PHYSICAL AND CHEMICAL CHARACTERISTICS OF CARAMBOLA (*Averrhoa carambola* L.) FRUIT AT THREE STAGES OF MATURITY

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ABSTRACT : The fresh fruits of carambola (*Averrhoa carambola* L.) are used in jelly making, for garnishing salads and to prepare drinks. In some Asian countries, the green mature fruit is relished and consumed fresh and used in pickle preparations. In the present work the physical and chemical properties of carambola fruits were studied at different maturity stages. The fruits were characterized for physical properties like length, diameter, fresh weight, dry weight and moisture content. The fruits were also analyzed for soluble protein, total sugars, reducing sugars, ascorbic acid, oxalic acid, amino acid, pectin and chlorophyll. The composition of fruit varied widely during maturation. The length, diameter, fresh weight and dry weight increased as fruit mature and ripen. The pH of the fruit increased with maturity. The contents of reducing sugars, total sugars, soluble protein, amino acid and oxalic acid increased with maturity. Total chlorophyll content increased from young to half ripe fruit but in full ripe fruit it decreased significantly.

Key words: - *Averrhoa carambola* L., Fruit, Physicochemical characteristics.

INTRODUCTION

The carambola (*Averrhoa carambola* L.) an attractive fruit of family Oxalidaceae, also known as 'Golden Star' had attained the status of a popular commercial crop in the United States (Campbell, 1986). Most carambola fruits are marketed in processed forms. It is edible and has numerous uses. The ripe fruit may be processed into fermented or unfermented drinks, jam or jelly, can be eaten fresh or as dessert. The unripe fruit may also be eaten as a vegetable (Campbell, 1965). The sweet type is processed into wine in Surinam (Lewis & Grocizam 1989). In Southern China, carambola fruits are preserved in thin packages and exported to other countries. However, scientific information on the physical and chemical characteristics of the fruit is scanty. Hence, the aim of this study was to investigate the physicochemical changes taking place in carambola fruit during maturation.

MATERIALS AND METHODS

Fruits of *Averrhoa carambola* L. at various stages of maturity (Plate: 1 B,C) were collected from Badlapur, Thane (M.S.) and brought to the laboratory of Department of Botany - Herbal Sciences, Birla College, Kalyan. The plant (Plate: 1A) was authenticated from Blatter Herbarium, St. Xavier's College, Mumbai. The specimen of plant has been deposited in the Department of Botany - Herbal Sciences, Birla College, Kalyan for future reference. The fruits were washed under running tap water and blotted dry. The fruits were classified into three stages of maturities according to their firmness and skin colour as:

1. Young : Firm texture and skin colour 100% green
2. Half ripe : Firm texture and skin yellowish green
3. Ripe : Soft texture and skin 100% yellow

Physical analysis

Ten fruits of each maturity group were individually analyzed for physical characteristics. Length and diameter of the fruit were measured. The maximum width of the fruit, measured in the direction perpendicular to the polar axis, was denominated as diameter.

For fresh weight determination the edible portion of the fruit was separated manually from the seeds. These fruits were further kept in pre-set oven at 60 ± 2^0 C till a constant weight was obtained, and this was recorded as the dry weight. Percent moisture was also calculated (Khandelwal, 1998). The *p*H of the fruit was measured with the help of pH meter.

Chemical analysis

The edible portion of the fruit was homogenized using a mortar and pestle. The biochemical analysis like soluble protein content (Lowry, et. al., 1951), reducing and total sugars (Folin & Wu 1927), ascorbic acid (Sadasivam & Manickam 1996), amino acid (Moore & Stein 1948), oxalic acid (Durman et. al., 2005), pectin (Moore & Stein 1948) and chlorophyll (Arnon, 1949) were estimated in the pulp at three stages of maturity.

RESULTS

The results of physical properties of the carambola fruit are presented in Table 1. The carambola fruit is a large berry with a length of 7.13 cm (young) to 10.17 cm (ripe). The diameter of the fruit was more for ripe fruit (5.45 cm) than that of the green young fruit (4.08 cm). The fresh weight of the green young fruit was found to be 29.12 gm, which increased gradually to 41.03 g and finally to 59.91 g in half ripe and full ripe fruit, respectively. Similarly an increase in dry weight and *p*H was also observed. The dry weight ranged from 1.28 g for young fruits to 2.57 g for ripe fruits. The *p*H of the fruit slightly increased with the advancement in maturity. Ripe fruits were significantly less acidic (*p*H 4.82) than green young fruits (*p*H 3.43) and half ripe fruits (*p*H 3.56). No significant change in moisture percentage was observed with ripening of fruits, the values being 95.60, 95.90 and 95.71 per cent in young, half ripe and full ripe fruit, respectively. The results of chemical analysis of carambola fruit is presented in Table 2.

Table 1: Physical evaluation of *Averrhoa carambola* L. fruit at different stages of maturity

S.No.	Parameter	Maturity Stages		
		Young	Half ripe	Full ripe
1.	Size			
	a) Length (cm)	7.13	8.78	10.17
	b) Diameter (cm)	4.08	4.78	5.45
2.	Fresh weight (g)	29.12	41.03	59.91
3.	Dry weight (g)	1.28	1.68	2.57
4.	Moisture content (%)	95.60	95.90	95.71
5.	pH	3.43	3.56	4.82

Table 2: Chemical analysis of *Averrhoa carambola* L. fruit at various stages of ripening

S. No.	Parameter	Young	Half ripe	Ripe
1.	Soluble Protein (% fresh weight)	0.65	0.83	0.85
2.	Reducing sugars (% fresh weight)	0.33	1.15	1.32
3.	Total sugars (%fresh weight)	1.12	1.50	2.25
4.	Ascorbic acid (mg/g fresh weight)	9.5	13.5	18.0
5.	Amino acid (%fresh weight)	0.12	0.16	0.17
6.	Oxalic acid (% fresh weight)	0.63	0.85	1.04
7.	Pectin (%fresh weight)	1.74	1.95	5.11
8.	Chlorophyll			
	a) Chlorophyll a (mg/100 g fresh tissue)	1.51	4.99	0.78
	b) Chlorophyll b (mg/100 g fresh tissue)	2.56	8.66	1.33
	c) Total Chlorophyll (mg/100 g fresh tissue)	4.05	13.60	2.10

The amino acid content increased from 0.12 % for young fruits to 0.17 % for ripe fruits. The content of reducing and total sugars increased with increase in maturity. The reducing sugars content increased from 0.33 % for young fruit to 1.32 % for ripe fruit. Total sugar content increased from 1.12 % for young fruit to 2.25 % for ripe fruit. The pectin content was recorded as 1.74, 1.95 and 5.11 % in young, half ripe and ripe fruits respectively. The protein content was found to increase from 0.65 % in young to 0.85 % in ripe fruits. The ascorbic acid content showed an increase in ripe fruit (18.0 mg/g) as compared to young (9.5 mg/g) and half ripe fruits (13.5 mg/g). The oxalic acid content increased from 0.63 to 1.04 % for young and ripe fruits, respectively. In the present study a significant decrease in chlorophyll content was observed in ripe fruits as compared to young and half ripe fruits, which was indicated by golden yellow colour of the fruit. The chlorophyll a values ranged between 0.78 to 4.99 mg/100g, whereas chlorophyll b values were recorded as 2.56 mg in young, 8.66 mg in half ripe and 1.33 mg/100g in full ripe fruits. Total chlorophyll was 4.05 mg in young, 13.60 mg in half ripe and 2.10 mg/100g in full ripe fruits.

A B

C

Plate No. 1: A- Flowering plant
B- Fruiting plant
C- Fruits at various stages of maturity.

DISCUSSION

The fruit of carambola varies widely in its composition during maturation. Many research workers have reported physical (Bezerra, et. al., 1989) and chemical (Lima, et. al., 1965; Oliveira, 1974; Herrman, 1994) composition of carambola fruit**.** In the present study an increase in length, diameter and average weight of the fruit was observed as it matures. Bezerra et. al. (1989) reported a range of 6.8 to 9.6 cm for length and 4.1 to 5.5 cm for diameter in different varieties of carambola fruits. Oliveira et. al. (1989) also reported length of 7.74 cm and diameter of 4.51 cm, for ripe carambola fruits. Bezerra *et al*. [11] reported fruit weights ranging from 39.6 to 89.5 g. An increase in fresh weight and dimensions during maturity stages were also recorded for *Averrhoa bilimbi* L. fruits (Mathew, et. al., 1993). In the present work, the moisture percentage had no significant difference at various stages of ripening thereby remaining almost constant to 95. Varying moisture percentage of 93.9 and 87.4 was also recorded (Wealth of India[17,] Hough, et. al. 1971). A 90% moisture value was recorded by many research workers (Abdullah & Ragab 1970 ; Mathews, 1989). The *p*H values increased from 3.43 to 4.82 as fruit matures suggesting fruits are ripening and becoming less acidic. The varieties of carambola fruits were described on the basis of differing *p*H values, like *p*H 3.8 – 4.1 for sweet and those with *p*H 2.2 – 2.6 for tart (Lewis & Grocizam 1989). Many researcher workers (Wealth of India [17], Sheth, 2005 [21,] Kapoor, 2005; Asolkar, et. al. 1965) reported the presence of oxalic acid, proteins and sugars in carambola fruit. In the present work, the ascorbic acid content was found to be higher in ripe fruits in comparison to young and half ripe fruits. This pattern has also been observed in bilimbi, guava (Esteves MTda, et. al. 1984)and camu-camu (Zapata, 1993) fruits. An increase in amino acid content was observed in ripe and half ripe fruits compared to young fruits. The amino acids along with other composition of the fruit have also been reported (Hall, et. al., 1980; Burguera, et. al., 1992). Oxalic acid has been identified as the main acid in carambola and bilimbi (Joseph, & Mendonca 1989; Wilson, et. al. 1982) and variation in oxalic acid 0.08 to 0.73 % for ripe carambola fruit was recorded in the present work. However, in the present investigation, an increase in oxalic acid content was observed with maturation, a characteristic that can be held responsible for low *p*H values of the fruit. The pectin content was high in ripe fruits as compared to the young and half ripe fruits.

CONCLUSION

The chemical composition of edible fruits may differ according to maturity. The composition of carambola fruits at different stages of maturity has been studied which revealed a large variation in the physical and chemical parameters. One unchanged characteristic of the fruit noted in the present study, despite of its maturing stages is the high moisture percentage. Reducing sugars, total sugars, soluble protein, amino acids, ascorbic acid, oxalic acid and pectin content increased with maturity. A significant decrease in chlorophyll content was observed in ripe fruits, in comparison to young and half ripe fruits, which was indicated by golden yellow colour of fruit at ripe stage.

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