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REVIEW ARTICLE

***Ceratonia siliqua*: Characterization, Pharmaceutical Products and Analysis of Bioactive Compounds: A Review**

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ABSTRACT:

Commonly known as the carob tree. The carob tree is native to the mediterranean region, including Southern Europe, Northern Africa, the larger mediterranean islands, the Levant and Middle-East of Western Asia into Iran; and the Canary Islands and Macaronesia. The carat, a unit of mass for gemstones, and of purity for gold, takes its name, indirectly, from the Greek word for a carob seed, kerátion. *C. siliqua* is the only Mediterranean tree with the main flowering season in autumn (September-November). However, the time and the length of the flowering period depend on local climatic conditions, as with most fruit and nut trees. Carob bean size is a highly variable character, influenced by many environmental factors as well as level of pollination and fruit set. Pollen dispersal is by insects, mainly bees, flies, wasps and night-flying moths. *C. siliqua* pods provide fodder for ruminants and non-ruminants. Endosperm and embryo of the seed can be ground and used for pet food. The fodder is now being used in zero-grazing in Mediterranean countries. Ripe carob pods contain large amounts of condensed tannins (16-20% of dry weight). Tannins extracted from the pulp act as an anti-diarrhoeic. Ground pulp and seed endosperm are used in the preparation of pharmaceutical products.

KEYWORDS: *Ceratonia siliqua*, Pharmaceutical, Bioactive Compounds, Review.

1. INTRODUCTION:

The *Ceratonia siliqua* tree grows up to 15 m (49 ft) tall. The crown is broad and semispherical, supported by a thick trunk with brown rough bark and sturdy branches. Leaves are 10 to 20 cm (3.9 to 7.9 in) long, alternate, pinnate, and may or may not have a terminal leaflet. It is frost-tolerant to roughly 20°F (–7°C). *C. siliqua* is a plant of the Mediteranean regions **Figure 1** and **Figure 2**. Also known as carob, the crude extract of the plant pod exhibited antioxidant properties higher than certain known polyphenols such as catechin, quercetin and gallic acid alone¹⁻³, due to the presence of carotenoids such as lutein, lycopene, carotene and -carotene.

Compound identification using High Performance Liquid Chromatography (HPLC) showed that carob pods contain flavonoids of quercetin glycosides, catechin and epicatechin gallate, polyphenols of gallic acid and ellagic acid, and anthocyanins such as proanthocyanidins and ellagitannins⁴⁻⁶, as well as epigallocatechin gallate⁷. Avallone et al. revealed that extract of carob pod can be used as a natural product with anxiolytic-sedative effects and act as a chemopreventive agent. The presence of gallic acid, epigallocatechin-3-gallate and epicatechin-3-gallate in carob pod can exert antiproliferative effects in-vitro. Proliferative effects are related to cancerous cells that grow and increase rapidly. The patented aqueous extract of *C. siliqua* pod revealed the antioxidant activity of the extract along with potential antitumor activity⁸⁻¹². The extract has equivalent antioxidant level to tea, but without the stimulant effects of caffeine and theophylline. The extract was prepared using hot distilled water for 15 minutes, then filtered and evaporated to dryness. The polyphenols content of the extract was 1.36

mg/g of pod powder. The pod extract at a concentration of 80 µg/mL was shown to effectively inhibit proliferation in liver tumor cells after 48 hours of treatment in-vitro¹³⁻²⁰. The extract of carob pod also has an antidepressant effects as exhibited in a study by Altameme et al. on mice using tail suspension and forced swim tests^{21,22}. The anti-diarrhea effect of carob pod dietary fiber, as patented by Mark et al. was observed in tube-fed patients²³. Dietary fiber of carob pod also proved to reduce total cholesterol and LDL-c levels significantly after six weeks of consumption before breakfast in 49 volunteers with mild to moderate cholesterol levels²⁴. Generally, pod extracts of *C. siliqua* were shown to possess health benefits for humans. However, the in vitro anti-proliferative and other beneficial effects need to be confirmed and extensively studied to evaluate its effectiveness in-vivo. The high antioxidant level of *C. siliqua* pod extract suggesting its potential development as a nutraceutical or pharmaceutical product.



Figure 1. *C. siliqua*, ripe carob fruit pods



Figure 2. Illustration of *Ceratonia siliqua*.

2. *Ceratonia siliqua* and pharmaceutical products:

2.1. Food: Carob pulp is high in total sugar content (48-56%). In addition, it contains about 18% cellulose and hemicellulose. Mineral composition consists of potassium, calcium, magnesium, sodium, iron, copper, iron, manganese and zinc.

In some countries, Egypt for example, carob syrup is a popular drink, obtained from carob kibbles with water. Unicellular organisms convert carob pulp into a high-protein feed; sugar solutions extracted from carob pods are an excellent substrate for culturing fungi such as *Aspergillus niger* and *Fusarium moniliforme*, and the dried mycelium is a palatable and nutritious feed, containing up to 38% crude protein by weight²⁵⁻²⁹. The carob product most widely used, especially in the food industry, is carob bean gum (CBG), or locust bean gum (LBG). This gum comes from the seed endosperm and chemically is a polysaccharide, a galactomannan. 100 kg of seeds yield 20 kg on average of pure dry gum.

2.2. The mucilaginous gum, known as 'tragasol', is used in a wide range of commercial products as a thickener, stabilizer, binder and gelling or dispersal agent. The food industry uses CBG for the production of a large number of different commodities: ice cream, soups, sauces, cheese, fruit pies, canned meats, confectionery, bakery products and pet foods³⁰⁻³⁶. Technical applications of CBG include cosmetics, pharmaceuticals, film emulsions, paints, polishes, ceramics and adhesives.

2.3. Pulp extracted and purified produces sugar and molasses. Powdered pulp is used as a food ingredient and cacao substitute and for preparing dietary products. Carob powder consists of 46% sugar, 7% protein and small amounts of numerous minerals and vitamins and is thus quite nutritious. Carob 'cocoa' has an advantage over chocolate in that it has fewer calories and neither caffeine nor theobromine. Ground seed embryo and endosperm can be used for human consumption; the latter, containing CBG and E-410, is a food additive and a dietary fibre³⁷⁻⁴⁰.

2.4. Fuel: The wood produces a slow-burning charcoal and can also be used for firewood.

2.5. Timber: *C. siliqua* timber is hard and close-grained and has been used to make utensils.

2.6. Gum or resin: Currently, the main use of the seed is gum extraction.

2.7. Alcohol: A high sugar content and its relatively low cost have made carob pulp among the earliest horticultural crops used for the production of industrial

alcohol by fermentation in several Mediterranean countries⁴¹⁻⁵³.

2.8. Other products: Technical applications of CBG (carob bean gum) include cosmetics, pharmaceuticals, film emulsions, paints, polishes, ceramics and adhesives^{54, 55}.

Table. Major phytochemical compounds identified in *Ceratonia siliqua*.

No.	Part of plant	System	Effects	Preparation	Ref.
1.	Pulp	Food	High in total sugar content (48-56%)	Eaten	42
			Contains about 18% cellulose and hemicellulose	Eaten	42
			Mineral composition consists of potassium, calcium, magnesium, sodium, iron, copper, iron, manganese and zinc.	Eaten	42
			Syrup	carob kibbles with water	43
			Culturing fungi	carob pods	43
			Food industry	carob product	43
			antioxidant	carob product	44
		Sugar and molasses	Food ingredient	Pulp extracted	40
			Cacao substitute has fewer calories		40
			Preparing dietary products		40
2.	Seed	Food	Dietary products sugar, protein, numerous minerals, vitamins and quite nutritious	powder	40
			High sugar content		47
			Anti-diarrhoeic.	Tannins extracted	47
		Medicine			
3.	Stem	Fuel	Gum human consumption food additive dietary fibre	seed endosperm	45
		The mucilaginous gum	Tragasol Pharmaceuticals, film emulsions, paints, polishes ceramics and adhesives.	commercial products	45
4.	Pods	Tannin or dyestuff	Human consumption		42
			Slow-burning charcoal and can also be used for firewood.	Hole plant	47
4.	Pods	Tannin or dyestuff	Ripe carob pods	extract	40

CONCLUSION:

C. siliqua is a dioecious tree with some hermaphroditic forms; male, female and hermaphroditic flowers are generally borne on different trees. Flowers of all 3 types secrete nectar; the volume of nectar and its sugar content are higher in female flowers than in male. Male and hermaphroditic flowers emit a semen-like odour that attracts insects. Most carob trees are dioecious, some are hermaphrodite. The male trees do not produce fruit. The trees blossom in autumn. The flowers are small and numerous, spirally arranged along the inflorescence axis in catkin-like racemes borne on spurs from old wood and even on the trunk (cauliflory); they are pollinated by both wind and insects. The fruit is a legume (also known less accurately as a pod), that can be elongated, compressed, straight, or curved, and thickened at the sutures. The pods take a full year to develop and ripen. The sweet ripe pods eventually fall to the ground and are eaten by various mammals such as Swine (Luke 15:16), thereby dispersing the hard seed. The seeds contain leucodelphinidin, a colourless chemical compound. Harvesting is the major cost in carob production. Collecting operations depend on yield, size and shape of pod, and orchard density.

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