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Physico-chemical characteristics of some wild tubers consumed in Chad: *Tacca leontopetaloides*, *Cochlospermum tinctorium* and *Dioscorea villosa*

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ABSTRACT

In order to evaluate the nutritional characteristics of *Tacca leontopetaloides*, *Cochlospermum tinctorium* A. Rich., and *Dioscorea villosa*, some samples were collected in order to evaluate the contents of proteins, lipids, some minerals, and vitamins. Standard methods were used to carry out the physico-chemical analyses. The results obtained show that the highest content of macronutrients was observed in *Cochlospermum tinctorium* A. (14.06%), and the lowest content was noted in *Tacca leontopetaloides* in Kélo (0.17%). The highest content of micronutrients was noted in *Dioscorea villosa* for potassium (10553 mg/kg), and the lowest content was noted in *Cochlospermum tinctorium* A. for sulfur (0.0032 mg/kg). The highest energy value was recorded for *Discorea villosa*, which is 155.22 kcal/100g and the lowest energy value was noted for *Cochlospermum tinctorium* A., which is 4.2 kcal/100g. *Cochlospermum tinctorium* A., had the highest levels of dietary fiber (1.03 g/100g DM), β-carotenes (1794.5 mg/100g DM), and lycopene (921.54 mg/100g). The consumption and popularization of these wild tubers among the populations could be envisaged to ensure availability throughout the year to ensure food security and thus contribute to the fight against malnutrition.

INTRODUCTION

Root and tuber crops are food crops primarily intended for human consumption or industrial starch extraction. They are high in starch and low in protein, fiber, and minerals. They are therefore energy foods that can replace cereals (Bindelle and Buldgen, 2004). The genus *Tacca* (Taccaceae) is a wild plant that produces starch-rich tubers as fruit (Zafilaza et al., 2017). The degradation of plant cover and soil is accelerating in terrestrial ecosystems, and wild plants are not left out (Aboh, 2008). However, it is a species very much consumed by village populations during the lean season. There are several species of the genus *Tacca*, and many are used as medicinal plants for treatment of some ailments (Jin-He et al., 2014). The geographical distribution of *T. leontopetaloides* extends from Sudano-Sahelian Africa, from Southeast Asia to Australia (Ndouyang et al., 2021). *Tacca* is a large genus, comprising about 15 species of medicinal plants (Taccaceae). Starch from *T. leontopetaloides* and *T. involucrata* has a high amylase content and has shown potential use in the food and drug systems (Ndouyang et al., 2021). Several studies have been carried out on the genus *Tacca*, namely the physico-chemical characteristics of *Tacca* in Fianga (Chad) (Ndouyang et al., 2009); the study on the quality of its

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starch (Ndouyang et al., 2021), physico-chemical characteristics before and after six months of storage (Zafilaza et al., 2017); or even on chemical studies pointed out that more than 120 constituents have been isolated from *Tacca*, including steroids, diarylheptanoids, phenolics, flavonoids, sesquitpenoids, triterpenoids, starch. The starch of *T. leontopetaloides* and *T. involucrata* has a high amylase content and has shown potential use in the food and drug systems (Jin-He et al., 2014). *T. leontopetaloides* being eaten in several towns in Chad, it would be important to have a nutritional review of this plant, which is still wild and consumed in several towns in Chad. The aim is to encourage the consumption of *T. leontopetaloides*.

Yams are monocotyledons of the genus *Dioscorea*, which is part (with three other genera, *Tacca*, *Stenomeris*, and *Trichopus*) of the family Dioscoreaceae of the order Dioscoreales and of the subclass Liliidae. This family, which has around 400 species in the world, is found mainly in tropical areas. Many species of *Dioscorea* have edible tubers that are eaten cooked or, for some of them, raw. Even poisonous or bitter species such as *D. sansibarensis*, *D. antaly*, or *D. ovinala* are consumed after retting, which is soaking in running water and drying (Vololoniaina et al., 2010). In West Africa, yams (genus *Dioscorea*) are creeping plants that produce tubers and sometimes bulbils (small aerial tubers). They play an important role in the human diet and in the traditional pharmacopoeia. Some wild species are still regularly collected today. They are frequent in both forest and savannah areas (Tchiègang et al., 2009). Wild species are at the origin of cultivated species, and are found in the natural environment (Trèche, 1989). For the same quantity of raw materials consumed, the energy value of yams is generally lower than that of other plants with roots, tubers, or starchy fruits, but their coverage of protein, mineral, and vitamin needs is more complete. The nutritional value of *Dioscorea villosa* is better than that of other commonly consumed species due to the particular physico-chemical characteristics of the starch of this species. (Berthaud et al., 1998). *Cochlospermum tinctorium* A. is a widespread plant in the Sahelo-Sudanian zone of Africa and belongs to the Bixaceae family. It has long been used as a welding food (Ndouyang et al., 2018). The tuberous root is used as food and as a medicinal plant organ (Ndouyang et al., 2018). *C. tinctorium* A. powder is rich in iron and zinc and is used to combat malnutrition in children aged 6 to 59 months (Agossadou et al., 2018).

RESULTS AND DISCUSSION

Physico-chemical characteristics

The dry matter, macronutrient and micronutrient content of *T. leontopetaloides* can be found in Table I. The dry matter content is higher 98.88% in Bongor and 99.39% in Kélo against 92.97% in Fianga in Chad (Ndouyang et al., 2009). The dry matter content of our samples is higher 98.88% in Bongor and 99.39% in Kélo against 92.97% in Fianga in Chad (Ndouyang et al., 2009). The macronutrient (protein, lipid and carbohydrate) content of *T. leontopetaloides* in Bongor and Kélo are relatively low to those found in the Fianga Region of Chad. The highest carbohydrate content is 6.86% in Kélo against 90.31% in Fianga; the highest protein content is 0.68% in Bongor against 2.74 in Fianga. Only and the lipid content is the highest in Bongor against 2.74% in Fianga (Ndouyang et al., 2009). This difference in content could be explained by the difference in the study environment. The contents of calcium, potassium, sodium and potassium are lower than those found by Ndouyang et al. (2009). The sulfur content is very low 0.004 mg/kg and the β-Carotene content is higher 426.85 mg/kg. It should be noted that only the sulfur content is significant at the 5% threshold for the Bongor and Kélo samples ($P<0.000$).

The dry matter, macronutrient and micronutrient content of *Diosora villosa* in Bongor can be found in Table 2. The highest macronutrient content is noted for carbohydrates (7.84 mg/100g DM) and the lowest content is noted for proteins and lipids (4.39mg/100g DM). The highest micronutrient content is noted for potassium (10553.95 mg/kg) and the lowest content is noted for sulfur (0.097 mg/kg). The carbohydrate (7.84 g/100g DM), phosphorus (179.36 mg/100g DM), calcium (302.91 mg/100g DM), iron (252.58 mg/100g DM) and potassium contents (1055.39 mg/100g of DM are higher than those of another variety of yam, *Dioscorea villosa* carbohydrates (5.2 g/100g of DM), phosphorus (158 mg/100g of DM) and calcium (63 mg/100 g of DM), iron (6.7 mg/100g of DM) and potassium (1050 mg/100g) of DM (Trèche et al., 1984; Nama, 2005).

The dry matter, macronutrient and micronutrient content of *C. tinctorium* A. at Kélo can be found in Table 3. The highest macronutrient content is noted for carbohydrates (14.06 mg/100g DM) and the lowest content is noted for protein (0.29 mg/100g DM). The highest micronutrient content is noted for calcium (3077.18 mg/kg) and the lowest content is noted for sulfur (0.0032 mg/kg). As the macronutrient and micronutrient content is generally very low, it is used as anqz enrichment based on moringa leaves for the fortification of infant flours (Agossadou et al., 2018).

The protein content of our three tubers is very low as it varies from 0.17% for *T. leontopetaloides* in Kélo to 4.39 g/100g DM for *D. villosa* in Bongor much lower than the wild species *Apios americana* which varies from 13-17 g/100g DM, or cultivated tubers such as cassava *Manihot esculenta* (3 g/100g DM), or potato *Solanum tuberosum* (9 g/100g DM) and sweet potato Ipomea batatas (5 g/100g DM) (Walter et al., 1986; Chandrasekara and Kumar, 2016; Kalberer et al., 2020; Boutell, 2021). The lipid content which varies from 0.99 g/100g DM for *C. tinctorium* A to 6.92 g/100g DM for *T. leontopetaloides*; and fiber which varies from 0.46 g/100 g DM for *D. villosa* to 1.03

Table 1. *Tacca leontopetaloides* content in dry matter, macronutrients and micronutrients in Bongor and Kélo.

Parameters (Unit)	Bongor	Kélo
Dry matter (g/100g)	98.88 ± 1.15[a]	99.39 ± 0.52[a]
As (g/100g)	0.57 ± 0.02[a]	1.42 ± 0.03[a]
Protein (g/100g)	0.68 ± 0.04[a]	0.17 ± 0.06[a]
Lipid (g/100g)	6.92 ± 0.03[a]	0.17 ± 0.06[a]
Total sugars (g/100g)	4.00 ± 1.13[a]	6.86 ± 0.24[a]
Energy value (kcal/100g)	19.18 ± 4.8[a]	0.22 ± 0.08[a]
Calcium (mg/kg)	1472.97 ± 3.85[a]	1597.62 ± 2.08[a]
Copper (mg/kg)	1.5 ± 0.14[a]	0.09 ± 0.007[a]
Iron (mg/kg)	175.7 ± 4.38[a]	164.73 ± 3.21[a]
Magnesium (mg/kg)	1385.97 ± 22.10[a]	1354.9 ± 1.83[a]
Manganese (mg/kg)	3.9 ± 0.26[a]	3.61 ± 0.36[a]
Zinc (mg/kg)	5.43 ± 0.66[a]	4.67 ± 0.43[a]
Phosphorus (mg/kg)	82.14 ± 0.78[a]	82.43 ± 1.18[a]
Potassium (mg/kg)	777.65 ± 0.9[a]	169.95 ± 4.87[a]
Sodium (mg/kg)	16.93 ± 0.23[a]	32.71 ± 0.83[a]
Sulphur (mg/kg)	0.07 ± 0.009[a]	0.004 ± 0.001[b]
β-Carotene (mg/kg)	28.82 ± 0.11[a]	426.85 ± 0.21[a]
Lycopene (mg/kg)	66.43 ± 0.8[a]	51.41 ± 0.83[a]
Fibers (g/100g)	0.52 ± 0.04[a]	0.28 ± 0.01[a]

[a,b]; Figures followed by the same letter in a column are not significant at the 5% level.

Table 2. Water content, macronutrients and micronutrients of *Dioscorea villosa* in Bongor.

Parameters (Unit)	Bongor
Dry matter (g/100g)	99.26 ± 0.38
Ash (g/100g)	1.24 ± 0.77
Protein (g/100g)	4.39 ± 0.57
Lipid (g/100g)	4.39 ± 0.57
Total sugars (g/100g)	7.84 ± 0.19
Energy value (kcal/100g)	155.22 ± 35.6
Calcium (mg/kg)	3029.11 ± 0.94
Copper (mg/kg)	2.66 ± 0.14
Iron (mg/kg)	252.58 ± 3.84
Magnesium (mg/kg)	1691.1 ± 2.52
Manganese (mg/kg)	25.17 ± 1.03
Zinc (mg/kg)	19.17 ± 1.13
Phosphorus (mg/kg)	1793.6 ± 1.83
Potassium (mg/kg)	10553.95 ± 11.52
Sodium (mg/kg)	2292.24 ± 5.76
Sulphur (mg/kg)	0.097 ± 0.02
β-Carotene (mg/kg)	114.55 ± 0.63
Lycopene (mg/kg)	39.9 ± 0.14
Fibers (g/100g)	0.46 ± 0.056

Table 3. Water content, macronutrients and micronutrients of *Cochlospermum tinctorium* A. in Kélo.

Parameters (Unit)	Kélo
Dry matter (g/100g)	10.28 ± 0.41
Ash (g/100g)	7.15 ± 0.05
Protein (g/100g)	0.29 ± 0.007
Lipid (g/100g)	0.99 ± 0.007
Total sugars (g/100g)	14.06 ± 0.19
Energy value (kcal/100g)	4.12 ± 0.12
Calcium (mg/kg)	3077.18 ± 37.64
Copper (mg/kg)	11.02 ± 0.07
Iron (mg/kg)	407.02 ± 0.48
Magnesium (mg/kg)	2090.77 ± 10.69
Manganese (mg/kg)	10.69 ± 0.72
Zinc (mg/kg)	13.05 ± 0.49
Phosphorus (mg/kg)	245.32 ± 0.81
Potassium (mg/kg)	580.85 ± 10.39
Sodium (mg/kg)	49.18 ± 1.43
Sulphur (mg/kg)	0.0032 ± 0.002
β-Carotene (mg/kg)	1794.5 ± 0.7
Lycopene (mg/kg)	921.54 ± 0.64
Fibers (g/100g)	1.03 ± 0.028

g/100g DM for *C. tinctorium* A. are also very low compared to that of the tiger nut *C. esculentus* L. whose lipid content is 32.13 g/100g DM and that of fiber is 6.26 g/100g DM (Lazizi and Ihadaden, 2021).

Energy value

The energy value is used to assess the energy intake per 100 grams for a given food. Thus, the energy values of *T. leontopetaloides* in Bongor (19.18 kcal/100g) and Kélo (0.22 kcal/100g); *D. villosa* in Bongor (155.22 kcal/100g); *C. tinctorium* A. at Kélo (4.12 kcal/100g) are all much lower than the recommended energy intake which is 400 kcal/100g (FAO, 2004).

Beta-carotene, lycopene and dietary fiber content

The beta-carotene, lycopene and dietary fiber content of *T. leontopetaloides* in Bongor and Kélo, of *D. villosa* in Bongor and *C. tinctorium* A. in Kélo can be found in tables 1, 2 and 3. *C. tinctorium* A. in Kélo presents the highest contents of β-Carotene (1794.5 mg/kg), lycopenes (921.54 mg/kg) and fibers (1.3 g/kg) *T. leontopetaloides* in Bongor presents the lowest contents in β-Carotene (28.82 mg/kg), lycopenes (51.41 mg/kg) and fiber (0.28 g/kg).

Conclusion

Wild tubers are a good source of macronutrients and micronutrients. It would be important to integrate them into our daily diet. It would also be interesting in future studies to study the antinutritional factors in order to assess the nutritional potential of the tubers in its entirety.

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