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Growth, Yield, Phytochemical Screening and Nutritional Profile of Some Varieties of Pumpkin (*Cucurbita* sp.) Cultivated in Kano State, Nigeria

[1]Ahmad H K., [1] Galalain A M.,[2] Zakari S I.,
[1] Plant Science and Biotechnology Department, Bayero University, Kano
[2]Biological Science Department, Kano State College of Education and Preliminary Studies
*Corresponding author's e-mail: hkahmad.bot@buk.edu.ng

Abstract: Pumpkin, a prominent member of the cucurbitaceae family, is a key vegetable crop globally, with widespread cultivation across various regions. This study investigates the growth, yield, phytochemicals and proximate composition of different pumpkin varieties grown in Kano State, Nigeria. Three local varieties ('Rugudu', 'Yar sululu', and 'Fara') were planted during the dry season at Bayero University's research farm to determine their vegetative, reproductive growth and yield. Phytochemical analysis followed the method by Trease and Evans (2009), while proximate composition was assessed using AOAC (2000) standards. Data analysis employed ANOVA, and correlation analysis examined the relationship between growth parameters and yield. Results indicated significant differences ($p \leq 0.05$) in growth and yield parameters among the varieties, with a strong positive correlation observed between growth and yield. Phytochemical analysis revealed the presence of flavonoids, saponins, terpenoids, and cardiac glycosides in both pulp and seeds of harvested pumpkin varieties. Proximate composition analysis highlighted notable variations in the nutritional content of both pulp and seeds among the varieties. In conclusion, significant variations were observed in the vegetative, reproductive growth, and yield among the pumpkin varieties studied. The presence of phytochemicals enhances the ethnobotanical significance of the plant, while the substantial nutrient content underscores its nutritional value. Therefore, the cultivation and consumption of pumpkin should be encouraged.

Keywords: *Cucurbita spp*, Growth, Yield, Phytochemicals, Proximate

INTRODUCTION

One plant group with the most species used as human food is the Cucurbitaceae family. The Cucurbitaceae family consists of about 100 genera and 1,000 species of plants including mostly tropical, annual or perennial, monoecious, and dioecious herbs (Chomicki *et al.* 2020). Within this family, the genus *Cucurbita* stands out as one of the most important (Sali *et al.* 2012). The *Cucurbita* genus is regarded as a major vegetable crop in many regions of the world (Zhang *et al.* 2008). The name pumpkin was derived from the Greek word 'pepon' meaning "large melon". It is known by various names: for instance, it is known as pumpkin or winter squash in

English, "Kabewa" in Hausa, "Anya" in Igbo and "Elegede/Isi", in Yoruba respectively; (Mohammed *et al.* 2014). Pumpkin is an important member of the Cucurbitaceae family and is among the 10 leading vegetable fruit crops worldwide (Okoronkwo and Okoli, 2021).

The pumpkin (*Cucurbita* sp.) has a very high nutritional value, and contains nutrients like carbohydrates, minerals, dietary fibers, and other substances as well as an inexpensive source of vitamins (Jahan *et al.* 2023; Jiang *et al.* 2023). Worldwide, the leaves are consumed as vegetables, and the pulp is used to produce soups, purees, jams, and pies. Pumpkin seeds are regarded for their substantial linoleic acid, important fatty acid, and high protein content. The pumpkin seeds contain amazing amounts of vital amino acids and many important trace elements (Aziz *et al.* 2023). It is an extraordinary vegetable with the potential to be used as medicinal as well as a nutritious multifunctional food (Ndinya 2019). Pumpkin is thought to provide several health advantages due to its range of bioactive components including antidiabetic, anticancer, anti-inflammatory (Sharma *et al.* 2020) and antioxidants (Bartosz and Anna 2019; Salehi *et al.* 2021). Pumpkin is a powerful anti-aging tool that fights melanoma, cataracts, and other diseases. It also has a large amount of carotene in it. Pumpkin is low in fat and salt, and devoid of cholesterol (Aziz *et al.* 2023). But despite these strengths, it has been well established that pumpkin has been neglected by institutional research and improvement programs in Africa (PROTA 2018; Ezin *et al.* 2022). Pumpkins (*Cucurbita* sp.) are one of the most overlooked and underutilized food and medicinal plants (Nyabera *et al.* 2021). According to Aruah *et al.* (2011), In Nigeria, the populace is unaware of the high nutritional values of *Cucurbita* species, rather it is regarded as traditional food mainly for low-income earners, thus has not benefited from the same level of research attention given to other vegetables crops like cucumber, watermelon and fluted pumpkin.

In spite of the popularity of *Cucurbita* species in the culinary culture of Northern Nigeria, very little is known and published on nutrients composition of the pulp and the potential value of other parts of these plant species. This study was carried out to determine the vegetative and reproductive growth, yield, phytochemicals and proximate composition of some varieties of pumpkin (*Cucurbita* sp.) cultivated in Kano State, Nigeria.

MATERIALS AND METHODS

Sample collection and Field experiment

Three local seed varieties of *Curcubita* species were purchased from Dangora local market in Kiru Local Government area, Kano State. The field study was conducted at the University research farm, Faculty of Agriculture, Bayero University, Kano during 2019 dry season (11.9728°N, 8.4259°E). A designated area measuring approximately 459 square meters (m^2) (27 meters by 17 meters) was chosen and demarcated. Ridges were formed, and three plots, each measuring 6 meters by 7 meters, were marked using pegs and replicated three times. Each replicate was separated by a meter. In total, nine plots were established, representing three varieties ('Rugudu','Yar sululu' and 'Fara') organized in a complete randomized block design (CRBD). Before planting, 35 kilograms of cow dung was integrated into the plots.

Watering was done using 100% irrigation or full irrigation method with an interval of 7-days throughout the study period as recommended by Yavuz *et al.* (2015). Compound fertilizer (N.P.K. 15-15-15) at the rate of 252g per plot (2.3 kg per 459 m^2) was applied by three weeks after sowing and 1.5 kg per 459 m^2 of Urea 46% N was also applied by six weeks after sowing respectively (Oluoch 2012). Weeding to eliminate unwanted plants was conducted at specific intervals, namely the 3rd, 6th, and 8th weeks after sowing. Following the guidance of agricultural experts,a narrow blade hand hoe was employed for the weeding process.

Cypermethrin (cymbush) was applied to prevent insect pests during flowering, fruit initiation and fruit formation stages at the rate of 91.8ml per 459m^2. Spraying starts from 5WAS (weeks after sowing) and stopped at 9WAS. Benomyl (benlate) was applied at the rate of 68.9 g per 459m^2 due to the presence of disease symptoms. Spraying was done at 6th and 8th weeks after sowing. Data were collected on number

of leaves, chlorophyll contents, total leaf area, days to first flower (DFF), 50% flowering, number of fruits per plant, fruit length, fruit circumference and fresh fruit weight.

Sample preparation

The harvested pumpkins were taken to the laboratory for further analysis. The pulp and seed of each variety was carefully washed with water and dried in the laboratory. The dried samples were made into powder with pestle and mortar and stored in air tight container separately prior to analysis.

Sample Extraction and Phytochemical Analysis

The aqueous extract of (pulp and seed) were prepared using cold maceration method of extraction as described by Ncube *et al.* (2008).Alkaloids, Tannins, Saponins, Flavonoids, Anthraquinones, Cardiac glycoside and Triterpenes were determined using the method described by Trease and Evans (2009).

Proximate Analysis

The ash contents, moisture content,protein,crude fat, crude fibre and carbohydrate of the samples (pulp and seed) were determined using the method described by the Association of Official Analytical Chemist (AOAC, 2000).

Data Analysis

Data obtained were subjected to analysis of variance (ANOVA). Means were separated using Fisher's LSD (Least Significant Difference) at 5% level of probability.

RESULTS AND DISCUSSION

Vegetative growth parameters of selected local Pumpkin varieties

Results obtained on number of leaves, chlorophyll content and leaf area for pumpkin varieties were presented in Table1.Significant difference was observed among the varieties on measurements taken on number of leaves throughout the sampling periods. 'Yar sululu' had statistically highest number while 'Rugudu' had the least number of leaves. It was observed that at 2WAP 'Rugudu' and 'Yar sululu' had statistically similar number (4.67^{a}and5.00^{a}) while at 8WAP 'Fara' pumpkin had the least number of leaves (115.00^{c}). Chlorophyll content was also observed to be significant in 'Rugudu' variety throughout the period. Lowest content was recorded in 'Fara variety, although statistically similar amount was recorded with 'Yar sululu' at 4WAP (54.33^{b} and 51.80^{b}). Area of leaves (mm^2) measured in pumpkin varieties was also significant during the experiment. Leaves with smaller area were observed in 'Fara' variety throughout the weeks of observation. 'Rugudu' was however, observed to have broader leaves throughout the study period. It can be observed that the three varieties showed differences in terms of the vegetative parameters investigated. The three varieties showed better growth performance in terms of response to vegetative growth parameters. The variation in leaf number among the pumpkin varieties observed in this study is consistent with previous research by Okonwu *et al.* (2018), who noted that increasing leaf numbers are expected as plants grow. The works of Rubatzky and Yamaguchi (1997) on differences in growth habits, physical features (like size of their leaves, tendrils, vines, fruits) of members of Cucurbitaceae plant family confirm that the differences observed in this study is common to members of the family.

Differences in chlorophyll levels observed in this research are corroborated by previous studies. Li *et al.* (2018b) suggested that chlorophyll, a crucial photosynthetic pigment in plants, is significantly impacted by environmental factors. Their findings elucidate that plants adapt to their surroundings by modulating chlorophyll levels. Additionally, Sheikh *et al.* (2017) observed that changes in chlorophyll levels vary according to seasonal fluctuations and environmental influences.

Reproductive growth parameters of selected local Pumpkin varieties

Mean number of days to first flowering, 50% flowering, number of fruits and fruit parameters as presented in Tables 2 'Rugudu' variety statistically took higher number of days to first flower (53.33^{a}) and reach 50% flowering (64.67^{a}) while days to first flowering (45.33^{c}) and reaching 50% flowering (59.33^{c}) in 'Fara' variety was within fewer days. Highest number of fruits per hectare (784.11^{a}) was observed in 'Yar sululu' (Table 3) but fruit with the highest weight (6.33kg), length (43.28cm) and circumference (68.04cm) was observed in 'Rugudu'.

Lower values of the reproductive parameters measured were generally recorded in 'Fara' variety. The observations regarding the timing of first flowering and reaching 50% flowering primarily arise from differences in varieties among the evaluated *Cucurbita* varieties, indicating a diverse range of Kano pumpkins. Ezin *et al.* (2022) and Gbemenou *et al.* (2022) suggested that the variations observed in the time taken to reach 50% flowering in *Cucurbita* varieties could be attributed mainly to within-species differences. Ezin *et al.* (2022), documented that the time to reach 50% flowering varied from 41.21 to 68.72 days in *Cucurbita* sp. Similarly, PROTA (2018) stated that flowering typically initiates 35 to 60 days after emergence and is more or less continues.

The variations observed in the number of fruits per plant and fruit weight among different varieties align with findings from previous studies (Aruah *et al.* 2010; Rahman *et al.* 2016), which indicated that these differences were primarily influenced by the variety. According to PROTA (2018), the average fruit weight is determined by the specific varieties or cultivars and typically ranges from 1 to 10 kg.

The diversity observed in fruit length and circumference can be attributed to genetic variations among the varieties, as noted by Nee (1990) and Abdullah *et al.* (2003), who documented that *Cucurbita* varieties produce fruits of different sizes based on their genetic makeup.

Correlation analysis between some Growth Parameters and Yield of Pumpkin varieties

The matrix of correlation coefficient (r) between growth parameters taken and yield of pumpkin varieties is presented in Table 4. From the analysis, number of leaves was observed to be highly significantly correlated with the fruit yield at ($P \leq 0.01$). Chlorophyll, leaf area and days to 50% flowering were observed to show positive correlation with the yield at ($P \leq 0.05$). Days to first flowering was only significantly correlated with fruit yield at ($P \leq 0.10$). The results have indicated highly significant positive correlation between 50% flowering and numbers of leaves, 50% flowering and days to first flowering, days to first flowering and numbers of leaves as well as, leaf area and chlorophyll. In addition, significant correlation ($P \leq 0.05$) was observed between chlorophyll content, days to first flowering and 50% flowering. Similar trend was also observed between leaf area and days to first flowering as well as 50% flowering. However, chlorophyll content and leaf area were only positively correlated with number of leaves at ($P \leq 0.10$). The highly significant correlation between number of leaves and fruit yield suggests that a greater number of leaves on the pumpkin plants are associated with higher fruit yield. This finding is consistent with studies that emphasize the role of leaf area and photosynthesis in determining fruit yield (Goudriaan and Monteith 1990). Positive correlation between chlorophyll and fruit yield indicates that higher chlorophyll content is linked with increased fruit production. Chlorophyll is essential for photosynthesis, influencing plant growth and yield (Murchie and Lawson 2013). Larger leaf area correlates positively with fruit yield. This relationship emphasizes the importance of photosynthetic capacity and nutrient assimilation (Ainsworth and Long 2005). Days to 50% flowering and yield are correlated, suggesting that flowering may influence crop productivity and improve yields. The correlation between days to first flowering and fruit yield ($P \leq 0.10$) though less significant, suggests that the timing of the first flowering event may also influence fruit yield, however to a lesser extent compared to days to 50% flowering. There is a highly significant positive correlation between the number of leaves and the timing of flowering. This relationship highlights the role of plant development stages in overall plant productivity (Boyes *et al.* 2001). Similarly, the timing of the first flowering event correlates positively with the number of leaves, indicating a relationship between vegetative growth and reproductive development (Heuvelink and Dorais 2005). Leaf area and chlorophyll shows a significant positive correlation, reflecting the interconnectedness of leaf morphology and physiology in plant productivity (Evans 1996).

Compounds identified in aqueous extract of plant parts of the selected local pumpkin varieties used in the experiments.

Results of the compounds identified in the pulp and seed extract of matured pumpkin varieties were presented in Table 5. The result revealed the presence

of flavonoid, saponin, terpenoid and cardiac glycoside in the pulp and seed extracts of the matured pumpkin varieties and thus, alkaloid, anthraquinone and tannin were not detected in extract of those parts. Pumpkin pulp, peel and seeds were observed by Hashash *et al.* (2017) to be one of the richest sources of phytochemicals. The presence of these phytochemicals in the aqueous extract of the pulp and seed of the matured pumpkin varieties showed that pumpkin possess many important chemical constituents which can be used to explore its medicinal value. The results of the present study coincided with earlier studies (Adnan *et al.* 2017; Muchirah *et al.* 2018; Okoronkwo and Okoli 2021) where presence of all the phytochemicals revealed in the current study from parts of *Cucurbita* varieties was reported.

Proximate composition of pulp and seed of selected pumpkin varieties

The results of analyses for the nutritional compositions of the pulp and seed of matured pumpkin varieties are presented in Tables 6. The results of the experiment have indicated significant variation in the values of ash, moisture, protein, crude fat, crude fiber and carbohydrate in both the pulp and seed of the varieties. However, significant variation in the values of moisture and crude fiber for the seed of the selected varieties were statistically not recorded. Where the variation observed, ash (6.09%), moisture (10.10%), protein (13.53%) and crude fat (3.64%) contents in the pulp of 'Rugudu' variety was significantly higher than in other varieties but with statistically similar ash content in 'Yar sululu'. Lower contents were however, recorded in 'Fara' pulp except for crude fat. Conversely, 'Fara' variety had statistically more crude fiber (58.94%) and carbohydrate (27.60%) contents in the pulp and the least content of these nutrients was found in the pulp of 'Rugudu' pumpkin.

The seed of 'Fara' pumpkin had been analyzed to contain the highest ash (4.83%), protein (24.40%) and crude fat (8.67%) contents, although 'Yar sululu' had statistically similar (4.88%) ash content with 'Fara'. The results also showed that 'Rugudu' had more carbohydrate (28.81%) and lowest composition of ash (3.33%), protein (18.90%) and crude fat (3.96%) in the seed. Least carbohydrate content (12.69%) among varieties was in the seed of 'Fara' pumpkin. The nutrient information and antioxidant properties enhance efforts to promote wide use of plants because of their nutritional benefits and medicinal properties (Wasagu *et al.* 2013).The differences in fruit composition depend on many factors such as the variety, stage of maturity, soil fertility, climate and cultural practices, among others (Enneb *et al.* 2020).In line with findings of the present study, the values of the ash for the pulp and seed obtained are within the range reported by Mohaammed *et al.* (2014) and Okoronkwo and Okoli (2021) but lower than values obtained by Aruah *et al.* (2011) and Adebayo *et al.* (2013). The percentage ash content shows that the pulp and seed of the pumpkin varieties have appreciable amounts of nutrient.

Moisture content is an index of stability of food. The amount of moisture in a food affects its keeping quality, the nutrients provided, type and rate of microbial spoilage (Oguche 2012).

The value of the moisture content for the seeds in both seasons were lower when compared to reports of Kim *et al.* (2012), Mohaammed *et al.* (2014), and Okoronkwo and Okoli (2021). The low moisture content of the seeds of the *Cucurbita* varieties implies that the seeds would be suitable for storage without spoilage. The result of the moisture content for the pulp is also comparable to the report of Mohaammed *et al.* (2014) for *Cucurbita maxima* fruit but slightly higher in other varieties.

Aruah *et al.* (2011) and Mohaammed *et al.* (2014) both reported protein pulp content that compares favourably with the results obtained in this study but slightly higher in some varieties. The percentage protein content of the seeds of the varieties upheld earlier results of the study conducted by Okoronkwo and Okoli (2021) but it was lower when compared to what was reported by Elinge *et al.* (2012) and Kim *et al.* (2012).

The fat content recorded from the pulp of all varieties was similar to what was reported by Aruah *et al.* (2011). However, Adebayo *et al.* (2013) have described pumpkins fruits to be characterized by low fat content (2.3%). The moderate fat recorded in the pumpkin pulps has been supported in earlier studies which revealed that leafy vegetables have low lipid (Aruah 2011). Crude fat content of the seeds was

lower when compared to reports from literature. According to Agostoni *et al.* (1995), non-starchy vegetables are the richest sources of dietary fiber. The fiber contents for all varieties in both parts studied were higher when compared to what was reported in the literature. This implies that pumpkin is a good source of fiber and it has been reported that a low fiber diet has been associated with preventing heart diseases, cancer of the colon and rectum, varicose veins, phlebitis, obesity, appendicitis, diabetes and constipation (Lajide *et al.* 2008). The amount of carbohydrate in both pulp and seed indicates that pumpkin is a carbohydrate rich food which can serve as an energy source.

Table 1: Vegetative growth parameters of selected local pumpkin varieties

Parameter	Varieties	2WAP	4WAP	6WAP	8WAP	10WAP
Number of Leaves	'Rugudu'	4.67^{a}	12.67^{c}	48.33^{c}	126.00^{b}	182.00^{c}
	'Yar sululu'	5.00^{a}	24.00^{a}	90.67^{a}	264.33^{a}	338.00^{a}
	'Fara'	4.00^{b}	16.67^{b}	56.67^{b}	115.00^{c}	203.67^{b}
	LSD (5%)	**0.51**	**2.12**	**6.55**	**17.16**	**14.34**
Chlorophyll Content (SPAD)	'Rugudu'	52.93^{a}	64.87^{a}	65.50^{a}	77.07^{a}	64.00^{a}
	'Yar sululu'	45.27^{b}	54.33^{b}	63.37^{b}	67.53^{b}	59.33^{b}
	'Fara'	37.47^{c}	51.80^{b}	59.70^{c}	64.33^{c}	57.33^{c}
	LSD (5%)	**4.89**	**2.82**	**0.73**	**0.71**	**0.73**
Leaf area (mm^2)	'Rugudu'	220.98^{a}	456.93^{a}	564.83^{a}	939.99^{a}	1015.38^{a}
	'Yar sululu'	199.49^{b}	415.66^{b}	493.16^{b}	643.54^{b}	678.62^{b}
	'Fara'	150.11^{c}	374.85^{c}	415.42^{c}	455.24^{c}	511.08^{c}
	LSD (5%)	**10.55**	**37.11**	**17.09**	**36.19**	**40.83**

Means followed by different superscript along column for a parameter are significantly different ($p \leq 0.05$) using Fisher's LSD (Least Significant Difference), WAP= weeks after planting

Table 2: Mean number of days to first flowering and 50% flowering of selected local pumpkin varieties

	Days of Observation	
Varieties	First Flowering	50% Flowering
'Rugudu'	53.33^{a}	64.67^{a}
'Yar sululu'	50.67^{b}	63.67^{b}
'Fara'	45.33^{c}	59.33^{c}
LSD (5%)	**1.54**	**0.89**

Means followed by different superscript along column are significantly different ($p \leq 0.05$) using Fisher's LSD (Least Significant Difference)

Table 3: Mean number of fruits and fruit parameters of selected local pumpkin varieties

Varieties	No. of Fruit(s) per Hectare	Weight of Fruit (kg)	Fruit Length (cm)	Circumference (cm) per Fruit
'Rugudu'	587.99^{b}	6.33^{a}	43.28^{a}	68.04^{a}
'Yar sululu'	784.11^{a}	5.37^{b}	40.65^{b}	60.90^{b}
'Fara'	392.22^{c}	2.77^{c}	29.25^{c}	52.79^{c}
LSD (5%)	**0.73**	**0.18**	**0.89**	**0.69**

Means followed by different superscript along column are significantly different ($p \leq 0.05$) using

Fisher's LSD (Least Significant Difference)

Table 4: Matrix of correlation coefficient (r) of relation between some growth parameters and yield of local pumpkin varieties under dry season (2019)

	NL	CH	LA	Dff	50%	FY
NL	1.00					
CH	*0.31	1.00				
LA	*0.34	***0.83	1.00			
Dff	***0.76	**0.54	**0.54	1.00		
50%	***0.79	**0.56	**0.54	***0.96	1.00	
FY	***0.80	**0.63	**0.69	*0.33	**0.53	1.00

NL = Number of Leaves, CH = Chlorophyll contents (SPAD), LA = Leaf Area (mm^2), Dff = Days to First Flowering, 50% = Days to 50% Flowering, FY = Fruit Yield (per hectare), *= Significant at P≤0.10, ** Significant at P≤0.05, ***Significant at P≤0.01.

Table 5: Compounds identified in aqueous extract of plant parts of the selected local pumpkin varieties used in the experiments

Pumpkin Parts	Compounds	Local varieties		
		'Rugudu'	'Yar sululu'	'Fara'
Pulp extract	Alkaloid	-	-	-
	Anthraquinone	-	-	-
	Flavonoids	+	+	+
	Saponin	+	+	+
	Tannins	-	-	-
	Terpenoids	+	+	+
	Cardiac Glycoside	+	+	+
Seed extract	Alkaloid	-	-	-
	Anthraquinone	-	-	-
	Flavonoids	+	+	+
	Saponin	+	+	+
	Tannins	-	-	-
	Terpenoids	+	+	+
	Cardiac Glycoside	+	+	+

Key: (+) = Detected (-) = Not detected

Table 6: Mean Values of Proximate composition of pulp and seed of selected local pumpkin varieties

Varieties	Composition (%)					
	Ash	Moisture	Protein	Crude Fat	Crude Fibre	Carbohydrate
			Pulps			
'Rugudu'	6.09[a]	10.10[a]	13.53[a]	3.64[a]	50.39[c]	16.25[c]
'Yar sululu'	5.54[a]	6.43[b]	7.93[b]	1.15[c]	55.69[b]	23.26[b]
'Fara'	0.10[b]	6.07[b]	4.67[c]	2.62[b]	58.94[a]	27.60[a]
LSD (5%)	**1.05**	**1.99**	**0.98**	**0.33**	**0.97**	**2.31**
			Seeds			
'Rugudu'	3.33[b]	2.86	18.90[c]	3.96[c]	42.14	28.81[a]
'Yar sululu'	4.88[a]	2.88	22.17[b]	6.13[b]	42.75	21.19[b]
'Fara'	4.83[a]	2.82	24.40[a]	8.67[a]	46.59	12.69[c]
LSD (5%)	**1.01**	**NS**	**2.10**	**0.94**	**NS**	**4.37**

Means followed by different superscript along column for a pumpkin part are significantly different ($p \leq 0.05$) using Fisher's LSD (Least Significant Difference).

CONCLUSION

The pumpkin (*Cucurbita* sp.) varieties grown in Kano State were observed to differ significantly in terms of vegetative and reproductive growth as well as yield. Flavonoids, saponins, terpenoids, and cardiac glycosides were present in the pulp and seeds using aqueous extraction. Thus, this adds value to the ethnobotanical property of the plant. In addition, considerable amount of nutrients in the pulp and seeds contained in significant quantities confirmed the nutritional quality of this plant species.

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