals are required to maintain osmotic balance of body fluid, the pH of the body, regulate muscle and nerve irritability and control glucose absorption [49, 28]. However the Na/K values were higher than 0.60 required to avoiding high blood pressure[50], for this Na source, food much higher in K concentration should be eaten to bring down the Na/K ratio. The tastes of KCl and NaCl are very similar.

Phosphorus- rich diets that are low in Ca have been associated with increased loss of Ca in the bones[51]. In animals, a Ca/P ratio above two (twice as much Ca as P) helps to increase the absorption of Ca in the small intestine. This may help increase the Ca content of bones. Food is considered “good” if the ratio is above one and “poor” if the ratio is less than 0.50. In Table IX, Ca/P range was none-500; here, both values of 2.34 and 500 were excellent, 1.18 was good and none (-) was poor. For the poor value, be careful unless food is good for other reasons. The value range in Ca/Mg was 0.78-4.50. Both values 0.78 and 0.83 were below the recommended level of 1.0 [52] which was more than satisfied by 1.25-4.50. The observed [K/(Ca +Mg)] was 0.19-0.83 milliequivalent. To prevent hypomagnesemia, Marten and Andersen[53] reported that the milliequivalent of [K/(Ca+Mg)] must be less than 2.2; this is the case in this report.

The standard mineral safety index (MSI) for the minerals are Na (4.8), Mg (15), P (10), Ca(10), Fe(6.7) and Zn(33). For Na, all MSI values were low (0.10-0.31) with positive values for the difference between the standard value of MSI and the calculated value of MSI. This meant that the samples might not be overloading the body with sodium. For MSI of Mg none was above the USRDA[54] (Table X); this same observation was made for Ca, P and Fe. All the zinc values were greater than $_{33}$ (Zn standard). This meant that all the samples have Zn values far above the recommended adult intake. The maximum toxic dose is 500 mg, or 33 times the RDA[54]. High doses of Zn can be harmful. Zinc supplements can decrease the amount of high density lipoprotein circulating in the blood, increasing risk of heart disease[55]. Excess Zn interacts with other minerals, such as Cu and Fe, decreasing their absorption. In animals, Zn supplements decrease the absorption of Fe so much that anaemia is produced[56]. When patients are given 150 mg of Zn per day, Cu deficiency results. Intakes of Zn only 3.5 mg/day above the RDA decrease Cu absorption[57]. In animals, Cu deficiency causes scarring of the heart muscle tissue and low levels of Ca in the bone[55]. Excess Zn also decreases the functioning of the immune system. From the foregoing, all the samples would lead to excess zinc consumption with its likely deleterious effects. The deficiency content of Zn in plants has been established as 1.0-2.0 mg/100 g dry weight. The report of Adeyeye[58] showed that the soils contain luxury level of Zn which enable the plants to translocate Zn from the roots and accumulated by the tops of the plant. It has been calculated by Baunmeister and Ernst[59] that up to 75% of the total Zn that is taken up is in the tops of young plants, whereas 20-30 % occurs in the tops of old plants. Zn content ranged from 1.2-73 ppm (DW) in apple and lettuce leaves, respectively. Mean values for Zn in wheat grains ranged from 24-33 ppm (DW). In grasses Zn ranged from 12-47 ppm (DW) and in clovers ranged from 24-45 ppm (DW)[60].

Conclusion

The results of the bell pepper showed that it would be a good source of crude fat, crude fibre and crude protein. The sample would contribute reasonable level of the following minerals when used in food source: Ca, Mg, Zn, K and Na. These ratios were good in the pepper: Ca/P, Ca/Mg and [K/(Ca+Mg)]. The Zn level might be deleterious because its MSI values were higher than the standard by between 106 to 1151 difference. Seeds had best concentration in virtually all the parameters determined.

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