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Research article

Effect of seasonal variation on the Elemental composition of selected vegetables from Fadama areas of Talata Mafara, Zamfara State, Nigeria

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Abstract

This study was undertaken to determine the effect of seasonal variation on the concentrations of macro and micro elements in amaranth, roselle and kenaf cultivated in two years (2009 and 2010) from selected agricultural fields in Talata Mafara, Zamfara state, Nigeria. Between dry as well as rainy season samples cultivated in 2010 and 2009, the mean values for only P, K and Cu of 2010 were higher than those of 2009. Clear trends were observed between dry and rainy season vegetables of both 2009 and 2010 in the concentrations some of the macro and micro elements. The values for P, K, Ca, and Mn in amaranth, Na and Cu in roselle as well as Mg, Fe and Zn in kenaf in the dry season samples were higher than those of their corresponding rainy season samples, while the values for rainy season samples were higher for Zn and Cu in amaranth, K and Ca in roselle, Cu and Mn in kenaf. Significant differences at 95% confidence level were observed for the concentration of the elements between dry and rainy season vegetables of both 2009 and 2010 except for Ni in roselle and Na in rainy season amaranth samples. It was also observed between dry and rainy season samples of 2009 except for Ca and Fe in roselle as well as Ni in both roselle and kenaf. Similarly, the differences were observed between dry and rainy season samples of 2010 except for Na K, P and Mg in amaranth, K, Mg and Cu in roselle as well as P, Mg, K, Ca and Ni in kenaf. The vegetables responded differently on the effect of seasonal variation in the concentrations of macro and micro elements which indicates that there other factors that need to be considered.

Keywords: Amaranth, roselle, kenaf, seasonal variation, elemental composition

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Introduction

Vegetables occupy an important place among the food crops of people in both rural and urban environments. This is because they provide adequate amounts of vitamins and mineral elements to both human and other animals. Through photosynthesis, vegetables and other plants are able to fix inorganic carbon dioxide from the atmosphere and convert it into organic matter which can be used as source energy by the plants, while animals get their energy from the plants.

$$6CO_2(g) + 6H_2O(l) \longrightarrow C_6H_{12}O_6(aq) + 6O_2(g)$$

Similarly, plants are able to get the required mineral elements from the soil by mobilizing them from the surrounding in the form that can be absorbed. In the process absorbing the nutrients, some are absorb in large quantities depending on their concentration, available form and or the requirements. High concentrations of elements occur rarely in soils under natural conditions. Animals on the other hand get their nutrients from water and directly or indirectly from plants [1]. The nutrient content of vegetables differs from one species to another and from one part of a plant to another [2]. Soil contamination by toxic substances are generally as a result human activities and this has negative effects on the productivity, microbiological process of the soil, plant growth and development as well as the quality of the of the agricultural products [3]. Although, the content of heavy metals in soils is an important indicator of soil contamination, it is not sufficient to characterize this as environmental hazards as it depends on the form available, pH and moisture conditions of the soil [3].

Plants have developed various biochemical mechanisms that have resulted in their ability to adopt and tolerate new or chemical imbalanced environment [4]. A significant change in the environment affects most plants growth and development as well as their nutrient composition. For instant, researches have shown that certain plants certain plants that mature during autumn contain higher amount of vitamin A than those that mature in poorer light of winter [5]. Similarly, during rainy season, when temperature distribution is normal, it is the rainfall distribution that affects the growth and development of plants. In the dry season, the environment temperature and water use requirements of individual plants that affect their growth and development.

The distribution of plants from one environment to another is affected by conditions such as weather and or soil composition. Since vegetables are essential component of human diet, the need for their availability throughout the year in all environments becomes necessary. The aim this study was to investigate the effect seasonal changes on the nutrient content of selected vegetables from the fadama areas of Talata in Zamfara state. The heardquarters of Talata Mafara are in the town of Talata Mafara about 15km from Bakolori dam on the Sokoto River. It lies on the southern edge of the major irrigation project fed by the dam. The local government area has an area of 1430km^2 with 12^{o}34’00N and 6^{o}04’00”E as its coordinates.

Materials and Methods

Sample collection and processing

Samples of each leafy vegetable type and their soils (0 - 30cm depths) were collected from three different farms both in the dry and rainy seasons between the fifth and sixth week after sowing. The collections were made in the year 2009 and 2010.

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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^oC to constant weight [6 and 1].

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^oC for 5 hours [7 and 8].

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^oC for 3 hours. 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. [9 and 10]. The crude lipid was extracted with n-hexane in a soxlet extractor. The Total dietary fibre was determined by non-enzymmatic-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^oC for 90 minutes. This was followed by precipitating with four volumes of 95% ethanol. One of the washed, dried and weighed residues was ashed at 525^oC for 3 hours 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 [11]. 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 [2, 10 and 12].

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 dried and powdered sample in to separate 100cm^3 Kjeldahl flasks, 30 cm^3 of 69.5% (w/w) HNO_3 were added to each of the flasks and heated until about 10cm^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 1cm^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 [13 and 14]. 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 1.0g of each of the oven dried and powdered sample in to separate digestion tubes, 30cm^3 of 69.5% (w/w) HNO_3 acid was added to each and heated until about 10cm^3 was left. This was followed with addition of 10cm^3 of 69.5% (w/w) HNO_3 acid and 2cm^3 of 60% $HClO_4$ acid and the heating process continued until clear solutions were obtained. Each of the digests was diluted with about 20cm^3 of distilled water, boiled for another 15 minutes, allowed to cool, filtered in to separate 50cm^3 volumetric flasks and made to the mark with distilled water. The solutions were stored in separate screw capped polyethylene bottles [15 and 16]. Blank solution was prepared in the same way but without any sample.

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/100g (proximate composition), Mg/100g (Macro elements) and µgg^{-1} (trace elements). Student't test was further used to test significant differences between the means of rainy season samples and that of the dry season [16 and 14].

Proximate Composition

Tables I and 2 contains the values for proximate composition of the dry and rainy season vegetables cultivated in both 2009 and 2010 expressed in g/100g dry or fresh weight.

Macro elements Composition

Tables 3 and 4 presents the values expressed in mg/100g dry weight of the macro element composition of the vegetables from the study areas in both dry and rainy seasons of 2009 and 2010. In all the vegetables, the mean values for P in both dry and rainy samples of 2010 were higher than those of their corresponding samples of 2009. In both 2009 and 2010, the dry season amaranths had values that were higher than those of their corresponding rainy season samples. In 2009 kenaf and roselle samples, the highest values were observed in rainy season samples, while in 2010 kenaf and roselle samples, the highest values were observed in the dry season samples. Significant differences at 95% confidence level were observed except between rainy and dry season amaranth and kenaf samples of 2010.Slightly high value of 664mg/100g [17] for P was reported in roselle. For Na concentration in amaranth samples, the mean values in both 2009 and 2010 rainy season samples were closely related, while the mean value for 2009 dry season samples was higher than that of 2010. In 2009, the value for the dry season samples was higher than that of the rainy season samples, while the values for both dry and rainy season samples in 2010 were closely related. For both roselle and kenaf samples, the mean values for Na concentration in both dry and rainy season samples of 2009 were higher than those of their corresponding 2010 samples. Similarly, in both 2009 and 2010 roselle samples, the values observed in the dry season samples were higher than those of their corresponding rainy season samples. In kenaf samples, the value for dry season samples of 2009 was higher, while in 2010, it was that of the rainy season samples. Significant differences at 95% confidence level were observed in the vegetables except between amaranth of rainy and dry season samples of 2010. The concentration of Na as observed in this research fall within the range of 2 – 150 mg/100g [18] reported in vegetables. For K concentrations in all the vegetable samples, the values of 2010 samples were higher than those of their corresponding 2009. In both 2009 and 2010, the mean values for the dry season amaranths were higher than those of their corresponding rainy season samples while the reverse was the case with roselle samples.

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Results and Discussion

Results

Table 1: Proximate Composition of the Rainy and Dry season Vegetables in g/100g in dry weight as of 2009

Vegetable	Season	Moisture	Ash	Crude Protein	Total Dietary Fibre	Crude Lipid	Carbohydrate
Amaranth	Rainy	90.91±2.07	15.47±1.48	35.22±0.35	25.72±0.93	6.97±0.38	16.62±0.35
,,	Dry	93.11±1.41	13.69±0.87	36.10±0.40	25.46±0.60	6.95±0.44	18.47±0.93
Roselle	Rainy	89.34±2.00	6.92±0.27	29.42±0.94	26.37±0.35	6.23±0.72	31.06±1.46
,,	Dry	87.61±1.41	6.62±0.15	30.55±0.78	27.27±0.31	6.67±0.53	28.89±0.56
Kenaf	Rainy	88.79±3.15	6.45±0.64	30.46±0.70	25.62±0.80	5.63±0.67	31.84±0.14
,,	Dry	84.08±1.19	5.85±0.64	28.66±0.89	26.30±0.55	5.31±0.38	33.88±0.69

Table 2: Proximate Composition of both Rainy and Dry season Vegetables in g/100g dry weight as of 2010

Vegetable	Season	Moisture	Ash	Crude Protein	Total Dietary Fibre	Crude Lipid	Carbohydrate
Amaranth	Rainy	91.44±0.80	11.65±0.84	31.94±1.00	24.79±1.11	5.51±0.52	26.45±1.27
,,	Dry	92.44±0.81	11.79±0.92	30.90±0.59	22.79±0.31	5.49±0.68	29.03±2.04
Roselle	Rainy	91.05±0.49	07.65±0.50	27.34±0.11	25.03±0.12	4.77±0.30	35.21±0.68
,,	Dry	89.23±0.34	06.58±0.53	28.13±0.39	24.40±0.20	5.41±0.19	35.48±0.10
Kenaf	Rainy	89.43±0.24	04.53±0.17	27.03±0.21	25.64±0.51	3.72±0.50	39.09±0.85
,,	Dry	87.86±0.38	05.79±0.48	25.70±0.34	27.89±0.58	4.48±0.37	36.12±0.69

Table 3: Macro element Composition of both Rainy and Dry season Vegetables (mg/100g) in dry weight as of 2009

Vegetable	**Season**	**P**	**Na**	**K**	**Ca**	**Mg**
Amaranth	Rainy	357.79±24.14	22.01±1.74	1078.03±73.89	809.84±22.18	689.07±33.92
,,	Dry	461.75±62.83	28.50±3.04	1350.56±159.29	1147.23±101.61	613.83±41.37
Roselle	Rainy	308.12±26.82	20.46±1.69	1141.65±107.23	808.12±83.23	638.39±39.67
,,	Dry	266.66±37.46	35.33±2.36	951.91±96.66	817.13±89.91	512.26±47.89
Kenaf	Rainy	324.44±35.77	23.17±1.11	684.43±58.02	791.77±28.37	654.81±33.48
,,	Dry	249.66±29.78	35.07±1.55	856.54±64.08	924.29±45.68	414.03±50.81

Table 4: Macro element Composition of both Rainy and Dry season Vegetables (mg/100g) in dry weight as of 2010

Vegetable	**Season**	**P**	**Na**	**K**	**Ca**	**Mg**
Amaranth	Rainy	553.46±71.05	22.93±1.92	1853.73±163.58	571.87±32.55	582.25±59.42
,,	Dry	592.06±55.50	22.86±0.48	1919.20±37.76	768.29±40.88	556.75±50.05
Roselle	Rainy	346.85±30.45	18.23±0.72	1368.41±45.49	623.72±30.16	430.55±31.96
,,	Dry	401.52±47.46	19.66±1.09	1290.04±118.08	584.42±26.45	452.44±26.31
Kenaf	Rainy	393.05±40.03	20.77±0.68	1707.95±74.59	593.19±42.38	394.80±21.02
,,	Dry	413.56±21.37	19.36±0.19	1664.89±62.34	564.46±27.71	409.27±63.47

Table 5: Micro element Composition of both Rainy and Dry season Vegetables in $\mu g g^{-1}$ dry weight as of 2009

Vegetable	Season	Fe	Zn	Cu	Mn	Ni
Amaranth	Rainy	68.35±03.59	13.17±1.19	17.26±01.26	18.24±2.03	3.52±0.18
,,	Dry	76.42±06.95	10.40±1.44	13.32±03.32	11.80±1.54	2.74±0.35
Roselle	Rainy	75.26±09.43	11.83±1.13	17.06±02.45	16.57±2.09	4.58±1.40
,,	Dry	83.51±09.45	13.99±1.09	22.27±02.16	21.42±2.80	5.15±0.95
Kenaf	Rainy	85.83±03.71	15.06±1.03	16.73±01.02	18.13±1.67	4.06±1.06
,,	Dry	116.65±17.43	19.05±1.06	13.72±02.18	13.17±1.82	4.31±0.92

Table 6: Micro element Composition of both Rainy and Dry season Vegetables in $\mu g g^{-1}$ dry weight as of 2010

Vegetable	Season	Fe	Zn	Cu	Mn	Ni
Amaranth	Rainy	251.81±33.84	21.38±3.55	22.77±1.94	12.26±1.19	4.12±0.25
,,	Dry	185.46±33.87	17.39±1.66	18.23±2.01	14.14±0.46	5.11±0.30
Roselle	Rainy	57.05±6.51	19.29±1.79	19.45±0.61	14.70±0.81	5.89±1.02
,,	Dry	49.84±3.47	16.55±0.77	29.41±1.85	17.36±0.71	4.81±0.75
Kenaf	Rainy	67.85±2.53	23.17±1.95	21.99±1.02	20.14±2.12	5.55±0.67
,,	Dry	72.83±2.94	26.74±1.55	19.62±0.69	16.73±1.13	6.00±0.81

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In kenaf samples of 2009, it was the dry season samples that had the highest mean value while the reverse was observed in samples of 2010. Significant differences at 95% confidence level were observed except between rainy and dry season amaranth, roselle and kenaf samples of 2010. Value as high as 1970 mg/100g [17] for K concentration was reported in roselle. Similarly, mean value of 2903 mg/100g [13] was reported in spinach. For both Ca and Mg concentrations in all the vegetable samples of the two seasons, the values for 2009 were higher than those of their corresponding 2010 samples. For Ca concentration in amaranths of both 2009 and 2010, the values for dry season samples were higher. The values for dry season roselle and kenaf samples of 2009 were higher than those of their corresponding rainy season samples; the reverse was the case in samples of 2010. Except in dry season amaranth of 2009 samples, the values for Ca in the vegetables irrespective of season or year of cultivation were much lower than 1240 mg/100g [17] reported in roselle. For Mg in amaranth, roselllе and kenaf samples of 2009, the values for rainy season samples were higher than those of their corresponding dry season samples, while the reverse was the case in roselle and kenaf of 2010. Significant differences at 95% confidence level were observed except between the values for Ca in rainy and dry season rosellle samples of 2009 as well as kenaf samples of 2010. Similarly, Significant differences were observed except between the values for Mg in dry and rainy season amaranth, roselle and kenaf samples of 2010 as well as between dry season amaranth samples of 2009 and 2010.

Micro element concentration

Tables 5 and 6 present the micro element composition in μgg^{-1} dry weight of both dry and rainy season vegetables of 2009 and 2010 respectively. For the concentration of Fe in the vegetables, it was only in amaranths that the mean values for rainy and dry season samples of 2010 were higher than those of their corresponding samples of 2009. In 2009, the mean values for dry season vegetables were higher than those of their corresponding rainy season samples, while in 2010 amaranth and roselle samples, the mean values of the rainy season samples were higher than those of their corresponding dry season samples. Generally, significant differences at 95% confidence level were observed except between the rainy and dry values for roselle of 2009. The values generally obtained for Fe in the vegetables were within the range 0f 18 -1000 μgg^{-1} as the natural Fe in folder plants reported by Adeyeye [4]. Except for the values of Fe in 2009 samples dry season kenaf and as well as dry and rainy season amaranths of 2010, other vegetables gave values that were lower than the range of 100 – 500 μgg^{-1} recommended as the normal Fe concentration in plants by ICAR [19]. For Zn concentration in the vegetables, only amaranth and roselle indicated mean values for both rainy and dry season that were higher than those of their corresponding 2009 samples. The rainy season samples of 2009 and 2010 had values that were higher than those of their corresponding dry season samples in amaranth and kenaf. Generally, the mean values obtained for Zn in this research were much lower than 72.90 μgg^{-1} reported in roselle by Sena et al [17], but where within the range of 5 – 300 μgg^{-1} Zn concentration in vegetables reported by Audu and Lawal [15]. For Cu concentration in both the dry and rainy season samples, the values for 2010 samples were higher than those of their corresponding 2009 samples. The rainy season amaranth and kenaf samples of 2009 and 2010 had values that were higher than those of their corresponding dry season samples. Between the values for Mn in rainy season amaranth and roselle samples of 2009 and 2010, the values for

2009 samples were higher than those of their corresponding 2010 samples, while in kenaf the same trend was observed between the values in dry season samples. Generally, the mean values for Mn obtained were observed to be much lower than 832.83 μgg^{-1} (amaranth) reported by Uba and Uzairu [8] and 114 μgg^{-1} (roselle) by Sena et al [17]. Significant differences at 95% confidence level were observed in the values for the concentrations of Zn, Cu and Mn between dry and rainy season samples in both 2009 and 2010. Similarly, it was also observed between dry season samples of 2009 and 2010 as well as between their rainy season samples. For the concentration of Ni between amaranth as well as kenaf samples of both 2009 and 2010, the mean values for both rainy and dry season samples of 2010 were higher than those of their corresponding samples of 2009, while in kenaf, similar trend was observed only in the rainy season samples. In 2009, the value for rainy season amaranth only was higher than that of the dry season samples, while in 2010 similar trend was observed only in roselle samples. The values obtained for Ni concentration in the vegetables were within the range of 0.1 – 10 μgg^{-1} recommended as its normal concentration in plants by ICAR [19]. The Significant differences at 95% confidence level was observed between dry and rainy season amaranth samples of 2009 and 2010, Similarly, it was also observed between dry season samples of 2009 and 2010 as well as between their rainy season samples. The difference was observed only between roselle samples of 2010. Similarly, significant differences were observed only between rainy season kenaf samples of 2009 and 2010 as well as between dry season samples of 2009 and 2010.

There were clear trends in the concentrations of some of the macro and micro elements (P, K, Ca, Mn, Na, Cu, Mg, Fe and Zn) between dry and rainy season vegetables of both 2009 and 2010. The values for P, K, Ca, and Mn (in amaranth), Na and Cu (in roselle) as well as Mg, Fe and Zn (in kenaf) in the dry season samples were significantly higher than those of their corresponding rainy season samples, while the values for Zn and Cu (in amaranth), K and Ca (in roselle), Cu and Mn (in kenaf) in the rainy season samples were higher than those of their corresponding dry season samples. The inconsistencies observed in the trend of concentration of some of the elements in the plants is an indication that there are other important conditions such as availability of individual nutrient element in the form that it can be absorbed by plant from the soil, plant's ability to absorb and retain a nutrient as well as plant's level of growth and development that need to be considered.

Conclusion

Vegetables are good sources of both macro and micro nutrient elements. The response of vegetables on the effect of seasonal variation in the concentration of macro and micro nutrient elements differ from one species to another and also on other factors such as availability of individual nutrient element in the form that it can be absorbed by a plant from the soil, soli acidity, the plant's ability to absorb and retain an element as well as plant's level of growth and development. The effect of seasonal variation on the concentration of macro and micro nutrient elements differ from plant species to another and on the type of nutrient element involved.

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