A. Introduction

1. Strawberry plant

1.1. Origin

The strawberry (*Fragaria x ananassa* Duch.) is a perennial plant, which belongs to the family Rosaceae. This family consists of about 100 genera and 3000 species, most of which are perennial herbs, shrubs and trees. The family is divided into three subfamilies: Rosoideae (rose subfamily), which contains Rosa spp., Rubus spp. (raspberries and blackberries), and Fragaria spp. (strawberries); Amygdoloideae (peach subfamily), which contains the genus Prunus (peach, cherry, apricot, almond and plum); and Maloideae (apple subfamily), which includes apple (Malus), pear (Pyrus), quince (Cydonia) and hawthorn (Crataegus) (Janick, 1979). The present cultivated strawberries appear to be hybrids between the North-American *F. virginiana* Duch. and the Chilean *F. chiloensis* (L.) Duch. (Wilhelm, 1974). *Fragaria chiloensis* (L.) Duch originated in Chile and was found from the southern coast of Chile to California and Hawaii (Staudt, 1989).

The cultivated strawberry definitely is a product of plant breeding. During the past century, hundreds of thousands of seedlings have been tested and over two thousands have been named. The varieties that are grown widely now combine the many qualities necessary for modern commercial production (Matlock, 1954).

1.2. Nutritional value

Strawberry fruits are naturally fat, sodium and cholesterol-free. They are high in vitamin C and folic acid and a good source of potassium and fibre. Strawberries are usually eaten raw, and they can also be stewed or pulped for sauces, mousses and jams.

Recently, evidence is accumulating from several fields of science, including epidemiology, human medicine and nutrition, suggesting that fruit and vegetable antioxidants play an important role in reducing the risk of degenerative diseases such as cardiovascular disease, various cancers and neurological diseases (Kalt *et al*., 1999; Wang *et al*., 1996). In this sense, on the basis of fresh weight of fruits (edible portion), strawberry had the highest antioxidative capacity (ORAC activity, oxygen radical absorbance capacity) followed by plum, orange, red grape, kiwi fruit, pink grapefruit, white grape, banana, apple, tomato, pear and honeydew melon. On the basis of dry weight of fruits, strawberry again has the highest ORAC activity followed by plum, orange, pink grapefruit, tomato, kiwi fruit, red

grape, white grape, apple, honeydew melon, pear and banana (Wang *et al*., 1996). Strawberry contains a variety of phenolic compounds implicated in health-promoting activities of human physiology. Some of these metabolites may also be important as defence compounds in plants against diseases (Dixon and Paiva, 1995). Phytochemicals found in high concentrations in strawberry fruit which are mainly responsible for antioxidant capacity, include anthocyanins and other flavonoid compounds. These phenolics (Wang and Lin, 2000) also play a role in quenching the activity of the biological damaging active oxygen radicals.

1.3. World production

From 1980 to 1999, strawberry world production increased by 53%, reaching almost 3 million tonnes (t). An increase in the strawberry crop was observed in all world areas except in Europe, where production remained more or less stable during the last decade (Faedi *et al*., 2002). Using the 1995-1999 period averages, Europe was the main production area (about 1 million t, 38% of world production, 67% of world strawberry surface), followed by North America and Asia. Sixty-two countries contribute to world strawberry production; although, 45 of them each represent less than 1%. The major strawberry producing nations are (1995-1999 averages): U.S.A. (750,000 t/year, 26.8% of the world production), Spain (294,000 t, 10.5%), Japan (192,000 t, 6.8%), Poland (176,000 t, 6.3%), Italy (172,000 t, 6.1%), Korea (160,000 t, 5.7%), Mexico (122,000 t, 4.4%) and Turkey (102,000 t, 3.7%). The first five countries together produced an average of 1.5 million t/year during the 1990-1999 period, accounting for 57.5% of the world production on 47.5% of the world surface (Faedi *et al*., 2002).

Among the major strawberry producers (more than 50,000 t in 1999), the highest increase in production in the last decade occurred in Turkey (+116%), Ex-USSR countries (+90%), Spain (+78%), Germany (+48%), Korea (+42%) and U.S.A. (+38%). Several major strawberry countries experienced reduced production, like Poland (-26%), Japan (-22%), France (-22%), Italy (-6%) and the United kingdom (-4%). Among the minor producers (less than 50,000 t/year) the highest increase of production was noted in Morocco (+900%), Iran (+164%), Australia (+155%), Chile (+114%) and Lebanon (+110%) (Faedi *et al*., 2002). During the last decade, strawberry production has continued to expand (Rosati, 1993). Three trends are notable for the observed changes in production mainly:

1. Expansion occurred in areas with mild winter climate. In 1999, about 56% of the world production was in areas with mild winters, compared to 50% in 1990, and only 35% in 1980.
2. Strawberries are now available as fresh fruit during the entire year, which has resulted from breeding (release of day-neutral varieties), intensive culture systems adoption and choice of appropriate environment. As a consequence, the fluctuation of fruit prices during the season was much more reduced, as compared to the past.
3. The remarkable increase and change in production patterns occurred as growers rapidly took advantage of research results from several different areas including breeding, cultural systems, plant physiology, fruit handling and post-harvest technology (Voth and Bringhurst, 1990).

Strawberry has increased in economic importance throughout the world and remains a crop of primary interest for both research and fruit production. The intense breeding activity all over the world produced many new varieties adapted to diverse environmental conditions. Nowadays, consumers are offered strawberries with better quality and lower prices than in the past. This fact, coupled with year-round product availability, has increased the demand for fresh strawberries as well as for processing fruit (Faedi *et al*., 2002).

2. Salinity

2.1. Sources of salinity

The world's land surface occupies about 13.2×10^9 ha, of which 7×10^9 ha are arable and only 1.5×10^9 ha of which are cultivated (Massoud, 1981). Of the cultivated lands, about 0.34×10^9 ha (23%) are saline and another 0.56×10^9 ha (37%) are sodic. A saline soil is a non-sodic soil containing sufficient soluble salts to adversely affect the growth of most plants, while a sodic soil is a non-saline soil containing sufficient exchangeable sodium to adversely affect crop production and soil structure under most conditions of soil and plant type (Kijne *et al*., 1998). Saline and sodic soils cover about 10% of total arable lands and exist in over 100 countries (Szabolcs, 1989).

Table 1 shows the regional distribution of salt affected soils, based on FAO/UNESCO 2000 soil map of the world. The areas given in the table are not necessarily arable but cover all salt affected land.

Table 1: Regional distribution of salt-affected soils in million ha

Regions	Total area	Saline soils	%	Sodic soils	%
Africa	1899.1	38.7	2.0	33.5	1.8
Asia and the Pacific and Australia	3107.2	195.1	6.3	248.6	8.0
Europe	2010.8	6.7	0.3	72.7	3.6
Latin America	2038.6	60.5	3.0	50.9	2.5
Near East	1801.9	91.5	5.1	14.1	0.8
North America	1923.7	4.6	0.2	14.5	0.8
Total	12781.3	397.1	3.1%	434.3	3.4%

Salt affected soils are not limited to semiarid and arid regions. In several other regions, the climate and mobility of salts produce saline waters and soils seasonally (Tanji, 1990). Salts are a common and necessary component of the soil, and many salts are essential plant nutrients. It is only when salts are present in relatively high amounts that plant growth is impaired. According to Tanji (1990) and Kijne *et al*. (1998), the problem of salinity manifests itself in the environment in a number of ways:

1. Natural primary source of salts in waters and soils is the chemical weathering of earth materials, i.e. minerals that are constituents of rocks and soils. Evaporative salinization, e.g. surface evaporation of water and transpiration by plants, and dilution, e.g. rainfall, snow-melt waters and irrigation waters, affect the level of concentration of dissolved mineral salts.
2. Natural secondary sources of salt include atmospheric deposits of oceanic salts along coastal areas, seawater intrusion into ground-water basins in coastal areas due to overdrafts, saline water from rising ground-waters, inland saline lakes and leaching of saline land forms.
3. Anthropogenic sources of salts include irrigation and drainage waters, soil and water amendments, animal manure and wastes, chemical fertilisers, sewage sludge and oil and gas field brines. According to FAO/UNESCO 2000 estimation, around 77 million ha of land is salt-affected by human-induced salinization (Table 2).