

MORPHOTAXONOMIC RE-CLASSIFICATION OF *C. ANNUUM* VAR. *ACCUMINATUM* FINGERH AS *C. FRUTESCENS* VAR. *ACCUMINATUM*

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ABSTRACT

The taxonomic identities of some *Capsicum* varieties are somewhat controversial. This study is aimed at using morphological characters to ascertain the *Capsicum* species to which variety *accuminatum* belongs. The study was conducted at the Experimental Plot of the Department of Pure and Applied Botany, Federal University of Agriculture, Abeokuta (Latitude: 7.214952; Longitude: 3.437090) using a Randomized Complete Block Design (RCBD) in 10 replicates. Quantitative and qualitative characters were evaluated through measurements and visual observation respectively. Data were analyzed using Statistical Analysis Systems version 9.2 and Duncan's Multiple Range Test was used to separate means at $p < 0.05$. The results revealed erect growth habit, lanceolate leaf shape, pendant flower position, white corolla colour, obtuse fruit shape at pedicel, elongated fruit shape, and pointed fruit shape at blossom end on variety *accuminatum* as characteristic features of *C. frutescens*. Plant canopy width $103.41 \pm (4.30)$ cm, number of branches per plant $24.70 \pm (0.15)$, days to flowering $73 \pm (0.21)$, fruit length $11.69 \pm (0.07)$ cm and fruit width $5.78 \pm (0.05)$ cm in variety *accuminatum* are closer to mean values in *C. frutescens*. This study showed that variety *accuminatum* is morphologically and evolutionary related to *C. frutescens*. Therefore, re-naming of *C. annum* var. *accuminatum* is hereby suggested and proposed to be *C. frutescens* var. *accuminatum*.

Keywords: *C. annum*, *C. frutescens*, morphology, taxonomy, variety.

INTRODUCTION

The genus *Capsicum* (L.) pepper belongs to the family Solanaceae, division Magnoliophyta, class Magnoliopsida and order Solanales (GRIN, 2010). Approximately thirty-five wild and five domesticated species have been reported. Considering this high number of species in the genus, a remarkably high level of morphological diversity is expected at the specific and varietal levels (Knapp *et al.*, 2004). *Capsicum* members are predominantly perennial shrubs, although

some are biennials, particularly *C. annum*, *C. frutescens* and *C. Chinense* while a few can develop into trees, for example *C. parvifolium* and *C. rhomboideum* (Walsh and Hoot, 2001; Abdullahi *et al.*, 2003).

As a common vegetable in Nigerian diet, pepper is widely consumed by the people in several dishes. Pepper cultivation is an important agribusiness in Nigeria, therefore it stimulates subsistence farming, increased employment and income generation in Sout-

west, Nigeria (Showemimo and Olanrewaju, 2000). In African medicine, pepper is used in treating sore throat (Abdullahi *et al.*, 2003).

The taxonomic identities of some *Capsicum* varieties are somewhat controversial. The confusion is mainly in terms of nomenclature within species, because *C. annuum* is sometimes called *C. frutescens* in scientific literature. But, Bosland and Vostava (2000) reoprted *C. frutescens* as a separate species from *C. annuum*, though many botanists consider the two to be conspecific. Zhang *et al.* (2002) are of the opinion that nomenclature confusion may be due to the use of growth forms alone to distinguish *C. annuum* from *C. frutescens* in the past. Falusi (2006) also reported that *C. annuum* and *C. frutescens* are sometimes treated as one species (*C. annuum*) with four cultivars in Nigeria. He reported the four cultivars to be *C. annuum* var. *grossum* L. Sendt. (Tatashe), *C. annuum* var. *abbreviatum* Fingerh (Ata-rodo), *C. annuum* var. *accuminatum* Fingerh, (Ata-Sombo), and *C. frutescens* var. *maximum* (Ata-wewe).

Araceli (2009) also reported that *C. annuum* is difficult to differentiate from both *C. chinense* and *C. frutescens* because of the overlap in most of their morphological features. He stated further that these three species share the same ancestral gene pool and are sometimes called the "annuum-chinense-frutescens complex". This nomenclatural confusion at specific level has also resulted into difficulty in classifying pepper variety into the appropriate species by researchers. For example, variety of *C. frutescens* is sometimes used interchangeably with variety of *C. annuum* due to the morphological similarities and overlap of traits among different species and even varieties. Thus, the

taxonomic identities of some varieties of species within the genus remain unclear and controversial. They were probably mis-identified, mis-classified or lumped up by some workers.

In addition to the classification made by Falusi (2006) on *Capsicum* species and their varieties in Nigeria, Daniel *et al.* (2014) also reported *C. annuum* to having the following varieties var. *abbreviatum* (Yor: rodo), var. *annuum* (Yor: rodo hausa), var. *accuminatum* (Yor: green tatashe), var. *grossum* (long tatashe), and var. *glabriusculum* (big tatashe). Their classification is largely based on the life cycle as annual crop alone. Both Falusi (2006) and Daniel *et al.* (2014) placed variety *accuminatum* into *C. annuum* based on few characters. This is contrary to the reports of Pabón-Mora and Litt (2011) that canvassed for the use of many morphological characters in plant classification.

It is worthy of mentioning that classification of several plant genera has been done with many morphological attributes (Noli *et al.*, 1997; Domyati *et al.*, 2011). This is because morphological characterization is considered the first step for species detection and classification (Smith and Smith, 1989). Many workers had also used morphological features in systematic and taxonomic studies Okwulehi and Okoli (1999), Chakrabarty and Gupta (1981), Olowokudejo (1990), and Nwachukwu *et al.* (2007). In view of this, we are of the opinion that the use of many morphological characters will provide a much more accurate and powerful means of analyzing and addressing some of these nomenclatural issues in the genus *Capsicum*. Thus, this present study is aimed at using morphological characters in nineteen accessions of *C. annuum* and *C. frutescens*

varieties with a view to ascertaining the species to which *Capsicum* variety *accuminatum* belongs between *C. annuum* and *C. frutescens*.

MATERIALS AND METHODS

Accessions collection and Seedling Establishment

Fresh fruits and seeds of nineteen (19) accessions were collected from rural farmers and some were bought from local markets, especially in the pepper growing areas within Southwest, Nigeria. The experiment was conducted at the Experimental plot of the Department of Pure and Applied Botany, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria (Latitude: 7.214952; Longitude: 3.437090).

Seedling Transplant into the Screen House

After nursery establishment, ten (10) healthy and well rooted seedlings of all accessions were randomly selected and subsequently transplanted into well arranged 10 litres plastic buckets filled with loamy soil, river sand and organic manure in a Randomized Complete Block Design (RCBD). Data were collected from ten (10) plants per accession for all morphological characters.

Qualitative vegetative traits

The qualitative vegetative traits observed were: hypocotyl colour, hypocotyl pubescence, cotyledonous leaf colour, and cotyledonous leaf shape, leaf colour, lamina margin, leaf pubescence, stem, nodal anthocyanin, stem shape, stem pubescence, plant growth habit, branching pattern and tillering (IPGRI, 1995). Photographs of the plants and plant parts were taken using digital camera.

Quantitative vegetative traits

Ten plants were randomly selected and measured for the following traits on each accession: cotyledonous leaf length (mm), cotyledonous leaf width (mm), plant height (cm), leaf length (cm), leaf width (cm), stem diameter (cm), stem length, plant canopy width, and number of branches per plant (IPGRI, 1995).

Qualitative reproductive traits

Visually observed characters on all accessions were: flower position, fruit shape at pedicel attachment, corolla colour, fruit shape, corolla spot colour, fruit shape at blossom end, corolla shape, filament colour, anther colour, fruit colour at mature stage, and fruit set. Photographs of the plants and plant parts were taken using digital camera.

Quantitative reproductive traits

The following traits: days to first flowering, number of flowers per axil, days to fruiting, days to ripening, fruit length (cm), fruit width (cm), fruit weight (g), fruit pedicel length (cm), number of fruits per plants and number of seeds per fruits were measured and recorded using measuring tape, ruler, vernier caliper and thread, where necessary (IPGRI, 1995).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using Statistical Analysis Systems (SAS 9.2 version) software package. Test for significant difference in the quantitative morphological characters at 5% probability level was conducted using Duncan's Multiple Range Test (DMRT). Pearson Correlation Coefficient and Principal Component Analysis (PCA) were employed to identify the dependence of characters on one another and reveal variation among morphological quantitative characters respectively.

RESULTS

Variations in qualitative vegetative characters of Capsicum varieties

All accessions of *C. annuum* var. *accuminatum* (Bell pepper "Atarodo") and *C. annuum* var. *abbreviatum* (Cayene pepper "bawa") revealed wide differences but few similarities in most of their qualitative vegetative characters (Table 1).

Similarities were observed in the hypocotyl colour, cotyledon leaf colour, stem pubescence, stem shape, leaf pubescence, branching habit, tillering and leaf colour between the two varieties (Table 1). Variation was observed in nodal pigmentation which ranged from green to light purple in *C. annuum* var. *abbreviatum* whereas it varied from light purple to dark purple in both *C. annuum* var. *accuminatum* and *C. frutescens* var. *chacoense* (Yor: shombo) (control) (Table 1). Plant growth habit varied from erect to prostrate in *C. annuum* var. *abbreviatum* while it was erect position in both *C. annuum* var. *accuminatum* and control. Leaf shape varied from deltoid, lanceolate to ovate in *C. annuum* var. *abbreviatum* while it was lanceolate in both *C. annuum* var. *accuminatum* and control *C. annuum* var. *chacoense* (Table 1).

Variations in qualitative reproductive characters of Capsicum varieties

Variations were observed in flower positions which ranged from pendant to intermediate in *C. annuum* var. *abbreviatum* while both *C. annuum* var. *accuminatum* and *C. frutescens* var. *chacoense* (control) had pendant position (Table 2). The corolla colour in *C. annuum* var. *abbreviatum* varied from light yellow to light green while it was white in both *C. annuum* var. *accuminatum* and control.

Also, variations were observed in fruit shape at pedicel attachment which was truncate in *C. annuum* var. *abbreviatum* but obtuse in both *C. annuum* var. *accuminatum* and control. Also, fruit shape was either blocky or campanulate in *C. annuum* var. *abbreviatum* while both *C. annuum* var. *accuminatum* and control had elongated fruit shape. Fruit shape at blossom end was pointed in both *C. annuum* var. *accuminatum* and control while *C. annuum* var. *abbreviatum* had blunt or sunken shape (Table 2).

However, similarities were observed in corolla spot colour, anther colour, filament colour, fruit colour at mature stage, fruit set and flower position in the two varieties and control (Table 2).

Table 1: Qualitative vegetative characters of *Capsicum* varieties

Species/ Varieties	Acc/ No	HC	HP	CLC	SC	NA	SS	SP	PGH	BH	Till	Leaf Col	LS	LM	LP
<i>C. annuum</i> var. abbrevi- atum Fingerh	Og001	Green	8	Light Green	Green	Green	Angular	3	Intermedi- ate	5	5	Light Green	Ovate	Entire	8
	Og002	Light Green	3	Light Green	Green Purple Stripe	Light Purple	Angular	5	Erect	5	5	Green	Deltoid	Entire	3
	Og004	Light Green	3	Light Green	Green	Green	Angular	3	Prostrate	3	3	Light Green	Deltoid	Entire	8
	Og007	Light Green	8	Green	Green Purple Stripe	Light Purple	Angular	3	Erect	3	3	Green	Deltoid	Entire	8
	Og010	Light Green	3	Light Green	Green Purple Stripe	Light Purple	Angular	3	Intermedi- ate	7	7	Green	Deltoid	Entire	3
	Os015	Light Green	3	Light Green	Green Purple Stripe	Light Purple	Angular	3	Erect	3	3	Light Green	Deltoid	Entire	8
	On017	Green	3	Light Green	Green	Green	Cylindrical to Angular Cylindrical	3	Prostrate or Intermedi- ate	7	7	Dark Green	Ovate or Lanceolate	Entire	3
	Oy018	Green	3	Light Green	Green	Green	Angular	3	Intermedi- ate	5	5	Light Green	Ovate or Lanceolate	Entire	8
	Ek021	Green	3	Green	Green	Light Purple	Angular	3	Intermedi- ate	7	7	Green	Deltoid and Ovate	Entire	3
	La026	Green	3	Light Green	Green Purple Stripe	Light Purple	Angular	3	Erect	7	7	Light Green	Deltoid to Lanceolate	Entire	3
	Oy032	Light Green	3	Green	Green Purple Stripe	Light Purple	Angular	5	Erect	3	3	Green	Deltoid	Entire	3

C. frutescens var. chacoense Fingerh	Og003	Green	3	Green	Green Purple Stripe	Dark Purple	Angular	3	Erect	3	3	Dark Green	Lanceolate	Entire	3
	Ek023	Light Green	5	Light Green	Purple	Light Purple	Angular	8	Erect	7	7	Green	Lanceolate	Entire	5
	Os012	Green	3	Light Green	Green Purple Stripe	Dark Purple	Angular	8	Erect	3	3	Green	Lanceolate	Entire	8
C. annum var. acuminatum Fingerh	Os013	Green	3	Light Green	Green Purple Stripe	Dark Purple	Angular	3	Erect	3	5	Light Green	Lanceolate	Entire	8
	On019	Light Green	3	Green	Green Purple Stripe	Dark Purple	Angular	8	Erect	5	3	Green	Lanceolate	Entire	8
	Ek024	Light Green	3	Green	Green Purple Stripe	Purple	Angular	3	Erect	7	3	Dark Green	Lanceolate	Entire	8
On027	Light Green	3-5	Green	Green Purple Stripe	Purple	Angular	8	Erect	5	5	Dark Green	Lanceolate	Entire	5	
Os033	Green	5	Light Green	Green Purple Stripe	Light Purple	Angular	8	Erect	3	3	Light Green	Lanceolate	Entire	3	
<p>3= Sparse, 5= Intermediate, 7= Dense, 8= Glabrous</p> <p>HC=Hypocotyls colour, HP=Hypocotyl pubescence, CLC=Cotyledonous leaf colour, LC=Life cycle, SC=Stem colour, NA=Nodal anthocyanin, SS=Stem shape, SP=Stem pubescence, PGH=Plant growth habit, BH=Branching habit, Till=Tillering, Leaf col=Leaf colour, LS=Leaf shape, LM=Lamina margin, LP=Leaf pubescence</p>															

Table 2: Qualitative reproductive characters of Capsicum varieties

Varieties	Acc/ No	FSPA	FC	FR set	FRC ma- ture	FR shape	FRSB	CS	AC	FLP	CC	CSC
<i>C. annuum</i> var. abbreviatum Fingerh	Og001	Truncate	Purple	Intermediate	Orange- Yellow	Blocky	Blunt	Rotate	Green	Intermediate	Light Yellow	Yellow
	Og002	Truncate	Purple	Intermediate	Orange- Yellow	Campanulate	Blunt	Campanulate	Blue	Intermediate	Light Yellow	Yellow
	Og004	Truncate	Yellow	Low	Red	Blocky	Sunken	Campanulate	Pale Blue	Intermediate	Light Yellow	Yellow
	Og007	Truncate	Light Purple	Low	Red	Blocky	Blunt	Rotate	Pale Blue	Pendant	Light Yellow	White
	Og010	Truncate	Light Purple	Low	Red	Blocky	Sunken	Rotate	Purple	Intermediate	Light Yellow	Green
	Os015	Truncate	Purple	Low	Red	Blocky	Sunken	Campanulate	Purple	Intermediate	Light Yellow	Yellow
	On017	Truncate	White	Low	Red	Campanulate	Blunt	Rotate	Blue	Pendant	Light Yellow	Yellow
	Oy018	Truncate	Yellow	Low	Red	Campanulate	Sunken	Rotate	Purple	Pendant	Light Yellow	Green
	EK021	Truncate	Purple	Intermediate	Dark Red	Campanulate	Sunken	Campanulate	Green	Pendant	Light Yellow	Yellow
	La026	Truncate	Purple	Low	Dark Red	Campanulate	Sunken	Campanulate	Green	Pendant	Light Yellow	Yellow
	Oy032	Truncate	Purple	Low	Red	Campanulate	Sunken	Rotate	Green	Intermediate	Light Yellow	Yellow

<i>C. frutescens</i> var. <i>chacoense</i> Fingerh	Og003	Obtuse	White	Low	Red	Elongate	Pointed	Rotate	Pale Blue	Pendant	White	Yellow
	Ek023	Obtuse	Light Yellow	High	Dark Red	Elongate	Pointed	Campanulate	Green	Pendant	White	Yellow
<i>C. annum</i> var. <i>acuminatum</i> Fingerh	Os012	Obtuse	White	Low	Red	Elongate	Pointed	Campanulate	Green	Pendant	White	Purple
	Os013	Obtuse	White	Low	Red	Elongate	Pointed	Campanulate	Blue	Pendant	White	White
	On019	Obtuse	White	Low	Dark Red	Elongate	Pointed	Rotate	Green	Pendant	White	Purple
	Ek024	Obtuse	Yellow	Intermediate	Dark Red	Elongate	Pointed	Rotate	Blue	Pendant	White	White
	On027	Obtuse	Yellow	High	Dark Red	Elongate	Pointed	Rotate	Green	Pendant	White	White
	Os033	Obtuse	Yellow	Low	Red	Elongate	Pointed	Campanulate	Purple	Pendant	White	White

Key: FSPA- Fruit shape at pedicel attachment, FRC mature- Fruit colour at mature stage, FR shape- Fruit shape, FRSB- Fruit shape at blossom end, FR set- Fruit set, FLP- Flower position, CC- Corolla colour, CSC- Corolla spot colour, CS-Corolla shape, AC- Anther colour, FC- Filament colour

Variations in quantitative vegetative characters of *Capsicum* varieties

Cotyledon leaf length ranged from $5.49 \pm (0.08)$ cm in Og010 to $9.66 \pm (0.14)$ cm in Ek021 for *C. annuum* var. *abbreviatum* while it ranged from $10.90 \pm (0.04)$ cm in Os033 to $11.70 \pm (0.06)$ cm in Os013 for *C. annuum* var. *accuminatum* and $10.80 \pm (0.08)$ cm in Og003 to $11.20 \pm (0.04)$ cm in Ek023 for control. Ranges of cotyledon leaf length in *C. annuum* var. *accuminatum* is closer to *C. frutescens* var. *chacoense* (control) (Table 3).

In addition, plant canopy width in *C. annuum* var. *abbreviatum* ranged from $60.31 \pm (3.34)$ cm in Oy032 to $133.62 \pm (1.92)$ cm in Og002 while plant canopy width ranged from $53.00 \pm (0.71)$ cm in Os012 to $103.41 (\pm 4.30)$ cm in On019 for *C. annuum* var. *accuminatum*. Plant canopy width of *C. annuum* var. *accuminatum* is closer to the mean values for (control) which ranged from $54.55 \pm (1.58)$ cm in Og003 to $101.30 \pm (2.61)$ cm in Ek023 (Table 3).

The number of branches per plant ranged from (6.4 ± 0.37) in Oy032 to (39.7 ± 1.53) in Ek021 for *C. annuum* var. *abbreviatum*. This is higher compared to ranges of $3.00 \pm (0.37)$ in On019 to $24.70 \pm (0.15)$ in On027 for *C. annuum* var. *accuminatum*. However, ranges of number of branches per plant in *C. annuum* var. *accuminatum* is closer to the mean values recorded for (control) $17.60 \pm (1.60)$ to $19.10 \pm (1.38)$ (Table 3).

Other variations observed in leaf length and leaf width between *C. annuum* var. *abbreviatum* and *C. annuum* var. *accuminatum* were recorded in Table 3.

Variations in Quantitative Reproductive Characters of *Capsicum* varieties

Days to flowering ranged from $69 \pm (0.30)$ days in Og004 to $94 \pm (0.20)$ days in La026 in *C. annuum* var. *abbreviatum* while it ranged from $59 \pm (0.07)$ days in Os013 to $73 \pm (0.21)$ days in Os033 in *C. annuum* var. *accuminatum*. Ranges of days to flowering in *C. annuum* var. *accuminatum* is closer to mean values $60.00 \pm (0.01)$ cm in Og003 to $71.00 \pm (0.22)$ cm in Ek023 for *C. frutescens* var. *chacoense* (control) (Table 4).

The fruit length ranged from $7.48 \pm (0.12)$ cm in On019 to $11.69 \pm (0.07)$ cm in Ek024 while fruit width was between $5.07 \pm (0.07)$ cm in Os013 and $5.78 \pm (0.05)$ cm Ek024 in *C. annuum* var. *accuminatum*. These were closer to the mean values of fruit length $7.54 \pm (0.07)$ cm in Ek023 to $7.18 \pm (0.12)$ cm in Og003 and fruit width values $4.17 \pm (0.13)$ cm in Og003 to $4.74 \pm (0.07)$ cm in Ek023 recorded for the (control) than fruit length $2.25 \pm (0.07)$ cm in On017 to $3.88 \pm (0.21)$ cm in Og007 and fruit width values $4.41 \pm (0.02)$ cm in La026 to $9.66 \pm (0.27)$ cm in Og010 for *C. annuum* var. *abbreviatum* (Table 4).

Other quantitative reproductive variations between *C. annuum* var. *abbreviatum* and *C. annuum* var. *accuminatum* were shown in Table 4.

Table 3: Quantitative vegetative characters of Capsicum varieties

Species/ Varieties	Acc/ No	CLL (cm)	CLW (cm)	PH (cm)	PCW (cm)	SD (cm)	SL (cm)	NB/P	LL (cm)	LW (cm)
C. annuum var. abbrevia- tum Fingerh	Og001	7.10±0.03 ^e	2.00±0.00 ^a	57.22±2.20 ^a	119.41±3.05 ^b	3.44±0.10 ^c	4.06±0.14 ^c	27.90±3.25 ^b	12.56±0.38 ^a	8.64±0.20 ^a
	Og002	7.20±0.01 ^e	2.00±0.00 ^a	51.65±1.78 ^b	133.62±1.92 ^a	3.54±0.04 ^c	3.85±0.23 ^d	30.30±2.88 ^b	13.01±0.16 ^d	7.60±0.14 ^b
	Og004	7.22±0.05 ^e	2.00±0.00 ^a	42.54±1.53 ^c	77.78±1.47 ^e	3.20±0.71 ^c	3.54±0.21 ^d	39.10±3.58 ^a	12.75±0.19 ^a	7.68±0.21 ^b
	Og007	7.12±0.03 ^e	2.00±0.00 ^a	36.09±1.06 ^d	75.86±3.40 ^e	3.55±0.09 ^c	3.15±0.12 ^d	28.30±0.72 ^b	11.62±0.1 ^b	7.48±0.03 ^b
	Og010	5.49±0.08 ^f	2.00±0.00 ^a	28.09±0.79 ^e	84.86±1.60 ^d	4.02±0.28 ^b	2.79±0.25 ^e	29.30±0.73 ^b	12.69±0.54 ^a	6.38±0.13 ^d
	Os015	7.20±0.04 ^e	2.00±0.00 ^a	61.78±1.83 ^a	74.09±4.78 ^e	3.53±0.10 ^c	3.64±0.22 ^d	14.10±1.03 ^e	10.03±0.19 ^c	7.18±0.06 ^{bc}
	On017	8.54±0.04 ^d	2.00±0.00 ^a	53.36±1.21 ^b	123.15±5.69 ^b	3.46±0.11 ^c	1.73±0.19 ^f	26.70±1.93 ^{bc}	12.79±0.03 ^a	6.78±0.04 ^d
	Oy018	7.28±0.05 ^e	2.00±0.00 ^a	32.78±1.08 ^d	64.47±4.51 ^f	3.61±0.24 ^c	3.84±0.29 ^d	13.80±1.01 ^f	12.75±0.03 ^a	4.45±0.09 ^{gh}
	EK021	9.66±0.14 ^c	1.88±0.03 ^b	54.81±0.78 ^b	122.38±1.72 ^b	3.57±0.14 ^c	2.67±0.20 ^e	39.70±1.53 ^a	9.39±0.14 ^d	7.21±0.18 ^{bc}
	La026	7.00±0.05 ^h	2.00±0.00 ^a	52.68±1.87 ^b	73.23±4.44 ^e	3.14±0.08 ^c	2.16±0.08 ^e	12.00±1.21 ^f	11.32±0.02 ^b	6.13±0.02 ^d
	Oy032	7.14±0.03 ^e	2.00±0.00 ^a	41.32±2.57 ^c	60.31±3.34 ^f	3.40±0.07 ^c	0.54±0.05 ^g	6.40±0.37 ^g	12.95±0.04 ^a	6.28±0.05 ^d

<i>C. frutescens</i> var. <i>chacoense</i> Fingerh	Og003	10.80±0.08 ^b	2.00±0.01 ^a	55.00±1.30 ^b	54.55±1.58 ^f	2.46±0.08 ^d	2.01±0.14 ^e	17.60±1.60 ^e	7.95±0.22 ^f	3.24±0.12 ^h
	EK023	11.20±0.04 ^a	2.00±0.01 ^a	54.23±1.88 ^b	101.30±2.16 ^c	2.98±0.10 ^d	2.84±0.07 ^e	19.10±1.38 ^d	7.35±0.19 ^f	3.29±0.12 ^h
<i>C. annuum</i> var. <i>accuminatum</i> Fingerh	Os012	11.00±0.07 ^a	2.00±0.00 ^a	54.19±0.71 ^b	53.00±0.71 ^f	4.12±0.14 ^b	1.86±0.19 ^f	12.90±0.77 ^f	7.69±0.23 ^f	4.54±0.06 ^{gh}
	Os013	11.70±0.06 ^a	2.00±0.00 ^a	31.94±1.19 ^d	85.50±3.20 ^d	3.07±0.03 ^c	3.75±0.30 ^d	18.90±2.26 ^d	7.75±0.22 ^f	5.36±0.14 ^e
	On019	11.09±0.22 ^a	1.45±0.07 ^c	26.71±1.82 ^e	103.41±4.30 ^c	5.15±0.29 ^a	7.23±0.12 ^a	3.00±0.37 ^g	8.95±0.31 ^e	5.09±0.05 ^{ef}
	EK024	11.00±0.04 ^a	1.00±0.00 ^d	45.38±0.83 ^c	81.69±5.09 ^d	3.29±0.12 ^c	4.95±0.08 ^c	15.70±1.18 ^e	8.50±0.06 ^e	5.07±0.02 ^{ef}
	On027	10.98±0.03 ^b	2.00±0.00 ^a	59.92±1.57 ^a	94.76±0.96 ^{cd}	3.70±0.15 ^c	5.20±0.30 ^b	24.70±0.15 ^c	9.37±0.12 ^d	5.16±0.13 ^{ef}
	Os033	10.90±0.04 ^b	1.00±0.01 ^b	52.80±3.42 ^b	81.30±2.59 ^d	3.75±0.18 ^c	6.17±0.07 ^a	17.50±1.38 ^d	6.55±0.08 ^f	3.33±0.03 ^h
<p>Mean values (± standard error) followed by different superscripts within columns are significantly different at (5%) using Duncan's Multiple Range Test (DMRT).</p> <p>Key: CLL- Cotyledon leaf length (cm), CLW- Cotyledon leaf width (cm), PH- Plant height (cm), PCW- Plant canopy width (cm), SD- Stem diameter (cm), SL- Stem length (cm), NB/P- Number of branches/plant, LL- Leaf length (cm), LW- Leaf width (cm)</p>										

Table 4: Quantitative reproductive characters of Capsicum varieties

Species/ Varieties	Acc/ No	DAFL	NF/A	DAFR	FRL (cm)	FRWI (cm)	FRWE (g)	FRPDL (cm)	DARIPN	NFP	NSPFR
C. annuum var. abbre- viatum Fingerh	Og001	79.00±0.01 ^{bc}	2.00±0.01 ^b	94.00±0.2 ^{cd}	3.59±0.13 ^e	5.64±0.12 ^c	2.66±0.22 ⁱ	2.71±0.06 ^c	125.00±0.22 ^b	40.90±2.92 ^a	18.28±2.30 ^{ed}
	Og002	83.00±0.20 ^{ab}	2.00±0.01 ^b	100.00±1.34 ^c	2.62±0.09 ^e	4.44±0.15 ^d	1.85±0.09 ^g	1.84±0.09 ^d	124.00±0.2 ^b	36.70±5.06 ^a	23.16±1.91 ^e
	Og004	69.00±0.30 ^d	2.00±0.01 ^b	101.00±0.11 ^c	3.09±0.10 ^e	7.96±0.18 ^b	3.89±0.12 ^f	4.18±0.05 ^a	123.00±0.11 ^b	10.50±1.13 ^d	3.37±0.70 ^g
	Og007	71.00±0.01 ^c	2.00±0.01 ^b	86.00±0.01 ^{ef}	3.88±0.21 ^e	8.63±0.35 ^a	9.21±0.26 ^a	2.73±0.09 ^c	119.00±0.56 ^b	19.80±3.05 ^b	35.12±4.81 ^d
	Og010	83.00±0.18 ^{ab}	1.00±0.01 ^c	90.00±0.22 ^e	3.38±0.06 ^d	9.66±0.27 ^a	7.49±0.17 ^c	2.48±0.07 ^c	90.00±0.52 ^d	20.50±1.93 ^b	19.82±1.77 ^{ed}
	Os015	78.00±0.32 ^c	2.00±0.01 ^b	100.00±0.27 ^c	2.97±0.08 ^e	7.40±0.11 ^b	4.74±0.18 ^e	2.60±0.05 ^c	121.00±0.12 ^a	14.40±1.54 ^c	26.21±1.58 ^e
	On017	81.0±0.01 ^b	3.70±0.00 ^a	92.00±0.21 ^{cd}	2.25±0.07 ^f	3.07±0.06 ^e	0.73±0.03 ^h	1.75±0.02 ^d	112.00±0.89 ^b	23.20±2.19 ^b	25.03±0.82 ^e
	Oy018	73.00±0.02 ^c	1.00±0.01 ^c	100.00±0.1 ^c	4.24±0.05 ^d	7.67±0.12 ^b	0.84±0.01 ^h	2.33±0.01 ^{jk}	133.00±1.24 ^{ab}	6.30±0.58 ^e	17.32±0.35 ^f
	Ek021	70.00±0.01 ^c	2.00±0.01 ^b	120.00±2.11 ^a	3.89±0.15 ^d	6.62±0.19 ^c	3.76±0.05 ^f	3.41±0.09 ^b	150.00±1.20 ^a	38.00±4.91 ^a	32.98±0.76 ^d
	La026	94.00±0.20 ^a	2.00±0.00 ^b	116.00±0.21 ^b	3.65±0.06 ^d	4.41±0.02 ^d	1.76±0.02 ⁱ	1.91±0.02 ^d	145.00±0.31 ^a	21.00±1.62 ^b	23.95±0.35 ^e
	Oy032	86.00±0.23 ^{ab}	2.00±0.00 ^b	101.00±0.25 ^c	3.77±0.03 ^d	8.25±0.04 ^a	4.36±0.06 ^e	2.63±0.03 ^c	112.00±0.72 ^{ab}	9.70±1.29 ^d	58.17±0.48 ^c

<i>C. frutescens</i> var. <i>chaocense</i> Fingerh	Og003	71.00±0.22 ^c	1.00±0.01 ^c	117.00±0.24 ^a	7.18±0.12 ^c	4.17±0.13 ^d	2.95±0.06 ^b	3.06±0.05 ^b	148.00±0.31 ^a	14.30±0.42 ^c	56.17±1.04 ^c
	Ek023	60.00±0.01 ^e	1.00±0.01 ^c	88.00±0.27 ^f	7.54±0.07 ^c	4.74±0.07 ^d	0.68±0.10 ^h	3.06±0.06 ^b	100.00±0.33 ^c	27.10±5.85 ^b	34.17±0.85 ^d
<i>C. annuum</i> var. <i>accu-</i> <i>minatum</i> Fingerh	Os012	70.00±0.02 ^c	1.00±0.01 ^c	96.00±0.2 ^{cd}	11.09±0.15 ^a	5.16±0.03 ^{cd}	8.21±0.17 ^b	3.66±0.08 ^b	124.00±0.34 ^{ab}	16.80±1.41 ^b	75.16±3.57 ^b
	Os013	59.00±0.07 ^h	1.00±0.01 ^c	80.00±0.2 ^{efg}	7.88±0.39 ^c	5.07±0.07 ^{cd}	6.56±0.09 ^d	2.29±0.08 ^c	91.00±0.32 ^d	15.50±1.20 ^c	75.40±1.52 ^b
	On019	70.00±0.01 ^c	1.00±0.01 ^c	83.00±0.15 ^{ef}	7.48±0.12 ^c	5.32±0.12 ^{cd}	6.58±0.11 ^d	3.02±0.06 ^e	110.00±0.68 ^{ab}	11.00±0.84 ^d	98.34±2.33 ^b
	Ek024	67.00±0.23 ^d	1.00±0.01 ^c	72.00±0.1 ^h	11.69±0.07 ^a	5.78±0.05 ^{cd}	8.93±0.01 ^b	3.53±0.02 ^b	103.00±0.00 ^c	23.00±2.18 ^b	113.60±1.9 ^{9a}
	On027	70.00±0.17 ^c	1.00±0.01 ^c	82.00±0.12 ^{ef}	8.66±0.20 ^b	5.45±0.13 ^{cd}	7.70±0.16 ^c	3.89±0.07 ^b	114.00±0.86 ^{ab}	28.50±3.94 ^b	79.59±0.83 ^b
	Os033	73.00±0.21 ^c	1.00±0.01 ^c	79.00±0.1 ^f	7.74±0.07 ^c	5.21±0.03 ^{cd}	5.37±0.04 ^{fg}	2.38±0.02 ^c	111.00±0.21 ^{ab}	10.70±1.35 ^d	108.46±1.3 ^{4a}

Mean values (± standard error) followed by different superscripts within columns are significantly different at (5%) using Duncan's Multiple Range Test (DMRT)

Key: DAFL- Days to flowering, NFA- Number of flower per axil, DAFR- Days to fruiting, FRL- Fruit length (cm), FRWI- Fruit width (cm), FRWE- Fruit weight (g), FRPDL- Fruit pedicel length (cm), DARIPN- Days to ripening, NFP- Number of fruits per plant, NSPFR- Number of seeds per fruit



Scale line represents 10 cm

Plate 1: Comparison between *C. annuum* var. *accuminatum* and *C. annuum* var. *abbreviatum* using *C. frutescens* var. *chacoense* as control

(A) *C. annuum* var. *accuminatum* Fingerh (Cayene pepper "Bawa") (B) *C. annuum* var. *abbreviatum* Fingerh (Bell pepper "Atarodo")

(C) *C. annuum* var. *accuminatum* Fingerh (Cayene pepper "Bawa") (D) *C. annuum* var. *chacoense* Fingerh (Yor: Shombo)

DISCUSSION

Sudré *et al.* (2010) described *C. frutescens* as *Capsicum* species with many varieties which are normally treated as perennial plants but usually cultivated as annuals. Abdul (2003) reported that *C. frutescens* is a primitive species, which is likely to be the ancestor of *C. chinense*. The morphological characteristics of *C. frutescens* as described by Sudré, *et al.* (2010) are as follows: stem is almost glabrous, and height is between 1-4 ft depending on the climate and growing condition. The leaves are usually elliptical, dark green, smooth, 10 cm and 7 cm or more in length and width respectively. The flowers are typically conical or obtuse shaped with five petals, usually fused and the colour ranges from white, red to yellow. The fruits are erect, ellipsoid-conical and pointed, 10-20 mm long, 3-7 mm in diameter. Fruit colour ranges from green when immature to purple, red, orange or yellow when matured, and the seeds are yellow or cream.

On the other hand, Sreelathakumary and Rajamony (2002) described *C. annum* as a tall herbaceous plant, usually grown as an annual, but sometimes as perennial subshrub. The species is branched and reaches up to 55 cm in height. It has simple ovate leaves. The species has green foliage with purple veins, beautiful purple flowers which usually decline at anthesis, corolla light yellow, yellow or occasionally purple, with diffuse spots at the base of straight lobes. It bears 3-4 fruits which are green when unripe and changing principally to red when ripe, although, some varieties may ripen to other colours including brown and purple. The fruits are berries, truncate shaped, blunt at the end and up to 15 cm long (Bosland, 1996).

Phenotypic variations observed on the qualitative characters of *C. annum* var. *abbreviatum* and variety *accuminatum* which were expressed in their growth habit, nodal anthocyanin, leaf shape and stem colour depicted genetic basis for the phenotypic expression.

Therefore, significant variabilities observed may be attributed to differences at their genotypic level. This is in agreement with earlier research on assessment of variability in *Capsicum* species with respect to some vegetative qualitative traits (Adetula and Olakojo, 2006; Del *et al.*, 2007; Bozokalfa *et al.*, 2009; Idowu-agida, 2009). However, erect growth habit, light purple to dark purple nodal anthocyanin pigmentation and lanceolate leaf shape observed in variety *accuminatum* is similar to *C. frutescens*. This suggests that var. *accuminatum* belongs to *C. frutescens*. These findings are in line with the reports of Idowu-agida (2009) and Sudre *et al.* (2010) in *C. frutescens*.

Pendant flower position, white corolla colour, obtuse fruit shape at pedicel attachment, elongated fruit shape, and pointed fruit shape at blossom end observed in variety *accuminatum* is similar to *C. frutescens*. This agreed with the reports of Castañón-Nájera *et al.* (2008) and Dagnoko *et al.* (2013). They used these reproductive traits in characterizing some pepper genotypes into *C. frutescens*. The findings of these workers justified the suggestion of classifying var. *accuminatum* into *C. frutescens*.

Quantitative vegetative characters such as mean values of canopy width, number of branches per plant, leaf length and leaf width in var. *accuminatum* are closer to mean values in *C. frutescens* earlier reported by Ahmed *et al.* (1996). This suggests that var. *accuminatum* belongs to *C. frutescens*. Also, quantitative reproductive characters such as days to flower-

ing, fruit length and fruit length in var. *accuminatum* are closer to *C. frutescens*. This shows some levels of genetic relatedness. This agreed with the findings of Ahmed *et al.* (1996) and suggests that var. *accuminatum* belongs to *C. frutescens*.

Variations and similarities in measured characters in this study could be assumed to have genetic basis and thus, justifying their use for classification of var. *accuminatum* into *C. frutescens*. This is because quantitative characters are usually believed not to be under the considerable influence of the environment. This assertion was premised on the similar reports made in studies of Guajillo pepper by Del *et al.* (2007). They grouped accessions of Guajillo pepper based on the quantitative characters.

CONCLUSION

All qualitative and most of the quantitative morphological variations are genetic rather than environmental. This is because all the accessions were raised in the same environment and subjected to similar cultural practices, which eliminated the influence of the environment in the phenotypic expressions of the characters. Hence, variations used for classification of varieties into species are embedded in their genome. The observed wide morphological differences between *C. annum* var. *abbreviatum* and var. *accuminatum* suggests that they are genetically and evolutionary different while morphological similarities between *C. frutescens* var. *chacoense* (control) and var. *accuminatum* suggests they are genetically and evolutionarily related. From the results of this study, re-naming of *C. annum* var. *accuminatum* (bawa) is hereby suggested and proposed to be *C. frutescens* var. *accuminatum* (Cayene pepper "bawa"). This assertion could further be confirmed at the DNA level. Therefore, further study on

molecular genetics is hereby recommended.

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