



ISSN NO. 2320-5407

Journal homepage: <http://www.journalijar.com>

INTERNATIONAL JOURNAL  
OF ADVANCED RESEARCH

## RESEARCH ARTICLE

### Studies on Industrial Importance and Medicinal Value of Chicory Plant (*Cichorium intybus L.*)

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#### Manuscript Info

##### Manuscript History:

Received: 15 November 2015  
Final Accepted: 16 December 2015  
Published Online: January 2016

##### Key words:

*Cichorium intybus L.*, Medicinal Value, Industrial Importance.

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#### Abstract

Chicory (*Cichorium intybus L.*) belongs to the family Asteraceae and it is a small aromatic biennial or perennial herb. The plant was grown on normal agroclimatic conditions and taken mature root for preparation of various items. The whole plant contains a number of medicinally important compounds such as inulin, esculin, volatile compounds (monoterpenes and sesquiterpenes), coumarins, flavonoids and vitamins. It has also an industrial importance for the production of various food preparations like pure instant chicory powder, chicory powder, agglomerated chicory powder, chicory flour, roasted chicory cubes, chocolate flavor and liquid chicory extract.

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#### Introduction:-

Chicory is a perennial plant indigenous to Europe, India, and Egypt. It was introduced to the US in the late 19th century. It grows as a weed in temperate climates and is widely cultivated in northern Europe. There are two principal types: The Brunswick variety has deeply cut leaves and generally spreads horizontally; the Magdeburg variety has undivided leaves and grows erect. Chicory has bright blue flowers that bloom from July to September. The dried root is the primary part of the plant used.

This plant has been in use as a pot herb from an early period. The ancient Egyptians, Greeks and Romans used it. Dioscorides mentions two kinds, the wild and the cultivated. The Romans called the plant Intubus or Intubum, and the plural of the latter word has furnished the Arabs with their name Hinduba. Phing called the wild plant Cichorium, Chreston (useful), Pancration (all powerful) and Ambubara or Ambubeia. It was supposed to be a panacea and to have the property of fixing the affections. The Syrian dancing girls, whom Cneius Manlius first brought to Rome, were also called Ambubaia on account of their attractive allurements. Ambubaia is a Syrian term, but the component parts of it, 'Ambui'- 'odor' and 'Baia'- 'full', occur in old Persia. Together they signify 'full of odours', i.e. allurements.

#### Origin and Distribution:-

The plant grows almost on all types of soil and occurs throughout North West India upto 6000 feet Punjab, Kashmir, Andhra Pradesh, Karnataka and Maharashtra other countries which produce chicory are Baluchistan, Belgium, Europe France, Germany, Persia, Netherlands, Switzerland, South Africa Waziristan, West Asia, United Kingdom (Anonymous).

Chicory grows well in many different conditions, and is commonly found on the roadsides in Europe, where it originated, but it has now naturalized into the Americas and can be found widely there. The leaves, buds, and roots

all have certain beneficial qualities, and the leaves are used in a similar way as spinach in many cultures. The root is often ground into a powder and used as a coffee substitute, which doesn't negate all of its health benefits. It has been used for hundreds of years as a herbal remedy for many diseases, and continues to prove its worth today.

#### Constituents of chicory roots:-

The main groups of compounds of the chicory root are carbohydrates, including saccharose, glucose and fructose, fructooligosaccharides and inulin, whose contents reach 21% on average. Inulin is a soluble polyfructan and belongs to a group of dietary fibre. Inulin chains consist of up to 100 D-fructofuranose units linked *via*  $\beta$ -(2 $\rightarrow$ 1) glycosidic bonds (Gałazka, 2002). Fructooligosaccharides, short chain fructans built of 2-10 residues linked *via*  $\beta$ -(2 $\rightarrow$ 1) glycosidic bond and with terminal unit of a glucose molecule linked with a fructose molecule by  $\alpha$ -(1 $\rightarrow$ 2) glycosidic bond, are structurally similar to inulin (De Leenheer, 1996). These fructans express prebiotic properties manifested by the stimulation of the growth of beneficial microflora and inhibition of pathogenic and putrid bacteria. Moreover, fructans enhance the absorption of minerals from diet (especially calcium, magnesium and ferrum), improve absorption of vitamins by an organism (mainly from B group) and stimulate gut peristalsis. They reduce the risk of hypercholesterolemia and colonic cancer by decreasing the content of toxic metabolites (including ammonia) and harmful enzymes in faeces (including  $\beta$ -glucuronidase) (Bornet *et al.*, 2002; Krol & Zdunczyk, 2005). Daily intake of 2.5-10 g of fructooligosaccharides (FOS) is recognised as a dose expressing prebiotic activity in humans, however, the average daily intake from natural sources is lower, *ca.* 0.8 g (L'homme *et al.*, 2001). This fact indicates the necessity of food supplementation with prebiotic FOS.

#### Characteristics of chicory:-

Root chicory, likewise wild chicory, is a source of sesquiterpenes and polyphenols (Mares *et al.*, 2005; Kocsis *et al.*, 2003; Hoste *et al.*, 2006). Chicory root has been demonstrated to contain lactones that occur mainly as lactucin, 8-deoxylactucin, lactupicrin and their 11 $\beta$ 13-dihydro derivatives (Mares *et al.*, 2005; Peters & Amerongen, 1997, 1998), with eudesmanolides and germacranolides occurring in smaller amounts (Peters & Amerongen, 1997; De Kraker *et al.*, 2001).

The predominating group of polyphenolic compounds in chicory are hydroxycinnamic acids represented by mono- (mainly 5-caffeoylquinic acid) and (3,4-, 3,5-and 4,5-) dicaffeoylquinic acids and chicoric acid (Haffke & Engelhard, 1986; Clifford, 2000). Polyphenolic acids of chicory root express a wide range of health-promoting activities such as antiviral, anticarcinogenic, antibacterial, anti-inflammatory, antifungal, antimutagenic, immunostimulating and antioxidant. Moreover, they can act against HIV virus, they can protect the alimentary tract and influence the reduction of cholesterol level in blood (Wang *et al.*, 2003; Innocenti *et al.*, 2005; Mares *et al.*, 2005). Therefore, preparations rich in prebiotic saccharides and polyphenols produced from chicory can be used as supplements promoting healthy properties of a diet.

The aim of this work was to evaluate the usability of different parts of chicory, *i.e.* roots, leaves, and seeds, for obtaining extracts rich in fructans and polyphenols. The production of fructan-polyphenol preparations was performed by multistage alcohol extraction in a laboratory extractor, followed by evaporation of ethanol, concentration and lyophilization the extracts.



Fig.1 Chicory plant

**Botany:-**

Chicory prefers a humid climate although wet summers are unfavourable. It is well adapted to the climate of Western Europe. Chicory is susceptible to soil-borne *Sclerotinia* and *Rhizoctonia* spp. so an adequate period between crops is essential. It is also a host of the nematode *Meloidogyne hapla* but it is not hampered by it. Chicory is not a host of the beet cyst nematode (*Heterodera schachtii*).

Chicory is a woody, herbaceous plant that has a wealth of health benefits, including the ability to ease digestive problems, prevent heartburn, reduce arthritis pains, detoxify the liver and gallbladder, prevent bacterial infections, boost the immune system, and reduce the chance of heart disease. It is also a natural sedative, and can protect against kidney stones, and benefit attempts to lose weight. All in all, this small plant is a powerful addition to any diet.

In terms of nutritive value, chicory is a great source of vitamins and minerals, including zinc, magnesium, manganese, calcium, iron folic acid, and potassium, as well as vitamins A, B<sub>6</sub>, C, E, and K. These are the main agents behind all of the health benefits that come from chicory, which are explained below.

Chicory is a familiar wild plant in many parts of Northern Europe, found particularly on calcareous soils. It has been traditionally cultivated in European agriculture as a grassland herb, as a root crop to produce a coffee substitute or as a vegetable, the young shoots being eaten. This is a hardy biennial or short-lived perennial belonging to the sunflower family. It has a long stout tap-root which penetrates deep into the soil. During the first season a rosette of shiny oblong leaves is produced, these have a prominent midrib and may be rounded or pointed at the ends. The stiffly erect, tough grooved stem appears during the second summer. The mature chicory plant may grow to 150cm in cultivated types. The flowers are large and azure blue, and occasionally, but rarely pink or white. Flowers are borne on upper parts of leaves on very short individual stalks. Flowers open successively upwards, though they will often close during dull weather.

**Chemistry:-**

Chicory flowers contain cichoriin, which is 6,7-glucohydroxycoumarin. The roots contain up to 8% inulin (a polysaccharide), a bitter principle consisting of 1 part protocatechuic aldehyde to 3 parts inulin, as well as lactucin and lactucopicrin (Balbaa S, et al,1973). Constituents of the greens include chicoric acid (dicaffeoyl tartaric acid), flavonoids, catechol tannins, glycosides, carbohydrates, unsaturated sterols and triterpenoids, sesquiterpene lactones, and tartaric acid (Proliac A, et al.,1976; Ruhl I, et al,1985). Leaf proteins from chicory greens have also been reported (Mahadevia S, et al., 1968) .

The root contains a large number of steam-distillable aromatic compounds. Acetophenone provides the characteristic chicory aroma. Upon roasting, inulin is converted to oxymethylfurfural, a compound with a coffee-like smell (Ruhl I, et al.,1985). Fructan: fructan 6G-fructosyltransferase (6G-FFT) was found to be an important enzyme in the formation of inulin. According to a report, introduction of 6G-FFT from a plant into chicory resulted in inulin synthesis (Vijn I, et al.1997). Chicory is the source of the taste-modifier maltol, which is known to intensify the flavor of sugar.

The caffeine content of beverages containing chicory was determined using high pressure liquid chromatography (HPLC). A coffee/chicory mixture substitute contains 3.18mg/fl oz of caffeine, whereas instant coffee contains 12.61mg/fl oz of caffeine (Galasko G, et al.,1989). In identifying closely related chicory varieties, the use of polyacrylamide gel electrophoresis followed by leucine aminopeptidase and esterase staining of bulked seed sample extracts has been developed (Baes P, et al., 1922).

**Chemical composition of chicory:-**

Analysis of the seeds gave the following values: Oil. 4.7%, fatty acid composition, saturated 21.7%, unsaturated 78.3%. The analysis of fresh roots gave the following values: moisture- 77.fat: 0.6gm , cellulose, inulin and fiber- 9.0gm, gummy matter- 7.5gm, Glucose- 1.1gm, bitter extractives- 4.0gm, ash- 0.8% . The roots contain the

sesquiterpenes lactones like sonchusides A and C, and, cytokinin, crepidiaside B, cichoriolide A, cichoriosides B and C, ribosylzeatin a nucleotide sugar, lactucopicrin, uridine-5'-diphosphoglucose and chlorogenic, neochlorogenic, 8-deoxylactucin, isochlorogenic, lactucin, caffeic and chicoric acids. The carbohydrates present in the roots include a series of glucofructosans between sucrose and inulin besides glucose and fructose, pentose, levulose and dextrose, taraxarcine and levulose. During storage the inulin is converted into inulide and finally into fructose due to the presence of an enzyme inulocoagulase (Anonymous, 1992). The roots of *Cichorium intybus* produce latex, inulin 58% a bitter compound composing of lactucin, lactucopicitin, intybin, cichorin taraxasteral, tannins, fructose, pectin, fixed oils, and alkaloids. Aerial part-inulin fructose, resin, cichorin, esculetin (Kokate C.K., 1981). The presence of tannin phlobaphenes and reducing sugars is also reported in the seeds (Goel & Bhattacharyya, 1981).

#### **Pharmacological characteristics:-**

##### **Antiulcer and Antioxidant Activity:-**

*Cichorium intybus* L. (Asteraceae) roots have been extensively used in Ayurveda medicine. It is variously used as a treatment for gallstones, gastro-enteritis, sinus problems, diabetes and constipation. Antiulcer effect of HACI was evaluated in rats by the oral administration of ethanol 99.5% (dose 1 ml/200 gm b. w.) and pylorus ligation method. HACI was administered at the dose of (300mg/kg and 500mg/kg. p. o.) Antiulcer activity was assessed by determining and comparing ulcer index, total acidity, free acidity, gastric volume and pH, in test drug group with that of ulcer control group. Ranitidine was used as a standard (50mg/kg/p. o.). Antioxidant activity of HACI has been assayed by using ABTS radical cation decolorization assay. Maximum ulcer reduction was observed at a dose of 500mg/kg p. o. of HACI, in ethanol and pylorus ligation induced model, producing a protection index of 46.66% and 43.93% respectively, where as Ranitidine produced greater protection index of 59.99% and 68.29% respectively. A significant reduction in volume of gastric juice and acid output was also observed in ulcer induced animals treated with HACI when compared with ulcer control group. Simultaneously, pH of the gastric fluid was increased significantly. The result of study indicates that the antioxidant properties of HACI may contribute to gastro protective activity probably due to its free radical scavenging activity. These results suggest that HACI root extract possess antiulcer activity. (Apte *et al*; 2011).

A recent study has shown that root of chicory consists of high alkaloids, and the root extract of this plant revealed anticancer, antitumor and immunomodulator properties (Angelina *et al.*, 1999; Hazra B., 2002). Chicory is used as an adulterant in coffee so as to reduce gastrointestinal problems like gastritis (Bremness L., 1998). The sesquiterpene lactones like lactucin and lactucopicrin were used for antibacterial and antimalarial activity (Bischoff *et al.*, 2004), antifungal activity (Monde *et al.*, 1990; Nishimura *et al.*, 1999). Chicory also has antibacterial and nematocidal effect (Nandagopal and Kumari, 2007). Even though it has antibacterial effect but still little is known on human pathogenic bacteria. Inulin is a dietary fibre which is a starch which is not digestible by the humans but can be used as an artificial sweetener (Kashyapa and Chand, 2000). Dried root is used as a diuretic, jaundice tonic, stomachic, liver enlargement, gout, used as a tonic in fevers, rheumatic complaints vomiting, diarrhea, and enlargement of the spleen (Kokate C.K., 2006; Chopra R.N., 2002).

##### **Kasni as Preboitics:-**

Chicory is rich in fibrous polysaccharide inulin, it is a soluble dietary fibre and resistant to digestive enzyme. It reaches to large intestine or colon essentially intact, where it is fermented by resident bacteria. Lactobacilli and bifidobacteria agent digest inulin and feed themselves on it. Hence prebiotics act as fertilizers for these symbiotic bacteria. Inulin serves the role of dietary fibre; safety of inulin has been evaluated and accepted by FDA of United States (Chopra *et al.*, 2002). The leaves and roots are used to treat diabetes (Pullaiah and Chandrasekhar, 2003). The Alcoholic extract of its root showed significant anti microbial activity against organisms causing gingival inflammation (Patel and Doshi, 1981). Chicory not only contains 58% inulin and sesquiterpene lactones but also contains vitamins and minerals. It is an excellent mild bitter tonic for liver and digestive tract and cleansing the urinary tract. Chicory is also taken as a mild laxative (Chevallier A., 1996). Therapeutics: lithotryptic, diuretic, rheumatism, gout, anti inflammatory, lowers blood sugar (Karnick C.R., 1994).

## Uses chicory in Unani system of medicine:-

It removes the visceral, hepatic and vascular obstruction. It is a good but not very strong astringent. Application of a paint prepared from its juice with white lead and vinegar elicits a remarkable cooling effect on the organs. It is used as plaster in case of gout. It is useful in chronic conjunctivitis. The latex of the wild variety removes opacity of the cornea. It is plastered on the chest with barley flour in cases of palpitation. It strengthens the heart; Purging cassia is dissolved in its juice and used as gargle in pharyngitis. It relieves nausea and counteracts the ill effects of excessive yellow bile, it strengthens the heart, and it is one of the best drugs for the stomach having a hot temperament. The wild endive is better than the cultivated variety for stomach diseases, endive is said to be suitable for all kinds of temperaments of the liver, the drug is particularly suitable for hot tempered livers, and however it is not harmful to cold tempered organs unlike some cold vegetables. Oral intake of endive especially of its wild variety along with vinegar causes constipation. Endive is useful in quartan fevers and also in fevers attributed to cold exposure. A plaster of the roots of endive as well as its roasted flour is beneficial against the bites of scorpion, insects, wasps, snakes etc. (Azmi W.A., 1997).

## Health Benefits of Chicory:-

**Digestive Issues:** One of the most common reasons for adding chicory to a diet is to improve various functions of the digestive system. Chicory contains, inulin, which is a powerful probiotic. Probiotics are a classification of bacteria that actually confer benefits on the host, rather than diseases, which is what bacteria are commonly associated with. Inulin is used to combat a number of intestinal and digestive concerns, including acid reflux disease, indigestion, and heartburn because it actively reduces the acidity of the body's systems.

**Heart Disease:** Inulin is not only beneficial for the digestive system, it has also been shown to reduce the levels of "bad" cholesterol in the body. This LDL cholesterol is one of the main causes behind atherosclerosis and high blood pressure, because it somewhat blocks the flow of blood when it binds to arteries and veins. It can also contribute to the possibility of heart attacks and strokes. Interestingly enough, the chemical pathway that inulin functions in to reduce the presence of LDL cholesterol is rarely active unless a person consumes a high level of carbohydrates, so this benefit has slightly smaller range of affect. However, more research is currently being done on how chicory can help heart health in other ways.

**Anti-thrombotic:** Chicory is also packed with plant phenols, which have been widely studied as anti-thrombotic and anti-arrhythmic agents. They are considered antioxidants, and studies have shown that chicory-based coffee rather than normal coffee can significantly improve the balance of blood and plasma in the body, which reduces chances of cardiovascular disease.

**Anticarcinogenic:** Research is ongoing in terms of the exact mechanism of prevention cancer, chicory extract has been linked to a reduction in tumor growth in various cancer studies. Early reports indicate that it is due to the fructans within chicory, which have anti-tumor qualities and antioxidant properties. The polyphenols and photochemicals within chicory also have a positive effect on preventing various types of cancer, including breast cancer and colorectal cancer.

**Reduce Arthritis Pain:** Chicory has traditionally been used as a treatment for arthritis, and studies have shown chicory to have significant anti-inflammatory properties, which is why it works to reduce the pain from conditions like osteoarthritis. In a 2010 study, 70% of test subjects who received the chicory treatment reported a noticeable improvement in the pain associated with their osteoarthritic condition. Chicory can also be used as a general anti-inflammatory agent for aches, muscle pains, and joint soreness for this same reason.

**Reduce Constipation:** Once again, inulin's role as a natural fiber comes as a major benefit to chicory eaters. The fiber helps to bulk up bowel movements, promote peristaltic motions, and the secretion of gastric juices. Basically, that means that digestion as a whole is improved, and constipation is greatly reduced. By maintaining a smooth and regulated digestive process, people can reduce the chances of a number of gastrointestinal conditions and diseases, including stomach and colon cancer.



**Immune System:** Chicory has a number of helpful qualities that make it a powerful booster for your immune system. It displays clear antibacterial effects on a number of dangerous strains of bacteria, and we have already mentioned the benefits of the polyphenolic compounds in chicory in terms of the immune system. There are also phyto-chemicals in chicory that act as antioxidants, further sweeping out free radicals from the blood stream, which reduces the chances of contracting a number of diseases or conditions, including heart disease and cancer.

**Kidney Health:** Chicory root extract is often used as a diuretic, which increases the amount of urination. Consistent and healthy frequency of urination can help to eliminate toxins that the body stores in the liver and kidneys, and preventing the dangerous conditions that can occur when toxins are allowed to remain in the body. Also, frequent urination can eliminate excess water weight, and even reduce fat, since 4% of urine is usually fat deposits that would otherwise be stored somewhere else in the body.

Chicory can also be used as a herbal remedy, particularly for its tonic affect upon the liver and digestive tract. Both roots and leaves can be used although roots are more active medicinally. Root extracts have experimentally produced slower and weaker heart rate. The latex in the stems can also be applied to warts to destroy them. The crop also has potential as a biomass crop for industrial use, they are rich in the starch 'inulin' which can easily be converted to alcohol. A blue dye has also been obtained from the leaves.

### Industrial uses of chicory:-

Chicory has been used in the production of different products which are used in the preparation of food products and beverages. Chicory dried has been prepared cutting of chicory root and sun/control dried. Roasted chicory cubes are prepared by roasting of chicory cubes at 150°C for 20 -30 minutes and form powder which are used as coffee additives. Chicory spray dried powder prepared by spraying slurry spray drier make powder used in various food preparations like chocolate and baby foods.



Fig 2: Chicory root granules



Fig3: Dried chicory cubes

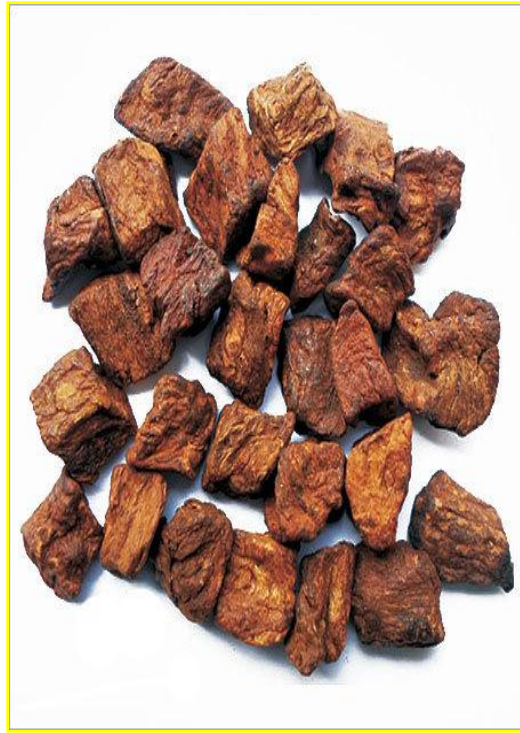


Fig 4:Roasted Chicory cubes



Fig 5:Roasted chicory cubes small size



Fig 6: Instant spray dried chicory powder

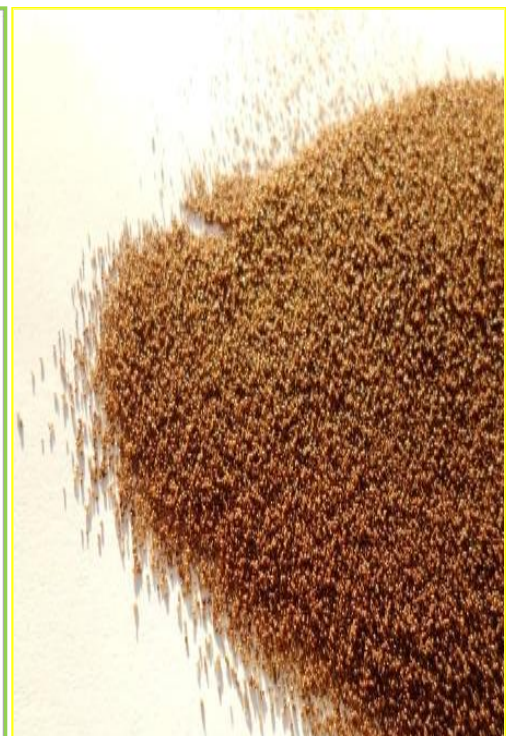


Fig 7: Spray dried chicory powder



Fig 8: Liquid chicory



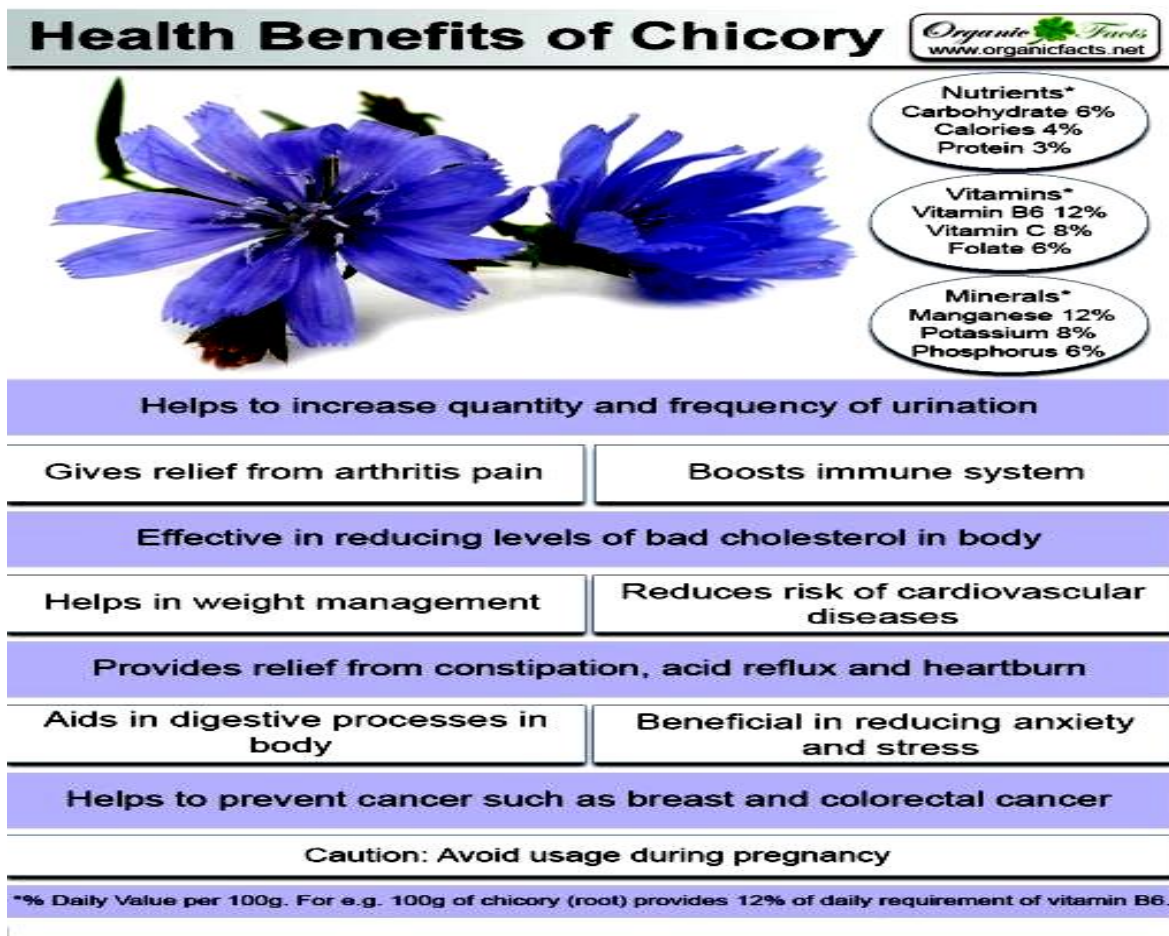


Fig 9: Health Benefits of Chicory

**Markets and Market Potential :-**

In many agricultural systems in Europe chicory is a more reliable producer of inulin than Jerusalem artichoke because crop yield is considerably less variable. Work to improve yields, root shape and disease resistance of the inulin producing varieties is ongoing in Belgium, Netherlands, France and Germany. Derivatives of inulin may be useful for a wide variety of industrial applications for example in the production of detergents, solvents, polymers, pharmaceuticals and plant protection agents. Chicory can be eaten in several forms; coffee, leaves, flowers and roots. Leaves and flowers can be added to salads but often have a rather bitter taste. Roots are cooked like parsnips and are eaten as a vegetable. Inulin is a starch that cannot be digested by humans; it tends to pass straight through the digestive system. Due to this inulin can be used to make a sweetener that is suitable for diabetics to use. The roasted root is used as a caffeine-free coffee adulterant or substitute. Young roots have a slightly bitter caramel flavour when roasted, roots over two years old are much more bitter. There are three main types of chicory grown for their leaves, there are many cultivars of each form:

- A bitter tasting loose-leaved form is grown as a green winter vegetable, especially in southern Italy.
- A narrow-leaved, witloof or Belgian form has a compact elongate head (chicon) which is blanched for use in salads or cooked dishes.
- A broad-leaved (usually red) form produces cabbage-like hearts, these are generally less bitter than the other forms and are eaten raw or cooked. These forms are often used as a winter salad crop.

## Quality Characteristics of Chicory:-

Chicory is of interest to industry because the swollen taproot contains a high proportion of the storage carbohydrate inulin. At harvest, roots contain 75% inulin on a dry matter basis. Inulin is a polymer of fructose molecules with an end glucose molecule and can be used for the production of fructose syrups. Fructose is approximately 1.3 times sweeter than beet sugar, so less calories are used for the equivalent sweet sensation. In addition fructose syrups may be used as feed stocks for fermentation processes and chemical transformations with a wide range of applications.

## Other Information :-

It is sometimes included in seed mixtures on shallow chalky soils in England, as pigs/cattle eat the leaves, and for the effect of the deep tap root breaking up the subsoil. Chicory can be a good plant for grazing producing forage with 18-22% protein and 62-77% dry matter content. Chicory should be grazed heavily, leaving a stubble height of 1.5-2 inches, for short periods of time. This intense grazing should prevent plants from bolting. A rest period of at least 25-30 days between grazing will allow chicory stand persistence and optimum performance.

It can be grown as a root crop, the roots being processed for the manufacture of a coffee substitute. For this Magdeburg chicory is used, drilled at about 5 kg/ha and yields about 25t ha<sup>-1</sup>. The crop requires deep, well-drained soils and although yields will be reduced, will tolerate a degree of drought. It is sown in April when the soil has warmed. Plant population should be 15 - 20 plants per m<sup>2</sup> in rows 45 - 50cm apart. Weed control is important during slow early growth. Some herbicides are available for use in chicory. It responds well to applications of N, P, and K. Up to 150 kg ha<sup>-1</sup> nitrogen, 200kg ha<sup>-1</sup> phosphate and 250kg ha<sup>-1</sup> potash is recommended for good yields. For optimum production pH should be in the range of 4.5-8.3 (preferably 5.5-7.0). Roots are normally lifted during October and November using the same techniques as for sugar beet. Machinery may have to be adapted to suit chicory as roots are generally smaller and more fragile, conveyor speeds should be reduced and chain links narrowed.

In Europe, chicory is generally followed in the rotation by a cereal crop. At least a five year rotation is strongly recommended to avoid soil exhaustion and other problems. It is recommended chicory does not follow these crops in the rotation: sugar beet, where weed beet can multiply; maize, where herbicide residues are a potential problem; and potatoes and oilseed rape, where volunteers can be a problem.

## Conclusion :-

*Cichorium intybus* is a medicinal and culinary herb which is used in traditional system of medicine since many years, even though it has many medicinal values and industrial uses. Chicory has necessary to scientifically validate with experimental and clinical study.

## Acknowledgement:-

Authors are thankful to Dr. Dharam Singh, Director General, Indian Medicinal Plants Marketing Federation, Ministry of Agriculture, New Delhi, for providing necessary facilities and proper guidance for carrying out this study work. Authors are also thankful to Dr. Vinod H. Jadhav, Principal Scientist, Noble Chemical Research Laboratory, GIDC, Makarpura, Vadodara, for his insightful suggestion during the preparation of this paper.

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