PHYSICOCHEMICAL PROPERTIES OF FOUR TOMATO CULTIVARS GROWN IN NIGERIA

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ABSTRACT

The physicochemical characteristics of tomato fruits from three commercial cultivars available in the local market were compared with a Wild cultivar. The results showed that the Ibadan-Local and Wild cultivars had a higher fruit yield than Ife-1 and Roma-VF cultivars. The Wild cultivar has a high skin and seed content. The shape of the fruits varied from spherical to pear-like. Physicochemical properties such as specific gravity, pH, titratable acidity, ash and refractive index did not vary significantly while total solids, longitudinal (stem→blossom end) and cross-sectional diameters (transverse diameter), vitamin C and reducing sugars were significantly different ($P > 0.05$) among the cultivars investigated. The results showed that the Wild cultivar has attributes (i.e., physicochemical characteristics) comparable to commercial cultivars to recommend it to breeders for cultivation.

INTRODUCTION

Tomato is a commercially important vegetable throughout the world both for the fresh-fruit market and the processed food industries. It is grown in a wide range of climates in the field, and even under protection in plastic greenhouses and heated glass houses (Atherton and Rudich 1986). Apart from its characteristic flavor and aroma, it is also a good source of vitamins (A and C) and minerals (Kaur *et al.* 1999; Akanbi and Oludemi 2003). Tomato is consumed in quite large quantities: directly as salads, cooked into soups or

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processed into juice, ketchup, whole-peeled tomato and tomato paste. Processing of tomatoes to a puree or paste is an added value, as it frees lycopene from the tomato matrix, thus enhancing its bioavailability. Processing has tremendous impact on the retention of nutrients and their availability in the body (Kaur *et al.* 1999). The tomato is being increasingly investigated in genetic, chemical and technological studies after it was shown that lycopene plays an important role in reducing cardiovascular disease and digestive tract tumors. Lycopene is the predominant carotenoid pigment of tomato that contributes to its characteristic red color. It also functions as an antioxidant and helps in lowering DNA damage, malignant transformations and other parameters of cell damage and reduces cancer risk (Kaur *et al.* 1999; Pagliarini *et al.* 2001).

Tomato production in Nigeria has more than doubled in the last 10 years and the production in 2001 alone was about 879,000 t. There are several tomato cultivars grown in Nigeria, but their availability is sometimes restricted to certain regions of the country. The three most commonly available tomato cultivars in the Southwestern Nigerian market are: Ibadan-Local, Roma-VF and Ife-1 (Akanbi and Oludemi 2003). Although many new tomato cultivars are being developed in order to improve yield, crack resistance, quality of fruit and so on (Moresi and Liverotti 1982; Adegoroye and Eniayeju 1988), there are still some wild cultivars that have potentials not yet harnessed. Atherton and Rudich (1986) reported that there is a wide range of adaptive and physiological traits in wild species that remain to be exploited by plant breeders. The Wild cultivar (*Lysopersicum pimpinellifolium*) has been reported to have a high yield and to fruit for a longer period than the Ibadan-Local, Roma-VF and Ife-1 cultivars. The Wild cultivar can flower during the dry season, is highly resistant to pests and can survive in a wide range of conditions (Adedeji 2005).

Based on the market demand for tomatoes for fresh and industrial processing, various studies have been carried out on the relationship between the chemical–physical and sensory parameters of tomatoes (Viswanathan *et al.* 1997; Pagliarini *et al.* 2001; Batu 2003). The design of appropriate machinery for mechanizing the processing of tomato requires knowledge of the physical properties of the fruits (Oje *et al.* 1999). The objective of this work was to compare the physicochemical characteristics of wild tomato (*L. pimpinellifolium*) with some known commercial cultivars like Roma-VF, Ife-1 and Ibadan-Local.

MATERIALS AND METHODS

Raw Materials

Seeds of four tomato cultivars: Wild (*L. pimpinellifolium*) [Jusl] Mill.); Ife-1 (*Lysopersicum esculentum* Mill. Cv.); Ibadan-Local (*L. esculentum* Mill.

Cv.); and Roma-VF (*L. esculentum* Mill. Cv.) were sown and nursery-raised at the Obafemi Awolowo University teaching and research farm. When the seedlings were 35 days old, they were transplanted and spaced at a distance of 0.5 m within rows. Each cultivar was replicated three times (25 plants per replicate). The harvesting of fruits started 2 months after transplanting (Ereifej *et al.* 1997) and it lasted for 3 months. Fully mature and ripened fresh tomatoes were obtained from the university farm on the same day the experiments were carried out. Some samples were stored in a refrigerator at 4C and then brought to room temperature for at least 3 h prior to use (Pagliarini *et al.* 2001).

Physical Properties

Twelve fruits of each replicate were randomly selected and the average fruit weights and specific gravity (weight in air/weight in water) were recorded (Ereifej *et al.* 1997). The seed–pulp–skin content – the individual weights of seeds, pulp (juice) and skin present in tomato fruits – were determined by separating them manually. The mean of 10 samples was evaluated (Viswanathan *et al.* 1997).

The size of the fruit was determined using a vernier caliper to values at least 0.01 mm. The diameters were measured along the longitudinal (stem to blossom end) and cross-sectional axis (transverse diameter). Twenty-five fruits from each cultivar were randomly selected for measurement and the mean value was evaluated as described by Viswanathan *et al.* (1997).

Chemical Properties

Six replicate samples of 12 fruits per treatment were homogenized in a laboratory blender at high speed for 1 min and then subjected to analysis. The pH, titratable acidity (as % citric acid), reducing sugars and ash content were determined by AOAC (1984) methods, while the refractive index was determined using a bench-top refractometer (model 110571, Carl Zeiss, Dresden, Germany). The homogenates were filtered and the total soluble solids of the resulting clear juice samples was determined by placing 2–3 drops of the undiluted juice in the refractometer. Analyses were carried out in duplicate. Moisture content of the fruits was determined by keeping the samples in a thermostatically controlled electric oven at 105 ± 1C for 2 h (AOAC 1984; Viswanathan *et al.* 1997). Total solids were obtained from the dry solids remaining in the moisture-content determination.

Statistical analysis

The data obtained from the experimental designs were analyzed statistically using the *t*-test and least significant difference test (LSD) among the means at 95% confidence interval according to Stoodley *et al.* (1980).

RESULTS AND DISCUSSION

The dimensions of the tomatoes are presented in Table 1. There is a significant difference ($P > 0.05$) in both the longitudinal (stem to blossom end) and cross-sectional (transverse diameter) dimensions of the cultivars. The Ibadan-Local cultivar has the highest longitudinal and cross-sectional diameters followed by Roma-VF. This result does not agree with that of Viswanathan *et al.* (1997) that the diameter along the cross-section is mostly greater than the longitudinal diameter. Rather, it agrees with the observation of Atherton and Rudich (1986) that tomato cultivars differ greatly in fruit shape and may be spherical, oblate, elongated or pear-like. Both the Wild cultivar and Roma-VF cultivar have their respective longitudinal and cross-sectional diameters measurements very close to each other. There was a distinct difference in the longitudinal and cross-sectional dimensions of the Ibadan-Local and Roma-VF cultivars.

Fruit weight varied significantly ($P > 0.05$) among the investigated cultivars (Table 1). The Ibadan-Local cultivar had higher weight than the others

TABLE 1.
PHYSICOCHEMICAL CHARACTERISTICS OF TOMATO CULTIVARS*

Properties	Tomato cultivars			
	Wild	Ife-1	Ibadan-Local	Roma-VF
Ash	0.60b	0.52a	0.55a	0.50a
Weight of whole fruit, g	4.85a	23.48b	74.58d	35.73c
Weight of seed, g (%)	0.56a	2.3c	3.90d	0.79b
	(11.55)	(9.80)	(5.23)	(2.21)
Weight of skin, g (%)	0.48a	1.36b	4.81d	2.50c
	(9.90)	(5.54)	(6.45)	(7.00)
Weight of pulp + juice, g (%)	3.8a	19.82b	65.87d	32.44c
	(78.56)	(84.41)	(88.32)	(90.79)
Average number of seeds/fruit	57a	108c	222d	91b
Average number of fruits per plant stand	1072d	103c	91b	62a
Fruit length (stem→blossom; cm)	1.62a	2.67b	3.49c	4.76d
Fruit length (transverse; cm)	1.71a	3.27b	6.28d	4.67c
Specific gravity (weight in air/weight in water)	1.025b	0.986ab	1.018ab	0.97a
Total solids (%)	6.4d	5.93c	4.64a	5.26b
Reducing sugars (%)	1.032b	1.625c	0.64a	2.17d
Refractive index	1.49a	1.44a	1.59b	1.44a
Vitamin C (mg/100g)	18.75b	24.75d	10.50a	22.50c
Titratative acidity (% citric acid)	0.70b	0.63a	0.8c	0.65ab
pH	4.26a	4.52a	4.32a	4.45a

* Means in each row followed by the same letter are not significantly different, $P < 0.05$.

followed by the Roma-VF cultivar. The Wild cultivar had the lowest fruit weight. However, going by the average number of fruits per stand, the Ibadan-Local cultivar has the highest fruit yield of 6.79 kg per stand followed by the Wild cultivar with approximately 5.20 kg of fruit per stand. The fruit yields of the other cultivars were 2.42 and 2.20 kg for Ife-1 and Roma-VF, respectively. The highest fruit-yielding cultivar would be of great interest to tomato growers (Atherton and Rudich 1986). Percentage-seed content by weight ranged between 2.21 and 11.55%, while the skin content by weight varied between 5.54 and 9.90%, with the Wild cultivar having the highest values. This agrees with the report of Atherton and Rudich (1986) that there is a strong negative correlation between fruit weight and percentage-locular tissue. Furthermore, these authors reported that locular tissues have a higher acid content than the pericarp. This may account for the higher titratable acidity content in the Ibadan-Local tomato cultivar. For an equal fruit weight of 74.58 g, the Ibadan-Local cultivar would have an average of 222 seeds (Table 1), while the Wild cultivar would have 877 seeds. To the processor, cultivars with lower skin and seed content are preferable as these are removed during processing, thereby constituting a loss.

The specific gravities of the four cultivars studied did not differ significantly ($P < 0.05$). The values were close (0.98–1.03), which agrees with the range of values reported by Ereifej *et al.* (1997). The specific gravity of a plant tissue is a valuable index of its maturity (Joslyn 1970) and this confirms that the tomato fruits used in experimentation were of similar ripeness. Refractive-index values for the four cultivars ranged between 1.43 and 1.60 for the Roma-VF and Ibadan-Local cultivars, respectively. There was a negative correlation between the refractive index and total weight of the Ibadan-Local cultivar. The Wild cultivar had the highest value of total solids (6.40%), while the Ibadan-Local cultivar – which has the highest value of refractive index – had the lowest value of total solids (4.64%). The total solids content of the four cultivars were significantly different ($P > 0.05$). This has implications for processing. It suggests that the Wild cultivar would require a smaller quantity of tomatoes to obtain a certain level of quality in production of products such as purees and pastes, thus reducing the cost of the product. This agrees with the report of Kaur *et al.* (1999).

Typical values were reported for ash content (Table 1). Although there were no significant differences among the cultivars studied, it is worthy to note that the Ibadan-Local and Wild cultivars had higher values than Ife-1 and Roma-VF. This implies higher mineral constituents in the Wild and Ibadan-Local cultivars (Joslyn 1970). There were significant differences ($P > 0.05$) in the content of reducing sugars among the cultivars. Values ranged between 0.64 and 2.18%. These values are low compared to the range of 1.1–4.1% reported for seven cultivars by Ereifej *et al.* (1997). It is interesting to note that

Ife-1 and Roma-VF were higher in reducing sugars than the Wild and Ibadan-Local cultivars. Atherton and Rudich (1986) reported that high sugar and high acid contents are required for best flavor (i.e., sweetness, sourness and overall flavor intensity) in tomatoes. The above observation could not be corroborated by the results of this study. The cultivars that had higher titratable acidity values showed lower contents of reducing sugars and vice versa, suggesting that these cultivars showed no superiority of quality over one another.

The vitamin C content varied among the cultivars. The Ife-1 cultivar had the highest vitamin C content of 24.75 mg/100 g closely followed by Roma-VF having a value of 22.5 mg/100 g. The Ibadan-Local cultivar had the least, with a value of 10.50 mg/100 g. The vitamin C content (18.75 mg/100 g) of the Wild species was not significantly different ($P < 0.05$) from those of the cultivated species (i.e., Ife-1 and Roma-VF). This wide range in values reported for vitamin C content of the cultivars agrees with the report that there is a large variation in vitamin C levels among cultivars and species (Atherton and Rudich 1986; Kaur *et al.* 1999). Vitamin C is a very heat-labile component and its retention is affected by thermal processing. Because tomato is mainly consumed in the processed form, using a cultivar with high vitamin C content is preferable.

Titratable acidity and pH values for the four cultivars were similar for all the cultivars; however, Ibadan-Local was the most acidic. The pH values were within the range of pH values reported by Moresi and Liverotti (1982) who attributed this to be mainly because of the presence of citric and malic acids. Atherton and Rudich (1986) noted that there is a tremendous variation among tomato genotypes for pH and titratable acids. High acid values are required for best flavor. Our data indicate that the Wild and Ibadan-Local cultivars as having higher acid values than Ife-1 and Roma-VF cultivars, which implies better flavor. Acids present in foods not only improve the palatability of many fruit products but also influence their nutritive value by playing a significant role in the maintenance of acid–base balance in the body. The acids influence the flavor, brightness of color, stability, consistency and keeping quality of the product. In addition, acidity of the tomato juice greatly influences the processing time and temperature of the product (Kaur *et al.* 1999).

CONCLUSION

The physicochemical characteristics of a wild tomato (*L. pimpinellifolium*) were compared with the available commercial cultivars of Roma VF, Ife-1 and Ibadan-Local. Some characteristics such as specific gravity, pH, titratable acidity, ash and refractive index did not vary significantly, while characteristics such as total solids, longitudinal and cross-sectional diameters,

vitamin C and reducing sugars were significantly different among the cultivars investigated. The Wild cultivar contains more solids, and is rich in some of the flavor-enhancing constituents such as vitamin C and titratable acidity. It is a high-yielding cultivar and its spherical shape will make it more amenable to design consideration parameters than the other nonconventional shapes. Thus, the Wild cultivar is recommended for deliberate cultivation. There is a wide range of adaptive and physiological traits in Wild species that remain to be exploited by plant breeders. Adedeji (2005) reported that the Wild cultivar fruits more and for a longer period than the other three cultivars studied. The Wild cultivar can flower during the dry season, is highly resistant to pests and can survive in a wide range of conditions. This genetic resource presents tremendous potential to breeders.

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