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Exploring the Potential of *Garcinia cowa* as a Phytogenic Feed Additive for Fish

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ABSTRACT

Research on natural feed additives in aquaculture has drawn attention to phytogenic compounds, such as those derived from tropical plant species of the *Garcinia* genus, due to their potential to promote growth, immunity, and microbial resistance in fish. *Garcinia cowa*, also known as Asam Kandis in Indonesian, is notable for its rich content of polyphenols, including hydroxycitric acid (HCA), a phytochemical with established roles in antioxidant and antimicrobial processes in humans. This article assesses the current research regarding the phytochemical composition, bioactivity, and potential application of *G. cowa* as a feed additive in fish nutrition. Notably, to date, no published studies have evaluated the effect of *G. cowa* inclusion in fish feed on growth performance, immune system, antimicrobial activity, and feed efficiency.

INTRODUCTION

Aquaculture is a significant protein source, with high productivity levels **(Kong *et al.*, 2020)**. The significant demand for animal protein has led to a fivefold rise in aquaculture production since 1990 **(Ottinger *et al.*, 2018)**. According to the **FAO (2024)**, aquaculture production has now reached 94 million tons, accounting for 51% of total fisheries production, with a production value of USD 296 billion. This value is projected to continue rising in response to the growing demand for animal protein. The enhancement of aquaculture production is dependent on the provision of adequate feed and nutrition, as these factors have been shown to influence growth, water quality, and fish health **(Yang *et al.*, 2021)**. Moreover, fish feed accounts for 50-70% of the total production cost **(Cottrell *et al.*, 2020; Cahya *et al.*, 2023; Andriani *et al.*, 2024)**, highlighting the critical importance of providing high-quality feed to optimize the efficiency of aquaculture operations.

The production of high-quality fish feed requires the use of premium ingredients, as well as the incorporation of feed additives that have been shown to promote accelerated growth and improve fish health. Following the 1997 establishment of regulations prohibiting the use of antibiotics by the World Health Organization (WHO) and the subsequent recommendations by the WHO, the Food and Agriculture Organization (FAO), and the Office International des Epizooties (OIE) in 2006 to reduce antibiotic use in aquaculture, the use of natural plant-derived ingredients as feed additives and immunostimulants in aquaculture has undergone continuous development **(Dawood *et al.*, 2018; Luthman *et al.*, 2024; Islamy *et al.*, 2025)**.

An analysis of the extant research on phytogenic feed additives reveals several benefits, including enhanced growth performance, reproduction, health, and product quality **(Wang *et al.*, 2024)**. One promising source of natural ingredients is *Garcinia* plants **(Hemshekhar *et al.*, 2011)**. *G. cowa* is a species known to contain hydroxycitric acid (HCA), xanthones, and flavonoids **(Hemshekhar *et al.*, 2011; Ritthiwigrom *et al.*, 2013)**, which exhibit antimicrobial and antioxidant properties **(Gupta *et al.*, 2021)**. Numerous ongoing studies provide a foundation for understanding the biochemical composition and potential applications of *G. cowa*. As posited by **Jena *et al.* (2002b)**, phytochemical analysis revealed the presence of hydroxycitric acid (HCA) at concentrations of 12.7% in the skin, 1.7% in the leaves, and 2.3% in the fruit. This finding was subsequently corroborated by **Jena *et al.* (2002a)** through a comprehensive review that elucidated the biochemical mechanism of HCA and its impact on lipid metabolism in various *Garcinia* species. Despite the promising potential of *G. cowa* as a feed additive in fish, the effects of its use on growth performance, immune modulation, palatability, feed efficiency, and feed storage have yet to be investigated.

In contrast, several studies have examined the effects of feed additive supplementation from other *Garcinia* species in fish feed, such as *G. mangostana* and *G. kola*. These studies reported positive outcomes on growth, feed efficiency, and immune function in two fish species: tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*) **(Dada & Ikuerowo, 2009; Soosean *et al.*, 2010; Dada & Oviawe, 2011; Nyadjeu *et al.*, 2019; Yostawonkul *et al.*, 2023)**. However, none of these studies have evaluated *G. cowa* in fish or fish feed. Therefore, this review explores the potential benefits of *G. cowa* supplementation as a feed additive in fish feed.

MATERIALS AND METHODS

This article review employed the systematic review method, a systematic and explicit approach to analyzing and identifying data focused on the topic of writing. The data search was conducted in June 2025 using the databases ScienceDirect, Scopus, and Google Scholar. The data search used a combination of keywords: (“Fish Feed” OR “Feed Additive”) AND (“Garcinia” OR “Garcinia cowa”) AND (“Bioactive Compound”). The screening process utilized inclusion and exclusion criteria (Table 1), which include the year of publication (2000-2025), the article's origin from research results, and the subject areas of agriculture, chemistry, and medicine.

Table 1. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Study Design	Research Article	Book, Review Article, Conference and Abstract
Topic Discuss	Garcinia cowa, Garcinia	Out of these topic
Language	English	Other language
Subject Area	Agriculture, Chemistry, Medicine	Out of these topics

RESULTS

Phytochemical compound of *G. cowa*

Garcinia is a tropical plant genus comprising more than 250 species **(Sweeney, 2008; Ritthiwigrom *et al.*, 2013)**, distributed across regions such as Africa, Asia, Polynesia, and Australasia **(Sweeney, 2008; Negi *et al.*, 2010; Gaudeul *et al.*, 2024)**. Members of the *Garcinia* genus have long been utilized in traditional medicines, with various parts of the plant—including leaves, fruits, flowers, rind, and stem bark—being applied for therapeutic purposes **(Hemshekhar *et al.*, 2011)**. *G. cowa*, known as Asam Kandis in Indonesia, Kandis in Malay, and Chamuang in Thai, is one such species. It is predominantly found in Southeast Asia, with notable prevalence in Thailand, Malaysia, Indonesia, and Myanmar **(Ritthiwigrom *et al.*, 2013; Yorsin *et al.*, 2023)**.

G. cowa has been recognized as a key component of traditional medicinal preparations used to treat fever, improve blood circulation, alleviate coughs, and ease indigestion **(Ritthiwigrom *et al.*, 2013; Wahyuni *et al.*, 2015; Yorsin *et al.*, 2023; Handayani *et al.*, 2024)**. According to **Negi *et al.* (2010)**, the fruit rind extract of *G. cowa* has demonstrated antioxidant, antibacterial, and antimutagenic properties. As shown in Table (2), numerous studies have indicated that *G. cowa* contains bioactive compounds throughout various parts of the plant, including the fruit, rind, twigs, stem bark, latex, and leaves.

Table 2. Bioactive compound of *G. cowa*

No	Bioactive compound category	Plant part	Extraction	Activity	Reference
1	α-mangostin (0.72%) xanthochymol (8.46%) total phenolic (64.72 mg GAE/g) total flavonoid (56.18 mg QE/g)	Fruits	Ethanol 70%	Antioxidant	**(Gupta *et al.*, (2021)**
2	hydroxycitric acid (1.68 g/100g) hydroxycitric acid (2.86 g/100g) hydroxycitric acid (12.70 g/100g) hydroxycitric acid (10.21 g/100g) hydroxycitric acid (12.26 g/100g)	Fresh leaves Fresh fruit Dried rinds Dried rinds Dried rinds	Water Water Water Acetone Methanol	Not reported	**(Jena *et al.*, 2002)**
3	Cowaxantone	Twigs	Acetone	Anti-inflammatory, antioxidant	**(Panthong *et al.*, 2009)**
4	not reported	Dried fruit rinds	Hexane Chloroform	Antioxidant, antimutagenic	**(Negi *et al.*, 2010)**
5	chamuangone (73.0 %)	Dried leaves	n-hexane	Not reported	**(Rahman *et al.*, 2024)**
6	total phenolic content (42.87 – 153.68 mg GAE/100 g)	Leaves Fruit rind Stem bark	Hexane, ethyl acetate, ethanol 70%	Antioxidant, Antidiabetic	**(Wanna *et al.*, 2023)**
7	total phenolic content (103.56 mg GAE/100 g) total flavonoid content (15.04 mg QE/100 g)	Leaves	Water ($70\ ^oC$)	Vasorelaxation	**(Yorsin *et al.*, 2023)**
8	garcicowanones A, garcicowanones B, 9-hydroxycalabaxanthone, β-mangosten, fuscaxanthone, cowaxanthone, cowanin, α-mangostin, cowagarcinone, and rubraxanthone	Immature fruit	Acetone	antibacterial	**(Auranwiwat *et al.*, 2014)**
9	rubraxanthone (32.42%)	Stem bark	Ethyl acetate	Not reported	**(Hamidi *et al.*,**

No	Bioactive compound category	Plant part	Extraction	Activity	Reference
					2017)
10	cowanone, β-mangostin, α-mangostin, cowanin, fuscaxanthone, 9-hydroxycalabaxanthone, garcinianone, cowanol	Dried infloroscenece s	Acetone	Antibacterial	**(Trisuwan & Ritthiwigrom 2012)**
11	methyl 2,4,6-trihydroxy-3-(3-methybut-2-enyl)benzoate garcinisidone-A 3-(1-methoxycarbonyl-4,6-dihydroxyphenoxy)-6-methoxy-3,5-di(3-methyl-2-butenyl)-1,4-benzoquinone	Leaves	Dichloromethane	Cytotoxic	**(Wahyuni *et al.*, 2015)**
12	Garciacowanin	Stem bark	n-hexane	Anti-inflammatory	**(Dewi *et al.*, 2025)**
13	polyhenol flavonoid	Leaves Stem bark root	Sabouraud dextrose agar (SDA)	Endophytic fungi for antimicrobial	**(Handayani *et al.*, 2024)**
14	cowabenzophenones A cowabenzophenones B	Ripe fruit	methanol	Cytotoxic	**(Sriyatep *et al.*, 2014)**
15	Not reported	leaves	Ethanol	antibacterial	**(Ngamsurach & Praipipat 2022)**
16	Xantone	latex	acetone	Not reported	**(Mahabusarakam *et al.*, 2005)**

The use of *G. cowa* extract in traditional health systems has been documented for its efficacy in addressing a wide range of ailments. As shown in Table (2), the phytochemical content of *G. cowa* includes xanthones and their derivatives, flavonoids, phenolic acids, and organic acids. Several studies have explored the potential of *G. cowa* extract as a natural antioxidant, particularly in biscuit production **(Nanditha *et al.*, 2009)**, focusing on its ability to inhibit advanced glycation end products (AGEs) and its anti-diabetic properties **(Charoensup *et al.*, 2022; Wanna *et al.*, 2023)**. Additionally, its role in reducing oxidative stress in Wistar rats has been investigated **(Gupta *et al.*, 2021)**, along with its antibacterial properties against *Staphylococcus aureus*, *Escherichia coli*, and methicillin-resistant *Staphylococcus aureus* **(Ngamsurach & Praipipat, 2022; Handayani *et al.*, 2024)**. Research by **Shiekh *et al.* (2019)** also reported its ability to inhibit melanosis and microbial activity in Pacific shrimp during storage. Furthermore, the vasorelaxant effects of *G. cowa* on Wistar rats have been documented **(Yorsin *et al.*, 2023)**. Despite these promising findings, there has been a lack of subsequent research on the effects of *G. cowa* extract on growth, health, or feed efficiency in fish.

The potential of *G. cowa* as phytogenic feed additive

The prohibition of certain antibiotics, coupled with the rapid emergence of diseases, necessitates the implementation of effective countermeasures to ensure the sustained productivity of aquaculture. Natural antimicrobials and antibacterials, which can serve as alternatives to antibiotics, are preferred due to their lower side effects compared to synthetic antibiotics **(Wang *et al.*, 2024)**. Existing literature highlights the significant antioxidant content of *G. cowa* extract **(Panthong *et al.*, 2009; Negi *et al.*, 2010; Gupta *et al.*, 2021; Wanna *et al.*, 2023)**. Additionally, the anti-inflammatory properties of *G. cowa* extract have been documented **(Panthong *et al.*, 2009; Dewi *et al.*, 2025)**. Furthermore, the antimicrobial and antibacterial properties of *G. cowa* extract have been demonstrated **(Trisuwan & Ritthiwigrom, 2012; Auranwiwat *et al.*, 2014; Ngamsurach & Praipipat, 2022; Handayani *et al.*, 2024)**, and several other bioactive compounds have shown significant potential for use as feed additives in fish (Table 3).

Table 3. Application of *Garcinia* on fish feed

Species	Object	Product used	Result	Reference
G. mangostana	*Clarias gariepinus*	Oil from seed	Defatted *Garcinia mangostana* (DGM) has been found to contain minerals such as potassium, magnesium, and iron. The supplementation of DGM at concentrations up to 72 grams did not exert a deleterious effect on the growth of *Clarias gariepinus*, and no discernible differences were observed among the various treatments.	**(Ajayi *et al.*, 2013)**
G. kola	*Clarias gariepinus*	Ethanol extraction	The incorporation of *G. kola* extract, with concentrations ranging from 2 g/kg of feed up to the maximum dosage, has been observed to enhance growth parameters such as weight gain (WG), specific growth rate (SGR), and average daily gain (ADG). Additionally, feed efficiency metrics, including feed conversion ratio (FCR), have demonstrated positive improvements. The effects of *G. kola* extract on haematological parameters such as white blood cell (WBC) count have also been documented, suggesting its potential to support the immune system.	**(Dada & Ikuerowo 2009)**
G. kola	Egg quality of *Clarias gariepinus*	Powder	The supplementation of feed with up to 200 g/kg of the subject material had no deleterious effect on the process of egg fertilization. In fact, it was found to have a positive effect on	**(Dada & Ebhodaghe 2011)**

Species	Object	Product used	Result	Reference
			fecundity and egg diameter. However, these increases were not statistically significant when compared to the control treatment.	
G. kola	*Clarias gariepinus* fingerling	Powder	The addition of *G. kola* at a dose of 100 g/kg feed resulted in optimal growth performance and feed efficiency, exhibiting a significant difference compared to the control treatment.	**(Dada & Oviawe 2011)**
G. mangostana	*Macrobranchium rosenbergii*	Hot water extraction	The injection of *G. mangostana* extract into *M. rosenbergii* has been demonstrated to positively impact the immune system and physiological regulation. These results demonstrate the potential of G. mangostana as a feed additive.	**(Kitikiew *et al.*, 2023)**
G. mangostana	*Macrobranchium rosenbergii*	Powder	The utilization of *G. mangostana* as an immunostimulant, administered through dietary interventions, has been demonstrated to enhance growth and fortify resistance to the pathogen *Lactococcus garvieae*.	**(Kuo *et al.*, 2023)**
G. mangostana	*Edwardsielle ictaluri*, *Flavobacterium columnare*, and *Streptococcus iniae*	Acetate and methanol extraction	*G. mangostana* extract demonstrated no activity against *E. ictaluri* and *S. iniae*. However, it was effective in inhibiting the growth of *F. columnare*. These results suggest the potential utilization of *G. mangostana* extract as a natural antibiotic for *F. columnare*.	**(Meepagala & Schrader 2018)**

Species	Object	Product used	Result	Reference
G. kola	*Oreochromis niloticus*	Powder	The supplementation of 6% *G. kola* meal has been demonstrated to enhance the growth performance of tilapia fingerlings. However, the utilization of *G. kola* has been observed to disrupt the gonadal development process, particularly in female specimens.	**(Nyadjeu *et al.*, 2019)**
G. kola	*Oreochromis niloticus*	Powder	The addition of *G. kola* meal to commercial feed has been demonstrated to enhance growth, with optimal levels ranging from 30g/ kg. However, the most effective treatment for inducing sex reversal is 20g/ kg. This study demonstrates the potential for an alternative method for 17-α-methyl testosterone in the sex reversal process, given its substantial cost.	**(Sarr *et al.*, 2023)**
G. mangostana	*Clarias gariepinus*	Methanol extraction	The study found that *G. mangostana* extract, derived from the leaf, fruit shoot, and fruit rind, exhibited a substantial increase in both red blood cells (RBCs) and white blood cells (WBCs). Regarding growth parameters, *G. mangostana* extract did not exert a Negative Impact on SGR, ADG, FCR, and CF.	**(Soosean *et al.*, 2010)**
G. mangostana	*Lates calcarifer*	Hot water extraction	The investigation revealed that the utilization of *G. mangostana* peel extract as a rearing medium for seabass infected with *Aeromonas hydrophila* yielded optimal performance at a concentration of 60 ppm. Indeed, the	**(Thiankham *et al.*, 2024)**

Species	Object	Product used	Result	Reference
			treatment involving *G. mangostana* extract demonstrated an augmentation in RBC, WBC, and Hb. Consequently, these findings suggest the possible utilization of *G. mangostana* as an antibiotic for *A. hydrophila*.	
G. mangostana	*Oreochromis niloticus*	Extraction loaded in nano-emulsion	The implementation of the nanoemulsion extraction method, subsequently incorporated into a commercial feed, resulted in enhanced growth and feed efficiency. Furthermore, the tilapia exhibited enhanced resistance to *Aeromonas veronii*, as evidenced by an increase in lysozyme activity, ACH50 activity, and total immunoglobulin levels.	**(Yostawonkul *et al.*, 2023)**
G. gummi-gutta	*Pangasionodon hypophthalmus*	Aqueos extraction	The utilization of a 2 g/kg diet of *G. gummi-gutta* extract on fish feed has demonstrated the potential to enhance immunity and growth performance in *P. hypophthalmus*.	**(Prasad & Priyanka 2011)**

Garcinia, a genus known for its rich phytochemical content, has been widely explored as a potential herbal ingredient to replace antibiotics in aquaculture. Several studies have investigated various species of *Garcinia* as fish feed additives, including *G. kola* **(Dada & Ikuerowo, 2009; Dada & Ebhodaghe, 2011; Dada & Oviawe, 2011; Nyadjeu *et al.*, 2019; Igwegbe *et al.*, 2021; Sarr *et al.*, 2023)**, *G. mangostana* **(Soosean *et al.*, 2010; Ajayi *et al.*, 2013; Meepagala & Schrader, 2018; Kitikiew *et al.*, 2023; Kuo *et al.*, 2023; Yostawonkul *et al.*, 2023; Thiankham *et al.*, 2024)**, and *G. gummi-gutta* **(Prasad & Priyanka, 2011)**. However, to date, no research has been conducted on the use of *G. cowa* extract in fish feed.

CONCLUSION

Garcinia cowa, also known as asam kandis, is a species within the *Garcinia* genus that shows considerable promise as a potential fish feed additive. The phytochemicals it contains, including hydroxycitric acid (HCA), xanthones, flavonoids, garciacowanin, mangostin, and polyphenols, have demonstrated efficacy in treating inflammation, bacterial infections, and oxidative stress. Additionally, these phytochemicals possess vasorelaxant properties and have been shown to promote growth. However, to date, there has been a lack of research, specifically addressing the use of *G. cowa* as a feed additive in fish. This paper aims to provide a scientific rationale for the experimental testing of *G. cowa* in relation to growth performance, immunity, health, hematology, and feed efficiency in aquaculture.

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