

PHYSICOCHEMICAL CHARACTERISTICS OF BILIMBI (*Averrhoa bilimbi* L.)¹

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ABSTRACT- The aimed of this work was to investigate the effects of maturity stages on the physicochemical characteristics of bilimbi (*Averrhoa bilimbi* L.) which were cultivated in Recife-PE. During one year, the fruits were harvested from five different trees (unidentified variety) in mature and half-mature stages. They were analysed on total soluble solids (TSS), oxalic acid and vitamin C. Ripe fruits had the highest levels of TSS and vitamin C and lowest levels of oxalic acid, independently of weather conditions. The results showed that maturity stage influenced on physicochemical characteristics of bilimbi fruits.

Index terms: *Averrhoa bilimbi* L., physicochemical characteristics, maturity stages.

CARACTERÍSTICAS FÍSICO-QUÍMICAS DO BILIMBI (*Averrhoa bilimbi* L.)

RESUMO- Este trabalho teve como objetivo investigar o efeito do estágio de maturação sobre as características físico-químicas do bilimbi (*Averrhoa bilimbi* L.) cultivado na Cidade do Recife - PE. Os frutos foram colhidos de 05 árvores (variedade desconhecida), nos estádios de maturação maduro e semimaduro, durante um ano. Foram realizadas as determinações de sólidos solúveis totais (SST), ácido oxálico e vitamina C. Os frutos maduros apresentaram maiores valores de SST e vitamina C, e menores de ácido oxálico, independentemente das condições climáticas. Os resultados demonstraram que o estágio de maturação influenciou nas características físico-químicas do bilimbi.

Termos para indexação: *Averrhoa bilimbi* L., características físico-químicas, estágio de maturação.

Averrhoa bilimbi L., commonly known as bilimbi, belongs to the family of the Oxalidaceae. It is widely cultivated in the tropics and its origins are not yet clear. Nevertheless, Corrêa (1926) reported that it is native of India, from where it was brought to Brazil centuries ago. In Brazil, this tree is cultivated in the states of Rio de Janeiro, Amazonas, Pará and Santa Catarina, but the distribution of its fruits is limited. In these places, it is locally known as “bilimbi”, “bilimbino”, “biri-biri”, “caramboleira amarela” or “limão de caiena”.

Bilimbi is a small tree up to 15 meters high. Fruits are fairly cylindrical with five broad rounded longitudinal lobes, and produced in clusters (Figure 1). During maturity stage occurs the maximum increase in fruits weight and dimensions, and their external green colour changes into light yellow (Mathew et al., 1993). Bilimbi fruits are very sour, and used in the production of vinegar, wine, pickles and in the preparation of Hindu dishes. The mature fruits can be eaten *in natura* or processed into jams and jellies. Medicinal uses are attributed to bilimbi, which include mixtures against cough, mumps, rheumatism, pimples and scurvy. The fruit juice has high levels of oxalic acid, and therefore may be used to remove iron-rust stains from clothes and to impart shine to brassware (Corrêa, 1926; Joseph & Mendonca, 1989, Lennox & Ragoonath, 1990; Wong & Wong, 1995).

Many researchers around the world have studied bilimbi. However, the chemical composition of the same strain of edible plants grown in different parts of the world may be very different because of many factors; chiefly: genetics, soil,

location, season and maturity stage. This is especially true for edible plants that have not been genetically standardised. Thus, it is usually advisable that physicochemical analysis should be made on raw plants that will be consumed by human beings (Harris, 1977). Hence, once local community eats this fruit, the aim of this study was to investigate the effect of maturity stages and weather conditions on the physicochemical characteristics of bilimbi cultivated in Recife, at the Northeast of Brazil.

Bilimbi fruits of an unidentified variety (collected from five different trees) were harvested at two stages of maturity, subjectively determined by colour development: yellowish-green fruits were considered ripe whereas those, which presented a light green hue, were considered half-ripe. The harvests took place during the periods of September/97 to April/98 (dry season) and May/98 to August/98 (rainy season), the average seasonal rainfall of which were the lowest (53.66 mm) and the highest (203.82 mm), respectively. The experiment was carried out in a randomised design and at each 30 days interval; five ripe and five half-ripe fruits from each tree were collected, into and around the canopy, in the morning and cleaned. The fruits were hand pressed so the juice could be obtained. They were analysed in duplicate by the following parameters: pH at 25°C; total soluble solids rate - TSS; total acidity (measured by titration, with 0.1 N NaOH using phenolphthalein as indicator). The total acidity results were expressed in g oxalic acid per 100g of fruit juice by using 0.045 as factor. All the parameters above mentioned were determined by AOAC methods (1990). Vitamin C content was

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determined by 2,4-dinitrophenylhydrazine spectrophotometric methods of Strohecker & Henning (1965). Oxalic acid, vitamin C and TSS data were submitted to variance analysis in order to compare the different stages of maturity and season. The differences between the averages were compared according to Tukey test at 5% of significance level. Minitab-10 for windows software was used.

Ripe bilimbi fruits have thin skin, yellowish-green colour, soft texture and a peculiar smell, which resembles the one of carambola, a fruit of the same botanical family. Half-ripe fruits have firm texture and imperceptible smell. Fruits in both stages of maturity have small seeds the number of which varies from 3 (in small fruits) to 15 (in big fruits). This fruit is juicy and yields 76.14% in juice.

The physicochemical characteristics of ripe and half-ripe bilimbi fruits are shown on Table 1. These values refer to the averages of the determinations made during September/97 to April/98 (dry season) and May/98 to August/98 (rainy season). The total soluble solids (TSS) in bilimbi ranged between 3.94 to 5.06%. These levels were lower than those reported for carambola (8.0%) by Neog & Mohan (1991). Ripe bilimbi fruits had higher levels of total soluble solids than half-ripe fruits, independently of the season in which they were harvested. This happens because during maturation the starch is converted to sugars, and the complex sugars become simple ones (Chitarra & Chitarra, 1990). The lowest levels of total soluble solids were found in fruits (of both maturity stages) harvested during the rainy season. The TSS in bilimbi of same maturity stage harvested in dry and rainy seasons were statistically similar. Thus, TSS was not influenced by climatic factors.

The oxalic acid levels in bilimbi ranged between 8.57 and 10.32 mg/g. These high levels of oxalic acid found in bilimbi are probably responsible for its extremely low pH value (0.9-1.5 in both maturity stages - data not showed on table). Similar pH values were found in the sour type of carambola (1.25-2.0) (Lennox & Ragoonath, 1990). The fruits, of both maturity stages, which were harvested during rainy season, had higher levels of oxalic acid than those harvested during dry season. The oxalic acid level in bilimbi (ripe and half-ripe) harvested in rainy season was statistically different from ripe fruits harvested in dry season.

Joseph & Mendonca (1989) also reported variations on levels of oxalic acid in bilimbi in Guyana, in two different seasons. The fruits collected during season I had the highest levels of this acid (11.2-14.7 mg/g in green fruits and 9.86-10.8 mg/g in ripe fruits) when compared to those harvested during season II (10.50-14.00 mg/g in green fruits and 8.45-9.00 mg/g in ripe fruits). Wilson et al., (1982) reported an oxalic acid variation of 0.8 to 7.3 mg/g for ripe carambola, which is lower than the variation detected in the present work. Oxalic acid has been identified as the main acid in carambola and in bilimbi (Bailey, quoted by Joseph & Mendonca, 1989). Other food also has high levels of oxalic acid, such as spinach (8.22 mg/g), cocoa powder (4.5 mg/g) and tea leaves (3.8-14.5 mg/g) (Franco, 1987).

Ripe bilimbi fruits have higher vitamin C content than half-ripe ones. This pattern has also been observed on guava (Esteves et al., 1984) and camu-camu (*Myrciaria dubia*) (Zapata & Dufour, 1993). In other fruits, like acerola (*Malpighia sp.*), the opposite happens: the highest levels of vitamin C are found in half-green and green fruits (Carvalho & Manica, 1993). The levels of vitamin C in ripe and half-ripe bilimbi fruits varied from 20.82 to 60.95 mg/100g, as shown on Table 1. The vitamin C levels in ripe and half-ripe bilimbi harvested in the same season were statistically different. Ripe fruits harvested during dry season had the highest vitamin C level. This result may have been influenced by climatic factors. As expected, during the dry season, an increase of photosynthetic activity (induced by rising solar radiation and reduced average seasonal rainfall) produces higher levels of vitamin C, since this vitamin is synthesised from hexose sugar precursors (Harris, 1977). In spite of the low levels of vitamin C in bilimbi, the ripe fruit has significant amount of this vitamin. Therefore, the medicinal use of this fruit against scurvy, which was recommended by Corrêa (1926) and Wong & Wong (1995), can be justified.

Based on results it may be concluded that maturity stage influenced on physicochemical characteristics of bilimbi fruit and ripe bilimbi harvest during dry season showed the lowest levels of oxalic acid and the highest levels of SST and vitamin C. Therefore, it is recommended that this fruit should be consumed when it is completely ripe.

Table 1 - Chemical characteristics in ripe and half-ripe bilimbi fruits harvested on dry and rainy seasons.

	Dry Season*		Rainy Season**	
	ripe fruits	half-ripe fruits	ripe fruits	half-ripe fruits
Oxalic acid (g/100g)	8.57 d	9.33 bd	9.82 bc	10.32 ab
Vitamin C (mg/100g)	60.95 a	32.23 cd	36.68 bc	20.82 de
TSS (°Brix)	5.06 a	4.34 bc	4.64 ab	3.94 cd

The averages on the same line followed by similar letters do not statistically differ from probability level of 5% (Tukey test)

* Values refer to the averages of determinations made during September/97 to April/98

** Values refer to the averages of determinations made during May/98 to August/98



FIGURE 1 - The bilimbi fruits

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