



A Review on Chemical Composition and Medicinal Importance of *Solanum lycopersicum* L

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Abstract

Solanum lycopersicum L (Tomato) is the second most consumed vegetable worldwide, and probably the most preferred garden crop, thus being an important source of nourishment for the world's population. This fruit is a dietary source of carotenoids (mainly lycopene), vitamins and phenolic compounds (hydrocinnamic acids and flavonoids) which contribute to its health-promoting effects. Unripe (green) tomatoes also contain glycoalkaloids (α -tomatine), compounds endowed with important bioactive properties. Recent studies have confirmed that tomato and tomato sauce lower blood pressure and the risk of heart disease. Effectiveness of tomatoes in lowering blood pressure is attributed to lycopene, a chemical present in tomato. Tomato extract contains carotenoids such as lycopene, beta carotene, and vitamin E, (known as effective antioxidants) to inactivate free radicals, and to slow the progression of atherosclerosis. Tomatoes are now eaten freely throughout the world; especially cooked tomatoes help to prevent prostate cancer. Lycopene has also been shown to improve the skin's ability to protect against harmful UV rays. Tomato can protect against sunburn and help keeping the skin looking youthful.

Keywords

Carotenoids, Heart disease, Lycopene, Atherosclerosis, Prostate cancer.

1. GENERAL DESCRIPTION ^[1-10]

Solanum lycopersicum L. (Tomato) is very essential vegetable crop. At present, about 160 million tonnes of fresh tomatoes are produced from 4.7 million ha (FAOSTAT, 2011). Tomatoes are native to South America, but were brought to Europe sometime in the 15th century, where they soon became popular

and were exported around the world. For a long time, tomatoes were known by the name *Lycopersicon esculentum*, but recent work has shown that they are part of the genus *Solanum* – as Linnaeus recognized when he first described the species. The tomato is consumed in diverse forms, including raw, as an ingredient in several dishes, sauces, salads, and

drinks. While it is botanically a berry fruit, it is considered a vegetable for culinary purposes. The fruit is rich in lycopene & Vitamins (A, C, & D) which has beneficial health effects.

The plants typically grow to 1–3 meters in height and have a weak stem that often sprawls over the ground. It is a perennial in its native habitat, although often grown outdoors in temperate climates as an annual. Most cultivars produce red fruits, but a number of genotypes with yellow, orange, pink, purple, green, black, or white fruit are also available. Multi-colored and striped fruits are also quite striking. Tomatoes grown for canning and sauces are known as plum tomatoes, which typically have lower water content with elongated fruits.

China, the largest producer, accounts for about one quarter of the global output followed by India and United States (Table1). Currently tomato has a higher consumption rate in more developed countries and is often referred to as a luxury crop. In developing countries, tomato is becoming more important part of the food basket; hence the farmers aim to increase quantity than quality of the produce. As improved varieties and new cultivars with better resistance to various biotic and abiotic stresses are developed, it will become easier to grow the crops in more marginal conditions and the tomato will become an important part of the diet in poorer countries as well.

Table 1: The World's Leading Tomato Producing Countries:

Rank	Country	Tomato production millions of tonnes
1	China	52.6
2	India	18.7
3	United States	14.5
4	Turkey	11.9
5	Egypt	8.3
6	Iran	6.0
7	Italy	5.6
8	Spain	4.9
9	World	170.8

1.1 Nomenclature and Classification:

The cultivated tomato, *Solanum lycopersicum*, is grown for its popular fleshy fruits and is known by different names worldwide like tomate (German), tomaatti (Finish), pomodoro (Italian), kamalis (Malay), jitomate (Spanish), pomidor (Russian) and tamatar (Hindi). Linnaeus (1753) classified tomatoes in the genus *Solanum* and described *S. lycopersicum* (the cultivated tomato) and *S. peruvianum* (Table 2). The very next year Miller (1754) followed Tournefort (1694) and formally described the genus *Lycopersicon*. Miller did not approve of Linnaeus's binomial system, and he continued to use polynomial phrase names for all plants until 1768. Miller's circumscription of the genus *Lycopersicon* also included potatoes as "*Lycopersiconradice tuberosa, esculentum*". Later, Miller (1768) began to use Linnaeus binomial system and published descriptions under *Lycopersicon* for several species. It included *L. esculentum*, *L. peruvianum*, *L. pimpinellifolium* and *L. tuberosum* (potatoes). In the posthumously

published edition of '*The gardener's and botanist's dictionary*' (Miller, 1807) the editor, Thomas Martyn, followed binomial system of Linnaeus and merged *Lycopersicon* back into *Solanum*. Following Miller's early work, a number of classical and modern authors recognized tomatoes under *Lycopersicon*, but other taxonomists included tomatoes in *Solanum*.

Today, based on evidence from phylogenetic studies using DNA sequences and more in-depth studies of plant morphology and distribution, there is general acceptance of the treatment of tomatoes in the genus *Solanum* by both taxonomists and breeders alike. The use of *Solanum* names has gained wide acceptance by the breeding and genomics community such as the Solanaceae Genomics Network (SGN) and the International SOL Project (<http://www.sgn.cornell.edu/>). These names in *Solanum* are being incorporated in germ plasm bank databases as in the C.M. Rick Tomato Genetic Resources Center (<http://tgrc.ucdavis.edu/>).

Table 2: Scientific classification

Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Eudicots
(unranked):	Asterids
Order:	Solanales
Family:	Solanaceae
Genus:	<i>Solanum</i>
Species:	<i>S. lycopersicum</i>

Binomial name

Solanum lycopersicum L.

Synonyms

Lycopersicon lycopersicum

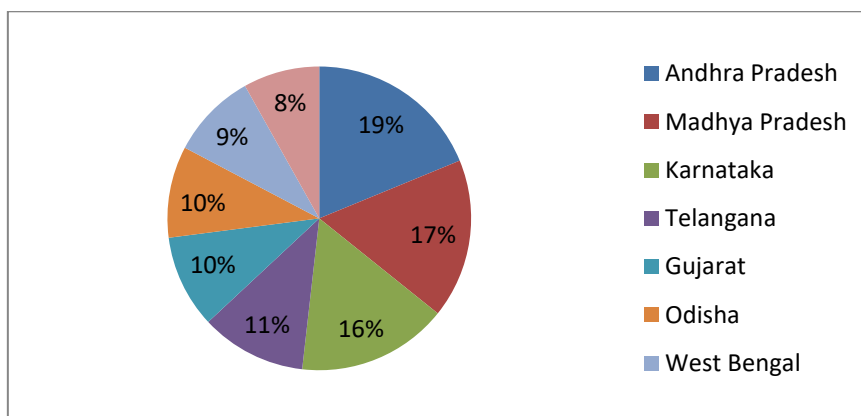
Lycopersicon esculentum

Tomato

Fig.1: Cross-section and full view of hothouse (Green house grown) tomato.
1.2 Distribution in India Includes Regions of Cultivation:

Tomato is cultivated in all the states of India from Jammu & Kashmir to Tamil Nadu (North- South) and Arunachal Pradesh to Gujarat (East-West). The major tomato producing states in India, as per 3 rd Advance

Estimate for 2016-17, Andhra Pradesh is the major Tomato producing state with 12.94% of production share, Followed by Madhya Pradesh, Karnataka, Telangana, Gujarat, Odisha, West Bengal with 11.68%, 11.05%, 7.75%, 6.82%, 6.71%, 6.31% share respectively.


Fig.2: Leading tomato producing states in India 2016-17
Source: State Departments of Horticulture & Agriculture

2. BOTANICAL DESCRIPTION ^[11]

Solanum lycopersicum L. is an annual herb, member of family Solanaceae; this plant is native to America. Tomato plant has decumbent stems, which bend under the weight of secondary branches, leaves and fruits; therefore, these plants usually grow on other plants or structures. Tomato stems and leaves are covered with hairs (trichomes).

The leaves are 10-25 cm long, pinnate, composed of 5-9 leaflets each leaflet 8 cm long), margins serrate. The stem and leaves are highly vascularized. The first 30 cm of roots are densely ramified. This root system is called tap root. Tomato flowers are hermaphrodite, 1-2 cm, with five lobed corollas, bright yellow in almost every tomato species; they appear in clusters of 3 to 12 flowers, separated by 3 leaves.

S.lycopersicum is grown worldwide because of its edible fruits, known as tomatoes. These fruits are slightly acid and brightly-colored berries, color ranging from yellowish to red, due to the presence of pigments lycopene and carotene. Wild tomatoes are 1-2 cm in diameter; cultivated varieties are much

larger. This fruit contains a large number of seeds, embedded in a slimy jelly-like pulp. The pulp contains much water and is very tasty and easy to eat. Tomato plants thrive in fertile, humid, organic soils.

Tomato extract is produced from the fruits of *Solanum lycopersicum* L.

3. CHEMICAL COMPOSITION ^[13, 14]

Besides water, the major constituents of tomatoes are carbohydrates – which give tomatoes a slight sweetness – and some organic acids, which give them a typical taste. Citric and malic acids are the most abundant acids, although some other acids such as acetic, formic, lactic and fumaric have been found. Tomato is a major source of certain minerals such as potassium and magnesium. Vitamins in tomatoes include: vitamin C, thiamin (vitamin B1) and nicotinic acid (vitamin B3). This fruit also contains carotenoids such as lycopene (a pigment that gives tomato its typical red color); flavonoids and other polyphenols such as naringenin and quercetin; and *p*-coumaric, caffeic, ferulic and chlorogenic acids.

Constituents	Content (per 100 g)
Water(g)	94.7
Protein(g)	1.0
Fat(g)	0.1
Fiber(g)	1.6
Carbohydrates(g)	
Glucose	0.9
Fructose	1.0
Organic acids(g)	
Citric	0.43
Malic	0.08
Vitamins(mg)	
Vitamin C	18
Thiamin	0.04
Riboflavin	0.02
Nicotinic acid	0.7
β – carotene (equivalent)	0.34
Minerals(mg)	
Potassium	200
Sodium	6
Calcium	8
Magnesium	10
Iron	0.3
Zinc	0.2

Table 3: Chemical composition of tomato

4. PRESENT-DAY CULTIVATION AND USAGE ^[12]

Tomatoes are one of the most important fruits in the human diet around the world. Global Production has increased by about 30% in the past four decades. The leading producers are China and the USA, followed by Turkey, India, Italy, Iran, Egypt, Brazil, and Spain. Tomatoes can be consumed as fresh fruit or in processed forms - as tomato preserves, dried tomatoes and tomato-based foods. Varieties of tomatoes used in processing have a determinate growth, dwarf habit, concentrated and uniform fruit set and ripening, and are harvested mechanically. Fresh market varieties are generally indeterminate, grown in greenhouses, and harvested by hand. There are a large number of cultivars, differing in size, form, color, flavor, taste, and shelf-life, as well as in the content of nutritional and bioactive compounds. Usually they are grouped into five major types: classic round tomatoes, cherry and cocktail tomatoes, plum tomatoes, beefsteak tomatoes, and vine or truss tomatoes.

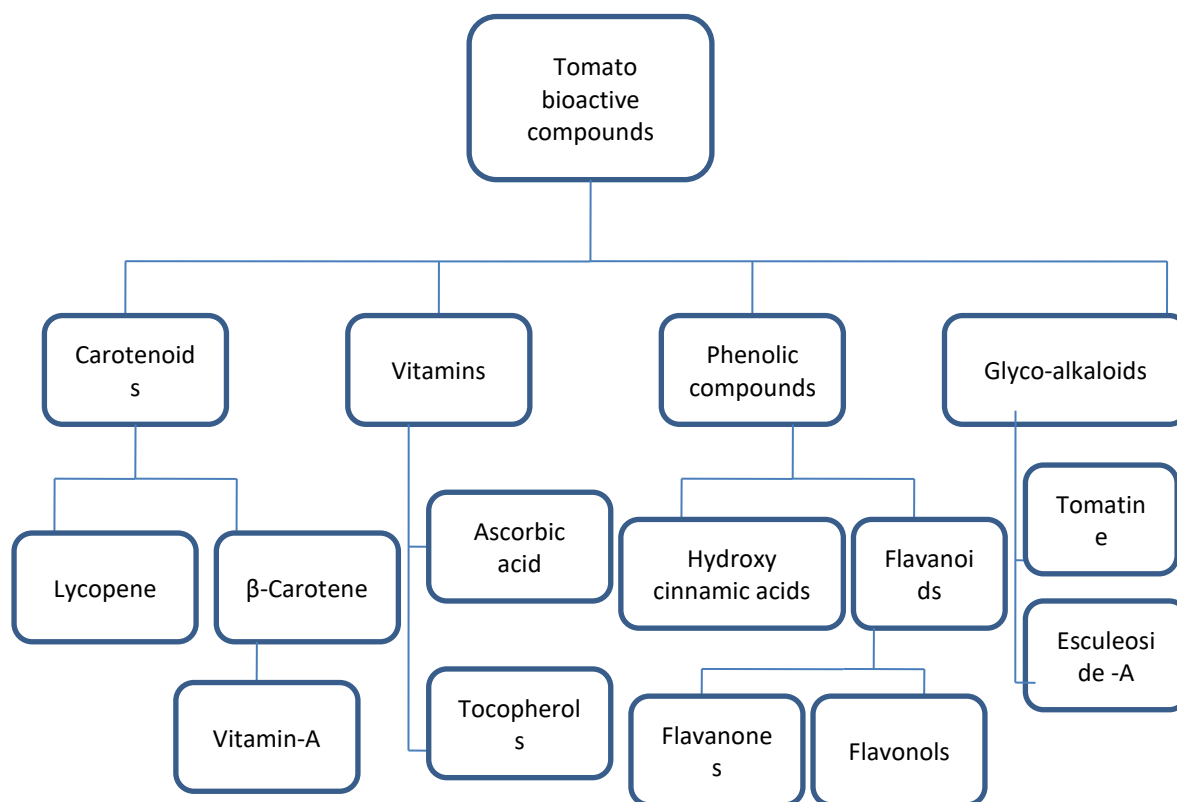
5. BIOACTIVE COMPOUNDS

Nowadays, consumers are increasingly made aware and better informed about the health benefits

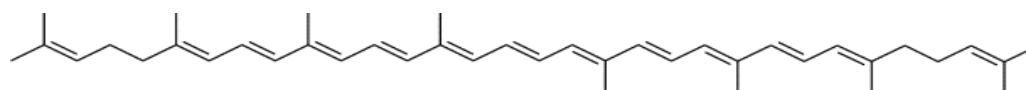
provided by food beyond its basic nutritional role. Actually, they are looking for foods with health promoting properties called “functional foods”. The tomato fruit is a good example, whose functionality or health claim properties are conferred by biologically active ingredients responsible for decreasing the risk of susceptibility to certain diseases.

The major compounds of this fruit (Fig. 3) are carotenoids (β -carotene and mainly lycopene), vitamins (ascorbic acid and tocopherols), and phenolic compounds including hydrocinnamic acids (mainly caffeic acid and its ester chlorogenic acid) and flavonoids such as narigenin and rutin ^[15-17]. Other bioactive compounds, such as glycoalkaloids and lectins also present in tomato fruits have shown relevant biological effects *in vitro* and *in vivo* ^[18, 19]. Nevertheless, the content of bioactive compounds in tomatoes is affected by environmental and genetic (cultivar or variety) factors, geographical location, agricultural practices, processing conditions, among others ^[15-17]. The main bioactive compounds of tomato fruit are described below.

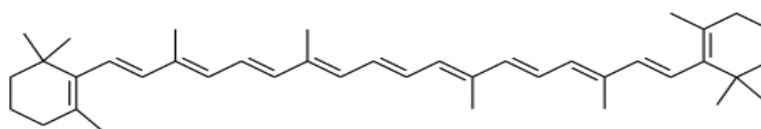
Fig.3: Groups of bioactive compounds of tomatoes:



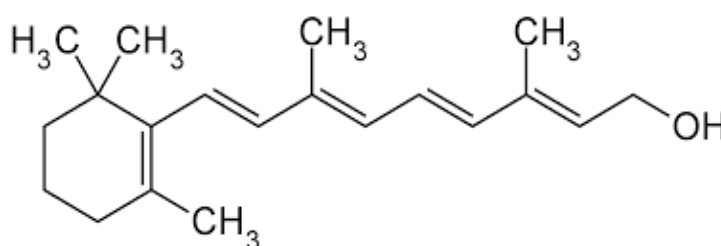
Carotenoids [22, 23]



Lycopene

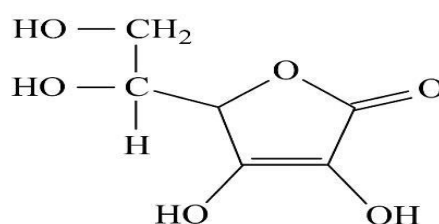


B-carotene



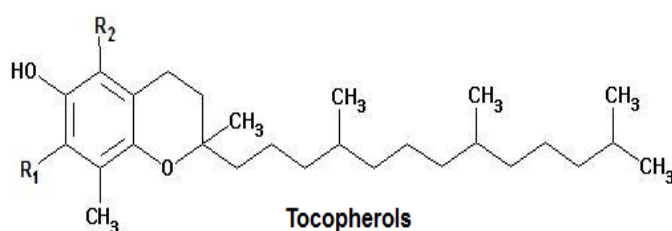
Vitamin A

Fig.4: Chemical structures of (a) lycopene, (b) β -carotene and (c) vitamin A. Vitamins [24]

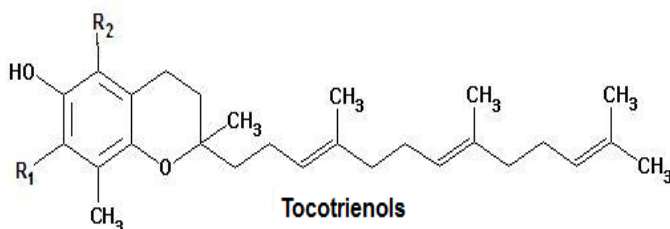


Ascorbic acid
(Vitamin C)

Fig.5: Chemical structures of Ascorbic acid.



Tocopherols



Tocotrienols

Tocopherol / Tocotrienol	R ₁	R ₂
α -	CH ₃	CH ₃
β -	H	CH ₃
γ -	CH ₃	H
δ -	H	H

Fig.6: Chemical structures of (a) tocopherols and (b) tocotrienols. [25]

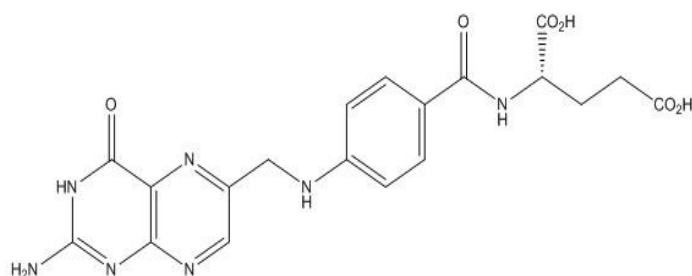


Fig.7: Chemical structure of folic acid. [26]

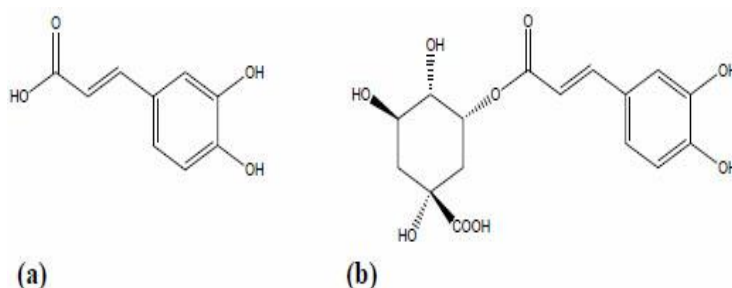


Fig.8: Chemical structures of (a) caffeic acid and (b) chlorogenic acid. [27]

Phenolic Compounds [28]

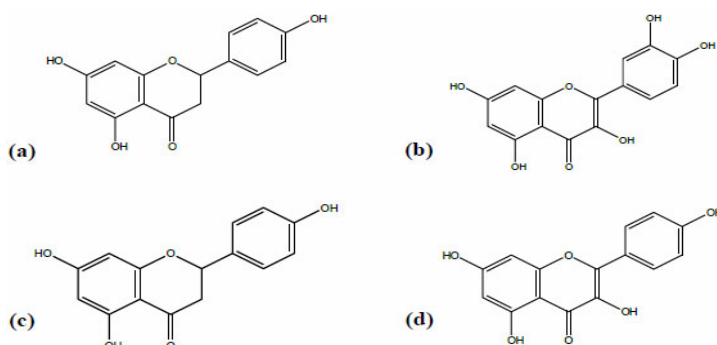


Fig.9: Chemical structures of (a) naringenin (b) quercetin (c) rutin and (d) kaempferol.

Glycoalkaloids [18, 19]

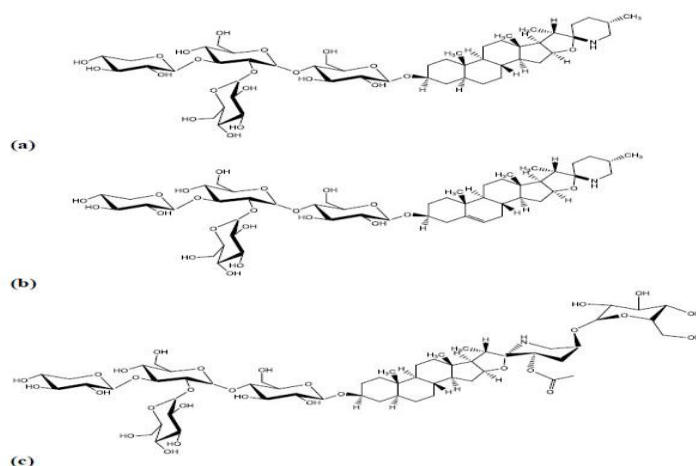


Fig.10: Chemical structures of (a) α-Tomatine, (b) dehydrotomatine and (c) Esculeoside A.

6. MEDICINAL USES OF *SOLANUM LYCOPERSICUM*: [29-35]

➤ **Good for your skin:**

Tomatoes contain a high level of lycopene, which is a substance that is used in some of the more pricy facial cleansers that are available for purchase over-the-counter. If you want to try tomatoes for skin care, you need to start with about eight to twelve tomatoes.

Peel the tomatoes and then place the skin on your face with inside of the tomato touching your skin. Leave the tomatoes on your face for a minimum of ten minutes, then wash. Your face will feel clean and shiny. Some redness may occur, but should fade with time.

➤ **Prevent several types of cancer:**

A number of studies have been conducted that indicate that the high levels of lycopene in tomatoes works to reduce your chances of developing prostate, colorectal and stomach cancer. Lycopene is a natural antioxidant that works effectively to slow the growth of cancerous cells. Cooked tomatoes produce even more lycopene, so go ahead and cook up a batch of your mom's famous tomato soup.

➤ **Maintain strong bones:**

Tomatoes contain a considerable amount of calcium and Vitamin K. Both of these nutrients are essential in strengthening and performing minor repairs on the bones as well as the bone tissue.

➤ **Repair damage caused by smoking:**

No, eating tomatoes is not the most recent fad to help you quit smoking. However, tomatoes can reduce the amount of damaged done to your body by smoking cigarettes. Tomatoes contain coumaric acid and chlorogenic acid that work to protect the body from carcinogens that are produced from cigarette smoke.

➤ **Provide essential antioxidants:**

Tomatoes contain a great deal of Vitamin A and Vitamin C. This is primarily because these vitamins and beta-carotene work as antioxidants to neutralize harmful free radicals in the blood. Free radicals in the blood stream are dangerous because it may lead to cell damage.

Remember, the redder the tomato you eat is, the more beta-carotene it contains. In addition, you also want to keep in mind that cooking destroys the Vitamin C, so for these benefits, the tomatoes need to be eaten raw.

➤ **Good for your heart:**

Because of the Vitamin B and potassium in tomatoes, they are effective in reducing cholesterol levels and lowering blood pressure. Therefore, by including tomatoes in your regular balanced diet you can

effectively prevent heart attacks, strokes as well as many other heart related problems that may threaten your life.

➤ **Good for your hair:**

The Vitamin A in tomatoes works perfectly to keep your hair shiny and strong. In addition, it also does wonders for your eyes, skin, bones and teeth.

➤ **Good for your kidneys:**

Adding tomatoes without seeds to your diet has been proven in some studies to reduce the risk of kidney stones.

➤ **Good for your eyes:**

The Vitamin A found in tomatoes is fantastic for improving your vision. In addition, eating tomatoes is one of the best foods to eat to prevent the development of night blindness.

➤ **Good for diabetics:**

Tomatoes are packed full of the valuable mineral known as chromium. It works effectively to help diabetics keep their blood sugar levels under better control.

➤ **Lower Cholesterol:**

A Tomato- cholesterol free and a good source for diet; it won't add cholesterol to the diet. A cup of tomato provides 9% of fiber that helps you to lower the high cholesterol levels. Tomatoes also contains niacin (vitamin B3), which has been used as a safe way to lower cholesterol levels.

➤ **Lower Blood Pressure:**

The tomatoes provide significant drop in blood pressure. After 8 weeks, ongoing tracking of daily tomato ingestion (in the form of lycopene complex – a tomato extract) showed a drop in both the blood pressure top number (systolic) by 10 points and the bottom number (diastolic) by 4 points.

➤ **Protection from cell Damage:**

The tomatoes are excellent source of antioxidant lycopene. Antioxidants travel through the body, neutralizing dangerous free radicals that otherwise damage cells and cell membranes. Free radicals escalate the progression or severity of atherosclerosis, diabetic complications, asthma, and colon cancer. High intakes of lycopene have been shown to help reduce the risk or severity of all of these illnesses.

➤ **Counteract Acidosis:**

Acidosis is a main cause of calcium loss, fatigue, headaches, sleeplessness, muscle aches, acne, eczema, arteriosclerosis, sexual dysfunction, hormone imbalance, depression, and degenerative conditions.

Our bodies are designed to maintain an alkaline balance with a pH of 7.365. By including plenty of alkaline minerals in our diets – calcium, magnesium,

potassium and sodium – we help our body maintain its alkaline balance naturally. Tomatoes are excellent sources of calcium, magnesium, and potassium and can aid in preventing acidosis.

➤ **Reduce Migraines:**

Tomatoes are an outstanding source of riboflavin, which helps for reducing the migraine attacks.

➤ **Boost Immunity:**

Due to consumption of tomatoes helps to avoid flu and colds, especially for males. These common illnesses are widely believed to be rooted in Carotenoids deficiencies, including low amounts of lycopene and beta carotene in our body. Drinking tomato juices assists in building defenses against colds and flu.

➤ **Treatment of Vasodilatation:**

Vitamin C has effectively resulted in proper dilation of blood vessels in the cases of atherosclerosis, congestive heart failure, high cholesterol, angina pectoris, and high blood pressure. It has been found that supplements of vitamin C improve blood vessel dilation.

➤ **Lead Toxicity:**

Lead Toxicity is a severe health problem found in children, especially in the urban areas. Abnormal development and growth has been found in children who are exposed to lead. They develop behavioral problems, learning disabilities and have low IQ. It may damage the kidney and increase blood pressure in adults. Vitamin C supplements reduce the blood lead level. Hence by intake of tomato lead toxicity can be reduced among the children. Hence tomato has rich in Vitamin c due to this it can able to lower this risk factor.

➤ **Combating Stroke:**

Vitamin C in tomato or Ascorbic Acid helps in reducing the risk of stroke, a kind of cardiovascular disease. A diet full of vegetables and fruits produces good quantity of vitamin C which maintains the appropriate blood pressure level. It also protects the body from free radicals which could be the reason for the stroke.

➤ **Mood:**

Vitamin C presents in the tomato plays a key role in the production of neither neurotransmitters, nor epinephrine. If vitamin c is less than they can affect the mood of a person and are critical to the proper functioning of the brain.

➤ **Wound Repair:**

Due to intake correct amount of tomato per day the Vitamin C present in it helps to repair wounds in the body. It facilitates the growth of the connective tissues that helps in the process of healing of wounds from our body.

7. HOME REMEDIAL USES ^[36]

✧ **Eye Irritation:**

Eating 1 or 2 fresh tomatoes first thing in the morning on an empty stomach is useful to relieve bloodshot eyes. Because of Vitamin C and Flavanoids in the tomatoes strengthen the blood vessels.

✧ **Face Peel:**

It loosens the top layer of dead skin cells and rub them off. Tomato is good for all types of skins. Rub tomato slices directly on face. It has healing powers, & an acid that removes dead skin and unplugs pores, making skin soft and radiant. Tomato is excellent for face peel.

✧ **Tomato Mask:**

For this slice a ripe tomato as thin as possible. Lie down and close your eyes. Apply the slices to your face, wait 10-15 minutes. Let the juices seep into your skin. After 15 minutes, use a slice to rub the juices further into the skin. It removes all dead and dry skin and leaving your face, glossy, and smooth.

✧ **Healing Sunburn:**

Tomato has Lycopene, it has improved the skin's ability to protect against harmful UV rays and tomato has been used to transform painful sunburn into a modest tan.

A slice of tomato placed on sunburn for 15 minutes takes away the burning feeling & prevents the skin from peeling or blistering; or soak peeled tomato slices in buttermilk, then apply them directly on the skin affected. It will close up the pores and relieve the pain.

8. CONCLUSION:

Tomato (*Solanum Lycopersicum*) is termed as "the most popular vegetable fruit". Tomato is cooked as vegetable alone or in combination with potato besides eaten raw when ripe. It is a fruit of good nutritive value as it is fairly rich in vitamins (vitamin C), and other minerals like calcium, phosphorus and iron. Considering its low cost, it qualifies for inclusion in the daily diet of young and growing children.

Tomatoes can make people healthier and decrease the risk of conditions such as cancer, osteoporosis and cardiovascular disease. People who ate tomatoes regularly have a reduced risk of contracting cancer diseases such as lung, prostate, stomach, cervical, breast, oral, colorectal, esophageal, pancreatic, and many other types of cancer. Tomato good for liver, reduce high blood pressure, it is an excellent fruit for rapid skin cell replacement.

Eating lots of tomatoes, one's health can be improved.

9. REFERENCES

- Linnaeus, C. (1753) *Species Plantarum*, 1st ed. Stockholm: L. Salvius.
- MacBride, J. F. (1962) Solanaceae. In *Flora of Peru*. Field Mus. Nat. Hist., Bot. Ser. 13: 3-267.
- Miller, P. (1768) *The gardener's dictionary*, Abridged 8th ed. London.
- Miller, P. (1807) *The gardener's and botanist's dictionary*, Posthumous edition, edited by Thomas Martyn, Cambridge. London.
- Mitkowski, N.A. and Abawi, G.S. (2003) Root-knot nematodes. *The Plant Health Instructor*.
- Moyle, L. C., and Nakazato, T. (2008) Comparative genetics of hybrid incompatibility: sterility in two *Solanum* species crosses. *Genetics* 179:1437-1453.
- National Horticulture Board data (NHB Database) 2013.
- Patil, B.R., Archak, S., Gautam, D. and Salimath, P.M. (2010) Narrow genetic base of private sector tomato varieties revealed by RAPD markers. *Electronic journal of Plant Breeding* 1(4): 1153-1158.
- Nutrient Data Laboratory, ARS, USDA National Food and Nutrient Analysis Program Wave 14c, 2009 Beltsville MD.
- Peralta, I., Knapp, S. and Spooner, D.M. (2005) New species of wild tomatoes (*Solanum section Lycopersicon: Solanaceae*) from northern Peru. *Syst. Bot.* 30: 424-434. L. Section *Lycopersicon*) Monogr. *Syst. Bot. Missouri Bot Gard.* 104:227-257.
- FAOSTAT. (2008). Food and Agriculture Organization of the United Nations Statistical Database. <http://faostat.fao.org> (accessed January 2010).
- National Academy of Sciences. (2005). Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. <http://www.nap.edu> (accessed December 2009).
- Kale PN. & Adsule PG. Citrus In Handbook of Fruit Science and Technology. Production, Composition, Storage, and Processing. New York: Marcel Dekker, Inc., 1995; 39-65 (ref. 641* SAL).
- Madhavi & Salunkhe Tomato In Handbook of Vegetable Science and Technology. Production, Composition, Storage, and Processing. New York: Marcel Dekker, Inc., 1998; p: 171-201 (ref. 641* SAL).
- Pinela J, Barros L, Carvalho AM, Ferreira IC. Nutritional composition and antioxidant activity of four tomatoes (*Lycopersicon esculentum* L.) farmer' varieties in Northeastern Portugal homegardens. *Food Chem Toxicol* 2012; 50(3-4): 829-34. [<http://dx.doi.org/10.1016/j.fct.2011.11.045>] [PMID: 22154854]
- Barros L, Dueñas M, Pinela J, Carvalho AM, Buelga CS, Ferreira IC. Characterization and quantification of phenolic compounds in four tomatoes (*Lycopersicon esculentum* L.) farmers' varieties in northeastern Portugal homegardens. *Plant Foods Hum Nutr* 2012; 67(3): 229-34. [<http://dx.doi.org/10.1007/s11130-012-0307-z>] [PMID: 22922837]
- García-Valverde V, Navarro-González I, García-Alonso J, Periago MJ. Antioxidant bioactive compounds in selected industrial processing and fresh consumption tomato cultivars. *Food Bioprocess Technol* 2013; 6(2): 391-402. [<http://dx.doi.org/10.1007/s11947-011-0687-3>]
- Friedman M. Anticarcinogenic, cardioprotective, and other health benefits of tomato compounds lycopene, α -tomatine, and tomatidine in pure form and in fresh and processed tomatoes. *J Agric Food Chem* 2013; 61(40): 9534-50. [<http://dx.doi.org/10.1021/jf402654e>] [PMID: 24079774]
- Friedman M. Chemistry and anticarcinogenic mechanisms of glycoalkaloids produced by eggplants, potatoes, and tomatoes. *J Agric Food Chem* 2015; 63(13): 3323-37. [<http://dx.doi.org/10.1021/acs.jafc.5b00818>] [PMID: 25821990]
- Aherne SA, Jiwan MA, Daly T, O'Brien NM. Geographical location has greater impact On carotenoid content and bioaccessibility from tomatoes than variety. *Plant Foods Hum Nutr* 2009; 64(4): 250-6. [<http://dx.doi.org/10.1007/s11130-009-0136-x>] [PMID: 19757067]
- Iglesias MJ, García-López J, Collados-Luján JF, et al. Differential response to environmental and nutritional factors of high-quality tomato varieties. *Food Chem* 2015; 176: 278-87. [<http://dx.doi.org/10.1016/j.foodchem.2014.12.043>] [PMID: 25624234]
- Palozza P, Catalano A, Simone RE, Mele MC, Cittadini A. Effect of lycopene and tomato products on cholesterol metabolism. *Ann Nutr Metab* 2012; 61(2): 126-34. [<http://dx.doi.org/10.1159/000342077>] [PMID: 22965217]
- Defo MA, Spear PA, Couture P. Consequences of metal exposure on retinoid metabolism in vertebrates: a review. *Toxicol Lett* 2014; 225(1): 1-11. [<http://dx.doi.org/10.1016/j.toxlet.2013.11.024>] [PMID: 24291063]
- Baiano A, Del Nobile MA. Antioxidant compounds from vegetable matrices: Biosynthesis, occurrence, and extraction systems. *Crit Rev Food Sci Nutr* 2015. In press. [PMID: 25751787]
- Carocho M, Ferreira IC. A review on antioxidants, prooxidants and related controversy: natural and synthetic compounds, screening and analysis methodologies and future perspectives. *Food Chem Toxicol* 2013; 51: 15-25. [<http://dx.doi.org/10.1016/j.fct.2012.09.021>] [PMID: 23017782]
- Martin H, Comeskey D, Simpson RM, Laing WA, McGhie TK. Quantification of folate in fruits and vegetables: A fluorescence-based homogeneous assay. *Anal Biochem* 2010; 402(2): 137-45. [<http://dx.doi.org/10.1016/j.ab.2010.03.032>] [PMID: 20361923]
- Tyagi K, Upadhyaya P, Sarma S, Tamboli V, Sreelakshmi Y, Sharma R. High performance liquid chromatography coupled to mass spectrometry for profiling and quantitative analysis of folate

- monoglutamates in tomato. *Food Chem* 2015; 179: 76-84.
[<http://dx.doi.org/10.1016/j.foodchem.2015.01.110>]
[PMID: 25722141]
28. Escarpa A, Gonzalez MC. An overview of analytical chemistry of phenolic compounds in foods. *Crit Rev Anal Chem* 2001; 31: 57-139.
[<http://dx.doi.org/10.1080/20014091076695>]
 29. Silaste ML, Alfthan G, Aro A. Tomato juice decreases LDL cholesterol levels and increases LDL resistance to oxidation. *Br J Nutr* 2007; 98:1251-1258.
 30. Blum A, Merei M, Karem A. Effects of tomatoes on the lipid profile. *Clin Invest Med* 2006; 29:298-300.
 31. Blum A, Monir M, Wirsansky I. The beneficial effects of tomatoes. *Eur J Intern Med* 2005; 16:402-404.
 32. Freeman BB, Reimers K. Tomato Consumption and Health: Emerging Benefits. *American Journal of Lifestyle Medicine* 2010.
 33. Polívková Z, Šmerák P, Demová H, Houška M. Antimutagenic Effects of Lycopene and Tomato Purée. *Journal of Medicinal Food* 2010; 13(6):1443-1450.
 34. Shidfar F, Froghifar N, Vafa M, Rajab A, Hosseini S, Shidfar S *et al.* The effects of tomato consumption on serum glucose, apolipoprotein B, apolipoprotein A-I, homocysteine and blood pressure in type 2 diabetic patients. *Int J Food Sci Nutr* 2011; 62(3):289-294.
 35. Pittenger, Dennis R. Vegetables That Contain Natural Toxins. *California Master Gardener Handbook*. ANR Publications, 643–644. ISBN 978-1-879906-54-9.
 36. Slow food upstate, medicinal properties available at <http://renatovicario.com/pdf/tomato>. Access on dated 09/12/13