EXPLORING THE ALLURE OF STRAWBERRIES

NASEEM ZAHRA*, MUHAMMAD KHALID SAEED, NOOR FATIMA, EZZA SHEHZAD, ASMA SAEED
Food and Biotechnology Research Centre, PCSIR Laboratories Complex, Ferozepur Road, Lahore, 54600, Pakistan.
Email: drnaseemzahra@gmail.com

Received: 7 June 2023, Revised and Accepted: 25 July 2023

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.

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 × ananassa duch 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 "Camorosa" 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 (Attyeh 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 herbarious, 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. 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 (Turemis, 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 Uttar 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). Vermicomposts containing nitrogen, phosphorous, potassium, and hormones are used that increase gibberellic acid in roots which

![Fig. 1: Strawberries: Rich source of Vitamin C](image1)

![Fig. 2: Strawberry Plant (Fragaria species)](image2)

![Fig. 3: Cultivation of strawberry](image3)

![Fig. 4: South-east Plasticulture Strawberries](image4)
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, 56F6 induced neurochemical changes and increased inflammation and oxidative stress in the prefrontal cortex and hippocampus. Strawberry diet significantly reduced 56F6 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 (Akhtman 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, 2000). Strawberries have the lowest calories among fruits (Graelak-Basczyk et al., 2017). As compared 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, Buendra 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**

<table>
<thead>
<tr>
<th>Component</th>
<th>Raw strawberries</th>
<th>Frozen strawberries</th>
<th>Frozen and sweetened strawberries</th>
<th>Canned strawberries, heavy syrup pack</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value per 100 g</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water (g)</td>
<td>89.07</td>
<td>89.97</td>
<td>78.05</td>
<td>75.3</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>35</td>
<td>35</td>
<td>78</td>
<td>92</td>
</tr>
<tr>
<td>Sugar (g)</td>
<td>4.56</td>
<td>4.56</td>
<td>18.61</td>
<td>21.83</td>
</tr>
<tr>
<td>Total lipid (g)</td>
<td>0.11</td>
<td>0.11</td>
<td>0.14</td>
<td>0.26</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>0.43</td>
<td>0.43</td>
<td>0.52</td>
<td>0.56</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>4.12</td>
<td>4.12</td>
<td>39.5</td>
<td>31.7</td>
</tr>
<tr>
<td>Vitamin E (mg)</td>
<td>0.29</td>
<td>0.29</td>
<td>0.24</td>
<td>0.19</td>
</tr>
<tr>
<td>Anthocyanidins (mg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malvidin</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cyanidin</td>
<td>1.96</td>
<td>1.96</td>
<td>1.27</td>
<td>-</td>
</tr>
<tr>
<td>Petunidin</td>
<td>0.08</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flavonols (mg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myrecitin</td>
<td>0</td>
<td>0.35</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kaempferol</td>
<td>0.46</td>
<td>0.49</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rhamnolin</td>
<td>0.037</td>
<td>0.037</td>
<td>0.077</td>
<td>0.034</td>
</tr>
</tbody>
</table>

• 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 arises 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).

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.

AUTHORS’ FUNDING
None.

CONFLICTS OF INTERESTS
There are no conflicts of interest.

REFERENCES
Afrin, S., Gasparini, M., Forbes-Hernendez, T. Y., Reboreda-Rodriguez,


