1.1 Milk thistle

*Silybum marianum* (L.) Gaertn. (Asteraceae), commonly known as milk thistle, is an important medicinal annual/biennial plant, widely found in Jammu and Kashmir, NWFP and Punjab at an altitude of 250-2400 m (Kottova et al., 1998).

The origins of *Silybum marianum* lie in the region of Southern Europe, the Mediterranean and Northern Africa. Its current distribution includes most temperate areas of the world. It is common in the Western U.S. as a weed afflicting pastures, wastelands and irrigation banks (Parsons, 1973). It is believed to have been introduced in cattle feed. *Silybum marianum* spread through both the southern and northern Central Valley of California during the 1940’s, demonstrating a remarkable ability for colonizing. "The agricultural environment that was invaded had been dominated by alien weeds for 180 years. For a species without vegetative propagation to invade a community of annuals underscores the competitive advantage of its germination characteristics" (Young et al., 1978). It is now common in both coastal and inland valleys.

*Silybum* has been used medicinally throughout Europe as a remedy for depression and liver problems for hundreds and perhaps thousands of years. The ancient Greeks described its medicinal properties in their herbals and Roman legionnaires carried the plants and seeds with them to Europe as food and medicine. Recent studies have validated this time-honoured herbal knowledge, proving *Silybum* ability to protect the liver from alcoholic and other forms of toxic damage.
1.2 Habitat and ecology of the plant

In general, milk thistle and thistles, occur in fertile lands of improved pastures that have been overgrazed and poorly managed (Sindel, 1991). It is a native of Southern Europe, especially the Mediterranean regions; *Silybum* is now naturalized throughout Europe, North and South America and Australia. The plant thrives in dry, stony or rocky areas, wastelands, fields and roadsides. Being an aggressive settler, *Silybum* was once seen as a sign of poor husbandry and a threat to farm lands. A bill was hence passed in the early twentieth century to destroy thistles and other weeds. More recently, it is regaining its popularity as an ornamental plant and is also grown commercially in countries like Argentina, Australia, Russia, China, Germany, Romania and Hungary (Chevallier, 1996; Czygan *et al.*, 1994; Keville, 1991).

*Silybum marianum* is grown and used medicinally in France, Italy, Germany, Hungary, Greece and Poland. It is also present in Canary Islands, Madeira and naturalized in the hot, dry areas of Central Europe. It also grows wild in Egypt in the Nile Valley. It is not generally found in Northern Italy, but it is frequent in the central and southern regions and in the islands.

In Italy, *S. marianum* is found on roadsides, waste places and cultivated ground and it is distributed from the sea to the submountain regions upto 700-1100 m of altitude. It is cultivated for ornamentation and naturalized or casual throughout a large part of Europe (Morazzoni, 1995).
California (USA) ranchers claim milk thistle loosens hard, compacted soil and make their own "clod-buster" from chopped plants soaked in 55 gallon drums of water (Hudson, 1996).

Each terminal head of the plant produces approximately 100 seeds; 10-50 heads are produced per plant (Young et al., 1978). Seed weight is approximately 22 mg (Wheatley, 1971). "From this we can calculate that 10-50 g of seed are produced per plant. With a conservative average density of 2 plants/square meter, the theoretical seed production reaches 500 kg/ha" (Young et al., 1978).

Seed dispersal is the only means by which the milk thistle spreads. The seeds are equipped with a large pappus which allows effective spread by wind (Parsons, 1973). Spread can also be attributed to their presence in grain and fodder (Wheatley, 1971). Other means of dispersal include water, mud, agricultural produce, vehicles, machinery and animals (Parsons, 1973).

The seeds of *Silybum marianum* germinate in the fall, after the first rains. "Plants develop slowly through the seedling stage, becoming flat rosettes by late autumn/early winter. Growth is rapid in late winter and early spring, producing large cabbage-like plants up to 3 feet in diameter from whose centre stems develop in spring. Flowering commences in late spring and continues into early summer" (Parsons, 1973).

The seedlings prefer disturbed soils which provide suitable bare areas for litter-free germination. Therefore, sheep camps, rabbit warrens, cultivated fire breaks, roadsides, overgrazed pastures and the like are ideal propagation sites. Seedlings do not establish in perennial pastures if the
soil is well covered with vegetation during late summer and autumn. Litter seems to be a highly important inhibitive factor in the germination ecology of milk thistle seed. Because its germination is reduced by accumulations of grass litter, milk thistle is not adapted as a landscape dominant in areas where there is a continuous ground cover provided by existing vegetation. This can also hold true for annual rangelands if they are managed properly (Young et al., 1978). However, if there is an absence of pasture or litter cover in late summer and early fall, infestations of thistle may develop. This occurs especially in periods of drought which reduce the persistence of many pasture species (Michael, 1968).

*Silybum* seed has the potential to remain viable in the soil for up to 9 years. The percentage of germination varies from year to year and can be less than 50% (Parsons, 1973). In an article on germination requirements of this species, written in 1978 by Young et al., the following results were recorded:

"One month after harvest, milk thistle seeds had after ripening requirements related to germination temperature that limited germination to 10 to 20º C. The time required to satisfy after ripening requirements was dependent on germination temperature. Generally the higher the incubation temperature during germination, the longer the after-ripening requirement (up to a maximum of 5 months). Once after ripening requirements were satisfied, milk thistle seeds germinated over a temperature range of from 0-30º C. Optimum germination occurred with 16 hour cold periods of 2-15º C alternating with 8 hour warm periods of 10-30º C. Emergence of milk thistle seedlings decreased with increased burial depth, but substantial emergence occurred from a depth of 8 cm."
Germination on the surface of the soil or litter was greatly reduced compared to that with slight soil or litter coverage.

Once *Silybum* has found a niche, it is a competitive thistle and it tends to establish in tall dense patches that eliminate other plant species either by shading or by competition for moisture and nutrients.

In areas of continual disturbance, eradication of *Silybum* is virtually impossible until the factors which cause the disturbance are removed. *Silybum* will stay localized in these areas unless disturbance becomes more widespread. Over-grazing and fire are two factors which encourage the spread of *Silybum* in large areas.

### 1.3 Active components of milk thistle

The Milk thistle, *Silybum marianum* (L.) Gaertn, has been used in medicine for more than 2000 years. The fruit of this plant contains an isomeric mixture of flavonolignans (silychristin, silydianin, silybin and isosilybin) known collectively as silymarin (Morazzoni and Bombardelli, 1995).

Silymarin was considered as a pure compound with the structure of 7-chromanol-3-methyl-taxifolin but, after the introduction of more accurate methods of analysis and separation, it was shown that silymarin consists of a large number of flavonolignans (see Fig. 1), including silybin (SBN\(_A\), SBN\(_B\)), isosilybin (ISBN\(_A\), ISBN\(_B\)), silydianin (SDN), silychristin (SCN) and toxifoline (TXF). Silybin has 16 diastereoisomers but, in nature, only two of them are produced. Silymarin is synthesised by oxidative coupling between the flavonoid taxifolin and a phenylpropanoid, usually coniferyl...
alcohol (Dewick, 2002). A number of other flavonolignans have also been found in the seeds including dehydrosilybin, desoxysilycristin, desoxysilydianin, silandrin, silybinome, silyhermin and neosilyhermin. Possibly due to their antioxidant and membrane stabilizing properties, the compounds have been shown to protect different organs and cells against a number of insults.

_Silybum_ contains 20-25% fatty acids; of this amount, 50-60% is linoleic acid and 25-30% is oleic acid (Hamid _et al._, 1983; Carrier _et al._, 2002). Linoleic acid is an essential fatty acid required for the production of prostaglandins, which help to reduce inflammation. Oil contains essential phospholipids and a relatively high content of vitamin E. It is therefore of interest as a natural source of vitamin E. Vitamin E functions primarily as an antioxidant, protecting the body tissues from damaging reactions (peroxidation) that arise from many normal metabolic processes and exogenous toxic agents (Ong and Choo, 1997).

Mucilage is primarily used for its topical emollient and demulcent properties. It produces a coating of slime, which provides cover and protection for any inflamed mucosal linings. It soothes pain, irritation and itching and, in the act of drying, draws and heals wounds and infected skin lesions (Mills _et al._, 2000).


_Silybum_ is effective in stimulating bitter taste receptors on taste buds, which fuel the release of the gastrointestinal hormone gastrin that, in turn, stimulates appetite. Bitters also increase digestive secretions, protect gut
tissues, promote bile flow and enhance pancreatic functions (Mills 1991; Weiss et al., 2000).

*Silybum marianum* L. (Asteraceae) is a plant rich in phenolics.

**Fig. 1** Structures of main silymarin components

![Chemical structure of silybin](image1)

**Fig. 1.1a** Chemical structure of silybin

![Chemical structure of isosilybin](image2)

**Fig. 1.1b** Chemical structure of isosilybin
Fig. 1.1c Chemical structure of silychristin

Fig. 1.1d Chemical structure of d, silydianin
1.4 Pharmacological importance of milk thistle

The extracts of the flowers and leaves of *Silybum marianum* have been used for centuries to treat liver, spleen and gallbladder disorders. The isolation led first to a mixture that was named silymarin and it was this flavonolignan mixture with which most of the clinical studies were carried out. One of the important issues regarding silymarin is that it may be accepted as a safe herbal product, since no health hazards or side effects are known, in conjunction with the proper administration of designed therapeutic dosages. Extracts of milk thistle fruits are supplied as capsules, tablets, liquids, powders and creams. Some important medicinal applications of milk thistle are as follows:

- Gastrointestinal/hepatic treatment
- Treatment of hepatitis
- Antilipemic
- Psoriasis
- Prostate cancer treatment
- Colon cancer treatment
- Antineoplastic
- Antioxidant
- Anti-inflammatory
- Antifibrotic
- Treatment of Irritable Bowel Syndrome
- Promotion of milk secretion
- Antisepsis
1.4.1 Gastrointestinal/hepatic treatment

Milk thistle is the main remedy used in Western herbal medicine to protect the liver and its many metabolic activities and help renew its cells. Milk thistle is used in the treatment of hepatitis and jaundice, as well as in conditions where the liver is under stress whether from infection, excess alcohol or from chemotherapy prescribed to treat diseases such as cancer. In this last instance, milk thistle can help to limit damage done to the liver by chemotherapy and speed up recovery from side effects once the treatment is completed. Milk thistle is unique in its ability to protect the liver and has no equivalent in the pharmaceutical drug world. In fact, in cases of poisoning with *Amanita* mushrooms, which destroy the liver, milk thistle is the only treatment option. It has been so dramatically effective that the treatment has never been disputed, even by the traditional medical community.

Hepatoprotectant: In human trials, silymarin, particularly silybin, is protective against hepatotoxins as diverse as acetaminophen, alcohol, carbon tetrachloride, tetrachloromethane, toluene and xylene (Muriel and Mourelle, 1990).

The most noticeable use of silymarin is the treatment of poisoning by the mushroom, *Amanita phalloides*. This genus is widely distributed in Europe and North America. These mushrooms contain two very strong hepatotoxins: amantina and phaloidin (DL50 of amantina is 0.1mg/kg of body weight).
Milk thistle extracts (such as silybin) are widely used in Europe to treat *Amanita* mushroom poisoning, and have reduced mortality rates by 60-80% (Floersheim, 1983).

Milk thistle extracts have also been used to treat adults with alcoholic liver damage. The patients treated with silymarin had a statistically significant improvement in liver enzymes and hepatic histology within four weeks (Salmi et al., 1982; Lang et al., 1988).

### 1.4.2 Treatment of hepatitis

Milk thistle is also used to treat patients with hepatitis C (Wichtl, 1994).

### 1.4.3 Antilipemic

Silymarin may inhibit hepatic synthesis of cholesterol: it has been suggested that milk thistle products be investigated as a treatment for patients with hypercholesterolemia. In a seven-month open clinical study in 14 type-II hyperlipidemic outpatients, treatment with silymarin (420 mg daily) was associated with a decrease in total cholesterol and an increase in HDL-cholesterol levels (Somogyi et al., 1989).

### 1.4.4 Psoriasis

Psoriasis is a disorder which affects the skin and joints. It commonly causes red scaly patches to appear on the skin. The scaly patches caused by psoriasis called psoriatic plaques, are areas of inflammation and excessive skin production. Skin rapidly accumulates at these sites and takes on a silvery-white appearance. Plaques frequently occur on the skin...
of the elbows and knees, but can affect any area including the scalp and genitals. It ultimately causes Type-2 diabetes.

Silymarin is used in the treatment of psoriasis, by its capacity to improve the excretion function of the liver which permits the removal of endotoxins. Furthermore, it inhibits the cAMP phosphodisterase and the synthesis of leukotriens (which are high in this sickness) (Kock, 1985).

1.4.5 Prostate cancer

Silybin reduces the cellular proliferation and the levels of PSA (specific prostatic antigen), increases the cellular differentiation and the apoptosis and inhibits angiogenesis, slowing the growth of human prostate tumors. On the other hand, silybin improves the cytostatic and apoptotic effects of various synthetic chemotherapics, like cisplatinum, carboplatinum, doxorubicin and at the same time reduces its secondary effects, e.g., the nephrotoxicity (Singh et al., 2003).

1.4.6 Colon cancer

The Centre for Disease Control and Prevention reported that colon cancer was the second leading cause of cancer-related deaths in the United States in 2004. It is the third most common cancer in men and women. There are approximately 56,000 annual deaths from colorectal cancer and 1,45,290 new cases have been diagnosed in 2005 according to the ACS. More than 90% of cases of colorectal cancer occur in those who are 50 years or older and the incidence increases with advancing age. Other risk factors include hereditary causes (familial adenomatous polyposis, hereditary nonpolyposis colorectal carcinoma, and inflammatory bowel disease),
history of colorectal cancer or polyps and a family history of colorectal cancer. Potential risk factors for the development of colorectal cancer include alcohol and tobacco use, lack of regular physical activity, a low-fibre and high-fat diet, inadequate fruit and vegetable consumption, and obesity. Silibinin shows antiproliferative effect on human colon cancer.

It also shows chemopreventive and chemotherapeutic effect on bladder and ovarian cancer. Silymarin has also been proven to inhibit azoxymethane-induced colon cancer in male F344 rats (Kohno et al., 2002).

1.4.7 Antineoplastic (Chemoprevention)

Silymarin and silybin have chemopreventive effects in human and mouse epidermal, prostate and breast cancer cell lines. Silibinin and silymarin have also been used for their UV-B photoprotective ability. A number of studies have shown that silymarin and silibinin have chemopreventive effects against UV-B induced photocarcinogenesis in animal models and silibinin may suppress UV-B damage to human keratinocytes as well (Dhanalakshmi, 2004).

1.4.8 Antioxidant

Antioxidants help organisms deal with oxidative stress, caused by free radical damage. Free radicals are chemical species, which contain one or more unpaired electrons due to which they are highly unstable and cause damage to other molecules by extracting electrons from them in order to attain stability.
Reactive oxygen species (ROS) formed *in vivo*, such as superoxide anion, hydroxyl radical and hydrogen peroxide, are highly reactive and potentially damaging transient chemical species. These are continuously produced in the human body, as they are essential for energy supply, detoxification, chemical signalling and immune function. ROS are regulated by endogenous superoxide dismutase, glutathione peroxidase and catalase but, due to over-production of reactive species, induced by exposure to external oxidant substances or a failure in the defence mechanisms, damage to cell structures, DNA, lipids and proteins occurs which increases risk of more than 30 different disease processes (Aruoma, 1998).

Flavonoids are naturally occurring substances that possess various pharmacological actions and therapeutic applications. Some of these, due to their phenolic structures, have antioxidant effect and inhibit free radical-mediated processes. Recently oxidized derivatives of silybin (the major component forming 70-80% of silymarin) and their antiradical and antioxidant activity were studied. In patients with alcoholic cirrhosis, silymarin enhanced erythrocyte and lymphocyte levels of superoxide dismutase, thereby enhancing antioxidant effects (Feher *et al.*, 1990).

**1.4.9 Anti-inflammatory effect**

Silymarin has shown significant anti-inflammatory effects in the hepatic tissue. Various studies show these effects which include stabilization of the mastocyte, inhibition of the migration of neutrophils, inhibition of Kupffer cells, strong inhibition of the leukotriene synthesis and formation of prostaglandins (Dehmlow *et al.*, 1996).
1.4.10 Antifibrotic effects

The stellar liver cells play a central role in hepatic fibrogenesis. As a reply to some fibrotic influences like chronic exposure to alcohol, carbon tetrachloruro, etc., these cells proliferate and transform into fibroblasts that are responsible for the deposition of collagen fibres in the liver. The effects of silybin on the transformation of the stellar hepatic cells in fibroblasts, show that silybin reduces the proliferation of stellar cells up to 75%. It reduces also the stellar cell conversion into fibroblasts and regulates the genetic expression of the extracellular matrix components, necessary for fibrosis (Fuchs, 1997).

1.4.11 Treatment of Irritable Bowel Syndrome (IBS)

It is the most common functional disorder of the intestine. Milk thistle works as a gentle and mild laxative due to its ability to increase bile secretion and flow in the intestinal tract. Its actions range from lubrication and softening of the stools to a mild laxative effect to actually balancing individuals that alternate between diarrhoea and constipation.

1.4.12 Promotion of milk secretion

Milk thistle promotes milk secretion and is perfectly safe to be used by all breast feeding mothers. Milk thistle has some estrogen-like effects that may stimulate the flow of breast milk in women who are breast-feeding infants. It may also be used to start late menstrual periods. Milk thistle's estrogen-like effect may also have some usefulness for men with prostate cancer.
1.4.13 Antisepsis

Sepsis is a serious medical condition characterized by a whole body inflammatory state (called a systemic inflammatory response syndrome or SIRS) caused by infection. The body may develop this inflammatory response to microbes in the blood. The related layman's term is blood poisoning. Recent studies have shown that sepsis is associated with enhanced generation of reactive oxygen metabolites, which lead to multiple organ dysfunctions. Activation of macrophages and cytokines by endotoxin and the subsequent formation of reactive oxygen and nitrogen species are of central pathogenic importance in various inflammatory diseases including sepsis. The release of endotoxin (lipopolysaccharide, LPS) from bacteria is generally believed to be the initial event in the development of sepsis. LPS activates inflammatory cells of the myeloid lineage that subsequently amplify the inflammatory response by releasing various cytokines, such as tumor necrosis factor-α (TNF-α) and interleukin-1β (IL-1β). This systemic inflammatory cascade results in polymorphonuclear leukocytes (PMNs) sequestration in the various systemic organs, e.g., lungs, heart. Subsequent PMN extravasation can lead to vascular dysfunction as well as parenchymal cell dysfunction. While antioxidants could be used to counteract the toxicity of reactive oxygen metabolites, free radical ablation for the treatment of sepsis was proposed to be useful in the clinical setting of sepsis-induced multiple organ failure. Recently oxidized derivatives of silybin (the major component forming 70-80% of silymarin) and their antiradical and antioxidant activity were studied (Gazak et al., 2004). Furthermore, its antioxidant, anti-inflammatory and anticarcinogenic properties were demonstrated in the studies conducted with silymarin against oxidative
stress, inflammatory responses, and benzoil peroxide-induced tumor promotion in mice (Zhao et al., 2000; Katiyar, 2005).

1.5 Action and effect of its medicinal value

Milk thistle is a hepatoprotective and it protects in three ways: by enhancing DNA polymerase, stabilizing cell membranes and scavenging free radicals. Silybin stimulates DNA polymerase, increasing the synthesis of ribosomal RNA and stimulating liver cell regeneration; it also stabilizes cellular membranes and increases the glutathione content of the liver. Silybin acts as a free radical scavenger, increasing the activity of both superoxide dismutase and glutathione peroxidase in human cell lines. It also inhibits the 5- lipoxygenase pathway in Kupffer cells, minimizing inflammation in the liver (Dehmlow et al., 1996).

Milk thistle extracts protect animals against the damaging effects of a variety of hepatotoxins including viruses, chemicals and naturally-occurring toxins such as Amanita mushrooms and alcohol. Pre-treatment of rats, mice, rabbits and dogs with silymarin provides substantial and significant protection from the lethal effects of Amanita mushroom poisoning (Trost, 1978). Silymarin has an inhibitory effect on the system of detoxification of the cytochrome P450. In an animal study, silybin showed inhibition of various specific enzymes of cytochrome P450. This effect explains some of the hepatoprotective effects of silymarin, particularly against the poisoning by Amanita mushrooms. The toxin amanitine kills the hepatocytes only after having been bioactivated by the system P450. The inhibition of the bioactivation of this toxin may reduce its toxic effects. Furthermore, silymarin and other antioxidants offer
certain protection against the free radicals that are generated by the enzymes of cytochrome P450 (Amdur et al., 1991).

**Table 1.1 Mechanism of action of various antioxidants against different diseases**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Pathology</th>
<th>Mechanism of action</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glutathione peroxidase (Gpx)</td>
<td>Neurodegenerative diseases</td>
<td>Catalyses the reduction of hydroperoxides at the expense of GSH. In this process, hydrogen peroxide is reduced to water whereas organic hydroperoxides are reduced to alcohols</td>
<td>Ursini et al. (1995)</td>
</tr>
<tr>
<td>Superoxide dismutase (SOD)</td>
<td>Neurodegenerative diseases, diabetic retinopathy, chronic inflammation</td>
<td>Catalyzes the one-electron reduction of superoxide into hydrogen peroxide and oxygen</td>
<td>Fridovich (1977)</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>Cancer, Neurodegenerative diseases, diabetic retinopathy, chronic inflammation</td>
<td>Shown a variety of biological activities such as inhibition of lipoxygenase and IL-6 cytokinetics against different tumor cell lines</td>
<td>Rudsky et al. (1993) and Guanaseko et al. (2003)</td>
</tr>
<tr>
<td>Citochromes</td>
<td>Neurodegenerative diseases, diabetic retinopathy, chronic inflammation</td>
<td>Enhance activity of SOD and catalase</td>
<td>Levites et al. (2001)</td>
</tr>
<tr>
<td>Carotenoids</td>
<td>Cancer, diabetic retinopathy, chronic inflammation</td>
<td>Mainly act as physical quenchers of reactive oxygen</td>
<td>Sandquist et al. (1994)</td>
</tr>
<tr>
<td>α-tocopherol</td>
<td>Cancer, neurodegenerative diseases, chronic inflammation</td>
<td>Scavenges lipid peroxyl radicals (LOO) through hydrogen atom transfer</td>
<td>Burton and Ingold (1981)</td>
</tr>
<tr>
<td>(−)-EGCG</td>
<td>Neurodegenerative conditions</td>
<td>Decreases the expression of proapoptotic genes (bax, bad, capase-1 and -6, cyclin dependent kinase inhibitor) thus maintaining the integrity of the mitochondrial membrane</td>
<td>Levites et al. (2003)</td>
</tr>
<tr>
<td>(+)-EGCG</td>
<td>Cancer, diabetic</td>
<td>Suppression of angiogenesis by inhibiting growth factor triggered expression of receptors and PKC. Downregulation of VEGF, action in tumour cells. Repression of AP-4, NF-κB and STAT-1 transcription factor pathways</td>
<td>Woolf and Jones (2001)</td>
</tr>
<tr>
<td>Ferulic acid</td>
<td>Diabetes</td>
<td>Decrease lipid peroxidation and enhances the level of glutathione and antioxidant enzymes</td>
<td>Balasubramanyi et al. (2004)</td>
</tr>
<tr>
<td>Glutathione</td>
<td>Cancer</td>
<td>Glutathione in the nucleus maintains the redox state of critical proteins sublythys that are essential for DNA repair and expression</td>
<td>Girod and Monier (1996)</td>
</tr>
<tr>
<td>Prostaglandin (PGF2)</td>
<td>Cardiovascular disorders</td>
<td>Inhibitory effects on proapoptotic and proangiogenic genes</td>
<td>Bergel et al. (2003)</td>
</tr>
<tr>
<td>Quercetin, Kaempferol, genistein, resorcinol</td>
<td>Colon cancer</td>
<td>Suppresses COX-2 expression by inhibiting tyrosine kinases important for induction of COX-2 gene expression</td>
<td>Lee et al. (1998)</td>
</tr>
<tr>
<td>Tannins</td>
<td>Cardiovascular disorders</td>
<td>Tannins are known to enhance synthesis of nitric oxide and relax vascular segments precontracted with norepinephrine</td>
<td>Dwivedi (1987)</td>
</tr>
</tbody>
</table>
1.6 Edible uses

Root - Raw or cooked. A mild flavour and somewhat mucilaginous texture. The roots, soaked in water overnight to remove bitterness, are eaten like salsify (*Tragopogon hispanicus*).

Leaves - Young leaves (with spines removed) are eaten as a vegetable in spring salads and as a spinach substitute. Young stalks, peeled and soaked, are eaten like asparagus (Foster, 1991). It is possible to have leaves available all year round from successive sowings.

Flower buds - Cooked. A globe artichoke substitute, they are used before the flowers open. The flavour is mild and acceptable, but the buds are quite small and even more fiddly to use than globe artichokes.

Stems - Raw or cooked. They are best peeled and can be soaked to reduce the bitterness. Palatable and nutritious, they can be used like asparagus or rhubarb or added to salads. They are best used in spring when they are young.

A good quality oil is obtained from the seeds.

The roasted seed is a coffee substitute.

Traditionally, tea made from the whole plant is used to improve appetite, allay indigestion and restore liver function.