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Physico-chemical properties of starfruit (*Averrhoa carambola*)

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Abstract
This study evaluates the physico-chemical properties of starfruit at two maturity stages. The physical properties of fruit length, width and weight were more in ripe fruit than halfripe fruit. The chemical properties of reducing, non-reducing sugar, titrable acidity, total sugars, and TSS contents increased with the stages of maturity. Ripe fruit was less acidic (pH 3.71) than halfripe fruit (pH 3.03). Starfruit contained good amount of vitamin C, in halfripe fruit (28.94 mg/100 g) and in ripe fruit (35.41 mg/100g). The potassium content in halfripe fruit was 119 mg/100 g and 125 mg/100 g in ripe starfruit. It also contained small amount of iron, phosphorus, calcium. The antinutrients content in carambola decreases with the maturity.

Keywords: starfruit, physical characteristics, chemical properties

Introduction
Starfruit *(Averrhoa carambola)*, or also known as carambola, is a fruit belonging to the family *Oxalidaceae*. The word Carambola is derived from Sanskrit word *karmaranga* meaning "food appetizer" (Monalisa *et al.*, 2014) [7]. Starfruit is a tropical fruit and is a native to the Philippines, Indonesia, Malaysia, Vietnam, Nepal, India, Bangladesh, Sri Lanka and Mauritius. The fruit is recognized as *belimbing manis* in many South East Asian regions and *kamrakh* in India. Starfruit can either be mildly sweet or extremely sour depending upon the cultivar type and amount of oxalic acid concentration. The fruit has a distinctive ridges running down its sides; when cut horizontally gives a star shape hence, the fruit is called as star-fruit. Starfruit is a seasonal fruit, in India the fruit flourishes during two particular times: September through October and December through January. The skin of starfruit is thin, smooth, waxy and turns a light green to dark yellow when it ripe.
In India, the starfruit prefers warm climate and it can be grown on the hills up to 1,200 m. In spite of its high availability, it is an underutilized fruit in the Indian market. A study on *Averrhoa carambola* by Dasgupta *et al.*, in 2013 [3] reported that the plant possess many medicinal properties such as anti-inflammatory, analgesic, hypoglycemic, antimicrobial, hepatoprotective and anti-ulcer activity and therefore its fruit and the plant can be used as a potent medicine. The fruit juice is also reported (Mia *et al.*, 2007) [6] to use as antioxidant, astringent, to treat diarrhoea, vomiting, dysentery, hepatic colic, bleeding piles and relieving thirst. The objective of the present study was to assess the physical and chemical properties of starfruit at two stages of maturity.

Material and Methods
Procurement of samples
Starfruit (Carambola) required during the investigation were procured from local market of Bangalore. Starfruit were collected during the maximum fruiting season and stored in deep freezer for further use. The fruits were washed, cleaned and dried prior to experimental trials. The fruits were categorized into two stages of maturity according to their firmness and skin color: (1) half ripe- firm texture with yellowish green color; (2) ripe fruit- soft texture with yellow color skin.

Physical characteristics
Weight (g)
Matured (No. 10) fruits from each group were randomly selected and measured individually by weighing in an electronic balance. The average was calculated.

Breadth (cm)
Matured (No. 10) fruits randomly selected from each group were measured in a horizontal axis by verneir calliper and the average breadth was calculated.

Length (cm)
Matured (No. 10) fruits randomly selected from each group were measured in a polar axis i.e. between apex and stem by verneir calliper and the average length was calculated.

Chemical composition
The edible portions of the fruit were separated from seeds and were homogenized using mortar and pestle. Moisture, ash, reducing, non-reducing sugar, titrable acidity, total sugars, ascorbic acid, iron, phosphorus, calcium, potassium, phytate and tannins were analyzed according to the method given by Ranganna (1986) [11]. The pH of the fruit was determined using digital pH meter and total soluble solids (TSS) contents were determined using a Hand Refractometer.

Results and Discussion
The physical analysis of half ripe and full ripe starfruit is presented in Table 1. Average length of the fruit was 7.75 cm (half ripe) to 7.92 cm (ripe) and diameter was 4.81 to 5.24 cm in half ripe and full ripe fruit, respectively. Narain *et al.*, (2001) [8] in a study reported a similar range of 7.65 to 7.92 cm for length and 5.22 to 5.24 cm for diameter of starfruit at different maturity. Patil *et al.*, (2010) [9] also reported similar values of 8.78 to 10.17 cm for length and 4.78 to 5.45 cm for diameter of half ripe and full ripe starfruit respectively. The fresh weight of the ripe fruit was 161.15g which was more than that of the half ripe fruit (152.27g). The weight of the ripe and half ripe fruits varied significantly at different maturity stage. A similar result was reported by Sharma *et al.*, (2015) [13] in fresh weight of carambola fruit. The half ripe fruit exhibited yellow-green, while the ripe fruit was yellow-orange with five distinctive ridges running down its sides; in cross-section. Moisture percentage in starfruit had no significant difference at both half ripe and ripe fruit; the percentage of moisture content was 90 %. Sharma *et al.*, (2015) [13] also revealed that the moisture content in carambola fruit produced in Manipur was 89 per cent. The reducing sugar content was 5.35 for half ripe fruit to 5.93 for ripe starfruit, whereas non reducing sugar values were 0.19 g in half ripe and 0.46 g in full ripe fruits. The reducing and non reducing sugar contents were different at all stages of maturity. Similar results were reported by Narain *et al.*, (2001) [8] and Patil *et al.*, (2010) [9]. The content of total sugars in starfruit varied according to stages the maturity 5.54 and 6.39 g in half ripe and ripe fruits, respectively. The present study showed that the total soluble solids (TSS) content in the starfruit varied significantly with the maturity. Total soluble solid (ºBrix) content was 6.9 in half ripe starfruit and increased to 7.36 in ripe starfruit. Sharma *et al.*, (2015) [13] reported on total soluble solid content of 5 ºBrix in ripe *Averrohoa carambola*, which was slightly lower than the result obtained from the present study. The values found were also similar to those cited by Narain *et al.*, 2001 [8], who analyzed carambola and revealed values ranged from 7.30 to 10.83 (ºBrix) at both maturity. Titratable acidity content in carambola decreases with the increase in maturity. The result obtained showed the values 0.39 g in half ripe and 0.26 g in full ripe fruits. Similar values were also reported by Narain *et al.*, (2001) [8], Soumya and Nair (2014) [14], in carambola fruit.

Table 1: Physical characteristics of starfruit at two stages of maturity

Sl. No.	Characteristics	Maturity stages	
		Half- ripe	Ripe
1.	Length of fruit (cm)	7.75	7.92
2.	Width of fruit (cm)	4.81	5.24
3.	Weight of fruit (g)	152.27	161.15
4.	Number of ridges	5	5

Table 2: Chemical composition in half-ripe and ripe starfruit

Sl. No.	Characteristics	Maturity stages	
		Half- ripe	Ripe
1.	Moisture (%)	90	89.53
2.	Ash (%)	2.79	2.88
3.	Reducing sugar (g)	5.35	5.93
4.	Non reducing sugar (g)	0.19	0.46
5.	Total sugar (g)	5.54	6.39
6.	Titrable acidity (g)	0.39	0.26
7.	pH	3.03	3.71
8.	Total soluble solid (° Brix)	6.9	7.36
9.	Ascorbic acid (mg)	28.94	35.41

Fig 1: *Averrhoa carambola* - stages of maturity of starfruit

Table 3: Mineral content in starfruit per 100g

Sl. No.	Minerals (mg)	Maturity stages	
		Half- ripe	Ripe
1.	Iron	0.43	0.40
2.	Calcium	3.24	4.52
3.	Potassium	119	125
4.	Phosphorus	21	19

Table 4: Antinutrients content in starfruit per 100g

Sl. No.	Characteristics	Maturity stages	
		Half- ripe	Ripe
1.	Phytate (mg)	0.06	0.04
2.	Tannin (mg)	0.25	0.16

Titratable acidity content was lower than other fruits such as pineapple 0.67 % of citric acid (Chanprasartsuk *et al.*, 2012) [2], star apple 3.80 % of citric acid (Abiodun and Oladapo,

2011) [1], Jamun fruit 1.26-1.58 % of citric acid (Shahnawaz and Sheikh, 2011) [12]. The pH content in ripe starfruit was less acidic (pH 3.71) than half ripe fruits (pH 3.03), thus characterizes ripe starfruit as a low-acid food. Narain *et al.*, (2001) [8], Patil *et al.*, (2010) [9], Soumya and Nair (2014) [14], Sharma *et al.*, (2015) [13] also reported similar results in their studies. Low pH had been reported to inhibit the growth of undesirable microorganisms (Abiodun and Oladapo, 2011) [1]. The ascorbic acid contents were 28.94 and 35.41 mg/100 g for half ripe and ripe fruit, respectively, indicating that the full ripen starfruit is richer in vitamin C. Lima *et al.*, (2001) [5] reported similar values of ascorbic acid in half ripe and ripe bilimbi fruit, being 20.82 and 36.68 mg/100 g, respectively. Ripe bilimbi fruits have higher vitamin C content than half-ripe ones; this may have been influenced by climatic factors. The data on iron, calcium, potassium and phosphorus contents were 0.43 to 0.40, 3.24 to 4.52, 119 to 125 and 21 to 19 mg/ 100g respectively. Mineral elements were found to vary between half ripe fruit and ripe fruit. In current study, the iron content, calcium content, potassium content and phosphorus content varied among fruits of different stages of maturity. Similar results were reported by Lee and Faridah (2005) [4] in *Averrohoa carambola.*

Table 4 present the antinutrients (Phytate and tannin) content in starfruit mg per 100g. Phytate and tannin content in half ripe and ripe carambola were 0.06 to 0.04 and 0.25 to 0.16 respectively. As the repining increased phytate and tannin content decreased. A similar finding was reported by Paul and Shaha in 2004 [10]. Phytic acid has the capability to chelate divalent elements like calcium thus decreasing their bioavailability. Tannins exhibit antinutritional potentials by precipitating dietary proteins and digestive enzymes to form complexes that are not readily digestible (Soumya and Nair, 2014) [14].

Conclusion

Starfruit is an under-utilized and seasonal fruit crop with good nutritional content. Based on the physico- chemical properties of the fruit different value added products can be developed and utilised during off season. Due to its seasonality, value addition to this fruit enables the consumers to use the fruit throughout the year.

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