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Extraction and Characterization of Natural Food Colorants from Canistel Fruit (*Pouteria campechiana*): A Comprehensive Evaluation of Physicochemical Properties

R.A.D.A. Ranasinghe[a], S.M.A.C.U. Senarathne[b], and W.A.J.P. Wijesinghe[c,*]

[a]Department of Export Agriculture, Uva Wellassa University, Badulla, Sri Lanka.

[b]Food Research Unit, Department of Agriculture, Gannoruwa, Peradeniya, Sri Lanka.

[c]Department of Food Science & Technology, Uva Wellassa University, Badulla, Sri Lanka.

Corresponding Author: janakaw@uwu.ac.lk, phone +94-701109698

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Abstract

A food colorant is a food additive that can be any kind of dye, pigment, or substance applied to foods. As artificial food colorants impart health hazards, this research aims to extract carotenoids from Canistel fruits (*Pouteria campechiana*) as a natural food colorant substitute for artificial food colorants. Carotenoid extraction was done using the solvent extraction method using a hexane, acetone, and ethanol (70%:15%:15) ratio. The instability of the carotenoid is one of the main drawbacks, and microencapsulation techniques have been used to overcome this. 10% MD, 5% MD + 5% GA mixture, and 10% GA were tested as the wall material treatments in the encapsulation process. Encapsulation with 10% MD showed an 11.91±0.29 g higher yield and higher total carotenoid content after spray drying, while 10% MD retained 45.64±5.3% more carotenoid concentration. The color Chroma meter values in three treatments were observed. When considering b* values, the highest yellowness and overall best color measurements were reported by the 10% MD treatment. The 2, 2-diphenyl-2-picrylhydrazyl (DPPH) assay method was used to find antioxidant activity. The highest antioxidant activity indicated the lowest IC50 value as recorded as 3.57±0.04 mg/mL, 4.38±0.20 mg/mL, and 5.19±0.24 mg/mL from the 10% MD, (5% MD + 5% GA) mixture, and 10% GA, respectively. Results revealed that the spray drying technique auspiciously encapsulated the carotenoids.

Keywords: canistel fruit, carotenoid, encapsulation, natural food colorant

Introduction

Colors are the magical attributes of foods that attract living beings. They play a major role in the taste and perception of food, along with flavor, perception, and preference. Color is the first characteristic of food that is noticed, predetermining our expectations of flavor and quality. Food coloring agents can be classified according to natural and synthetic sources [1].

Natural food coloring agents are extracted from natural sources like plant parts like leaves, roots, seeds, fruits, vegetables, animals, minerals, and algae. But the problem is that they have very low stability, weaker tectorial strength, interactions with food ingredients, and an inability to match desired hues. They highly affect the sunlight, temperature, and pH of the medium. Chemical reactions produce synthetic colors. The European Union (EU) permits a wide range of colors, such as (E 100) curcumin and (E 163) anthocyanin. They have been used more because of their high stability and low cost. Most of them are not suitable for our health. Consumer perception and demand have driven the replacement of synthetic colorants with naturally derived alternatives. However, the use of synthetic food colorants is declining as most of them hurt health, are carcinogenic, toxic, and have bad effects on nervous and heart health.

Pouteria campechiana, or Canistel, is an evergreen, tropical fruit. It is a member of the Sapotaceae family. It is also called Egg-fruit, Yellow Sapota, and Lavulu. The main thing is that it is an underutilized fruit in Sri Lanka. The investigation of the carotenoid content of underutilized, non-domesticated, and/or exotic plant foods has been prominent in recent decades and continues to be significant [2, 3]. Liquid-liquid extraction is the traditional extraction method. However, numerous recently developed extraction techniques have been described and reviewed elsewhere. These include ultrasound-assisted extraction (UAE), microwave-assisted extraction (MAE), enzymatically assisted extraction (EAE), pressurized liquid extraction (PLE), also known as accelerated solvents, extraction (ASE), and supercritical fluid extraction (SFE) [4-7]. Use hexane and acetone as ideal solvents as carotenoids are lipid-soluble compounds.

This paper examines the current state of food colorants and aims to develop an application of natural food colorants extracted from *Pouteria campechiana* fruits. Additionally, it explores the best wall material for carotenoid encapsulation and evaluates the concentration of the pigments and other physicochemical properties. Also, value-added for Canistel fruits may reduce the postharvest loss.

Materials and Methods

Materials

Fully ripened, fresh fruits were manually harvested from Canistel trees in Galagedara city in Kandy District, Central Province, Sri Lanka. Pests, insects, and other disease-free fruits were sorted through visual examination. The chemicals used in this study were analytical grade 99.9% acetone, ethanol absolute, and hexane, distill Water, DPPH, and 80% methanol.

Pre-Treatment of Samples

Sorted fruits were cleaned using clean water and wiped out using a clean cloth. Then, they were kept for a few minutes to dry at room temperature (25± 2°C). Then, they were separated from the flesh part of the fruit and crushed the pulp using a mortar and pestle while adding 10 mL of Acetone occasionally.

Carotenoid Extraction

Carotenoid was extracted from the prepared pulp using the liquid-liquid solvent extraction method with the optimum solvent ratio according to Pandya (2017), with some modifications [8]. Then, 50 g of pulp was put into a conical flask. Then the 250 mL of hexane: Acetone: Ethanol mixture dissolves in a 70: 15: 15 ratios according to González-Peña et al., (2021) [9]. After that, the sample was shaken for 30 minutes at 200 rpm to extract the carotenoid pigment. Then, the solution was filtered into the separating funnel using a NO. 1 filter paper, and the remaining pulp was again mixed with the solvent mixture until colorless. Then, both filtrates were combined, and the pigment-bearing hexane layer was separated and homogenized the extracted carotenoid with three types of wall materials: 10% MD (Treatment 1), 5% MD + 5% GA mixture (Treatment 2), and 10% GA (Treatment 3) [4]. Here, the percentage was calculated relative to the extracted volume.

Preparation of Encapsulation Mixture

After finishing the carotenoid extraction using Canistel fruit pulp, the weight of the extract was measured. The wall materials were added while stirring continuously as a 10% MD (Treatment 1), 5% MD + 5% GA mixture (Treatment 2), and 10% GA (Treatment 3), respectively, and three replicates from each of the three treatments were prepared. Then, the mixture was homogenized using a magnetic stirrer to achieve a stable emulsion. It ensures the carotenoids are uniformly distributed within the encapsulation matrix.

Encapsulation Process

For the spray drying, first machine was washed, cleaned, and dried, then set up the spray dryer with an appropriate inlet and outlet temperature. Then, the homogenized mixture was fed into the spray dryer. After that, encapsulated carotenoid powder was carefully collected. Here, the rapid drying process forms a protective coating around the carotenoids, ensuring the stability of the encapsulated carotenoid powder. Then extracted carotenoids were encapsulated to develop carotenoid powder using a spray dryer as mentioned by Diep et al., (2020) and modifying temperature as the inlet temperature was 250 °C and the outlet temperature was 150 °C.

Determination of Color

The color was determined using the Chroma meter (Model Konica Minolta CR 400/410). Initial calibration was done using a standard white tile, and the samples' CIE L*, a*, and b* values were determined. The total color differences were calculated according to González-Peña et al., (2021).

L*represent- darkness to lightness values ranging from 0 to 100 a*represent- greenness to redness values ranging from -128 to +127 b*represent- blueness to yellowness values ranging from -128 to +12.

Determination of Total Carotenoid Content in Extracted Pigment

The total carotenoid content of the extract was calculated according to the equation in the previous study of de Carvalho et al., 2012 [10, 11]. According to the Beer-Lambert law, the absorbance of a dissolved, pure compound is linked to its concentration. The total carotenoid content in extracted pigment was calculated by using Equation 1:

$$\text{Carotenoids Content } (\mu g g^{-1}) = \frac{A \times V \times 10^{-4}}{A_{1cm}^{1\%} \times P} \qquad \text{Equation (1)}$$

Where A: Absorbance (nm), V: Total extracted volume (mL), P: sample weight (g), $A_{1cm}^{1\%}$= 2592 (β -carotene Extinction Coefficient in Hexane)

Determination of Total Carotenoid Content in Spray-Dried Carotenoid Powder- UV/VIS Spectrophotometric Analyses

Spray Dried carotenoid powder was reconstituted in 5 mL of acetone and vortex for 2 minutes, then samples were filtered through NO:1 filter paper to reduce the turbidity as mentioned in Biehler et al., (2010) with some modifications [12]. Then, absorbance was recorded using a UV/VIS Spectrophotometer ((Model-ATO-VIS-72IG, USA). Calculated the concentration as above (Equation 1). Then the carotenoid retention percentage was calculated according to Equation 2 from the method described by Barbosa et al., (2015) [13].

$$\text{Apparent percentage of retention} = \frac{\frac{carotenoid\ content}{g\ of\ processed\ food\ (fresh\ bass)} \times 100}{\frac{carotenoid\ content}{g\ of\ unprocesses\ food\ (fresh\ basis)}} \qquad \text{Equation (2)}$$

Determination of Water Solubility in Spray-Dried Carotenoid Powder

As mentioned in González-Peña et al., (2021) 0.2 g of each powder was dissolved in 10 mL of distilled water. The mixture was centrifuged at 3000 rpm for 10 minutes (IEC HN-SII Centrifuge). Then, 9 mL of the suspension was removed, and the residue was dried at 105 ° C for 24 h. Water solubility was calculated using below Equation 3. Determinations were performed in triplicate.

$$\text{Solubility} = \frac{Final\ weight \times \frac{10}{9}}{Initial\ weight} \qquad \text{Equation (3)}$$

Determination of Water Activity in Spray-Dried Carotenoid Powder

The water activity of spray-dried carotenoid powder samples was measured using a water activity meter (Model Novasina, Lab Start-aw, Switzerland). Water activity was analyzed according to the AOAC 978.18

modified method at 25 °C. A plastic chamber filled with the sample was kept in the water activity meter to obtain the corresponding water activity.

Determination of Antioxidant Activity in Spray-Dried Carotenoid Powder

The antioxidant activity of the samples was measured using the 2, 2-diphenyl-2-picrylhydrazyl (DPPH) assay method. The absorbance was measured at 517 nm using a UV-VIS spectrophotometer (Model- ATO- VIS-721G, USA). IC50 values were calculated against the Gallic acid standard curve reported by Shirazi et al., (2014) using powder garlic acid (0, 0.1, 0.5, 1, 2.5 mg/mL), respectively [14]. The percentage of the carotenoid powder's radical scavenging activity was calculated using the following formula.

$$\text{Radical scavenging Activity \%} = \frac{ABS\ Control - ABS\ Sample}{ABS\ Control} \times 100 \qquad \text{Equation (4)}$$

Where ABS Control: Absorbance of 0.5 mL of 80% methanol + 2.5 mL absolute Methanol (nm), ABS Sample: Absorbance of powder + 2.5 mL DPPH (nm).

Determination of pH in Spray-Dried Carotenoid Powder

According to Jayamali et al., (2022), the first 0.5 g of powder was taken and mixed with distilled water [15]. The solution was mixed for 1 to 2 minutes at 35 rpm. Finally, pH was measured using a standard Bench pH meter (Model Mi 150 pH/Temperature Bench Meter).

Determination of Particle Size in Spray-Dried Carotenoid Powder Samples

The particle size of the spray-dried carotenoid powder was determined using optical microscopy (Model BX43F OLYMPUS TOKYO 163-0914, JAPAN). After the microscope and software are set, check the particle size according to the 40x magnification. Samples of the dried extracts were placed on the microscope slide, and fixed-stage images of the powders were obtained using an Optical microscope coupled with a digital camera.

Statistical Analysis

Here, three replicates from each of the treatment. Group information was taken by treatment for the experiments. Data were analyzed using the ANOVA test by MINITAB 17 statistical software. Complete Randomized Design (CRD) was used as the experimental design, and grouping information was taken using Tukey's method with 95% confidence.

Results and Discussion

Physicochemical Properties

According to the observations, the hexane: acetone: ethanol-70:15:15 ratio was the most suitable for carotenoid extraction from Canistel fruits. The yield of carotenoid powders ranged from 7.75±0.19 g to 11.91±0.29 g. The highest yield was obtained from the 10% MD. There was also no significant difference ($p > 0.05$) between the 10% MD treatment and the 5% MD + 5% GA treatment, and there was no significant difference between the 5% MD + 5% GA treatment and the 10% GA treatment.

These results build on the existing evidence of González-Peña et al., (2021) regarding solvent mixture, solvent ratio, and wall material. In the literature Fang et al., (2017), the authors describe the polarity of solvents [16]. The hexane: acetone: ethanol solvent mixture yields the highest carotenoid yield compared to the solvents used alone. Ethanol has 0.654, acetone has 0.355, and hexane has 0.009 relative polarities. So, the combination of the above solvents enhances the simultaneous extraction of polar and non-polar carotenoids.

Table 1. Yield, Total carotenoid content, carotenoid retention percentage, water activity, water solubility, and particle size of the encapsulated carotenoid powder with three different treatments

Treatment	Yield (g)	Total carotenoid content (µg/g)	Carotenoid retention percentage	Water activity	Water Solubility (%)	Particle size (µm)
10% MD	11.91±0.35^{a}	5.37±0.69^{a}	45.64±5.30^{a}	0.39±0.06^{a}	11.29±0.44^{b}	37.50±4.94^{a}
5% MD + 5% GA	9.57±1.02^{ab}	5.44±0.48^{ab}	34.01±1.86^{ab}	0.25±0.05^{a}	12.68±1.67^{b}	46.11±2.50^{b}
10% GA	7.75±0.24^{b}	4.97±0.63^{b}	27.20±2.04^{b}	0.28±0.05^{a}	20.11±1.48^{a}	69.85±8.55^{c}

Values in each column represent the means of three replicates ± standard error, and the same letter following the value indicates no significant difference at $p<0.05$ as analyzed by one-way analysis of variance (ANOVA).
(MD = Maltodextrine, GA = Gum Arabic)

Total Carotenoid Content and Carotenoid Retention Percentage of Encapsulated Carotenoid Dry Powders

Estimating the total carotenoid content of the encapsulated carotenoid dry powder is the most common method for checking the quality of the dried powder when developing a natural food colorant. The method depends on the encapsulated process and environmental factors like light, heat, temperature, oxygen, and moisture. According to Meléndez-Martínez et al. (2022), there was a significant variation in beta-carotene influenced by variety, cultivation, harvesting, post-harvesting, and fruit storage [17]. The data suggested that the 5% MD + 5% GA mixture showed a higher carotenoid concentration after encapsulation (Table 1). However, the results do not fit with the results of the previous studies on carotenoid retention percentage because of the differences in encapsulation techniques, purity of the carotenoid, and mainly storage conditions.

As shown in Table 1, there was no significant difference ($P > 0.05$) between the total carotenoid content of the 10% MD treatment and the 5% MD + 5% GA treatment, and there was no significant difference ($p > 0.05$) between the carotenoid retention percentage of the 10% MD treatment and the 5% MD + 5% GA treatment. Increasing MD or GA percentages can improve encapsulation efficiency but may reduce carotenoid stability. Increasing GA can enhance the protective barriers but may increase costs and alter powder texture. Combining MD and GA optimizes the encapsulation matrix, providing practical, adequate protection while maintaining cost efficiency and desirable product characteristics.

MD provides an optimal balance between encapsulation efficiency and protective capability, forming a sufficient barrier around the carotenoids. It also creates an effective barrier against light and oxygen, minimizing oxidation without forming a permeable barrier. MD's hygroscopic properties allow it to absorb moisture, providing adequate protection without causing hydrolytic degradation. Its cost-effectiveness makes it a practical choice for encapsulating carotenoids.

Compared to the other two treatments, 10% MD showed the highest carotenoid retention percentage, making it the most effective treatment in terms of preserving the carotenoids. The data contributed to a clearer understanding of carotenoid retention percentages. Additionally, as shown by the results, the carotenoid retention percentage of powders increased with increasing MD concentration.

Water Activity of Encapsulated Carotenoid Powder

"Water activity" is the measurement of the available water inside the food. Observations showed no significant difference ($P > 0.05$) between the water activities of the three treatments. So, the water activity did not depend on the type of wall material. Water activity is one of the most important factors that significantly influence the shelf-life of every food product, including powders. According to the researcher Kha and Nguyen (2017), water activity levels greater than 0.7 cause perishable foods to deteriorate [18]. If the water activity is lower than 0.6, it will enhance the shelf life by suppressing the growth of microbes and biochemical reactions by reducing the amount of free available water.

The average water activity of powders and powder-related products should be 0.2 -0.4. In line with the hypothesis, these results build a positive relationship between existing evidence. To some extent, they can be regarded as microbiologically stable. The powders' water activity results aligned with the findings of Quek et al., (2007). They stated that the encapsulation process did not significantly change the water activity of spray-dried watermelon powders [19].

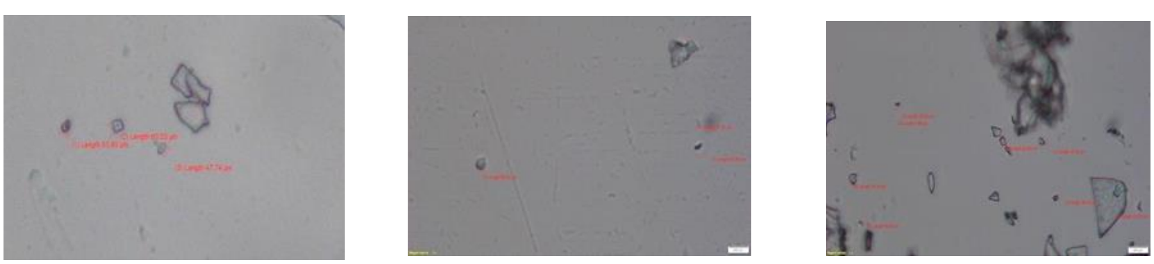
Water Solubility

Water solubility is a measurement of the ability of a chemical substance to dissolve in water at a specific temperature. It is a very important physical property for manufacturers and consumers of natural or artificial food coloring agents, as if the final product is insoluble in mixtures or water, it will affect the product's organoleptic quality. In the present study, there was a significant difference (P<0.05) in water solubility between the 10% MD treatment and the 10% GA treatment. In comparison, there was no significant difference in water solubility between the 10% MD treatment and the 5% MD + 5% GA treatment and between the 5% MD + 5% GA treatment and the 10% GA treatment. The 10% GA treatment showed the highest water solubility, indicating that it might be a suitable choice if water dispersibility is critical. These values were lower when compared to results for spray-dried tomato powders [20]. Further, the solubility of powders can be affected by many parameters, such as the initial composition of the wall material to be spray-dried and the spray-dried temperature [21-23]. The water solubility of powders decreased with increasing MD concentration. Carotenoids are much more soluble in oil at room temperature than in water. Many studies report that the encapsulation of carotenoids successfully increased the solubility in water [24].

Particle Size

The particle size distribution was determined using image analysis by optical microscopy. Samples of the dried extracts were dispersed on the surface of microscopy laminas, and images of the powders were obtained at 40× magnification using an Olympus microscope (model BX60MIV) coupled with a digital camera (model 3.2.0, SPOT Insight, Diagnostic Instruments) and analyzed using Image-Pro plus 7.0 software. MD. The 10% MD gave the most appropriate particle size range. As it was in the 50- 100 μm range, it indicates excellent potential for high solubility and uniform color distribution, making the powder ideal for beverages and liquid-based food products. Nevertheless, values can vary slightly because of the effects of the encapsulated wall material, nozzle size in the spray dryer, concentrated total solids, outlet and inlet temperatures of the spray dryer, packing material, moisture absorption, etc. These powders tend to form aggregates of different sizes and shapes due to moisture absorption and forces between particles, as they affect their flow properties [25]. Powdered food colorants typically have particle sizes between 1 and 100 μm. Smaller particles enhance solubility and dispersion, while larger particles may cause uneven coloring or settle in liquid products but are preferred for certain applications.

The study of Santos et al., (2018) found the spray drying temperature had a highly significant effect on particle size [26]. Its outlet temperature was 150 °C, and the inlet temperature was 250 °C. In this case, both were at very high temperatures, so particles tend to stick together through Van der Waals forces as they have a larger contact surface.



A B C

Figure 1. Microscopic observations of Particle size in encapsulated carotenoid powder in three different treatments (40×) (A) = 10% MD, (B) =, 5% MD + 5% GA (C) = 10% GA (MD = Maltodextrin, GA = Gum Arabic)

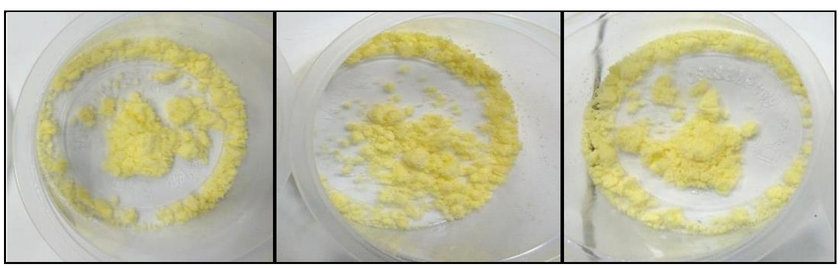
Table 2. Particle size, Antioxidant activity, IC50, pH, and color values of the encapsulated carotenoid powder of three different treatments

Treatment	Antioxidant activity (% of Inhibition)	IC_{50} (mg/ml)	pH	Color		
				L*	a*	b*
10% MD	18.22±0.19[b]	3.57±0.05[c]	5.38±0.15[a]	85.64±0.56[a]	9.49±1.17[b]	39.87±1.92[a]
5% MD + 5% GA	21.78±0.22[a]	5.19±0.24[a]	4.72±0.13[b]	83.36±0.51[b]	6.33±0.69[a]	33.55±0.49[b]
10% GA	16.09±0.99[c]	4.38±0.20[b]	4.69±0.03[b]	82.51±0.38[b]	6.31±0.33[a]	33.77±0.91[b]

Values in each column represent the means of three replicates ± standard error. The same letter following the value indicates no significant difference at $p<0.05$ as analyzed by one-way analysis of variance (ANOVA). (MD = Maltodextrine, GA = Gum Arabic)

Color of the Encapsulated Carotenoid Powder

Changes in the color measurements of encapsulated carotenoid powder with three different treatments are reported in Table 2. These changes happened due to the wall materials, stored temperature, and light-like factors. The 10% MD showed the highest lightness compared to GA treatments due to its whiteness. The* values of all treatments gave negative values, indicating a dominant green hue. When considering b* values, the highest yellowness was reported by the 10% MD treatment. Overall, 10% MD gave the best color measurements of encapsulated carotenoid powder. The variations in color values were mainly due to the three different wall materials.



A B C

Figure 2. Results of encapsulated carotenoid powder, A- 10% MD, B- 5% MD + 5% Gum Arabic, C- 10% Gum Arabic

Chemical Properties

DPPH Radical Scavenging Activity of the Encapsulated Carotenoid Powder of Three Different Treatments Antioxidants are compounds capable of reducing oxidative stress's causes and effects. Reactive oxygen species are highly reactive free radicals. Results from Table 2 showed the percentage of inhibition and IC50 values. It measures the ability to inhibit DPPH-free radicals using the radical scavenging effect of antioxidants in encapsulated carotenoid powder. Low IC50 values indicate high antioxidant activity. In the context of antioxidants, the IC50 value represents the antioxidant concentration required to scavenge 50% of free radicals in a given assay. DPPH is a stable free radical with an observed absorption maximum of 517 nm. Gallic acid has the characteristics of potent antioxidant and free radical-scavenging activities and is used as a reference standard. The results indicate that the antioxidant activity of encapsulated carotenoid powder is affected by the encapsulated wall material.

When considering the antioxidant activity results, the highest antioxidant activity was shown by 10% MD, while the least antioxidant activity was given by the 5% MD + 5% GA mixture. The highest antioxidant activity (10%) is achieved from 10% MD, which forms a stable matrix around carotenoids, protecting them from environmental factors. This results in a homogeneous matrix, ensuring even distribution and better protection. Maltodextrin also enhances solubility and release, increasing the bioavailability of carotenoids.

However, the combination of maltodextrin and gum Arabic may not form a stable matrix, leading to lower antioxidant activity. Additionally, the mixture may cause phase separation and inconsistent release, reducing overall antioxidant activity. Carotenoids are highly sensitive to heat, temperature, and light-like factors. Most of the research reported that microencapsulation of carotenoids exactly helps to prevent capacious losses of carotenoids and their antioxidant activities [27].

pH of the Encapsulated Carotenoid Powder of Three Different Treatments

The power of an acid or base is measured on the pH scale. pH denotes the "power of hydrogen." Typically, the pH scale ranges from 0 to 14. Acids have a pH of less than 7, bases have a pH of higher than 7, and neutral pH is 7. According to Yadav and Prabha (2014), the central primary stability of carotenoids can be seen in the pH 6–7 range [28]. Food pH values range from 2 to 7, and alkaline foods are rare in nature. The pH of foods affects their color, flavor, appearance, texture, nutritional value, and safety.

The pH values of the encapsulated carotenoid powder were affected by the type and proportion of ingredients used in the encapsulation process. According to the results, pH has ranged from 4.69-5.38, respectively, from treatment 10% GA to treatment 10% MD. Their pH levels influence carotenoids' stability. Acidic conditions can lead to degradation, color changes, and hydrolysis, reducing their stability and bioavailability. Neutral pH (pH 6-7) is ideal for maintaining structural integrity and antioxidant properties. High pH can cause degradation, saponification, and oxidative stress, affecting their molecular structure. The pH range of 4.69 to 5.38 is slightly acidic, affecting the stability of encapsulated carotenoid powders. This range may cause instability but is not as detrimental as lower pH levels.

Encapsulating materials like maltodextrin or gum Arabic can protect carotenoids from acidic conditions, maintaining stability. Maltodextrin stabilizes carotenoids in mildly acidic conditions, forming a protective barrier. Gum Arabic, while slightly less effective, offers controlled release and solubility. However, carotenoids can still be prone to oxidative degradation and hydrolysis, leading to potential loss of efficacy.

Conclusion

The extraction of natural food colorants from Canistel fruit (*Pouteria campechiana*) demonstrates significant potential in the food industry due to its vibrant color and favorable physicochemical properties. The study reveals that the canistel fruit contains carotenoids that can be effectively extracted and encapsulated, ensuring stability and enhancing bioavailability. The evaluation of physicochemical properties indicates that the canistel-derived colorant has desirable characteristics such as good solubility, stability under light and heat, and effective antioxidant activity, especially when encapsulated. The current research supports the possibility of developing natural food colorants from Canistel fruits and confirms potential culinary applications at this level. The 10% MD can be selected as the best wall material based on the evaluated physicochemical properties of yield, carotenoid retention percentage, particle size, highest yellowness, antioxidant activity, and pH. The value addition of Canistel fruits contributed to their support for food development while ensuring food security and health of reducing diseases related to synthetic food colorants. Therefore, the study of natural food colorant development should continue to be encouraged, and there is a large body of studies dealing with these aspects.

Research Highlight

- Canistel fruit (*Pouteria campechiana*) is an underutilized fruit crop in Sri Lanka that is highly rich in health benefits.
- As artificial food colorants impart health hazards, natural carotenoid extraction and development as a natural food colorant is a more suitable substitute for artificial food colorants.
- Carotenoids extracted from Canistel fruit exhibit a bright, appealing color suitable for food applications.
- 10% MD is one of the best wall materials that can be used in the encapsulation technique to ensure the stability of carotenoid powder.

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