International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 3, No. 6, p. 7-12, 2013

INNSPUB

RESEARCH PAPER OPEN ACCESS

Analysing fruit shape in safou (*Dacryodes edulis*) fruit by using aspect ratio

Alain Serges Ondo-Azi[1*], Crépin Ella Missang[1,2], Pamphile Nguema N[1], Thomas Silou[3]

[1]*Institut National Supérieur d'Agronomie et de Biotechnologies, Université des Sciences et Techniques de Masuku, BP : 941, Masuku Franceville, Gabon*

[2]*Institut de Recherche Technologique, CENAREST, B.P. 14.070, Libreville, Gabon*

[3]*Pôle d'Excellence Régional AUF, Equipe Pluridisciplinaire de Recherche en Alimentation et Nutrition B.P.: 389, Brazzaville, Congo*

Article published on June 21, 2013

Key words: *Dacryodes edulis*, fruits characteristics, aspect ratio, shape.

Abstract

Fruit shape is one of the most important quality criteria for evaluation by customer preference. Aspect ratio (A.R.) was used as physical parameter to perform the choice of ratios for fruits shape determination. This study proposes a relationship between fruit shape and morphological parameters in bush butter fruits (*Dacryodes edulis*) collected on 35 bush butter trees. The results show that bush butter fruits present some shapes. To describe fruit shapes the use of morphological characteristics is possible. So, the unique parameter used in our study was A.R., width over length. All of 35 trees analyzed were regrouped in three types; those types were assimilated at shapes in bush butter fruit designated by elliptical, spheroidal and obovate shape. On fruit shapes, the analysis of variance shows that the mean values of aspect ratio are significantly different shape as shape. So, it indicates great distinction in the three fruit shapes presented. The distance calculus proposes also a bush butter categorization model based on A.R. A model to describe fruits source of the new trees is proposed.

* **Corresponding Author:** Alain Serges Ondo-Azi ✉ ondoazi@gmail.com

Introduction

Fruit shape shows a considerable variation in wild and domestic trees as reported under polygenic control (Nunome et al., 2001). It is generally measured subjectively by comparison with silhouettes of standard cultivars and objectively using ratios (Thibeault *et al.,* 1983). Some authors have measured several parameters to give a more accurate comparison of shape (Heijden & Vossepoel, 1994). However, the use of ratios allows a direct comparison of shape between fruits of different size. On bush butter fruits, the characterization of fruits shows some considerable variation on morphological traits (Anegbeh *et al.,* 2004, Ondo-Azi *et al.,* 2009) and fruit shape. Regarding fruit shape, Laroussilhe et al. (1964) described four (4) types of bush butter fruits harvest in Congo and Ivory Coast. According to Kengue (1990) and Ladipo *et al.* (2002), bush butter fruits given ten (10) and seven (7) shapes, respectively. Ekeke *et al.* (2006) presented six (6) types. In fact, Youmbi *et al.* (2010) described four (4) fruit shapes in *D. edulis*: extended, oval, globular and conical. However, none of these studies was expressed use of ratios to fruit shape's description as described on other fruits. In fact, several ratios were used to describe fruit shape; such as length to width or length to diameter. Generally, fruit shape showed that bush butter fruits are in majority elliptical or spherical. Moreover, to describe morphological parameters of bush butter, Omoti and Okiy (1987) and Kapseu *et al.* (1998) used length and circumference or diameter have some others fruits. For practical reasons, Silou et al. (2000) kept length and width. This second approach is current by used in bush butter fruits characterization. Also, by using this last approach, Kama-Niamayoua (2006) and Ondo-Azi *et al.* (2009) announced that it is necessary to use the ratio of width to length. These last authors showed that this ratio varied from 0.3 to 0.9 and it is generally greeter than one and appears to be variable. For these reasons length and width can be used to analyze bush butter shape.

The aims of the present study were thus to describe bush butter shape by subjective and applied statistical tools to justify the use of aspect ratio in fruit shape determination and to predict shape for new safou fruits.

Materials and methods

Sampling of bush butter

Thirty five (35) bush butter trees were selected from Franceville (Southwest Gabon); they were selected in whole of the city. Fresh bush butter fruits were collected on the tree from each direction (north, south, east and west) and transported in netted sacks to the laboratory. Fruits were stored to discard damaged and twenty fruits per tree were collected.

Classification of the fruit

Fruits were observed and classified according to their similarities in different groups appointed types. Each fruit was observed and the tree was classified.

Morphological sizes

For each fruit, length and width were measured by using callipers graduated (least count 1mm), as previously defined (Silou *et al.,* 2000).

Aspect ratio

Ratio was calculated by using the following formula:
Aspect Ratio = Width/Length (W/L).

Statistical analysis

Data were analyzed using Microsoft Excel to determine mean and standard deviation. Aspect ratio was calculated and data were analyzed to determine its relationship with fruit shape. The different ratios in several types were subjected to an analysis of variance (ANOVA) to separate the types' means. Treatment means were separated using least significance difference (LSD) at 5% level of probability. For all statistical analyses, xls.stat 2007 software was used.

After ANOVA analyses, new observations were assigned to classes by using distance's calculation which gave values by using the following formula:

$D_n = |R- \overline{X}_n|$

Where n is the type (shape) of fruit, D represents the distance. R is the aspect ratio (Width/Length) of new observation and $\overline{X}$ the mean calculated for each fruit type.

Results and discussion

Morphological characteristics and fruit classifications

Table 1 shows the morphological characteristics of thirty five (35) samples studied. It presents length and width of the fruit arithmetic mean, standard deviation (SD) and ratio W/L. The means correspond to twenty (20) fruits per tree.

Table 1. Characteristics of several cultivars.

Cultivar	Length*	Width*	Ratio	Type
	——————cm——————			
1	6.24 (0.33)	3.54 (0.23)	0.57	2
2	5.31 (0.22)	3.41 (0.11)	0.64	1
3	7.81 (0.29)	4.56 (0.15)	0.58	2
4	5.12 (0.21)	2.76 (0.16)	0.54	1
5	6.07 (0.27)	3.93 (0.29)	0.65	2
6	7.53 (0.33)	3.61 (0.28)	0.48	1
7	7.14 (0.34)	3.40 (0.13)	0.48	1
8	5.63 (0.40)	3.07 (0.16)	0.55	2
9	5.58 (0.22)	3.86 (0.12)	0.69	2
10	7.26 (0.30)	4.57 (0.22)	0.63	3
11	5.71 (0.41)	3.90 (0.19)	0.68	2
12	5.40 (0.40)	3.51 (0.20)	0.65	2
13	6.79 (0.17)	3.74 (0.15)	0.55	1
14	7.23 (0.26)	3.64 (0.20)	0.50	1
15	7.96 (0.52)	4.39 (0.25)	0.55	2
16	6.03 (0.38)	3.67 (0.14)	0.61	2
17	5.00 (0.35)	2.89 (0.11)	0.58	1
18	5.59 (0.22)	3.77 (0.24)	0.67	3
19	6.03 (0.19)	3.27 (0.12)	0.54	1
20	6.77 (0.29)	3.48 (0.16)	0.51	1
21	5.31 (0.23)	3.29 (0.09)	0.62	2
22	7.14 (0.47)	3.42 (0.23)	0.48	1
23	5.24 (0.86)	3.54 (0.23)	0.68	3
24	6.20 (0.34)	2.82 (0.24)	0.45	1
25	3.91 (0.52)	2.99 (0.25)	0.76	3
26	6.77 (0.36)	4.42 (0.28)	0.63	3
27	5.74 (0.64)	3.21 (0.33)	0.56	1
28	7.15 (0.33)	3.85 (0.38)	0.54	2
29	4.55 (0.64)	3.34 (0.29)	0.73	3
30	6.53 (0.26)	3.38 (0.13)	0.52	1
31	7.34 (0.33)	3.22 (0.14)	0.44	1
32	5.29 (0.11)	2.84 (0.09)	0.54	1
33	6.31 (0.91)	2.97 (0.13)	0.47	1
34	5.57 (0.38)	3.24 (0.11)	0.58	2
35	4.80 (0.19)	2.95 (0.10)	0.62	1

*Numbers in parentheses are standard deviations of the means.

The fruit length and width varied considerably. The length mean was 6.12 cm, this parameter ranged from 3.92 to 7.96 cm and width from 2.76 to 4.57 cm. Both the upper and lower limit values of the range of all characteristics observed in the present study are comparable to those reported in bush butter areas (Silou *et al.,* 2002, Anegbeh *et al.,* 2004, Ondo-Azi *et al.,* 2009).

Table 2. Statistic description of length and width of the 500 fruits.

	Length	Width
	———cm———	
Arithmetic mean	6.12	3.49
Variance	0.97	0.22
Median	6.03	3.42
Standard deviation	0.99	0.47
Minimum	3.91	2.76
Maximum	7.96	4.57

According to these authors, in Congo, the fruit length varies between 5.9 and 6.7 cm and width from 3.5 to 4.7 cm. In Cameroon, the variations observed were considerable: length ranging from 5.7 to 7.5 cm and width from 3.1 to 3.9 cm.

In Gabon, in the same region, fruit length ranges from 3.3 to 11.1 cm and width from 2.5 to 5 cm. For these parameters, the fruits described in this study are small compared to those from Gabon, Congo or Cameroon. But they are larger than those studied in

south east of Nigeria with the fruit length of 5.3 cm, width of 2.9 cm and thickness of 0.4 cm.

From these data it can be observed that all parameters vary considerably. Some descriptive statistical parameters of the fruit samples are given in Table 2.

Table 3. Shape's frequency.

Shape	Population	Percentage (%)
Type 1	17	48.6
Type 2	12	34.3
Type 3	6	17.1
Total	35	100

Table 4. Aspect ratio for each fruit shape.

Fruit shape	Mean	Variation
Ellipsoidal (Type 1)	0.52[a]	0.44-0.64
Obovate (Type 2)	0.60[b]	0.48-0.69
Spheroidal (Type 3)	0.68[c]	0.63-0.76

According to Kengue (1990), ten fruit shapes in bush butter were described, named A to J respectively. For our study, fruits picked from 35 bush butter trees were classified by using shape drawed up. Amount these cultivars were in order Type 1 (48.6%) > Type 2 (34.3%) > Type 3 (17.1%) (Table 3).

Normally, the repartition doesn't consider shoulderings or apical shapes. It does only take into account the typology of fruits. It's true that ratio of fruit is genetically controlled (Chaim et al., 2003) but can be described by using morphological characters and aspect ratio precisely. In bush butter fruit, Ekeke et al. (2006) present six (6) fruit shapes according to length and width (Mean-Small, Large-Small, Small-Small, Mean-Big, Large-Big and Small-Big).

To consider fruit dimensions in bush butter description, it's important to research relationship between the three types and an aspect ratio.

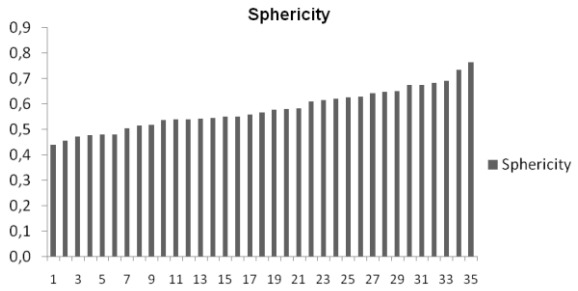

Fig. 1. Continue variation of aspect ratio.

Ratio (weight/length)

The ratio (W/L) ranged from 0.44 to 0.76, with a mean of 0.58 (Table 4). This index has been used to describe proprieties of mango (Jha et al., 2006). These authors show that the ratio varied between 0.67 and 0.7 for mango, so it's seems. For bush butter fruit, the ratio varies a lot (Figure 1). The results show that in Franceville bush butter fruits had some types. Kama-Niamayoua (2006) reported that when aspect ratio is near to 1, fruits have globulous or spheroidal shape; and tapering shape at 0.5 of aspect ratio. Table 4 presents the variation of aspect ratio according to fruit type. This table 4 shows that for Elliptical fruits (Type 1), the aspect ratio varied between 0.44 and 0.64. The mean of this ratio is 0.52. For obovate fruits (Type 2), ratio ranged to 0.48 at 0.69 with 0.60 as mean. Type 3 (spheroidal) presented an aspect ratio ranging between 0.63 and 0.76 with 0.68 as mean. Data show overlaps between parameters; in contrary, mean values of aspect ratio were statistically distinct.

The observation of aspect ratio of three types shows an increasing ratio from type 1 (0.52) to type 3 (0.68). Generally, figure 1 shows that this parameter presents a continuous evolution.

The use of the value presents the general shape. It's important to emphasize the limitation of each fruit shape.

Table 4 presents the aspect ratio of any of these three fruits types. It shows that:

- Ellipsoidal shape is characterized by a ratio = 0.52. This class has 17 trees;
- Obovate shape is characterized by a ratio = 0.60. This class is a clump of 12 trees.
- Spheroidal shape is characterized by a ratio = 0.68. This class is a clump of 6 trees.

The use of the ratio gives the standardization model. The model flows to some calculi described in the board. So, the equation gives the standard model which facilitates bush butter classification using of only the aspect ratio. That why we use the distance calculation between fruit shapes.

The distance calculus is described in the equation. The tree shape is both have the one which have the low distance as make in our shape defined.

Statistical model

Distance calculated using the below equation give the indication on the fruits shape. These calculation use only the ratio of the fruit as reported below:

Elliptical: $D_1 = |R-0.52|$;

Obovate: $D_2 = |R-0.60|$;

Spheroidal: $D_3 = |R-0.68|$.

where R represents the ratio of the new fruits. The lowest distance gives the class of bush better tree. Then, all bush butter trees in Franceville can be easily classified using this model. Moreover, some investigations on bush butter morphological characteristics in many production zones including Cameroon, Congo, Congo Kinshasa and Nigeria showed some similarities with bush butter from Franceville (Okafor, 1983, Youmbi et al., 1989, Kapseu et al., 1998, Silou et al., 2000). Accordingly, this model can be used to describe bush butter shapes from these other countries.

Also, the descriptive statistics on 35 trees studied at Franceville (Gabon) show that the traits are meanly similar with the others in Cameroon, Congo, Democratic Republic of Congo and Nigeria. The results lead to one idea, the model obtained can be used to characterize bush butter in some areas, because bush butter fruits present some similarities in some production areas. The treatment can be improved in the future by undertaking this study in the others bush butter production areas.

Conclusions

This study has highlighted that fruit ratio (width over length) affects directly fruit shape. The ratio used has presented continuous variation for the 35 bush butter trees analyzed. The subjective classification has given three bush butter types. The analysis of ratio in fruit types showed a statistical significant difference. The calculation of correlation ratio for the three fruit types has given a correlation ratio of 0.99 (near to 1). This result shows that the parameter ratio is a good character to describe bush butter type. According to ratio values and subjective analysis, fruit types were assimilated to fruit shapes called elliptical, obovate and spheroid currently used in fruit shape determination. The study has given a model necessary to classify new bush butter trees.

Acknowledgements

This work was supported by the "Agence Universitaire de la Francophonie (AUF)" and Agrifood process engineering (GP3A) network.

References

Anegbeh PO, Ukafor V, Usoro C, Tchoundjeu Z, Leakey RRB, Schreckenberg K. 2004. Domestication of *Dacryodes edulis*: 1. Phenotypic variation of fruit traits from 100 trees in southeast Nigeria. New Forests **29**,149-160.

Chaim BA, Borowsky Y, Rao GU, Tanyolac B, and Paran I. 2003. fs3.1: a major fruit shape QTL conserved in *Capsium*. Genome **46**, 1-9.

Ekeke BA, Oyebade BA, Adesina M. 2006. Germination and seedling growth as influence by seed of *Dacryodes edulis* (G.Don) H.J. Lam in Nigeria. European Journal of Scientific Research **15 (3)**, 336-343.

Heijden GW, van der Vossepoel AM. 1994. On defining length and width for botanical object discrimination. Aspects of visual form processing, 562-573.

Jha SN, Kingsly ARP, Sangeeta Chopra. 2006. Physical and mechanical proprieties of mango during growth and storage for determination of maturity. Journal of Food Engineering **72**, 73-76.

Kama-Niamayoua R. 2006. Valorisation alimentaire du safou (*Dacryodes edulis*). Quantification et caractérisation de la matière première, évaluation des potentialités technologiques en vue de la production d'huile. PhD Thesis, Université Marien Ngouabi, Congo.

Kapseu C, Mapongmetsem PM, Silou T, Roques M. 1998. Physicochimique du fruit du bush buttertier (*Dacryodes edulis*) camerounais. Tropicultura **16-17**, 37-42.

Kengue J. 1990. Le bush buttertier (*Dacryodes edulis* (G.Don) H.J. Lam). Premières données sur la morpholgie et la biologie d'une Burseraceae fruitière et oléifère d'origine africaine. PhD thesis. Université de Yaoundé, Cameroun, 62-68.

Ladipo DO, Adewusi HG, Omaliko CPE, Sarumi MB, Adebisi AA, Gbadamosi LM, Okeke AI, Asiegbu JE. 2002. *Dacryodes edulis* germplasm collection from southern Nigeria. p. 93. *In* 3e séminaire international sur la valorisation du safoutier et autres oléagineux non conventionnels, Cameroun. 3–5 Octobre 2000. Presses universitaires d'Afrique, Yaoundé, Cameroun.

Laroussilhe (De) F, Schwob R, Wolf JP. 1964. Le bush butter, source de matières grasses. Présentation au Premier Congrès International des Industries Agricoles et alimentaires des zones Tropicales et Subtropicales. 14-19 December, Abidjan.

Massamba P, Kama-Niamayou R, Mampouya D, Silou T. 2006. Evolution de la production et caractérisation des fruits au cours de sept premières années d'un verger de marcottes des safoutiers (*Dacryodes edulis* (G. Don) H.J. Lam) à Boko, au Congo Brazzaville. Annales de l'Université Marien NGOUABI **7**, 12-25.

Nunome T, Ishiguro K, Yoshida T, Hirai M. 2001. Mapping of fruit shape and color development traits in eggplant (*Solanum melongena* L.) based on RAPD and AFLP markers. Breeding Science **51**, 19-26.

Okafor JC.1983. Varietal delimitation in *Dacryodes edulis* (G. Don) H.J. LAM (Burseraceae). International Tree Crops Journal **2**, 255-265.

Omoti U, Okiy DA. 1987. Characteristics and composition of the pulp oil and cake of the African pear, *Dacryodes edulis* (G.Don) H.J. Lam. Journal of the Science of Food and Agriculture **38**, 67-72.

Ondo-Azi AS, Ella Missang C, Silou T. 2009. Classification of *Dacryodes edulis* (G.Don) H.J. Lam by using morphological and physical characteristics of the fruits: a statistical approach. Forests, Trees and Livelihoods **19**, 99-109.

Silou T, Rocquelin G, Gallon G, Molagui T. 2000. Contribution à la caractérisation des bush butters (*Dacryodes edulis*) d'Afrique Centrale. Note II- Composition chimique et caractéristiques nutritionnelles des bush butters du district de Boko (Congo-Brazzaville). Variation inter-arbre. Rivista Italiana delle Sostanze Grasse **77**, 85-89.

Silou T, Rocquelin G, Mouaragagja I, Gallon G. 2002. Chemical composition and nutritional characteristics of bush butter (*Dacyodes edulis*) of Cameroon and the Congo-Brazzaville, the Congo-Kinshasa and Gabon. Rivista Italiana delle sostanze Grasse **79**, 177-182.

Thibeault B, Watkins R, Smith RA. 1983. Descriptor list for pear. International Board for Plant Genetic Resources. IBPGR/82/57.

Youmbi E, Mbeuyo M, Tchinda ND, Amougou A. 2010. Physico-chemical characterization and classification of fruits of *Dacryodes edulis* from the major agro-ecological zones of Cameroon. Fruits **66**(**6**), 355-365.