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Study on effect of processing and storage conditions on total phenolic and antioxidant properties of tomato

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Abstract
From the last decade there has been a tremendous increase in demand of ready to eat food products by the consumers behind which there are several reasons such as growing awareness, increase in working women etc. These kind of products are healthy, appetising, nutritive with natural flavours. Tomato is one of the largest commercial vegetable in the world and second most consumed vegetable in the world.
The awareness of harmful effects of free radicals for human health has recently increased. Free radicals are very unstable molecules arising physiologically during cellular aerobic metabolism (2-3% of oxygen consumed by a cell is converted into free radicals). These free radicals react quickly with other compounds and begin the chain reactions. Normally, the human body can handle these compounds, but if their amount becomes excessive, damage can occur.
Antioxidants are capable of stabilizing, or deactivating, free radicals before they attack cells. Antioxidants are absolutely critical for maintaining optimal cellular and systemic health and well-being. Antioxidants involve variety of components, both endogenous and exogenous in origin, that function interactively and synergistically to neutralize free radicals.
The comparative study shows that the total phenolic content and antioxidant properties of fresh tomato is less and it increases after processing.

Keywords: antioxidants, total phenolic content, free radicals

Introduction
Tomato (*Lycopersicon esculantum* M.) belongs to the family of *Solanaceae.* Tomato is one of the most important commercial vegetable in the world. Tomatoes are the second-most consumed vegetables around the world. Tomato is one of the most cultivated crops around the world, reaching about l.239x I 0^8 tonnes in 2007. India ranked fourth in tomato production with 10.26 MMT out of the total world production in 2008-09.
Literature on composition of tomato and its processing into value added products was reported extensively. Tomatoes are a rich source of lycopene (60-90 mg/kg), vitamin C (60-240 mg/kg), polyphenols (10-50 mg/kg) and small quantities of vitamin E (5-20 mg/kg).
Tomatoes are used in many processed foods, such as canned and sun-dried tomatoes, juices, ketchup, pastes, purees, salads, sauces, and soups. The increasing demand for healthy and nutritious products as a consequence of consumers being better educated and more demanding contribute to a continuous need for new products.
The awareness of harmful effects of free radicals for human health has recently increased. Free radicals are very unstable molecules arising physiologically during cellular aerobic metabolism (2-3% of oxygen consumed by a cell is converted into free radicals).
These free radicals react quickly with other compounds and begin the chain reactions. Normally, the human body can handle these compounds, but if their amount becomes excessive, damage can occur. Free radicals have been indicated as probable pathogenesis determinants of many degenerative and chronic diseases that develop with age, such as cancer, cardiovascular disease, cataract, and immunity system dysfunctions.
Fortunately, free radical formation is controlled naturally by various beneficial compounds known as antioxidants. It is when the availability of antioxidants is limited that this damage can become cumulative and debilitating.
Antioxidants are capable of stabilizing, or deactivating, free radicals before they attack cells. Antioxidants are absolutely critical for maintaining optimal cellular and systemic health and well-being.

Antioxidants involve variety of components, both endogenous and exogenous in origin, that function interactively and synergistically to neutralize free radicals.
So for the potential role in preventing such diseases, natural compounds with antioxidant activity have gained the attention of researchers and nutritionists and estimation of the antioxidant activity is becoming, in fact, an evaluation parameter for the nutritional quality of food.

Material and Methodology

Raw Material

Raw material selected on the basis of size, shape, color and maturity of tomato and spices and condiments were taken as per the requirement.

Tomato

Tomato was procured from local market of Aurangabad. After the removal of unripe and spoiled one, they were washed thoroughly with water and stored at refrigeration temperature (4 ± 1ºC) until further use.

Other materials and Chemicals

The other materials and chemicals that were required for dehydration, product preparation and chemical analysis were procured from the local market of Aurangabad and made available from Department of Agricultural Engineering, M.I.T. Aurangabad.

Equipments and Instruments

The different equipments required for the preparation of different tomato products and study their physicochemical characterization were made available from the Department of Agricultural Engineering, M.I.T. Aurangabad.

Drying Techniques

The selected fresh whole fruit was subjected to two different methods:

Sun Drying

Tomatoes fruits were distributed on the stainless steel trays and dried under direct sunlight at temperature between 25 and 30°C, for 5 hours for 2 days.

Tray Drying

Tomatoes were dried in tray drier at temperature 70ºC.

Hot air oven drying

Tomatoes were cut into slices and then dried in the hot air oven at 94º C for 6-7 hrs.

Products Prepared

Fresh and ripe tomatoes were used for preparing different tomato products.

Ketchup

It is a sweet, tangy and spicy sauce chiefly made from tomatoes and vinegar, used as a relish.

Puree

It is a thick liquid made by cooking and straining tomatoes.

Paste

It is a thick paste made by cooking tomatoes for several hours to reduce the water content, straining out the seeds and skin and cooking the liquid again to reduce the base to thick and rich concentrate.

Physical Properties

Length, fullness index and width were measured by vernier calliper method (Mohsenin, 1970) and density was measured by toluene displacement method (Mohsenin, 1986; Gezer *et al*. 2002).

Proximate Analysis

The selected whole fruits fresh, its products and dried under the influence of selected methods were analyzed for proximate composition (moisture, ash, fat, protein and carbohydrates). Proximate analysis was analyzed in triplicates. Moisture, ash and fat content were determined by AOAC, 2000. Carbohydrates were determined by anthrone method (Hedge and Hofreiter, 1962). Protein was determined by micro-kjedahl method (AOAC, 2000). Dietary fiber (cellulose, hemicelluloses and lignin) were determined by Van Soest, (1977). Mineral content were estimated by GC-MC (2008, AYUSH).

Phytochemical Composition

The phenolic content in the fruit extract were determined in triplicate in Gallic acid equivalent by using Folin-Ciocalteu method (Thimmaiah, 1999). Total antioxidant activity measured by Kekuda *et al*. (2010). Flavonoid content was determined by spectrophotometer and expressed as quercetin (Luximon-Ramma *et al*. 2002). Anthocyanin was determined by pH-differential method. And absorbance was measured at 520nm and 700nm and expressed as cynidine-3-glycoside equivalents per 100 gm of fruits (Giusti and Wrolstad, 2001). Alkaloid was estimated by Herborne, (1973). Tannins was determined by using Spectrophotometric methods (Iwuoha and Kalu 1995).

Results and Discussion

The data contained physical properties, proximate and phytochemical composition depicted in Tables and Figures given below:

Table 1: Physical properties of Tomato

Parameters	Fresh Tomatoes
Weight(Kg)	114.5± 2
Volume(ml)	85±2
Specific Gravity(gm/cc)	0.524±0.01

*Values are average of three determinations

Table 1 depicted the weight of *Lycopersicon esculantum M* was ranged from 114.5 Kg to 116.4 Kg depending on the size of the fruit. The volume ranged from 85 ml to 88ml. Similar findings have been reported by Behzad, (2011).The result of the weight and volume showed that there was a significant difference between the samples.The length, width, volume, weight depends on the size and the sphericity of the fruits (Milovan *et al*. 2011). Isik and Izli (2007) reported similar results with our study i.e. length decreased as the moisture content decreased. The density or specific gravity of *Lycopersicon esculantum M* was ranged from 0.504gm/cc to 0.536 gm/cc for fresh fruits. Similar results were reported by Sayed *et al*. (2010). Result showed that density of fresh fruit was less as compared to dried because of increased density during drying process due to the variation in the mass, volume and structure of the cell wall and removal of water content (Pacco *et al*. 2007; Baryeh, 2002; Ratti, 1994).

Table 2: Nutritional Composition of *Lycopersicum esculantum* M

Parameters	Fresh Tomatoes
Moisture (%)	94.2±0.5
Total Solids (%)	6.00±0.5
Ascorbic Acid (%)	31.6±1
Acidity (%)	0.53± 0.1
TSS (%)	4
Total-Antioxidants (% RSA)	38.6±0.22
Total Phenolics	25.4±0.25

*Values are average of three determinations

The moisture content was determined and depicted in (Table 1.2) and it ranged from 94.2 % to 94.7%. These results were consistent with the findings of (Mehmeet *et al*. 2009; Maha *et al*. 2013). The low moisture content is important during storage as they can be kept for a longer time without spoilage.The total solids of tomato ranged from 6.00 % to 6.5%. (Soni *et al*. 2014) reported similar results. Ash is the amount of mineral present in a sample or a substance. Ash content is one of the methods which are used for finding out how much minerals are present in a particular sample.High content of ash may be due to the removal of moisture content (Morris *et al*. 2004). The Ascorbic acid of the sample reported from 31.6 % to32.5%. Similar results have been obtained by Mehmeet *et al*. (2009). The titratable acidity ranged from 0.53 per cent to 0.6% Similar results have been obtained by Maha *et al*. (2013). In this study it was observed that the TSS of fresh tomato is 4%.Tomatoes are rich in antioxidants. The vital antioxidant present in tomato is Lycopene. Total antioxidants is measures in terms of Radical Scavanging Activity (RSA).It ranged from 38.6 % RSA to 38.82 % RSA. Similar results have been obtained by (Mehmeet *et al*. 2009). Total phenols present are measured in terms of GAE (Gallic Acid Equivalent) which ranged from 25.4% to 25.7%.

Table 3: Effect of processing on total phenolics content and antioxidant properties of tomato.

Tomato Product	Total Phenolic (mg of GAE/100gm)	Total antioxidant properties (%RSA)
Ketchup	65.25±0.17	58.50±0.17
Puree	72.31±0.14	59.18±0.6
Paste	81.90±0.11	62.32±0.04

*Values are average of three determinations

Total phenolic content is expressed as mg of gallic acid equivalents in 100 g of the sample (mg GAE per100 g the sample)

Total antioxidant propertie is expressed in terms of radical scavenging activity (%RSA).

The total phenol in different tomato products is showed in Table 1.3 which shows that results of the total phenol content that there was a significant difference between the samples. Phenolic compounds are known to act as antioxidants not only because of their ability to donate hydrogen or electrons but mainly due to their stable radical intermediates, which prevent the oxidation (Cuveliev and Berset, 1992; Maillard *et al*. 1996). Total phenolic content increases after processing. (Sablani *et al*. 2011). According to this study, it was observed that the phenolic content increased after processing due to loss of moisture (Sarsavadia, 2007) and (Slatnar *et al*. 2011) have been obtained similar findings. When the pulp is processed the heat treatment is responsible to release the bond phenolic compounds from matrix during the breakdown of cellular constitutents (Arslan and Ozcan, 2010). The table 1.3, mentioned above also represents the antioxidant properties of different tomato products. It showed that the antioxidant properties of tomato products also increases after processing. The total phenolic content of tomato ketchup, puree, paste ranged from 65.25, 72.31, 81.90 mg of GAE/100gm respectively whereas the total antioxidant properties ranged from 58.50, 59.18, 62.32 %RSA respectively.

Table 4: Effect of drying on total phenolics content and antioxidant properties of tomato.

Parameter	Oven drying 160 min	Sun drying 460 min	Shade drying 2880 min	Tray drying 310 min
Moisture (%)	21.73±0.2	22.91±0.2	20.88±0.2	21.91±0.2
Total phenolics (mg of GAE/100gm)	116.02±0.1	131.75±0.2	129.95±0.2	134.74±0.2
Total antioxidants (%RSA)	54.40±0.04	61.31±0.07	65.26±0.03	62.70±0.05

*Values are average of three determinations

The above mentioned table shows the effect of different modes of drying on total phenolic content, antioxidant properties and moisture content of tomato. The moisture content was decreased to 21.73, 22.91, 20.88, 21.91% respectively from 94.2% in oven drying, sun drying, shade drying and tray drying. The total phenolic content also increasedcompared to fresh tomato and even more compared to processed tomato products. The antioxidant properties increases in drying compared to fresh tomatoes but remains consistent compared to processed tomato products. According to the study it was observed that the phenolic content increased after drying due to loss of moisture. Drying is responsible to release phenolic bond compounds from the matrix during the breakdown of cellular constituents. Tray drying increased the phenolic content as compared to sun drying due to less duration of heat treatment. Incase of sundrying the sample is exposed to the atmospheric oxygen that caused reduction in phenolic compounds. (Sarsavadia, 2007). Radical scavenging activity enhanced after thermal processing due to inhibition of oxidative enzymes and destruction of the cell wall which release the antioxidant compounds (Yamaguchi *et al.* 2001)

Conclusion

From the data presented, it is observed that tomato has high moisture content so it is a highly perishable commodity so, it requires immediate processing after harvesting.It is also observed that tomato is a very good source of ascorbic acid and phenolic compounds.The comaparative study shows that the total phenolic content and antioxidant properties of fresh tomato is less and it inreases after processing.Also rate of total phenolic content and antioxidant properties is directly propotional to storage period i.e it increases with increase in storage time.Comparison between fresh and dried tomatoes showed that total phenolic content increases during drying which is due to increase in lycopene content.

This study concludes that these selected methods: Sun drying and tray drying have a significant impact on the physico-chemical, nutritional and phytochemical properties. Compare to fresh, sun drying and tray drying method would be used to produce good quality dried fruit in terms of protein, carbohydrates, ash content and minerals. Purpose of the study is to generate awareness among people about the influence of processing methods on fruits and to increase the intake of underutilized fruits in their daily diet. The future studies should focus on a nutrients retention by using different drying methods (shade dried, vacuum air dried, freeze drying, microwave drying) and different pretreatments.

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