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DOMESTICATION OF *DACRYODES EDULIS* IN WEST AND CENTRAL AFRICA: CHARACTERISATION OF GENETIC VARIATION

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ABSTRACT

New initiatives in agroforestry are seeking to integrate trees with marketable products into farming systems. This is being done in order to provide marketable timber and non-timber forest products from farms that will enhance rural livelihoods by generating cash for subsistence farmers. *Dacryodes edulis* (Safou) is one of the candidate tree species in West and Central Africa for domestication, which has commercial potential in local, regional or even international markets. This paper describes: (i) the characterisation of tree-to-tree variation in fruit traits and the opportunities for selecting *D. edulis* cultivars based on the intraspecific variation found in local populations in Cameroon and Nigeria, (ii) the identification of multi-trait ideotypes for potential cultivar development, (iii) the organoleptic attributes which are important traits for selection, and (iv) an assessment of the relationships between fruit mass and market prices in fruit samples from three markets, at the peak of season, in Cameroon.

Key words: Dacryodes edulis, safou, agroforestry, cultivars, ideotypes, market and customer preferences, organoleptic variation, rural livelihoods, sustainable land use.

RESUME

Des initiatives nouvelles en agroforesterie visent à intégrer des arbres à produits commercialisables dans les systèmes agricoles. Ces initiatives ont pour but de relever le bien-être des paysans à travers des revenus générés par la commercialisation des produits forestiers ligneux et non-ligneux provenant des exploitations agricoles. *Dacryodes edulis* (safou), arbre à potentiel économique tant local qu'international est une espèce candidate à la domestication dans la région de l'Afrique de l'Ouest et du Centre. Le présent article décrit (i) la caractérisation de la variation phénotypique des fruits et les opportunités de sélection de *D. edulis*, (ii) l'identification d'idéotypes à caractères multiples pour un développement potentiel de cultivars, (iii) les attributs organoleptiques qui constituent des traits importants pour la sélection et (iv) une quantification des relations prix-poids du fruit à l'aide d'échantillons provenant de trois marchés du Cameroun au pic de la saison

Mots clés: Dacryodes edulis, safou, agroforesterie, cultivars, idéotypes, préférences du marché et des clients, variation organoleptique, bien-être rural, utilisation durable des terres.

INTRODUCTION

The marketing of non-timber forest products (NTFPs), especially products of indigenous trees, generates cash for rural communities (Falconer 1990, Arnold 1996). *Dacryodes edulis* (G. Don) H.J. Lam (Burseraceae), commonly known as African Plum, African Pear or 'Safou', is the most important NTFP marketed in the humid forest zone of Cameroon in terms of quantity (Ndoye and Ruiz-Perez 1995). Its national trade in 1997 was worth around US$7.5 million (Awono *et al.* 2002).

Safou is an oleiferous fruit tree native to Southern Nigeria and perhaps to Cameroon (Vivien and Faure 1996). Its current geographic range is from Central Africa to Sierra Leone in the West, to Uganda in the East and to the Northern part of Angola in the South (Troupin 1950). Okafor (1983) in Nigeria identified two varieties of *D. edulis* (var. *edulis* and var. *parvicarpa*) on the basis of their size and the relationship between their longitudinal and mid transverse circumferences. Likewise, Youmbi *et al.* (1989) identified two morphological types in markets in Cameroon, while Silou *et al.* (in press) in the Congo recently characterised four fruit types that vary in size and shape. In contrast, Leakey and Ladipo (1996) reported continuous variation in fruit size and other fruit characteristics between samples from Yaoundé markets.

The fruit flesh of safou is part of the staple diet of people in Cameroon and Nigeria during the fruiting season. The fruits are eaten roasted or boiled (Vivien and Faure 1996), often with maize, and are also the source of an edible oil (Fonteh 1998). The high amino and fatty acid contents (Omoti and Okiy 1987) and the ascorbic acid content (Achinewhu 1983) of its pulp are well known. Because of its richness in carbohydrates, essential amino acids, oils and minerals, the flesh is recognised as a nutritious food, which with the kernels can also be fed to animals (Omoti and Okiy 1987). The nutritional and commercial importance of this species make it a suitable species for domestication, and it was ranked second in importance after *Irvingia gabonensis* (Bush mango / Dika nut), in a priority setting exercise for tree domestication in the humid lowlands of West and Central Africa (Franzel *et al.* 1996).

Studies for the selection and domestication of safou have been increasing (Okafor 1990, Fonteh 1998, Ndoye and Kaimowitz 1998, Nwufo and Anyim 1998, Kengue 1998, see review by Leakey 1999). As part of the present study, Waruhiu (1999) and Usoro *et al*. (unpublished)[1] have identified tree-to-tree variation in fruit and nut mass, fruit length and width, flesh depth, fruit and skin colour, and flesh taste. It is also known that there is great variation in taste and protein content, although two contrasting fruit types were not found to differ significantly in fatty acid content (Kapseu and Tchiegang 1996). All this variation within a more or less 'wild'[2] population offers an opportunity for plus-tree selection, as has also been found for *Irvingia gabonensis*, another indigenous fruit tree of West and Central Africa (Atangana 1999, Atangana *et al.* 2001). Consequently, techniques to identify and capture useful intraspecific variation are being developed (Leakey *et al.* 2000), in collaboration with the Agroforestry Tree Domestication Programme of the International Centre for Research in Agroforestry (ICRAF) (Leakey and Simons 1998). This programme is targeting the vegetative propagation of 'superior trees' for the creation of cultivars within a participatory tree domestication programme in 8 villages in Cameroon and 4 villages in Nigeria (Tchoundjeu *et al.* 1998, Tchoundjeu *et al*. 2002).

Traits with economic importance can be improved through selection and cultivation (Okafor 1985) in a way that satisfies both farmers' domestic needs and the markets. In Cameroon, the main markets for safou are New Bell (Douala), Mfoundi (Yaoundé), Mbouda (West Province) and these are the main points of export of safou fruits to Gabon, other neighbouring countries and to Europe (Ndoye *et al.* 1997). The main markets in Nigeria are in the South-east and include Oil-Mill market in Port Harcourt, and Ogbeta and Central markets in Enugu. In addition, there are important markets in Lagos (Ketu) and Ibadan (Obaoja). There is however, a need for much greater control on quality (Temple *et al*. 1999, Ladipo 1999, Tabuna 1999). In this respect, there is a need for better information about the variation in price *vis à vis* fruit colour, size (Leakey and Ladipo 1996), as well as cooking qualities and the preferred organoleptic characteristics of consumers. This study includes a preliminary examination of the desirable and undesirable organoleptic characteristics of safou.

Enhancing the marketability of safou fruits should improve the incentive for planting more trees on farms, so improving the livelihoods of poor subsistence households and increasing the sustainability of agriculture (Leakey and Tchoundjeu 2001). Consequently, as described in this paper, the commercialisation of safou fruits is being linked to fruit characteristics influencing consumer preferences and market prices. However, little is known about how markets perceive the genetic variation in fruit characteristics or whether, through the price paid by customers, they reward producers for more desirable fruit types. This study examines these questions in major retail and wholesale markets.

[1]The fieldwork for this study was carried out by Usoro in Nigeria, and by Waruhiu (1999) in Cameroon.

[2]'Wild' is used here to mean that the tree has not been subject to a formal process of improvement. It is, however, located predominantly in farmers' fields where it is retained during clearing or planted from seed (see Schreckenberg *et al.* 2002).

CHARACTERISING INTRA-SPECIFIC VARIATION

In parallel with ICRAF's identification of superior trees by farmers (Tchoundjeu *et al.* 2002), a study was made to determine the range of variability in fruit traits within safou populations. Fruits of both species were collected from up to one hundred trees in four villages in Cameroon (Makénéné, Elig Nkouma, Chop Farm and Nko'ovos II) and one in Nigeria (Ilile) (Table 1). Twenty-four ripe fruits were collected from each tree as they ripened over the fruiting season (May–October) in 1999. Fruit length, fruit width and flesh depth were measured using callipers graduated to 0.1mm, while fruit mass and kernel mass were determined using portable kitchen scales graduated to 2g, based on the methods of Leakey *et al.* (2000) for *Irvingia gabonensis*. Flesh mass (fruit mass – kernel mass) was derived by difference. Fruit taste and oiliness were scored from 1 to 5 for bitter-to-sweet and dry-to-oily respectively. Skin and flesh colours were assessed on a 3-dimensional basis (hue, tone and intensity) against a colour chart based on the Methuen Code of Colour (Kornerup and Wanscher 1978).

With the exception of kernel mass, all these assessments of fruit and kernel characteristics have confirmed that there is continuous tree-to-tree variation and that this variation is considerable (Figure 1). The detailed and extensive measurements of 300 trees of safou identified significant tree-to-tree variation in fruit mass (10.2±1.21 to 114.0±2.24 g), as well as in fruit size (length, width, and flesh depth); increasing in scale between three and twenty times for the different traits (Waruhiu 1999). Interestingly, both the Cameroon and Nigerian populations have a few trees with large fruits. Rather than between villages, this variation was predominantly within each village; accounting for 80, 86, 88, 84, 84, and 97% of the variation in length, width, flesh depth, fruit mass, flesh mass, and kernel mass respectively. The differences between mean values per village were, nevertheless, also significant for all traits except kernel mass. Considerable differences were observed in skin and flesh colour of mature safou fruits using the Methuen Colour Code. The most common of the 25 identified skin colours

TABLE 1

Sites for safou morphological characterisation in Southern Cameroon and Southeast Nigeria between May and August 1999

Village	Altitude; latitude and longitude	No. of trees collected
Chop Farm, Cameroon	10.5 m a.s.l. 3º57'N, 9º15'E	31
Elig Nkouma, Cameroon	461 m a.s.l. 4º07'N, 11º24'E	57
Makénéné, Cameroon	580 m a.s.l. 4º52'N, 10º48'E	100
Nko'ovos II, Cameroon	610 m a.s.l. 2º56'N, 11º21'E	12
Ilile, Nigeria	54 m a.s.l. 5º19'N, 6º56'E	100

and 23 identified flesh colours were 18D6 (greyish violet) and 29A7 (yellowish) respectively. It should be emphasised that taste and oil content were assessed by a single assessor rather than by a trained tasting panel, like that used below for the organoleptic study. The organoleptic characteristics of the fruit flesh should provide further detail on this subject (Kengni *et al*. 2001), while work to characterise the oils for industrial and nutritional use is also on-going (Silou *et al* in press, Kalenda *et al*. 2002, Mbofung *et al*. 2002). To date, the study of the oils is examining quantitative and qualitative differences in oil properties at the population level, rather than the tree-to-tree variation.

In Elig Nkouma, Makénéné and Nko'ovos II, most safou trees were found in cocoa farms, while in Chop Farm they were most commonly found in forest fallow. Overall in Cameroon, safou trees were mostly found in cocoa fields (65.5%), crop fields (16.5%), home gardens (9.5%) and fallow fields (7.5%) (see also Schreckenberg *et al.* 2002). In Ilile, Nigeria, safou trees were mostly (57%) found in the large homegardens typical of South-east Nigeria (which include cocoa), with only 4% specifically in pure cocoa farms. In Cameroon, no relationships were found between land-use systems and any fruit traits and land use explained minimal amounts of the trait variation; length (20%), width (14%), flesh depth (12%) and fruit mass (16%). In both countries, the majority of trees (82% in Cameroon [18% not known]; 99% in Nigeria) had been planted by the farmers or their parents.

The extensive and continuous intraspecific variation found in this study (Figure 1) means that for any one trait there are relatively rare genotypes which

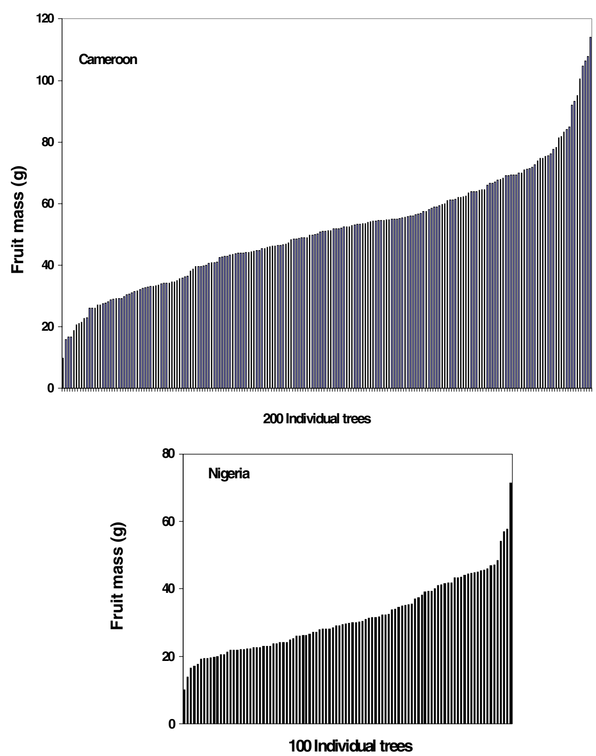
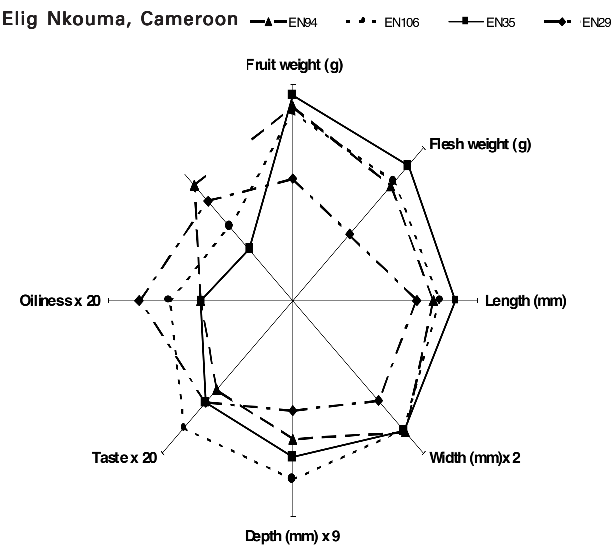
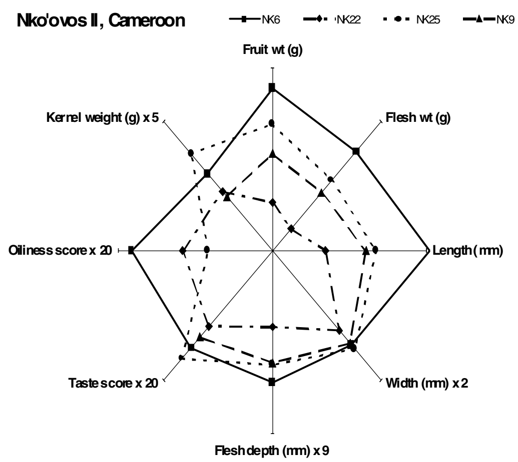
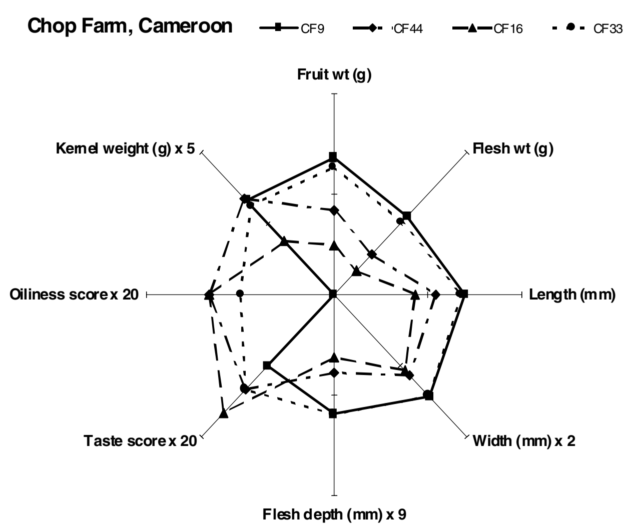


Figure 1. Continuous intraspecific (tree-to-tree) variation in fruit mass of *D. edulis* in (a) Cameroon and (b) Nigeria.


Elig Nkouma, Cameroon
EN94
EN106
EN35
EN29
Fruit weight (g)
Flesh weight (g)
Length (mm)
Width (mm)x 2
Depth (mm) x 9
Taste x 20
Oiliness x 20


Nko'ovos II, Cameroon
NK6
NK22
NK25
NK9
Fruit wt (g)
Flesh wt (g)
Length (mm)
Width (mm) x 2
Flesh depth (mm) x 9
Taste score x 20
Oiliness score x 20
Kernel weight (g) x 5


Chop Farm, Cameroon
CF9
CF44
CF16
CF33
Fruit wt (g)
Flesh wt (g)
Length (mm)
Width (mm) x 2
Flesh depth (mm) x 9
Taste score x 20
Oiliness score x 20
Kernel weight (g) x 5

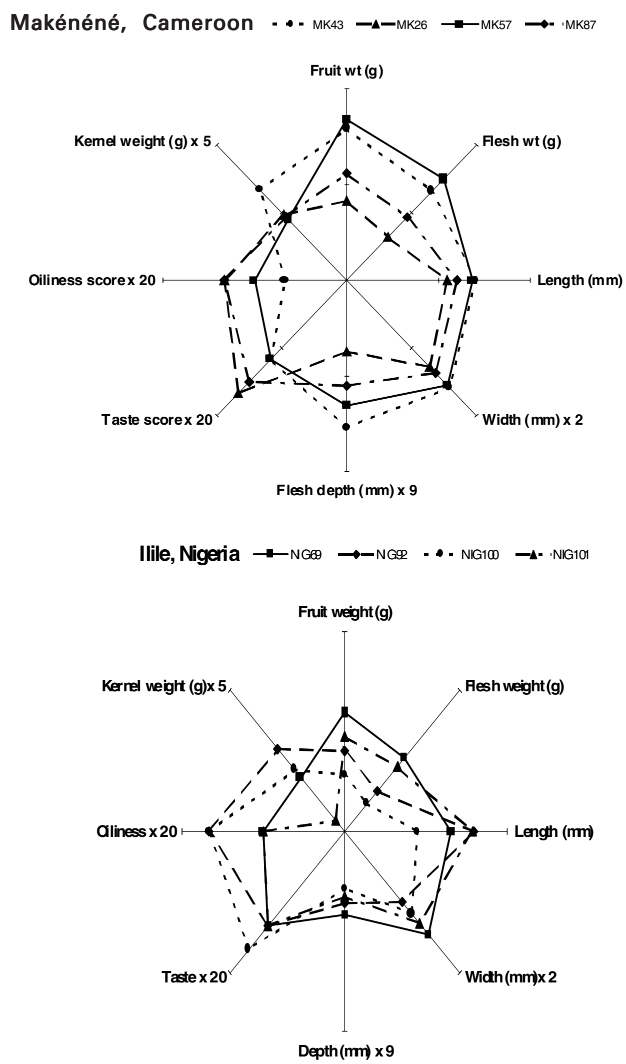


Figure 2. Multi-trait web diagrams of intraspecific (tree-to-tree) variation in fruits and kernels of *D. edulis* in 4 villages in Cameroon and 1 in Nigeria—4 best trees per village.

display superiority; so called 'plus-trees' which, if multiplied vegetatively as cultivars, would offer considerable improvements in the selected traits over the average for a village. Unfortunately, trees with superiority in one trait (e.g. fruit size) are not necessarily superior in other traits (e.g. fruit taste), and consequently there is a lower probability of finding the rare trees with superiority in two or more traits. For example, in *I. gabonensis*, which has commercially important kernels as well as edible fruit flesh, multiple trait selection for trees with good flesh qualities as well as good kernel qualities seems to be very unlikely, consequently Leakey *et al*. (2000) and Atangana *et al*. (2001) have focussed on the identification of a combination of traits that together form either a fruit or a kernel ideotype. Currently, this ideotype approach is not so relevant for safou as there is only a single fruit product—the edible flesh, and there are relatively strong relationships between different fruit traits (i.e. trees with heavy fruits are usually also those with long ones). This can be seen by the relatively similar shapes of the web-diagrams for the four trees in each village with the best combinations of traits (Figure 2). However, as the different organoleptic components of taste and consumer preference are elucidated, it is possible that specific combinations of unrelated morphological and organoleptic traits (including skin and flesh colour) may need to be combined to identify a fruit ideotype. Similarly, as industrial uses of the oils from safou fruits become more important, and different biochemical traits of these oils are identified there may, once again, be a need to combine morphological and biochemical traits into a series of oleiferous ideotypes.

These ideotypes will also help researchers and extension agencies to explain to farmers what traits, or combinations of traits, are important for selection (Leakey *et al*. 2000). They can also be used to demonstrate to policy makers the level of improvement which is possible without recourse to the more expensive and time-consuming options of tree breeding and biotechnology. It should be remembered that while such multiple trait selection is desirable in a domestication programme, the more traits for which selection is desired, the larger is the number of trees that need to be screened. To minimise this problem, the ICRAF/IRAD project in Cameroon and the ICRAF/IITA project in Nigeria have involved farmers in the process of screening and selecting trees in their villages. This participatory approach to domestication (Tchoundjeu *et al*. 2002) also ensures that the programme conforms to the requirements of the Convention on Biological Diversity, which supports the rights of farmers over their indigenous knowledge and their germplasm. The results of the present study provide a sound basis on which this participatory approach to domestication can be implemented by ICRAF and partners. These on-farm results should be compared with the preferred fruit traits in the marketplace, so indicating the opportunities and options for enhancing domestication options.

The results of the present study have confirmed the findings of Leakey and Ladipo (1996) that, with the exception of kernel mass, there is continuous variation in all the measured traits with high levels of phenotypic variability (e.g. 11-fold variation in fruit mass). This raises a question about the validity of the suggestion that there are varieties of *D. edulis* (Okafor 1983). Likewise, it questions the categorisation of safou fruits into size categories for market studies (Ndoye 1995, Youmbi *et al*. 1989) as these overlook the big differences in other traits, which may also be of significance in determining the market price of fruits.

ORGANOLEPTIC CHARACTERISATION OF FRUITS

Much is known about the proximate analysis (31.9% oil, 25.9% protein, 17.9% fibre, 13.5% carbohydrate) of safou fruits (see review by Leakey 1999), but little is known about the interactions between the chemical composition of the fruits and their organoleptic characteristics. There are, however, some reports of linkages between morphological variation and other chemical composition. For example, Youmbi *et al*. (1989) have reported that large fruits are characterised by a higher lipid content in the mesocarp than in the seed, and the converse in small fruits. Fatty acid content was, however, said not to differ significantly between two contrasting fruit types (Kapseu and Tchiegang 1996), while non-structural carbohydrates are reported to be higher in the seed than in the mesocarp of both fruit types (Youmbi *et al*. 1989). There is also much reported variation in taste, and some variation in protein content (Kapseu and Tchiegang 1996). The further characterisation of these differences is important in the domestication of the species and their suitability for different markets.

Market stallholders sell fruits in piles of similar looking fruits, which may in fact all originate from the same tree. In the current study in Cameroon, 30 fruits of 12 visually distinct samples of safou were bought in Mokolo market, Yaoundé in July 1999 and rapidly transferred to the laboratory for morphological characterisation (fruit length, width, flesh depth, flesh and kernel mass), assessment of skin and flesh colours (Table 2), using Methuen Colour Codes (Kornerup and Wanscher 1978), prior to their sensory evaluation a day later by a trained panel of six tasters (Kengni *et al*. 2001). The fruits spanned the range of skin and flesh colours reported by Waruhiu (1999) in four localities of the humid forest zone of Cameroon, but excluding the whitish-green type she described. Eighteen washed fruits selected at random from each of the samples were stored overnight at 5^{o}C and then cooked in an air-forced oven for 6-10 min at 50^{o}C. Each of the six tasters seated in a clean, well illuminated and quiet environment, independently assessed three fruits per sample in four separate sessions, for a series of predetermined flavour, odour and visual attributes, as described by Watts *et al*. (1991). They washed out their mouths between each fruit.

TABLE 2

The descriptors of fruit size (large, medium or small) and skin / flesh colours of safou samples assessed organoleptically in Cameroon.

Skin colour (Methuen Colour Codes)	Flesh colour (Methuen Colour Codes)	Fruit size
Bluish GG (22B3)	1. Deep green (29A7)	L
	2. Pale green (28A3)	S
Greyish red (10B5)	1. Orange grey (6B2)	L
	2. Pastel green (26A4)	M
Dark blue (21F8)	1. Green (27A7)	M
	2. Green (27A7)	S
Deep blue (20D8)	1. Greyish green (27E7)	L
	2. Pale green (28A3)	S
Greyish blue (20C4)	1. Green (27A7)	M
	2. Deep green (29A7)	S
Dark violet (18F8)	1. Pastel green (26A4)	L
	2. Deep green (29A7)	M

The main results of the tasting panel's evaluation of fruits were that:

- 100% were aromatic (an overall sensation created by the volatile flavouring compounds present in the pulp),
- 100% were oily (the sensation of the oil/fat content on the tongue),
- over 95% were acidic (a pleasant snappy flavour created as the acids combine with sugars to increase the overall smoothness),
- over 80% were astringent (a taste closely associated with polyphenolics, such as tannins),
- over 75% were bitter (a taste associated with some organic compounds, such as alkaloids).

Other characteristics noted by the panel were that 83% of fruits were fibrous (presence of fibres in the pulp), 50% were sour (a sharp biting taste, associated with organic acid compounds such as formic, citric, acetic and tartaric acids) and 17% were described as salty and, similarly, also as watery. The above characteristics are probably all inherent traits relevant to a genetic selection programme.

The tasting panel also observed other characteristics, which are more likely to arise from environmental influences. For example, 3 samples had skin blemishes probably attributed to insect damage during the maturation period, and 2 samples smelt of fungicides and insecticides. Others had signs of deterioration, thus 2 samples smelt musty, while 1 sample smelt rotten.

From this study, it can be concluded that a panel trained in tasting the organoleptic attributes of safou fruits can assess many attributes of these fruits likely to be under genetic control, as well as some arising from environmental conditions. Together the morphological and organoleptic studies provide a good understanding of the biological opportunity for genetic improvement through plus-tree selection.

RELATIONSHIPS BETWEEN FRUIT TRAITS AND MARKET PRICES

To determine if the markets reward farmers for producing fruits with desirable characteristics, fruits were purchased at random in three markets situated in rural (Makénéné Centre and Makénéné Est) and urban (Mfoundi, Yaoundé) areas (Table 3) at the peak of season (3rd to 17th of August 2000) in Cameroon. The area around Makénéné, and the markets in town have a reputation for producing and selling safou fruits, with many of them being bought by Gabonese traders for export to Gabon.

As for previous characterisation studies (Leakey *et al*. 2000, Atangana *et al*. 2002), 24 fruits constituted a sample. Samples were collected either from a wholesaler's basin or bag, or from a stallholder's fruit piles, ensuring that each sample was from fruits of similar nature (probably originating from the same tree) and selling at the same price. Each sample was individually identified and later weighed (fruit and kernel mass) and measured (fruit length and width, flesh

TABLE 3

Market details and sampling scheme for safou fruits in Cameroon

Market	Market type	No of samples	No of fruits/ sample
Makénéné Centre	(wholesale)	50	24
Mfoundi	(wholesale)	18	24
Mfoundi	(retail)	16	24
Mfoundi	(roadside retail)	16	24
Makénéné Est	(roadside retail)	49	24

depth) using the same equipment as for the morphological characterisation. Skin and flesh colour were also assessed as previously.

Highly significant differences were found between samples for each parameter in each market, but the relationships between fruit traits and prices were found to be weak in wholesale markets (Table 4). However, in retail markets, fruit mass, length and width were positively correlated with price per fruit, indicating that small-scale traders can benefit from consumer preferences for large fruits. Interestingly, the relationship between fruit mass and price was stronger in the urban Mfoundi market than in more rural Makénéné Est market, suggesting that traders in urban areas are more appreciative of fruit size.

The most frequent skin and flesh colours were violet (41%) and Georgetown lime (57%), coded 18D6 and 29A7 respectively in the Methuen Code of Colour (Kornerup and Wanscher 1978).

Flesh mass, the commercially and nutritionally important part of the fruit, had the strongest relationship with price per fruit. In contrast, flesh mass is weakly and negatively correlated with price per kg of pulp in wholesale markets and has a weak positive correlation with price per kg in retail markets (Table 4). Big fruits with the heaviest pulp fetch the highest prices in retail markets, indicating that retailers, who are in closest contact with consumer demands, take into account phenotypic variation in fruit size and mass when fixing price per fruit and price per kg of pulp. However, in a roadside retail market survey in Yaoundé, Leakey and Ladipo (1996) found that while big fruits tended to have high market prices, some small fruits were also highly priced, suggesting that they were desirable for some qualitative trait, such as taste. Wholesalers on the other hand, do not appear to take the characteristics of individual fruit types into account when pricing fruits. It seems that they are only interested in price per kg of pulp, which presumably reflects their greater interest in transport costs.

In Makénéné Est market, one sample with a whitish green skin (28A3) was very expensive compared to others of similar size. This fruit type is relatively rare and was reported by farmers in Elig Nkouma, Cameroon to be highly appreciated for its taste and was highly priced (Waruhiu 1999). These two observations, suggest that there is definitely more to the pricing of safou fruits than fruit size.

The morphological, organoleptic and price variation found for fruits of safou,

TABLE 4

Relationships in safou between (i) fruit traits and prices per fruit, and (ii) flesh mass and price per kg of pulp in wholesaler and retail markets

Traits	Makénéné Centre (n=50)	Mfoundi (n=18)	Makénéné Est (n=49)	Mfoundi (n=16)	Mfoundi (n=16)
	Wholesalers		Roadside retailers		Retailers
Fruit length *v.* price per fruit	r^2 = 0.08	r^2 = 0.04	r^2 = 0.58	r^2 = 0.67	r^2 = 0.35
Fruit mass "	r^2 = 0.20	r^2 = 0.26	r^2 = 0.49	r^2 = 0.64	r^2 = 0.73
Fruit width "	r^2 = 0.27	r^2 = 0.24	r^2 = 0.38	r^2 = 0.32	r^2 = 0.62
Flesh depth "	r^2 = 0.06	r^2 = 0.12	r^2 = 0.36	r^2 = 0.42	r^2 = 0.57
Kernel mass "	r^2 = 0.07	r^2 = 0.03	r^2 = 0.002	r^2 = 0.17	r^2 = 0.003
Flesh mass "	r^2 = 0.17	r^2 = 0.25	r^2 = 0.56	r^2 = 0.56	r^2 = 0.74
Flesh mass *v.* price per kg of pulp	r^2 = –0.13	r^2 = –0.28	r^2 = 0.012	r^2 = 0.27	r^2 = 0.14

emphasises the opportunity to select cultivars which meet the specific needs of the food industry. This however, will require further interaction between traders, producers and the agroforesters involved in tree domestication. The trade is also interested in improving the year round supply of the product. Selection for the seasonality of production can almost certainly have considerable impact on the availability of products, as there is typically some within-species variation in phenology with a few trees flowering and fruiting outside the main season. Seasonality is an important issue in safou as fruits have a very short shelf life and there is either a need to extend the productive season or to develop storage and/or processing techniques.

CONCLUSIONS

Together these three studies on the characterisation of safou take a major step forward in understanding the potential for the domestication of this indigenous fruit tree. The characterisation of morphological variation indicates the extent to which domestication will be able to increase fruit size, etc., without recourse to alternative costly and time-consuming tree breeding or biotechnology. It also indicates which desirable traits can be easily combined within a cultivar, through multiple trait selection, to maximise the market opportunities and to increase the income of producers. Of these traits, taste is probably the most difficult to assess. The organoleptic study demonstrated the potential of this assessment technique to greatly improve the assessment of tree-to-tree variation in fruit taste, and hence to assist the domestication programme to refine the ideotype developed by the study of morphological variation. The market study confirmed the importance of individual fruit characteristics in the retail market, but interestingly identified that the wholesale market was more interested in the bulk price. Overall, it is clear that more work is needed in the domestication programme for safou to integrate studies on the morphological variation with those of the organolepsis, and the marketplace.

Since the end-user of fruits from agroforestry trees is the consumer, large fruits with high flesh mass and other traits such as recognisable skin colours and good taste that fetch high market prices should guide the selection of 'elite trees' for domestication (Atangana *et al.* 2001, Waruhiu 1999). To achieve this there is a need for greater understanding of the relationships between morphological traits, organoleptic characteristics and market price, in for example, the trees being selected by ICRAF for cultivar development. Highly desirable and easily recognised cultivars should be named, so that traders can identify their products and consumers can be assured of the quality of their purchases.

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