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Evaluating the Variability in Lycopene and Agronomic Characteristics of Different Tomato (*Lycopersicon esculentum Mill*) Genotypes

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ABSTRACTS: The study was aimed at generating data in breeding for tomato varieties with improved lycopene content. Different tomato genotypes were evaluated for variability in lycopene and agronomic characteristics. The lycopene content obtained ranged from 0.024 ±0.004mg/g to 0.190±0.008mg/g. LOO170 recorded the highest lycopene while NGRM10001 recorded the lowest lycopene. Lycopene in all tomato genotypes evaluated showed a coefficient of variation of 55.10%. This indicated variability in the lycopene content of tomato varieties. Traits such as fruit weight, number of fruits per plant and growth rate also showed high estimate of coefficient of variation thus suggesting a positive correlation with lycopene content. High coefficient of variation in these traits thus serves as indices for selection in tomato breeding programme.

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Tomato (*Lycopersiconesculentum Mill*) is one of the world's major traded vegetable. It is very important as a source of vitamin A and C, minerals and carotenoids such as lycopene. According to Ahmad and Sharma (2011), tomato is regarded as a protective food with several nutritive value traits especially antioxidant compounds which are used in several commercial therapeutic formulation. Recent studies indicate that lycopene (carotenoid that gives ripe tomato its bright red color), is very effective natural antioxidant and quencher of free radicals (Mascio, Kaiser and Sies 1989). The ability of lycopene to act as a potent antioxidant is thought to be responsible for protecting cells against oxidative damage and thereby decreasing the risks of diseases such as nervous system problems, heart diseases, skin diseases (induced by ultraviolet light), cancer and obesity (Ibitoye *et al*. 2009; Giovannucci 2002; Adewuyi and Ademoyegun 2008 and Loco 2011). Lycopene content of tomato typically ranges from 7 to 13 mg/100g depending on variety, geographical location, technique of cultivation, climatic conditions and degree of ripeness of the fruit (Schierle *et al*. 1997).

The above value may have been deduced from the evaluations that have been carried out thus far. Rao and Agarwal (1998) reported lycopene in fresh tomatoes to range from 2.5-20mg/100g. While Garcia and Barrett (2006) reported a lycopene range of 5.5 to 18.1mg/100g in nine tomato genotypes evaluated. More recently, Ibitoye *et al*. (2009) reported a lower range of 7.25 to 14.73mg/100 in nine cultivated tomato germplasms evaluated for their lycopene content. Ahmad and Sharma (2011) stated that genetic variability is essentially the first step in breeding for improvement.It therefore means that the varied lycopene content in tomato is directly highlighting the possibility of higher yield, hence we decided in this research work, to screen for genotypes with lycopene yield higher than those obtained from previous evaluation. Also considering the potential health benefits of lycopenes, it will be worthwhile to seek genotypes that serve as a high reservoir of lycopene for further breeding program. Lycopene levels in plants have been observed to be directly related to ripeness and increasing pH (Sandei*et al*. 2003). As a result, we also decided to correlate the lycopene content with some selected agronomic traits.

A lot of tomato improvement has been achieved via the introgression of new valuable genes into the tomato gene pool (Passam *et al.* 2007). Presently, the focus in tomato breeding is on nutritional quality (Bai and Lindhout 2007; Atanassova 2003; Shimelis and Laing 2012.). This nutritional quality has stirred up a global effort in developing tomato cultivars rich in lycopene, processing traits, high yielding and quality fruits. In order to the meet this goal, we decided in addition to evaluating for lycopene content to also include some agronomic traits that could be used in

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composite breeding. Here we report on the variation in lycopene content and its correlation with some agronomic traits as our first step in pursuing the above stated mandate.

MATERIALS AND METHODS

Plant Materials: The following germplasm were collected from the National Centre for Genetic Resource and Biotechnology (NACGRAB); NGB01255, NGB01232, NGHAA/SEP/09037, L00169, NG/AA/SEP/09/053, NGMR09005, NGMR/MAY09/005, L00170, NGSA10002 and NGRM10001. LOCAL X1 and LOCAL X2 were collected from farmers at Igbodo, Delta State.

Study area: This work was carried out in the Botanical garden of the Department of Plant Biology and Biotechnology, Faculty of Life Sciences, University of Benin, Benin City, Edo State, Nigeria. The Spectrophotometry and other laboratory work were carried out in the same Department as above.

Experimental Design and Field management: After the nursery, the transplanted tomato seedlings were seeded on the prepared soil using a randomized complete block design in three replicates. The experimental plot contained 25 plants arranged in five rows spaced 40cm apart with 1m spacing between and within each plot. The total field area measured 9.4x 5.0 m, the varieties were taken as treatments. The normal cultural practice such as weeding, application of manure and irrigation during the period of very low rainfall was carried out regularly.

Agronomic Traits evaluation: Preliminary evaluation were carried out on the following traits; Number of fruits per plant at first flush, Fruit size, Fruit fresh weight, Fruit pH.

Determination of number of fruits per plant at first flush: The number of ripe fruits harvested from each plant at first flush was recorded as the number of fruits per plant.

Determination of fruit size: The transverse section of the fruits of each genotype was placed on a graph paper. The mark made on the paper was measured to give the fruit diameter.

Determination of fruit fresh weight: The fresh weight of the fruits for different genotypes was taken using an electronic weighing balance.

Determination of fruit pH: The pulp from the fruits of each tomato genotype was placed in a bottle. The electrode of a standardized pH meter was dipped into each of the bottles and the pH reading was taken when a steady stage was reached.

Lycopene Estimation: The lycopene content of the fruits were analyzed spectrophotometrically at a wavelength of 503nm. The lycopene of the tomato fruits were extracted using a mixed solvent of hexane, ethanol and acetone in a 2:1:1 ratio as described by Ibitoye *et al.* (2009). Three readings were taken for each accession representing fruits of different flushes. The lycopene values were expressed in mg/g of tomato fruit.

RESULTS AND DISCUSSION

Agronomic Parameters: Among the number of fruits produced by each tomato genotypes at first flush, LOO169 recorded the highest number of fruits (10.67±1.86) representing the highest yield. However this genotype had the lowest fruit weight and size (Table1). The highest fruit weight was recorded from NGB0155 with fruit weight and size of 86.57±3.32g and5.04±0.05 respectively. The fruit pH recorded in all the tomato genotypes range 3.60-4.57 indicating that tomato is purely acidic. The lowest pH of 3.60 was recorded fromNGRM10001.

Lycopene Content: In this project the lycopene trait showed a high coefficient of variation (55.10%). Among the tomato genotype, LOO170 recorded the highest lycopene content of 0.190±0.008mg/g followed by GAASEP09053 and NGMRO9005 (table2). The lowest lycopene content was recorded for GRM10001 and LOO169 with a mean value of 0.024±0.004mg/g and 0.030±0.013mg/g respectively.

Correlation of Lycopene with Agronomic traits: Evaluation of the different tomato genotypes showed the relationship between some agronomic traits and lycopene content in the fruit of the tomato genotypes studied. Fruit characteristics such as fruit weight and size varied among the tomato genotypes. LOO169 and NGRM1001 recorded the lowest fruit weight and lycopene content. While NGB01255 genotype had the highest fruit weight and size but low lycopene content. However, LOO170 showed high fruit weight and high lycopene content. Generally, the fruit weight varied along with the lycopene content

The lycopene content in the fruits of twelve (12) tomato genotypes were analyzed. Based on the analysis, the lycopene content ranged from 0.024 to 0.190mg/g (table2). The lycopene in the fruit of LOO170 was found to be high compared to previously reported values. Ahmad and Sharma (2011) reported a lower range of 1.98-4.62mg/100g in fresh tomato. Dufera (2013) also reported a lower range of 0.97-

3.29mg/100g. Brandt *et al*. (2003) and Ibitoye *et al*. (2009) reported a comparable lycopene range of 6-16mg/100g and 7.02-14.73mg/100g respectively. The range of the lycopene evaluation in this work in accordance with other reports signify a high variation in lycopene content in tomato varieties grown in different regions of the world. This is implicated by the high coefficient of variation (55.10%) obtained in this work. The high coefficient of variation could serve as indices for selection in tomato breeding. The difference in lycopene recorded in fruits of tomato genotypes could be as a result of responses to different environmental conditions. Schierle *et al.* (1997) reported that the lycopene content of tomato typically ranges from 7 to 13mg/100g depending on variety, geographical location, technique of cultivation and climatic condition.

Table 1: Selected agronomic traits; Fruit Characteristics of Tomato genotypes

Accession Number	Fruit Weight (g)	Fruit Size (cm)	Fruit pH	No. of Fruits per Plant
Local X_1	28.68 ± 4.12*cd*	3.59 ± 0.14*f*	3.90	8.50 ± 1.50*ab*
Local X_2	26.27 ± 0.66*bcd*	2.15 ± 0.03*b*	4.00	3.50 ± 0.50*a*
NGBO 1255	86.57 ± 3.32*e*	5.04 ± 0.05*g*	4.13	3.00 ± 1.00*a*
NGBO 1232	17.89 ± 0.90*b*	3.28 ± 0.09*def*	4.15	7.33 ± 1.09*b*
NGHAA/SEP09037	29.54 ± 0.62*cd*	3.61 ± 0.06*f*	4.05	4.00 ± 1.08*ab*
LOO 169	1.42 ± 0.13*a*	0.86 ± 0.14*a*	4.00	10.67 ± 1.86*b*
NGAA/SEP09053	19.15 ± 0.70*bc*	3.15 ± 0.12*de*	4.57	7.50 ± 2.50*ab*
NGMR 09005	31.53 ± 10.39*d*	3.45 ± 0.21*ef*	4.34	3.33 ± 0.33*a*
NGMRMAY 09005	17.30 ± 1.59*b*	3.05 ± 0.10*cd*	4.60	5.50 ± 3.30*ab*
LOO 170	27.85 ± 0.94*bcd*	3.60 ± 0.09*f*	4.00	3.33 ± 0.88*a*
NGSA 10002	6.23 ± 0.16*a*	2.45 ± 0.02*b*	3.90	10.50 ± 1.46*b*
NGRM 10001	0.43 ± 0.06*a*	0.92 ± 0.16*a*	3.60	10.33 ± 1.45*b*
Means ± S. E.	**24.41 ± 6.47**	**2.93 ± 0.34**	**4.10 ± 0.68**	**6.46 ± 0.88**
C. V. (%)	**91.87**	**11.67**	**1.98**	**47.23**

Values with same subscripts (letters) are not significantly different at 0.05 levels of significance.

L00170 recorded the highest lycopene content of 0.190±0.008mg/g which is reasonably high when compared to other varieties (table2). This suggest that this variety can be used as a parent in breeding for higher lycopene especially with marketable varieties.
In this work, marketable tomato varieties, LOCAL X1 and LOCAL X2 showed low lycopene content compared to some of the genotypes from NACGRAB. This highlighted the importance of a targeted breeding. In such breeding programme, identification of tomato varieties with high potential of lycopene and crossing them with varieties having other economically important traits is the first step in breeding strategies (Dufera 2013). This kind of breeding, we have also coined in this work as composite breeding.

Table 2: Fruit lycopene content of tomato genotypes

Accession Number	Fruit Lycopene Content (mg/g)
Local X_1	0.067 ± 0.002*bcd*
Local X_2	0.086 ± 0.010*cde*
NGBO 1255	0.059 ± 0.004*bc*
NGBO 1232	0.083 ± 0.005*cde*
NGHAA/SEP09037	0.042 ± 0.009*ab*
LOO 169	0.028 ± 0.008*a*
NGAA/SEP09053	0.097 ± 0.022*e*
NGMR 09005	0.096 ± 0.003*de*
NGMRMAY 09005	0.091 ± 0.010*de*
LOO 170	0.190 ± 0.008*f*
NGSA 10002	0.080 ± 0.007*cde*
NGRM 10001	0.024 ± 0.004*a*
Means ± S. E.	**0.079 ± 0.013**
C. V. (%)	**55.10**

Values with same subscripts (letters) are not significantly different at 0.05 levels of significance.

In search of economically important traits, we decided to evaluate some agronomic traits along with lycopene. The high coefficient of variation observed in lycopene, was also seen in growth rate, fruit weight and number of fruits per tomato plant evaluated.This suggests a correlation between lycopene and these agronomic traits. In our future work, we hope to check the segregation of lycopene gene with the aforementioned agronomic traits through molecular studies.

In conclusion, it is evident from this work that tomato varieties differ in their level of lycopene and yield. The high coefficient of variation recorded by these characters can serve as a basis for breeding and improving tomato varieties. Moreover, on the basis of the potential health benefits of lycopene, screening for tomato with high lycopene content with high fruit quality is worthwhile.

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