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Physicochemical Properties of Three Different Tomato Cultivars of Telangana, India and Their Suitability in Food Processing

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ABSTRACT

Tomato (Solanum lycopersicum) fruits of three commercial tomato cultivars Pusa Ruby, Lakshmi and US440, were harvested at red riped stage and physicochemical parameters like colour, TSS, p^H, weight of fruit and lycopene content were assessed. Among the three Pusa Ruby cultivar was selected for further processing due to its desirable traits like high lycopene content (5.49 mg/100 g) high TSS (6.93° Brix), pH less than 4.5 and uniform red colour. Tomato powder was processed and physicochemical analysis showed that lycopene content of tomato powder was 4.19 mg/100 g, rehydration ratio was 1.09% and dehydration ratio was 22.49%.

Key words : *Solanum lycopersicum*, Pusa Ruby, Lakshmi and US440, physico-chemical qualities, lycopene

Introduction

Tomato (*Solanum lycopersicum*) is one of the world's major fruits. India ranks second position in tomato production after China. On a global scale, tomatoes are the most important vegetable crop with about 182.2 million tons of production (FAO stat, 2013). The production of tomato in Andhra Pradesh is 22.86 tonnes/ha and Telangana is 20.18 tonnes/ha (Horti stat, 2015). Tomato is one of the most important vegetable crops in Telangana supporting the livelihood and improving the economic life of many tomato growers in the state. It is often called "poor man's orange" because they are good source of vitamins, particularly vitamin A and C. It is also a rich source of natural lycopene, a carotenoid possessing anti-oxidative activity (Purkayastha 2011).Some of the Indian tomato varieties are Sankranti, Pusaruby, Arka-alok, Arka abha and Vaibhav (Kumar *et al.*, 2015).

Many factors such as genetics (cultivar variety), environment (light, temperature, mineral nutrition and air composition) and cultural practices (ripening stage at harvest and irrigation system) affect the chemical composition of tomatoes (Raiola *et al.*, 2014).

Tomato has a limited shelf life at ambient conditions and is highly perishable and is not available in all parts of the country throughout the year at uniform price. These growing market opportunities led to the development of technologies for the preservation and sale of the product especially in a dry format. The nutrient content is another important factor that impacts on the consumer choice for preserved products. Processing has tremendous impact on the retention of nutrients and their availability in the body. Processing of tomatoes to a puree or paste enhances bioavailability of lycopene as it will free from tomato matrix. Among the tomato processed products, tomato dried powder is most accessible and convenient form to use in most ready to eat products (Purkayastha and Mahanta, 2011).

Drying of fruit and vegetables is one of the oldest methods of preservation. Generally there is no microbial proliferation in dried vegetables containing 5-7% moisture. So, dried vegetables can be stored for long period. The reduction in mass and volume during drying also improves the efficiency of packaging, sorting and transportation. The dried tomato flakes have considerable market potential, but tomato powder has higher consumer acceptability. The tomato powder can be reconstituted into juice or used as a starting material for the preparation of products like sauce, ketchup, chutney, etc. It can also be used as a flavouring agent/nutrient supplement in good mixes, baby food, health food, etc.

In the present study, the local variety of tomatoes Pusa ruby, Lakshmi and US440 were cultivated and evaluated for physico-chemical properties.

Material and methods

Selection of tomato cultivars: Tomato (*Solanum lycopersicum)* fruits from three commercial tomato cultivars namely *viz* Pusa Ruby, Lakshmi and US440, were grown in Dept of Horticulture farm, college of Agriculture PJTSAU, Rajendranagar, Hyderabad.

Raising of tomato nursery and transpantings: Tomato cultivars namely *viz.*, Pusa Ruby, Lakshmi and US440 seed was sown on raised nursery beds on 2nd June 2015. Need based plant protection measures were taken up during nursery growth period.

Thirty days old tomato seedlings were transplanted on date 30th July 2015 at the spacing of 75*45 cm in a row with 30 plants.

Fertilizer application and Intercultivation: Recommended dose of N, P, K fertilizers were applied @ 150:80:80 kg per ha^{-} 1in the form of urea, single super phosphate and Murate of potash respectively. Half dose of N, K_2O were applied as split doses at 30 and 50 days after transplanting. Intercultural operations like staking, weeding and need based plant protection measures were taken up during crop growth period.

Harvesting: Tomatoes were harvested at red riped stage (Bharambe *et al.*, 2016) and TSS, color and lycopene content were estimated according to the method (Ranganna, 2003).

p^{H}: The p^{H} was determined with a p^{H} 700 Digital meter at 25.0 ± 2 °C. The p^{H} meter was standardized using p^{H} buffer of 4.0, 7.0 and 10.2 (Kathiravan *et al*., 2014).

Total soluble solids: TSS was determined by refractometer (Model Misco®) with a range of 0 to 32 ° Brix and a resolution of 0.2° Brix by placing 1 to 2 drops of clear juice on the prism. Between samples the prism of the refractometer was cleaned with distilled water and dried before use. The refractometer was standardized against distilled water (0° Brix TSS) (Tigist *et al*., 2013).

Colour: Colour quality of the samples was estimated by using Hunter lab calorimeter (Colour Quest XE Hunter Lab, USA). Colour lab scale values (CIE LAB scale) were determined by using hunter calorimeter. L* indicates lightness and extends from 0.0 (black) to 100.0 (white). The other two coordinates a* and b* represent redness (+a*value) to greenness (-a*value) and yellowness (+b*value) to blueness (-b*value) respectively (Hunter Lab, 2013).

Statistical analysis

Data represents means of triplicates (n=3) for physicochemical parameters The values of standard deviation are also calculated for each parameter. Correlation coefficients were calculated using Pearson's technique for important parameters in different cultivars.

Preparation of tomato powder

Three selected varieties of tomatoes were screened for lycopene content (Ranganna, 2003) and the variety Pusa Ruby having highest lycopene content among the three was selected and processed for further making of tomato powder (Nagamani, 2014).

Dehydration ratio: Dehydration ratio was calculated by taking the weights of tomatoes before and after drying (Sheshma and Raj, 2014).

$$\text{Dehydration ratio} = \frac{\text{Weight of sample before drying}}{\text{Weight of sample after drying}}$$

Rehydration ratio: 5.0 g of dried tomato powder was added to 150 ml of distilled water in a beaker. The beaker was placed on a hot plate and covered with a watch glass. The water was brought to boiling point which takes approximately 3 min and then kept for 5 min. At the end of the rehydration period, the sample was transferred to a Buchner funnel, covered with No. 4 Whatman filter paper and the excess water removed by applying a slight vacuum. The sample was then removed and weighed (Sheshma and Raj, 2014)

Results and discussion

Physicochemical properties of tomato cultivars

In the present experiment tomato plants were cultivated for screening of physico chemical characteristics of the tomato cultivars. The important physicochemical characteristics of the tomato cultivars are reported in Table 1, 2 and 3

Total soluble solids: Significant ($P \leq 0.05$) difference was observed in TSS (Total soluble solids) content of the tomato cultivars (Table 1). At harvest, the TSS content of Pusa Ruby was highest while that of US440 was the least. The TSS values of the tomato cultivars ranged from 6.93° Brix in Pusa Ruby to 6.53° Brix in US440 cultivar. The values are higher than the TSS content reported by Madhumathi and Sadarunnisa (2013). Starch is accumulated in green tomatoes that start to fall with the onset of ripening. This decrease in starch is accompanied by rising soluble solids (Eskin, 2000). It has been also reported that total soluble solids increased with color and maturity (Tigist *et al.*, 2013).

Total soluble solids content is one of the most important quality parameters in processing tomato cultivars, having higher TSS content are better suited for the preparation of processed products like tomato powder, canned products, ketchup, sauce and chutney (Singh *et al.*, 2014). High TSS is desirable to yield higher recovery of processed products. Purkayastha (2011) also reported that the total soluble solids content ranged from 3.60 to 5.40° Brix in five different cultivars of North Eastern Hill region.

p^H: The p^H value of tomato cultivars are presented in Table 1. The p^H of tomato fruits have no significant difference among the cultivars. The results showed that p^H ranged from 3.90 in US440 to 4.14 for Pusa ruby. The study is in confirm with the literature information available on the p^H of tomato fruit (Singh *et al.*, 2014). Although the p^H of ripe tomatoes may exceed 4.6, tomato products are generally classified as acidic foods (p^H <4.6). p^H below 4.5 is a desirable trait, because it halts proliferation of microorganisms (Tigist *et al*., 2011)

Fruit weight: Tomato fruit weight plays an important role in consumer preference as well as in processing industry. The present study revealed that tomato had a wide and significant variation in fruit weight among the different varieties. The mean weight of the fruit ranged from 28.61 g to 32.08 g and the maximum being in Lakshmi, whereas the minimum was found in US440 variety (Table 1). These findings are differed with reported value of Madhumathi and Sadarunnisa (2013) in cultivar Pusa Ruby (35.27 g).

Table 1 Physicochemical properties of tomato cultivars

S .No	Cultivars	Average fruit weight (g)	TSS (° Brix)	p^H
1.	Pusa Ruby	28.90 ±0.86	6.93^a±0.06	4.14^a± 0.01
2.	Lakshmi	32.08±0.55	6.57^b±0.06	4.07^a±0.11
3.	US440	28.61±0.26	6.53^b±0.06	3.90^a± 0.10
4.	**Mean**	29.86	6.68	4.04
5.	**CD value**	1.4175	0.1195	0.2392
6.	**SE**	0.5105	0.0430	0.0861
7.	**CV (%)**	2.090	0.789	2.140

Note: Values are expressed as mean ± standard deviation of three determinations.

Means within the same column followed by a common letter do not significantly differ at $p \leq 0.05$.

Colour: Tomato changes in color during different stages of maturity and ripening i.e., from green to pale white, then yellow and finally red. The yellow color is owing to the presence of carotene. The red color appears when the lycopene is formed in the fibers. Lycopene is responsible for the attractive red color of the fruit and its products. Therefore, growers should select varieties with the brightest, most red and yellow color because those are the most influential characteristics behind consumer acceptance.

The results of color scores of the fresh fruit varieties is presented as L*, a* and b* values and given in Table 2. The L* value ranged from 0 to 100 indicating luminance or lightness component along with two chromatic components a* component (from green to red) and the b* component (from blue to yellow). The L*a*b* units are often used in food research studies because of uniform distribution of colors and as L*a*b* units are very close to human perception of color (Sahin *et al.*, 2011).

The* value (35.40) and b* (28.49) value are significantly higher ($p<0.05$) for Pusa Ruby tomato cultivar compared to the other two cultivars (Table 2). But L* value was significantly lower ($P<0.05$) in Pusa Ruby tomato cultivar (50.86) compared to the other two cultivars. This was because of the characteristic nature of red color in all the cultivars. Similar results of mean L* a* b* values for fresh tomatoes of different cultivars were (47.92, 39.44 and 32.83) reported by Sahin *et al*. (2011).

Lycopene content: The lycopene content of raw tomatoes were analyzed in all three cultivars. The lycopene content ranged from 5.49 to 4.10 (mg/100 g) on fresh weight basis (Table 2). This is comparable to values (5.80 mg/100 g) reported for fresh tomatoes by Haddadin and Haddadin (2015). Significant differences ($P< 0.05$) in the lycopene content in the raw samples were observed among the three cultivars studied. The variation in the lycopene content of tomatoes is probably due to the differences in the genetic nature of cultivars.

Table 2 Colour and lycopene values of fresh tomatoes

S. No	Tomato varieties	∆L	∆a	∆b	Lycopene (mg / 100g)
1.	Pusa Ruby	50.86^{b}±0.59	35.40^{a}±0.20	28.49^{a}±1.41	5.49^{a}±0.05
2.	Lakshmi	51.55^{b}±0.32	33.73^{a}±0.36	25.86^{b}±0.54	4.77^{b}±0.04
3.	US440	57.66^{a}±0.29	29.69^{b}±1.50	27.51^{ab}±0.63	4.10^{c}±0.04
4.	**Mean**	53.36	29.69	27.29	4.79
5.	**CD**	1.0539	1.9623	2.5583	0.0138
6.	**SE**	0.3793	0.7068	0.9214	0.0050
7.	**CV (%)**	0.87	2.69	4.13	0.127

Note: Values are expressed as mean ± standard deviation of three determinations.
Means within the same column followed by a common letter do not significantly differ at $p \leq 0.05$.

Pearson's correlation coefficient of physicochemical parameters of selected tomato cultivars

The correlation study (Table 3) clearly depicts the relationship between tomato cultivars and their physicochemical properties. For instance, in all the investigated cultivars, lycopene showed the highest correlation with p^{H} (>0.99), followed by Hunter "a" value (>0.94) and least with TSS (>0.91). This indicates that as lycopene content increases, p^{H} and Hunter "a" value i.e. redness also increased. This again confirms that different cultivars from same region or environment have different physicochemical properties. It has usually been reported that total soluble solids content increased with colour and maturity (Thompson *et al.*, 2000).

Quality and flavor of the processed products depend on chemical components like reducing sugar, acidity, ascorbic acid, lycopene, β-carotene, T.S.S and total sugar which has been reported to vary greatly with variety (Thompson *et al*., 2000). The desirable qualities for a tomato cultivar to be used for processing includes high total soluble solid (4-8° Brix), acidity not less than 0.4%, p^H less than 4.5, uniform red colour, smooth surface, free from wrinkles, small core, firm flesh and uniform ripening (Chattopadhyay *et al.*, 2013). Hence in the present study Pusa Ruby variety was selected for further processing because it had all the desirable qualities mentioned above and high lycopene content.

Table 3 Pearson's correlation coefficient for physicochemical properties of tomato cultivars

S. No	Parameters	p^H	TSS (°Brix)	Hunter 'a' value	Lycopene (mg /100g)	Protein
1.	**pH**	1.00000	0.94383	0.94568	0.99718	-0.05353
2.	**TSS**		1.00000	0.78513	0.91635	0.27943
3.	**Hunter 'a' value**			1.00000	0.94742	-0.37527
4.	**Lycopene**				1.00000	-0.12837
5.	**Protein**					1.00000

Physicochemical properties of tomato powder

Tomato powder has good potential as substitute of tomato paste and other tomato products. In order to protect physicochemical properties and nutritional quality of tomato during dehydration process tray drying was used for dehydration, where as calcium chloride ($CaCl_2$) and potassium meta-bisulphite (KMS) were selected for pretreatment. Lycopene content, dehydration ratio and rehydration in addition to moisture are studied.

Rehydration ratio: Rehydration can be considered as a measure of the injury to the material caused by drying and treatment preceding dehydration (Sheshma and Raj, 2014). Rehydration ratio of dehydrated tomato powder was 1.09%. Similar results (0.68-1.51) were reported by Sheshma and Raj (2014).

Dehydration ratio: Dehydration ratio reported as, ratio of mass of tomato slices before loading into the drier to the mass of dehydrated products. In the present study dehydration ratio of tomato powder was 22.49%. Total moisture content of tomato was 4.11%.

Lycopene content: Lycopene content of tomato powder was 4.19 mg/100 g (Table 4). Results indicate that hot air drying significantly (<0.05) decreased lycopene retention in tomato powder, subjected to drying (Table 4). However, literature supports that use of potassium metabisulphite and calcium chloride had significant protective effect on lycopene degradation and it was more effective when combination of $CaCl_2$+KMS was used (Sheshma and Raj, 2014). Treatment with calcium of cut tissue reduces its respiration and intensifies the repair process; the firmness is either maintained or increased. Calcium appears to help maintain structural integrity of membranes and cell walls. Calcium binds to the cell wall and cross- lines, particularly with pectin components of the middle lamella (Ghavidel and Davoodi, 2010).

Table 4. Physicochemical parameters of tomato powder

	Rehydration ratio (%)	Dehydration ratio (%)	Lycopene (mg/100g)	Moisture (%)
Tomato powder	1.09±0.01	22.49 ± 0.07	4.19±0.05	4.11± 0.03

Note: Values are expressed as mean ± standard deviation of three determinations.

Conclusion: Tomatoes, aside from being tasty, are very healthy as they are a good source of Vitamins A and C. Lycopene is a very powerful antioxidant which can help to prevent the development of many forms of cancer. Tomato (*Solanum lycopersicum)* fruits of three commercial tomato cultivars Pusa Ruby, Lakshmi and US440, were subjected to physico chemical parameters like colour, TSS, p^H, weight of fruit and lycopene content among the three cultivars Pusa Ruby showing high lycopene content. It was processed into tomato powder and assess the physico chemical properties like rehydration ratio and dehydration ratioand lycopene content.

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