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Review

A comprehensive scientific overview of *Garcinia cambogia*

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ABSTRACT

The fruit rind of *Garcinia gummi-gutta*, commonly known as *Garcinia cambogia* (syn.), is extensively used traditionally as a flavourant in fish curries due to its sharp sour taste. Additional ethnobotanical uses include its use as a digestive and a traditional remedy to treat bowel complaints, intestinal parasites and rheumatism. This small fruit, reminiscent of a pumpkin in appearance, is currently most popularly used and widely advertised as a weight-loss supplement. Studies have shown that the extracts as well as (−)-hydroxycitric acid (HCA), a main organic acid component of the fruit rind, exhibited anti-obesity activity including reduced food intake and body fat gain by regulating the serotonin levels related to satiety, increased fat oxidation and decreased *de novo* lipogenesis. HCA is a potent inhibitor of adenosine triphosphate-citrate lyase, a catalyst for the conversion process of citrate to acetyl-coenzyme A, which plays a key role in fatty acid, cholesterol and triglycerides syntheses. The crude extract or constituents from the plant also exerted hypolipidaemic, antidiabetic, anti-inflammatory, anticancer, anthelmintic, anticholinesterase and hepatoprotective activities in *in vitro* and *in vivo* models. Phytochemical studies of various plant parts revealed the presence of mainly xanthones (e.g. carbogiol) and benzophenones (e.g. garcinol) together with organic acids (e.g. HCA) and amino acids (e.g. gamma aminobutyric acid). Currently, a large number of *G. cambogia*/HCA dietary supplements for weight management are being sold although the possible toxicity associated with the regular use of these supplements has raised concerns. In most cases, complaints have been related to multicomponent formulations and at this stage *G. cambogia* has not been confirmed as the potentially toxic culprit. This review presents a scientific overview of *G. cambogia* with reference to relevant botanical aspects, ethnobotanical uses, phytochemistry and biological activity as well as toxicity.

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Abbreviations: Acetyl-CoA, acetyl coenzyme A; ALP, alkaline phosphatase; ALT, alanine transaminase; AST, aspartate aminotransferase; ATP, adenosine triphosphate; BW, body weight; cPLA2, cytosolic phospholipase A2; CRP, C-reactive protein; DPPH, 2,2-diphenyl-1-picrylhydrazyl; HCA, hydroxycitric acid; HCAL, hydroxycitric acid lactone; HIV, human immunodeficiency virus; IC_{50}, inhibitory concentration 50%; IFN, interferon; IL, interleukin; iNOS, inducible nitric oxide synthase; LC_{50}, lethal concentration 50%; LPS, lipopolysaccharide; MDI, 3-isobutyl-1-methylxanthine, dexamethasone and insulin; MPO, myeloperoxidase; PGE2, prostaglandin E2; p.o., per oral; mRNA, messenger RNA; miRNA, microRNA; NF-κB, nuclear factor kappa-light-chain-enhancer of activated B cells; NOAEL, no observed adverse effects level; ROS, reactive oxygen species; SSRI, selective serotonin reuptake inhibitor; TNBS, 2,4,6 trinitrobenzenesulfonic acid; TNF, tumour necrosis factor.

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1. Introduction

Garcinia gummi-gutta (L.) Roxb. or the Malabar tamarind, commonly known by its previous scientific name *Garcinia cambogia* (Gaertn.) Desr. (Clusiaceae), is native to Southeastern Asia. The fruit rind is commonly used as a food preservative, flavouring agent or food-bulking agent [1], and as a traditional remedy to treat constipation, piles, rheumatism, oedema, irregular menstruation and intestinal parasites in many Asian countries [2]. Earlier phytochemical reports on the plant led to the isolation of various organic acids [3], benzophenones [4] and xanthones [5] as major constituents and numerous scientific studies have indicated biological activity such as anti-obesity [6,7], hypolipidaemic [8] and anticancer activity [9] amongst numerous others.

Commercial products containing *G. cambogia* catapulted onto the market and have received considerable positive and negative media attention. It's popularity and notoriety is confirmed by the more than 11 million links displayed when entering the search term "*Garcinia cambogia*" on Google®. Perhaps its most positive (and negative) connotation was with the television personality Dr Mehmet Oz. Dr Oz has been quoted as saying that *G. cambogia* is the "Holy Grail of Weight-Loss" [10]. However, he has recently been reprimanded for his health claims in general by a senate subcomittee in the USA. *G. cambogia* is also mentioned fleetingly as one of "Dr Oz's three biggest weight-loss lies" [11]. It is evident that there is uncertainty about the use of this plant especially as more information becomes available. In an article in the popular media entitled "*Garcinia cambogia*: weight-loss supplement may be toxic to some", the author describes an incident of possible serotonin toxicity which may or may not be attributed to the concomitant consumption of *G. cambogia* and an antidepressant [12]. *Garcinia* supplements contain from 20 to 60% hydroxycitric acid (HCA), and many of these products are a combination of different active ingredients rather than *G. cambogia* alone [13]. This should also be considered when assessing the quality, efficacy and safety of these products. It has also been reported that in many products, the claimed concentration of HCA is lower than the value specified [14].

HCA, an α-, β-dihydroxy tricarboxylic acid [15], is the key component present in the fruit rind which may be responsible for its weight-loss property [16]. The fruit contains approximately 10% to 30% HCA which can be isolated in the free form, as a mineral salt or as a lactone [17]. HCA is available on the market in the form of its various salts such as calcium, magnesium and potassium as well as their mixtures [18]. HCA also occurs in various bacterial species, which could be an alternative source for natural HCA [19]. In addition, hydroxycitric acid can be synthesised using citric acid as starting material. Citric acid first undergoes dehydration to form aconitic acid, which forms hydroxycitric acid *via* oxidation [20]. It has been found that HCA reduced weight-gain by inhibiting adenosine triphosphate (ATP)-citrate lyase, the enzyme responsible for catalysing the extra mitochondrial cleavage of citrate to oxaloacetate and acetyl-coenzyme A (acetyl-CoA), a building block of fatty acid synthesis [21]. Various studies suggested that HCA promotes weight-loss in humans without stimulating the central nervous system [22]. It is evident that many conflicting views on the efficacy and safety of *G. cambogia* exists. This review presents a succint overview of the available scientific evidence of biological activity and toxicity of *G. cambogia* and HCA in addition to phytochemical, botanical and other important aspects.

2. Botanical description

Garcinia is the largest genus of the Clusiaceae family comprising of 390 species [23]. These polygamous trees or shrubs are mainly distributed in tropical Asia, Polynesia and Africa [24]. *Garcinia gummi-gutta* (L.) Roxb. is one of the most