

Full Length Research Paper

Agronomic evaluation and quality characteristics of three *Cucurbitaceae* varieties acclimated in Benin

Adam Salifou¹, Cherif Alidou¹, Fidèle P. Tchobo¹, Bruno Barea² and Mohamed M. Soumanou^{1*}

¹Unité de Recherche en Génie Enzymatique et Alimentaire, Laboratoire d'Etude et de Recherche en Chimie Appliquée, Ecole Polytechnique d'Abomey-Calavi, Université d'Abomey-calavi, 01 BP 2009, Cotonou, Bénin.

²CIRAD, UMR Ingénierie des Agro-polymères et Technologies Emergentes, Campus Supagro/INRA, Montpellier, France.

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The present study aimed to evaluate some agronomical, physical and nutritional characteristics of seeds of three species of Cucurbitaceous, namely *Citrullus lanatus*, *Lagenaria siceraria* and *Cucumeropsis edulis*. Agronomic experiments were investigated over a two-year period during which, some agronomic performances of the tested varieties were evaluated. The physical characteristics of the collected fruits were also determined. The nutritional composition of the seeds, in particular their moisture, oils and proteins contents were then evaluated. Finally, the physicochemical characteristics, such as acidity, peroxide index, saponification index and the composition of fatty acids present in the oils extracted from seeds were performed. Results show that the species of *C. lanatus* and *L. siceraria* germinated respectively five and seven days after sowing. The flowering was observed 36 and 42 days, respectively, after sowing while the fructification appeared 44 and 58 days after sowing. According to results obtained during the two years of experimentation, the three species of *Cucurbitaceous* investigated in the present study could be ranged in short-cycle species (*C. lanatus* and *L. siceraria*) and long cycle species (*C. edulis*). Moreover, *C. lanatus* could be classified as the most productive as compared to others species of Cucurbitaceous plants investigated in the present study. *C. edulis* seeds are the longest (1.76 and 1.83 cm) in opposition to the seeds from *C. lanatus* (1.33 and 1.49 cm). Results of physicochemical analyses revealed the presence of fat (49.5 - 51.9%), with a high protein contents (18.46 - 31.41%). The composition of the fatty acids detected in oils extracted from seeds showed a strong concentration of linoleic acid (66.65%) and the presence of oleic acid (13.76%). The high unsaturated fatty acids proportion detected in oils from *L. siceraria* seeds was 80.40%. The saturated fatty acids detected were C16:0 and C18:0; and were more concentrated in the species of *C. lanatus*.

Key words: *Cucurbitaceous*, *Citrullus lanatus*, *Lagenaria siceraria*, *Cucumeropsis edulis*, oil, seeds, Benin.

INTRODUCTION

In developing countries, the exploitation of local plant resources is certainly a way to achieve food security, especially in countries with a high demographic growth (Sabo, 2014). However, it requires the preservation and

availability of a high level of genetic diversity of these resources. Among these vegetal resources, Cucurbitaceous have an important place in the various uses of plant resources. *Citrullus lanatus*, *Lagenaria*

siceraria and *Cucumeropsis edulis* were cultivated for their high content in oils and proteins in West Africa (Levi et al., 2001; Zoro Bi et al., 2003; Schippers, 2004). In Benin, these three species are also widely grown by farmers (Vodouhe et al., 2001). However, little research was focused on the characterization of Cucurbitaceous for their valorization. Previously, studies reported a high content of trace elements with at least 45% of oil content in Cucurbitaceous plants (Vodounhe et al., 2008). They are also rich in polyunsaturated fatty acids which are known to be essential for human health (Schippers, 2004).

All parts of the plant are used in food production or in folk medicine. Indeed, in rural areas, more than 80% of the populations depend on food mainly based on cereals. The animal protein consumption is exceptional because the best proteins are those of animal origin (egg, milk, meat and fish). However, these animal products are expensive and very often exceed the financial capacities of the populations. Therefore, for nutritional safety of the populations, the introduction of vegetal proteins into the food chain appeared suitable. Based on this, it is very important to inquire vegetal with good sources of proteins which can improve the nutritional value of food accessible by the low income populations. In order to achieve this objective, the present study was interested in seeds of some Cucurbitaceous such as *C. lanatus*, *L. siceraria* and *C. edulis*. Although, several studies were carried out on their pharmacological potential (Prajapati et al., 2010) and the various rough levels of nutriment (Nmila et al., 2002; Sabo et al., 2005a, b; Sadou et al., 2007; Ullah et al., 2012), very few works were focused on the biochemical composition of these seeds (Abiodun and Adeleke, 2010). In Benin, previous researches were focused on the agronomic evaluation of some species of Cucurbitaceous used in the foodstuff in Benin (Achigan Dako et al., 2006) in order to develop a model of prediction. Then, the present study aimed to improve scientific knowledge on some species of Cucurbitaceous (*C. lanatus*, *L. siceraria* and *C. edulis*) through the identification of some agronomic aspects during two years of experimentation and evaluated the physical properties of seeds and physicochemical characteristics of oils extracted from these seeds for their industrial valorization.

MATERIALS AND METHODS

Collection of seeds for farming practices

Seeds of *Cucurbitaceae*, namely, *C. edulis*, *L. siceraria*, *C. lanatus*

used for farming practices were previously collected at Abomey-calavi (south Benin) and were identified at the national herbarium, where voucher specimens are deposited. These species were chosen, because they were the three important species of *Cucurbitaceae* mostly cultivated in Benin (Vodouhe et al., 2008).

Sites and experimentation

The sites used for agricultural experimentation were located at Polytechnic School of Abomey-Calavi's University (Benin). Growing experimentations were conducted during the first year from June 2013 to January 2014 and in the second year from April to December 2014.

During growing, some agronomical parameters, such as durations of germination, flowering and fructification, as well as the number of fruits per seedling were evaluated. The seeds obtained were then collected and kept in dry place for analysis.

Determination of the durations of germination flowering and fructification

The duration of germination is evaluated starting from the date of sowing to the period of appearance of the cotyledons above the ground. The duration of flowering is calculated, starting from the date of sowing to the period of appearance of the first floral button. The duration of fructification corresponded to the time which separated the sowing date and the appearance of the first fruits.

Determination of the shape of seeds

The length and the breath of 10 seeds were measured per species, using a slide caliper. Then, the shape index calculated as the ratio breath/length was determined for each seed in order to appreciate their forms (Cowan and Smith, 1993). This ratio expresses the degree of circularity of seed. It is equal to the unit for seeds round and close to zero for lengthened seeds (Cowan and Smith, 1993). In addition, three forms according to the value obtained from the relationship between width (l) and the length (L) were observed (Cowan and Smith, 1993): $l/L = 1$ (seeds are round); $l/L > 1$ (seeds are broad); $l/L < 1$ (seeds are lengthened). At the complete maturation of the fruits, the mass of the fruits, the average number of seeds per fruit, the mass of seeds, the ratio masses/average of seeds, the mass of 100 peeled seeds and unpeeled seeds, and the ratio almonds report/seeds were determined.

Chemical and biochemical analyses

Moisture content of samples was determined by desiccation using the method of De Knecht and Brink (1998). Protein was analyzed by the Microkjedhal nitrogen method, using a conversion factor of 6.25 and fat content was obtained by Soxhlet extraction. Ash was determined according to the standard methods described by the Association of Official Analytical Chemists (AOAC, 1990). Acidity of extracted oils was determined by titration with 0.01 mol/L of sodium hydroxide solution, using phenolphthalein as indicator

*Corresponding author. Email: msoumanoufr@yahoo.fr, mohamed.soumanou@epac.uac.bj.

Table 1. Agronomic characteristic of three species of *Cucurbitaceae* cultivated.

Species	Germination duration (days)		Flowering date (days)		Fructification date (days)		Number of fruits per plant	
	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year
<i>Citrulus lanatus</i>	5.01±1.38 ^a	5.09±1.17 ^a	36.32±0.24 ^a	35.74±0.64 ^a	45.26±6.18 ^a	44.31±5.58 ^a	08.02±0.04 ^a	08.23±0.01 ^a
<i>Lagenaria siceraria</i>	7.14±0.88 ^a	7.11±0.18 ^a	42.23±0.54 ^a	42.18±0.23 ^a	58.04±9.21 ^b	58.10±8.81 ^b	06.08±0.15 ^a	06.06±0.10 ^a
<i>Cucumeropsis edulus</i>	10.76±0.44 ^b	10.54±0.34 ^b	81.23±0.54 ^b	46.23±0.54 ^a	-	68.22±4.17 ^c	-	02±0.07 ^b

Values are means. The means followed by same letter in the same column are not significantly different according to ANOVA and Tukey's multiple comparison tests.

(AOAC, 1990). Peroxide and saponification indexes of extracted oils, were performed as described respectively by NF T 60-220 (1993) and NF ISO 3657 (1993). The composition in fatty acids of the oil extracted from seeds of three investigated Cucurbitaceous species are performed as follows: the methyl esters of the oil samples were prepared by transesterification with sodium methylate of sodium according to NF standard T60-233 (1995), and then analyzed using an Agilent series 6890 chromatograph equipped with a capillary column Supelcowax 10. The temperatures of the detector and the injector were respectively 250 and 270°C and the oven was programmed from 150 to 225°C with a gradient of 5°C/min. The carrier gas is helium with a flow rate of 1 ml/minute. The identification of methyl esters was done by comparison of retention time with the methyl esters of standard previously analyzed.

Statistical analysis

Experiments were performed in triplicate, and data analyzed were mean subjected to one-way ANOVA. Means were separated by the Turkey's multiple range tests when ANOVA was significant ($p < 0.05$) (SPSS 10.0; Chicago, IL, USA).

RESULTS AND DISCUSSION

Agronomic characteristic of cultivated species

To provide samples for agronomic and physicochemical characteristics, a two-year seeds

production of three Cucurbitaceae species was experimented. As listed in Table 1, results related to the determination of germination, flowering, fructification duration, as well as those relating to the number of fruits per plant was reported. Statistical analysis indicated that, the duration of germination as well as the time of flowering of the species such as *C. lanatus* and *L. siceraria*, were not significantly different ($p < 0.05$) during the first and the second year of the experimentation. Indeed, the germination of seeds was observed, respectively at the fifth and the seventh days after sowing, and their flowering periods respectively took place thirty-six and forty-two days after sowing. In addition, there are significant differences between results obtained with *C. edulus* which has a germination and flowering periods of eleven (11) and eighty-one (81) days respectively, as compared to those of *C. lanatus* and *L. siceraria* during the first year. However, during the second year of the experimentation, the difference was not statistically significantly ($p < 0.05$). Based on the fructification duration, the obtained results indicated a significant difference between investigated species, with an average period of forty four (44), fifty eight (58) and sixty eight (68) days after sowing, respectively for *C. lanatus*, *L. siceraria* and *C. edulus*. The number of fruits is also statistically different with an average of two

(02), six (06) and eight (08) fruits per plant, respectively for *C. edulus*, *L. siceraria* and *C. lanatus*. According to the results listed above during the two years of experimentation, the three species of Cucurbitaceous investigated in the present study, could range in short-cycle species (*C. lanatus*, *L. siceraria*) and long cycle species (*C. edulus*). Moreover, *C. lanatus* could be classified as the most productive as compared to other species of Cucurbitaceous plants investigated in the present study. In the work of Sabo (2014), which described Cucurbitaceous plant from Niger, *L. siceraria* was reported as lower productive species and an average of 3-10 berries was found in the first year.

Physical characteristic and results of proximate analysis

Cucurbitaceae are among the most important plant families supplying humans with edible products. The study of physicochemical characteristics of the seeds of these plants is of great interest. As observed, the tested species have diversity of fruit shape (Table 2). According to these results, seeds length of *C. edulus* ranged from 1.76 to 1.83 cm. It then represents the species with longest seeds length, as compared to other species investigated in the study. The shortest one was collected from

Table 2. Characteristics of the three tested species of *Cucurbitaceae* seeds.

Species	Length of seeds (cm)		Width of seeds (cm)		Width/Length	
	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year
<i>Citrulus lanatus</i>	1.33±0.06 ^a	1.49±0.03 ^a	0.76±0.04 ^a	0.81±0.04 ^a	0.57±0.07	0.54±0.05
<i>Lagenaria siceraria</i>	1.63±0.09 ^b	1.56±0.09 ^a	0.64±0.17 ^b	0.62±0.07 ^b	0.49±0.06	0.39±0.01
<i>Cucumeropsis edulus</i>	1.76±0.99 ^b	1.83±0.11 ^b	0.53±0.06 ^c	0.57±0.02 ^b	0.30±0.08	0.31±0.05

Values are means. The means followed by same letter in the same column are not significantly different according to ANOVA and Tukey's multiple comparison tests.

Table 3. Physical composition of the produced fruits of three species of *Cucurbitaceae* tested.

Species	Weight of the fruits (kg)		Numbers of seeds by fruit		Weight of seeds by fruit (g)		Ratio of weight of seeds to weight of the fruits	
	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year
<i>Citrulus lanatus</i>	0.80±0.39 ^a	0.80±0.91 ^a	160.79±27.80 ^a	189.21±15.72 ^a	32.42±1.69 ^a	36.78±1.64 ^a	0.04	0.04
<i>Lagenaria siceraria</i>	0.99±0.17 ^a	1.08±0.27 ^b	186.46±23.82 ^b	196.35±15.32 ^a	36.58±1.18 ^a	39.77±3.11 ^b	0.03	0.03
<i>Cucumeropsis edulus</i>	-	1.55±0.09 ^c	-	420.91±17.24 ^b	-	60.43±1.27 ^c	-	0.03

Values are means. The means followed by same letter in the same column are not significantly different according to ANOVA and Tukey's multiple comparison tests.

C. lanatus (1.33 - 1.49 cm respectively in first and the second year). The shape index (ratio width/length) obtained, indicated that the whole of produced seeds were lengthened forms (ratio lower than 1). These results are similar to those of Sabo et al. (2014) on species of *C. colocynthis* and *L. siceraria* used for food in Niger. The physical characteristics of the produced fruits are given in Table 3. A significant difference can be observed during the second year between the three cultivated species. However, statistical difference ($p < 0.05$) was observed during the first year of production. In addition, there was proportionality between the numbers of seeds by fruit and the masses of the fruits. Statistical analyses revealed a significant difference between the investigated

species when compared the mass of 100 of unpeeled fruits (Table 4).

However, when the fruits were peeled a difference between the various species was observed. The ratio of masses of almond to the mass of seeds varied from 65 to 77% during the first year while it however varied from 66 to 78% during the second year. Heaviest seeds were those of *C. edulus* while the least heavy are those of the species *C. lanatus*. On the other hand, results of proximate analyses of seeds are presented in Table 5. The moisture content varied from 6.31 to 9.24% and the ash content ranged from 4.46 and 4.65%. Statistical analysis indicated that there are no difference in moisture and fat contents of seeds from *C. lanatus* and *C.*

edulus. However, there are significant differences in protein contents in seeds from Cucurbitaceous species ($p=0.05$). The highest protein content is observed in the seeds of *C. edulus*. This protein content is similar to those reported for important vegetal which contain, in general, 7.8 to 22.8 g/100 g (Bullock et al., 1989) but is higher than those reported in locust bean pulp (Dahouenon-Ahoussi et al., 2012). This high protein content could be lead to classified *C. edulus* in the group of vegetal in which valorization could be contributed to overcome the nutritional problems. Indeed, according to Umaru et al. (2007), edible wild indigenous plants are an alternative source of food with high potential of proteins and other interesting elements, particularly during seasonal

Table 4. Weight of 100 seeds (g) of three tested species of *Cucurbitaceae*.

Species	Weight of 100 not peeled seeds		Weight of 100 peeled seeds		Weight of 100 hulls		Ratio of Almonds/seeds (%)	
	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year
<i>Citrulus lanatus</i>	14.65±0.70 ^a	15.10±0.40 ^a	9.58±0.61 ^a	9.99±0.34 ^a	5.07±0.02 ^a	5.11±0.03 ^a	65±0.01 ^a	66±0.00 ^a
<i>Lagenaria siceraria</i>	16.15±0.04 ^b	16.50±0.07 ^b	11.65±0.06 ^a	11.86±0.23 ^b	4.50 ±0.01 ^a	4.64 ±0.05 ^a	72±0.00 ^b	71±0.08 ^b
<i>Cucumeropsis edulus</i>	16.63±0.13 ^b	16.68±0.04 ^b	12.81±0.12 ^b	13.03±0.03 ^c	3.65±0.05 ^b	77±0.00 ^b	77±0.00 ^b	78±0.01 ^c

Values are means. The means followed by same letter in the same column are not significantly different according to ANOVA and Tukey's multiple comparison tests.

Table 5. Complete proximate analysis of seeds of three species of *Cucurbitaceae* tested.

Variety	Water (%)		Ash (%)		Oil (%)		Protein (%)		Total sugar (%)	
	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year	1 st Year	2 nd Year
<i>Citrulus lanatus</i>	9.14±0.22 ^a	9.04±0.19 ^a	4.57±0.11 ^a	4.65±0.22 ^a	49.78±0.81 ^a	49.87±0.69 ^a	18.46±1.98 ^a	19.64±0.4 ^a	4.42±0.06 ^a	4.41±0.04 ^a
<i>Lagenaria siceraria</i>	6.32±0.30 ^b	6.31±0.76 ^b	4.46±0.08 ^a	4.48±0.07 ^a	52.15±0.71 ^b	51.90±0.91 ^b	27.42±0.96 ^b	27.79±0.82 ^b	7.66±0.04 ^b	7.68±0.90 ^b
<i>Cucumeropsisedulus</i>	9.23±0.23 ^a	9.24±0.17 ^a	4.72±0.26 ^a	4.68±0.29 ^a	49.53±1.93 ^a	49.51±1.86 ^a	31.41±0.69 ^c	31.27±0.54 ^c	4.12±0.66 ^a	4.09±0.57 ^a

Values are means. The means followed by same letter in the same column are not significantly different according to ANOVA and Tukey's multiple comparison tests.

Table 6. Composition of fatty acids of the oil of three species of *Cucurbitaceae* tested.

Variety	C16 :0		C18 :0		C18 :1		C18 :2	
	1 st Year	2 nd Year						
<i>Citrulus lanatus</i>	15.1	14.97	13.80	13.81	17.1	16.99	54.1	54.23
<i>Lagenaria siceraria</i>	13.2	13.21	6.4	6.4	13.76	13.74	66.64	66.65
<i>Cucumeropsis edulus</i>	11.2	11.21	10.4	10.39	19.89	19.89	58.1	58.11

food shortage.

Characteristics of extracted oils

Besides protein content of *Cucurbitacea* plants, some species showed potential uses as edible oils. In the present work, fatty acid composition of

oils extracted from harvested seeds was investigated. As listed in Table 6, palmitic, oleic, stearic and linoleic acids were the fatty acids detected in all the recovered oils. There are more unsaturated fatty acids than saturated acids in the analyzed oils. Moreover, linolenic acid was in high concentration in all the oils. The high unsaturated oils described above from fatty acid composition were confirmed by the high iodine values

presented in Table 7. Besides fatty acid composition of the oil seeds, biological active part of oils such as unsaponifiable matter was also extracted and determined (Table 7). Highest amount of unsaponifiable fraction was found in oil extracted from *C. lanatus* seeds. The characteristics of analyzed oils were similar to common edible oils and those reported by Kapseu (1993).

Table 7. Quality parameters of the oil of various varieties of *Cucurbitaceous*.

Variety	Iodine value (g I ₂ /100g)		Unsaponifiable (%)	
	1 st Year	2 nd Year	1 st Year	2 nd Year
<i>Citrullus lanatus</i>	242.39±4.58 ^a	238.47±5.24 ^a	1.61±0.13 ^a	1.58±0.23 ^a
<i>Lagenaria siceraria</i>	183.76±6.23 ^b	188.63±7.03 ^b	0.59±0.18 ^b	0.62±0.06 ^b
<i>Cucumeropsis edulus</i>	202.79±4.6 ^c	201.97±5.15 ^c	0.96±0.21 ^c	0.95±0.61 ^c

Values are means. The means followed by same letter in the same column are not significantly different according to ANOVA and Tukey's multiple comparison tests.

Conclusion

The present work contributes to knowledge on seeds of three varieties of *Cucurbitaceae* for agronomic and technological improvements. *C. lanatus* and *L. siceraria* show good agronomic performances. All cucurbitaceous seeds investigated were also rich in oil and protein. These potentials of cucurbitaceous seeds investigated, could be taken into account in the traditional plants development programs

Conflict of Interests

The authors have not declared any conflict of interests.

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