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Full Length Research Paper

Seasonal variation in nutrient content of some selected vegetables from Wamakko, Sokoto State, Nigeria

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The effect of seasonal variation on the nutrient and anti-nutrient contents of some selected vegetables cultivated under local agricultural practices by farmers from Wamakko, Sokoto State, were investigated. The concentrations of the elements in their soil were also studied. For the macroelements, significant differences at P<0.05 were observed in tomato for Na and K. In amaranth, it was observed only in Na, Ca and Mg. In roselle, it was observed in Na, K and Ca; while in kenaf, it was observed in all the elements except in P. Significant differences at P<0.05 were observed in all the trace elements except Fe, Mn and Pb in tomato, Cu, Zn and Mn in amaranth, Zn, Mn and Pb in roselle and Zn and Mn in kenaf. In most cases the values for the trace elements except Ni and Pb were higher in the rainy season samples. The soils for rainy season samples indicated higher values for all the macro elements, while an irregular trend was observed for the trace elements. No significant difference was observed for vitamin A, oxalate and nitrate concentrations in the samples. For vitamin C, only amaranth and kenaf indicated significant differences. The effect of seasonal variation on the concentrations of each of the nutrients varies from one vegetable to another.

Key words: Dry and rainy seasons, nutrient, antinutrient, vegetables.

INTRODUCTION

Vegetables are good source of vitamins, mineral elements, fibre and other nutrients the body requires. They also contain antinutritional compounds such as oxalate, nitrate. Oxalate in particular is known to form insoluble calcium oxalate with Ca thereby making it unavailable for its biochemical roles. The accumulation of the insoluble compound in the renal glomeruli leads to the formation of renal calculi and kidney damages (Nwachukwu and Obi, 2007; Maikai and Obagaiye, 2007). Nitrate is more toxic to young children when reduced to nitrite by intestinal bacteria (Miroslav and Vladimir, 1999). During evolution and cause of life, plants have developed several biochemical mechanisms that have resulted in adaptation to and tolerance of new or chemical imbalanced environments (Adeyeye, 2005). Crops are often influenced significantly by a few weather factors for their growth and development. For instance, crops that mature during autumn contain higher vitamin A than those that mature in poorer light of winter (Tunde, 1988). During the rain season, when temperature is normal it is the distribution of rain fall that becomes important. In the dry season temperature and water-use requirements of individual plant becomes paramount (ICAR, 2006). Seasonal changes in concentration result mainly from movement of nutrients into component during growth and the reverse process when senescence approached although individual nutrients differ in their mobilities. These changes are most evident in photosynthetic tissues such as leaves. Translocation affects N, P and K in particular whilst the less mobile elements such as Ca tend to be retained and even increased in apparent concentration as the leaf becomes older though changes of this nature vary from species to

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species (Stewente et al., 1974).

Some vegetables such as spinach and cassava are common in all areas of the country, while some such as onions and baobab are restricted in their natural distribution. Similarly, there is also seasonal variation in the availability of many vegetables (Tunde, 1988). Since vegetables are essential component of human diet, the need for their availability through out the year becomes necessary. This has led to the cultivation of vegetables in both dry and rainy seasons with the application different types of fertilizers and other chemicals that may enhance production.

Wamakko is a local government area in Sokoto state in Northwestern Nigeria. Its headquarters are in the town of Wamakko on the Sokoto River. It has an area of 697KM2 with 13°2'16N and 5°5'37°E as its coordinates. The climate is tropical continental and is dominated by two opposing air masses – the tropical maritime, which is moist and blows from the Atlantic and the tropical continental air mass which dominates in the dry season, it is dry and blows from the Sahara Desert. The rain fall of Wamakko is usually from April – October and is between 500 mm - 1000 mm annually. The rainfall was between May – October in 2008 as shown in Figure 1. Average temperature of about 41°C is observed in the months of April – June, while cold weather (harmattan) with temperature as low as 21°C is between November – February.

Amaranth (*Amaranthus caudatus*), roselle (*Hibiscus sabdariffa*), kenaf (*Hibiscus cannabinus*) and tomato (*Lycopersico esculentum*) are among the most common vegetables cultivated by farmers of Wamakko in Sokoto State, Nigeria both in the rainy and dry seasons. The vegetables grow in varied types of soil – sandy loam to clay and also tolerate moderate acidic and saline soils. Tomatoes are warm season vegetables which also grow extensively in cool season. The optimum temperature for its cultivation is 15 to 27°C. Amaranth is a quick – growing green leafy vegetable and is often uprooted when it is 8 to 10 cm tall (3 to 4 weeks after sowing). First cutting can be made 3 weeks after sowing and subsequent cuttings are made at 10 to 15 days interval depending on the vegetative growth. Its flowers mature in 90 to 95 days. Roselle is an annual herb of the malvaceae family, it bears leaves, calyces and seeds which are edible and have versatile uses. The plant has an overall growing period of 4 to 6 months. The young plant is often uprooted when it is 3 to 4 weeks old for consumption. Kenaf is a very important source of cellulose fibre for production of pulp and paper. It is a non-woody annual, with a short life cycle of between 100 to 130 days. The leaves are usually harvested regularly to enable the plant grow without branches. Data on the effect of seasonal variation on the nutrient contents of the selected vegetables from the study area is limited. Similarly, nutritional data on vegetables such as kenaf and roselle is inadequate. In view of this, the present study was initiated to investigate both the nutritional and anti-nutritional composition of the selected vegetables and also the effect of seasonal variation on their nutrient and anti-nutrient compositions.

MATERIALS AND METHODS

Sample collection and processing

Samples of each leafy vegetable type and their soils (0 to 30 cm depths) were collected from three different farms both in the dry and rainy seasons between the fifth and sixth week after sowing, while tomatoes were collected when ready for harvest. The collections were made in the year 2008. In the laboratory, each set of vegetables was air dried and crushed into fine powder before storing in clean and clearly labeled polythene bag. Powdered samples were used in all the analyses except in moisture content determination where fresh samples were oven dried at 105°C to constant weight (Hassan et al., 2005; Miroslav and Vladimir, 1999). The soils were air-dried, crushed and sieved to separate the fine earth fractions (2 mm) from coarse materials and stored in clean polyethylene bags for pH and metal analysis (Aiboni, 2001).

Reagents and glass wares

All reagents used in this work were of analytical grades and double distilled water was used throughout the analyses. The glass wares were washed with liquid soap, rinsed with water and then soaked in 15% HNO_3 for 48 hours before rinsing with distilled water and dried in an oven at 55°C for 5 h (Haw-tarn et al., 2004; Uba and Uzairu, 2008).

Proximate analysis

The ash contents of the samples were determined by using 2.00 g of each of the oven dried powdered sample in a muffle furnace (Lenton furnace, England) at 550°C for 3 h. The protein content was determined by heating 2.0 g of each of the sample with 20 cm^3 of concentrated H_2SO_4 (98% w/v) in the presence of selenium as catalyst. The distillation and titration processes were carried out in a 2300 kjeltec Auto Analyzer using 35% NaOH solution, 2% boric acid solution containing methyl red and bromocresol green mixed indicator at the proportion of 100:1 and 0.1 M HCl. (Mendham et al., 2000; AOAC, 1997). The crude lipid was extracted with n-hexane in a sohxlet extractor. The total dietary fibre was determined by non-enzymatic-gravimetric method which was carried out by suspending 500 mg of each of the samples in two separate beakers with distilled water and incubated at 37°C for 90 min. This was followed by precipitating with four volumes of 95% ethanol. One of the washed, dried and weighed residues was ashed at 525°C for 3 h while the second duplicate was analysed for crude protein using Kjeldahl method. The weight of the residues after correcting for crude protein and ash corresponds to the total dietary fibre (AOAC, 1998). The available carbohydrate was determined as the difference between 100 g dry mass of a sample and the sum of the values for ash, fibre, crude lipid and protein (Stewente et al., 1974; AOAC, 1990; McDonald et al., 1994).

Analysis of macro elements in the vegetables

Wet ashing technique was used and the digestion processes in triplicates were carried out by weighing 1.0 g of each of the oven

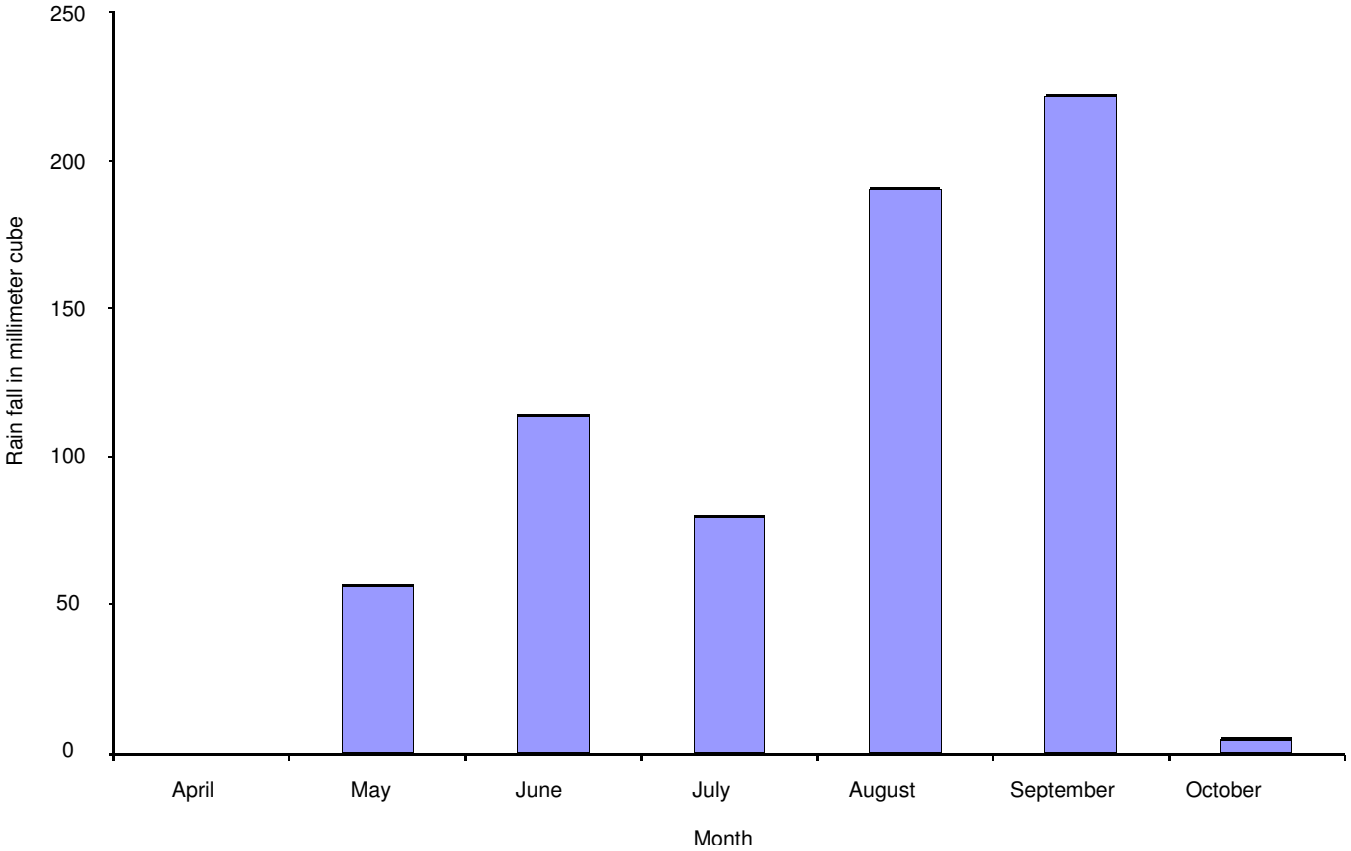

Figure 1. Rain fall distribution (2008) in Wamakko. Source: Energy research center Umanu Danfodiyo University Sokoto.

dried and powdered sample in to separate 100 cm^3 Kjeldahl flasks, 30 cm^3 of 69.5% (w/w) HNO_3 were added to each of the flasks and heated until about 10 cm^3 of each of the solution remained. This was followed with the addition of 2 cm^3 of 60% $HClO_4$ acid, 10 cm^3 of 69.5% (w/w) HNO_3 and 1 cm^3 of 98% (w/w) H_2SO_4 in to each of the flasks. The mixtures were further heated in a fume cupboard until the appearance of white fumes. The resulting solutions after cooling were each filtered in to separate 50 cm^3 volumetric flasks and diluted to the mark with distilled water (Miller and Baker, 2000; Daniel, 2003). Na and K were determined by flame emission spectroscopy (Corning 400 model), P was determined by colorimetric (phosphor-vanadomolybdate) method using spectrophotometer (6100, Jenway, UK). Mg and Ca were determined by AAS (S4 Atomic Absorption Spectrometer Thermo Electron, Cambridge, 2002).

Analysis of trace elements

The process was carried out in triplicates by weighing out 1.0 g of each of the oven dried and powdered sample in to separate digestion tubes, 30 cm^3 of 69.5% (w/w) HNO_3 acid was added to each and heated until about 10 cm^3 was left. This was followed with addition of 10 cm^3 of 69.5% (w/w) HNO_3 acid and 2 cm^3 of 60% $HClO_4$ acid and the heating process continued until clear solutions were obtained. Each of the digests was diluted with about 20 cm^3 of distilled water, boiled for another 15 minutes, allowed to cool, filtered in to separate 50 cm^3 volumetric flasks and made to the mark with distilled water. The solutions were stored in separate screw capped polyethylene bottles (Audu and Lawal, 2006; John, 2000). Blank solution was prepared in the same way but without any sample.

Analysis of vitamins A and C

Vitamin A was estimated by spectrophotometry using a CE440/UV-Vis Double Beam Scanning spectrophotometer at 450 nm after extraction with petroleum ether from a mixture of 1.0 g of a sample in 95% ethanol. The ether extract was concentrated by heating in a rotary vacuum evaporator. Further separation was carried out in a chromatographic column packed with silica gel by eluting with petroleum ether. The first yellow eluate was collected in a 25 cm^3 flask and the absorbance was taken immediately (Muchoki et al., 2007; AOAC, 1998). The vitamin C content was determined by iodometric titration with 0.1 M $Na_2S_2O_3$ solution after 2.00 g of sample was treated with 10 cm^3 of metaphosphoric and acetic acid mixture to prevent oxidation of ascorbic acid, inactivate enzymes and reduces interference of ions present (Aminullah et al*.,* 1993; Ceriwyn, 1998).

Analysis of oxalate and nitrate

The oxalate content was determined by heating 2.0 g of powdered sample in distilled water and 0.3 M HCl. The cold filtrate was treated with 2 to 3 drops of methyl red indicator and NH_4OH solution before heating the mixture to 90 to 100^oC. After cooling, the

filtrate was heated further before the addition 10 cm^3 of 10% $CaCl_2$ solution and allowed to stand over the night. After filtration, the precipitate formed was washed to remove traces of Ca^{2+} before dissolving in H_2SO_4 solution (1:4). The solution formed was brought to near boiling by heating before titrating with 0.05 M $KMnO_4$ solution (Daniel, 2003; Ceirwyn, 1998; AOAC, 1998). In nitrate analysis, 1.0 g powdered samples were taken into separate 500 ml volumetric flasks containing 200 mls of distilled water. The mixtures were shaken and then filtered. Then 20 ml of each filtrate, standard and water blank were taken into separate 10 ml volumetric flasks.

To each flask, 1 drop of sulphite-urea reagent was added and placed in a tray of cooled water. This was followed with the addition of 2 ml of antimony reagent and 1 ml of chromotropic acid. The solutions were diluted to the marks with concentrated H_2SO_4 and allowed to stand for 45 min before measuring the absorbance at 410 nm in a spectrophotometer (UV-Visible Spectrophotometer SM752s) using 1 cm cell (Miroslav and Vladimir, 1999; AOAC, 1998).

Soil analysis

The soil pH determination was at a ratio of 1:1 with distilled water. Exchangeable cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+) were extracted with 1 M NH_4-acetate at pH 7. The Na^+ and K^+ were determined with a flame photometer, while Ca^{2+} and Mg^{2+} were analysed with AAS (Fasina et al*.,* 2005; Badora and Filipek, 1998; Wilcke et al*.,* 1998). The soil samples were prepared for trace metal analysis by refluxing 1.0 g of air dried sample with 10 cm^3 of HNO_3 for 45 min. Heating was continued with 10 cm^3 of aqua-regia and finally with 10 cm^3 HNO_3. The filtrates were diluted to the marks of 50 cm^3 volumetric flasks and the determinations were carried using AAS (Uba and Uzairu, 2008). The available phosphorus in the soils was determined using Bray 1 method (Ibitoye et al*.,* 2005).

Statistical analysis

Except for moisture content, mean and standard deviation of results obtained in this research work were on dry weight basis either expressed in g/100 g (proximate composition), μgg^{-1} (macro and trace elements and nitrate composition) or mg/100 g (vitamins and oxalate composition). Student's t-test was further used to test significant differences between the means of rainy season samples and that of the dry season (John, 2000; Daniel, 2003).

DISCUSSION

Proximate composition

Table 1 presents the proximate composition of both the dry and rainy season vegetable samples expressed in g/100 g dry weight basis (except moisture content which was in fresh weight basis). The mean values for the moisture ash, total dietary fibre and total lipid contents of the dry season samples compared well with those of their corresponding rainy season samples except in tomato. The values obtained for protein in amaranth, roselle and kenaf were higher than 21.33 g/ 100 g in Tsaida leaves (Hassan et al., 2005) and 21.6 g/ 100 g in Amaranthus incartus (Asibey-Berko and Tayie, 1999). Values ranging from 42.4 to 49.3 g/100g were reported in cassava leaves (Adoji and Valentine, 2005). Similarly, the values were within the range of 20.48 to 41.66 g/100 g reported as protein content in green leafy vegetables (Tiaga et al., 2008). Significant differences were observed in the values of ash, total dietary fibre and total lipid for tomato and it was the rainy season samples that had the highest values. In Amaranth, significant differences were observed only in the values of crude protein and total lipid. In roselle, it was observed in total dietary fibre. In both cases, rainy season samples had the highest values.

Macro element composition

Table 2 presents the concentrations of macro elements in both the dry and rainy season vegetables expressed in mg/100g dry weight. While Table 5 presents the pH and the available and exchangeable forms of the macro elements in the soils of the vegetables. The availability of elements to plants is influenced by various soil factors among which according to literature data is soil reaction which is observed to occur at pH below 4.2 (Badora and Filipek, 1998). The pH range observed in the soils is almost neutral. The observed values for K in tomato were lower than 3427 mg/100 g reported by USDA (2008), but higher than 114 mg/100 g reported by Rumeza et al. (2006). The values for K in amaranth were lower than 2903 mg/100 g for spinach reported by Miller-Ihli and Baker (2000). Value as high as 1970 mg/100 g was reported for roselle (Sena et al., 1998). The rainy season samples generally indicated higher values when compared with their corresponding dry season samples. With the exception of amaranth, others indicated significant differences at $P<0.05$. Soil is the main source of K to plants and the anthropogenic activities by farmers influences its concentration. They were all higher than the range of 28.50 to 31.50 μgg^{-1} reported by Dauda (2008), but were below 180 to 210 μgg^{-1} and 268 μgg^{-1} reported by Kashif et al. (2009) and Uzairu A (Ahmadu Bello University Zaria unpublished article) respectively. Except for soils of amaranth and roselle, significant differences were observed in others. Potassium along with sodium help in nerve and muscle excitability, carbohydrate metabolism and also it is part of the structures of bones (Brain and Allan, 1993).

The values of observed for Na concentration in both the dry and rainy season samples were lower than 58.5 mg100 g (spinach) and 440 mg/100 g (tomatoes) by Rumeza et al. (2006). The dry season samples generally gave values that were higher than those of their corresponding rainy season samples. Generally, the values compared well with the range of 33.00 to 41.30 µgg-1 reported by Dauda (2008), but were lower than 95.40 µgg-1 reported by Uzairu A (Ahmadu Bello University Zaria unpublished article).

The highest values of 390.64 mg/100 g (dry season) and 374.81 mg/100 g (rainy season) for P concentration were observed in amaranth. Though dry season vegetables gave values that were slightly higher than

Table 1. Proximate composition in g/100 g dry weight of both the dry and rainy season vegetables.

Vegetables	Season	Moisture	Ash	Crude protein	Crude fibre	Total lipid	Carbohydrate
Tomato	D	93.36±0.98	8.53±1.74[a].	19.69±1.09	24.96±0.43	8.99±0.83[a]	37.72±1.84[a]
	R	92.42±1.93	10.28±1.83[a]	21.27±0.95	24.28±0.52	10.21±0.47[a]	33.95±2.22[a]
Amaranth	D	90.59±0.83	12.25±1.37	36.53±0.82[a]	27.95±0.65	7.29±0.83	15.98±1.58[a]
	R	88.78±1.90	12.77±1.31	38.91±0.75[a]	27.62±0.92	8.12±0.80	12.58±1.36[a]
Roselle	D	84.98±1.83	6.14±0.68	26.96±1.06	32.42±1.32	6.00±2.04	28.40±4.02
	R	85.52±2.55	6.49±0.69	26.78±0.81	30.61±1.01	6.85±1.82	29.27±3.69
Kenaf	D	82.26±1.17	5.78±0.73	32.17±1.81	26.54±1.40	5.16±0.77	30.35±3.04
	R	82.89±1.31	5.28±0.57	31.14±1.52	26.33±0.53	5.01±0.97	32.24±0.57

D = dry season samples, R = rainy season samples and [a] = means of the same vegetable type were significantly ($p<0.05$) different.

Table 2. Macro element composition in mg/100 g dry weight of both dry and rainy season vegetables.

Vegetables	Season	K	Na	P	Ca	Mg
Tomatoes	D	316.21±24.34[a]	27.09±4.18[a]	281.76±26.47[a]	238.08±76.14	183.97±36.82
	R	399.71±24.58[a]	21.95±3.22[a]	242.00±37.60[a]	235.26±66.18	144.43±49.52
Amaranth	D	511.03±35.04	33.02±3.13[a]	390.64±36.35	997.06±283.29[a]	1247.86±48.14[a]
	R	483.84±33.68	24.17±3.93[a]	374.81±39.15	3434.72±597.46[a]	1169.33±91.73[a]
Roselle	D	474.22±34.87	25.41±2.43[a]	261.63±28.85	689.67±206.45[a]	475.78±79.95
	R	394.84±70.24	19.47±2.36	272.98±56.16	1834.72±169.10[a]	458.88±65.16
Kenaf	D	382.89±40.43[a]	24.76±3.43[a]	352.42±40.97	894.6±344.40[a]	625.76±217.52[a]
	R	472.51±35.79[a]	18.03±2.10[a]	351.98±27.52	1774.08±349.91[a]	386.38±29.26[a]

D = dry season samples, R = rainy season samples and [a] = means of the same vegetable type were significantly ($p<0.05$) different.

those of their corresponding rainy season samples, a significant difference at $P<0.05$ was observed only in tomato. USDA (2008) reported values as high as 356 mg/100 g in tomato and 303 mg/100 g in onions, while Miller-Ihli and Baker (2000) reported 5500 μgg^{-1} in spinach. The values obtained for the soils compared well with those reported by Alhassan and Mashi (2008). Significant differences ($P<0.05$) were observed in all the soils.

Calcium concentrations in the samples were relatively high in the leafy vegetables particularly in the rainy season samples. Sena et al. (1998) reported mean values of 12400 μgg^{-1} in roselle, 14700 μgg^{-1} in Adansonia digitata and 14400 μgg^{-1} in Moringa oleifera. Robert et al. (1997) reported 20,000 μgg^{-1} in Adansonia digitata and 11,300 μgg^{-1} in roselle. All except tomato indicated significant differences at $P<0.05$. The values observed for Ca in the soils of the vegetables compared well with those reported by Dauda (2008), but were lower than the mean value reported by Uzairu A (Ahmadu Bello University Zaria unpublished article). Ranges of 9.30 to 694 μgg^{-1} and 3.75 to 37.50 μgg^{-1} were reported by Buszewski et al. (2000). Significant differences were observed in all the soils except for tomato.

Mg determination, the values obtained for tomato closely relate with 194 mg/100 g reported by USDA (2008), while the values for roselle were lower than 786.5 mg/100 g reported by Sena et al. (1998). The values for dry season samples were higher than those of their corresponding rainy season samples. Significant differences were observed in only amaranth and kenaf samples. Like Ca, the values for Mg in their soils compared well those reported by Dauda (2008), but were lower than those reported by Uzairu A (Ahmadu Bello University Zaria unpublished article).

Similarly, ranges of 5.00 to 134.37 μgg^{-1} and 12.50 to 65.08 μgg^{-1} were reported by Buszewski et al. (2000). All except soils for tomato indicated significant

Table 3. Trace metal composition in µgg^{-1} dry weight of both the dry and rainy season vegetables.

Vegetables	Season	Fe	Mn	Cu	Zn	Ni	Pb	Cd
Tomatoes	D	23.00±06.90	16.22±1.14[a]	66.74±10.88[a]	12.41±0.84[a]	7.75±2.52[a]	2.36±0.63	0.12±0.08[a]
	R	26.59±04.29	17.88±1.81[a]	81.43±11.53[a]	14.07±1.08[a]	4.78±1.32[a]	1.82±1.35	0.04±0.02[a]
Amaranth	D	94.73±49.73[a]	43.38±3.89	81.75±26.14	18.77±2.33	12.65±2.38[a]	5.35±2.65[a]	0.26±0.14[a]
	R	158.79±74.41[a]	38.39±10.15	90.07±12.52	20.44±1.84	7.46±1.12[a]	2.88±1.21[a]	1.47±0.48[a]
Roselle	D	59.87±28.00[a]	71.70±20.80	83.64±12.50[a]	19.06±6.57	8.49±2.07[a]	4.47±1.82	0.09±0.07[a]
	R	131.48±32.17[a]	69.12±26.64	71.90±9.46[a]	16.39±3.96	5.24±0.87[a]	4.19±2.45	2.07±1.00[a]
Kenaf	D	92.26±06.45[a]	56.72±8.73	52.35±14.57[a]	13.76±2.06	6.49±0.68[a]	5.56±2.93[a]	0.42±0.33[a]
	R	76.00±18.57[a]	59.60±4.96	76.51±6.14[a]	12.11±1.13	2.52±0.72[a]	2.39±1.94[a]	2.04±0.53[a]

D = dry season samples, R = rainy season samples and [a] = means of the same vegetable type are significantly ($p<0.05$) different.

differences.

Micro element composition

Tables 3 and 6 present the concentrations of the micro elements expressed in µgg^{-1} in the vegetables and their soils respectively. The values for Fe concentration in the vegetables were lower than 1191 µgg^{-1} for roselle and 986 µgg^{-1} for Adansonia digitata by Sena et al. (1998), but were within the range of 18 to1000 µgg^{-1} natural Fe content in folder plants (Adeyeye, 2005). Only rainy season samples of amaranth and roselle were within the range of 100 to 500 µgg^{-1} recommended as the normal Fe content in plants (ICAR, 2006). All sets of values indicated significant differences at $P<0.05$ with rainy season samples having higher values except in kenaf. High but closely related values for Fe were observed in the soils for tomato and amaranth which compared well with 2527.34 µgg^{-1} reported by Amusan et al. (2005). A range of 21,000 to 115,000 µgg^{-1} was reported by Kretzschmar, et al. (1998). The high value for rainy season amaranth indicated that weather favours Fe accumulation. Similar trend was observed in the concentration of Fe in roselle and its soil. For Mn concentration in dry season samples, the values for roselle were lower than the 114 µgg^{-1} reported by Sena et al. (1998). Uba and Uzairu (2008) reported a value of 832.83 µgg^{-1} in Amaranth. Though the dry season samples (except tomato and kenaf) gave slightly higher values when compared with their corresponding rainy season samples, all except tomato indicated no significant difference at $P<0.05$.

The values obtained for the soils were lower when compared with those reported by Uba and Uzairu (2008), but were all within the range of 20 to 800 µgg^{-1} reported as normal Mn concentration in German soils (Kretzschmar et al., 1998). Difference in weather has little or no effect on the concentration of Mn in the vegetables studied. Copper concentrations in the vegetables were relatively high. Values of 13.5 µgg^{-1} (in rosellle) and 14.23 µgg^{-1} (in tomatoes) were reported by Sena et al. (1998) and USDA (2008), respectively. The sets of values observed were higher than the range of 5 to 20 µgg^{-1} as the normal Cu content in plants (ICAR, 2006). With the exception of amaranth, others indicated significant differences at $P<0.05$ with the rainy season samples of tomato and kenaf having the highest values. The values obtained for Cu in the soils of the vegetables were observed to be higher than the range of 1 to 40 µgg^{-1} as normal Cu concentration in German soils, but were within the range of 30 to 330 µgg^{-1} in Costa Ricca soils both reported by Kretzschmar, et al. (1998). Like their vegetables, the soils for rainy season kenaf and tomato gave higher values. This indicated that apart from the rainy season weather, the concentration of Cu in the soil is also important.

The concentrations of Zn in tomato were higher than those reported by Abdullahi MS (Ahmadu Bello University Zaria, Nigeria, M.Sc. dissertation) and USDA (2008), while the values for roselle were lower than 72.9 µgg^{-1} reported by Sena et al.

Table 4. Vitamins and anti-nutritional compositions of the vegetables in mg/100 g dry weight.

Samples	Season	Vitamin A	Vitamin C	Oxalate	Nitrate (μgg^{-1})
Tomatoes	D	206.02±31.7	156.17±35.17	29.2.5±7.04	6.00±1.00
	R	181.46±48.70	153.43±14.63	27.14±3.2.1	7.00±1.00
Amaranth	D	195.24±26.84	106.24±16.56[a]	19.29±3.17	14.00±1.00
	R	152.64±33.76	74.04±07.81[a]	24.38±2.62	14.67±3.06
Roselle	D	98.64±20.26	133.64±19.08	14.56±2.45	13.33±2.52
	R	110.01±24.24	108.79±13.70	15.39±1.23	12.67±2.52
Kenaf	D	121.45±13.65	152.75±20.25[a]	13.27±2.25	13.00±1.01
	R	111.87±21.85	103.92±14.59[a]	15.99±1.61	10.67±1.16

D = dry season samples, R = rainy season samples and [a] = means of the same vegetable type are significantly ($p<0.05$) different.

(1998). All values were within the range of 5 to 300 μgg-1 in vegetables (Audu and Lawal, 2006), but only rainy season amaranth was within the range of 20 to 150 μgg^{-1} normal Zn content in plants (ICAR, 2006). Only tomato samples indicated a significant difference at $P<0.05$. Values for soils of the vegetables were lower than those reported by Amusan et al. (2005), but were all within the range of 3 to 100 μgg^{-1} normal Zn concentration in German soils reported by Kretzschmar, et al. (1998). Significant difference was observed only in soils for kenaf. The difference in weather has little influence on the concentration of Zn in amaranth, roselle and kenaf. Nickel content in the dry season roselle compared well with the value of 8.00 μgg^{-1} reported by Sena et al. (1998), while Miller-Ihli and Baker (2000) reported 6.00 μgg^{-1} in spinach. All values (except in dry season amaranth) in this research work were within the 0.1-10 μgg^{-1} range recommended as the normal Ni content in plants. All dry season vegetables indicated values that were higher than those of their corresponding rainy season samples and significant differences at $P<0.05$ were observed. The high concentration of Ni observed in the dry season vegetables can be attributed to their ability to absorb and retain Ni during the dry season weather. In Pb determination, the values obtained in this research work were much lower than those reported by Anthony and Balwant (2009), but were within the 6.0 μgg^{-1} standard set by Hong Kong (Haw-tarn et al., 2004; Yi et al., 2004). Significant differences at $P<0.05$ were observed only in amaranth and kenaf samples. The Cd content in the vegetables was low in both the sets of the samples. The values for the rainy season amaranth, roselle and kenaf were higher those of their corresponding dry season samples. All the vegetables indicated significant differences at $P<0.05$.

Vitamins A and C, oxalate and nitrate composition

Table 4 present the concentrations of vitamins A and C and oxalate in mg/100 g and also nitrate in μgg^{-1} in the samples. The values observed for vitamin A in both the dry and rainy season samples were closely related. The values for tomato were slightly below the 62.2 mg/100 g for sun-dried tomato reported by USDA (2008). Values of 392.0, 388.0 and 408. mg/100 g were reported in Amaranth (A. paniculatus); Spinach (S. oleracea) and red amaranth (A. tricolor) respectively were reported by Agte et al. (2000). There was no significant difference at $P<0.05$ in the sets of values which indicated that the weather condition has no influence on the vitamin concentration in the vegetables.

Mammals cannot synthesize vitamin A which is an important precursor to 11-cis-retinal. β-carotene from plants is converted to vitamin A (retinol) with the help of enzymes from the liver. The concentrations of vitamin C in the dry season amaranth, roselle and kenaf were higher than those of their corresponding rainy season samples. The values for tomato were higher than 39.20 mg/100 g reported for tomato by USDA (2008) and 34.38 mg/100 g in the fresh weight samples (Carr and Frei, 1999). Tunde (1988) reported 405.0 mg/100 g in water leaf samples and 54 mg/100 g in raw roselle leaves. Vitamin C is highly sensitive to air, water and temperature, drying process is enough for some of the vegetables lose part of their vitamin C. Significant differences at $P<0.05$ were observed in amaranth and kenaf samples and in both, the dry season samples had the highest values. Human beings are among the few vertebrates that cannot synthesize vitamin C an important antioxidant (David et al., 2008). Closely related values for oxalate were observed in the vegetables. Slightly higher values of 50 mg/100 g (tomato) by USDA (2008), 88.21 mg/100 g (Hibiscus sp) and 56.37 mg/100 g (Amaranthus viridis) were reported by Sheela et al. (2004). No significant difference at $P<0.05$ was observed in the samples. Similarly, the values for nitrate in the dry season samples were observed to be closely related with those of their corresponding rainy season samples. The range of 8.2 to 54.60 μgg^{-1} in tomato was reported by

Table 5. pH, available phosphorus and cation concentration in soils of the vegetables samples.

Soils	Season	pH	P (ugg^{-1})	Na^+ (ugg^{-1})	K^+ (ugg^{-1})	Mg^{2+} (ugg^{-1})	Ca^{2+}(ugg^{-1})
A1	D	7.55±0.17	6.44±2.10[a]	22.92±2.26[a]	50.37±12.18[a]	31.36±3.31	28.30±2.25
	R	7.20±0.22	10.19±0.34[a]	20.47±1.94[a]	83.94±12.04[a]	33.37±3.62	30.07±2.81
B2	D	7.24±0.16	0.71±0.21[a]	22.74±2.23	59.08±15.95	34.85±3.17[a]	32.36±2.10[a]
	R	6.73±0.36	6.32±1.48[a]	28.00±1.96	72.77±15.33	38.78±3.19[a]	38.33±2.99[a]
C3	D	7.05±0.20	0.93±0.21[a]	23.45±1.49	56.41±23.23	24.33±3.27[a]	37.70±2.48[a]
	R	7.22±0.32	5.62±1.08[a]	22.24±2.43	60.30±12.62	31.20±2.87[a]	28.88±3.03[a]
D4	D	6.68±0.47	0.81±0.13[a]	20.98±2.21[a]	52.10±11.61[a]	28.00±3.12[a]	27.86±2.86[a]
	R	7.30±0.26	6.17±1.99[a]	35.05±4.89[a]	80.36±19.45[a]	32.72±2.56[a]	36.41±4.04[a]

A1 = soils for tomatoes, B2 = soils for amaranth, C3 = soils for roselle, D4 = soils for kenaf, D = dry season samples, R = rainy season samples and [a] = means of soils of the same vegetable type are significantly ($p<0.05$) different.

Table 6. Micro element concentration (µgg^{-1}) in the soil samples of the vegetable samples.

Soils	Season	Fe	Zn	Cu	Mn	Ni	Pb	Cd
A1	D	2366.37±821.41	10.94±0.67	54.86±11.23	97.47±12.45[a]	6.62±2.12	3.67±2.34	2.04±0.45
	R	2130.52±545.41	9.60±2.60	74.33±11.80	82.66±16.75[a]	6.38±1.05	2.46±1.10	1.82±0.18
B2	D	2718.87±305.00	17.90±4.71	69.34±14.69	151.75±14.18	5.20±1.54	8.25±3.71[a]	1.24±0.70
	R	2782.76±184.68	20.16±3.37	69.42±7.65	188.35±82.91	5.18±0.95	2.08±0.75[a]	2.16±1.42
C3	D	183.26±125.20	14.08±2.39	61.23±7.94	81.08±22.53	7.96±1.16[a]	7.01±5.28	1.46±0.46
	R	1372.87±265.76	14.43±1.52	53.61±9.59	81.56±22.73	6.09±0.85[a]	3.54±1.92	1.29±0.59
D4	D	1267.97±489.33[a]	12.84±3.49[a]	54.06±21.81[a]	158.73±24.80	6.17±2.40	5.42±2.95	1.31±0.98[a]
	R	3738.96±1613.63[a]	34.47±21.75[a]	71.75±3.22[a]	175.14±54.87	5.26±1.33	3.10±1.79	2.90±0.77[a]

A1 = soils for tomatoes, B2 = soils for amaranth, C3 = soils for roselle, D4 = soils for kenaf, D = dry season samples, R = rainy season samples and [a] = means of soils of the same vegetable type are significantly ($p<0.05$) different.

Fytianos and Zarogiannis (1999). Similarly, the values for tomato were within the group of <200 µgg^{-1} NO_3^- concentration classified by Pietro (2006). The sets of values were lower than the maximum levels of 300 to 400 mg/100 g NO_3^- concentration that may be present in leafy vegetables (Miroslav and Vladimir, 1999) and no significant difference at $P<0.05$.

Conclusion

The analytical data on the proximate, elemental, vitamins A and C, oxalate and nitrate contents in some of the vegetables clearly indicates that their presence and concentrations depends not only on the seasonal conditions, but on the carrying capacity of individual plant and availability of the nutrient or its source in the soil. In some of the nutrients, both weather conditions and soil concentration had no effect on their concentrations in the vegetables.

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