Original article

Physico-chemical characterisation and classification of fruits of *Dacryodes edulis* from the major agro-ecological zones of Cameroon

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Physico-chemical characterisation and classification of fruits of *Dacryodes edulis* from the major agro-ecological zones of Cameroon.

Abstract — Introduction. A study of accessions from the major production areas of *Dacryodes edulis* (Don) Lam. (Burseraceae) in Cameroon was carried out in order to assess the impact of pedoclimatic parameters and genetic factors on the characteristics and the classification of the fruits. The work focused on statistical analysis of fruit morphological and chemical parameters to distinguish accessions. **Materials and methods**. The fruits were collected from five localities of Cameroon (Obala, Boumyebel, Makenene, Njombe and Kekem). Twenty-six characters, among which were eleven quantitative morphological, nine qualitative morphological and six chemical characters, were the object of a correlation analysis, a principal component analysis and hierarchical classification. **Results**. Among the twenty-six characters studied, eighteen presented interesting morpho-chemical characters to discriminate the accessions. The fruit quantitative morphological characters were not significantly different, while the qualitative morphological and chemical characters showed significant differences for the localities concerned. A principal component analysis and hierarchical classification distinguished three major groups at a genetic distance of between 5.70 and 6.92: group I consists of accessions from Makenene and Kekem, discriminated by five characters (lipids, protein, grain colour, texture and colour of the mesocarp); group II consists of accessions from Njombe and Obala and was discriminated by six characters (weight of fruits, amino acids, sugars, phenols, epicarp colour and shape of grains); group III consists of the accession from Boumyebel and was discriminated by seven characters (fruit length and diameter; [fruit diameter / fruit length] ratio; weight of fruit, mesocarp and grain; and mesocarp thickness). **Discussion and conclusion**. Like agro-forestry species such as *Ricinodendron heudelotii* and *Irvingia gabonensis, D. edulis* presents intra-specific variations that are related to pedoclimatic conditions and genetic factors.

Cameroon / *Dacryodes edulis* / agroclimatic zones / fruits / quantitative analysis / qualitative analysis / chemical composition / classification

Caractérisation physico-chimique et essai de classification des fruits de *Dacryodes edulis* des grandes zones agro-écologiques du Cameroun.

Résumé — Introduction. Une étude d'accessions présentes dans les zones importantes de production de *Dacryodes edulis* (Don) Lam. (Burseraceae) au Cameroun a été réalisée afin d'évaluer l'impact des paramètres pédo-climatiques et des facteurs génétiques sur les caractéristiques et la classification des fruits de cette espèce. Les travaux ont porté sur l'analyse statistique de certains paramètres morphologiques et chimiques des fruits afin de discriminer les accessions. **Matériel et méthodes**. Les fruits ont été prélevés dans cinq localités du Cameroun (Obala, Boumyebel, Makénéné, Njombé et localité de Kékem). Vingt-six caractères, parmi lesquels onze caractères quantitatifs, neuf qualitatifs et six caractères liés à la composition chimique des fruits, ont fait l'objet d'une analyse des corrélations, d'une analyse en composantes principales et d'une classification hiérarchique. **Résultats**. Parmi les vingt-six caractères étudiés, dix-huit de type morpho-chimique se sont révélés intéressants pour discriminer les accessions. Les caractères quantitatifs décrivant la morphologie des fruits n'ont pas présenté de différences significatives, tandis que les caractères qualitatifs et ceux portant sur la composition chimique ont révélé des différences significatives selon les localités concernées. L'analyse en composantes principales et la classification hiérarchique ont discriminé trois grands groupes ayant une distance génétique comprise entre 5,70 et 6,92 : le groupe I est composé des accessions des localités de Makénéné et Kékem, discriminées par cinq caractères (lipides, protéines, couleur du grain, texture et couleur du mésocarpe) ; le groupe II est constitué des accessions de Njombé et Obala et il est discriminé par six caractères (poids des fruits, acides aminés, sucres, phénols, couleur de l'épicarpe et forme des grains) ; le groupe III correspond aux accessions de Boumyebel et il est discriminé par sept caractères (longueur et le diamètre du fruit ; rapport [diamètre du fruit / longueur du fruit], poids du fruit, du mésocarpe et du grain, épaisseur du mésocarpe). **Discussion et conclusion**. De même que d'autres espèces agroforestières telles que *Ricinodendron heudelotii* et *Irvingia gabonensis*, *D. edulis* présente des variations intra-spécifiques qui seraient liées aux conditions pédo-climatiques et à des facteurs génétiques.

Cameroun / *Dacryodes edulis* / zone agroclimatique / fruits / analyse quantitative / analyse qualitative / composition chimique / classification

1. Introduction

In the framework of improving agricultural production in Cameroon and the quest for food self-sufficiency, we undertook studies on the Africa bush butter tree (*Dacryodes edulis*), which is an oilseed fruit tree species, native to the region of Central Africa and the Gulf of Guinea [1]. The geographical area of this tree covers about 2/3 of the Cameroonian territory corresponding to the periforestry savannah regions, the western highland and along the Atlantic coast [2]. Its fruit, commonly called safou, is a food and a source of income for many rural and/or urban populations. Economically, safou occupies the third position among the most important fruits in Cameroon, coming only after banana and kola. A study conducted in five markets in southern Cameroon on the production and marketing of safou estimated that 4 500 t of safou, worth approximately € 461 600, are exported annually to the countries of the European Union [1].

In response to damage caused to the environment through deforestation, which reduces the diversity of species, and in order to ensure the livelihood of the populations, domestication of agro-forestry trees is a necessity. It consists initially of determining the priorities and preferences of the populations for species to valorise, and then to explore intra- and inter-specific variation of these species based on the specific selection criteria of the population for later genetic improvement [3]. In Cameroon, the Africa bush butter tree is a plant whose domestication process by marcotting and characterisation of the accessions is more advanced compared with other multipurpose agroforestry species [3]. The Biotechnology and Environment Laboratory of the University of Yaoundé I, in collaboration with the Laboratory of Botany and Traditional Medicine of the Institute of Medical Research and the Study of Medicinal Plants of Yaoundé, organised fruit harvests in various agro-ecological zones of Cameroon. Studies of these harvests showed a variation in shape, texture, taste, weight and chemical composition of the fruit [4]. This variability resulted from allogamy due to the separation of male and female plants in the population of *D. edulis*. Other studies have shown intra-specific variation in some wild tropical species such as *Ricinodendron heudelotii* [5], *Irvingia gabonensis* [6, 7] and *Canarium schweinfurthii* [8].

Among the research undertaken on the physico-chemical characterisation of fruits of *D. edulis* [9–13], there is very little that is based on physico-chemical characterisation to classify safous for geno-morphotype delineation. Yet these data are important for the choice of individuals or accessions to multiply in breeding programmes. In an attempt to classify the fruits of *D. edulis*, Silou incorporated the notion of size, limiting himself to a few quantitative morphological characteristics of the fruits (weight of fruit and grain, length of fruit and thickness of the mesocarp), and the notion of the water and oil content of the fruit [14]. It is necessary to extend this study to other quantitative descriptors associating qualitative variables of the fruits such as shape, colour, taste and texture. The purpose of our study was to investigate the degree of discrimination of the main physico-chemical characters currently used by the IPGRI (International Plant Genetic Research Institute), to characterise and classify accessions of *D. edulis*. For that, we surveyed five localities of agro-ecological zones of Cameroon.

2. Materials and methods

2.1. Biological material

Our study was conducted from June to September 2008 at the Laboratory of Biotechnology and Environment, University of Yaoundé I (Cameroon). Ripe fruits of *Dacryodes edulis* were harvested from trees older than fifteen years, planted in farmers' fields through massal selection. These fruits were harvested from two localities of the Centre region (Makenene and Obala), one locality in the West region (Kekem) and two localities in the Littoral region (Njombe and Boumyebel). All these localities are found in safou production zones of Cameroon [1]. The climate of Makenene (906 mm rainfall) and that of Obala (1577 mm rainfall) are equatorial, while that of Boumyebel (2809 mm rainfall) is tropical humid. Those

of Kekem (1832 mm rainfall) and Njombe (2900 mm rainfall) are equatorial coastal regions. The altitude of these locations varies between (80 and 1200) m, and they are located between lat. 3°20' and 6° N, and long. 9°40' and 13° E (*table I*). The soils are ferrallitic predominantly sandy clay in the localities of Obala, Boumyebel, Makenene and Kekem, while they are volcanic with a clay loam texture in the locality of Njombe [15].

With the assistance of farmers, fifteen trees were randomly selected in each region, at a minimum distance of 150 m from the nearest tree to favour heterogeneity of the population. In each community, two samples of 50 fruits were randomly harvested per tree of *D. edulis* (*i.e.*, 1500 fruits per locality). A first batch of 750 fruits per locality was used to determine the qualitative morphological parameters and the other for evaluating quantitative morphological and chemical parameters.

Table I.
Geographical coordinates and annual rainfall for five localities where fruits of *Dacryodes edulis* were collected during a survey in Cameroon (750 fruits collected per sampling, two samplings per locality).

Localities	Longitude (E)	Latitude (N)	Altitude (m)	Annual rainfall (mm)
Boumyebel	10°20'	3°20' and 4°10'	650	2 809
Kekem	10° and 10°08'	5°01' and 5°15	650	1 832
Makenene	10° and 13°	4° and 6°	1200	906
Njombe	9°40'	4°35' and 4°40'	80	2 900
Obala	11°45' and 11°50'	3°50' and 4°50'	710	1 577

2.2. Qualitative morphological characterisation

The fruit and grain shapes were determined by a rating scale as 1: extended, 2: oval, 3: globular, 4: conical. The epicarp colour was differentiated by 1: black, 2: blue, 3: violet; the mesocarp colour, by 4: green, 5: white, 6: violet; and the grain colour, by 7: light brown, 8: light green, 9: violet, 10: grey. The mesocarp taste was evaluated with a rating scale as 1: no acid, 2: acid, 3: less acid. The texture of the mesocarp was determined through 1: non-fibrous, 2: fibrous, 3: less fibrous. Furrow presence and escarpment were assessed with a rating scale ranging from 1: present to 2: absent.

2.3. Quantitative morphological characterisation

The diameter of the fruit and fruit length were determined using a Junior Roche-type calliper. The weight of the whole fresh fruit was obtained using a Sartorius Basic precision balance (accuracy 0.001). Each fruit was then pulped using a stainless steel knife. The number of cotyledon lobes was determined. The grain diameter and length were also measured. [Fruit diameter / fruit length] and [grain diameter / grain length] ratios were calculated.

2.4. Chemical characterisation of fruit

2.4.1. Water content

The pulp was dried for 8 days at room temperature and dry matter was determined by Wolff's method [16]. The rate of dry matter was used to determine the water content.

2.4.2. Extraction and analysis of sugars and total amino acids

Sugar and total amino acids were extracted by the method of Booy *et al.* [17]. The pulp (1 g) of each separate fruit was crushed in 5 mL of ethanol 80° at 4 °C. After reflux heating for 20 min at 25 °C, the homogenate was centrifuged at 5000 *g* for 25 min. The supernatant represents the fraction of soluble sugars and total amino acids. The sugars were dosed with anthrone and measured in a spectrophotometer at 670 nm, according to the method of Ashwell [18]. Amino acids were dosed with ninhydrin at 570 nm, according to the method of Yemn and Cooking [19].

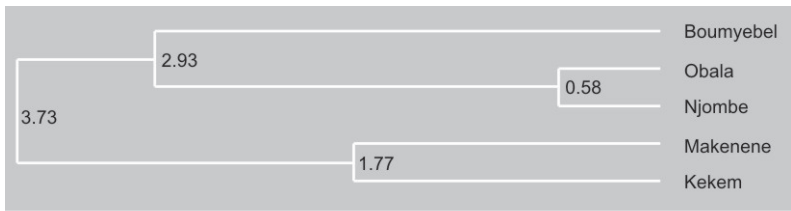

Figure 1.
Dendrogram of five accessions of *Dacryodes edulis* based on the matrix distance of nine quality morphological parameters of the fruit.

2.4.3. Extraction and analysis of phenols

Phenols were extracted by the method of Macheix *et al.* [20]. Pulp (1 g) was crushed in 5 mL of methanol 80° at 4 °C. The homogenate was centrifuged at 5000 *g* for 25 min. The supernatant was the soluble fraction of total phenols. The phenols were measured in Folin-Ciocalteu reactive in a spectrophotometer at 725 nm using the method of Marigo [21].

2.4.4. Extraction and analysis of proteins

The total soluble proteins were extracted using the method of Leconteux *et al.* [22]. Pulp (1 g) was crushed in 5 mL of 0.25 M pH 7 buffer phosphates and centrifuged at 6000 *g* for 25 min. The supernatant constituted the soluble protein fraction. The proteins were measured in a spectrophotometer at 595 nm using the method of Bradford [23].

2.4.5. Extraction and analysis of lipids

Lipids were extracted by soxhlet [24]. Pulp (100 g) packed in a paper filter was placed in a cartridge and subjected to continuous washing by petroleum ether (40–60 °C). The solvent was removed after extraction through a rotary evaporator and then dried in an oven for 20 min. The lipid content was expressed as a percentage of the initial weight of the sample.

2.5. Statistical analysis

The different morphological and chemical parameters of fruits measured were subjected to an analysis of variance (ANOVA) to separate the treatment means. Correlation analysis was used to measure the links between dependent fruit variables. Principal and multiple component analysis and hierarchical classification were used to determine the variability of the population and to distinguish between different groups within accessions. These various data were processed with the software SPAD 4.01 and SPSS 10.1 for Windows.

3. Results

3.1. Qualitative morphological characteristics

Of the 3750 fruits harvested on 75 trees from five localities, the qualitative parameters such as fruit shape and grain; mesocarp, epicarp and grain colour; mesocarp texture and taste; and furrow presence and escarpment were studied.

All the fruit shapes were found. However, the elongated shape was found in all regions at a frequency of 94.6%, significantly different ($p \leq 0.01$) from other fruit forms. The globular form (4.4%) was found in the localities of Kekem and Makenene. The oval and conical fruit forms were found in all the localities with low frequencies (0.3% and 0.6%, respectively), with no significant difference ($p \leq 0.01$). For most fruits studied, the unique grains per fruit had almost the same shape. The colour of the epicarp (black, blue, violet) and mesocarp (green, white and purple) were similar to tree level and did not depend on the localities. The mesocarp had either an acid, less acid or non-acid taste at (4.4, 14.5 and 79.1)%, respectively.

The measurement of links between the parameters of the different accessions led to the establishment of a positive correlation between colour and texture of the mesocarp ($r = 0.873$), the colour of the grain and the taste of the mesocarp ($r = 0.913$), and a negative correlation between fruit shape and colour of the mesocarp ($r = –0.761$), and fruit shape and texture of the mesocarp ($r = –0.814$).

The multi-component analysis led to a variation of 75.28%. The first axis, which describes 47.37% of this variability, is defined by all the parameters except the form of the grain, while the second axis,

Table II.
Variation in the quantitative morphological parameters of the fruits of *Dacryodes edulis* as a function of localities of sampling in Cameroon.

Accessions	Fruit weight (g)	Mesocarp weight (g)	Grain weight (g)	Fruit length (FL) (cm)	Fruit diameter (FD) (cm)	Grain length (GL) (cm)	Grain diameter (GD) (cm)	Mesocarp thickness (cm)	Number of cotyledon lobes	[FD / FL] ratio	[GD / GL] ratio
Boumyebel	44.66 a	31.90 a	14.03 b	7.31 b	3.60 b	4.70 b	2.19 b	0.68 a	9.96 a	0.524 a	0.493 a
Kekem	34.56 a	24.72 a	9.97 a	6.28 a	3.09 a	4.21 a	1.80 a	0.59 a	9.99 a	0.509 a	0.442 a
Makenene	43.12 a	31.45 a	12.21 a	7.11 a	3.49 a	4.35 a	2.09 a	0.63 a	9.74 a	0.511 a	0.503 a
Njombe	47.28 b	35.75 b	11.26 a	6.80 a	3.49 a	4.00 a	1.83 a	0.67 a	9.98 a	0.519 a	0.463 a
Obala	39.85 a	28.97 a	12.09 a	6.65 a	3.27 a	4.23 a	1.80 a	0.58 a	9.45 a	0.518 a	0.435 a

Means followed by the same letter in the same column are not significantly different according to Duncan's test ($p \leq 0.01$).

describing 27.91% of the variability, is also defined by all the parameters, except colour of the epicarp and grain.

A hierarchical classification was established to distinguish the different groups better (*figure 1*):

– group I is represented by accessions from Kekem and Makenene, which had as distinctive characters the colour of mesocarp and grain, texture and taste of the mesocarp, and furrow presence and escarpment;

– group II is represented by accessions from Njombe and Obala, which had as distinctive characters the shape of the fruits, and furrow presence and escarpment;

– group III is represented by the accession from Boumyebel with the distinctive characters fruit shape, epicarp and mesocarp colour, and mesocarp texture.

3.2. Quantitative morphological characterisation

The fruit, mesocarp and grain weight, the fruit length and diameter, the grain length and diameter, the mesocarp thickness, the number of cotyledon lobes, the ratios of diameter over the length of the fruit, and the diameter over the length of the grain were measured on 750 fruits of *D. edulis* from each locality surveyed (*table II*).

The fruit weight varied from 34.56 g (Kekem) to 47.28 g (Njombe), and the mesocarp weight from 24.72 g (Kekem) to 35.75 g (Njombe). However, only the fruit and mesocarp weight of the accession from Njombe were significantly different ($p \leq 0.01$) from the other accessions. Except for the Boumyebel accession, the characteristics of weight grain, and fruit and grain length and diameter were not significantly different ($p \leq 0.01$). For the other characteristics, there was no significant difference whatever the locality.

Measurements of links between dependent variables on the 3750 fruits studied for quantitative morphological characterisation allowed us to observe a positive correlation between fruit weight and the mesocarp weight ($r = 0.966$); fruit weight and grain weight ($r = 0.609$); fruit weight and fruit length ($r = 0.732$); fruit weight and grain length ($r = 0.355$) and fruit diameter and mesocarp thickness ($r = 0.435$). However, a negative correlation was obtained between the fruit length and the [fruit diameter / fruit length] ratio ($r = –0.535$); and the grain length and the [fruit diameter / fruit length] ratio ($r = –0.310$).

The principal component analysis yielded a variability of 80.7% represented by axes 1 and 2 (*figure 2*). In general, only axes with Eigenvalues greater than 1 are taken into account [25]. The first axis, which describes 62.79% of the total variability, is defined by all the parameters except the length of the grain, while the second axis, which represents 17.91% of the variability,

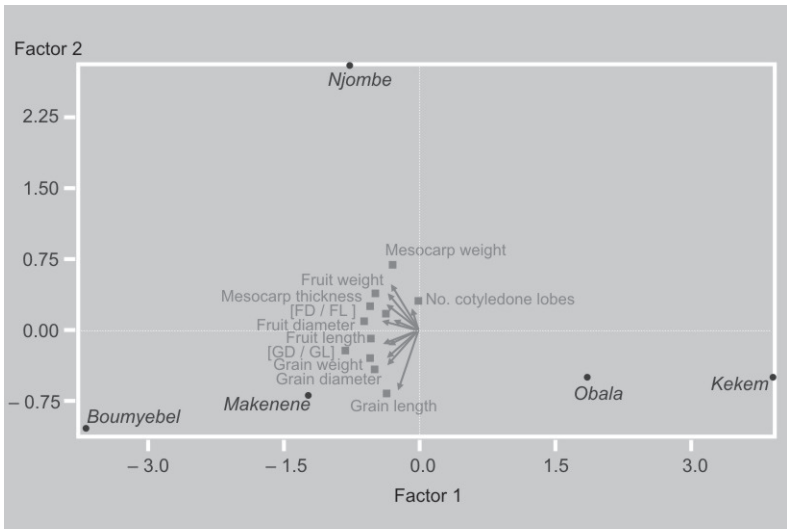

Figure 2.
Distribution according to five different localities in Cameroon for quantitative morphological parameters of the fruits of *Dacryodes edulis* by principal component analysis defined by axes 1 and 2.

is defined by four parameters (fruit weight, mesocarp weight, grain length and grain diameter). These data provided a hierarchical classification comprising three large groups:

– group I is represented by accessions from Makenene and Boumyebel, which are discriminated in all parameters except the length of the grain and the number of cotyledon lobes;

– group II is represented by the accession from Njombe, which is discriminated by the weight of the fruit and mesocarp;

– group III is represented by accessions from Obala and Kekem; it is not under the influence of any parameter.

3.3. Characteristics of chemical metabolites

The lipid content, sugars, water, amino acids, phenols and total protein of the mesocarp of safou were determined (*table III*). The total lipid oil had rates between 29.76% and 43.83% with significant differences between accessions from Kekem, Boumyebel and Makenene. The same trend is observed with water content, amino acids and total protein, where the variability leads to significant differences ($p \leq 0.01$) at the level of accessions. Keeping the localities of Njombe and Obala aside, the mesocarp water contents were not significantly different ($p \leq 0.01$) in the localities of Kekem, Boumyebel and Makenene. Measurements of links between dependent variables of 75 fruits resulted in a negative correlation ($r = –0.241$, $p \leq 0.01$) between the levels of lipids and total amino acids. The principal component analysis achieved a 76.29% variability accounted for by axes 1 and 2. The first axis, with 43.32% of this variability, is defined by the single parameter water content, while the second axis, which describes 32.97% of the variability, is defined by the levels of lipids and phenols. A hierarchical classification distinguished three groups (*figure 3*):

– group I is represented by the accession from Njombe, characterised by a high content of phenols;

– group II, formed by the accessions from Boumyebel and Obala, is characterised by a high water content;

Table III.
Variations in chemical parameters of the fruits of *Dacryodes edulis* according to localities of sampling in Cameroon.

Accessions	Lipids	Sugar	Water	Amino acids	Phenols	Proteins
Kekem	43.83 a	5.13 a	28.14 a	3.64 a	53.02 a	3.26 a
Boumyebel	29.76 b	5.37 ac	30.19 b	8.47 b	44.21 b	2.03 b
Makenene	34.55 c	5.16 a	31.27 b	6.60 c	52.74 a	4.45 c
Njombe	30.66 b	8.71 b	24.63 c	9.99 d	59.40 c	2.51 b
Obala	31.33 c	3.59 c	28.13 a	12.95 e	52.61 a	2.77 b

Means followed by the same letter in the same column are not significantly different according to Duncan's test ($p \leq 0.01$).

– group III, represented by accessions from Makenene and Kekem, is characterised by high water content, lipids and phenols.

3.4. Trial on the classification of accessions

The combined set of 26 fruit morphological and chemical characters was studied. The principal component analysis obtained resulted in a variation of 68.14% (*figure 4*). The first axis and the second axis describe 24.79% and 16.06% of the variability, respectively. Of the 26 traits studied, 19 are of great interest for discriminating the accessions. A hierarchical classification distinguished three groups (*figure 5*):

– group I is represented by accessions from Kekem and Makenene, which are discriminated by the chemical and qualitative morphological characters (proteins and lipids; mesocarp texture and colour, plus grain colour);

– group II consists of accessions from Njombe and Obala, discriminated by three groups of characters (phenols, amino acids and sugars; epicarp colour, grain shape and fruit shape);

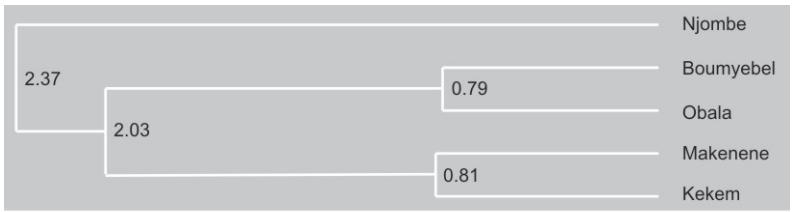

Figure 3.
Dendrogram of five accessions of *Dacryodes edulis* based on the distance matrix of six chemical parameters of fruits.

– group III, represented by the accession from Boumyebel, is discriminated only by quantitative morphological characters.

4. Discussion

The study of physico-chemical parameters of *D. edulis* fruits showed that there were many changes, both qualitative and quantitative, among these fruits. It is well known that intra- and inter-specific variations exist within populations of tropical trees [26]. The fruits of *D. edulis* have various forms, but the elongated shape is the most common. This form is the most requested by 90% of farmers compared with others in the system of selection and cultivation of safous. This preference may explain the low frequency of other forms of fruits encountered in various localities. The grains had almost the

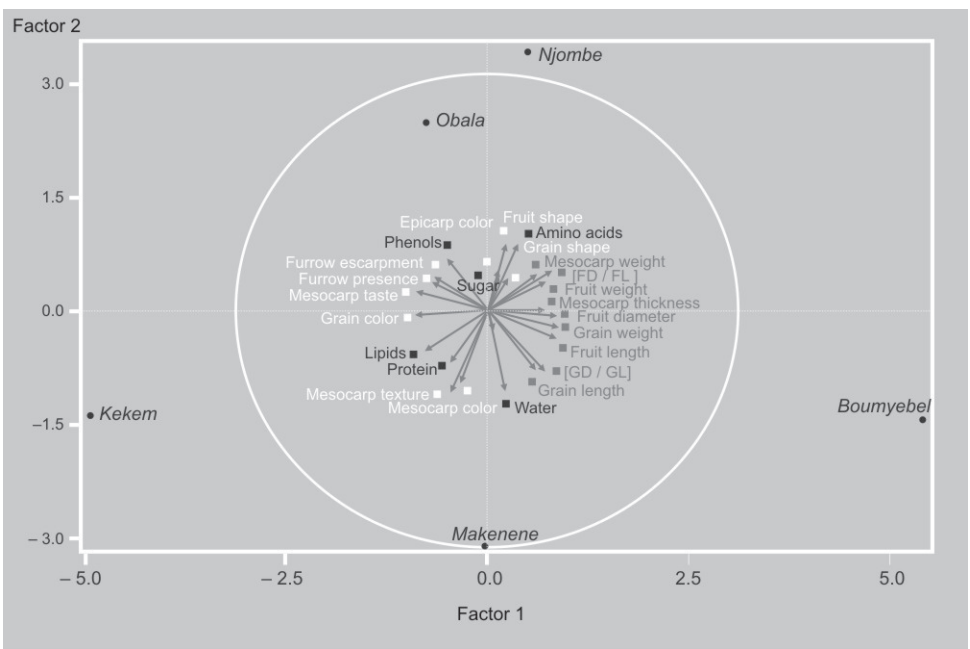

Figure. 4.
Distribution according to different localities in Cameroon for morpho-chemical parameters of the fruits of *Dacryodes edulis* by principal component analysis defined by axes 1 and 2.

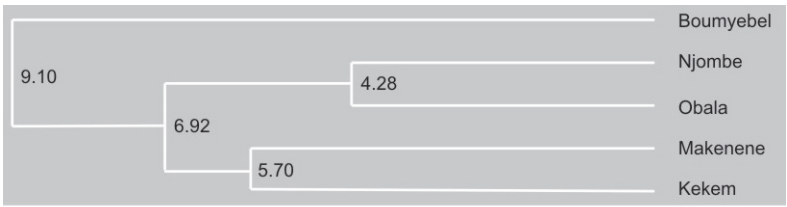

Figure. 5.
Dendrogram of five accessions of *Dacryodes edulis* based on the distance matrix of 26 morpho-chemical parameters of fruits.

same shape as the fruit, but they always have one side flattened [1]. Ladipo *et al.* obtained similar results in studying the different forms of fruit from a collection of germplasm of southern Nigeria [27]. The mesocarp being the fruit's edible part, its taste is a criterion for choosing the best safous [1]. Outside the localities of Obala and Makenene, which had 2.6% of trees with more or less acidic fruit flavour, other localities were characterised by non-acidic fruits. The taste is usually evaluated according to an acid index expressed in mg of $KOH \cdot g^{-1}$ lipid [8]. The study of correlations between these qualitative parameters showed that the mesocarp may have a colour and present many textures, while each type of fruit is characterised by a particular mesocarp colour and texture. The multicomponent analysis helped identify three major groups at a genetic distance between 1.9 and 2.93.

The analysis of quantitative morphological parameters showed homogeneity in the thickness of the mesocarp, the number of cotyledon lobes and the [fruit diameter / fruit length] and [grain diameter / grain length] ratios. The same trend was observed first, with the fruit mesocarp weight in all localities except Njombe, and secondly, with the grain weight, the fruit and grain length, and the grain diameter in all the localities, outside of Boumyebel. However, heterogeneity was observed with the fruit length and grain, and the fruit diameter. Similar work done by Silou on the characterisation of safous in Central Africa showed homogeneity of morphological data of fruit within the same ecological zone [14]. Generally, in forest trees such as *Irvingia gabonensis* and *Irvingia wumbulu* [27], *Canarium schweinfurthii* [8] and *Ricinodendron heudelotii* [5], the fruit diversity is remarkable. In accessions of *Dacryodes edulis* in which the domestication process is advanced, the use of homogeneous selected genetic material generally from marcotting in planting programmes and the choice of fruit forms made traditionally by the population have certainly helped the 'erosion' of the genetic basis, hence the trend of standardisation of tree populations in different regions. This hypothesis suggests that quantitative morphological characteristics of fruits of *D. edulis* are more influenced by genetic factors than soil and climate. The study of the correlations between various parameters showed that, to choose fruit with a thick mesocarp, one can rely on either their length or their weight. The principal component analysis identified two major groups at a genetic distance between 1.7 and 2.21. The diversity of qualitative morphological characteristics is more remarkable than quantitative morphological characteristics.

Unlike quantitative morphological parameters, the analysis of biochemical parameters showed heterogeneity at the levels of lipids, sugars, water, amino acids, phenols and proteins. The oil contents (29.76% to 43.83%) obtained in the safou are not different from those obtained by Kapseu and Tchiegang in the same species [12]. The quality and quantity of oil in the mesocarp are part of the selection criteria for the best safous. In this regard, the localities of Kekem and Makenene have higher oil contents in the fruit. Fruits of these localities can be recommended for industrial exploitation of safou oil. The phenolic compounds contribute significantly to the organoleptic properties and colour of many fruits [28]. Changes in the phenol content of the different accessions could explain the different taste and coloration of fruits obtained in our study. The heterogeneity of the chemical characteristics can also be explained by environmental factors such as soil type, climate, farming practices and fertiliser application. In general, the correlation analysis shows that fruits with high lipid content have low total amino acids.

The combined analysis of 26 morphological and chemical characters led to a classification of the accessions. Only 18 characters out of 26 were discriminating. The inertia expressed by the first two axes of the

AFC represented 68.14% of total inertia. The strong representation of the two lines demonstrates the presence of genotypic and phenotypic organisation of the large accessions studied [29].

5. Conclusion

This work is part of research work aimed at the exploration, characterisation, conservation and evaluation of plant genetic resources of *Dacryodes edulis* in Cameroon. Our interest was focused on the study of the discriminating power of morphological and chemical characters currently used for the characterisation and classification of *D. edulis* accessions. Of the 26 traits studied, eighteen were of great interest for discriminating the accessions. The most important are those corresponding to the size and category (lipids) of the fruit. An attempt at classification distinguished three main groups: group I with characters related to the quality and category of the fruit; group II with characters related to the size, category and quality of the fruit; and group III with characters related to fruit size.

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Caracterización físico-química e intento de clasificación de los frutos de *Dacryodes edulis* de las grandes zonas agroecológicas del Camerún.

Resumen — Introducción. Se llevó a cabo un estudio de las presentes accesiones en las zonas importantes de producción de *Dacryodes edulis* (Don) Lam. (Burseraceae) en el Camerún para poder evaluar tanto el impacto de los parámetros pedoclimáticos como los factores genéticos en las características y en la clasificación de los frutos de esta especie. Los estudios se basaron en el análisis estadístico de ciertos parámetros morfológicos y químicos de los frutos con el fin de discriminar las accesiones. **Material y métodos**. Se tomaron los frutos de cinco localidades del Camerún (Obala, Boumyebel, Makénéné, Njombé y localidad de Kékem). Veintiséis caracteres, entre los cuales, once caracteres cuantitativos, nueve cualitativos y seis caracteres relacionados con la composición química de los frutos, fueron el objeto de un análisis de las correlaciones, de un análisis de los compuestos principales y de una clasificación jerárquica. **Resultados**. Entre los veintiséis caracteres estudiados, dieciocho del tipo morfoquímico resultaron ser interesantes para discriminar las accesiones. Los caracteres cuantitativos que describían la morfología de los frutos no presentaron diferencias significativas, mientras que los caracteres cualitativos, y aquéllos basados en la composición química, mostraron diferencias significativas para las localidades implicadas. El análisis de compuestos principales, así como la clasificación jerárquica, discriminaron tres grandes grupos con una distancia genética comprendida entre 5,70 y 6,92: el grupo I se compone de accesiones de las localidades de Makénéné y de Kékem, discriminadas por cinco caracteres (lípidos, proteínas, color de la semilla, textura y color del mesocarpio); el grupo II se constituye de accesiones de Njombé y Obala y se discrimina por seis caracteres (peso de los frutos, aminoácidos, azúcares, fenoles, color del epicarpio y forma de las semillas); el grupo III corresponde a las accesiones de Boumyebel y se discrimina por siete caracteres (longitud y diámetro del fruto; relación [diámetro del fruto / longitud del fruto], peso del fruto, del mesocarpio y de la semilla, espesor del mesocarpio). **Discusión y conclusión**. Al igual que otras especies agroforestales, tales como *Ricinodendron heudelotii* o *Irvingia gabonensis*, *D. edulis* presenta variaciones intraespecíficas que estarían relacionadas a las condiciones pedoclimáticas y a factores genéticos.

Camerún / *Dacryodes edulis* / zonas agroclimáticas / frutas / análisis cuantitativo / análisis cualitativo / composición quimica / clasificación