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Gac (*Momordica cochinchinensis Spreng*) fruit as a promising functional food: A comprehensive review

Pathumi Madhushika Ariyarathna [1,*] and Himashani Shamika Dandangoda Gamage [2]

[1] *Sri Lanka School of Agriculture, Department of Agriculture, Pelwehera, Sri Lanka.*
[2] *Sri Lanka School of Agriculture, Department of Agriculture, Angunakolapelessa, Sri Lanka.*

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Abstract

Gac (*Momordica cochinchinensis Spreng.*) is a tropical vine indigenous to South and Southeast Asia. Traditionally utilized in Asian cuisine for its vibrant red color and purported vision-enhancing properties, Gac fruit has garnered attention in recent years as a rich source of carotenoids, particularly lycopene and β-carotene. Alongside these carotenoids, Gac fruit contains various bioactive compounds such as phenolics, flavonoids, and trypsin inhibitors, which offer numerous health benefits including antioxidant, anti-cancer, anti-inflammatory activities, and more. Commercial products derived from Gac, such as Gac powder and Gac oil, have been developed as natural colorants and medicinal supplements. This review comprehensively explores the scientific literature pertaining to the nutritional composition, biological activities, processing techniques, and commercial products derived from Gac fruit. This will direct the scientific society of the world to make use of this novel fruit as a functional food ingredient or nutraceutical in the food industry or pharmaceutical industry.

Keywords: *Momordica cochinchinensis Spreng*; Gac fruit; Phytochemical composition; Pharmacological activities; Processing methods

1. Introduction

Momordica Cochinchinensis Spreng (Gac) is a tropical plant belonging to the Cucurbitaceae family, characterized by its vigorously perennial vines where males and females flower on separate plants. Cultivated from seeds, branches, and roots, this plant yields fruit approximately 9 to 10 weeks after pollination. The ripe fruit, typically round or ovoid, features an exterior skin covered in short spines and is harvested from August to February in outdoor growing systems. Indigenous to South and Southeast Asia, including Vietnam, China, Thailand, and India, it is known as Gac in Vietnam, 'Cochinchin gourd' in English, and has various other names such as baby jackfruit and sweet gourd (1,2).

Despite its rich cultural heritage and nutritional value, Gac fruit is currently cultivated on a limited commercial scale primarily in Vietnam and Thailand. It has long been integrated into regional cuisines, with Vietnamese cuisine utilizing it as a colorant for dishes like red glutinous rice or Xoi Gac, often served on festive occasions. In Thailand, the immature Gac fruit, known as green fruit, is commonly consumed as a vegetable (2, 3, 4).

Nutritionally significant, Gac fruit is rich in carotenoids, particularly lycopene and β-carotene, found in its aril, seeds, peel, and pulp. Additionally, it contains essential fatty acids, α-tocopherol (vitamin E), phenolic compounds, and flavonoids, offering various health benefits. This has led to an increasing demand for Gac aril, reflected in the development of health products by Vietnamese and international companies (4)

* Corresponding author: Pathumi Madhushika Ariyarathna

Moreover, the total carotenoid content (TCC) in the yellow pulp of the Gac fruit is notably high compared to many other plant foods, making it an attractive natural coloring agent (2, 3). Its intense red color has led to its use as a substitute for artificial coloring agents such as Tartrazine, Sunset yellow, and Quinine yellow. Furthermore, various novel products such as frozen Gac aril, Gac juice, Gac oil capsules, and dried Gac powder have emerged, finding applications in food additives, cosmetics, and pharmaceuticals (1).

This review aims to explore the potential of Gac fruit as a source of bioactive compounds, particularly carotenoids, and its associated biological activities, processing techniques, and utilization. The insights gleaned from this review will be instrumental in shaping current and future agricultural practices for the commercialization of *M. cochinchinensis* across the medicine, food, and nutrition industries.

1.1. Distribution and vernacular names

M. cochinchinensis is native to Southeast Asia, encompassing regions such as Vietnam, Thailand, China, and India, with various vernacular names attributed to it depending on the country of origin (Table 1). The presence of multiple vernacular names within the same country can often be attributed to the utilization of distinct dialects within tribes or regions of that country.

Table 1 Vernacular names of *M. cochinchinensis* based on the different Asian countries

Country	Vernacular name	Reference
Bangladesh	Kakrol	(5)
China	Da Ye Mu Bie Zi, Mu Bie, Mù-BiēGuǒ, Mu Bie Zi, Teng Tong, Tu Mu Bi	(5)
India	Bhat Kerala, Golkara, Kakrol, Gangerua,Gulkakra, Kakur, Kakrol, Kantola, Kathaamla	(5, 6, 7)
Indonesia	Pupia, Torobuk, Toropu	(5)
Laos	Khaawz	(5)
Malaysia	Teruah	(4,5)
Philippines	Tabog-Ok, Tabog-Uak	(5,8)
Thailand	Bai-Khai-Du, Fakkhao, Phak-Khao, Khika-Khrua Yawd-Fak-Kao	(4,6,9)
Vietnam	Red Gac, Moc Miet Tu	(2,6)

1.2. Fruit Morphology

Figure 1 Anatomical components of Gac fruit (1. Seed, 2. Pulp, 3. Aril, 4. Peel with spines)

The fruit of *M. cochinchinensis* typically presents in an oblong shape, although variations in round, ovoid, or tapered forms are also observed. Differences in spine density and fruit tips contribute to its varied appearance (4). Each mature fruit encompasses black seeds enveloped by an oily red membrane (aril), encased within an orange spongy mesocarp (pulp), and enclosed in an orange-red peel adorned with surface spines (Figure 1). The density of spines on the fruits varies, ranging from dense and closely spaced to hard and widely spaced (10). As the fruit ripens, its color undergoes a transition from green to yellow, then orange, culminating in a vibrant red. Within the exocarp resides a spongy orange mesocarp, with the aril enveloping brown or black seeds. The pulp (mesocarp) constitutes the highest proportion of anatomical components, accounting for 49% by weight (11). Nevertheless, the edible aril, making up only 18% by weight, holds the utmost value due to its rich carotenoid and fatty acid content (1).

1.3. Bioactive compounds of Gac Fruit

1.3.1. Carotenoids

Carotenoids play a pivotal role in defining the vibrant colors observed in various flora and fauna, such as the red hue of tomatoes and watermelon, the orange tint of carrots, and the deep green pigment found in leafy vegetables (3). Beyond their role in natural pigmentation, plant-based carotenoids play a crucial role in human health.

Previous studies have identified all parts of the Gac fruit including its peel, pulp, and aril as exceptionally rich sources of bioavailable carotenoids (4). Lycopene and β-carotene emerge as the predominant carotenoids in Gac fruit (Table 2). Comparative analyses have revealed lycopene concentrations in Gac fruit to be at least five times higher than those found in other well-known fruits such as grapefruit, tomato, papaya, guava, and watermelon (3). It was reported the lycopene and β-Carotene concentrations of the edible portion of Gac fruit to be 802 and 175 µg/g respectively (12). Meanwhile, Gac aril contains 380 µg/g of lycopene and 101 µg/g of β-carotene (3). Notably, both the yellow pulp and peel of the Gac fruit also serve as rich reservoirs of carotenoids, with the total carotenoid content in the pulp recorded at 283 µg/g, a concentration notably higher than that of other carotenoid-rich fruits (13).

In addition to β-carotene and lycopene, minor carotenoids such as α-carotene, α-tocopherol, zeaxanthin, β-cryptoxanthin, and lutein have been identified at considerable levels in Gac fruit (3) (Table 3). Particularly noteworthy is the remarkably high lutein content discovered in the peel (52.02 mg/g) of medium ripe fruit, surpassing other fractions and followed closely by the pulp (18.1 mg/g) of immature fruit (9). This observation underscores the potential of Gac peel and pulp as valuable sources of lutein, highlighting the importance of not discarding them as mere waste products of Gac processing.

Table 2 Lycopene and β-carotene content in different parts of Gac fruit

Fruit Part	Extraction method	Lycopene mg/g	*β*- carotene mg/g	Reference
Aril	Homogenized fruit	0.45 (FW)	0.01 (FW)	(9)
	Chloroform: methanol (2:1)	0.49 (FW)	1.18 (FW)	
	Petroleum ether	0.30 (FW)	0.14 (FW)	
	Hexane	0.21 (FW)	0.12 (FW)	
	Hexane/acetone/ethanol(2:1:1)	7.02 (DW)	1.60 (DW)	
	Ice cold methanol Acetone	2.23 (FW) 0.38 (DW)	0.72 (FW) 0.10 (DW)	(2,3)
	THF (Tetrahydrofuran)	0.41 (FW)	0.08 (FW)	(13,14)
	THF and methanol (4:1)	3.28 (FW)	0.36 (FW)	
Mesocarp	Hexane/acetone/ethanol (2:1:1)	1.6–5.9 (DW)	3.0–5.4 (DW)	(9)
	Acetone	0.0009 (DW)	0.02 (DW)	(3)
Peel	Hexane/acetone/ethanol (2:1:1)	1.6–3.4 (DW)	1.6–5.9 (DW)	(9)

FW: Fresh Weight, DW: Dry Weight

Table 3 Summary of minor carotenoids in different parts of Gac fruit

Part of fruit	Phytochemical	Concentration (mg/g)	Reference
Aril	α-carotene	0.11 FW	(2,13)
	α-tocopherol	0.76 FW	(9)
	Zeaxanthin	0.01 DW	(9)
	β-cryptoxanthin	<0.01 DW	(9)
Mesocarp	α-tocopherol	31.00 FW	(13)
	Lutein	18.10 DW	(9)
	Zeaxanthin	FW	(3)
	β-cryptoxanthin	FW	(3)
Peel	Lutein	52.02 DW	(9)

FW: Fresh Weight, DW: Dry Weight

1.4. Fatty Acids

In addition to carotenoids, researchers have explored the significant presence of monounsaturated and polyunsaturated fatty acids in Gac fruit, particularly within the aril and seeds (Table 4). According to (2), a predominant portion of the fatty acids found in Gac fruits are unsaturated. This suggests that Gac-derived fatty acids could serve as a beneficial alternative to saturated fats in the diet, with these fatty acids playing a crucial role in the absorption of carotenoids and other fat-soluble nutrients (13,15).

Gac fruit is notably rich in linoleic acid omega-6 and omega-3 fatty acids. The primary fatty acids identified in the aril include oleic, palmitic, and linoleic acid, whereas the seeds are predominantly composed of stearic acid followed by linoleic, oleic, and palmitic acids (2,8) (Table 3). The Gac aril harbors substantial amounts of fatty acids, measuring at 102 mg/g of fresh weight (FW) (12). Seventy percent of the total fatty acids in the aril are unsaturated, with 50% of these being polyunsaturated (16).

The total fatty acid content in Gac seeds is between 15.7% and 36.6% of the total weight of the seed (2). Both Gac aril and seeds contain α-linolenic acid, which offers notable health benefits. For instance, α-linolenic acid has been observed in several studies to play a significant role in reducing the incidence of cardiovascular disease (17).

Table 4 Fatty acid composition of seeds and aril of Gac fruit (% of total fatty acids)

Fruit Part	Type of fatty acid				Reference
	Oleic	Palmitic	Stearic	Linoleic	
Aril	32.0	29.0	7.7	28.0	(3)
	34.1	22.0	7.1	31.4	(18)
	59.5	17.3	7.5	13.9	(8)
Seed	9.0	5-6	60.5	20.0	(2)

1.5. Phenolic and Flavonoid Compounds

Flavonoids and polyphenolic compounds, commonly found in plants, serve pivotal roles in plant growth, reproduction, and defense mechanisms. Recent studies have identified the Gac fruit as a rich source of phenolic compounds, particularly evident in its green fruit stage. Immature green fruit, in particular, exhibits a phenolic content of 26 mg of gallic acid equivalent and a total flavonoid content of 1.3 mg of catechin equivalent per 100 g of fresh fruit (7,9). Notably, p-hydroxybenzoic acid and ferulic acid emerge as the major phenolic acids present in the fruit.

Further analysis has revealed that the highest concentration of total flavonoids is found in the aril (376 mg/g DW), followed closely by the pulp of ripe red fruit (302 mg/g DW). Among these flavonoids, apigenin, and rutin are identified as the predominant compounds in the pulp and aril, respectively (9). These findings underscore the significant presence of flavonoids and phenolic compounds in Gac fruit, highlighting its potential as a valuable source of these bioactive compounds.

1.6. α-Tocopherol (Vitamin E)

Vitamin E, also known as α-tocopherol, stands out as a crucial fat-soluble antioxidant, potentially playing a pivotal role in the prevention of cardiovascular diseases, including coronary heart disease (19). In comparison to other fruits, Gac fruit boasts a higher concentration of vitamin E. Specifically, the Gac aril contains 76 µg/g of fresh weight of α-tocopherol, while the fruit's oil harbors 357 µg/mL of α-tocopherol. With an impressive nearly 8 mg of alpha-tocopherol per 100 g, Gac fruit could significantly contribute to meeting the recommended intake of vitamin E (15 mg/day of alpha-tocopherol) for adults (13).

1.7. Biological activities

Numerous biological activities have been attributed to Gac fruit, including its antioxidant, anticancer, and antimicrobial properties.

1.8. Antioxidant activity

Many studies have focused on the antioxidant activity of Gac fruit as well as on the changes in the antioxidant activity of processed products. The antioxidant activity of Gac fruit has been examined using diphenyl-picrylhydrazyl (DPPH) radical scavenging, ferric reducing antioxidant power (FRAP), and 2,2'-azino-bis (3-ethy lbenzothiazoline-6-sulphonic acid (ABTS).

Research findings reveal that at the fully ripened stage, Gac aril exhibits the highest FRAP value, measuring 531.17 µmol/g. In the same vein, the DPPH assay indicates that Gac peel and pulp demonstrate their highest antioxidant activity during the immature stages, measuring at 2.56 and 2.35 µmol/g, respectively (9). Another study reports that 100 g of Gac fruit extract, assessed through DPPH and FRAP assays, yielded values equivalent to 45.1 and 5.8 mg, respectively (7). Furthermore, Gac peel extract, utilizing ethyl acetate, exhibited an ABTS antioxidant capacity yield of 737 µM Trolox equivalent (TE) per 100 g dry weight (DW), accompanied by a total carotenoid content of 271.1 mg per 100 g DW (20).

The significant decline in phenolic levels during the fruit's developmental stages may contribute to the decrease in antioxidant activity observed. Moreover, subsequent storage and processing procedures are likely to impact the bioactive compounds and antioxidant activity of Gac fruit, with drying identified as a key process resulting in a reduction in antioxidant activity (8).

1.9. Antimicrobial Activity of Gac Fruit

The antimicrobial potential of Gac fruit pulp (flesh) and seed pulp (aril) was investigated against a spectrum of both Gram-positive and Gram-negative bacteria. Results indicated that water and ethanolic extractions of Gac pulp exhibited a more pronounced antibacterial effect against Gram-positive strains compared to Gram-negative strains. Particularly noteworthy was the highest antibacterial activity observed in the ethanolic extract of Gac flesh against both strains of Micrococcus luteus 745 (20 mm) and M. luteus 884 (18.5 mm) (6).

In another study, the antimicrobial activities of different parts of the Gac fruit (peel, pulp, and aril) were evaluated against six pathogenic bacteria strains: *Escherichia coli, Staphylococcus aureus, Bacillus cereus, Pseudomonas aeruginosa, Salmonella typhimurium, and Klebsiella pneumonia*. The results confirmed that ethanolic extraction from various parts of the Gac fruit exhibited antimicrobial activity against all pathogenic strains tested, consistent with previous findings (21).

1.10. Pro-vitamin A activity

Red Gac aril stands out as an exceptional source of vitamin A, primarily owing to its abundant β-carotene content, a precursor to this essential nutrient. In Vietnamese culinary tradition, Gac aril and Gac oil have long been incorporated into dishes such as steamed rice, Xoi gac, to support healthy vision and address eye ailments stemming from vitamin A deficiency (13). The impact of β-carotene supplementation from Gac aril was investigated through a study where participants were divided into three groups, each consuming a variation of steamed glutinous rice: one fortified with 3.5 mg of β-carotene per serving from Gac aril, another with 5.0 mg of synthetic β-carotene powder per serving, and a control group without fortification. Following 30 days of consumption, the group consuming Gac aril displayed a significantly greater increase in plasma retinol concentration compared to both the control and synthetic β-carotene powder groups. This notable enhancement in β-carotene absorption, attributed to the oil-rich aril, led to higher plasma β-carotene and retinol concentrations compared to the group receiving synthetic β-carotene. Consequently, the enhanced bioavailability of β-carotene in Gac-infused rice is believed to be influenced by various components within the Gac fruit, including the presence of a significant amount of fat, known to promote the intestinal absorption of β-carotene in humans (22).

1.11. Anti-inflammatory activity

Gac fruit is renowned for its rich lycopene content, known to possess protective properties against inflammation (23). Additionally, research indicates that Gac seed extract exhibits anti-gastritis effects, particularly evident in ethanol and diclofenac-induced gastritis in rat models. Notably, Gac seeds harbor various triterpenoids and saponins, with Momordica saponin I identified as a potent inhibitor of nitric oxide (NO) production and transcriptional activation of inflammatory genes. Furthermore, this compound demonstrates suppression against the activation of inflammatory signaling proteins. Another noteworthy saponin found in Gac seeds is a quillaic acid glycoside, exhibiting inhibitory effects on the induction of IL-6 and iNOS expression, as well as NO synthesis in RAW 264.7 cells (24). Collectively, these findings suggest the potential therapeutic utility of Gac seeds in the management of inflammatory diseases.

1.12. Processing of Gac fruit

Gac fruit is renowned for its high content of carotenoids, α-tocopherol, and fatty acids distributed across its various fractions, including the aril, seeds, yellow pulp, and skin. Among these fractions, the Gac aril is particularly susceptible to oxidation and degradation when exposed to environmental factors such as oxygen, light, temperature fluctuations, and microbial activity. Therefore, it is imperative to preserve the integrity of these bioactive compounds, optimize their efficacy, and devise suitable extraction methods (25).

Presently, several potential strategies have emerged to achieve this goal, encompassing drying processes, extraction of oil and bioactive compounds, encapsulation techniques, and integration of Gac fruits into diverse food products (4) (Figure 2). These approaches aim to safeguard the potent nutritional and medicinal properties of Gac fruit while enhancing its utilization in various applications.

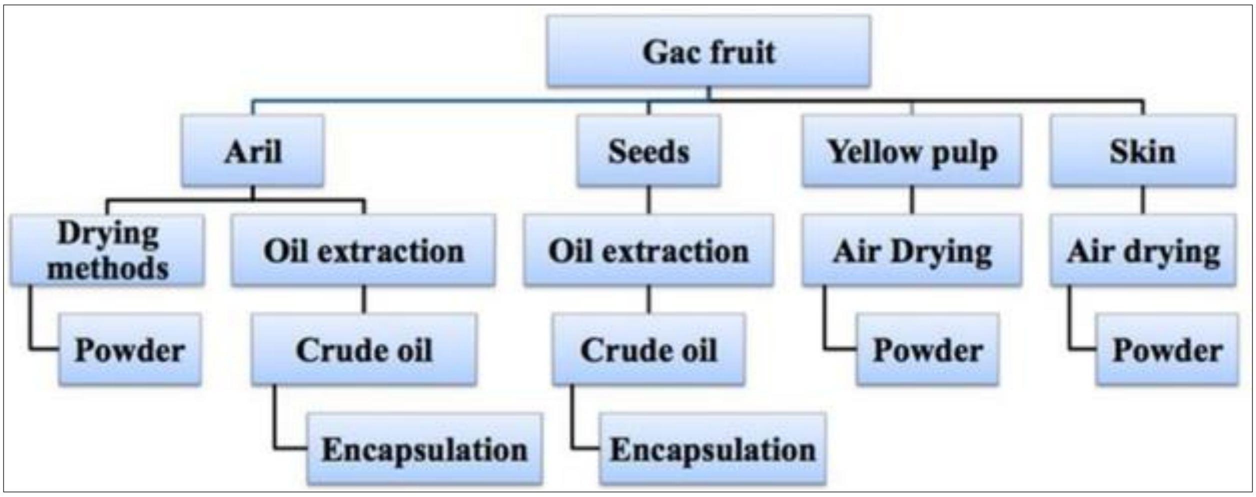

Figure 2 A potential processing scheme of Gac fruit

1.13. Dehydration to produce Gac powder

Dehydration of Gac fruit holds paramount importance as it offers numerous advantages, including prolonged shelf life of products, reduced transportation and storage costs, and expanded availability during off-season periods (26). Traditionally, fresh Gac aril undergoes sun exposure until fully dried, following which the seeds are separated and stored for use as a food colorant (13). However, past studies have revealed significant losses of lycopene and β-carotene due to degradation caused by direct sunlight exposure and oxygen during this traditional drying process. Hence, the selection of suitable modern drying technologies to preserve the nutritional value and content of carotenoids and other bioactive compounds in Gac fruit holds paramount importance for the food and pharmaceutical industries (4).

Among five different drying methods including oven drying, air drying, vacuum drying, spray drying, and freeze-drying, it has been found that freeze-drying is the most suitable for retaining the sensory, nutritional, and functional properties of the fruit. Freeze drying produces Gac powder with the highest carotenoid content and the brightest color (27). Notably, dried Gac aril produced by freeze drying exhibited the highest total carotenoid content (7577 µg/g), followed by vacuum drying (5523 µg/g), air drying (5426 µg/g), oven drying (4825 µg/g), and spray drying (380 µg/g). The highest degradation of carotenoids during spray drying was associated with an inlet air temperature of 200 °C. Therefore, an inlet temperature of 120 °C was determined to be the most suitable condition for retaining carotenoids and total antioxidant activity of the dried powder (11).

To mitigate the significant loss of carotenoids during the drying of Gac aril, various pretreatments, and antioxidative agents have been explored for their protective effects. These include blanching (in citric acid or steaming), soaking in bisulfite or ascorbic acid, pretreatment using different enzymes (e.g., maltodextrin-gelatin mixture 1:1), and utilization of antioxidant agents (e.g., Vitamin C and E) (28). Presoaking with ascorbic acid or sodium bisulfite prior to drying has been shown to significantly reduce the loss of carotenoids and antioxidant power of dried Gac aril (11). Among the various pretreatment methods, steaming for 6 minutes was found to be the most effective in protecting the total carotenoid content in Gac powder (28). However, it's worth noting that while heat and enzymatic pretreatments facilitate the separation of aril from seeds, they also contribute to the high degradation of carotenoids during Gac powder production (29).

1.14. Gac oil extraction

Given the high levels of carotenoid-rich oil present in Gac aril, various extraction processes have been explored to obtain this oil efficiently. Consequently, selecting the appropriate extraction method and optimizing extraction conditions are crucial to achieving high yield and quality (4). Traditional extraction methods utilizing potentially harmful organic solvents have been phased out due to health risks, environmental concerns, and quality deterioration. It is imperative to adopt alternative extraction techniques employing non-organic solvents or food-grade solvents. Numerous studies have demonstrated that plant oil extraction can be accomplished using methods such as supercritical carbon dioxide (SC-CO2) extraction, aqueous enzymatic extraction, microwave-assisted extraction, and ultrasound-assisted extraction. These methods are environmentally friendly and do not involve the use of solvents (25).

Among these approaches, SC-CO2 extraction stands out as the most promising alternative method due to several advantages. SC-CO2 extraction offers benefits such as the absence of solvent residues, shorter extraction times, higher extraction yields, and superior retention of nutritional and valuable bioactive compounds (30).

1.15. Encapsulation Process

Encapsulation involves enveloping bioactive components, such as food oils, within a protective wall for purposes of stabilization, protection, and controlled release of these ingredients. Despite the significance of lycopene and β-carotene as key bioactive compounds in Gac oil, they are highly prone to degradation during storage (13). Hence, recent investigations have focused on encapsulating Gac oil using various methods, with spray drying encapsulation emerging as the predominant technique in the Gac processing industry (25). This method offers potential advantages such as cost-effectiveness, flexibility, and preservation of encapsulated material quality.

To enhance the encapsulation efficiency of Gac oil, optimization of spraying conditions and selection of appropriate wall materials are imperative. Key parameters for spray drying include feed temperature, air inlet and outlet temperatures, atomization type and conditions, drying air flow rate and humidity, and powder particle size. Various encapsulating agents, categorized as carbohydrates, cellulose, gum, lipids, and proteins, have been identified as effective in providing protection against heat, light, and oxidation (31, 32).

Optimal encapsulation of Gac oil powder has been achieved using a protein-polysaccharide matrix as the wall material at a concentration of 29.5% (v/v) relative to the Gac oil. Additionally, inlet and outlet air temperatures were optimized at 154 °C and 80 °C, respectively. Under these optimal conditions, the encapsulated powder retained approximately 80% and 74% of the β-carotene and lycopene present in the oil, respectively. The resulting powder exhibited an attractive orange-red color and high solubility in water, facilitating its incorporation into various food products (11).

1.16. Storage of Gac fruit and Gac products

The red aril of the Gac fruit stands out as the most prized component due to its rich concentration of carotenoids, which are particularly vulnerable to degradation caused by environmental and storage factors such as light, oxygen, and temperature fluctuations. Consequently, safeguarding against carotenoid loss emerges as a critical concern in the storage of Gac products. Intrinsic factors like variety and maturity stage, as well as extrinsic influences such as growing and storage conditions, can significantly impact the nutritional quality of Gac fruit. For short-term postharvest storage and immediate consumption, Gac fruit is ideally harvested at the fully ripe stage, exhibiting superior carotenoid content compared to medium-ripe fruits (9).

After separation from the seeds, the Gac aril is portioned and packed for storage in the freezer until use. Frozen Gac aril maintains its palatability from the end of one harvesting season to the beginning of the next, or even for up to a year. Despite Gac fruit being recognized as one of the richest sources of carotenoids, there remains a limited understanding of the effects of storage on its nutritional quality and carotenoid content, as well as that of its derived products. A study on the storage of fresh Gac fruit observed changes in carotenoid content over a two-week period under ambient conditions (14).

The findings indicated that storing Gac fruit at lower temperatures significantly reduced the loss of total carotenoids. Furthermore, the inclusion of antioxidative agents during the drying process of Gac aril not only prevented carotenoid loss in the resulting Gac powder but also effectively shielded the carotenoids during storage (29). These strategies underscore the importance of proper storage techniques and the use of protective measures to maintain the nutritional integrity of Gac fruit and its derived products over time.

1.17. Utilization of Gac products

Gac fruit holds significant potential for utilization across various industries including pharmaceuticals, cosmetics, and food. Incorporating Gac powder or encapsulated Gac oil into food products serves as a natural colorant and nutrient supplement. Natural carotenoid extracts, derived from Gac fruit, find application as food colorants in a wide array of processed products, spanning from oily items like margarines, oils, fats, and shortenings, to fruit juices, beverages, dairy products, soups, confectionery, salad dressings, meat products, pasta, baked goods, and more (33).

Gac aril powders, processed using various drying methods such as freeze-drying, vacuum drying, and spray-drying, can be seamlessly integrated into a variety of dishes including the traditional Vietnamese dish “Xoi Gac,” pasteurized Gac juice, milk beverages infused with Gac, yogurt, fettuccine pasta, and creamy sauces (11). Moreover, Gac fruit undergoes processing to yield components suitable for use as ingredients or fortification in food products. The commercial market now offers an array of Gac products such as frozen aril, puree, Gac oil, dried Gac aril powder, and Gac juice.

Beyond its culinary applications, the cultivation of Gac crops extends beyond the fruits themselves, with young leaves, leafy shoots, and flowers also finding their way into culinary practices. In developing countries, these components are blanched and served with chili sauce, or added to soups. In regions like India, Thailand, and Bangladesh, young and immature green fruits are incorporated into various dishes, including boiling, stuffing, stir-frying with pork or shrimp, or cooking in curries (8, 9).

2. Conclusion

Gac fruit is renowned for its exceptionally high concentrations of carotenoids, particularly lycopene and β-carotene, along with significant levels of α-tocopherol and fatty acids distributed across its various parts, including the aril, seeds, yellow pulp, and skin. Additionally, Gac fruit harbors other bioactive compounds such as polyphenols and flavonoids. Numerous studies underscore the pivotal role these valuable compounds play in promoting human health. Over recent decades, Gac fruit has garnered attention as a promising resource for the functional food industry, owing to its rich array of bioactive compounds and their associated biological activities.

However, further in vivo and clinical studies are essential to ascertain its potential as a functional food ingredient. These studies are crucial for determining effective doses and toxicity levels, as excessive consumption may pose health risks.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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