Original Research Article

Title- Effect of age at harvest and leaf position on the yield and nutritional composition of *Celosia argentea*L.

Abstract

A pot experiment was carried out at the nursery site of the Department of Crop Production,Federal University of Technology,Minna(9°36'N, 6°33'E) Niger state, Nigeria. The study aimed at determining the effect of age of celosia plant at harvest on the yield and nutritional composition of the plant as well as the concentration of nutrients at different leaf positions. The experiment was a 3x3 factorial combination of three harvest periods (5, 7 and 9WAS-weeks after sowing) and three leaf positions on the mother plant (upper, middle and basal) arranged in a completely randomized design. Harvested leaves were analyzed for the nutritional composition. The results showed that the whole plant fresh weight,varied significantly ($p<0.05$) with the age of plant at harvest, having the maximum and the minimum values at 9WAS (266.19 g/pot) and 5 WAS (96.12g/pot) respectively. The leaf fresh weight and leaf dry weight followed the same trend with the whole plant fresh weight.Crude protein and Na reduced significantly ($p<0.05$) with the age of the plant with the highest values recorded at 5WAS. Zn was highest at 7WAS.K and Vit. C content were significantly higher at 9WAS. Ca was highest at 9 WAS but there wasno significant difference in the value obtained at 9 and 5WAS. Higher values of Fe were obtained at 7 and 9WAS. The Mg content was not significantly affected by the age at harvest. The middle leaves had significant higher content of Mg and Vit. C when compared to the basal leaves but there was no significant difference between the values obtained in upper and middle leaves. Significant ($p<0.05$) higher values of Ca, Fe, and crude protein were recorded in the basal leaves. There was no significant difference in the values of K, P, Na, Fat and Zn obtained at the different leaf positions.

Please write weeks on complete word, because WAS is so confusing.

Key words: *Celosia argentea*, leaf positions, age at harvest, nutrients, yield

1.0 Introduction

Lagos spinach (*Celosia argentea* L.) is a tropical annual leafy vegetable, and a leading leafy vegetable in SouthWestern Nigeria where it is known as 'Sokoyokoto'. The leaves and tender stems are cooked into soups. It is rich in protein,minerals and vitamins.It had been documented that the nutritional composition of *Celosiaargentea*per 100 g edible portion is 83.8 g water; 185kj energy; 4.7 g protein; 0.7 g fat; 7.3 g carbohydrate;1.8 g fibre ; 260 mg Ca; 43 mg P and 7.8 mg Fe, respectively (2). However, the composition of *Celosia argentea*is stronglyinfluenced

by environmental factors such as soil fertility,fertilizer application and age of the plant atharvest(2). Various methods had been used to harvest vegetables; they could be uprooted orratooned in such a way that the lower leaves are left unharvest. Even when the whole plant parts are harvested, some people do not consume the lower leaves (older leaves)believing that it is too fibrous and less nutritiouswhen compared to the upper leaves (younger leaves). The mineral content in the different plant tissues is related to their mobility in the plant. In conditions of mineral deficiency, some nutrients may be translocated from the mature leaves and fruits to the younger leaves(3).Some nutrients are relatively immobile in plants and cannot be easily redistributed to younger leaves or other parts(4, 5, 6) thus: making the concentration of such nutrients higher in some plant part than the other.In view of the above, this research was carried out with the aim ofdetermining the best age to harvest the plant to get the highest yield and optimum nutrients as well as the leaf position in which the derivable nutritional potential is highest.

2.0 Materials and Methods

The pot experiment was carried out at the Horticulture Nursery of Federal University of Technology Minna($9^{o}36'N, 6^{o}33'E$), Niger state in the raining season of 2013. It was a 3x3 factorial experiment arranged in completely randomized design. The treatments were 3 harvest periods: 5, 7 and 9 weeks after sowing and 3 leaf positions (upper, middle and basal leaves). The treatments were replicated three times. Each pot was filled with 8kg top soil. Four seeds of TLV8 variety were sown per pot and at two weeks after planting, the seedlings were thinned to two per pot.NPK 20:10:10 fertilizer was applied at the rate of 80kg N ha^{-1}, 40kgP_2O_5 ha^{-1} and 40kg K_2O ha^{-1} at two weeks after planting. Weeds werehand-picked whenever noticed. The plants were harvested at the sampling period stated above and fresh weights were taken after which they were separated into the upper, middle and the basal leaves.The leaves were dried inan oven at $65^{0}C$ till constant weight was obtained to get the leaf dry weight and were subsequentlyanalyzed for protein, fat, carbohydrate, crude fibre, Vit. C and mineral elements(Fe, Mg, Zn, Ca, P, Na and K).

The mineral elements (Fe, Mg, Ca, Na and K)in the test samples were determined by digesting sample in mixture of concentrated HNO_3 and perchloric acid and read using atomic absorption 752 UVspectrophotometer(model-YM1208PTSI). Flame photometer was used for Na and K only. The P was determined using the molybdate method and quantified using a spectrophotometer. The ascorbic acid concentration in thesamples was determined by 2, 6-dichlorophenol indophenol titrimetric method. The crude protein was determined based on total N content by Kjeldahl method (1).All the datacollected were subjected toanalysis of variance (ANOVA) using version 9.0 of SAS (GLM procedure).Treatment means were separated using the least significant difference where significant differencesoccurred at 5% level of probability.

3.0 Result and Discussion

Table 1 reveals that the yield obtained (whole plant fresh weight, leaf fresh weight and leaf dry weight) increased with the plantage and the highest value was recorded at 9 weeks. This could be attributed to dry matter accumulation with increase in age.Several authors have reported that there is increase in dry matter yield as plant age. (7, 8). However, the difference between the yield values obtained at 5 and 7 WASand between 7 and 9 WAS were not statistically different.

Table. Include legend

Whole plant fresh weight (g/pot)		Leaf fresh weight (g/pot)	Leaf dry weight (g/pot)
Age (Weeks?)			
5	96.12±	36.18±	3.03±
7	173.94±	56.94±	3.93±
9	266.19±	58.83±	5.71±
SE±	59.54±	7.94±	0.57±
LSD (0.05)	169.65±	22.53±	1.61±

*WAS-Weeks after sowing; LSD- Least significant difference (0.05). Please include the SE for each menan value at each age material condition..

The result of the effect of the age at harvest and leaf position on the nutritional content of celosia are presented in Table 2. The result shows that there were significant differences in calcium content with respect to the plantage. The highest value of calcium was recorded at 9WAP. This is

in agreement with the result obtained for Amaranthus by (9) who recorded the highest amount of calcium at the highest sampling period (60 DAP). Calcium content was significantly higher in basal leaves than the other two leaf positions. This value (146.60mg/100g) obtained in *Celosia argentea* doubled the amount (42-62mg/100g) recorded for different *Amaranthus species* reported by (9). This confirms the fact that *Celosia argentea* is rich in calcium(10). The value obtained in this study is still far below the recommended dietary allowance of 1000-1200mg/ day (11).(12) also observed that the highest amount of calcium was recorded in the basal leaves. This could be because calcium is immobile (non-translocatable) within plants and remains in the older tissue throughout the growing season. This is why the deficiency symptoms of Ca appears first in the young growing part of the plant (6).There was no significant difference between the amounts of calciumrecordedin upper and middleleaves.

The age of the plant at harvest did not contribute significantly to the variation in Magnesium content recorded in the leaves. The magnesium value of the upper and the middle leaves were at par and were both significantly higher than the value for the lower leaves. This confirms the fact that Mg is withdrawn from ageing leaves due to its highly mobile nature (5). (13), observed no significant difference between the values of Magnesium obtained at the basal, middle and upper leaf position of *Hibiscus sabdariffa* plant.

The amount of K recorded in plant harvested at 9WAS (94.94mg/100g)was significantly higher than those obtained at 5 and 7WASwhich were at par.(14), recorded the highest amount of K at 6WAS in Amaranthus. There was no significant difference between the values of K recorded at the different leaf positions.

The Fe content increased with the age of the plant. This is in agreement with the report of(15). The highest value of Fe (38.98mg/100g)was obtained at 9WAS but was statistically similar to the value obtained at 7WAS. The basal leaves contained significantly more Fe than other leaf positions.This may be becauseFe is relatively immobile in plant (5).(16) also recorded the highest Fe content (27.53mg/kg) in the basal leaves of *Amaranthuscruentus*and with no significant difference between the values recorded in the upper and middle leaves.

Phosphorus value significantly decreased with the age of the plantwith30.17mg/100g, 19.87mg/100g and 17.36 mg/100g recorded at 5, 7 and 9WAS respectively.(14) recorded the highest P content at 4WAS(160mg/100g) beyond which the values declined in*Amaranthuscruentus.* There was no significant difference between theamounts of P recorded at the different leaf positions. This may be attributed to the fact that phosphate is easily redistributed in most plants from one organ to another (4).

Significantly higher amount of Na was recorded at 5WAS (18.90mg/100g) compared to the values obtained at 7(16.74mg/100g) and 9 WAS (17.33mg/100g). There was no significant difference between the values obtained at 7 and 9 WAS. There was no significant difference in the amount of Na recorded in the three leaf positions. (12) also reported similar findings

130 in*Telfariaoccidentalis*. The basal leaves of *Hibiscus sabdariffa*were however reported by (13) to
131 contain significantly higher value (3.38mg/kg) of the mineral than the middle and the upper
132 leaves. Though the valuesobtained in this study is lowwhen compared with the recommended
133 dietary allowance of 2300mg/day (11) but table salt is the primary source of this mineral.Intake
134 of a teaspoon of salt per day is capable of supplying the recommended rate of Na.

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137 **Table 2**. Effect of the age at harvest and positions of leaf on the nutritional content of *celosia argentea*

Treatments	Ca	Mg	K (Mg/100g)	Fe	PO4	Na	C.P (g/100g)	Fat	Vit.C Mg/100g	Zn
Separated										
5	134.52±	21.12	79.74	26.68	30.17	18.90	3.20	2.70	27.92	3.13
7	115.51±	23.17	74.84	35.41	19.89	16.74	2.90	3.02	35.00	4.03
9	144.97±	24.43	94.94	38.98	17.36	17.33	2.64	2.61	38.10	3.10
SE±	4.11	1.41	3.59	1.40	0.84	0.39	0.11	0.18	0.93	0.18
LSD	11.77	NS	10.19	4.05	2.37	1.10	0.30	NS	2.60	0.51

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139 *CP- Crude protein; LSD- Least significant difference (0.05); WAS; Weeks after sowing; SE- Standard error of the mean;

140 NS- Not significant. *All the parameters were measured in mg/100g except crude protein which was measured in g/100g.

141 Please include the SE for each menan value at each age material component..

142 Please include the following data in a separated table

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146 Table 3. Include a legend

Position										
Weeks age?										
Upper leaves	132.04±	24.33	90.65	30.78	23.76	17.94	2.66	2.61	34.44	3.72
Middle leaves	123.31±	24.41	80.52	29.20	21.77	18.32	2.81	3.06	35.89	3.63
Basal leaves	146.60	20.69	81.44	38.38	23.18	17.38	3.34	3.06	29.67	3.81
SE±	4.79	1.22	4.21	1.63	1.05	1.05	0.20	0.53	1.06	0.22
LSD(0.05)	13.59	3.50	NS	4.67	NS	NS	0.34	NS	3.01	NS
Interaction (Age x position)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*CP- Crude protein; LSD- Least significant difference (0.05); WAS; Weeks after sowing; SE- Standard error of the mean; NS- Not significant. *All the parameters were measured in mg/100g except crude protein which was measured in g/100g.

Please include the SE for each menan value at each age material component..

Crude protein reduced with the age of the plant. The valueobtained (3.2g/100g) at 5WAS was significantly higher than at 7 and 9 WAS. There was no significant difference between the values obtained at 7 and 9 WAS. This concurs with the reports of (7, 14, 17).(18)observed that crude protein content increasedfrom 4WAS till 7 WAS in *Sesamumradiatum*leaves after which there was a decline in amount till 10 WAS. The basal leaves had the highest crude protein content (3.34g/100g) which was significantly higher than the other positions which were at par.The highest value ofcrudeprotein obtained in the basal leaves (3.34g/100g) in this study is lower than the values obtained in *Amaranthuscruentus* leaves (23%) as reported by (19). This confirms the assertion of (9) that *Amaranthus*is higher in protein than Celosia. (2)reported that the amount of protein found in Celosia was 4.7g/100g. Varietal factors and the environment could also contribute to the variation in the value of crude protein obtained.

There was no significant difference between the fats amount obtained at the different harvesting periods and the different leaf positions. This is in line with the report of (18) who reported that the age of plant did not have any effect on the fat content of *Sesamumradiatum* leaves.

Vitamin C (Ascorbic acid) content increased progressively and significantly with age. The values recorded at 5, 7 and 9WAS were 27.92mg/100g, 35.00mg/100g and 38.10mg/100g respectively.The values obtained for both upper and middle leaves were statistically similar but significantly higher than the value for basal leaves.(13) recorded the highest Vit. C content in the middle leaves of *Hibiscus sabdariffa*. The value of Vit. C obtained implies that if 200g of *Celosia* is eaten, it could supply the daily recommended daily allowance of 75mg/day (11) if minimally processed. This confirms the assertion of (10) and (20) that *Celosia* is a good source of Vit. C.

The value of zinc (4.03mg/100g) recorded at 7WAS was significantly higher than those at 5 and 9 WAS which were similar statistically. There was no significant difference between the values of zinc obtained at the different leaf position. This could be because the mineral is highly mobile and is found in every part of the plant (4). (3) also observed that leaf position had no significant effect on the zinc content of *Hibiscus sabdariffa*. However, in *Amaranthuscruentus*,(16) recorded the highest value(0.11mg/kg) in the middle leaves. This value obtained in *Amaranthuscruentus* is low compared to the value obtained in *Celosia argentea*. This suggests that *Celosia argentea* is a moderately rich source of zinc. Deficiency of this mineral could cause growth retardation and poor sexual development in animal(11).

4.0 Conclusion

Consumption of Celosia at younger age(5 weeks after sowing) seems better as P, Na, Ca and Crude Protein values were significantly higher in leaves harvested at this age. However, for higher yield,harvesting at 9WAS can be considered. The value of K, Fe and Vit. C were higher in leaves harvested at 9WAS. The lower leaves have significant higher levels of Ca, Fe and crude protein.

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