CHAPTER 1

GARCINIA CAMBOGIA
A BRIEF REVIEW

1.1 INTRODUCTION

Garcinia cambogia trees are found in the tropical countries. They belong to the family Guttiferae [Lewis and Neelakantan, 1965]. This is a small or medium sized tree with rounded crown and horizontal or drooping branches. Leaves are dark green and shining, elliptic obovate, 2-5 inch long and 1 – 3 inch broad. Fruits are ovoid, 2 inches in diameter, yellow or red when ripe, with 6 – 8 grooves; seeds 6-8 surrounded by a succulent aril. (Other names: Marathy – Dharambe; Telengue – Simachinta; Tamil – Kodakkapuli; Kannada. – Upagi mara, simai hunase; Malayalam –Kadumpuli, Kodapuli) [Wealth of India, Vol. IV].

Garcinia cambogia is found commonly in the evergreen forests of Western ghats, from Konkan southwards to Travancore, and in the Shola forests of Nilgiris up to an altitude of 6,000 feet. It flowers during the hot season and fruits ripen during the rains. The fruits are edible, but too acid to be eaten raw. They are valued for their dried rind, which is used in

Travancore – Cochin and Malabar as a condiment for flavouring curries in place of tamarind or lime. In Ceylon, the fruits are pickled under ripe, the thick pericarp cut into sections, dried in the sun and preserved for future use. Large genus of evergreen trees of Guttiferae are distributed in tropical Asia, Africa and Polynesia. Around 30 species occur in India and the important ones are the following [Wealth of India, Vo. IV].

1. Garcinia atroviridis

A moderate – sized, graceful tree, 30 – 50 feet high, found in the north – eastern districts of upper Assam. The fruit rind is too sour to be eaten raw, but tastes excellent when stewed with sugar. In Malaya, the rinds of under – ripe fruits are cut into slices, dried in the sun and sold in bazaars as a sour relish for use in curries in place of tamarind and for dressing fish. The fruit is used as fixative with alum in the dyeing of silk. A decoction from leaves and roots is used in the treatment of earaches.

2. Garcinia cowa roxb.

(Other names: Hindi – Cowa; Beng. – Kau; Nepal – Kaphal; Assam – Kujithekera, Kauthekera)

A tall or medium – sized dioecious tree with short drooping branches often reaching the ground. The tree is found in the eastern parts of India (Orissa, Bihar, Bengal and Assam) and in Andaman Islands.

The fruits are edible, though not very palatable due to their acid taste. They can be made into jam or preserve. In Assam, sun–dried slices of the fruit are used in dysentery. In Burma, young leaves of the tree are cooked and eaten as vegetable. The bark is reported to be used for dyeing clothes yellow. The tree produces a yellow gum – resin, which resembles gamboges.

3. *Garcinia dulcis*

A handsome evergreen tree, 30 – 40 feet high, found wild in Malaysia. It has been introduced into India and cultivated in botanical gardens. The fruit contains citric acid and is suitable for jams and preserves. The seeds are medicinal and are used externally. The bark is used in Java for dyeing mats.

4. *Garcinia echinocarpa*

(Other names: - Tamil – Madul; Malayalam – Para)

A handsome tree, 4-50 feet high, with subglobose dark red fruits, containing 1-3 seeds, found in the moist forests of southern Travancore and Tinnevelly at altitudes of 3000 – 5000 feet and in Ceylon.

The seeds of *Garcinia echinocarpa* yield a thick viscous oil (64.4% on the weight of kernels and 49.6% on the weight of seeds), which solidifies slowly at about 26°C to a soft brown fat.

5. *Garcinia hombroniana*

A small tree resembling *Garcinia mangostana*, rose red fruits, 1-2 inches in diameter, found in Nicobar Islands and further east in Malaya, chiefly on sandy and rocky coasts. The pulp surrounding the seeds is edible. It has a sour taste and a delicate peachy flavour. The fruit is reported to cause constipation. The root and leaves are used for itch in Malaya. The timber is used for house building and oars.

6. *Garcinia Indica*

(Other names : Hindi – Kokam; Gujarathi. – Kokan, Marathi. – Amsol, Bhirand, Katambi, Kokam, Ratamba, Tamil. – Murgal, Kanada. – Murgala; Malayalam. – Punampuli)

A slender evergreen tree with drooping branches, leaves ovate or oblong lanceolate, 2.5 – 3.5 inch long and 1 – 1.5 inch broad, dark green above and pale beneath, fruits globose or spherical 1 – 1.5 inch diameter, dark purple when ripe enclosing 5 – 8 large seeds. The tree is found in tropical rain forests of Western Ghats, from Konkan southwards in Mysore, Coorg and Wynaad.

The fruit has an agreeable flavour and a sweetish acid taste. It is used in Konkan chiefly in the form of Kokam prepared by drying the outer rind, soaking it repeatedly in the juice of the pulp and sun-drying. Kokam contains approximately 10% malic acid and a little tartaric or citric acid. The fruit of the *Garcinia Indica* is anthelmintic and cardiotonic and useful in piles, dysentery, tumours, pains and heart complaints. The fruit rind of *Garcinia indica* also contains Hydroxy citric acid [Krishnamurthy *et al.* 1982]. The seeds of the fruit yield (23 – 26% on the weight of seed, and 44% on the weight of kernels) a valuable edible fat known in commerce as Kokam butter.

Kokam butter, like other Garcinia fats, is rich in combined stearic and oleic acids. It contains about 75% of mono-oleodisaturated glycerides and possesses a fairly low melting point. Kokam butter is considered to be nutritive, demulcent, astringent and emollient. It is suitable for ointments, suppositories and other pharmaceutical purposes. It is used as a local application for ulcerations and fissures of lips, hands etc.

7. *Garcinia lanceafolia*

A shrub or small tree up to 12 feet high, growing under the dense shade of other trees. The tree is common in the evergreen forests of Assam and Khasi hills up to 3000 feet and is often cultivated in villages for its fruits,

which are acid and eaten with relish. The leaves are sub-acid and are reported to be eaten by Mikirs after cooking.

8. *Garcinia Livingstonei*

A small tree with short branches and oblong elliptic leathery leaves, introduced into India from tropical East Africa and grown in botanical gardens. It bears reddish or purple fruits, 2-2.5 inch long and 1-1.2 inch broad, which are edible. The fleshy pericarp and the colored pulp are used in preparing a fermented beverage. The plant is a promising rootstock for mangosteen.

9. *Garcinia Mangostana Linn.*

(Other names : Hindi, Bengali & Marathi – Mangustan,. Malayalam.-Mangusta,Tami-Mangustanpazam,English-Mangosteen).

A small or medium sized tree, 20 –45 feet high, with deep green, leathery leaves [Sathyvathi *et al.* 1987].

1.2 GARCINIA CAMBOGIA FRUIT

In the west coast of South India, *Garcinia cambogia* is commonly known as "Malabar Tamarind". The fruit, which is 4 – 5cm in diameter is green in colour changes to yellow or red when ripe and resembles a small pumpkin. It has deep longitudinal grooves (6-8) and 6 to 8 seeds, surrounded by a succulent aril (Figure1.1 and 1.2). With exceeding sharp but pleasant acidity the fruit though edible, is eaten raw perhaps at meals, as an appetizer in the East Indies [Rau and Simonsen, 1922]. Scientific data showed that hydroxy citric acid is the major constituent present in *Garcinia cambogia* [Lewis *et al.* 1964]. The seeds contain 30 – 31% edible saturated fat resembling kokam butter obtained from *Garcinia indica*. The Garcinia fat is rich in oleic acid. Garcinia seed fat is used as cosmetic ingredient, since it has a good emollient feeling.

1.3 TRADITIONAL PROCESSING OF THE FRUIT

Usually the ripe fruit is halved or sectioned and spread in thin layers, dried in the sun for three to seven days to moisture level of about 15 to 20 percent and smoked. Commercially available rind is loaded with considerable amounts of common salt, which is added during drying. In Sri Lanka, the thick rind was cut into sections, dried in the sun and preserved for future use. This dried material along with salt is used for curing [Chandraratna, 1947]

Fig. 1.1: Fresh fruit of *Garcinia cambogia*

Fig. 1.2: Dried fruit rinds of *Garcinia cambogia*

1.4 TRADITIONAL APPLICATION OF GARCINIA CAMBOGIA FRUIT

The fruit rind and extracts of Garcinia species are used in many traditional recipes especially for fish curries [Lewis *et al.* 1964]. In the Indian Ayurvedic system these types of fruits having sour taste are said to promote digestion. Various species of Garcinia are used in food preparation in Thailand, Malaysia, Burma and other southeast Asian countries [Wealth of India, Vol. IV]. The " Colombo curing" is a method of fish preservation in which the anti-bacterial properties of the Garcinia fruit are considered [Wealth of India, Vol. IV; Chandraratna 1947, Deraniyagala, 1933]. Apart from these uses in food preparations and preservation, the fruit juice possesses anti-scorbutic, anthelmintic and cardiotonic properties. Hence it finds application in the treatment of piles, dysentery, tumors, pains and heart complaints [Verghese J, 1991]. The decoction of the fruit rind is given in rheumatism and bowel complaints. It is also employed in veterinary medicine as a rinse for diseases of the mouth in cattle. The dried rind is also used for polishing gold and silver and as a substitute for acetic and formic acids in the coagulation of rubber latex. The yellow resin obtained from the fruit is soluble in turpentine and used as varnish.

1.5 MODERN APPLICATION OF GARCINIA CAMBOGIA FRUIT

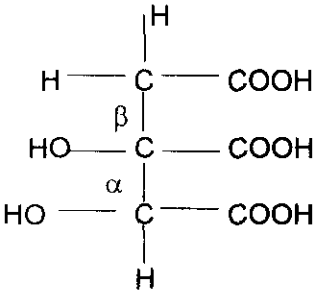
Apart from the traditional uses of *Garcinia cambogia*, it finds a wide value of applications in "Neutraceutical" field. Neutraceutical is the word used for any nutritional / herbal product which is marketed as OTC (Over the counter sale) products. The major market is in US, followed by Japan and Europe [Clouatre and Rosenbaum, 1994]. *Garcinia cambogia* is a revolutionary component in neutraceutical / dietary supplement areas as a source of Hydroxy citric acid (HCA), which is known as a weight reducing agent [Lowenstein, 1971; Sullivan and Triscari, 1977]. In addition to tablets and capsules, it is marketed as biscuits, chewing gum, snack bar etc. Water-soluble HCA is available as soft drinks and beverages

The modern applications are based on the fact that in the body carbohydrates of the food are broken down into glucose which is stored as glycogen. When glycogen storage is saturated, excess glucose is converted into fat and cholesterol. *Garcinia cambogia* extract inhibit body's conversion of glucose into fat and cholesterol by inhibiting certain enzyme process [Chee *et al.* 1977; Sullivan *et al.* 1973]. The increase in glycogen stores, help significantly reduce cravings for food, reduce appetite and induce weight loss [Greenwood *et al.* 1981].

1.6 CONSTITUENTS AND ACTIVE INGREDIENTS

The active ingredients of *Garcinia cambogia* fruit is identified as **(–) hydroxy citric acid (HCA)** which provides characteristic acidic taste. Chemically HCA is very similar to the citric acid found in orange and other citrus fruits. Previously this was mistakenly identified as tartaric and citric acids [Kurian and Pandiya,1931; Sreenivasan and Venkataraman , 1959]. Now it is clear that the major acid is a di-hydroxy tri-carboxylic acid or hydroxy citric acid [Lewis *et al.* 1964] (Figure 1.3). HCA is 1,2 di-hydroxy propane 1,2,3 tri-carboxylic acid. The sour taste of the fruit is mainly due to this compound. HCA is very unstable and usually exists as its lactone. Apart from this organic acid the dried fruit contains very low percentage of some other organic acids like citric acid, proteins, crude fibre, pectins, reducing sugars, carbohydrates and plant pigments like anthocyanins [Lewis and Neelakantan 1965]. The commercial grade dried fruits usually contain 20 – 25% moisture.

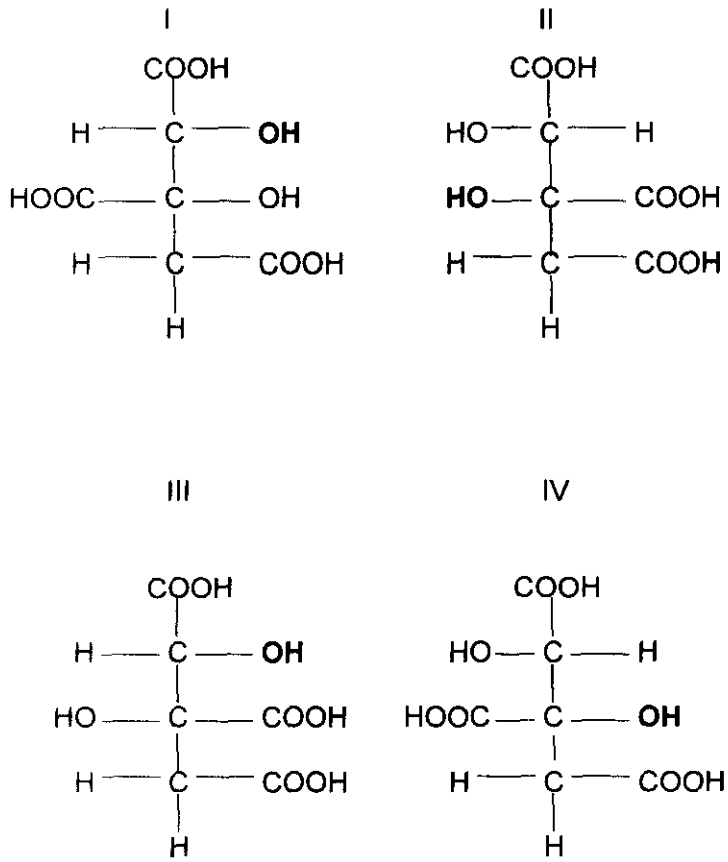
Figure 1.3: Structure of Hydroxy citric acid
(α, β di-hydroxy tri-carboxylic acid)



1.7 CHEMISTRY OF HCA

Studies conducted by Lewis *et al.* (1965) showed that HCA molecule is known to have four isomers by varying the position of hydrogen and oxygen atoms, each with slightly different effects upon the body [Greenwood and Cleary, 1981]. These isomers are shown in Figure 1.4.

Figure 1.4 : Different isomers of Hydroxy citric acid



I Ds Dg – Hydroxy citric acid

Erythro – Ds – Hydroxy citric acid

II Ls Lg – Hydroxy citric acid

Erythro – Ls Hydroxy citric acid

III Ds Lg – Hydroxy citric acid

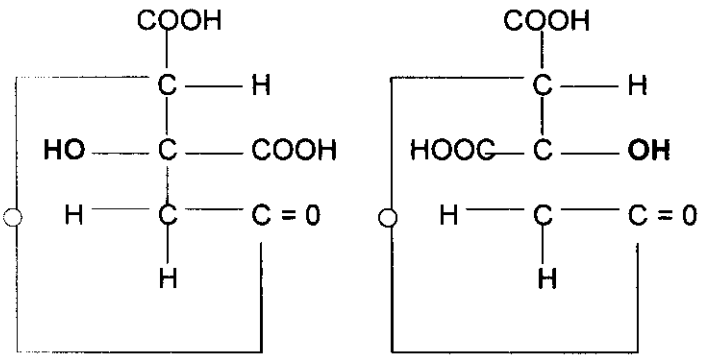
Threo – Ds Hydroxy citric acid

IV Ls Dg – Hydroxy citric acid

Threo – Ls Hydroxy citric acid

Since hydroxy citric acid (1,2 – di-hydroxy propane 1,2,3 tri-carboxylic acid) has two asymmetric centers, two pairs of diastereo isomers or four different isomers are possible [Stallings *et al.* 1979]. Being an alpha, beta di-hydroxy acid, the molecule cyclizes easily to form the corresponding lactone [Lewis and Neelakantan, 1965]. The structure of lactones are shown in Figure 1.5.

Figure1.5: Structure of Hydroxy citric acid Lactones



Lactone from acid (II) Lactone from acid (IV)

Hydroxy citric acid of Garcinia *cambogia* is (-) – erythro – Ls hydroxy citric acid. Some other plants such as *Hibiscus sabdariffa* posess (+) – threo – Ls – hydroxy citric acid

1.8 PHYSIOLOGICAL SIGNIFICANCES OF HCA

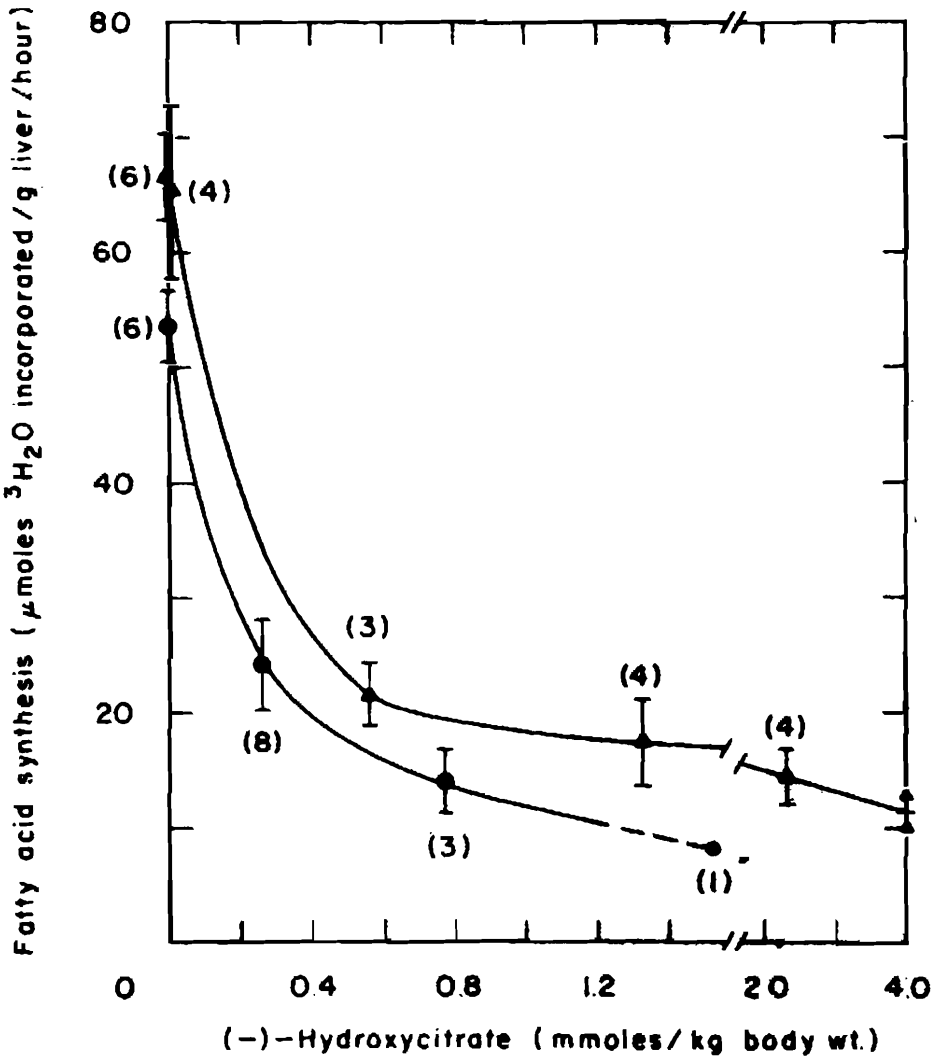
Scientific reports suggest (–) hydroxy citric acid found in Garcinia has tremendous effects in biochemical and physiological systems of animals and man. Sergio suggested that 'Malabar Tamarind' is effective in the treatment of obesity [Sergio, 1988].

The following points summarise most of the activities of HCA

1. Blocking the enzyme ATP – Citrate Lyase

HCA reduces the conversion of carbohydrate calories into fats. It does this by inhibiting the actions of ATP – Citrate lyase, the enzyme that converts citrate into fatty acids and cholesterol in the primary pathway of fat synthesis in the body [Watson *et al.* 1969; Lowenstein 1977]. The inhibition pattern is shown in Figure 1.6.

Fig. 1.6 Inhibition of fatty acid synthesis by (-)-hydroxycitrate



The inhibitor was given intraperitoneally 45 min before injecting ^3H_2O. Animals received a diet high in glucose (■) or fructos (▲). The weight of the animals at the time of use was 137.2 g (SE = +4.3, number of animals = 18) and 158.8 g (SE = +4.3, number of animals = 21) on the diets high in glucose and fructose, respectively. The points show the mean + SE. The number of animals per point is in parentheses. The point (●) at 1.53 mmol of hydroxycitrate per kilogram of rat represents a single animal; the points (▲) at 4.0 mmol of hydroxycitrate per kilogram of rat represent two rats and the mean.

$$\text{Citrate} + \text{CoA} + \text{ATP} \xrightarrow{\text{ATP citrate lyase}} \text{Acetyl CoA} + \text{Oxalo acetate} + \text{ADP} + \text{Pi}$$

Acetyl coenzyme A is the precurser of fatty acids. By inhibiting the formation of Acetyl coenzyme A, fatty acid synthesis is controlled.

The actions of HCA increase the production and storage of glycogen (which is found in the liver, small intestine and muscles) while reducing both appetite and weight gain [Sullivan *et al.* 1983, Sullivan and Gruen, 1985]. HCA also causes calories to be burnt an energy cycle similar to thermogenesis.

2. Inhibiting Lipogenesis

By inhibiting the actions of ATP-Citrate lyase, HCA reduces the availability of acetyl coenzyme A, the building block for fatty acid and cholesterol synthesis [Greenwood and Robinson, 1999]. This may also cause the body to remove low density lipoprotein (LDL) from the blood. Effect of HCA on fatty acid synthesis and insulin release was studied by Sener and Malaisse, [Sener and Malaisse, 1991]. The reduction in cholesterol synthesis is greater than the reduction in fatty acid synthesis. Animal trials have resulted in the reduction of triglycerides, cholesterol, food consumption and weight gain. Similar results were obtained when chromium was added to HCA in the diet [Greenwood and Robinson, 1999; Mc Carty, 1994]

3. Suppressing the appetite

Tests to establish the appetite suppressing effects of HCA revealed that a single large oral dose or two divided oral doses resulted in a 10 percent or greater reduction in food consumption in experimental animals fed a high sugar diet. This result continued over many weeks with the chronic intake of HCA. The appetite control mechanism of HCA did not involve any conditioned aversion for food, i.e., HCA did not alter taste, cause gastric distress or illness, etc. Rather, this control stems from the increased production of glycogen and concomitant stimulation of glucoreceptors in the liver, which results in early satiety through signals sent to the brain via the vagus nerve. Hydroxy citric acid suppresses the appetite by increasing the production of glycogen, which signal the brain to stop eating. It also enhances fat burning by interfering with malonyl Coenzme A, an enzyme involved in fat synthesis [Greenwood and Robinson, 1999].

One more mechanism suggested for the appetite suppression is its effect on Seratonin, which is a neutral vital Neurotransmitter. Seratonin is involved in a wide range of behavioral functions in the body, including mood, sleep and appetite control. Increased plasma levels of Seratonin are associated with decreased food intake, reduced weight gain and increased energy expenditure. Scientific studies showed that hydroxy

citrates produced significant increase in serum Seratonin levels (45–70%) which in turn resulted in decreased food intake, reduced weight gain and increased energy expenditure. According to Hayamizu *et al.* (2003) it is also observed that hydroxy citrate produced significant decrease in the serum leptin level. Leptin is a 167 amino acid protein hormone encoded by the obesity regulatory gene, synthesized and secreted by adipocytes (Fat cells). Two preliminary human trials suggest that HCA may work better when combined with chromium and / or other insulin potentiators and / or mimics. Diets high in fat and alcohol will reduce the lipogenesis inhibiting and appetite suppressing effects of HCA.

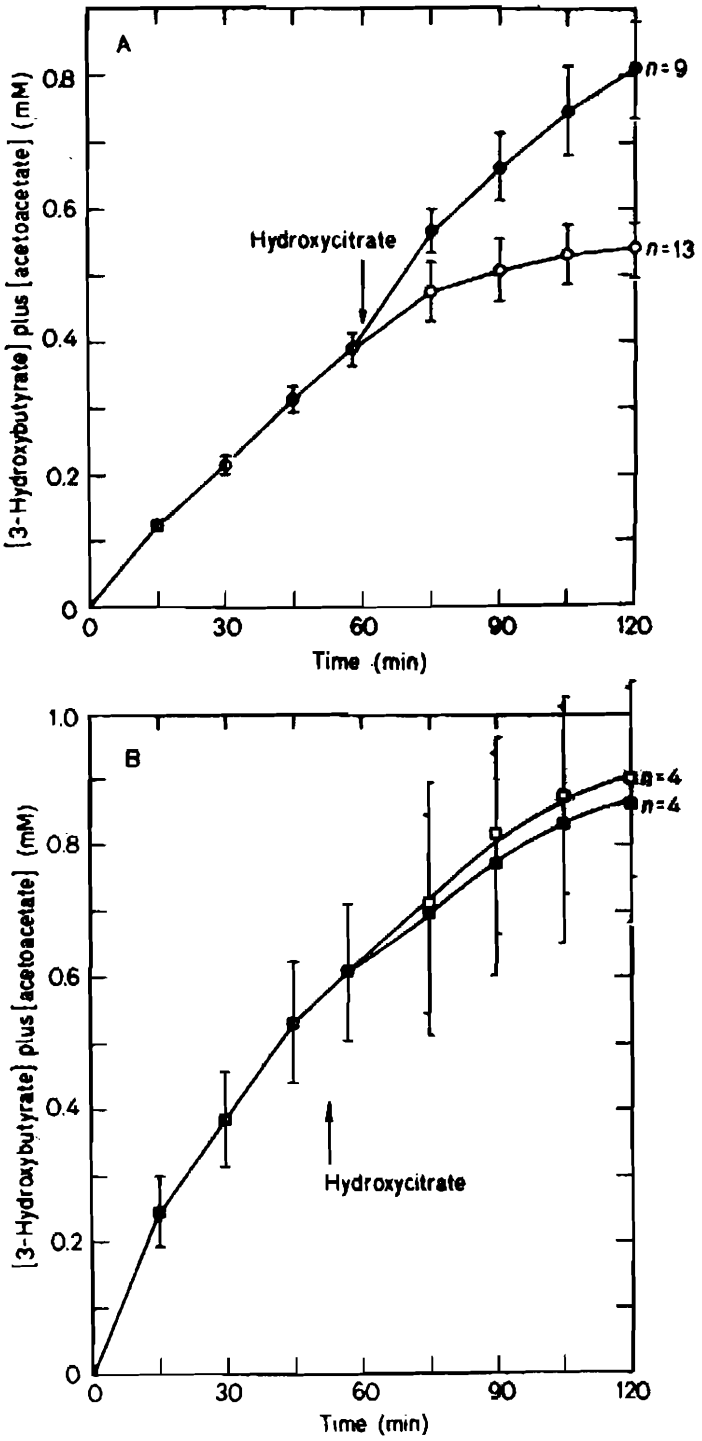
4. Stimulating thermogenesis

A thermogenic (heat – generating) effect has been postulated to account for some of the weight loss found experimentally using HCA [Mc Carty, 1994]. There are both theoretical and experimental evidences for suspecting that this may take place and for suggesting that L – carnitine is used in conjunction with HCA. However, no actual trials have been conducted to test the hypothesis. Other methods which are known to improve themogenesis in the overweight, such as supplementation with sufficient quantities of GLA (gamma–linolenic acid), potassium and magnesium, might be used in conjunction with HCA without causing unwanted central nervous system (CNS) stimulation.

Hydroxy citrates have many biochemical activities in the system [Glusker *et al.* 1971]. It inhibits fatty acid synthesis by rat liver in vivo and by perfused liver [Sullivan *et al.* 1973; Brunengrber *et al.* 1978]. The pattern of inhibition is shown in Figure 1.7. It inhibits β– hydroxysterol synthesis and also fatty acid synthesis in rat brain [Patel and Owen, 1976; Sterling *et al.* 1978].

Ohia et al. found out that HCA can increase seratonin release from isolated rat brain cortex [Ohia *et al.* 2002]. It is also proved that the *Garcinia cambogia* extract can inhibit lipid droplet accumulations in fat cells without affecting adipose conversion in 3T3-L1 cells [Hasegawa, 2001]. Ishihara *et al.* studied that the chromic administration of HCA promotes lipid oxidation and spares carbohydrate utilization in mice at rest and during exercise [Ishihara *et al.* 2000].

Fig. 1.7 Effect of hydroxycitrate on 3-hydroxybutyrate plus acetoacetate output by perfused livers.



(A) Livers obtained from fed rats were perfused with 25m*M* glucose. (B) Livers obtained from starved rats were perfused with 4 m*M* glucose. The number of livers in each group in indicated by *n.* (●, ■) Controls; (O) 2 m*M* hydroxycitrate added at the arrow; (o) 0.5 m*M* hydroxycitrate added at the arrow.

1.9 TOXICOLOGY OF HCA

The dried rind of *Garcinia cambogia* fruits have been used for centuries in Southern India as a condiment for flavouring curries in place of tamarind or lime and as a food preservative. Having a long history of traditional use as preservative and flavouring material, *Garcinia cambogia* and its extracts have proved as safe for human consumption. Neither acute nor chronic toxicity is reported with regular consumption of Garcinia products as food or as dietary supplement [Greenwood and Cleary, 1981]. The side effects and toxicity study of HCA concentrate was conducted by Sullivan and Triscari (1985). According to their investigations the LD_{50} (lethal dose for 50 percent of the animals tested) was greater than 2000mg/kg for intra peritoneal administration and greater than 4000mg/kg for oral administration [Sullivan and Triscari, 1973]. This level is more than the LD_{50} value of citrate, which is 975mg/kg as indicated in the Merck index [Merck Index, 1996]. This shows that HCA is safer than citric acid. Safety of HCA on other tissues like liver, blood, brain etc. were also studied and proved. Mahendran *et al.* stated that *Garcinia cambogia* extract prevent the acid or alcohol induced gastric mucosal injury [Mahendran *et al.* 2002].

1.10 DOSAGE OF HCA

The typical daily dosage necessary for weight management is equivalent to the half of a dried fruit. But it is very difficult to consume as raw. The presence of other materials present make it bitter. Hence it is ideal to take HCA as the different salts forms.

One of the study of the 200 subjects, 1500mg HCA daily was supplied in addition to carnitine and chromium and the subjects lost twice as much weight as controls [Kaats *et al.*]. In another study 1320mg daily intake of HCA was given and the weight reduced was twice as much weight as controls [Thom, 1996]. Hence dosage recommended is 1500mg of HCA in 2-3 divided dosages per day one hour before meals [Heymsfield *et al.* 1998].

HCA is also found to be useful for reducing genetic obesity [Rothaikerdra and Waitman, 1997]. This is achieved by decreasing serum leptin level [Hayamizu *et al.* 2003]. It did successfully reduce the weight in the animal model, but did not improve the ratio of fat to lean tissue [Hayamizu *et al.* 2003].

The main advantage of using HCA is that this does not affect Central Nervous System (CNS) by reacting with the catecholamine neuro transmitters dopamine and norepinephrine which in turn releases adrenaline [Ohia *et al.* 2002].

1.11 REVIEW ON EARLIER WORKS

Garcinia cambogia has been the subject of extensive phytochemical and physiological studies because of its derivatives used in human body metabolism. The major part of research activities and publications concentrate on weight reduction and fat metabolism [Jena *et al.* 2002]. As shown earlier, *Garcinia cambogia* fruit is identified as a natural source of HCA [Lewis and Neelakantan, 1965]. HCA is chemically very similar to citric acid found in oranges and other citrus fruits. Rather than the traditional uses and applications, recent studies revealed the pharmacological applications of HCA. It has been reported that HCA affects Lipid metabolism [Kriketos *et al.* 1999; Mc Carty 1994,1995]. Hydroxy citric acid has a respectable history of scientific investigation. HCA is found to be the first natural weight loss compound without adversely affecting the central nervous system [Charles *et al.* 1985]. This shows that Garcinia is not a stimulant, that it will not interfere with sleep and it will not cause changes in heart rate or blood pressure. Hence HCA is known as a safe fat fighting agent. HCA is available as herbal supplement and decreases adipose tissue weight after ingestion for few weeks. [Chee *et al.* 1977; Greenwood *et al.* 1981; Rau and Sakariah, 1988].

HCA is a competitive inhibitor of ATP citrate lyase (E.C 4.5.3.8), which inhibits fatty acid synthesis and reduces appetite in rodents [Watson *et al.* 1969; Hellerstein and Xie 1993] reported that administration of HCA increased liver glycogen. Ishihara *et al.* proved that administration of 10mg of HCA elevated serum FFA concentration and increased muscle glycogen concentration in mice at rest [Ishihara *et al.* 2000].

Findings by Hayamizu *et al.* suggested that *Garcinia cambogia* extract efficiently improved glucose metabolism and leptin like activity [Hayamizu *et al.* 2003). Apart from this the anti-ulcer activity of *Garcinia cambogia* extract, its ability to decrease acidity and mucosal defense is well studied by Mahendran and Sabitha (2002). The same was repeated in gastrointestinal mucosa and increase in the mucosal defence in the gastric areas were obtained [Mahendran *et al.* 2002]. Studies conducted by Ishihara *et al.* suggested that the chronic administration of HCA promotes lipid oxidation and spares carbohydrate utilization in mice at rest and during running [Ishihara *et al.* 2000].

1.12 ANALYSIS PROCEDURES OF HCA

Garcinia cambogia extract and its derivatives are commonly used in western countries as a fat burning agent. Though these products possess great physiological significances, one of the limiting factors for its use as a regular product is the unavailability of its estimation procedures.

Early studies disclosed the fact that the rind is rich in non volatile acids [Chandraratna, 1947], which were wrongly identified as tartaric acid and citric acid. Later Lewis *et al.* (1964) by paper chromatography confirmed that the spot closed to tartaric acid is a di-hydroxy tri-carboxylic acid known as Hydroxy citric acid.

HPLC method was developed in western countries with some conflicting results. HPLC method developed by JIX Antony *et al.* (1998) is not practical since the method used is a comparative measure. With these backgrounds one of our main focus was to develop and standardize new methods to analyze HCA.

1.13 OBJECTIVES OF THIS STUDY

Hydroxy citric acid, the active ingredient in the spice *Garcinia cambogia* is found to be a good fat burning agent, reduces obesity and lipid level. During the course of this study isolation and purification of HCA from *Garcinia cambogia* are described. New methods like spectrophotometric, HPTLC and HPLC methods are developed. Being a gamma - hydroxy acid it is readily converted to its lactone. Hence more efficient methods are described to convert HCA into stable salts like calcium hydroxy citrate, sodium hydroxy citrate, potassium hydroxy citrate and magnesium hydroxy citrate. Physical and chemical properties of all these salts are studied, which are biochemically important, stable and value added. Comparative studies of HCA with respect to rind, leaves and fruits collected from different sources are planned. In order to compare the climatic conditions and soil constituents on HCA, samples from different places were also screened.

The main objectives of this research work are summarized as

1. Isolation and comparative study of HCA present in *Garcinia cambogia* fruits grown in different places.

2. Comparison of HCA percentage in different parts of *Garcinia cambogia* tree like leaves, rind and stem bark.

3. Development of UV, HPLC and HPTLC methods for estimation of HCA

4. Conversion of HCA into different stable salts and study of physical and chemical properties of the salt.