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Mini Review

A Mini Review on Therapeutic Potential and Chemical Constituents of Tomato

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Abstract. Tomato is the second most important and generally grown vegetable in the world. It is popular as vegetable in many prepared structures (e.g. ketchup, canned entire or in pieces, puree, sauce, soup, squeeze or sun-dried). Tomato and prepared tomato items are important component of the Mediterranean diet. It is a rich source of minerals and strong antioxidants, which provide good health and prevents us from cardiovascular disorders and diabetic blood pressure. The aim of this review is to evaluate the historical record, uses, potential biological activities and chemical constituents of tomato.

Keywords: tomato, historical background, chemical constituents, mediterranean diet

Introduction

Botanical classification of tomato. The botanical name of tomato is *Solanum lycopersicum* L. It is related to the kingdom plantae, class: Magnoliopsida, division: Magnoliophyta, genus: *Solanum*, specie: *lycopersicum* and family is *Solanaceae* (night shade family). The Magnoliopsida class is further split into the order. The order of tomato plant is Solanales (Eric *et al*., 2015).

The family: *Solanaceae*. The tomato plant belongs to the diverse family Solanaceae. This family contained approximately 3000 species. This family related species are used for many economic purposes such as food items, ornamental purpose and medicine. Different vegetables of this family are peppers, potatoes and eggplants.

The genus: *Solanum*. Tomato belongs to the genus *Solanum.* This genus contained several species. These vegetables are used in salad. The word "*lycopersicum*" is derived from Greek word lyco means "wolf" and persicum means "peach". Philip miller placed the tomato into the *Solanum* genus in 1768. Some species belong to this genus show several toxic alkaloids.

World distribution of tomato. World second largest vegetable is tomato. It is distributed in different varieties all over the world (Table 1). It shows the rapid growing ability and its production increases 49% between the years of 2000-2013. Globally 130 million tons tomatoes production is observed, 88 million tons is estimated in fresh form, while 42 million is detected in process form. US, China, India, EU and Turkey are ranked 5 tomatoes production countries. They produce 70% tomatoes. In all vegetables tomatoes takes number one position in European Union (EU) that share 19% fresh tomatoes products. 1.5 million tons tomatoes export the world largest exporter country Mexico. In 2014, almost 40.5 million tons tomatoes are produced by China, takes 8th ranked in term of export that is behind the US. In 2014, Russia produced 2.1 million tons tomatoes and globally it produced 1.6%. Turkey and Jordan are the top tomatoes exporter middle eastern countries. Spain is the 3rd largest fresh tomatoes producer European country. The France produced 614,165 tons tomatoes in 2016. In France, 2,298 hectares tomatoes were cultivated in shelter and open fields whereas 599,600 tons tomatoes were obtained from green house (Qasim *et al*., 2018).

Cultivation of tomato in Pakistan. In 2000-2010, the cultivated tomatoes area approximately was 50 thousand hectares. The production of tomatoes increases from 268.8 to 476.8 thousand tons. Major cultivated areas of tomatoes in Balochistan are Khuzdar, Pishin, Loralai and Killa Saifullah. Sindh areas that harvest tomatoes including Badin, Hyderabad, Thatta, Nowshero Feroz, Mirpur Khas, Nawabshah, Larkana and Sukkur. Northern and southern areas of KPK are north Waziristan,

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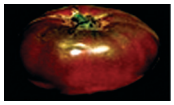
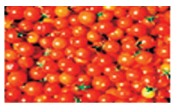
Table 1. Different varieties of tomatoes

Name of variety	Country	Figure	Description
Adoration	Netherland		Red colour, small size and intermediate growth. Hybrid tomato variety.
Alicante	UK		Dark red colour and use in classic breakfast. Its taste is good and medium size.
Azoychka	Russia		Yellow colour, fully covered, softball like structure. Lemony flavour.
Beefsteak	USA		Mostly used in winter, resemble from buttercup squash, appeared in three colours. Largest cultivated variety. Weight is 450 g.
Better boy	USA		Found in yellowish red colour, also called summer squash, sweet taste used in different recipes.
Big beef red	USA		Yellowish orange colour, contains maximum carotene content, central part shown maximum seeds.
Black krim	Russia		Winter squash, commonly known as Japanese squash, provides vitamins and fibres.
Campari	USA		It shows sweet, fluffy texture, taste like russet potato, used in soups.
Cherokee purple	USA		Seeds are used in cooking, best source of dietary fibre and observed less amount of carotene content.
Early girl	USA		Summer squash, available in pale green and red colour.
Great white	USA		Creamy white colour. Sweet melon like flavour. Used in slicing, sandwiches, sauces and salad.
Green zebra	USA		45 kg weight and 510 mm diameter, bright orange colour, round shape tomato like a pumpkin.

continued .....

Kumato	Spain		It is a standard size tomato, shows radish brown green or purple colour. It contains more fructose as compare to the other tomatoes.
Matt's wild cherry	Mexico		It is smaller in size as compare to the cherry tomatoes, yellow colour and originated from Mexico.
Red currant	Western South America		Wild species of tomato. Small size plant normally grown in garden. Commonly called currant tomato.
Roma	USA and Mexico		Plum tomato variety is used in canning and pastes. It is also called Italian tomato.
San Marzano	Italy		A variety of plum tomato. It is pointed and thinner as compare to roma tomato, acidic and sweeter taste.
Santorini	Santorini, Greece		It is like a cherry tomato. Developed from Santorini. Commonly known from its flavour.
Super sweet 100	USA		It is a hybrid variety, contains long plant stem that hold hundred or more tomatoes.
Tomaccio	Israel		It shows intense sugar flavour. Its height about 9 feet, provides 13-18 pounds tomatoes in each season.
Yellow pear	Europe		This variety is available in pear shape. It is observed in different colours. But most common variety is yellow.
Micro tom	Northern America		World smallest variety of tomato. This variety of tomato is mostly used in laboratory experiments.
Monterosa	Italy		Hybrid tomato. Combination of two varieties makes it unique. Taste is sweet.
Plum tomato	Italy		Commonly called paste tomato, used in packing. It shows cylindrical shape and used in cooking purposes.
Raf tomato	Spain		Present in different flavour and texture. It shows the resistance f rom water.

Charsadda, Malakand, Mardan, Swat, Swabi and Nowshera. Central and southern tomatoes cultivated areas in Punjab are Bahawalnagar, Rahimyarkhan, Khanewal, Bahawalpur, Sheikhupura, Okara, Sargodha, Gujranwala, Faisalabad, Sahiwal and Sialkot (Fig. 1). The Balochistan annual production of tomatoes in five years was recorded 205.6 thousand tons while the production of Sindh and KPK were observed 80.4 and 153.1 thousand tons, respectively. The production of tomatoes decreases in monsoon months from June to August just because of rains and the highest heat. The production of tomatoes changes from lowest land summer to highest land cooler regions. The production depresses from December to January. This vegetable is cultivated almost in all years although the variation occurs in its production quantity (Qasim *et al*., 2018).

Benefits of tomato. The several benefits of tomato are as follows (Bhowmik *et al*., 2012):

- It contains lycopene content. Lycopene fight against the cancerous cell because it does not form body itself.
- Four types of carotenoids are observed in tomato; α and β-carotenes, lycopene and lutein. All types provide individual benefits in the body.
- It contains three most powerful antioxidants; β-carotene, vitamin E and vitamin C. Vitamin C repairs the wounds in our body.
- Tomatoes are major source of minerals. The study shows that half cup of tomato sauce contains 454 mg potassium and one cup of tomato juice contains 534 mg potassium.

Fig. 1. Map represents the different cultivated areas of tomato in Pakistan.

- According to study when we eat tomatoes along with avocado and olive oil, the body absorbs the highest level of carotenoids and phytochemicals.
- Tomato peel is the rich source of carotenoids, flavanol and phytochemicals so it is beneficial for us to consume tomato along with their skin.
- Tomatoes contain enough amounts of calcium, potassium and vitamins that help to strong bones and repair minor problems of bones.
- It contains chlorogenic and coumaric acids that protect from damages by smoking.
- Tomatoes are necessary for our heart because they contain vitamin B and potassium that involve decreasing blood pressure and cholesterol level.
- Tomatoes are good for our skin, eyes, teeth and hairs. They contain vitamin A, which is necessary for silky and shiny hairs.
- It is good for our kidney to decrease the risk of kidney stones.
- It contains sufficient level of chromium that helps to control diabetic blood pressure.
- Tomato juice maintains the blood alkaline and rich source of potash and iron salts. Half ripe tomatoes are good for liver troubles, diarrhoea and dysentery.
- It is essential for many types of nervous disorders.
- Glutathione is a powerful antioxidant present in tomatoes, which helps to eliminate the reactive oxygen species in living organisms. It is responsible to eliminate the toxin substance especially the trace metals that accumulated into the body from dietary sources and environment. Glutathione have ability to remove the lead efficiently from the body. It also decreases the blood pressure and maintaining the liver functions in the body.
- Half ripe tomatoes prevent from heat and sun strokes in summer.

Chemical constituents of tomato. Tomato shows different types of antioxidants like phenolic compounds, flavonoid content, carotenoids, minerals, fatty acids and amino acids. These substances are responsible to neutralize the reactive oxygen species.

Phenolic compounds. Phenolic compounds are the main antioxidants present in tomatoes such as coumaric acid, naringenin and quercetin (Fig. 2). The concentration of total phenolic content increases during maturation of tomatoes except chlorogenic acid, which decreases during maturation. It was observed that the concentration of phenolic content found maximum in external tissues of pericarp. Previous study reported that 53% of total

phenolic compounds are present in tomatoes seeds and skin (Serio *et al*., 2005).

Flavonoid contents. The composition of total flavonoid content was varied in different varieties of tomatoes. Most important flavonoid present in tomato is quercetin, which was analyzed the highest in final red ripe stage of tomato while other second and third most important flavonoids are rutin and naringenin (Fig. 3). Rutin present in the lowest amount at initial stage while its concentration increases in final red stage (Bhandari *et al*., 2016).

Carotenoids. The real phytochemicals in tomato are the carotenoids comprising of 60 to 64% lycopene, 10 to 12% phytoene, 7 to 9% neurosporene and 10 to 15% carotenes (Fig. 4). Tomato based food are the rich source of lycopene. The daily recommended value of lycopene for human body is 25 mg/day. Almost 85% lycopene is obtained from fresh tomatoes. The fresh tomato on approximately contains around 35 mg/Kg of lycopene with red cultivars containing in normal 90 mg/Kg of lycopene and yellow ones just 5 mg/Kg. Processed form of tomatoes (sauce, juice and ketchup) contains 20 to 40-fold higher lycopene than freshly prepared tomatoes.

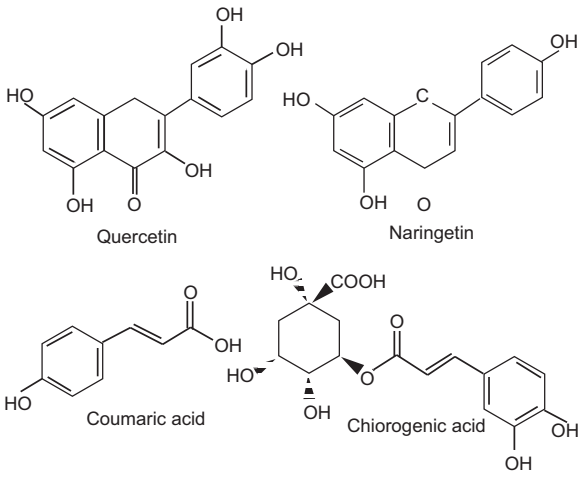


Fig. 2. Phenolic compounds in tomato.

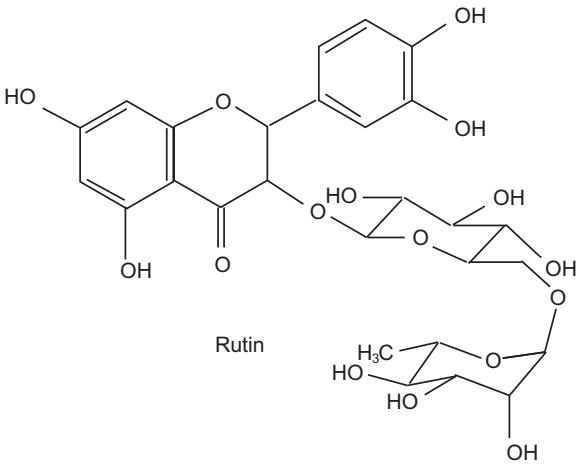


Fig. 3. Flavonoid contents in tomato.

Minerals. Tomato skin and seeds are rich source of mineral content including Fe, Zn, Cu and Mn. Previous study suggests that the tomato peel is a rich source of Mg, K, Na and Ca (Elbadrawy and Sello, 2016). Tomatoes are the upper rank contributor of K in most of the advance countries. USA national health survey (1999-2000) on food data, observed top 7 ranks of tomatoes after potatoes and so on as K source. Dietary reference intake recommends the daily intake of K is less. In 2004, the daily reference intake of K enhances (4700 mg) related to the previous recommended value (3500 mg) reported in 1989. The highest value of K recommended just because of their function to maintain the blood pressure, concentration of Na in the blood and prevent from kidney stone. K taken from vegetable is beneficial than other source because it maintains the ratio of bicarbonate and citrate, beneficial for bone health.

Fatty acids. Tomatoes contain unsaturated fatty acids including linolenic acid (ω6) and oleic acid. Palmitoleic acid and linolenic acid (ω3) are also analyzed in tomatoes peel. These four types of fatty acids contained almost 77.6% of total unsaturated fatty acids while the saturated fatty acids including palmitic, myristic and stearic acids are observed in tomatoes peel. Although the peel of tomatoes contains small amount of oil but shows maximum level of linolenic acid (ω3) and linolenic acid (ω6). These two types of fatty acids are essential

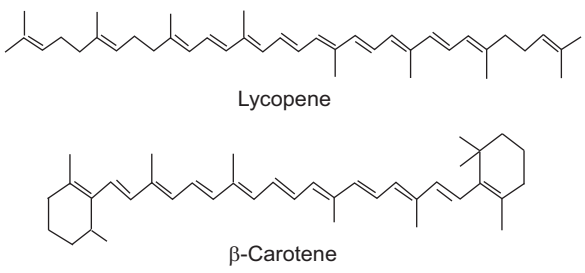


Fig. 4. Carotenoids in tomato.

to protect the human body from cardiovascular diseases (CVD) (Elbadrawy and Sello, 2016).

Amino acids. The most abundant amino acid in tomatoes peel is glutamic acid. Peel of tomatoes contains essential amino acids such as lysine, leucine, isoleucine, phenylalanine and valine while the other non-essential amino acids are glycine, glutamic, alanine, tyrosine and glutamic acid. The lowest amino acids are aspartic acid and cysteine (Elbadrawy and Sello, 2016).

Organic acids. Organic acid present in tomatoes are malic and citric acids. They provide the taste of tomatoes. Other types of acids are also detected in less amount including galacturonic, acetic, trans-aconitic, lactic, formic and α-oxo-acids (Elbadrawy and Sello, 2016) (Fig. 5). Acidity of tomatoes decreases from maturation of tomato from green to red stage. Higher acidity is detected in green and light pink colour tomatoes.

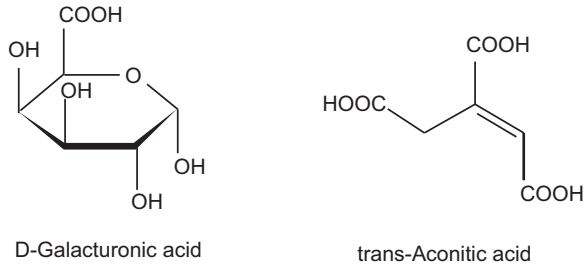


Fig. 5. Organic acids in tomato.

Vitamins. Tomatoes contain a huge number of vitamins C, E and B6, folic acid and niacin. Vitamin C in fresh tomatoes is totally depending upon the variety of tomatoes and their development conditions (Beecher, 1998). Vitamin E in fresh tomatoes is showed α-tocopherol. These tomato antioxidants play important support in heart diseases including growth, neuro-degenerative disorder, asthma and protect immune system of human being.

Compositional studies of tomato. ***Minerals evaluation*****.** Iliæ *et al*. (2014) estimated the heavy metals and nitrate content in tomato fruit grown in organic and conventional production systems in north eastern Greece. This study evaluated the concentration of heavy metals and nitrate contents in two cultivars. Higher concentration of Pb, Zn, Cu and Ni were observed in conventional type of tomatoes. The detected level of trace metals showed lower amount as compared to the recommended limits. This study confirms that the nitrate content in all cultivars present in significant level but analyzed lower in organically cultivated tomatoes. Nour *et al*. (2013) studied the antioxidant compounds, minerals content and antioxidant activity of several tomato cultivars grown in south western Romania. Tomatoes contained ascorbic acid, lycopene, phenolic content, antioxidants, minerals (K, Na, Ca and Mg) and heavy metals (Fe, Cu, Mn, Cr, Zn and B). The cocktail type "Tiger" and cheery type "Belle" contained the greater amounts of antioxidants and phenolic content as compared to the other types of tomato cultivars, which show significant levels of ascorbic acid and lycopene content. Minerals and trace metals concentration also varied in different cultivars.

Phenolic and antioxidant evaluation. Donker *et al*. (2015) estimated antioxidant potential of different tomato paste extracts found on major markets in Accra Metropolis (Ghana). Total phenolic content was determined by Folin-Ciocalteu reagent. Flavonoid content was estimated through aluminium chloride colourimetric assay and finally the antioxidant activity determined through DPPH radical scavenging assay. Maximum and significant correlation was observed between phenolics, flavonoids and antioxidant activity. Boonkasem *et al*. (2015) determined ascorbic acid and total phenolics related to the antioxidant activity of some local market tomato varieties in Thailand. Five local varieties of tomato collected from markets namely Rashinee, Cherry, Puang, Tou and Sida. DPPH radical scavenging and 2-6 dichorophenolindophenol assays were used to determine their antioxidant activity, while Folin-Ciocalteu reagent was used to find out the phenolic content in tomatoes. Extract was made in methanol, ethanol and aqueous medium. The results showed the highest antioxidant activity in methanolic extract than ethanol and aqueous extracts. Mostapha *et al*. (2014) determined the antioxidant activity of eight types of tomato varieties grown in Algeria. The ascorbic acid and carotenoids content were determined in tomatoes using spectrophotometric method. Antioxidant activity was estimated by DPPH radical scavenging assay and reducing power assay. Different varieties of tomatoes show the difference in antioxidant amount. Two varieties of tomato, Joker and Marmande show maximum level of carotenoid and phenolic contents. Borguini *et al*. (2013) investigated the antioxidant potential of tomatoes cultivated in organic and conventional systems in Brazil.

The objective of this study was to compare the antioxidants activity of tomatoes, which was cultivated on organic and conventional system. The alcohol and aqueous extracts of organic tomatoes showed more antioxidant potential by DPPH radical scavenging assay than conventional tomatoes. Organic tomatoes observed significantly higher level of ascorbic acid and total phenolic content. The results confirmed the hypothesis that types of tomatoes effect on the secondary metabolites of tomatoes. Georgé *et al*. (2011) studied the changes in the contents of carotenoids, phenolic compounds and vitamin C during technical processing and lyophilization of red and yellow tomatoes in France. Two types of tomato red and yellow were used to analyze their carotenoids, total phenolic content and vitamin C on process forms. Micronutrients observed in fresh and pure tomatoes. Yellow tomato contained low level of lycopene, β-carotene and vitamin C, while maximum level of polyphenolic content than red tomato. Thermal processing did not affect the carotenoids content in red tomato but decrease level of β-carotene in yellow tomato. The process of lyophilization reduced the number of carotenoids in both red tomato and yellow tomato as well as vitamin C concentration in both types. Guil-Guerrero and Rebolloso-Fuentes (2009) analyzed the nutrient composition and antioxidant activity of eight tomato varieties in Almeria (Spain). The components determined were crude proteins, carbohydrates, dietary fibres, vitamins, minerals and nitrate content. The results have shown more amounts of vitamin C and carotenoids in eight types of tomato than conventional varieties of tomato. The antioxidant activity of tomato determined through β-carotene breaching and DPPH radical scavenging assay. The maximum antioxidant activity was observed in all types of tomatoes. Luthria *et al*. (2006) estimated the total phenolic content, phenolic acids in tomato (*Lycopersicum esculentum* Mill.) fruits as influence by cultivars and solar UV radiation in USA. After cultivation, the fresh tomatoes collected and found the antioxidant capacity, phenolic acid by applying the different assay and standard methods. The three types of phenolic acid were extracted from different types of tomatoes. It was observed that the difference in phenolic acid and their antioxidant activity was found because of the difference in UV radiation during cultivation periods. Result concluded that the difference in UV radiation effect on the properties of tomato and their role in human body. Toor and Savage (2005) evaluated the antioxidant activity in different fractions of tomato in New Zealand. The antioxidant activity of three cultivars of tomato fractions (skin, seeds and pulp) were determined. It was observed that the skin showed the higher antioxidants (phenolic, flavonoid, lycopene and ascorbic acid) by ABTS assay as compared to the seed and pulp.

This study indicates that skin contained more amount of antioxidants so it is better for us to use tomato along with their skin and seed during cooking, which give maximum antioxidants and provide more health benefits. George *et al*. (2004) studied the antioxidants in tomato (*Lycopersicum esculentum*) as a function of genotype in New Delhi (India). 12 genotypes of tomato studied due to their antioxidant activity. Ascorbic acid and lycopene content shows the 1-4-fold and 1-2-fold difference between fresh and dry weight tomatoes. Antioxidant activity indicated variations among different genotypes of *Solanum lycopersicum* L. in both free radical quenching assay and FRAP assay. Activity was observed greater in hexane fraction that contains lycopene related to the methanolic fraction observed phenolic content. Tomato peel showed maximum lycopene, phenolics and antioxidants content. Cherry tomato contains the highest content of antioxidant activity than other types of genotype, it also shows maximum titratable acidity and total soluble solids. Sahlin *et al*. (2004) investigated the antioxidant properties of tomatoes after processing in New Zealand. ABTS assay was used to estimate the antioxidant properties. The study suggested that the tomatoes contain highest amount of lycopene, ascorbic acid and phenolic contents and showed maximum antioxidant activity. Processing tomatoes from boiling and frying tends to decrease the antioxidants related to the raw tomatoes but they also contained useful level of antioxidants when it consumed in daily diet.

Conclusion

Tomato belongs to the family Solanaceae. It is commonly used as vegetable all over the world. Tomato contains adequate amount of lycopene, which acts as antioxidant and reduces the cancer cells in the body. It contains the most powerful antioxidants including α and β-carotenes, lutein, vitamin C and vitamin E. However tomato can be utilized for these bioactive compounds as an alternative to medicines with no adverse effects regarding natural mode of treatment for multiple diseases. Previously mostly authors describe its two types of

tomato red and yellow were used to analyze their carotenoids, total phenolic content and vitamin C on process forms, while micronutrients observed in fresh in pure tomatoes. Yellow tomato contained low level of lycopene, β-carotene and vitamin C, while maximum level of polyphenolic content than red tomato. Thermal processing did not affect the carotenoids content in red tomato but decrease level of β-carotene in yellow tomato. The process of lyophilization reduced the number of carotenoids in both red tomato and yellow tomato as well as vitamin C concentration in both types and antioxidant activity of eight tomato varieties described in Almeria (Spain). The components determined were crude proteins, carbohydrates, dietary fibres, vitamins, minerals and nitrate content. The results have shown more amounts of vitamin C and carotenoids in eight types of tomato than conventional varieties of tomato. The antioxidant activity of tomato determined through β-carotene breaching and DPPH radical scavenging assay. The total phenolic content, phenolic acids presents in tomato specie of (*Lycopersicum esculentum* Mill.) and as a fruit is influence by cultivars and solar UV radiation in USA. After cultivation, the fresh tomatoes collected and found the antioxidant capacity, phenolic acid by applying the different assay and standard methods. The three types of phenolic acid were extracted from different types of tomatoes. It was observed that the difference in phenolic acid and their antioxidant activity was found because of the difference in UV radiation during cultivation periods. Result concluded that the difference in UV radiation effect on the properties of tomato and their role in human body. It was observed that the skin showed the higher antioxidants (phenolic, flavonoid, lycopene and ascorbic acid) by ABTS assay as compared to the seed and pulp. This study indicates that skin contained more amount of antioxidants so it is better for us to use tomato along with their skin and seed during cooking, which give maximum antioxidants and provide more health benefits. The antioxidants in tomato (*Lycopersicum esculentum*) as a function of genotype described in New Delhi (India). 12 genotypes of tomato studied due to their antioxidant activity. Ascorbic acid and lycopene content shows the 1-4-fold and 1-2-fold difference between fresh and dry weight tomatoes. Antioxidant activity indicated variations among different genotypes of *Solanum lycopersicum* L. in both free radical quenching assay and FRAP assay. Activity was observed greater in hexane fraction that contains lycopene related to the methanolic fraction observed phenolic content. Tomato peel showed maximum lycopene, phenolics and antioxidants content. Cherry tomato contains the highest content of antioxidant activity than other types of genotype, it also shows maximum titratable acidity and total soluble solids. The antioxidant properties of tomatoes after processing in New Zealand, the ABTS assay was used to estimate the antioxidant properties. Finally this study suggested that the tomatoes contain highest amount of lycopene, ascorbic acid and phenolic contents and showed maximum antioxidant activity. Processing tomatoes from boiling and frying tends to decrease the antioxidants related to the raw tomatoes but they also contained useful level of antioxidants when it consumed in daily diet.

Conflict of Interest. The authors declare that they have no conflict of interest.

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