

# Classification of Some Wild Yam Species Based on Their Chemical Composition

**\*Sahoré Drogba Alexis<sup>1</sup>, N'Guessan Amani Georges<sup>2</sup>**

<sup>1</sup>UFR Sciences et Technologies des Aliments, Université Abobo-Adjamé 02BP801, Abidjan. Côte d'Ivoire

<sup>2</sup>UFR Sciences et Technologies des Aliments, Université Abobo-Adjamé 02BP801, Abidjan. Côte d'Ivoire

\*Corresponding : E-mail : [alexissahore@yahoo.fr](mailto:alexissahore@yahoo.fr)

---

## Abstract:

The tubers of some species of wild yam (eight) found in the Ivorian forest were collected. Their classification according to their nutrients & their anti-nutritional factors was performed by principal component analysis (PCA).

The principal component analysis, of individuals formed by species based on nutrient taken as variables, showed two main axes F1 and F2 with percentages varying dispersion of 72.26% and 20.24% respectively. The distribution around the axes of individuals revealed 4 classes: around the axis F1 (72.26%): one class combining species (*D.minutiflora*, *D.hirtiflora* and *D. bulbifera* bulbil), characterized by water content and one class combining species (*D.burkilliana*, *D. bulbifera* tuber *D.dumetorum*, *D.praehensilis* and *D.mangenotiana*), characterized by the dry matter content and around the F2 axis (20.24%) : one class combining the species (*D. burkilliana*, *D.bulbifera* tuber *D.dumetorum* and *D.praehensilis*) characterized by the starch content and one class combining the species (*D. minutiflora*, *D.hirtiflora*, *D.bulbifera* bulbil and *D.mangenotiana*) characterized by ash and cellulose

This same method, of principal components analysis (PCA) based anti-nutrients, shows two main axes F1 and F2 with percentages of dispersion of 35 variables, 88% and 31.99% respectively. The distribution around the axes of individuals revealed 3 classes: around the axis F1 (35.88%): one class combining the species (*D. mangelotiana*, *D.dumetorum*, *D.burkilliana*, *D.bulbifera* bulbil, *D.togoensis*, *D.bulbifera* tuber and *D.praehensilis*) characterized by the content of alkaloids and tannins and around the axis F 2 (31.99%): one class grouping species (*D. togoensis*, *D.dumetorum*, *D.minutiflora*, *D.mangelotiana*, *D.praehensilis*, *D.bulbifera* bulbil) characterized by the oxalic acid content and one class grouping species (*D. togoensis*, *D.hirtiflora*, *D.minutiflora* and *D.dumetorum*) characterized by the content of sapogenins.

**Keywords:** principal components, spontaneous yams, tubers, Antinutritional factors, nutrients

---

## Introduction

The word yam is a generic term for a group of plants of several species of the genus *Dioscorea* left on all continents (Knuth, 1924; Miede, 1952; Degras, 1986, Hamon *et al*, 1995). Besides the cultivated yams, sometimes celebrated (Perrot, 1997), there are also spontaneous yams that is to say, the species of yam grown in the wild and which are still being picked. (Hamon *et al*, 1995)

The yams in general and its wild forms in particular contain varying amounts of chemicals (alkaloids, tannins, sapogenins, polyphénols, phytates, oxalates, etc. ...).

If some of these substances only give a bitter taste to tubers after cooking, like other alkaloids are toxic. These alkaloids when ingested can cause severe symptoms or death (Coursey, 1983; Hladik *et al*, 1984; Webster *et al*, 1984; Degras, 1986), it is therefore necessary that these wild tubers are processed to reduce or destroy toxic substances for a better consumer (Dumont *et al*, 1994).

The yam is also used for other purposes as food in Africa including wild yams are used in traditional medicine for their therapeutic properties. They are also used because of their toxic properties (Miede, 1977)

In this paper we study the classification of eight species of spontaneous yams in Côte d'Ivoire according to their nutrients and their antinutritional factors by principal component analysis (PCA). The principal component analysis (PCA) allowed discriminating these species of yams in relation to their nutritional and antinutritional components which in the context of a possible domestication introduce wild species in carefully selected cropping systems.

## Material and Methods

Plant material consists of various spontaneous yam tubers (yams, which are not cultivated but grow wild). The yam tubers were collected in the forest zone south of the Coast - Ivory particularly in the area Memni 80 km from Abidjan in July and August 2002, with the help of farmers. The samples were identified at the Institute Floristic University of Cocody in Abidjan.

These were the tubers of spontaneously yam species: *Dioscorea praehensilis*, *D. hirtiflora*, *D. bulbifera* (tuber and bulbil), *D. burkilliana*, *D. togoensis*, *D. dumetorum*, *D. mangelotiana* and *D. minutiflora*. The tubers were stored at room temperature in bags. The following methods are used:

Water content is determined by desiccation with the drying oven of the sample at 105°C until constant weight (AOAC, 1980). Ash content is determined by incineration with the muffle furnace of the sample at 650°C (AOAC, 1980). Total sugars content are determined by Luff Schoorl iodometric method (BIPEA, 1976). Total carbohydrates are determined by difference. Starch content is calculated starting from the percentage of total carbohydrates and total sugars. Acidity is determined with solution of NaOH 0.1 N in the presence of phenolphthalein. Crude protein content was determined from the determination of total nitrogen by the method Kjeldhal (BIPEA, 1976). Lipids were assayed using the device Soxhtec System HT 1043 - (Germany), extraction solvent is diethyl ether (BIPEA, 1976). Starch content was determined by the polarimetric method (BIPEA, 1976). Cellulose content was determined by Weende method (Multon, 1991). Energy value was calculated by applying the thermal coefficients of Atwater (1889) with 4 calories 1g protein; 9.3 calories per 1g of fat and 3.75 calories per 1g of carbohydrates. The energy value (cal / 100 g) = 4 x% protein + 9.3 x% fat + 3.75 x% carbohydrates.

Directly titratable acidity of the sample is measured, the result is expressed in milliequivalent or g / 100 g of acid determined in the case of oxalic acid (Rashid, 1978).

The tannins content was determined by the method of the acidified vanillin after soaking the sample in methanol (Burns, 1971). The hydrocyanic acid content was determined by alkaline titration method (Holleman and Aten, 1956). The alkaloids of the sample are dissolved by soaking in a mixture of diethyl ether and chloroform extracts and HCl (Anonymous, 1998). The extraction of the sapogenins was made by boiling under reflux (30 min) sample (5 g) in 50 ml of ethanol. The alcoholic extract was concentrated to syrup which is hydrolyzed by heating with 10 ml of sulfuric acid (4 N) for 2 hours. The sapogenins are precipitated and isolated by filtration, and then, they are dried and weighed (Asiedu, 1991).

The analysis of variance (ANOVA) at  $p < 0.05$  means and standard deviations were carried out to compare the levels of nutritional factors and antinutritional nutrients in the tubers

The principal components analysis (PCA) were performed using the software test-ed Statsoft.99. Newman - Keuls (NCSS, Kaysville, USA) to classify the tubers of yam spontaneous according to their different nutrients and anti nutrients to determine the characteristic property of every kind of spontaneous yams studied.

## Results

### Classification of yam species based on nutrient

The principal component analysis (PCA) on spontaneous, species studied based on variables, represented by nutrients, shows two main axes F1 and F2 with percentages varying dispersion of 72.26% and 20.24% respectively ( Figure 1). The circle of correlation which expresses the correlations of variables with axes F1 and F2 is shown in Figure 1a.

F1, which represents 72.26% of dispersion of variables (Figure 1a), is correlated with the variable water towards positive values and with variable starch, cellulose, ash, fat, protein, total sugars and energy to negative values. F2, which represents 20.24% of dispersion of variables (Figure 1a), is correlated with the variables total sugars, starch and energy towards positive values and with variable water, fat, protein, cellulose and ash toward negative values

The individuals represented by species, projected on axes F1 and F2 (Fig. 1 b) are grouped into four classes: 1) around the axis F1: one class includes the species *D. minutiflora*, *D. hirtiflora* and *D. bulbifera* bulbil to positive values of F1 and one class includes the species

*D. burkilliana*, *D. dumetorum*, *D. bulbifera* tuber, *D. praehensilis* and *D. mangelotiana* to negative values of F1.

2) around the axis F2: one class includes the species *D. burkilliana*, *D. bulbifera* tuber, *D. dumetorum* and *D. praehensilis* to positive values of F2 and one class includes the species *D. minutiflora*, *D. hirtiflora*, *D. bulbifera* bulbils and *D. mangelotiana* to negative values

### Classification of yam species based on anti-nutrients

The Principal Component Analysis (PCA) of yam species, studied based on variables represented by the anti-nutritional factors, shows two main axes F1 and F2 with percentages varying dispersion of 35.88% and 31.99 % respectively (Figure 2). The correlation circle of variables with F1 and F2 is represented by Figure 2:

F1 axis, which expresses 35.88% dispersion of variables (Fig. 2a), is correlated with the variable sapogenins to positive values and variables with oxalic acid, hydrogen cyanide, alkaloids and tannins to negative values.

F2 axis, which expresses 31.99% dispersion of variables (Fig. 2a), is correlated with variables sapogenins, oxalic acid, hydrocyanic acid and tannins to positive values and with variable alkaloids towards negative values.

The individuals represented by the yam species studied, projected on axes F1 and F2 (Fig. 2b) are grouped into three classes:

One class that includes the species *D. dumetorum*, *D.togoensis*, *D.bulbifera* bulbil, *D.mangenotiana* and *D. praehensilis* ; one class that includes the species *D. dumetorum*, *D.togoensis*, *D.bulbifera* bulbil, *D.bulbifera* tuber *D.burkilliana*, *D.praehensilis* and *D.mangenotiana* and another intermediate class that includes the species *D. dumetorum*, *D.togoensis*, *D.minutiflora* and *D.hirtiflora*

## Discussion

In the case of the yam species classification studied based on their nutrient (Figure 2), observation, of the correlation of axes F1 and F2 with nutrients taken as variables and the distribution of individuals formed by the yam spontaneous species around the axes F1 and F2, can be deduced that:

1) Around F1

- The class that includes the species *D. minutiflora*, *D.hirtiflora* and *D.bulbifera* bulbil to positive values of F1 is characterized by variable water
- The class that includes the species *D. burkilliana*, *D. bulbifera* tuber *D.dumetorum*, *D.praehensilis* and *D.mangenotiana* to negative values of F1 is characterized by varying starch, cellulose, ash, energy, fat, protein and total sugars set of variables related to dry matter.

2) Around F2

- The class that includes the species *D. burkilliana*, *D. bulbifera* tuber *D.dumetorum* and *D.praehensilis* to positive values of F2 is characterized by variable sugars
- The class that includes the species *D. minutiflora*, *D. hirtiflora*, *D.bulbifera* bulbil *D.mangenotiana* and to negative values of F2 is characterized by variable ash and cellulose.

The four species groups as revealed by principal component analysis (PCA) are differentiated by their nutrient content characteristic. According to Woolf (1987), the nutrient content of tubers in general vary from one location to another, depending on climate, soil, variety of the plant, the harvest period and many other factors such as modes of post-harvest conservation.

We also observed that the variable moisture content is negatively correlated with all other variables related to dry matter and especially with the energy variable. According to Bradbury (1988) the energy value of a tuber is inversely related to its water content. This could explain the negative correlation between the variable water content and variable energy ( $R = -0.94$ ). These two variables are more significant correlation links with other variables.

Except the variable ash and total sugars, which are uncorrelated, all variables are most significantly correlated with each other ( $p < 0.05$ ).

This is reflected by the fact that they are almost all located on the circle of correlation (Figure 18a) which expresses the correlations of variables with axes.

In the case of the yam species classification studied based on their anti-nutritional factors (Figure 3), observation, of clustering of individuals formed by yam species around axes F1 and F2 and the correlation of anti-nutritional factors used as variables with axes F1 and F2, can be deduced that:

- The class that includes the species *D. dumetorum*, *D.togoensis*, *D. bulbifera* bulbils, *D.mangenotiana* and *D.praehensilis* around the axis F2 is characterized by variable oxalic acid
- The class that includes the species *D. dumetorum*, *D.togoensis*, *D.bulbifera* bulbil, *D. bulbifera* tuber *D.burkilliana*, *D.praehensilis* and *D.mangenotiana* around the axis F1 is characterized by the variables tannins and alkaloids,
- The class that includes the species *D. dumetorum*, *D.togoensis*, *D.minutiflora* and *D.hirtiflora* to positive values of F2 is characterized by variable sapogenins.

The three classes of spontaneous yams revealed by principal component analysis (PCA) are differentiated by their content of antinutritional factors characteristics. We also observed that the variables: oxalic acid, hydrocyanic acid, tannins and sapogenins seem like bond correlation slightly acidic. Tannins and sapogenins which are phenols and alcohols could act as weak acids (Conia, 1987).

This would explain the significant correlation between these two variables. But when alcohols or phenols are protonated they acquire a weakly basic character (principal component analysis (PCA)). This could explain the negative correlation between the sapogenins and alkaloids (strong base)

## Conclusion

Principal Component Analysis (PCA) allowed discriminating these species of yams in relation to their nutritional and antinutritional components which in the context of a possible domestication introduce species in selected cropping system Through this study we could also get an idea of the toxicity of tubers of each species of wild yam in relation to the nature of anti-nutritional factors that characterizes them.

## References

W. Atwater; A new respiratory calorimeter and experiments on the conservation of energy in human body. II – Physical Rev. 9. 214 – 251(1899).

[A.O.A.C] Association of Official Analytical Chemist Official; 'methods of analysis' 11<sup>th</sup> edition, Arlington VA, USA: (1980).

- Edition* J.J. Asiedu ; 'La transformation des produits agricoles en zone tropicale Approche technologique'. Karthala, Paris, **(1991)**.
- [J. O. 371 L 0250 / CEE] ; Méthodes d'analyse des composants des aliments d'animaux. **(1998)**
- R.E. Burns; Agronomy Journal, **63**, 511-512 **(1971)**
- [BIPEA].Bureau Interprofessionnel d'Etude Analytique; 'méthodes d'analyse des Communautés Européennes', Gennevilliers, France, **(1976)**.
- J. H. Bradbury; ASEAN Food Journal, **4**, 3-13 **(1988)**
- D.G. Coursey ; Ressources principales plantes racines : leurs possibilités d'utilisation par l'homme, l'animal, l'industrie..In Actes du second symposium de la société internationale pour les plantes racines tropicales d'Afrique, pages 27-36, Douala, Cameroun, 14-19 Août **(1983)**.
- Edition* J.M. Conia ; 'Introduction à la chimie organique'. Inter. Paris. **(1987)**
- Edition* L. Dégras ; 'L'igname, plante à tubercule tropical. Techniques agricoles et production tropicale'. Maisonneuve et Larose. Paris, **(1986)**
- Edition* R. Dumont, P. Hamon, C. Seignobos ; 'Les ignames au Cameroun'. CIRAD, CA, Coll. Repères, cultures annuelles, Montpellier, **(1994)**.
- Edition* L.W.J. Holleman, A. Aten; Agriculteur. Cahier, **54**, FAO, Rome, Italie, **(1956)**.
- A. Hladik S. Bahuchet C. Okatillon C.M. Hladik ; Rev.Ecol (terre vie) **39**,248-290 **(1984)**
- Edition* P. Hamon, R. Dumont, J. Zoundjhekpou, B. Tio-Touré, S. Hamon ; 'Les ignames sauvages d'Afrique de l'Ouest. Caractères morphologiques', ORSTOM, Paris, **(1995)**
- Edition* N. Ildefonse; 'Agriculture vivrière ouest africaine à travers le cas de la Côte d'Ivoire'. IDESSA, Bouaké**(1995)**
- R. Knuth. "Dioscoreaceae". In Engler. Das Pflanzenreich, **87 (IV-43)**1- 387 **(1924)**
- J. Miège ; Contribution à l'étude systématique des Dioscorea d'Afrique occidentale. Thèse Sc. Nat. Paris, **(1952)**
- Edition* J. Miège : 'Stratégies végétales'. Musée de Genève, **172**, 13 – 17. **(1977)**.
- Edition* J.L.Multon ; 'Techniques d'analyse et de contrôle dans les Industries Agroalimentaires', Ed. Lavoisier, 4, Paris, **(1991)**
- C.H. Perrot ; L'igname dans les cérémonies politico-religieuses de l'aire culturelle Akan. In l'igname plante séculaire et culture d'avenir. Actes du séminaire international CIRAD-INRA – ORSTOM-CORAF. D. Berthaud, N. Bricas, J.L. Marchand (Eds), Montpellier, France, 3 - 6 Juin **1998**).
- J.Webster, W.Beck, B.Ternai; Journal Agric. Food Chem. **32**, 1087 – 1090. **(1984)**.
- Edition* J.A. Woolf; 'Sweet potato an untapped food resource' University Press, Cambridge', **(1987)**

| Table II: Nutrient Composition of tubers (% dry matter) |         |          |        |                 |                        |         |           |        |                           |
|---------------------------------------------------------|---------|----------|--------|-----------------|------------------------|---------|-----------|--------|---------------------------|
| elements<br>Species                                     | Water   | protein  | Fat    | Total<br>Sugars | Total<br>Carbohydrates | Starch  | Cellulose | Ash    | Energy<br>(cal /<br>100g) |
| D.minutiflora                                           | 84.95 b | 10.56 d  | 2.95 a | 2.37 b          | 67.53 c                | 81.73 b | 4.30 c    | 4.76 d | 376a                      |
| D.hirtiflora                                            | 81.89e  | 9.55 bcd | 3.35 b | 1.42 a          | 67.40 c                | 82.27 b | 5.98 d    | 4.84 d | 377a                      |
| D. bulbifera bulbil                                     | 81.44 e | 8.82 bc  | 3.99 c | 3.59 c          | 57.15 a                | 82.44 b | 7.67 f    | 4.74 d | 381bc                     |
| D.burkilliana                                           | 71.59 d | 8.24 b   | 3.26ab | 2.34 b          | 70.05 d                | 83.77bc | 3.64 a    | 4.73 d | 377a                      |
| D. bulbifera tuber                                      | 69.80 c | 6.29 a   | 3.53 b | 2.29 b          | 73.01 d                | 86.87 c | 3.31 b    | 3.71ab | 383d                      |
| D. dumetorum                                            | 69.65 c | 9.93 cd  | 3.43 b | 3.77 c          | 68.05 c                | 83.36 b | 4.03 bc   | 3.27 b | 384d                      |
| D. praehensilis                                         | 68.05to | 9.48 bcd | 3.61 b | 3.81 c          | 69.37 d                | 84.51bc | 3.62 a    | 2.40a  | 389 <sup>th</sup>         |
| D. mangelotiana                                         | 66.24 a | 14.18 e  | 4.61 d | 2.25 b          | 58.83 b                | 74.94 a | 7.33e     | 6.27 c | 380b                      |

The values represent the average of three determinations (n = 3)

\* In each column the values assigned by different letters are significantly different at p <0.05. Those affected by identical letters are not.

Table II: Composition in antinutritional factors of yam tubers

| Species            | Oxalic acid<br>(mg/100g ms) | Tannins<br>mg/100 g ms) | hydrocyanic acid<br>(10-2. Mg / kg dm) | Alkaloids<br>mg/100 g ms | Sapogenins<br>(% M.S) |
|--------------------|-----------------------------|-------------------------|----------------------------------------|--------------------------|-----------------------|
| D.dumetorum        | 12.93h                      | 33.03 e                 | 560.10 e                               | 167.70e                  | 0.78 b                |
| D.togoensis        | 12.63 e                     | 456.03 e                | 214.80 a                               | 2.00 c                   | 1.49 h                |
| D.minutiflora      | 10.03 e                     | 385.73 b                | 2.00 a                                 | 101.03 a                 | 0.90 b                |
| D.bulbifera bulbil | 470.03 f                    | 9.33 cd                 | 1.97 a                                 | 165.63 d                 | 0.22 a                |
| D.mangenotiana     | 9.03 h                      | 4.00 d                  | 570.30 b                               | 150.63 c                 | 0.05 a                |
| D.praehensilis     | 8.33 c                      | 20.03 c                 | 410.73 d                               | 175.70 f                 | 0.26 a                |
| D.bulbifera tuber  | 6.83 b                      | 421.00 c                | 248.23 d                               | 10.03 i                  | 0.08 a                |
| D.hirtiflora       | 6.50 a                      | 7.00 b                  | 315.03 c                               | 107.63 b                 | 1.34 c                |
| D.burkilliana      | 5.43 a                      | 4.03 b                  | 489.23 g                               | 187.03 g                 | 0.20 a                |

The values represent the average of three determinations (n = 3).  
In each column the values assigned by different letters are significantly different at p <0, 05.

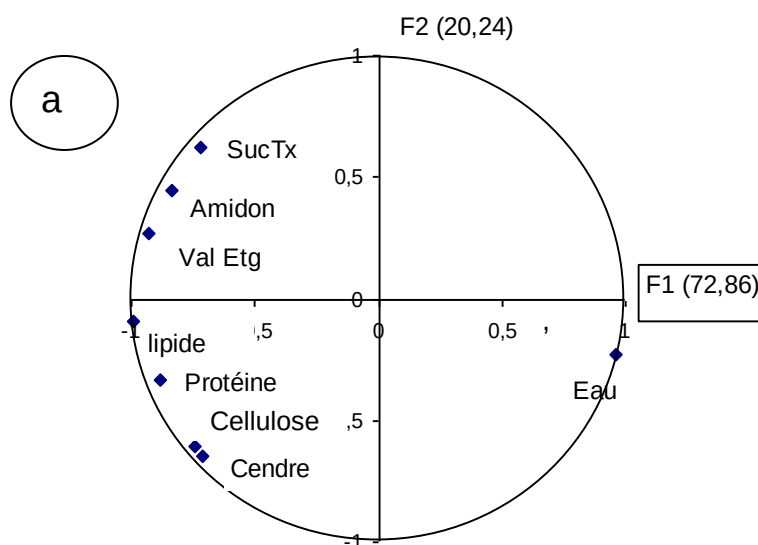


**Figure 1a: Circle of correlation of wild yam species nutrients**  
 SucTx: total sugars; lipide: lipids; proteine : protein ; cendre : ash ;  
 ValeEtg: energy; amidon: starch

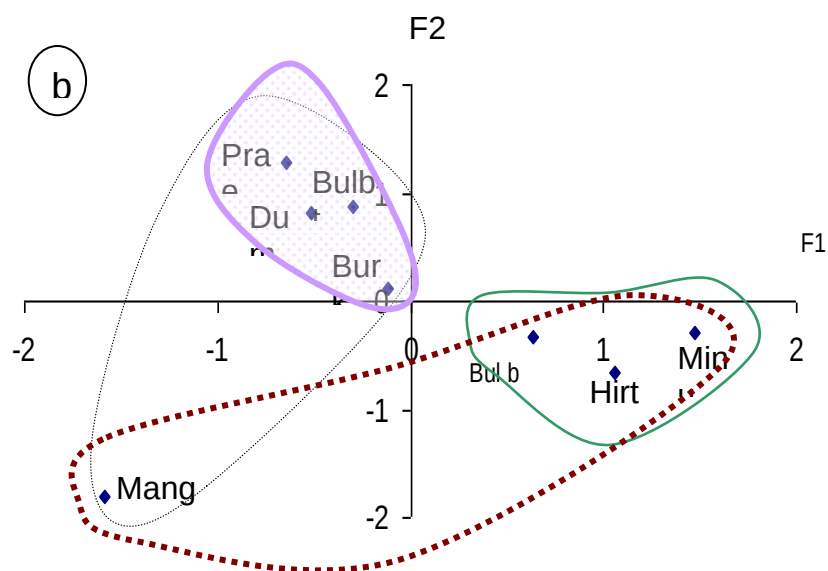


**Figure 2b; Classification of wild yam species according to their nutrients**  
 Mang: mangelotiana; Bulk: burkilliana; Dum: dumetorum; Bulb b: bulbifera (bulbil);  
 Bulb t: bulbifera (tuber); Hirt: hirtiflora Minu: minutiflora; Prae: praehensilis

**Figure 1: Principal component analysis (PCA) on the composition of wild yam species nutrient**

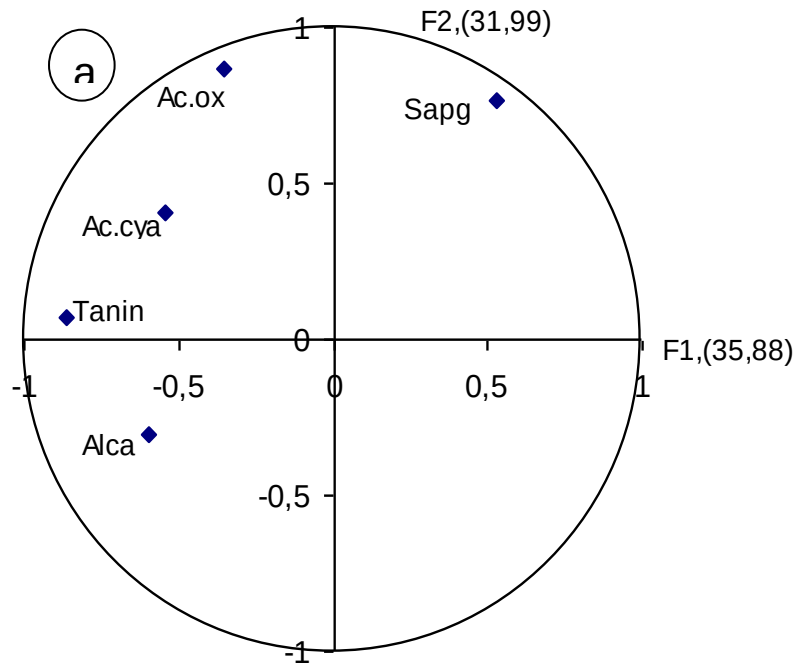


**Figure 2a: Circle of correlation of wild yam species antinutritional factors**  
**Sapg:** sapogenins; **Ac. ox. :** Oxalic acid **Ac. cya:** hydrogen cyanic acid; **Alca:** alkaloids

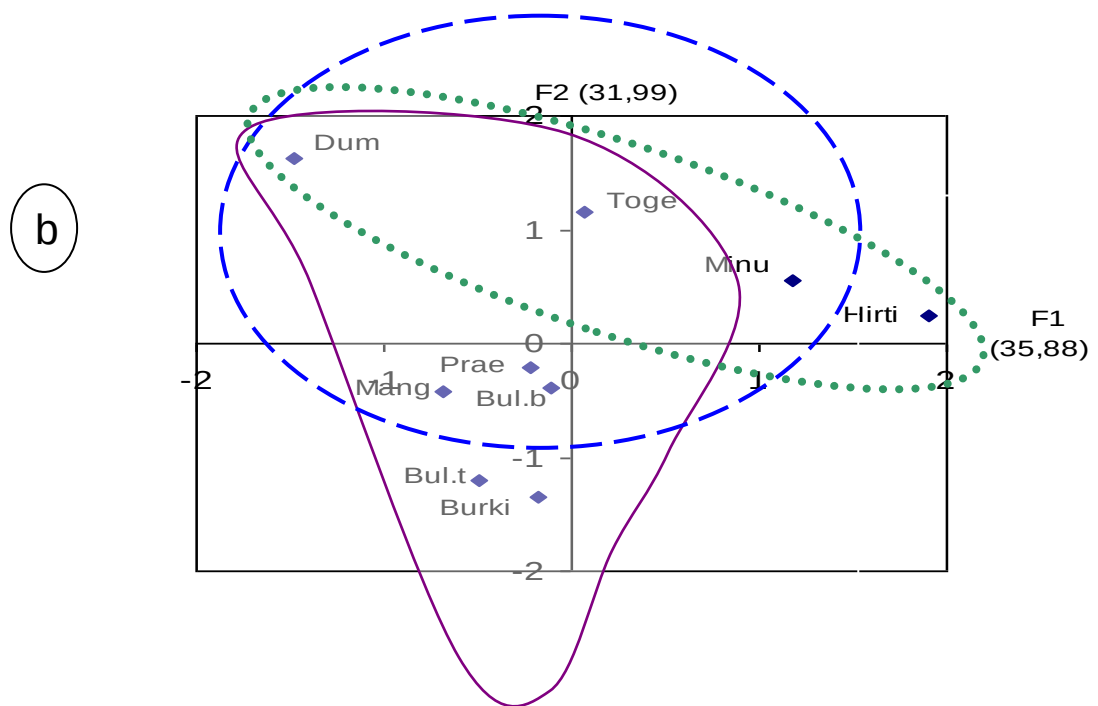


**Figure 2b; Classification of wild yam species according to their antinutritional factors**  
**Mang:** mangelotiana; **Bulk:** burkilliana; **Dum:** dumetorum; **Bulb b:** bulbifera (bulbil);  
**Bulb t:** bulbifera (tuber); **Hirt:** hirtiflora **Minu:** minutiflora; **Prae:** praehensilis

**Figure 2: Principal component analysis (PCA) on the composition of wild yam species antinutritional factors**