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Biodiversity of cucurbits consumed as sauce thickener in Ivory Coast: a capital resource for the economic prosperity of rural women

Zoro Bi, I.A.¹, K.K. Koffi¹, Y. Djè¹, M. Malice² & J.-P. Baudoin²

¹ Université d'Abobo-Adjamé, UFR des Sciences de la Nature 02 BP 801, Abidjan 02, Ivory Coast. bamhiakalou@vahoo.fr

² Unité de Phytotechnie tropicale et d'Horticulture, Faculté Universitaire des Sciences agronomiques de Gembloux, Passage des Déportés, 2. B-5030 Gembloux, Belgique.

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Abstract

A survey of the biodiversity of cucurbit species consumed as sauce thickener in Ivory Coast was carried out in the framework of a collaborative research project involving Gembloux Agricultural University (FUSAGx, Belgium) and the University of Abobo-Adjamé (UAA, Ivory Coast). Collecting missions from different ecological regions of the country resulted in a germplasm collection of 176 plant introduction accessions composed of 13 cultivars in five species and genera. These species are *Citrullus lanatus* var. *citrroides*, *Cucumeropsis mannii*, *Cucumis melo* var. *agrestis*, *Cucurbita pepo* and *Lagenaria siceraria*. The most common species is *C. lanatus* var. *citrroides*. There was a moderate diversity within species (2 to 4 open-pollinated cultivars per species) probably due to the farmer's selection process that reduces the genetic richness. All these cucurbits are mostly grown by women as minor plants intercropped with major food crops. Data obtained from these investigations also showed that the studied species have good market potential so that their promotion can contribute to the economic well-being of rural people. Indeed, these species are widely accepted at both cities and villages levels, due to their cultural and culinary values.

Introduction

The conservation and characterisation of indigenous genetic resources are crucial to fulfil the needs of breeders for both present and future generations (Frankel, 1974; Brown & Briggs, 1991; Eyzaguirre, 1995). The chance for fulfilling future demand of genetic resources is better when a high level of genetic diversity is conserved and made available (Given, 1987; Anonymous, 1991; Given, 1994). This challenge should not be missed, particularly for the neglected and underutilised crops in Africa such as fonio, bambara groundnut, and indigenous cucurbits that have numerous agronomic and economic potentials, making them materials for which improved production and uses can result in food security and incomes generation for peasants (Chweya & Eyzaguirre, 1999; I PGRI, 2002). Indeed, many neglected and underutilised crops (so called orphan crops) are reported to be rich in nutrients, well adapted to extremely divergent agro-ecosystems and various cropping systems characterized by minimal inputs.

To address these issues, a collaborative project involving Gembloux Agricultural University (Belgium) and the University of Abobo-Adjamé (Ivory Coast) has been implemented using



the main edible-seeded cucurbit species cultivated or growing naturally in Ivory Coast as plant materials. Specifically, the following topics were defined for the project: plant material collecting in various ecological regions of the country, botanical identification and genetic characterization of ecotypes, agronomic evaluation of the most common species, study of their reproductive biology and improved cropping systems implementation. The studied cucurbits are prized for their oleaginous seeds consumed as soup thickener, preferentially during popular feasts and prestigious ceremonies (van Epenhuijsen, 1974; Akobundu *et al.*, 1982; Badifu, 2001; Zoro Bi *et al.*, 2003). We report herein preliminary results obtained from investigations on inter- and intraspecies diversity of the target plant materials, as well as the current cropping systems involved and some major constraints to production.

Materials and methods

Study sites and plant materials

This study was carried out during the period 2000-2004 in Ivory Coast, covering 322.462 km² and located between latitudes 4°30'N-10°30'N and longitudes 2°30'W-8°30'W. The country is bordered by the Atlantic Ocean to the south, Ghana to the east, Guinea Conakry and Liberia to the west, and Burkina Faso and Mali to the north. Investigations were made in three sites (designated south, centre and east), selected in three agro-ecosystems, also differing by the food habits of the local populations.

The south site is localized between latitudes 4°41'N-6°00'N and longitudes 4°00'W-7°30'W. In this zone, rainfalls are abundant (annual mean > 2000mm) and the mean annual temperature is 28°C, with an annual amplitude of 5-10°C. Vegetation is mainly consisting of tropical rain forest, with mangrove on the coastal side. Two departments (Alépé and San Pedro) and 10 villages were selected in this site for field observations.

The east site is limited by latitudes 6°00'N-8°00'N and longitudes 3°00'W-5°00'W and includes three departments (Abengourou, Daoukro and Bongouanou) and 10 villages. This site is characterized by the transitional woodland savanna, with several blocks of semi-deciduous forests. Rainfalls vary from 875 to 1910mm, with an annual mean of 1250mm; the annual mean temperature is 27°C.

The centre site is also composed of three departments: Beoumi, Sakassou and Zuénoula. It is limited by latitudes 6°00'N-8°00'N and longitudes 5°00'W-7°00'W. A total of 20 villages were visited in this site. Annual rainfalls vary from 800 to 1400mm, with an annual mean of 1200mm; the annual mean temperature is 27°C. The vegetations are dominated by woodland savannas.

Plant materials are the indigenous edible-seeded cucurbits cultivated by rural people or growing naturally. To extract the seeds, the fruits are split using a piece of wood or a machete, placed on the ground with the inner part downward, and covered with the help of banana leaves or a plastic awning until the solid flesh starts to decay. The seeds are then extracted, washed, dried, shelled, and winnowed to get the kernels. Then the kernels are slightly toasted and ground for use as thickener of a traditional soup called 'egussi' soup in most sub-Saharan countries and 'pistachio' soup in Ivory Coast. Edible oil can also be extracted from the seeds (van Epenhuijsen, 1974; Badifu, 2001).

Data collection and analysis

In each zone, a participatory rural appraisal-based method (Chambers, 1992) was used to gather local community knowledge of traditionally cultivated cucurbit species, namely their

vernacular names, diversity, relative cultural and social importance, and uses. To check if morphological variations observed within a species were not due to environmental conditions prevailing in the original sites, representative samples of each plant introduction (PI) accession were grown at the experimental station of the University in Abidjan for 2-4 seasons, with two replicates and 20-50 seeds per plot of 25m x 25m. Within each species, morphological differences between cultivars were examined considering the following traits: mature fruit shape and colour, seed shape, seed size (estimated as height x width), and 100-seed weight. The estimates of seed size and 100-seed weight were then used to compare cultivars using Student t-test (for two cultivars) or one-way analysis of variance (for more than two cultivars) that was completed by the Newman-Keuls test, if necessary (Zar, 1996). Statistical analyses were performed using the StatsDirect™ statistical package for Windows, release 2.4 (StatsDirect, 2005).

Results and discussion

Inter- and intraspecies diversity

A total of 176 PI accessions composed of five species in five genera were collected throughout the three zones: *Citrullus lanatus* var. *citroides* (Thumb.) Matsum. & Nakai. (90 PI accessions), *Cucumeropsis mannii* Naudin (43 PI accessions), *Cucumis melo* var. *agrestis* L. (25 PI accessions), *Cucurbita pepo* L. (5 PI accessions), and *Lagenaria siceraria* (Molina) Standl. (13 PI accessions). Intraspecies diversity based on fruit and seed traits was observed in the five species.

Citrullus lanatus var. *citroides*

This species is a monoecious, yellow flowered and creeping annual vine, presenting leaves deeply divided into 5-7 more or less subdivided lobes. Locally called 'wléwlié', the species is the most common edible-seeded cucurbit species cultivated in Ivory Coast. The fruits are round or oval (Figure 1), uniformly light green or mottled light and dark green and contain a white bitter flesh embedding about 200 seeds. The mature dried seeds are yellowish in color (Figure 1). Various fruit and seed shapes and colours are reported in *C. lanatus* (Gusmini, 2003). Two cultigroups were reported for this species. The first cultigroup, containing three cultivars (defined on the basis of seed size), has smooth seeds that are tapered to the point of attachment. Fruits of the second cultigroup, with one cultivar, are round and narrow or wide striped. The seeds are ovoid and flattened, with a thickened and roughened margin. Statistical analyses highlighted significant differences between and within cultigroups for 100-seed weight and seed size (Table 1). Note that a type which presents slightly colored-flesh fruit, with brown seeds is often observed on permanent rubbish or on plots of unbuilt grounds in cities. This form could be a weedy type probably derived from the edible-fleshed *C. lanatus* var. *lanatus* that is widely consumed in towns. Our hypothesis is supported by the fact that some watermelon accessions held in the U.S. Department of Agriculture (USDA) show the edible seed phenotype, designated by breeders as the *egussi* seed type (Gusmini, 2003). Results from many studies devoted to genes controlling *C. lanatus* seed traits and their segregation patterns (see review by Gusmini *et al.*, 2004) are also in accordance with our observations.

With regard to the mating system, it is worth noting that andromonoecy, a recessive trait that is reported to be common in *C. lanatus* var. *citroides* (Gusmini, 2003), was not observed in the collected cultivars.

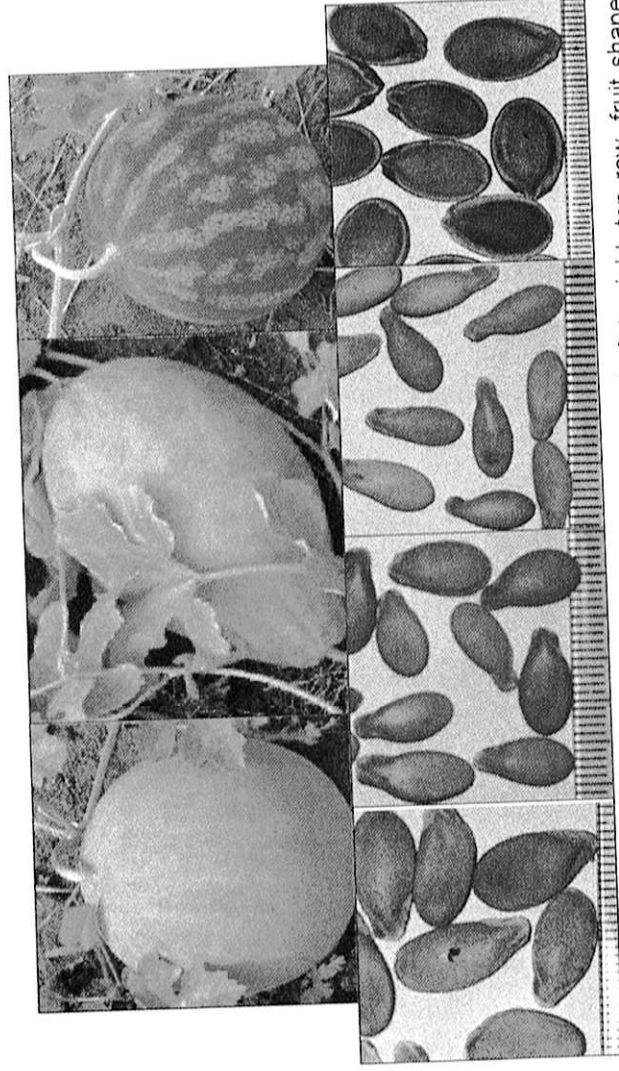


Figure 1. Fruits and seeds of *Citrullus lanatus* var. *citroides*. Left to right, top row, fruit shape and color: round and light green; oval and light green; and round and wide striped. Bottom row, seed shape, color, and size: tapered, yellowish, and big-sized; tapered, yellowish, and medium-sized; tapered, yellowish, and small-sized; ovoid, flattened, yellowish, and big-sized.

Table 1. Difference between cultivars of edible-seeded cucurbits from Ivory Coast, based on mean values (\pm SD) of seed size and 100-seed weight (n = sample size)

Species	Cultivar / Type	Seed size (mm ²) (n = 100)	100-seed weight (mg) (n = 10)
<i>Citrullus lanatus</i>	Big seeds	120.41 \pm 16.94 ^c	11.50 \pm 0.61 ^a
	Medium seeds	058.81 \pm 9.76 ^b	05.49 \pm 0.23 ^b
	Small seeds	42.07 \pm 7.17 ^a	04.26 \pm 0.26 ^c
	Thickened margin seeds	179.06 \pm 26.11 ^d	17.45 \pm 0.60
<i>Cucumeropsis mannii</i>	Big seeds	138.31 \pm 12.90 ^c	11.87 \pm 0.59 ^a
	Medium seeds	096.80 \pm 10.79 ^b	10.73 \pm 0.33 ^b
	Small seeds	049.44 \pm 7.68 ^a	04.47 \pm 0.15 ^c
<i>Cucumis melo</i> var. <i>agrestis</i>	Green-fruited	019.16 \pm 2.59 ^b	01.11 \pm 0.04 ^a
	Orange-fruited	013.24 \pm 1.48 ^a	00.58 \pm 0.11 ^b
<i>Cucurbita pepo</i>	Green-fruited	79.59 \pm 9.12 ^a	7.54 \pm 0.34 ^a
	Yellow-fruited	123.92 \pm 11.48 ^b	07.87 \pm 0.53 ^a
<i>Lagenaria siceraria</i>	Round-fruited	159.08 \pm 19.43 ^a	25.08 \pm 0.70 ^a
	Blocky-fruited	190.78 \pm 26.88 ^b	21.60 \pm 2.80 ^b

NB: For each trait and each species, means within a column followed by different superscripts were significantly different ($P \leq 0.01$), based on Student *t* or Newman-Keuls tests.

Cucumeropsis mannii

This species is a monoecious annual climbing vine, locally called 'n'viélé'. It can climb up to a height of 3-5m. The leaves are embossed, with three notched lobes. Fruits are uniformly slight green or yellowish and blocky. Seeds are whitish, flattened, and tapered to the point of attachment (Figure 2). According to peasants, maximizing yield of this species implies vertical training of the vines. For this reason, in the target zones, *C. mannii* is systematically intercropped with yam, since the latter also needs training trellis to yield. Three cultivars defined on the basis of seed size were found for this species (Figure 2 and Table 1).

Cucumis melo var. *agrestis*

Two andromonoecious types, with dark green leaves, yellow flowers and small oval fruits (3-7cm length) were collected in the target zones. The most common type (Figure 3) is cultivated and locally called 'lomi n'gatè'. The seeds of this type are toasted, ground, and eaten as soup thickener. The flesh of fruits is light green, lacks aroma, and has a bitter taste. The second type, less widely cultivated, is often found along the roads, on permanent rubbish or on plots of unbuilt grounds in villages and cities. Its mature fruits are orange in colour (Figure 3), possess aroma and are exclusively used as vegetable. The fruits are cut into slices and added to soup. In addition to mature fruit colour, the other differences between the two types are related to seed size and 100-seed weight (Table 1).

The melon family is a worldwide economically important crop that includes wild types and numerous varieties, either consumed as desert fruit, vegetable or sauce constituent (van Epenhuijsen, 1974; Akobundu *et al.*, 1982; Chweya & Eyzaguirre, 1999; Badifu, 2001; Zoro Bi *et al.*, 2003). Varieties vary widely in fruit size, morphology and taste, as well as vegetative traits and climatic adaptation (Silberstein *et al.*, 1999; El Tahir & Taha Yousif, 2004). The most recent classification of *C. melo* L. subdivides this species into two subspecies: *agrestis* and *melo* (Pitrat *et al.*, 2000). Within the subspecies *agrestis*, 5 botanical varieties are recognised, while in the subspecies *melo*, 11 varieties are recognized. The two forms of *C. melo* var. *agrestis* observed in the present study are probably cultivars belonging to one of the five botanical varieties described by Pitrat *et al.* (2000). Unfortunately the publication of the latter is mainly based on the fruit traits and do not contain illustrations which could help clarifying the botanical classification of our specimens.

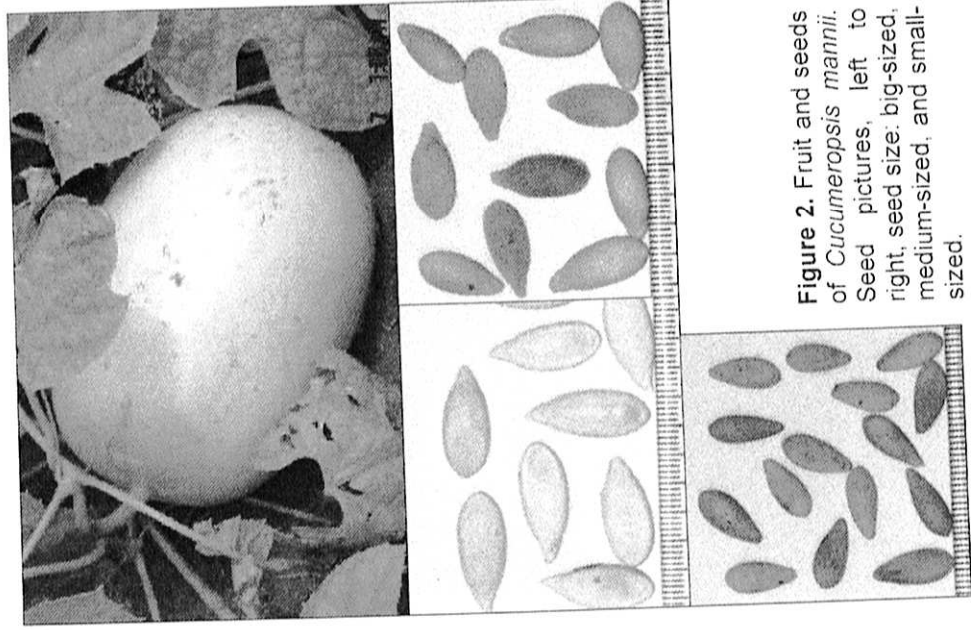


Figure 2. Fruit and seeds of *Cucumeropsis mannii*. Seed pictures, left to right, seed size: big-sized, medium-sized, and small-sized.

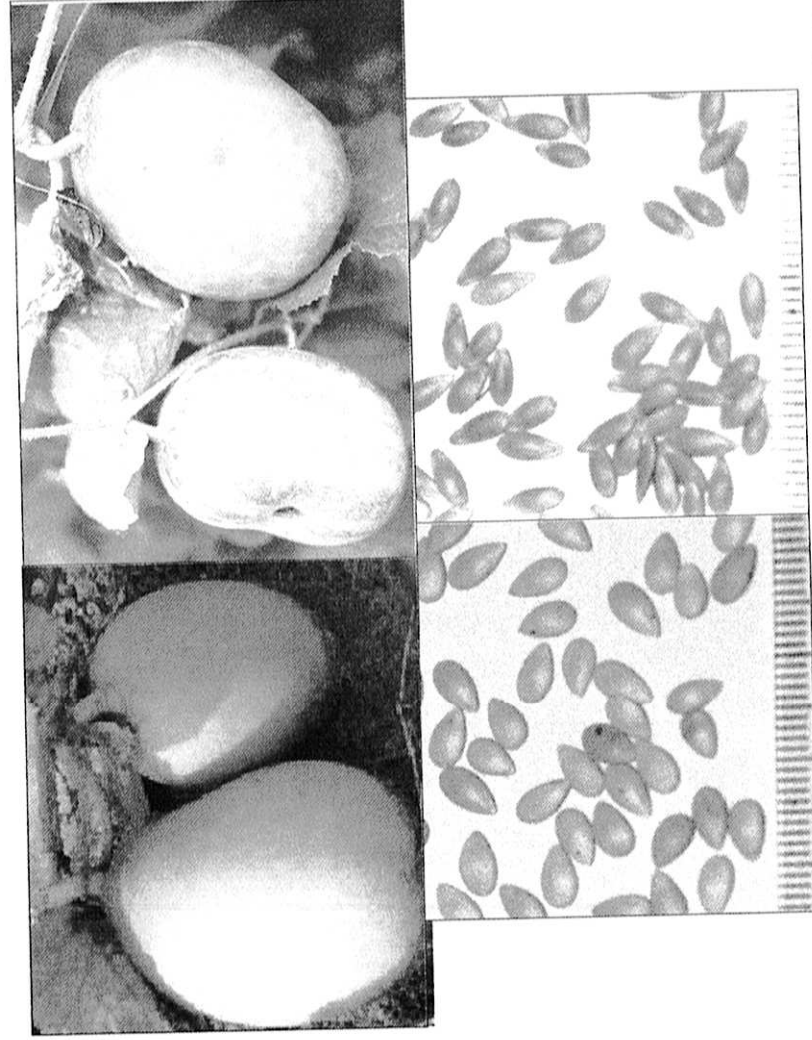


Figure 3. Fruits and seeds of *Cucumis melo* var. *agrestis*. Top row, left to right: cultivated type; uncultivated type. Bottom row, left to right: seed of the cultivated type; seed of the uncultivated type.

Cucurbita pepo

Two open-pollinated cultivars, identified as *C. pepo* on the basis of the study of Paris (2001) and locally named 'n'gando', were collected. The cultivars present yellow flowers and blocky fruits with orange flesh. This species is found in backyard gardens or on plots of unbuilt grounds in villages and cities. The main difference between the two cultivars is related to the colour of the mature fruit that can be mottled light and dark green or yellow, and to the seed size (Figure 4 and Table 1).

C. pepo is among the economically most important vegetable crops worldwide and is grown in both temperate and tropical regions (Paris, 2001; Bisognin, 2002; Sanjur *et al.*, 2002). It is also one of the most variable species for fruit traits. The species includes both edible-fruited forms (pumpkins and squash) and small-fruited, often bitter, and inedible forms known as gourds (Hart, 2004). In many cases, variability in fruit traits among cultivars can be related to differences in quality needed for the culinary uses of the mature fruit and seeds. The two cultivars described in the present study have fibrous flesh so that they are solely cultivated for their seeds. Nevertheless, they expressed obvious morphological differences.

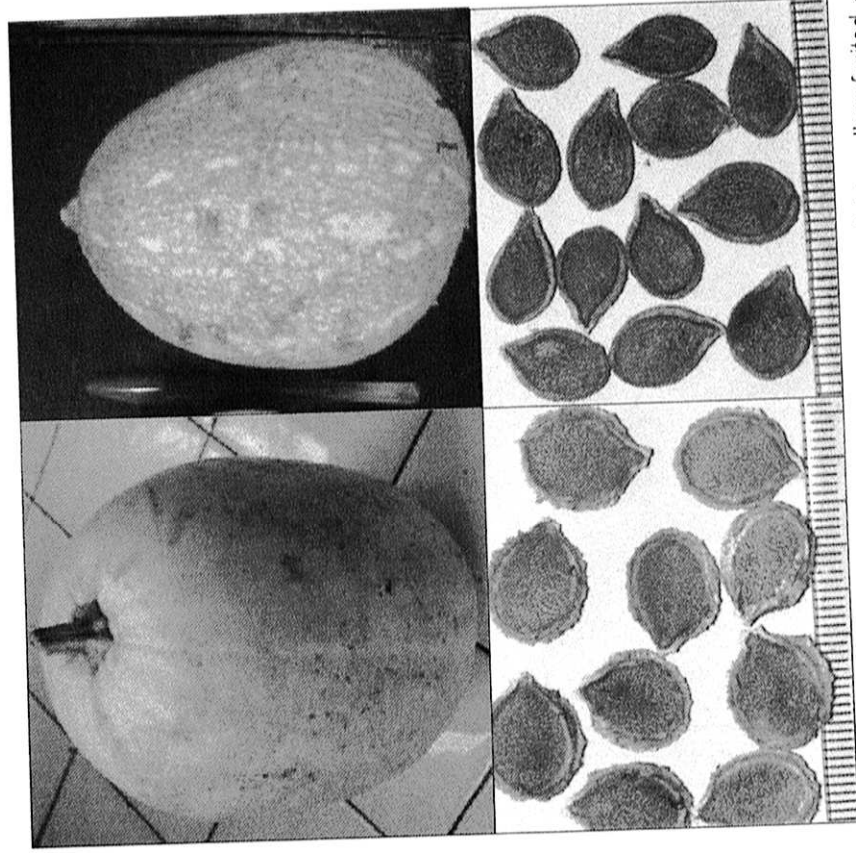


Figure 4. Fruits and seeds of *Cucurbita pepo*. Top row, left to right: yellow-fruited cultivar; green-fruited cultivar. Bottom row, left to right: seed of the yellow-fruited cultivar; seed of the green-fruited cultivar.

Lagenaria siceraria

This is a species of the monoecious white flowered gourds locally called 'bebout'. The local name is related to the manual shelling of the seeds, due to their hard coat. Two cultivars, recognizable by the fruit shape (blocky or round), were collected. Fruit and seed shape and size are reported to be highly variable in *Lagenaria* (Bisognin, 2002). In our case, seeds from the round-fruited cultivar are characterized by the presence of a cap on the distal side (Figure 5). With regard to seed size and 100-seed weight, significant differences were observed between the two cultivars (Table 1).

Cropping systems and main constraints to production

The first conducted surveys in the country covered about 100 farms distributed in the three regions (centre, east and south). Traditional cucurbit species consumed in sauce in Ivory Coast are mainly grown by women as minor crop in association with major food, spice or perennial commercial crops. The most common associated plants are in the south: eggplant, pepper and okra, in the east and the centre: cassava, yam, maize, vegetables (eggplant, tomato and pepper), cotton and acajou. Nevertheless, in the centre site *C. lanatus* var. *citroides* is sometimes cultivated as major crop in monoculture. The contribution of women to plant biodiversity management and conservation is common in developing countries (Hoddel *et al.*, 1999; Howard, 2003). In many cases it has been demonstrated that they are farmers and plant breeders, particularly of indigenous crops.

In the selected sites, overall, areas cultivated with indigenous cucurbit species are small in size (0.25-0.50ha), depending on needs, work tasks, and capacities of the women, as well as on their relative independence in the households. In the surveyed sites, men are in fact the dominant decision-makers concerning selection of land and crop. In the choice of crops, preference is usually given, in decreasing order, to: local perennial plants with economic potential or value (coffee, cacao, acajou, etc., according to the site), food staple crops and crops cultivated by women. Therefore, despite their economic and cultural importance, the edible-seeded cucurbits which are under the women's responsibility are often neglected. The second problem related to the cultivation of these plants is the lack of adapted reliable cropping practices allowing stable and sufficient production. This problem concerns particularly sowing date and density, weeding schedule, and fertilization.

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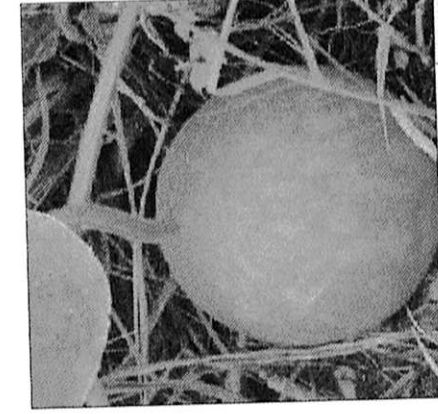
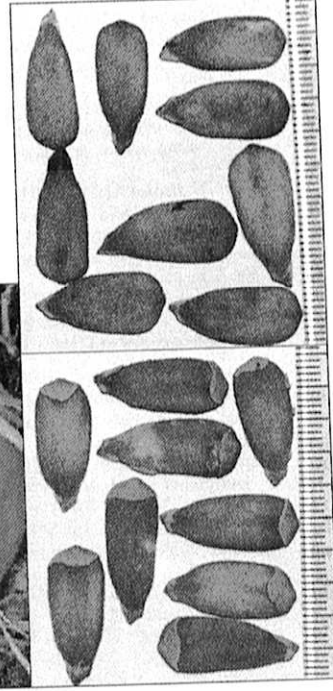


Figure 5. Fruit and seeds of *Lagenaria siceraria*. Bottom row, left to right: seed of the round-fruited cultivar, seed of the blocky-fruited cultivar.



Conclusion

This study highlighted the occurrence, in Ivory Coast, of five species of cucurbit incorrectly called 'pistachio' in cities and cultivated on a small scale by women for their oleaginous seeds that represent a great importance in the socio-cultural life of several peoples. Production and uses of the recorded species are mainly carried out by rural women, making these underexploited crops capital resources for women economic prosperity. The intraspecies diversity was however limited to 2 to 4 varieties. This small number of variety seemed to be the product of two main factors: a relatively limited farmers' knowledge about varietal diversity and a selection process oriented towards the most common cultivars, based on the needs and goals of the household.

In order to valorise the cucurbits biodiversity in Ivory Coast, priorities are given to the following investigations:

- Identification of diversity sites to collect new germplasm covering the whole agro-ecological situation of the country;
- Genetic organization at inter- and intraspecies levels, using both morphological and molecular descriptors;
- Study of reproductive biology, with in-depth examination on forms of sex expression, flowering sequences, seed physiology and viability;
- Identification of major biotic and abiotic constraints and improvement of crop husbandry in both sole and multiple cropping systems.

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