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Review Article

Cultivation of chicory (Cichorium intybus L), an extremely useful herb

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ABSTRACT: Chicory (Cichoriumintybus L.) belongs to the Asteraceae family. Because of its many uses, it is almost grown in all regions of the world**.** Its leaves and root are consumed as fresh or cooked vegetables and coffee substitute, respectively. All parts of the plant including roots, stems, leaves, and flowers get dry and are used as powder form in a variety of herbal medicines. Inulin is the main component of its root that has many food and medicinal uses. If its reproductive growth is not controlled, Chicory stems and fleshy roots can grow up to 2 m and 75 cm, respectively. Because of its excellent acclimation to different soils, drought, high or low temperatures and its resistance to diseases, wild chicory cultivation is very easy.

***Keywords*:** Chicory, Cichorium intybus L, food, Pharmaceutical, forage, inulin

INTRODUCTION

In recent years, the consumption of food products with animal origin has sharply increased, that along with reduction in the consumption of plant foods rich in fiber, vitamins and trace elements has caused a series of health problems (Paniangvait et al., 1995; Lentini F, Venza., 2007a). Many researches conducted over the past decade has identified that fresh leafy vegetables, are very important in the diet because of the vitamins, minerals and biologically active compounds (Kimura & Rodriguez- Amaya, 2003; Kmiecik et al., 2001; Su et al., 2002). Herbal remedies in both traditional and modern society have a long history as a combination purifier that has been approved by the Food and Drug Administration (Butler, 2004; Balunas and Kinghorn, 2005; Koehn and Carter, 2005; Jones et al., 2006). Cichorium intybus is a known plant with many food costs and various biological activities. In this review we summarize Introduce and identify this useful plant.

1. History and distribution

Cichorium intybus L. (common chicory) a member of the Asteraceae family, is a perennial herb, native to Europe, many parts of Asia, Africa, and America (Clapham et al., 1962). as early as 4,000 years ago, Cichorium intybus L. was used by Egyptians in therapeutic activities and its usage in folk medicine is widely reported. It is considerable that the start of chicory cultivation is not exactly determined. But around 50 AD, it has been registered with lettuce by a Roman historian named Plinius (Kiers 2000). Until the seventeenth century, it was used as fodder in the North of Europe. Elliott pioneered the use of chicory in the pasture in England (1902, cited by Foster, 1988). In New Zealand, chicory was recorded for the first time in 1867. In Pennsylvania, chicory was listed as a noxious weed until 1993 (Jung et al., 1996). Cichorium intybus L (Common chicory) in eastern Anatolia known as tahlisk, kanej or hindiba and is one of the most widely used herbal medicines and a multi-purpose edible plant. Eastern Anatolia region of Turkey is very mountainous and heavily fragmented therefore it offers favorable conditions for the development of diverse plants (Tabata et al., 1994; Özgökce and Ozcelik., 2004)**.** In Italy, wild chicory can be

found in coastal areas and in the mountains (Conti et al. 2005). At the present time, the demands are rising in Italy and Some Seed companies have started producing wild chicory seeds. intybus Cichorium not only in the various regions of Italy (Guarrera et al., 2006; Lentini., 2000; Passalacqua et al., 2007; Guarrera and Savo., 2013), but also in Morocco (Jouad et al., 2001), Tunisia (Leporatti and Ghedira; 2009), India, North and South Europe (Bais and Ravishankar 2001) and in Spain (Benìtez et al; 2010) is also well known. Since domestic raw materials for the production of sustainable and cost-effective products are in demand, expanding the cultivation of root chicory to Hokkaido in northern Japan is an attractive option.

2. Botanical description

Wild chicory or blue daisy (Cichorium intybus L.) is a diploid plant species (2n = 18) belonging to the Asteraceae family, subfamily Cichoriodeae, tribe Lactuceae or Cichorieae (Funk et al., 2005) and commonly known as witloof cichory. Wild chicory is perennial but the crop has been selected to be cultivated as a biennial species (Kiers et al., 1999).

3. Morphological description

Cichorium intybus L. (Common chicory) is an erect perennial plant that is 80-90 cm in height predominantly, it has reddish leaves and bright blue flowers occasionally white or pink and its Fleshy root grows up to 75 cm. fresh buds are always located near the soil surface. The flowers open early in the day and closed in the afternoon. Italian red variety of chicory (Cichorium intybus L.) has been determined on the basis of speckled or multi-colored leaves or more or less uniformly coloured red blades.

4. Uses

4.1. Food

Different types of C. intybus L. are used as food. Chicory (Cichorium intybus L. var. sativum Bisch.) is a horticultural crop grown for direct consumption as a cooked food and an industrial crop for the extraction of polysaccharide. Chicory roots can be used after processing to produce a coffee substitute or supplement (Taylor, 1981; Wealth of India, 1992), particularly in India (Arya and Saini, 1984) and South Africa, in which more than 90% of all consuming coffee contains chicory. Chicory leaves of green leaf varieties including 'catalogne' and 'blond' or 'red' varieties of the ‘Radicchio’ cultigroups from northern Italy are consumed as fresh or cooked vegetables (Lucchin et al; 2008). Chicory grows as a vegetable or salad green in Europe (George, 1985; Schoofs and de Langhe, 1988). In Sicily, the aerial parts of the Common chicory are fried with egg and eaten with seasoned olive oil (Lentini and Venza; 2007b). In Madonie and Nebrodi regional parks in particular, is widely used for pasta sauce. Its root is also used as a chewing gum. Industrial Chicory, Cichorium intybus L, grown for the production of inulin, which is either commercially or after partial hydrolysis, as a glucose syrup and fructose and is often used as a soluble fiber in the diet (Kaur and Gupta, 2002; Pool-Zobel, 2005).

4.2. Pharmaceutical

The extracted coumarins extracted from hairy roots of C. intybus are used as a skin protector and as an indicator of microbiological agents (Bais et al., 2000). Leaves are used as infusions for anemia and digestive disorders. The flowers have cholagogic activity. They are also used in washing the skin, cooling and conditioning (Chopra et al; 1958). Cichorium intybus L., commonly known as Chicory or Kasni (among Iranian folk) has been used in traditional medicine to treat a variety of diseases including high blood sugar (Mares et al., 2005; Muthusamy et al., 2008; Jamshidzadeha et al., 2006). In traditional Indian medicine, Ayurvedic tonic prepared from C. intybus has been used to treat fever, diarrhea, and enlarged spleen (Chopra et al., 1958). Its leaf extract was very useful in the treatment of jaundice, enlargement of the liver, gout, and rheumatism (Pushparaj et al., 2007).

Modern research has been able to confirm the antidiabetic, antihyperglycemic , wound healing, antioxidant (Innocenti et al., 2005; Pushparaj et al., 2007; Spina et al., 2008;Azay-Milhau et al., 2013; Carazzone et al., 2013; Morales et al.,2014; Tousch et al., 2008) antiulcerogenic, anti-inflammatory, analgesic (Cavin et al., 2005; Ivashkin and Lapina., 2003; Krylova et al., 2001 & 2003;) hepatoprotective, antioxidant, hypoglycemic, diuretic , anti-testicular toxicity, hypolipidemic, immunomodulatory (Ahmed et al., 2003 & 2008, Jamshidzadeha et al., 2006; Hassan, 2008; Mulabagal et al., 2009, Tousch et al., 2008; Zafar and Mujahid Ali, 1998) hypolipidemic and atheroprotective (Keshk and Noeman., 2015; Lin et al., 2015) effects of chicory. The diverse biological effects are the result of a variety of important medicinal compounds, such as alkaloids, inulin, sesquiterpene lactone, coumarins, vitamins, pigment chlorophyll, unsaturated sterols, flavonoids, saponins, tannins, organic acids and

polyphenols that have been spread in all parts of the plant in different proportions (Abbas et al., 2015; Ferrazzano et al., 2011; Sampaio et al., 2009; Yoo et al., 2011).
Recently, the methanol extract of leaves of C. intybus L showed moderate antibacterial activity against intestinal bacteria (Rani & Khullar, 2004), In addition, it is used for lowering blood sugar levels (Muthusamy et al., 2008). Research of Adele Papetti et al (2013) and Patel and Bhatt (1985) showed that C. intybus contains a number of active components against inflammatory diseases of the gums and tooth decay.

4.3. Forage

Chicory (Cichorium intybus L.) has been a component of natural grasslands in many parts of the world for thousands of years but it has only a relatively recent history as a forage crop. Chicory (Cichorium intybus L.) is a nutritious forb that Used for establishing available forage with high nutritional value for grazing ruminants in the summer (Barry, 1998). PUNE chicory has a high production (Belesky et al., 1999; Hare et al., 1987; Lancashire, 1978), high food quality (Barry, 1998; Clark et al., 1990), and high mineral content (Foster, 1988; Hoskin et al., 1995). PUNE chicory has a higher digestibility of organic matter (OM) than grass-based pastures during the spring, summer and autumn (Kusmartono et al., 1996; Niezen et al., 1993). In addition, PUNE chicory does not cause flatulence when used for feeding cattle (Barry, 1998), and reduce the effects of internal parasites in small ruminants such as sheep infected with gastrointestinal parasites compared to grass (Scales et al., 1995; Marley et al., 2003b). Reducing the number of worm eggs in faeces (Scales et al., 1995; Knight et al., 1996; Hoskin et al., 1999; Athanasiadou et al., 2007), reducing the ability of infective larvae to establish within the host (Tzamaloukas et al., 2005), reducing the number of male worms in the host animal (Tzamaloukas et al., 2005), and reducing the ability to develop or survive infective larvae in feces (Marley et al., 2003a), are the other benefits of using chicory to feed the animals.

4.4. Improve the soil

Decontamination of soil contaminated with heavy metals remains one of the most complex problems of Clean-up technology. Phytoremediation is an emerging and Affordable technology that Makes use of plants to remove, transform, or stabilize contaminants in water, sediment, or soil. C. intybus exhibits greater root biomass than many other species. The results of a number of researches showed that the C. intybus collect high concentrations of Pb and As a result, this species is considered as a hyper accumulator of pb in shoot can be used to disinfect the contaminated soil with pb (Baker and Brooks, 1989; Baker et al., 1994**)**. Furthermore, chicory, a perennial rooted plant, which can reduce nitrate leaching and deep drainage. Therefore, it can reduce the rate of acidification of soil and salinity in dry areas.

5. Plant parts used

5.1. Aerial parts and leaves

The aerial parts and leaves of this plant are used to prepare salads and soups in some regions of Italy including Latium and Tuscany (Guarrera., 2003; Pieroni., 2001). In Sicily, the aerial parts of the Common chicory have been fried with egg and are eaten with seasoned olive oil (Lentini and Venza., 2007b)**.** In Madonie and Nebrodi regional parks in particular, is widely used for pasta sauce. Leaves are used as infusions for anemia and digestive disorders. Its flowers have cholagogic activity and are also used in washing the skin, cooling and conditioning (Chopra., 1958).

5.2. Seed

Seed extract of chicory showed the highest antioxidant capacity compared to extract from the leaves and roots **(**Milala et al., 2009**)**.

5.3. Root

The root is used as infusion to clear the organism and to stimulate appetite. The roots of some types are used as a substitute for coffee after. The root is also used as a gum.

6. Chemistry

Fresh chicory usually consists of 68% inulin, 14% sucrose, 5% cellulose, 6% protein, 4% ash, and 3% other compounds, while dried chicory contains about 98% inulin and 2% other compounds **(**Meehye and Shin, 1996). Leaves of chicory have anthocyanins, vitamins A and C as well as potassium, calcium and phosphorus and multi-hydroxy acid derivative (Mulabagal et al., 2009). In the root extract of C. intybus L, alkaloids, flavonoids, triterpenoids, tannins and saponins can be found (Nandagopal and Kumari., 2007) Hydroxycinnamates, flavonoids,

phenolic acids and anthocyanins (in red species) are responsible for high antioxidant and antiradical potential of chicory.

Sesquiterpene lactones, are responsible for the bitter taste of C. intybus (Peters and Van Amerongen., 1998). Other components such as coumarins (Bais and Ravishankar 2001), flavonoids derivatives (Dem'yanenko and Dranik., 1972; Dem'yanenko and Dranik., 1973), carbohydrates (glucose, fructose and inulin) (Poli et al., 2002) and vitamins (Dinelli PP, Morelli., 1984) are present in this plant. The components are widely varied, not only from one cultivar to another, but also within a single cultivar, depending on which period of the year the crop is harvested (Chillemi., 1997) and also according to the method used for extract preparation (Van Beek et al., 1990; Anastas., 1999).

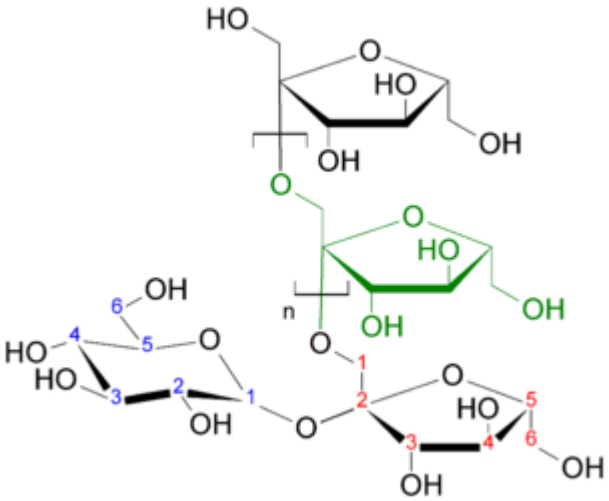

Figure 1. Structure of inulin

7. Growth of chicory

PUNE chicory in the warm seasons is active but dormant in winter (Lancashire and Brock, 1983). There are four periods and nine age states in In the course of its life: the period of primary dormancy (dormant seeds); virginal (seedlings, juvenile, immature, and virginal plants); generative (young, middle-aged, and old generative plants); and senile (senile plants). In its first growing season, it has an intact crown which is divided into multi-crowns from its second growing season **(**Hume et al., 1995; Li et al., 1997). The rapid development of chicory reproductive stems causes its rapid growth rate (up to 150 kgDMha^{-1} day^{-1}) in the late spring and early summer (Hare et al., 1987; Matthews et al., 1990). PUNE chicory starts flowering in late spring and continues until summer **(**Hare et al., 1987). Chicory matures quickly and produces a hollow primary stem in mid-spring. When its length reaches to 60 cm, it begins to thicken and harden and continues to grow to over 2 m tall if reproductive growth is not controlled **(**Barry, 1998; Hare et al., 1987; Rumball, 1986). The number of reproductive shoots per individual in natural habitats varies from 1 to 12. Depending on age and life state may be found on chicory shoots up to 17 achenes per calathidium. Some researchers have subdivided the term seed productivity into two terms: potential seed productivity (PSP) referring to the number of seed buds and real seed productivity (RSP) referring to the number of seeds (Vainagii, 1973; Khodachek, 1970; Levina, 1981**)**. Percentage ratio between these indices (semination coefficient) gives us an important index describing the degree of population adapt to environmental conditions. Middle-aged individual have the largest number of productive shoots and inflorescences and the highest seed productivity and semination coefficient.

8. resistance to environmental factors

8.1. heat

Chicory is resistance against the long summer drought due to its thick and deep taproot. The avoidance of dryness during the summer and high DM production **(**Hare et al., 1987; Lancashire, 1978**)** ensures feed availability when livestock requirements are high **(**Hunt and Hay, 1990**)**. During the 1990–1991 summer drought in central NSW, Australia, Puna chicory was the only pasture species that produced useful quantities of green leaf (Kemp et al., 2002**)**.

8.2. Cold

Chicory has stout taproot with high dry matter content which enables it to survive at low temperatures (down to -7 ° C) for several weeks **(**Neefs et al. 2000; Skinner and Gustine 2002**)**. Since the chicory is resistant to low temperatures in the winter it is mainly used as salad when available fresh leafy vegetables are limited (Carazzone et al., 2013**)**.

8.3. PH

The most suitable pH for Puna chicories growing is 5.6-6.0, however, these plants are able to tolerate a wide range of pH (4.8-6.5) **(**Crush and Evans, 1990**).**

8.4. soil salinity

Salinity of agricultural areas, due to the severe practices and irrigation, is an important feature of limiting product. The plants which are exposed to salt stress, Make changes in their metabolism, to deal with the environment **(**Tuteja 2007**)**. Seed germinability wild chicory is 91%. Lucrezia Sergio et al (2012) demonstrated that Wild Chicory seeds are able to germinate in saline conditions: seed germination percentage of chicory decreased slightly (<10 %) with increasing concentration of NaCl to a concentration of less than 140 mm, While germinability was reduced to below 40% when the concentration of NaCl reached out to more than 200 mM. These results are consistent with data reported by Cucci et al (1994). As well as Salt-induced enhancement of antioxidative enzymes indicated that wild chicory has a high capacity to activate protective mechanisms against the oxidative damage generated by salt stress, in both roots and leaves.

8.5. Insects

Some of the compounds found in chicory, such as sesquiterpene lactone, flavonoids, coumarins, caffeic acid and phenolic compounds are as allelopathic agents or feeding deterrent, so it is free from herbivore attack and distasteful to some insects (Poli et al., 2002; Pyrek., 1985; Rees and Harborne., 1985).

9. Planting methods

In many cities of the Madonie Regional Park, Common chicory usually grows in the kitchen garden, and the Cultivation techniques used for this product is similar to spinach and salad rocket. Only with some minor modifications, the sowing and harvesting techniques used for sugar beet and potato can be used for chicory roots, so that we need no investments in equipment. In vitro regeneration of C. intybus, it also has been reported through shoot organogenesis or somatic embryogenesis using different explant types including leaf, root, callus and suspension cultures, and various hormonal combinations (Profumo et al. 1985; Pieron et al. 1993; Mohamed-Yasseen and Splittstoesser 1995; Vesseur et al. 1995; Belletre et al. 1999; Park and Lim 1999; Rehman et al. 2003; Bennici et al. 2006).

10. Soil, fertilizers, and pruning requirements

Like all highly productive forage species, chicory needs to have a high nutrient input to maintain high production especially in soils with low fertility (Belesky et al., 2001**)**. The best conditions for growing Puna chicory is well-drained soils with medium to high fertility **(**Hare et al., 1987**)** that is fed with nutrients such as Olsen phosphorus, potassium, sulfur **(**Moloney and Milne, 1993**)** and N fertilizer Especially during seedling development. Puna chicory seems to be more sensitive to the N rate than timing of N application, as it is able to compensate between development of stem and branches **(**Rowarth et al., 1996).

Chicory is a short-lived perennial species that can eventually be productive in grazing conditions for about four years. Proper management can extend the life of chicory. However if high quality food is required, chicory should be pruned well to prevent the formation of flowering stems. Chicory should be pruned to below 10 cm at three weekly intervals in spring and early summer, and pruned to below 15 cm at five weekly intervals after mid-summer.

11. cultivar populations, lines and varieties

Several different classification is described for the different chicory cultivar groups. Classification Kiers (2000) is supported by the AFLP and ITS analysis **(**Kiers 2000; Van Stallen et al. 2001), so here we will investigate this classification. This classification system, divided cultivated forms of C. intybus into three groups (chicory leaves, chicory root, and witloof), as outlined below: 1- The leaf chicory group consists of leafy vegetables that can be consumed fresh or cooked. This classification divided this group into two sub-groups: Sugarloaf and Radicchio.

The sugarloaf subgroup also Known as C. intybus var. porphyreum that is grown mainly in Central and North-West Europe and the Radicchio subgroup also Known as C. intybus var. latifolium that is grown in Southern Europe, mainly in northern Italy. 2- The root chicory group, also known as industrial chicory or C. intybus var. sativum and Characterized by a large tap root, like sugar beet, it was originally developed as a coffee substitute but is now mainly grown for inulin production. 3- The Witloof group, also known as C. intybus var. foliosum that is grown mainly in the central and northwestern Europe (eg Belgium and the Netherlands) that can be consumed as salad or cooked.

A closely related species of chicory (C. intybus L.) and endive (C. endivia L.) has been domesticated. Wild chicory forms distributed widely in Europe, North Africa and Central Asia and have been naturalized in North America (Simmonds 1976**)**. Wild and cultivated varieties of chicory, Cichorium intybus L., can be imported due to the overlap in distribution areas **(**Kiers 2000; Van Cutsem et al. 2003**)**, For example, the leaf chicory group and wild C. intybus individuals seems closely related to each other.

12. Harvesting and yields

The sesquiterpene lactone content varies widely not only from one figure to another, but also within a single cultivar which can help to determine the exact moment of harvest **(**Peters & Van Amerongen, 1996**)**. Since the sesquiterpene lactones are responsible for the flavor of chicory, depending on what period of the year the crop is harvested, the flavor varies greatly for a single cultivar **(**Chillemi, 1997; Pimpini & Chillemi, 1993**)**.

High root yield, the content of inulin and longer inulin chains will be affected generally by sowing date, harvest date and genotype. Degrading fructan enzymes are active in the autumn, which reduces the average length of inulin chain. So, early harvest is necessary for the longer-chain inulin. Best quality inulin is produced in September while the highest root biomass is reached a few weeks later. Seed productivity of common chicory depends on the number of productive shoots per individual, the number of calathidia per shoot, and the number of achenes per calathidium.

13. Plant disorders during storage

During storage after harvest, several disorders may be created in the product. One of the major defects is red discoloration. This red discoloration considerably affects the commercial value of the product. Cell damage that causes red spots, Can be a result of mechanical stress caused by the growth of floral stem during postharvest storage **(**Gillis et al. 2001; Van Kruistum, 1997**)** that finally causing the oxidation of phenolic compounds (Martinez and Whitaker, 1995). The probability of red discoloration increases with the increase of chicory head's weight (1.5% increase in red discoloration per 1 g increase in weight of the chicory head). Red discoloration is also associated with stem length of the chicory **(**Van Kruistum and Embrechts, 1994; Gillis et al., 2001**)**. Storage at low temperature was more efficient than Storage at higher temperatures. However, the effect of weather conditions was more significant than the effect of temperature So that Storage at 5 ° C in the air led to a higher proportion of red discoloration than storage under 10% O2 + 10% CO2 at 12 ° C. Second defect is the bitter taste Resulted of internal core or flower stem that should be avoided as much as possible from continuation of their growth during postharvest storage.

14. Conclution

Chicory (Cichorium intybus L) is a perennial herb belonging to the Asteraceae family that has been used as early as 4,000 years ago in folk medicine. Cichorium intybus L has high compatibility with different soils, drought, high or low temperatures and is high resistance to disease and insects. It is one of the best forage for livestock. all parts of this plant can be used, such as aerial parts and leaves are used to prepare salads and soups, also the leaves and roots have medicinal properties and its seed is a rich source of antioxidants.

In the last decade, wild chicory has been increasingly used in food and medicine preparations and in the future, it could play an important role as a source of nutraceuticals, principally due to having antioxidant compounds. More detailed research about this plant is required in order to identify and isolate several drug combinations. Moreover, problems will arise for plant during postharvest storage, researchers should concentrate more on the optimum storage conditions of plant.

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