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Seasonal Variations in Capsaicin Content, Vitamin C and Carpometric Characteristics of Long Cayenne Pepper Accessions from South-Western Nigeria

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ABSTRACT

Accessions of long cayenne peppers were obtained from different locations in south-western Nigeria. The seeds were processed and planted in an experimental plot at two major seasons (rainy and dry season) to evaluate the effect of seasonal variation in the level of capsaicin content, vitamin C and carpometric properties in its fruits. Capsaicin, which is responsible for the sensation of pungency or heat in pepper, varied with a mean of 2.98 ± 0.34 and 3.31 ± 0.48 mg/g dry weight (DW), ascorbic acid of 20.14 ± 6.67 and 31.01 ± 15.80 mg/100 g FW, pH of 5.06 ± 0.20 and 5.09 ± 0.16, total soluble solid of 5.55 ± 0.98 and 9.59 ± 0.80% and ash contents of 1.11 ± 0.26 and 1.15 ± 0.21% for the rainy (25 of April – November, 2008) and dry (7 August, 2008 – March, 2009) seasons, respectively. There were significant differences in the level of ascorbic acid, total soluble solid (°Brix) and capsaicin, but not for pH and ash contents ($P > 0.05$). This study indicates that capsaicin, ascorbic acid and total soluble solid can vary considerably with changes in planting season as a result of environmental conditions.

Keywords: dry season, bioactive content, physical properties, rainy season, recommended dietary allowance

INTRODUCTION

Pepper is a vegetable of importance in human nutrition. In recent years, peppers have grown in popularity, and a wide number of varieties are now available in the grocery stores. Peppers are a good source of vitamins C and E, provitamin A, and carotenoids (Materska and Perucka 2005). Peppers also contain various phenolics and flavonoids (Amakura *et al*. 2002; Delgado-Vargas and Paredes-Lopez 2003; Materska and Perucka 2005). These compounds are antioxidants and can reduce harmful oxidation reactions in human body; thus consumption of peppers may prevent various diseases associated with free radical oxidation, such as cardiovascular disease, cancer, and neurological disorders (Doll 1990; Hollman and Katan 1999; Harborne and Williams 2000; Delgado-Vargas and Paredes-López 2003; Shetty 2004).

The group of pungent components peculiar to the fruits of *Capsicum* plants is called capsaicinoids. Capsaicinoids are produced in glands on the pepper placenta and on the white ribs that run down the middle, and along the sides, of a pepper. As a result, the glands and white ribs are the hottest parts of a red pepper. Since the seeds are in close contact with the ribs, they are also often hot (Dong 2000; Vega-*Gálvez et al*. 2009). Bosland (1994) determined that there are great diversities in the contents and composition of capsaicinoids among fruits of *Capsicum* species, and even among cultivars. The environment, especially the climate, light, soil, moisture, fertilization and temperature during plant growth, is considered to have an impact on capsaicinoid levels, as does the age of the fruit (Estrada *et al*. 2002; Titze *et al*. 2002). Capsaicinoids also have strong physiological and pharmacological properties. In addition to its widespread use as a neuropharmacological tool, capsaicin is of great medical value and it has been reviewed to evaluate its effect in treatment of painful conditions such as: rheumatic diseases, cluster headache, painful diabetic neuropathy, postherpetic neuralgia, etc. (Tsuchiya 2001; Vega-Gálvez *et al*. 2009). They decrease the myocardial and aortic cholesterol levels even when used at low levels in the diet. In recent years, capsaicinoids have been studied and found to be effective treatment for a number of sensory nerve fiber disorders including arthritis, cystitis, human immunodeficiency virus, etc. (Materska and Perucka 2005). They have also been reported as having an antioxidant and antibacterial effect on a certain group of bacteria (Henderson and Slickman 1999; Dorantes *et al*. 2000).

Vitamin C is another functional and nutritional constituent of pepper fruit, well-known as being an antioxidant and a biologically active compound (Deepa *et al*. 2006). The above-mentioned composition of *Capsicum* fruit can vary greatly by genotype and maturity. The content of ascorbic acid of pepper fruit increases upon maturation (Howard 2001). They are also influenced by growing and processing conditions (Deepa *et al*. 2007). Among studies on other crops, Howard (2001) reported that the antioxidant capacity and phenolic content of spinach was greatly affected by the growing season. They attributed the variation to the difference in growing temperatures and light intensity. Therefore, it is hypothesized that changes in climate received and temperatures in different seasons may affect the physical and biochemical components of cayenne grown as well. The main objective of this study was to investigate changes in the major carpometric characteristics, capsaicin and ascorbic acid content in traits of 31 accessions Long Cayenne pepper from South-western Nigeria in two major seasons in the tropical zone (rainy season: 25 of April – November, 2008 and dry season: 7 August, 2008 – March, 2009.

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Short Communication

MATERIALS AND METHODS

Chemicals used

Capsaicin standard and metaphosphoric acid were purchased from Sigma-Aldrich Co. Ltd. (St. Louis, USA). Other chemicals and solvents used in this experiment were of analytical grade.

Experimental location and design

The experiment was carried out at the National Horticultural Research Institute (NIHORT) vegetable experimental field in Ibadan latitude 7° 22′ N Longitude 3° 58′ E and covers an area of 304 ha. The field used had been under continuous cultivation for over 30 years. Fruits of Long Cayenne pepper were collected from 31 locations in South-western Nigeria. The fruits obtained from each location were macerated to extract the seeds. The seeds were air-dried, bulked and packaged as accessions from each location. A total of 31 accessions were evaluated. The planting field experiment was design in randomized complete block

Carpometric characteristics

Values of pH were measured with a digital pH meter (PHS-25, Precision scientific Instrument Co., Ltd., Shanghai, China). Buffers of pH 4.0 and 7.0 were used to standardize the equipment. The total soluble solid (TSS) contents were recorded in a refractometer at 20°C with values being expressed as °Brix.

Capsaicin

Capsaicin content in the samples was estimated by spectrophotometric measurement of the blue coloured component formed as a result of reduction of phosphomolybdic acid to lower acids of molybdenum (Sadasivam and Manikkam 1992). Two grams of dry sample was extracted with 10 ml of dry acetone using pestle and mortar. The extract was centrifuged at 10,000 rpm for 10 min and 1 ml of supernatant was pipetted into a test tube and evaporated to dryness in a hot water-bath. The residue was then dissolved in 0.4 ml of NaOH solution and 3 ml of 3% phosphomolybdic acid. The contents were shaken and allowed to stand for 1 h. The solution was filtered to remove any floating debris and centrifuged at 5000 rpm for 15 min. Absorbance was measured for the clear blue solution, thus obtained, at 650 nm using reagent blank (5 ml of 0.4% NaOH + 3 ml of 3% phosphomolybdic acid). Capsaicin content calculated from the standard curve was expressed as mg/100 g on a dry weight basis.

Ascorbic acid estimation

Ascorbic acid content was determined by the method as described by Albrecht (1993), titrating a known weight of sample against 2,6-dichlorophenol-indophenol dye using 3% metaphosphoric acid as extracting medium. The procedure used was the indophenol method involving aliquots in 3% metaphosphoric solution are titrated with standardized sodium 2-6 dichlorophenolindophenol dye to a faint pink colour that persisted for 5 to 10 sec. The dye was standardized every 48 h and kept for not more than two weeks. 2 g of the fresh sample was mixed with 30 ml of 3% metaphosphoric acid and filtered through No. 4 Whatman filter paper. 10 ml aliquot was pipetted for titration in a 50 ml Erlenmeyer flask with 0.04% dye to a faint pink end point lasting for 5 to 10 sec.

Data analysis

The planting field experiment was design in randomized complete block. The data was subjected to analysis of variance (ANOVA) using the generalized linear model (GLM) of SAS (Statistical Analysis System) software version 8.02. Means were separated by Duncan's multiple range test (DMRT) and significance level was determined at $P < 0.05$.

Table 1 Capsaicin content, vitamin C and carpometric characteristics of 31 accessions of long cayenne pepper from Southwestern Nigeria (rainy season).

Accession	Capsaicin mg/g DW	Ascorbic acid mg/100 g FW	Brix %	pH	Ash
Sango	3.10 ± 0.34 efg	21.73 ± 0.68 g	5.33 ± 0.58 ghi	4.5 ± 0.10 h	1.04 ± 0.05 lmn
Saasa	2.82 ± 0.29 ghi	14.92 ± 0.79 klm	6.17 ± 0.29 cde	5.2 ± 0.3 bcd	1.10 ± 0.05 jkl
Oja-oba	3.35 ± 0.33 ab	15.98 ± 0.88 ijk	6.40 ± 0.36 bcd	5.0 ± 0.06 fg	1.19 ± 0.11 ghi
Bodija	2.40 ± 0.12 k	13.89 ± 1.04 mn	6.17 ± 0.29 cd	5.0 ± 0.0 fg	1.57 ± 0.12 b
Ogbomoso	3.26 ± 0.23 bc	14.70 ± 0.65 klm	5.27 ± 0.25 hij	5.2 ± 0.20 bcd	0.67 ± 0.14 r
Odo-oba	3.07 ± 0.12 efg	15.27 ± 0.43 l jk	4.67 ± 0.58 lm	5.4 ± 0.10 a	0.7 ± 0.17 r
Saki	2.98 ± 0.14 fgh	12.80 ± 1.12 n	4.90 ± 0.36 klm	4.8 ± 0.2 g	1.29 ± 0.03 cde
Ikire	2.94 ± 0.12 fgh	20.02 ± 0.79 h	5.73 ± 0.64 def	5.1 ± 0.2 def	1.67 ± 0.09 a
Ile-ife	3.20 ± 0.35 cd	14.10 ± 0.93 lmn	5.10 ± 0.36 jkl	5.2 ± 0.0 bcd	0.80 ± 0.04 pqr
Osogbo	3.00 ± 0 fgh	37.26 ± 0.29 a	5.45 ± 0.40 efg	5.4 ± 0.1 a	1.41 ± 0.12 bc
Ikirun	3.63 ± 0.15 a	21.92 ± 1.14 g	5.50 ± 0.50 efg	4.9 ± 0.1 g	1.57 ± 0.12 ab
Ado-ekiti	3.10 ± 0.17 efg	24.98 ± 0.85 de	6.0 ± 0 de	5.0 ± 0.1fg	0.93 ± 0.04 nop
Ikole	2.92 ± 0.08 gh	20.80 ± 0.64 gh	4.67 ± 0.58 lm	4.9 ± 0.2 g	1.16 ± 0.14 hij
Aramoko	3.12 ± 0.16 def	19.54 ± 0.46 h	4.77 ± 0.68 klm	5.4 ± 0.3 a	0.99 ± 0.21 mno
Ifaki	2.93 ± 0.11 gh	38.55 ± 0.65 a	4.67 ± 0.58 lm	5.1 ± 0.1 def	0.91 ± 0.09 opq
Otta	3.00 ± 0 fgh	25.69 ± 0.92 cd	4.57 ± 0.60 lm	4.9 ± 0.06 g	1.09 ± 0.10 klm
Abeokuta	2.97 ± 0.06 gh	17.02 ± 1.56 i	4.97 ± 0.60 klm	4.9 ± 0.06 g	1.04 ± 0.16 lmn
Sagamu	2.44 ± 0.05 jk	33.53 ± 0.15 b	5.37 ± 0.35 fgh	5.0 ± 0.15fg	0.96 ± 0.07 nop
Ago-iwoye	2.59 ± 0.15 ijk	19.97 ± 0.69 h	5.23 ± 0.25 ijk	4.9 ± 0.06 g	1.11 ± 0.03 ijk
Offa	2.88 ± 0.17 ghi	17.06 ± 0.73 i	6.50 ± 0.50 bcd	5.2 ± 0.20 bcd	1.13 ± 0.06 hij
Ilorin	3.13 ± 0.28 de	16.10 ± 0.90 ij	7.33 ± 0.58 a	5.1 ± 0.10 def	1.01 ± 0.04 mno
Igbaja	3.57 ± 0.12 a	16.76 ± 0.91 i	7.33 ± 0.58 a	4.9 ± 0.06 g	1.24 ± 0.04 fgh
Omu-aran	3.00 ± 0 fgh	24.20 ± 0.96 ef	4.50 ± 0.50 m	5.1 ± 0.12 def	1.23 ± 0.05 fgh
Ikorodu	2.83 ± 0.15 ghi	14.36 ± 1.39 lm	6.83 ± 0.76 ab	5.1 ± 0.20 def	1.00 ± 0.11 mno
Ipaja	2.50 ± 0.37 jk	26.80 ± 0.60 c	6.67 ± 0.58 ab	5.0 ± 0.0fg	1.2 ± 0.0 ghi
Oshodi	3.23 ± 0.12 bc	15.01 ± 0.91 klm	6.50 ± 0.50 bc	5.1 ± 0.20 def	1.28 ± 0.05 def
Agege	2.73 ± 0.16 hij	23.31 ± 0.37 f	5.60 ± 0.53 ef	5.1 ± 0.15 def	1.32 ± 0.03 cd
Akure	3.05 ± 0.10 efg	15.27 ± 0.58 jkl	5.43 ± 0.12 fgh	5.0 ± 0.0fg	1.25 ± 0.21 efg
Ore	3.20 ± 0.17 cd	14.86 ± 0.85 klm	4.33 ± 0.58 mn	5.0 ± 0.0fg	0.92 ± 0.01 opq
Ikare	3.07 ± 0.09 efg	16.01 ± 0.30 ijk	6.47 ± 0.50 bcd	5.0 ± 0.0fg	0.79 ± 0.08 qr
Ifon	2.37 ± 0.15 k	21 89 ± 1.15 g	3.67 ± 0.42	5.2 ± 0.15 bcd	0.87 ± 0.03 pq
LSD(0.05)	0.301	1.376	0.786	0.218	0.164
RSD %	6.179	4.186	8.671	2.638	9.029

Values are means of triplicate analysis ± standard deviation. Means in the same column with different superscript letters are significantly different from each other ($P < 0.05$)

RESULTS AND DISCUSSION

Eating quality is important for determining the value of long cayenne pepper accessions. Total soluble solid (TSS), pH and ash content are important factors for evaluating pepper quality. In this experiment, TSS, pH and ash content were determine in 31 accession of long cayenne pepper from southwestern Nigeria cultivated in two major season in the tropics: rainy and dry seasons. All data obtained are shown in (**Tables 1, 2**).

The pH values for the two seasons were the only evaluated characteristic that showed little variation of relative standard deviation (RSD %) of less that 3%. The pH of the rainy season (**Table 1**) and dry season (**Table 2**) ranged from 4.5 to 5.2 and 4.9 to 5.3, respectively. Total soluble solid is an estimate of fruit sugar content and eating quality. Soluble solids varied from 3.67 to 7.33 °Brix for rainy season and 7.8 to 10.95 °Brix for the dry season. The RSD % of the two season greater than 3% which shown high variability. While the ash content varied from 0.67 to 1.67 % with (RSD 9.029%) for the rainy season. While the dry season for ash content ranged from 0.83 to 1.51% with (RSD 7.228%).

In the bioactive contents, large differences in ascorbic acid content were observed among the 31 accession of long cayenne pepper (**Tables 1, 2**). Ascorbic acid content in long cayenne pepper ranged from 13.89 to 38.55 mg/100 g in rainy season (**Table 1**), and it ranged from 16.95 to 76.75 mg/100 g in dry season (**Table 2**). There was statistically significant difference ($P < 0.05$) among the ascorbic acid content of all accession. With regard to recommended dietary allowance (RDA), a 100-g serving of fresh pepper could supply more than 100% of RDA (60 mg/day) for vitamin C. However, four accession of the long cayenne pepper in the dry season were found to be exceptionally good as they exceed 100% of RDA. All the accessions of the long cayenne pepper during the rainy season were found to be low in the ascorbic acid, which the accessions does not meet the 100 % RDA. However, variation in ascorbic acid content can be attributed to multiple factors such as temperature conditions, accession response and sampling variation. Overall, the interaction of accession and planting period were also significant. The results show (**Table 3**) a 1.63-fold increase in ascorbic acid content in dry season than the rainy season.

The capsaicin which responsible for the pungency in pepper, varied between 2.37 and 3.63 mg/g dry fruit (6.18% RSD) for the rainy season (**Table 1**) and 2.74 and 3.92 mg/g dry fruit (4.81% RSD) for the dry season (**Table 2**). The low capsaicin content for a given accession depends upon various factors: the level of expression of the genes, physiological, morphological characteristics intrinsic to the accession, growth condition and periods. The pungent of pepper (*Capsaicum annuum* L.) contain very high amount of capsaicin ranging from 42 to 64.8 mg/g dry weight (DW) (Pino *et al*. 2007).

However, the cayenne pepper accession analysed in the present study contains low content of capsaicin, which contributes to their characteristics flavor and also make them suitable for culinary preparation. Furthermore, pungency is

Table 2 Capsaicin content, vitamin C and carpometric characteristics of 31 accessions of long cayenne pepper from Southwestern Nigeria (dry season).

Accession	Capsaicin mg/g DW	Ascorbic acid mg/100 g FW	Brix %	pH	Ash
Sango	3.1 ± 0.14 jk	31.49 ± 1.19 g	10.0 ± 0.62 def	5.1 ± 0.12 def	1.10 ± 0.13 ghi
Saasa	3.46 ± 0.21 fgh	19.98 ± 0.24 p	7.8 ± 0.72 m	5.0 ± 0.0 def	0.83 ± 0.10 l
Oja-oba	3.33 ± 0.09 hij	43.68 ± 0.40 e	10.27 ± 0.46 bcd	5.1 ± 0.17 de	1.51 ± 0.07 a
Bodija	2.36 ± 0.21 n	26.23 ± 0.54 j	10.07 ± 0.40 def	4.9 ± 0.1 f	1.35 ± 0.12 bc
Ogbomoso	3.71 ± 0.26 cde	16.95 ± 0.39 r	9.87 ± 0.47 cde	5.0 ± 0.0 def	1.02 ± 0.03 ij
Odo-oba	2.67 ± 0.26 lm	25.87 ± 0.34 j	9.57 ± 0.45 ghi	5.1 ± 0.17 de	0.95 ± 0.07 jkl
Saki	2.86 ± 0.12 kl	19.66 ± 1.01 pq	8 87 ± 0.54 kl	4.9 ± 0.17 f	0.99 ± 0.09 ijk
Ikire	3.43 ± 0.14 fgh	21.53 ± 1.79 no	9.97 ± 0.30 def	5.13 ± 0.12 cde	1.51 ± 0.09 a
Ile-ife	3.59 ± 0.32 def	65.02 ± 0.91 c	9.47 ± 0.54 jk	5.0 ± 0.0 def	1.00 ± 0.09 ijk
Osogbo	2.89 ± 0.09 kl	32.11 ± 0.56 g	10.30 ± 0.75 bcd	5.1 ± 0.12 de	1.04 ± 0.07 ij
Ikirun	3.49 ± 0.24 efg	76.75 ± 0.39 a	8.83 ± 0.29 l	5.1 ± 0.12 de	1.03 ± 0.05 ij
Ado-ekiti	3.81 ± 0.10 abc	25.11 ± 1.01 jk	9.62 ± 0.38 ghi	5.1 ± 0.12 de	1.16 ± 0.03 efg
Ikole	2.34 ± 0. 04 n	25.16 ± 0.88 j	8.87 ± 0.16 kl	5.0 ± 0.0 def	1.24 ± 0.10 cde
Aramoko	2.83 ± 0.13 l	30.83 ± 1.09 g	9.99 ± 0.24 def	5.1 ± 0.12 de	1.08 ± 0.04 hij
Ifaki	2.48 ± 0.21 mn	21.04 ± 1.49 nop	9.41 ± 0.37 jkl	5.1 ± 0.17 de	1.26 ± 0.11 cd
Otta	3.22 ± 0.21hij	61.00 ± 0.70 d	9.81 ± 0.37 efg	5.0 ± 0.0 def	1.10 ± 0.09 ghi
Abeokuta	3.58 ± 0.09 def	18.28 ± 0.77 qr	10.59 ± 0.53 bc	5.0 ± 0.0 def	1.24 ± 0.05 cde
Sagamu	3.36 ± 0.08 hij	21.01 ± 1.02 nop	10.07 ± 0.37 cde	5.5 ± 0.1	1.13 ± 0.11 fgh
Ago-iwoye	3.40 ± 0.13 ghi	27.83 ± 0.55 hi	9.40 ± 0.17 jkl	5.1 ± 0.17 de	1.25 ± 0.10 cd
Offa	3.69 ± 0.17 cde	28.21 ± 0.28 h	9.02 ± 0.28 kl	5.1 ± 0.17 de	0.98 ± 0.16 ijk
Ilorin	3.63 ± 0.20 cde	28.28 ± 0.72 h	10.93 ± 0.70 a	5.1 ± 0.12 de	1.47 ± 0.05 ab
Igbaja	3.75 ± 0.15 bcd	25.80 ± 1.40 j	9 73 ± 0.98 fgh	5.1 ± 0.10 de	1.53 ± 0.09 a
Omu-aran	3.82 ± 0.07 abc	26.53 ± 0.85 ij	8.99 ± 0.24 kl	5.1 ± 0.21 de	0.99 ± 0.01 ijk
Ikorodu	3.83 ± 0.08 abc	20.61 ± 0.83 nop	9.08 ± 0.14 kl	5.3 ± 0.12 abc	1.03 ± 0.03 ij
Ipaja	3.48 ± 0.03 efg	23.57 ± 1.09 kl	9.00 ± 0.25 kl	5.2 ± 0.12 bcd	1.30 ± 0.09 c
Oshodi	3.17 ± 0.18 ij	20.91 ± 1.33 nop	8 .31 ± 0.34l	5.1 ± 0.12 de	1.48 ± 0.06 ab
Agege	2.87 ± 0.13 kl	23.10 ± 0.40 lm	10.95 ± 0.33 a	5.2 ± 0.20 bcd	1.04 ± 0.09 ij
Akure	3.77 ± 0.15 bc	41.56 ± 1.13 f	8.96 ± 0.30 kl	5.0 ± 0.0 def	0.93 ± 0.09 kl
Ore	3.92 ± 0.06 a	71.04 ± 1.31 b	10.63 ± 0.32 ab	5.1 ± 0.17 de	1.23 ± 0.03 def
Ikare	3.86 ± 0.07 ab	20.27 ± 1.40 op	9.33 ± 0.39 jkl	5.3 ± 0.20 abc	1.01 ± 0.08 ijk
Ifon	2.87 ± 0.08 kl	21.87 ± 0.46 mn	9.17 ± 0.29 jkl	5.0 ± 0.0 def	0.95 ± 0.09 jkl
LSD (0.05)	0.260	1.540	0.735	0.209	0.136
RSD %	4.811	3.043	4.693	2.521	7.228

Values are means of triplicate analysis ± standard deviation. Means in the same column with different superscript letters are significantly different from each other ($P < 0.05$)

Table 3 *t*-Test to compare the rainy and dry season of capsaicin, ascorbic acid, TSS, pH and ash contents in 31 accessions of long cayenne pepper.

Season	Capsaicin	Ascorbic acid	Brix %	pH	Ash %
Rainy	2.98 ± 0.34 b	20.14 ± 6.67 b	5.55 ± 0.98 b	5.06 ± 0.20 a	1.11 ± 0.26 a
Dry	3.31 ± 0.48 a	31.01 ± 15.80 a	9.59 ± 0.80 a	5.09 ± 0.16 a	1.15 ± 0.21 a
LSD (0.05)	0.120	3.509	0.259	0.053	0.067

Means in the same column with different superscript letters are significantly different from each other ($P < 0.05$)

not only organoleptic feature chosen for local cooking, since aroma; flavor and colour are also appreciated, which is maintaining a demand for long cayenne pepper. However, it was interesting to note that though there were drastic differences in capsaicin levels among the accession and there was a 1.2-fold increase in the capsaicin level between the two seasons.

CONCLUSION

The present work showed the seasonal growing period of 31 accession of long cayenne pepper on capsaicin, ascorbic acid and carpometric characteristics. The total soluble solid, capsaicin and ascorbic acid content of long cayenne pepper were markedly affected by the choice of seasonal growing period. Since pepper is an importance vegetable in human nutrition, it is very interesting to know what the contribution of an individual food product is to daily nutritional needs and how change in environment affect nutritive composition and carpometric characteristics.

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