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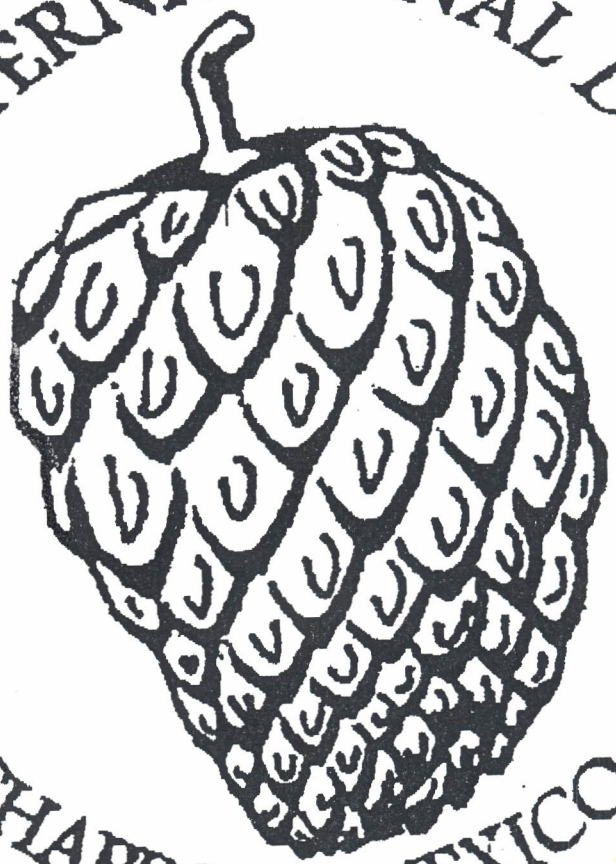

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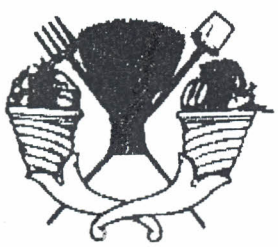

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PHYSICAL, PHYSICO-CHEMICAL AND CHEMICAL CHANGES DURING GROWTH AND MATURATION OF SUGAR APPLE (*Annona squamosa* L.)

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KEY WORDS: *Annona squamosa* L., sugar apple, harvest indices, study growth, maturation.

ABSTRACT

Brazilian fruit production has been increasing due to favorable ambient conditions, mainly in irrigated areas. This fact leads to increased income and job offer as well as new opportunities in the international trade of fresh fruit. Among commercially cultivated Annonas, sugar apple (Annona *squamosa* L.) can be considered as one of the most representative. This work aimed to study growth and maturation of sugar apple fruit, in order to gather information for the determination of their harvest indices. Seven Hundred ninety two -792 - plants from a commercial orchard in Petrolina, Pernambuco state, Brazil, were used in the experiment. The plants were 2 years old and were located within an area of 4 x 1.5 m. 239 new by formed fruits in 156 plants were tagged. Weight and diameter were measured weekly, in a sample of tagged fruits until their completion of growth., Total soluble solids, titrable acidity of pulp and chlorophyll content of peel were also measured periodically during the experiment. Results showed that there were increases in total soluble solids from 4.2 to 27.56 °Brix and titrable acidity from 0.14 to 0.29 %, while chlorophyll content decreased from 68.97 to 27.57 mg/100 g. It could be concluded that fruits reached complete maturation in 15 weeks.

ALTERACIONES FÍSICAS, FISICO-QUÍMICAS E QUÍMICAS DURANTE EL DESARROLLO E MADURACIÓN DE FRUTOS DE LA "ANÓN" (*Annona squamosa* L.).

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PALABRAS-CLAVES: *Annona squamosa* L., anón, desarrollo y maduración,

SUMMARY

El Brasil viene presentando un aumento significativo en la producción de frutas, debido sus características edafoclimáticas favorables, notadamente, en los polos irrigados. Este cuadro viene generando empleos y renta para millones de personas, bien como conquistando nuevos espacios en el competitivo mercado internacional de frutos in natura. Entre las annonaceas cultivadas con interés comercial , la "anón", (*A. squamosa* L.), tambien llamada de pinha o fruta del conde es uno de los principales representantes de la familia. Con el objetivo de estudiar el desarrollo y maduración de los frutos de "anón", asi como obtener subsidios para la determinación del punto de cosecha, fué instalado el experimento utilizandose 792 plantas de un pomar comercial irrigado, localizado en la alcaldia de Petrolina - PE. El área utilisado fué compuesto por plantas de 2 años sembradas en espaciamento de 4 x 1,5 m. Fueron marcados 239 frutos recién formados en 156 plantas. En una muestra de frutos marcados, a cada 7 días eran realizadas mediciones de largura e diámetro, hasta el completo desarrollo del fruto. Paralelamente a 0, 21, 35, 49, 56, 63, 70, 77, 84, 91, 98, 105 dias, eran cosechados 5 frutos para el acompañamiento de alteraciones fisicas, fisico-quimica y químicas. Los frutos alcanzaron su completa maduración en 15 semanas. Los frutos presentaron durante el desarrollo y maduración, aumento en los teores de sólidos solúbles totales de 4,2 para 27,56 y de acidez titulable de 0,14 para 0,29, en cuanto que ocurrió una diminución en el teor de clorofila de la cáscara de 68,97 para 27,57.

INTRODUCTION

Brazil has been recognized as an important fruit producer, specially the tropical and subtropical ones. Annonas have been grown in this country for a long time.

Annonaceae family has a great number of genus and species, the major number native of tropical or subtropical regions. Among those which have commercial interest, sugar apple is considered as important (KAVATI, 1992).

Sugar apples are trade as fresh fruits, with restrict use in industry. Sugar apple is considered as the main one in the family Annonaceae, being important in various Brazilian Northeast states and Sao Paulo.

Sugar apple trees were formed with seed plants. Fruit characteristics are variable, mainly the form of fruit and its color, rugosity of each carpel, intercarpel tissues coloration, and que quantity of cells in pulp.

Development of fruit occurs in a variable rate, in function of dichogamy associated to climate conditions: high temperature and low relative humidity dry the stigma very fast; rain obstructs pollen transport, while low temperatures diminish polinizing insects action.

COGEZ & LIANNAZ (1994) observed that development percentage vary depending on the cultivar THAI LUP type, in open polinization shows 0% of development and cv. New caledonian, 3.6%. When manual polinization is used, development rate exceeded 90%.

Tryings to increase shelf life of sugar apples for fresh consumption's must consider their own characteristics: their formation and maturation physiology, chemical and physical characteristics. Through these parameters, harvest and post-harvesting techniques are defined.

Annonaceae fruits are classified as climateric, due the increase in respiratory activity and ethylene production during their maturation. These fruits complete ripening process after harvesting. Sugar apple show only one climateric peak, differently from the other annonaceae fruits (BROWN et a., 1988; TSAY & WU, 1990; KUMAR, 1995). According to LEAL (1990) climacteric respiratory occurs before ethylene production, although the phenomenon begins to increase before the respiratory maximum. (BROWN et al. 1988).

Increasing in the respiratory activity in annonas is accompanied by fast modifications in chemical composition, where taste and aroma becomes very pleasant, while pulp firmness diminishes (BROW et al. 1988). Soluble solids increases, mainly carbohydrates and organic acids, and volatile compounds. Maximum quality for consumption is reached with high soluble solids and titrable acidity (LEAL, 1990; LILIA & REGINATO, 1990; TAYLOR, 1993).

High proportion of sugars, specially fructose, exceeding the level of sucrose, contributes for the very sweet taste of these fruits, because fructose is 1,7 times sweeter than sucrose (LEHNINGER, 1976).

When soluble solids values increase, pulp pH values decrease significantly, and titrable acidity increases about ten times, from 0,067 g to 0,67 g of malic acid per 100 grams of pulp, due an increase of 7 times in malic acid concentration values and three times in citric acid (PAULL et al., 1983).

Volatile compounds production is parallel with ethylene production, reaching the maximum 5 days after harvesting, in the same occasion where it can be seen maximum values for sugars and acids (PAULL et al., 1983) and higher sensorial acceptability.(LIZANA & REGINATO, 1990).

After peak, there is a falling in the main aroma compounds production, with the release of volatile compounds which are associated to strange aroma of super ripened fruit. (PAULL et al., 1983). This same tendency is observed in relation to sugars and organic acids. Therefore, fruits loss their quality after the ripened stage.

Sugar apples must be harvested manually before maturation, in order to avoid splits and damage caused by falling of fruits from the tree. Sugar apples are very difficult to harvest due their tendency of splitting caused by carpels separation (LEAL, 1990). BLEINROTH et al. (1992) recommends the use of ladders in the harvesting operation, and fruits must be gotten with scissors or knife, never by twisting them.

MATERIAL AND METHODS

Seven Hundred ninety two -792 - plants from a commercial orchard in Petrolina, Pernambuco state, Brazil, were used in the experiment. The plants were 2 years old and were located within an area of 4 x 1.5 m. Two hundred thirty nine just formed fruits were tagged i 156 plants.

Length and diameter measurements were done each 7 days , until fruits were completely developed and ripened.

In parallel, 5 tagged fruits were harvested and taken to Physiology and Postharvest Laboratory of EMBRAPA/CNPAT. After physical measurements, fruits were peeled manually with aid of knifes. Skin, seed and pulp were separated and pulp was homogenized for chemical and physico chemical analysis. Methods used are described below:

- weight: a semi-analytical electronic balance was used. Results were expressed as grams, to the nearest 0.01 grams.

- length and diameter - measuring with callipers. Results were recorded in centimeters (cm), to the nearest 0,01 mm.

- pH: measured by potenciometry using glass electrode. Results expressed in pH units.

- titrable acidity: titrable acidity was done with diluted sodium hydroxide, as recommended by Instituto Adolfo Lutz (1985). Results were expressed as percentage of malic acid.

- Soluble solids: measuring with refractometer and expressed in °Brix as recommended bu AOAC (1990)

- total chlorophyll: extracted in acetone according to BRUISMA (1963), and calculated as mg/100 g of sample, according to the equation given by ENGEL et al. (1991), after measuring absorbancy at 652 nm.

RESULTS AND DISCUSSION

As can be observed in figure 1, development of fruit is a progressive variable. Weight gain values(figure 2) indicate a double sigmodial development model.

In this experiment conditions, fruits reached physiological maturity in 98 days (14 weeks). They showed a slight increase in solid values during development until reaching an value of 3,5 °Brix.

After maximum development , when stored during a period of 7 days at 24,5 °C and 75% R.H., solid soluble valve was 27,6 °Brix (FIGURE 3).

PAL & KIMAR (1985) observed two peaks during development: one between 45 and 60 days and another at 90 - 105 days. In São Paulo state conditions, fruits harvest before the second peak, don't reach consumption point, wilting and becoming-petrous fruits harvest in the beginning of ripening stage, whose main characteristic is carpels separation, leading to low quality pulp.

LIZANA & REGINATTO (1990) observed that from the blooming to the first peak it takes 100 days. In Chile, the ideal maturation index for harvest is reached after 9 months (± 39 weeks) .

Sugar apples showed an average of 35,5 seeds and weight of 347,39 grams.

According BEERTH et al. Apud PAL & KUNAR (1995), there is no relationship between fruit size and number of seeds, maybe due to the insufficient pollination, as prorosed by MAZUMDAR (1977). After reaching maximum development, fruits reach consumption point in 2 to 5 days, at ambient temperature of 28 ± °C.

FIGURE 4 shows pH values, which ranged from 5,28 to 5,80 at and 35 and 98 days, respectively. After harvesting and storage at ambient temperature, pH valvues diminished to 5.08. Titrable acidity expressed as citric acid was almost constant for 91 days, increasing until physiological maturation, completing the increment during storage (FIGURE 5).

REGO et al. (1989), analyzing pulp of mature fruits found the following values: Ph 4,35, 24 °Brix and titrable acidity of 0,88%. SILVA et al. (1986) found pH 4,62, titrable acidity 0,21mg/100g of pulp (citric acid) and 22,36 of total soluble solids (mg/100g).

BEERH et al. Apud PAL &KUMAR (1995) assure that for ripened fruits, total solids values vary from 20,6 to 28,0 °Brix, while titrable acidity ranges between 0,3 - 0,4 % mainly citric acid.

Harvest index usually used for sugar apples is the external appearance of the fruits, when they show carpels separation and yellowish-green color. In FIGURE 6 it is possible to see the lowering of chlorophyll values in the fruits skin, from 68,77 to 27,57 mg/100 g. At 98 days, when the fruits had reached physiological maturation, they showed in average values, 60,63% of pulp; 34,85% of skin and 4,43 % of seeds.

Comparing to values obtained for ripened fruits (45,55% of pulp, 46,66% of skin and 6,79% of seeds), there was only a slight difference between the two stages (FIGURE 7). Fruits with 350 to 450 grams of weight, diameter of 10 cm and length of 9 to 10,5 cm, show 56,6 of skin; 4,8 of

seeds and 38,6 of pulp. Fruits with 250 to 350 grams shows in average values, 107 carpel, about go normal ones, 27 under develoed and 65 seeds, generally, they have diameter of 9 cm and length of 9 cm. Skin is 52,8% of total weight, seeds 5,8 and pulp 41,4% (KAVATI, 1987).

Fruits analyzed by MAIA et al (1986) showed 54,19% of pulp, 38,18% of skin and 7,60 of seeds.

CONCLUSIONS

- In the experimental conditions, fruits can be harvested at 98 days (physiological maturation) and stored for 7 days at ambient temperature, reaching ripening.

- More studies about development of sugar apples are suggested, for establishment of another characteristic which were not indicated in this work and a study about the stability of such characteristics during storage.

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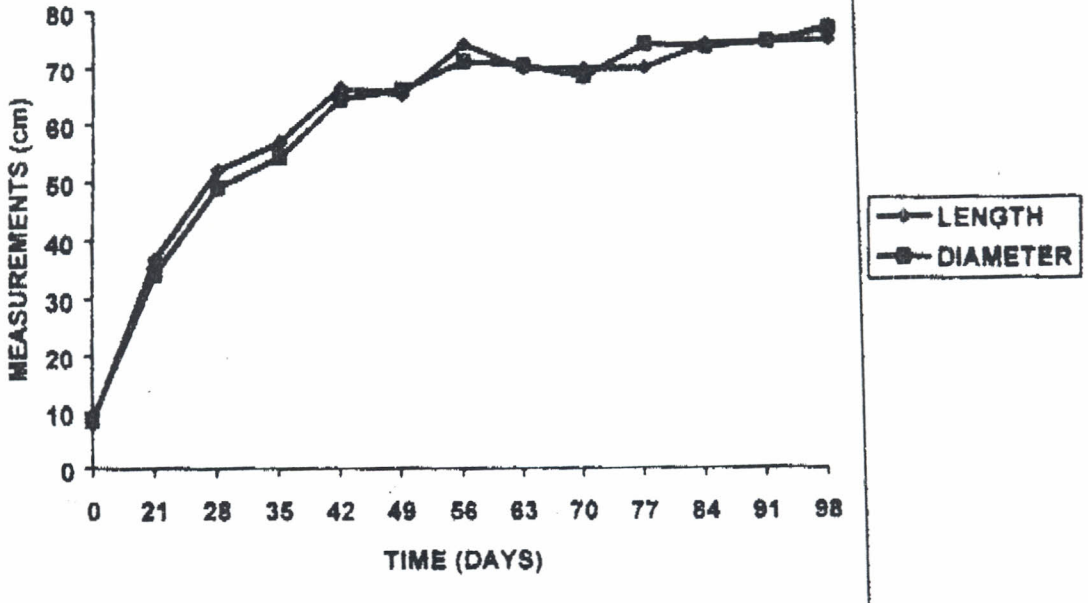

FIGURE 1 - Length and diameter values expressed as centimeters of sugar apples (*Annona squamosa* L.) during their development in Petrolina - Brazil

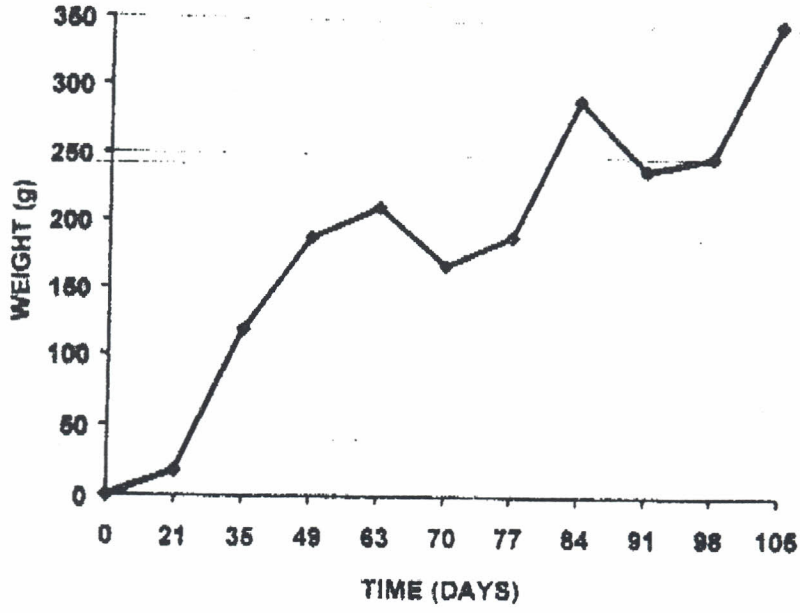

FIGURE 2 - Weight of sugar apples (*Annona squamosa* L.) during their development in Petrolina - Brazil

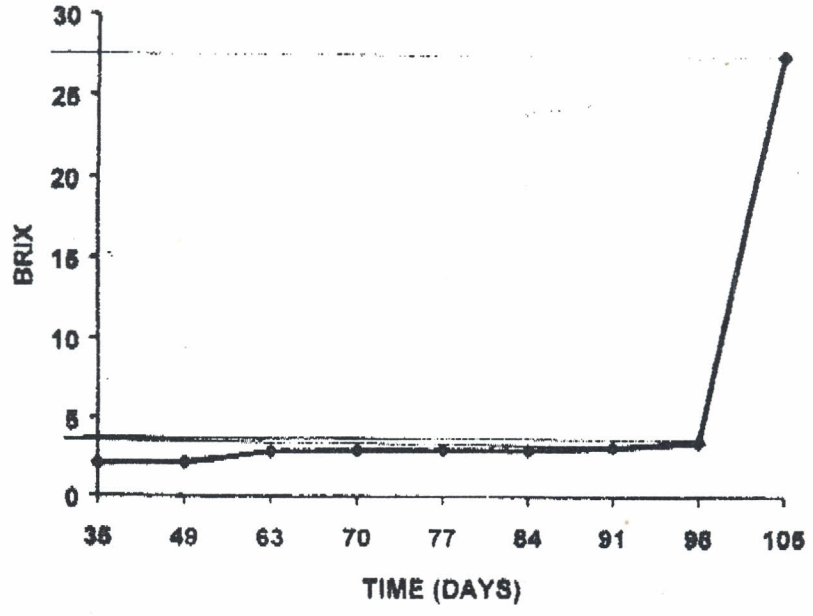

FIGURE 3 - Total soluble solids expressed as °Brix in sugar apples (*Annona squamosa* L.) during their development in Petrolina - Brazil

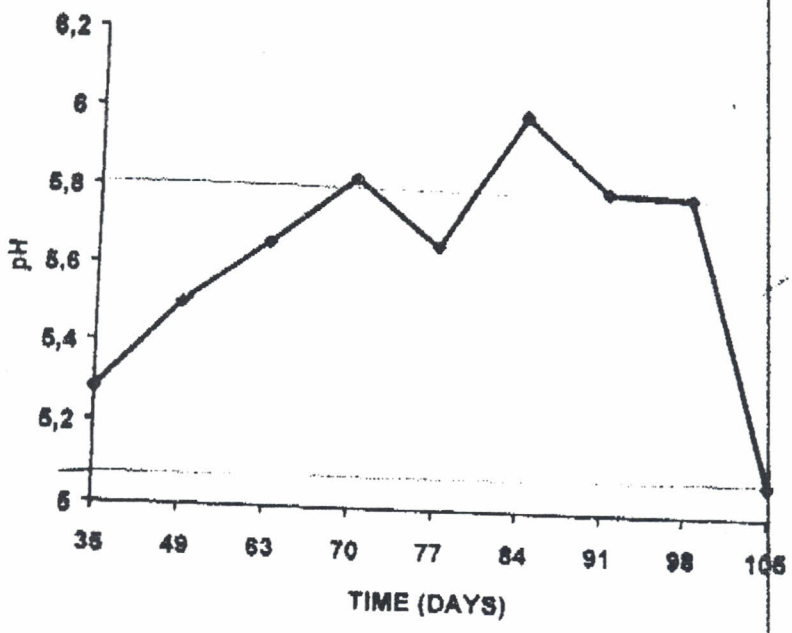

FIGURE 4 - pH values of sugar apples (*Annona squamosa* L.) during their development in Petrolina - Brazil

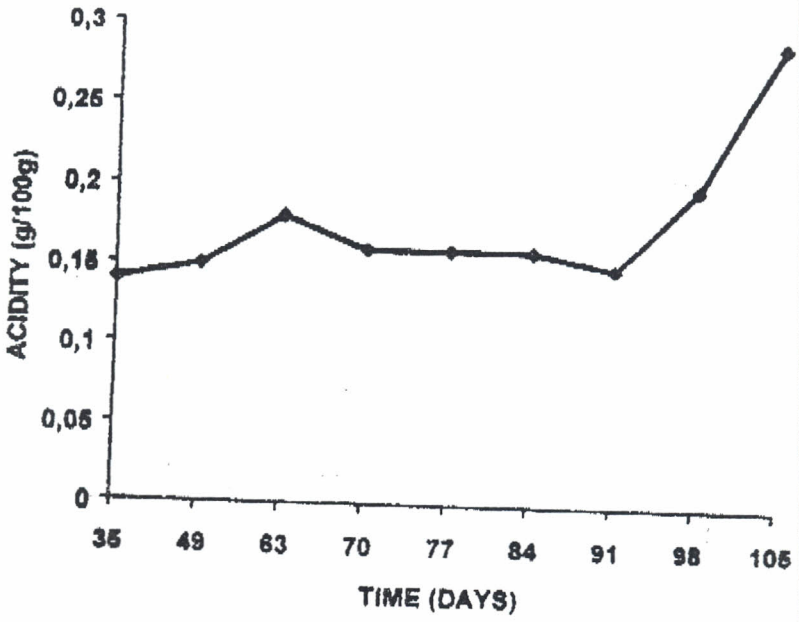

FIGURE 5 - Titrable acidity values expressed as percentage of citric acid in sugar apples (*Annona squamosa* L.) during their development in Petrolina

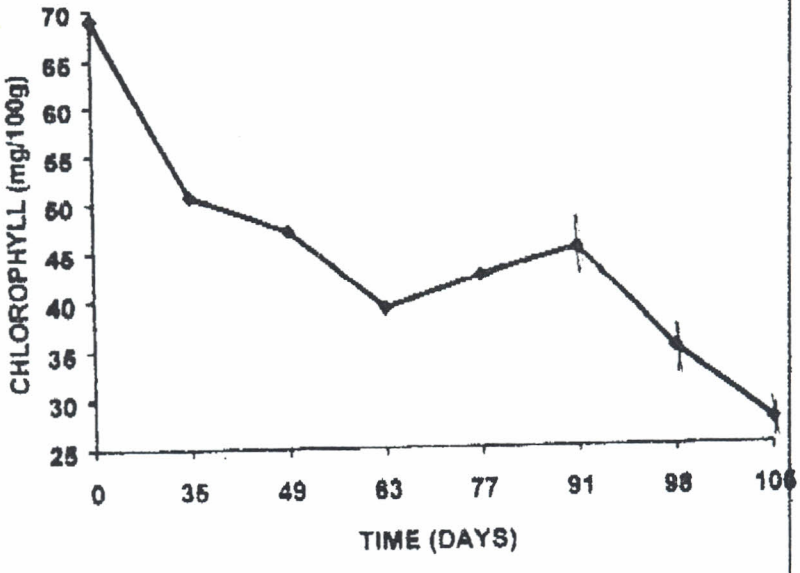

FIGURE 6 - Chlorophyll values expressed mg per 100g of skin of sugar apples (*Annona squamosa* L.) during their development in Petrolina

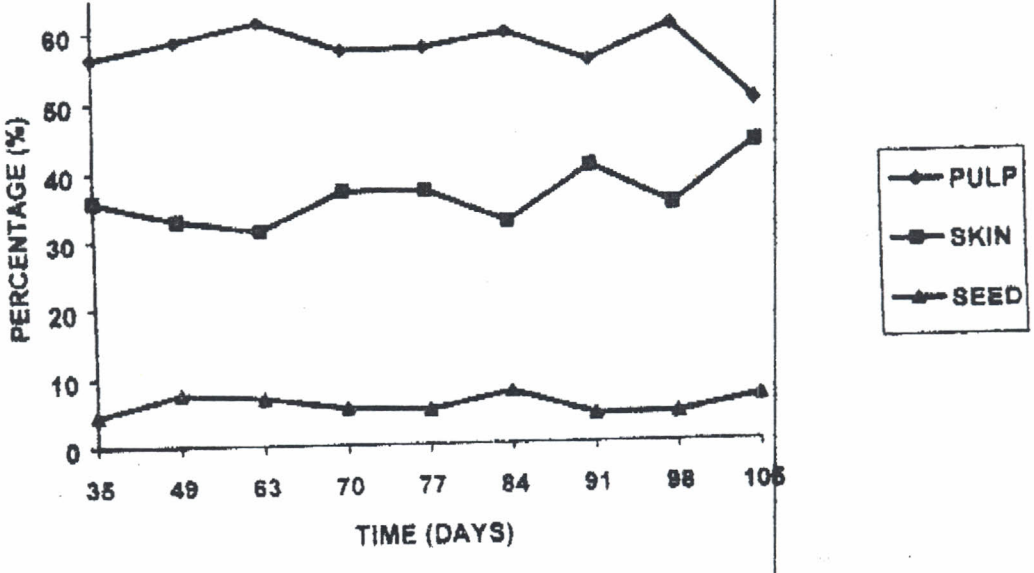

FIGURE 7 - Percentages of pulp, skin and seeds, of of sugar apples (*Annona squamosa* L.) during their development in Petrolina - Brazil.

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