

EXPLORING THE ALLURE OF STRAWBERRIES

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ABSTRACT

Strawberry is a member of family Rosaceae. *Fragaria x ananassa* are two important species which grown throughout the world. It is a rich source of Vitamin C, also contains sugar, organic acid, and major constituent is water. It is utilized in fresh form as well as processed such as jam and juices. Organic food products are beneficial for the people around the globe. From the past years, organic food production is increased abruptly. Plasticulture strawberry production system is used which enhances the yield of strawberry doubles times as compared to matted rows. Different kinds of plastic mulches used which give protection to plant and soil and increase the yield. As we know due to health concerns that occurred due to excessive use of chemicals and fertilizers, it is hazardous to use chemical fertilizers on unpeelable fruits like strawberry. It enhances risks for human health. Many constituents of strawberries such as ellagic acid, anthocyanins, and ellagitannins provide different health benefits to humans. It has anticarcinogenic and anti-antioxidant properties, and they prevent human from heart diseases and many other problems such as obesity.

Keywords: Strawberry cultivars, Plasticulture strawberry, Mulches, Antioxidant, Vitamin C.

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INTRODUCTION

Strawberry is a juicy, delicious, and soft fruit among berries. It is a seasonal fruit cultivated under wide ecological conditions all over the world. Its two cultivated species *Fragaria x ananassa* are significant among fruits. Other species grow wild all over the world (John *et al.*, 1994). *Fragaria x ananassa* cultivated large-fruited strawberry derives in Europe in the 18th century. In the 19th century, many other countries cultivated different varieties which grown under suitable climate conditions (Britannica, 2020). Strawberry has a sweet, fruity, and tart flavor. It is deep red in color. It belongs to the family Rosaceae. The major constituent in strawberries is water. It is a highly perishable fruit. It requires immediate utilization when it is in raw form or it utilizes as processed product (Fig. 1).

Different cultivars of strawberries are used for the preparation of various products such as jam, juices, purees, and alcoholic beverages such as strawberry wine. Cultivars such as “Polka”, “Jewel”, and “Tenira” are used for the preparation of processed products. Others such as “Camarosa” and “Chandler” are used for wine production. Strawberry flavor is commonly used in many products such as ice cream, bakery fillings, yogurts, and cake mixes (Sharma *et al.*, 2009).

From the past few years, organic food production is increased abruptly. Plasticulture strawberry production system is used in many areas such as California and Florida which enhances the yield of strawberry doubles times as compared to matted rows (Darrow *et al.*, 1966). Different kinds of plastic mulches such as clear mulch, black mulch, reflective mulch, and selective light transmission mulch used which give protection to plant and soil and increase yield. Organic fertilizers use to protect the soil and plant and it improves the soil fertility and provides essential nutrients to plants for better production (Atiyeh *et al.*, 2002). Many constituents of strawberry such as ellagic acid, anthocyanins, and ellagitannins provide different health benefits to humans. It has anticarcinogenic and anti-antioxidant properties (Afrin *et al.*, 2016).

PHYSICAL DESCRIPTION

Plants of strawberry are low growing and they do not have woody stem; it means that they are herbaceous, having soft green stem. Basal leaves

originate from crown part in the form of three leaflets and are hairy and sawtooth edged. Flowers on strawberry plants are white in color bear on stalks and are grown in small clusters. It has a fibrous root system and it becomes woody when the plants age (Britannica, 2020) (Fig. 2).

CULTIVATION OF STRAWBERRY

In Pakistan

For past 15–20 years, strawberry is being cultivated in various areas of Pakistan on large scale as Haripur, Peshawar, Sialkot, Swat, Jhelum, and Mardan. While wild strawberry plants cultivated in the hills of Chitral, Gilgit, and Kohistan. Hybrid of two species *Fragaria chiloensis* and *Fragaria virginiana* is the most cultivated species of strawberry (John *et al.*, 1994). This species is a rich source of Vitamin C. It contains 50 mg of ascorbic acid in 1 g of strawberry. As compared to sugar cane, strawberry crop gives 4 times higher profit and 9 times higher than wheat crop (Afridi *et al.*, 2009). However, input cost of propagation of strawberry is higher than other crops such as wheat and sugar cane (Fig. 3).

Harvesting period of strawberry is 30–40 days. In one acre of land, 35,000 of plants can be planted. Ploughing should be done with care as root system of strawberry can be damaged. Husking is done after some days to avoid weed growth around strawberry plants. Mostly, organic fertilizers are preferred for good yield and production. Inorganic fertilizers are also used (Türemis, 2000).

In Abroad

Tropical and sub-tropical climate conditions are better for strawberry cultivation. It can be grown in kitchen gardens and hanging baskets. After sowing, the seeds profit comes within 6 months (Asad *et al.*, 1997). This fruit is fourth highest in terms of production and fifth highest in consumption (Boriss *et al.*, 2010). Major strawberry-producing countries are USA, Korea, Russia, Japan, and Poland. In India, it is cultivated in areas of Jammu and Kashmir, Haryana and Utter Pradesh (Sharma *et al.*, 2009). Strawberries are propagated either in open farms or green houses. In California and Florida, outdoor cultivation is preferred because these are warmer cities. As in Northern Europe, strawberry is cultivated in green house due to cold environment (Freeman and Nicoli, 1999). Strawberry cultivation is done in two

growing seasons, summer and winter planting which is common in Europe. However, now single growing system (autumn planting) is used in Florida, California, and Mediterranean region (Fig. 4).

PLASTICULTURE STRAWBERRY

It is the hill training system in which transplants of strawberry are planted in the densities in double rows. It is a commercial growing system in North Carolina and Mid-South. It is done in early fall. Transplanted "green" strawberry is planted on raised beds which are fumigated with methyl bromide and covered with plastic mulch. This technique was introduced in the 1980s by the researchers of NC State University to the Mid-South. This production system gives double benefits as compared to matted row but it requires intensive management. In this system, strawberries can be harvested in 7–8 months. The major problem in this production system is the risk of infection of anthracnose fruit rot which reduces the fruit yield (Darrow *et al.*, 1966).

TYPES OF SOIL MULCHES

Various types of plastics used during the cultivation. They play a role in covering and protection. Each has its specific effect on plants and soil.

Black mulch

It elevates the temperatures of soil and surface 19°C and 7°C. Moreover, it prevents weed germination (Himelrick, 1981; Lamont, 1993). This mulch has long life, efficient, and is cheap (Himelrick *et al.*, 1996). It is most used in Florida, California, Spain, and Morocco. It has one side

effect, that is, it burns the leaf and fruit if cover and plants come in contact during hot season (Lamont, 1993).

Clear mulch

It is transparent polythene mulch that increases plant growth and fruit production under cool temperature. It increases the temperature of soil (Branzanti *et al.*, 1967; Hancock, 1999). In Mediterranean regions, early harvesting is done due to early root development due to elevated soil temperatures (Himelrick, 1982). This mulch is not used in Florida and California due to excessive soil temperatures. It is commonly used in Mediterranean regions. It is applied before flowering and after appearance of flowering buds to prevent damage to flowers and excessive vegetative growth (Hancock, 1999).

Reflective mulch

These are of white and silver colors used to increase diffused radiation as they reflect radiation (Sondern, 1967). They also attract or repel insects such as white flies. They distract their vision and attract them to other colors (Antignus *et al.*, 1996; George 1971).

Selective light transmission mulch

Red, blue, and green colors are used in a few areas whereas brown color mulch is widely used. It prevents weed germination (Himelrick *et al.*, 1996). They pass some part of the light spectrum through and heat the soil. They filter out the light in photosynthesis active radiation region (Lamont, 1999; Olmstead and Tarara, 2001).

Effect of organic fertilizers on strawberry plant

Organic fertilizers are used worldwide to protect the soil from deterioration. They ensure the availability of essential nutrients to plants and improve soil fertility (Atiyeh *et al.*; 2002). Vermin composts containing nitrogen, phosphorous, potassium, and hormones are used that increase gibberellic acid in roots which



Fig. 1: Strawberries: Rich source of Vitamin C



Fig. 2: Strawberry Plant (*Fragaria species*)



Fig. 3: Cultivation of strawberry



Fig. 4: South-east Plasticulture Strawberries

enhances flowering buds and fruiting sites. If there is deficiency of nitrogen and phosphorous then it leads to reduction in number of flowers and fruits (Tagliavini *et al.*, 2005). Manures are used which increases fruit size and weight by the formation of carbohydrates (Odongo *et al.*, 2008). Organic manures decrease the acid content of strawberry. Plants that are treated with organic manures have increased juice percentage, TSS, and total sugars (El-Hamid *et al.*, 2006). Strawberries are cultivated easily in the areas having fertilized soil with moisture and proper draining facility and it is very complicated in the areas where temperature rises above 40°C. Use of chemical fertilizers attributes damage to strawberry due to increase concentration of ion (Davis, 1952). Biofertilizers fix atmospheric nitrogen and stimulate growth hormones. Biofertilizers with azotobacter increase the biological activities of soil. Strawberry plants that are inoculated with azotobacter increased the fruit size and improve yield (Rana and Chandel, 2003). Compost is a good source of nutrients for small crops. Strawberry plants treated with banana compost give the highest fruit yield (Turemis, 2002).

Effect of UV light on antioxidant property of strawberry

A sedentary lifestyle and unhealthy eating habits are considered major causes of obesity (Han *et al.*, 2010). In addition, high blood pressure that contains large amounts of sugar and purified fats causes brain injury and systemic oxidation stress (Freeman *et al.*, 2014). For example, unique Korean foods (HFD) stimulate adipose tissue accumulation, which leads to the development of obesity, which is associated with increased oxidation stress in both human and animal models (Hunsche *et al.*, 2017; Panchal *et al.*, 2011; Salmon, 2016). Thus, oxidative stress causes cell dysregulation, increases the production of pro-inflammatory molecules, causes energy imbalance, and increases risk factors for Type 2 diabetes, hypertension, hyperlipidemia, and brain damage (Ye *et al.*, 2015). Dietary supplementation with the antioxidant curcumin reduces brain damage by increasing oxidative stress (Martínez-Morúa *et al.*, 2013) and brain-derived neurotrophic factor (BDNF) levels in obese and diabetic mice (Franco-Robles *et al.*, 2014). Interestingly, a berry diet increased the expression of neuroprotective trophic factor (IGF-1) in the brain of mice, suggesting that berries are potent modulators of brain signals associated with improved cognitive function (Shukitt-Hale *et al.*, 2008). In an experimental animal model fed a high-fat diet, strawberries reduced obesity and improved glycemic control (Prior *et al.*, 2008). In rats, 56Fe induced neurochemical changes and increased inflammation and oxidative stress in the prefrontal cortex and hippocampus. Strawberry diet significantly reduced 56Fe radiation-induced neurotoxicity (Poulose *et al.*, 2014). Similarly, strawberry extract scavenges free radicals (Basu *et al.*, 2009), and ellagic acid isolated from strawberries prevents oxidation of low-density lipoprotein (LDL), which promotes

aortic smooth muscle proliferation (Chang *et al.*, 2008). In addition, supplementing with freeze-dried strawberry powder in women with metabolic syndrome reduced lipid peroxidation and serum cholesterol levels (Basu *et al.*, 2009). Strawberry flavonoids thus play a beneficial role in human health. On the other hand, ultraviolet (UV) light increased the antioxidant capacity of fresh fruits by increasing the content of polyphenols and flavonoids (Allothman *et al.*, 2009; Younis *et al.*, 2010). However, high doses of UV can cause oxidation of bioactive materials (Rivera-Pastrana *et al.*, 2014). Therefore, the effectiveness of UV light depends on the dose, light source, type, breed, etc. Regarding UV radiation, Ayala *et al.* reported that this radiation increased the concentration of phenolic compounds and various antioxidants in strawberries (Ayala and Lozoya, 2016). Therefore, the aim of this study was to obtain extracts from UV-irradiated strawberries and determine their effect on oxidative stress in HFD-fed rats.

Nutritional aspects

It is rich source of Vitamin C, Vitamin B, and Vitamin E, minerals such as potassium and phosphorus, proteins, folic acid, carotenoids, and flavonoids. They also contain phytosterols, tannins, and ellagic acid (Stoner *et al.*, 2006; Aaby *et al.*, 2007; Basu *et al.*, 2010). Vitamin C, phenolics, and flavonoids are higher in strawberries as compared to other berries (Häkkinen and Törrönen *et al.*, 2000). Strawberries have the lowest calories among fruits (Grzelak-Błaszczuk *et al.*, 2017). As compare to other berry fruits Vitamin C, phenolics, phytochemicals, and flavonoids percentages are greater (Trevino-Garza *et al.*, 2015). Nutritional content of raw strawberries, frozen strawberries, and processed strawberries is given in Table 1.

Strawberries have some beneficial properties as anticarcinogenic, antihypertensive as it has phytochemicals as ellagitannins, anthocyanins, and ellagic acid (Basu *et al.*, 2014). Strawberries were included among the rich source of polyphenols in diet. This provides more than 2 mg polypeptides per serving and having ranking on list of foods (Pérez-Jiménez *et al.*, 2010). Phenols are diverse which provides most of health benefits. Its deep color is due to plant secondary metabolite such as anthocyanin. Quantification and characterization in strawberries are done by food scientists (Aaby *et al.*, 2007; Buendia *et al.*, 2010). Important contributors of antioxidants and anticarcinogenic effects in strawberries are provided by Ellagic acid.

Properties of strawberry

The properties of strawberries (Afrin *et al.*, 2016) are given below:

- It has anticarcinogenic property.
- It prevents cardiovascular diseases.
- It has antioxidant properties

Table 1: Nutritional content of strawberries

Value per 100 g	Raw strawberries	Frozen strawberries	Frozen and sweetened strawberries	Canned strawberries, heavy syrup pack
Water (g)	89.07	89.97	78.05	75.3
Energy (kcal)	35	35	78	92
Sugar (g)	4.56	4.56	18.61	21.83
Total lipid (g)	0.11	0.11	0.14	0.26
Protein (g)	0.43	0.43	0.52	0.56
Vitamin C (mg)	41.2	41.2	39.5	31.7
Vitamin E (mg)	0.29	0.29	0.24	0.19
Anthocyanidins (mg)				
Malvidin	0	0	0	0
Cyanidin	1.96	1.96	1.27	-
Petunidin	0.08	-	-	-
Flavonols (mg)				
Myricetin	0	0.35	-	-
Kaempferol	0.46	0.49	-	-
Riboflavin	0.037	0.037	0.077	0.034

Source: National Nutrient Database for Standard Reference Service Release 22 Agricultural Research Services, United States Department of Agriculture, 2009; Database for the Flavonoid Content of Selected Foods Release 2.1, 2007 Beltsville MD: Agricultural Research Services, United States Department of Agriculture, 2007

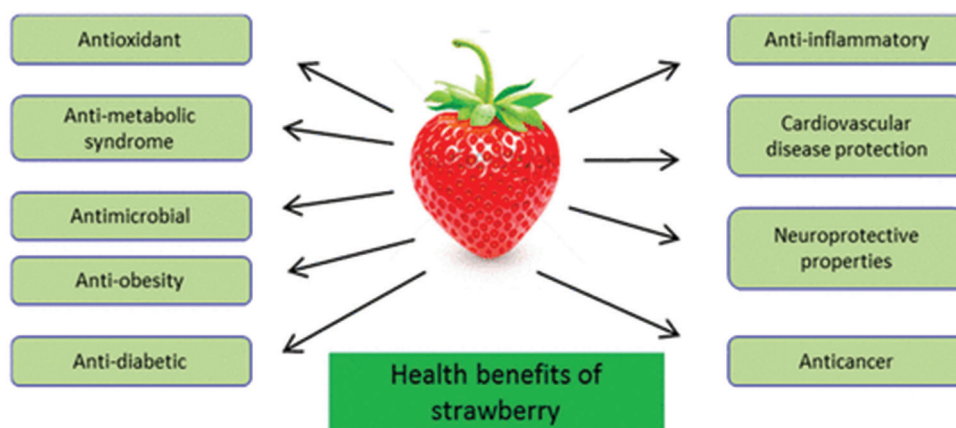


Fig. 5: Promising health benefits of the strawberry

- It is used against fungal infections
- It is also used against bacterial infections.
- It has anti-inflammatory property.
- It reduces obesity in men and women.

IMPORTANT USES OF STRAWBERRY OVER HEALTH

Use of strawberry for inflammation

Inflammation is a natural immune response from body that helps the injuries or wounds to heal. Problem arrives when inflammation causes risk to body and leads toward increased progression of various diseases such as obesity, diabetes, heart diseases, and cancer. Researchers have shown that strawberries have anti-inflammatory action. Vitamins and polyphenols play a role in such properties of strawberries (Land *et al.*, 2021).

Use of strawberries for heart diseases

Some components of strawberry act against heart problems and prevent heart dysfunction. Various components of strawberries such as phenolic acid, flavonoids, anthocyanins, ellagic acid, and many other nutrients protect heart diseases and risk of cardiovascular diseases. Researchers conducted a study on volunteers who intake strawberries on regular basis. It was concluded that people who consumed strawberries on regular basis have lower risk of hypertension (Hudiyawati and Suswardany, 2021; Tarantul and Eliseeva, 2019).

Use of strawberries for atherosclerosis

As due to deposition of cholesterol at the inner side walls of arteries, arteries become narrow, this situation is termed as atherosclerosis. Researchers worked on it and concluded that freeze dried strawberries may help in reduction of deposition of cholesterol (Ibrahim *et al.*, 2023).

Use of strawberries for obesity

Variety of minerals and nutrients present in strawberry plays an important role in weight loss. Strawberry is packed with antioxidants and anti-inflammatory enzymes and enough fiber that prevents weight gain. It is lower in calories and a natural sweetener. It repairs damaged tissues due to anti-inflammatory property. Adiponectin and leptin are important hormones produced by strawberries. These two hormones help in burning the fat and induce the metabolism of body. They also help in easy bowel movements (Basu *et al.*, 2021).

Potential use of strawberries for diabetes

Strawberry juices play an important role as having free radicals which decreases the progression of lipoprotein. Strawberry has cellular antioxidant activity and oxygen radical absorption capacity as compared to other fruits. Flavonoids are important content of strawberry that plays a role in control of diabetes. This is done by inhibition of glucose uptake and helps in maintenance of blood-sugar levels (Yuliwati and Nugroho, 2021; Casto *et al.*, 2013).

Use of strawberries for cancer

As we know cancer, these days is untreatable disease, a really serious sort of disease. According to researchers, after conducting a study concluded that strawberries may lower the risk of esophageal squamous cell carcinoma. It also concluded that it may help to reduce risk of cancer of neck and head. It is a defensive role for various types of cancers (Shi and Chen, 2022).

Use of strawberries for neurodegenerative disorders

Components of strawberries as flavonoids, terpenes, and phenolic acids play an important role in preventing nervous system disorders (Devi *et al.*, 2021).

Use of strawberries against microbial infections

As we know that strawberries are rich in Vitamin C and other many antioxidants which help in lowering risk of many infections. Many phenolic compounds present in strawberry causes deactivation of microbes (Afrin *et al.*, 2016; Cruz *et al.*, 2018) (Fig. 5).

CONCLUSION

Strawberry is very beneficial for health. It contains many nutrients such as zinc, iron, and Vitamin C which play significant roles in human. It also contains antioxidants as flavonoids, polyphenols, etc. which prevent from heart dysfunction and many other infections. Plastic culture strawberry production is commonly used which prevents weed germination and gives double yield as compared to matted rows.

AUTHORS' CONTRIBUTION

Dr. Naseem Zahra and Dr. Muhammad Khalid Saeed collected data and wrote article, Noor Fatima and Ezza Shehzad help in writing, and Dr. Asma Saeed reviewed article.

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CONFLICTS OF INTERESTS

There are no conflicts of interest.

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