METALOSATE® CALCIUM DOSAGES IN POST-HARVEST QUALITY OF BANANA

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SUMMARY

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ABSTRACT

Banana is considered the second most consumed fruit among Brazilians, with great domestic consumption and little export because it is a climacteric fruit of high perishability. The post-harvest quality of these fruits is fundamental for their commercialization, and the addition of calcium can prolong the quality of the fruits. In this study, the post-harvest quality of fruits submitted to doses of Metalosate of Ca was evaluated. A completely randomized design was used in a 5x4 factorial scheme, with five doses of Metalosate® of Ca (0.0, 0.1, 0.2 , 0.3, 0.4%) and four seasons (0,48,96,144 hours), with three replications. The fruit color was evaluated with a colorimeter, and determinations of soluble solids, pH and titratable acidity were performed. It is concluded that: a) untreated fruits mature and senescence early, but do not undergo undesirable changes in total soluble solids, pH and titratable acidity; b) the doses of Metalosate ® do not alter the total soluble solids, pH and the titratable acidity of the fruits; and c) Metalosate® Ca treated fruits remain green longer and maintains yellow color after maturation.

Keywords: Banana, quality, post-harvest, calcium.

1. INTRODUCTION

Originally from South-West Asia, the banana (Musa spp.) Is rich in vitamins and minerals, has great importance in the national agricultural scenario, ranks second among the fruit species produced in the country being surpassed only by orange.
In the 1980s, Brazil presented the largest areas of banana cultivation in the world and led the ranking of the largest producers of fruit, over the years this reality was changing and currently ranks fifth among the largest producers, surpassed by India , The Philippines, China and Ecuador. Even with this decline in the world scenario, culture has great possibilities of retaking the old placement, being necessary the investment in research and extension, resulting in improvements in the cultivation techniques for the producers.
With important importance in tropical countries, the banana stands out among other fruit crops for its ease of consumption, low acidity and soft texture being appreciated by different age groups in the consumer market.
Post-harvesting of the banana plays an important role in obtaining quality fruits. Post-harvest management is directly related to factors used for banana cultivation, such as crop organization, available labor, existing structure and final destination of production.
Of short longevity, the fruit resists a maximum of three weeks under refrigeration, whose high perishability is directly related to high respiratory rates observed in post-harvest.
In recent years, the use of foliar fertilizers containing calcium has been intensified, mainly due to the beneficial effects of this nutrient on the quality of the fruits and the improvement of its post-harvest conservation.
Calcium is essential for maintaining the integrity of the cell wall of plants, especially the stem and fruits. In addition, the nutrient acts on cell elongation and division, cell membrane structure and permeability, nitrogen metabolism and carbohydrate translocation. Calcium deficiency in plants results in a physiological disturbance that, in addition to reducing yields of fruit species, degrades fruit quality. In addition to this fact, the difficulty of correcting Ca deficiency problems in fruits due to low mobility of the nutrient in the phloem is limited, which limits its redistribution to fruit formation, which is why it is recommended to target the applications for growing fruit.

Different conditions may induce Ca deficiency in fruit, even when climate and soil conditions are considered adequate. One is the exacerbated application of nitrogen fertilizers, due to the N moving much faster than the Ca, causing the plant to grow much faster than Ca can move in plant tissues, inducing nutrient deficiency in growth regions and fruits. Another reason is that Ca moves passively through the xylem in perspiration, and the leaves exhibit higher perspiration rates than fruits. Under conditions of low availability of this nutrient in the soil (acid soils), excess moisture (low transpiration) or water stress (competition by sap), the calcium contents in the fruits may not reach adequate values.
As a result of this, the fruits present low levels of calcium, although the nutrient contents in the leaves are considered adequate. From the reports it can be assumed that the various forms of application of Ca recently used did not present great gains for the fruit species, however this reality changed with the arrival to the market of a new foliar product - Metalosate® technology, which has been demonstrating great efficiency in the ability to promote calcium translocation from the leaves to the fruits, resulting in gains in fruit quality, commercialization and post-harvest quality.
Based on the above facts and the lack of research of this nature, the present study was designed to evaluate the physiological effects of Metalosate® Ca on the post-harvest quality of banana cv. Nanicão in the region of Sinop-MT.

2 BIBLIOGRAPHICAL REVIEW

2.1. Economic and Social Importance of Banana Farming

Banana is considered one of the most consumed fruits in the world, presenting great economic potential in the international market, its cultivation is usually carried out by tropical countries where the climate is more appropriate to the development of the fruit species.
According to FAO - Food and Agriculture Organization of the United Nations, approximately 84% of the bananas produced in the countries are destined to feed the local population, with only 16% exported, generating an annual revenue of 8.4 billion dollars, boosting the economy many developing countries.
The consumption of the fruit is by processed products, fried, cooked, and mainly in natura.
According to Cordeiro (2009) in 2004 the banana was the most produced fruit in the world, being cultivated in 4.54 million hectares in 128 countries, with production of 70.59 million tons.
In the Brazilian harvest of 2012, the area planted was 523,421 hectares, harvested area was 476,744 hectares with production 6,846,611 tons obtaining average yields of 14,361 kg / ha (IBGE, 2013).
According to Fioravanço (2003), culture is important both economically and socially for the entities involved in the production system, contributing to job creation and development in the producing regions. According to Alves et al. (2007) in Brazil, its cultivation is practiced practically everywhere, but in the north and northeast of the country, banana cultivation is significantly superior to the other regions, where there are more than 110 thousand hectares of small crops conducted by agriculture family, with an annual production of 1.7 million tons in 2005. Borges (2004) states that in this crop, the small properties belonging to family agriculture have significant role in the final production of the fruit because they occupy 60% of the cultivated areas.

2.2. Post-Harvest Quality of Banana Fruits

The post-harvest quality concept encompasses several characteristics; the exteriority defined by the visual aspect (color, imperfections, freshness and shape), texture (firmness and resistance), taste, smell or aroma, nutritional quality and food safety. Still according to the author, the nutritional quality and health of the food are considered important characteristics when dealing with human health, these being decisive aspects in the acceptance of the consumer.

According to Lichtemberg (1999), the correct postharvest management provides higher quality to banana fruits, and poor management results in devaluation in the domestic market and lower export of fruit. Lichtemberg (1999) states that ripening and storage are essential to obtain quality fruits, and maturation induced in controlled maturation chambers is used. This author further states that atmospheric air, air circulation and exhaust, ripening gas, relative humidity, and temperature are basic requirements to standardize the maturation and sale of the product.
Banana is a climacteric fruit, which has high rates of respiration, which trigger numerous biochemical and physiological transformations during maturation. The fruits are removed from the field still green at the end of the physiological development, with the disappearance of the corners of the fruits (BLEINROTH et al., 1992).
Moreira (1987) states that in the physiological maturation of the banana, the exogenous ethylene (C2H4) is applied in climatized environments providing a fast ripening of the fruit. On the other hand, high respiration rates allied to environmental factors such as relative humidity and temperature accelerate physiological processes such as endogenous ethylene production and high transpiration rates. These processes are related to banana conservation and durability (Finger et al., 1995).
Post harvest is considered one of the most difficult stages to handle in the crop, the product in natura provides high losses for the producer. The lack of pre-cooling causes phytopathological damage, increases the attacks of micro-organisms. Mechanical damage is the major cause of fruit injury (BLEINROTH et al., 1992). Inadequate management of fruits after harvest results in devaluation of the product in the national and international markets (Lichterberg, 1999). The high perishability and storage conditions are responsible for losses between 20 and 80% of banana production in developing countries (TADINE et al., 2008).

2.3. Calcium in Pre and Post-Harvest Fruits

According to Prado et al., (2004) calcium deficiency leads to a marked deterioration of the membranes, with a change in their architecture, fluidity and permeability to the passage of water. There is a tendency to associate increase in firmness with elevation of the calcium content in them. It is stressed that the maintenance of the cell wall integrity and the firmness of calcium treated fruits is the result of the reduction of the depolymerization due to the Ca + 2 bonds to the free carboxyl groups of the cell wall polygalacturonate polymers and the middle lamella. Thus, it can be understood that calcium deficiency would cause internal collapse of the fruits.

Although it is possible to increase the availability of calcium in the soil through liming or calcium nitrate fertilization, however, studies have shown that gains in production and product quality are small or insignificant.
According to Souty et al. (1995), the benefits of calcium application in improving fruit conservation have been attributed to the fact that this nutrient reduces the rate of softening of fruits and ripening in general. Calcium treatments did not affect the production and solids content (ºBrix) during storage, however, it was verified that post-harvest treatments with 2% calcium chloride were beneficial in maintaining the hardness of kiwis in all sizes especially in the larger ones (ANTUNES et al., 2005)
Quaggio et al. (1998) in a study with orange cultivar verified increases in the accumulated production of four orange crops due to the addition of gypsum, but the low intensity of response would not justify the application of the product. Takasu et al. (2006) reported a higher shoot growth and roots and higher calcium uptake by melon seedlings treated with

agriculturalgypsum.
The application of Ca in pre-harvesting of apples increased hemicellulose, total pectins and Ca content in the pulp, reducing the rate of cell wall hydrolysis, caused by the enzymes β-D-galactosidase, polygalacturonases (PG) and pectilmethylesterases (PME) (SIDDIQUI & BANGERTH, 1995).

Thus, in order to preserve the integrity of the cell wall, several studies have shown that calcium helps reduce the post-harvest quality loss of fruits (LARA et al., 2005; HERNÁNDEZ-MUÑOZ.et.al.,2006).
Evangelista et al. (2000) evaluated the influence of pre-harvest calcium levels (0, 2.5 and 5.0%), observing its effect on the activity of polygalacturose, pectinamethylesterase and b-galacturose enzymes in 'Tommy Atkins' as in storage. They concluded that the fruits that received the treatment 5.0% CaCl2 presented a significantly firmer texture. There was no significant difference in PG activity in fruits. Regarding β-galactosidase activity, the higher the calcium concentration, the lower the observed activity.
Senevirathna and Daundasekera (2010) studying the effect of vacuum infiltration of calcium chloride on the life and quality of tomato cv. 'Thilina' found that increases in CaCl2 concentration resulted in delayed fruit color development, decreased ethylene production rates and time delay required to reach climacteric ethylene. Treatment with CaCl2 does not have a considerable effect on fruit pH, total soluble solids and titratable acidity.
Silva and Menezes (2001) evaluated the post-harvest quality of the 'Tommy Atkins' mango submitted to the pre-harvest application of CaCl2 and refrigerated storage.

The foliar sprays were started about 35 days after anthesis, within 15 days. CaCl2 concentrations did not result in an increase in calcium content in the fruit and did not influence fruit firmness either.
Recently, products containing amino acid-chelated calcium molecules (Metalosate®) have been accredited to attend to organic farming, these products lead to the plant amino acids and nutrients required by the various metabolic routes that influence the development and cell division ALBION (2000). This author explains that Metalosate® Ca results from the union of two glycine (amino acid) so that calcium to be absorbed by the plant is recognized as a photoassimilate, enabling its translocation by the phloem making the nutrient more mobile in the plant.
ALBION (2000) reports that studies with sprays of Metalosate Calcium and polycarboxylic acid associated with calcium nitrate in grapes have shown that applications with Metalosate® Ca have led to greater accumulations of calcium in fruits. This report also reports that the farmers noticed that grapes treated with Metalosate ® Ca had lower incidence of gray rot - Botrytis cinérea, because it presented a more resistant bark. According to this author, a positive point of the use of Metalosate® Ca is that besides being able to be associated with gibberellic acids, insecticides and fungicides, this still has synergistic effects with these products.

2.4 Fruit Color Assessment - Colorimetry

Color is one of the most important criteria when choosing food. The coloring of foods makes it possible to understand part of their nutritional composition and can be useful in the formulation of balanced meals. The more colors involved in feeding the greater variety of nutrients ingested, each color refers to specific nutrients and benefits for each food. This rule applies especially to fruits, vegetables, and grains. The main pigments responsible for coloring in foods are chlorophylls, carotenoids and anthocyanins. The color of the banana peel is directly related to the shelf life of the fruit and its commercialization, being the degradation of chlorophyll the most important physiological event (CHITARRA and CHITARRA, 2005). Vilas Boas et al. (2001) states that the green color of the banana peel in the pre-climacteric period is due to the presence of the chlorophyll pigment, which is rapidly degraded during fruit ripening, revealing the carotenoids which are the pigments responsible by the yellow color of ripe banana peel. Colorimetry has been used in the determination of different pigment colors that are part of plant morphology and physiology such as anthocyanins, which are plant pigments found in flowers, fruits, leaves, stems and roots with varying color between red and violet. Chlorophyll, considered as the most abundant pigment in plant species occurring in leaves and other plant tissues with more intensity in the pre-climacteric stage, characterized by green coloration, its tonality is established by the presence of chlorophyll a and b. The loss of color of climacteric plants is related to the breakdown of chlorophyll structures resulting from the change in pH of the medium, the presence of oxidizing agents and the presence of chlorophyllase enzymes that separate phytol from porphyrin in the chlorophyll molecule, causing degradation of the pigment and giving space to the carotenoids (AWAD, 1993). Carotenoids are groups of pigments responsible for the yellow to red color in vegetables, and are important in human food for their conversion into vitamin A, considered a great ally in the fight against the nutritional problems currently faced. In the banana the presence of carotenoids evidences the maturing of the fruit and its synthesis happens before the total degradation of chlorophyll (VILAS BOAS et al, 2001).

The destruction of chlorophyll is made by the activity of the enzyme chlorophyllase allowing the appearance of the yellow in the bark of the fruit. Enzymatic activity and fruit respiration rates are correlated in time until climacteric fruit maximal respiration occurs (AWAD, 1993).

The techniques found for color determination vary between a simple visual perception and even digital devices called colorimeters and spectrophotometers (LOPES et al., 1998). Understanding the characteristics that influence the determination of coloring favors the processes of color conversion in numbers. The color is influenced by the characteristics involved in each measurement, such as hue, luminosity and degree of saturation. In research to determine the color of food, the coordinates L *, a * and b * in the CIELAB scale are the most indicated because they are the ones closer to the human vision (Mélchesi and Boschi, 1999).

The colorimetric determination is based on the CIE (Commission Internationale de l'Eclairage) system that has standardization of illuminants and observers. The CIE has established color coordinates L *, a *, b * for color determination. According to Farkas (2003), in the CIEL * a * b * color system, the value L * is the luminosity measured on a scale from 0 (totally black) to 100 (totally white), the value a *, which defines the axis which varies between green (-60) and red (+60), where negative values mean the predominance of green and the positives of red; and the value b *, represented by the axis that varies between blue (-60) and yellow (+60), with negative values indicating the predominance of blue and positives of yellow. The formula ΔE = [(L) 2+ (a) 2+ (b) 2] 0.5 establishes the difference of colors by the CIELAB system, Δ refers to the variation of the highest and lowest values of the respective coordinate (MINOLTA, 1998).

3 MATERIAL AND METHODS

3.1. Place of Experiment

The fruits used in the experiment were collected at the rural property of Mr. Getúlio Bianchi, called Sítio das Videiras in Sinop-MT, whose geographic coordinates are 11 ° 42'12 "S and 55 ° 27'36" O, with an altitude of 380 m . The analyzes of the vegetal material were carried out in the Laboratory of Food Technology of UFMT - Sinop.

3.2. Climate Description

According to the classification of Köppen, the climate of the region is Aw, characterized by high temperatures and average annual precipitation of 2000 mm with well defined dry season, winter and summer. The average temperature difference between the hottest month (October) and the coldest (June) is 15 ° C, with an average annual temperature of 30 ° C.

3.3. Plant Material Used

Bananas of the cultivar nanicão from the production area of Mr. Getúlio Bianchi in Sinop -MT were used. It was decided to evaluate the post-harvest useful life of this cultivar because it is the most commercialized in the region and does not have many studies related to post-harvest and technologies suitable for the conservation and quality of the fruits. Three bunches of bananas were selected for the study, all of them receiving the same cultural treatments, fertilization, pest and disease control and crop management.

3.4. Experimental Design and Treatments

A completely randomized design was used in the 5 x 4 factorial scheme with three replicates, with five doses (0.0, 0.1, 0.2, 0.3 and 0.4% of Metalosate® of Ca and four evaluation (0,48,96 and 144 hours). The experimental units were composed of 4 fruits per plot.

3.5. Conducting the Experiment

The harvest was performed on April 18, 2015 in the early hours of the day and sunny weather conditions occurred manually and randomly. The bunches were washed in running water with detergent solution to remove latex and dirt from the field. Soon after the cleaning the fruits were transported in plastic packaging to the Bianchi Food Industry, where fruits with visible imperfections and presence of disease and / or pest attack were discarded.

Diluted and selected bananas were immersed in a solution containing Metalosate® of Calcium (0.1, 0.2, 0.3 and 0.4%) for a period of 5 minutes, after immersion, cooling was carried out in chambers of refrigeration at temperatures of 13ºC ± 1ºC and 75% ± 5% relative humidity for a period of 12 hours. After cooling, the bananas were harvested for air conditioning in an environment with a temperature of 14ºC ± 2ºC and relative humidity of 75% ± 5% and subjected to a treatment with ethylene aiming at the uniformity of ripening, for a period of 24 hours. During refrigeration and air conditioning the bananas were kept in the same containers used for transport. Soon after the climatization, the fruits were taken to the Laboratory of Food Technology of UFMT-SINOP where the chemical and physical analyzes of the plant material were carried out.

3.5.1. Physical-chemical analysis of collected fruits

a) Fresh Fruit Pasta - obtained with the use of a RADWAG digital scale, model WTB3000 with precision of 0.1 g and capacity for 3 kg.
b) pH: 10 g of pulp were diluted in 100 ml of water until complete homogenization and then the pH was determined on a model bench pHmeter.
c) Soluble solids: after grinding of the pulps in the blender the solution was filtered to make the reading of soluble solids using a portable refractometer, brand IMPAC and 25º C standard temperature. The results were expressed in ºBrix degrees, according to Adolfo Lutz Institute's Analytical Standards (1985).
d) Titratable acidity: 5 g of crushed pulp was weighed and transferred to a 125 ml

Erlenmeyer flask containing 50 ml of water. The solution was added 4 drops of phenolphthalein, titrating it with 0.1 or 0.01M sodium hydroxide solution, until rosacea was reached. The results were expressed in% of malic acid according to Adolfo Lutz Institute (1985).

e) Coloring of the Fruit: a Colorimeter, model CR-400, brand Konica Minolta, was used, whose readings are expressed in the CIELAB system, which is the color system most used for food assessment. The Colorimeter performs readings through reflectance and its measurements are based on the L * variables (measures the clarity of the sample and ranges from 0 to 100 where 0 refers to total black, and 100 to total white), a * (positive, trend of red color, negative color trend for green color) and b * (positive, color trend for yellow tint, negative, color trend for blue tint).

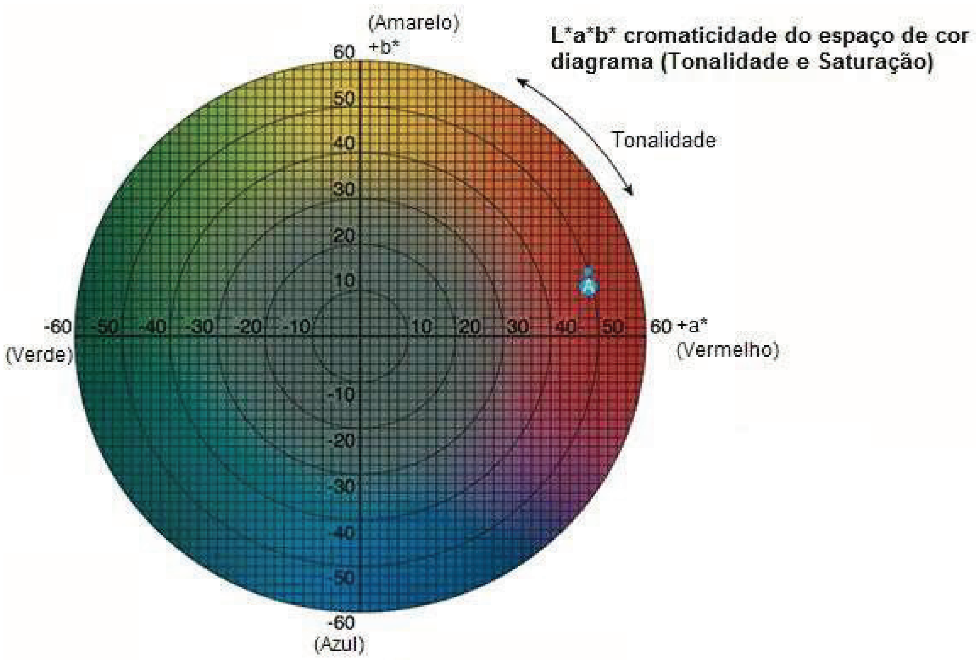

Figure 1. Graphical representation of the coordinates L * (luminosity), a * (red-green component), and b * (yellow-blue component) of the CIELAB system (MINOLTA, 1998).

From each fruit were measured at two central points (upper and lower) with the same distance between them as proposed by Francis (1980) and Boudhriouaet al. (2002) using the means obtained to determine the results. Using the methodology Witherspoon & Jackson (1996), with each measurement performed the fruit was turned 90º reducing color change and improving the handling of the apparatus. Then the mean was calculated for the readings of each of the components of the CIELAB system.

3.6. Statistical Analysis

The data were submitted to analysis of variance by the F test, and the doses and the epochs of evaluation were analyzed through polynomial regression models using the SISVAR® statistical program (Ferreira, 2011).

4 RESULTS AND DISCUSSION

4.1 Colorimetric Evaluation of Fruits

The Metalosate® doses of Ca resulted in differences in the a * coordinate readings, not influencing the others (Table 1). The epochs of evaluation resulted in differences in all coordinates, the same occurred with the interaction between doses of Metalosate ® of Ca and epochs of evaluation.

Tabela 1. Valores do teste F da análise de variância para os valores das coordenadas CIELAB de frutos de bananeira submetidos a doses de Metalosate® de Ca em quatro períodos de avaliação. Sinop, UFMT – MT, 2015.

Fontes de variação	GL	Leitura L*	Leitura a*	Leitura b*
Metalosate® Ca	4	1,406 ns	5,184**	1,576 ns
Épocas	3	19,164**	65,0,34**	71,74**
Met. Ca x Épocas	12	0,0039**	3,027**	0,0077**
CV(%)		4,53	20,57	7,01

ns – não significativo pelo teste F (p <0,05); ** - significativo pelo teste F (p <0,01)

It was observed that the fruits of the control treatment presented higher values of L * (lighter) up to 48 hours after the climatization, evidencing that the ripening of these was more advanced (Figure 1). The values of brightness of the control group decreased after this period, which would indicate a darkening of the fruits, which could denote the beginning of the process of senescence of the same.
In the fruits that received doses of Metalosate ® Ca, the luminosity readings were inferior (dark colors) to the control until 72 hours after the climatization. This fact evidences that the fruits treated with Metalosate ® of Ca delayed the maturation, and maintained the readings stabilized until the end of the evaluations (144 hours), indicating that the fruits matured in a uniform and lasting way.
It should be emphasized that the addition of 0.3% of Metalosate® of Ca did not present the same behavior as the others, keeping the luminosity readings stabilized in the evaluation periods, which may mean a greater retention of the natural color of the fruits in these treatments.
Lamikanra and Watson (2004) conducted a research where the fruits of melons were immersed in solution containing calcium at low temperature, observed that the respiration rate was reduced increasing the storage of the fruits. Rolle and Chism (1987) state that concentrations of calcium salts in fruits cause several benefits such as increased firmness and decreased cellular respiration. The benefits of calcium in fruits are linked to the preservation of the integrity of the cell wall increasing its desirable characteristics for consumption (LINHARES et al., 2007).
The loss of firmness of the fruits at ripening results in changes in the polysaccharides of the cell wall stimulating various biochemical reactions such as degradation of the cell wall components and increase of the enzymatic activities that degrade the chlorophyll consequently altering its color (HOPKINS and HUNER, 2004).

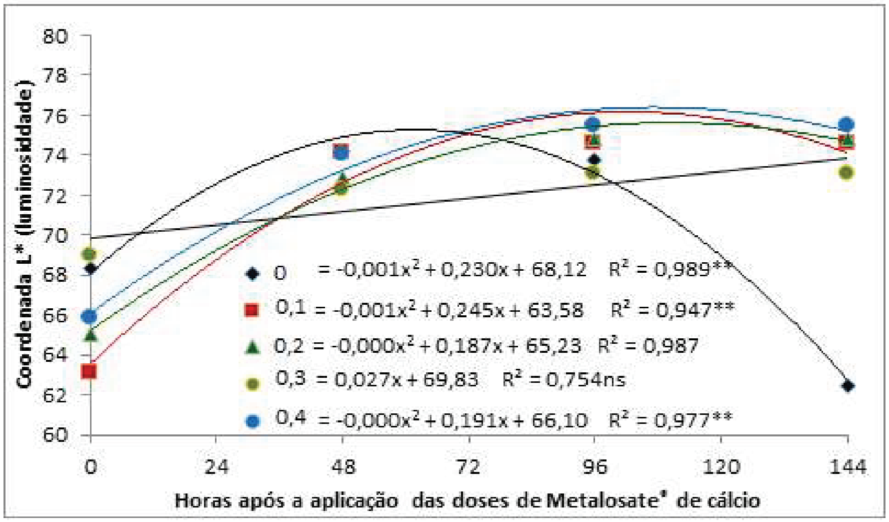

Figure 2. L * coordinate readings (luminosity) of banana fruits submitted to doses of Metalosate of calcium in different evaluation periods. UFMT, Sinop-MT, 2015.

According to Witherspoon & Jackson (1996), the coordinate a * is the most important to indicate the degree of maturation of the fruits, since it has more pronounced variations. Negative values of the coordinate denote a tendency for green color, that is, for the preservation of chlorophyll in fruits. In the absence of treatments, increases were constant, whereas at doses of 0.1; 0.2 and 0.4% of Metalosate® from Ca the readings stabilized after 96 hours (Figure 3), which shows the persistence of chlorophylls in the fruits, indicating that the fruits remained green longer and therefore, the which would prolong the shelf life of the fruits. At 0.3% of Metalosate® Ca, the readings of component a * were lower than the others, allowing the fruits to stay green longer, as evidenced by the luminosity readings (Figure 2).
Similarly to the readings of brightness, the a * coordinate readings on the treated fruits remained stable after the first 72 hours following the climatization. This fact evidences that the addition of Metalosate® Ca delays maturation of the fruits, since the more negative the readings, the greater the trend towards green tones. On the other hand, the untreated fruits presented a linear behavior in the a * coordinate readings throughout the evaluations, reaching the end of the study with positive values, which would indicate a tendency for red tones, that is the ripening of the fruits. This fact confirms the previous results, demonstrating the positive effect of Metalosate® on Ca in delaying fruit maturation, prolonging the shelf life of the bananas or their transport period.

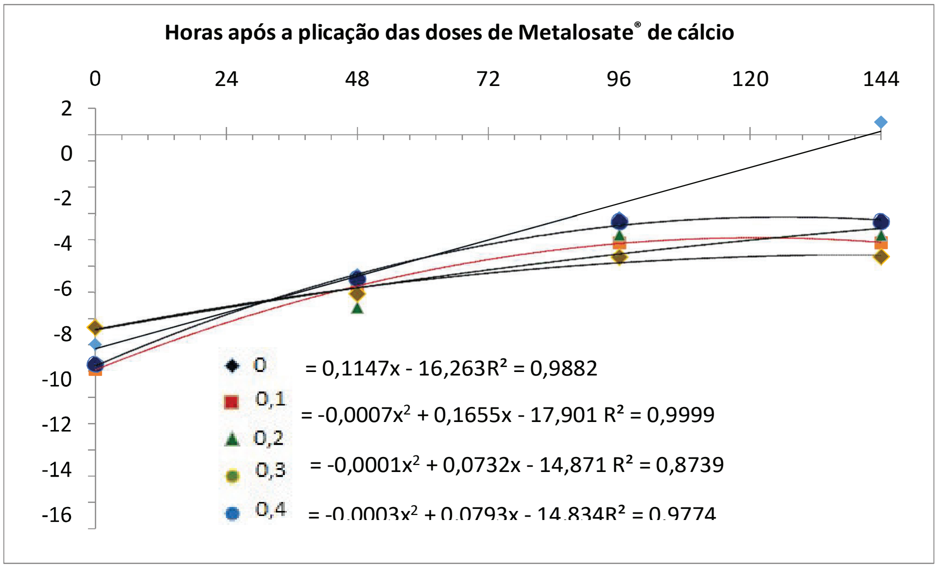

Figure 3. Colorimetric readings of a * (red-green component) coordinates of banana fruits submitted to doses of Metalosate of calcium at different evaluation periods. UFMT, Sinop-MT, 2015.

Alvarés et al. (2003) studying the coloration of the bark of silver banana fruits treated with exogenous ethylene found values of the coordinate a * ranging from -36.65 and -52.74 in the 48 hour time, which differ from those found in this study that varied between -10.4 and -12.3 on the second day after the climatization. This difference can be attributed to the way the fruits were acclimatized and to the use of ethylene, which aims to ripen, unlike the Ca Metalosate that acts in delaying the ripening of the fruits. Polygalacturonic acid binds to calcium in the middle lamella reinforcing the cell wall and plant tissues. The destruction of this acid by the enzymatic activity of polygalacturonase is significantly diminished by the high calcium concentration, and these two components are polygalacturonic acid and calcium have direct relation with the susceptibility of the vegetal tissues to the pathogens (MARSCHNER, 1995).

According to Scalon (1996), the use of calcium chloride in either immersion or spraying increases firmness and slows fruit sensitivity by increasing calcium bound to the wall

cell phone. Evaluations of papaya fruits treated with calcium chloride showed fruit stability for greater firmness (BICALHO et al., 2000).

Thus, it can be understood that the exogenous supply of Ca by means of the application of Metalosate® of Ca can act in the sense of inhibiting the activity of the polygalacturonase, causing the fruits to remain with the bark more firm, resisting more to the transport and probably having a longer shelf life.

The loss of green color of the fruit is related to the breakdown of the structure of the chlorophyll molecule, mainly involving the activity of the chlorophyllase enzyme, which is modulated by ethylene (Yamauchi et al., 1997; Mendonça et al., 2003). It may be suggested that the application of Ca has some direct effect on chlorophyllase activity. The effect of calcium on plant senescence and fruit ripening is the delay and reduction of the senescence rate. Calmodulin, a calcium-binding protein, has been shown to control the biochemical action of calcium in animals and plants. The calcium-calmodulin complex appears to activate various plant enzymes, and to control calcium signals by regulating cell metabolism (Tanaka et al., 1996).

According to Sisler et al. (2006), ethylene performance begins with its binding to its receptor in the cell, triggering, in cascade, a series of phosphorylation reactions, which signal for expression of genes related to maturation and senescence of the fruits. Thus, it can be assumed that Ca acts in the interruption of the ethylene binding to its receptor site, retarding its action and, consequently, the ripening of the fruits.

The doses of Metalosate of Ca allowed the fruits to preserve the yellow color for a longer period, which is evidenced by the readings of the coordinate b *, whose positive values indicate a tendency towards the yellow color, and the higher these values, the more yellow they will be the fruits (Figure 4). Thus, the fruits treated with Metalosate of Ca presented more yellowish colors than those of the control (lower value b *), which would indicate a tendency for the browning of the fruits after 72 hours of its air conditioning. On the other hand, the treated fruits showed a greater stability in the readings after 96 and 144 hours of the air conditioning, evidencing that these fruits remain yellow longer, extending their shelf life and having a better acceptance by the consumer.

This is confirmed by the results of Lester and Grusak (1999), who used Metalosate de Ca in post-harvest treatments of melon fruits. These authors verified that the applications extended the melon half life from 10 to 24 days.

The banana, during its maturation, shows a change in the color of the bark from green to yellow, resulting in an increase in the values of the color parameters a * and b *. The increase of the coordinate a * reflects the loss of green color and the increase of b * represents the yellowing of the bark (Yang et al., 2009).

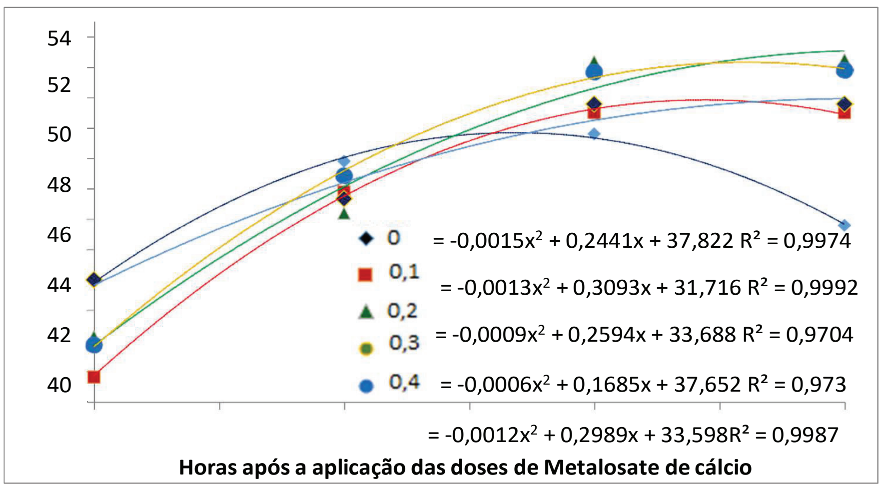

Figure 4. Colorimetric readings of the b * (yellow-blue component) coordinates of banana fruits submitted to doses of Metalosate of calcium at different evaluation periods. UFMT, Sinop-MT, 2015

This fact can be rewarding for both parties, for the consumer who could take home a fruit that looks good and would have a longer post-shelf life of the market, for the market that would not have to discard the fruits early and finally for the producer who would have to replenish a smaller fraction of discarded fruit and who could also receive a better remuneration for the superior quality of their fruits.

Analyzing together the values of the coordinates L *, a * and b * it is shown that the application of Ca metalosate resulted in fruits with greater persistence of green tones, therefore higher chlorophyll content and that after maturation of the same, they maintained its ripe color (yellow) for a longer time than the control. Calcium interferes with the firmness of the cell wall and helps to decrease physiological disorders (POOVAIAH, 1986).

4.2 Total Soluble Solids (TSS), pH and titratable acidity

Although the doses of Metalosate of Ca improved the visual quality of the fruits that were treated, they did not influence the accumulation of soluble solids in the fruit, indicating that they maintained their nutritional value (Figure 5), with small differences in the initial values . According to figure 5, the fruits evaluated showed soluble solids values varying between 9.79 and 23.74 during the evaluations. The fruits treated with 20 ml of Metalosate Ca on the third day of evaluation (96 hours) had the highest value of degrees Brix °, different from the value observed by Viviane and Leal (2007) in silver-dwarf bananas under conditions of temperature and ambient humidity.

The maturation stage is related to the soluble solids content in the ripening, its increase is progressive due to the fact that growth occurs in the respiration rate, resulting in the degradation of polysaccharides to maintain the physiological activities of the fruits (ASSMANN et al, 2006) . Ethylene activity begins with its binding to the cellular receptor, resulting in several phosphorylation reactions (Sisler et al., 2006), which indicate the expression of genes involved in fruit senescence. Thus, the interruption of this binding to the receptor cell may decrease the activity, influencing the ripening of the fruit (SISLER & SEREK, 2003).

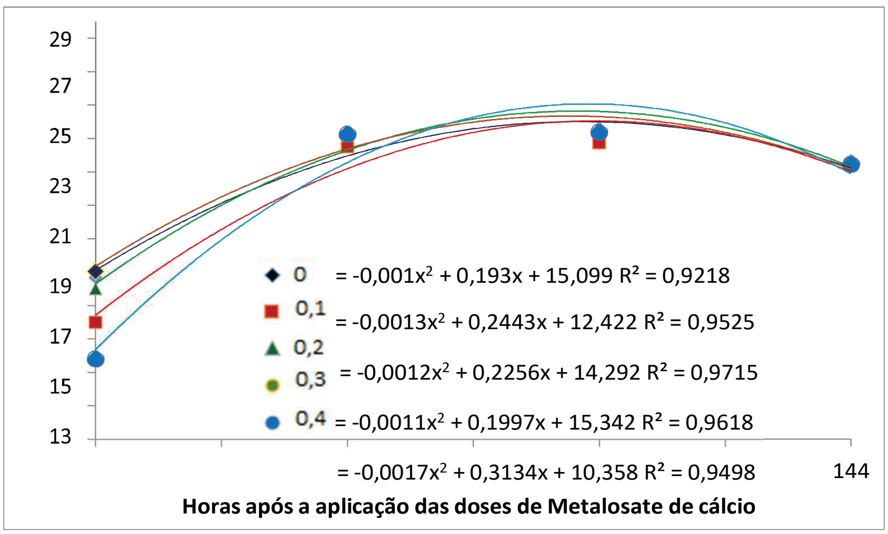

Figure 5. Total soluble solids content of banana fruits submitted to doses of Metalosate of calcium in different evaluation periods. UFMT, Sinop-MT, 2015.

According to Rocha (1984), during the maturation occurs the conversion of the starch into glucose, fructose and sucrose. Changes in acidity, soluble solids and the transformation of insoluble pectin or prototin or pectin into soluble pectins are also observed, resulting in changes in the firmness of the fruit.
Similarly to the soluble solids (Figure 6), the pH values were not altered by the doses of Ca metalosate, which could indicate that the molecule would act only as a complement to the nutrition of the fruits and that this would not significantly alter the metabolism, that is, the treated fruits have the same characteristics as the untreated ones. The differences found were only in the first moment and were reduced after 48 hours of the air conditioning.
Senevirathna and Daundasekera (2010) studying the effect of vacuum infiltration of calcium chloride on the life and quality of tomato cv. Thilina found that increases in CaCl2 concentration resulted in delayed color development

the reduction of ethylene production rates and the time delay necessary to reach climacteric ethylene. Treatment with CaCl 2 does not have a considerable effect on fruit pH, TSS or% TA.

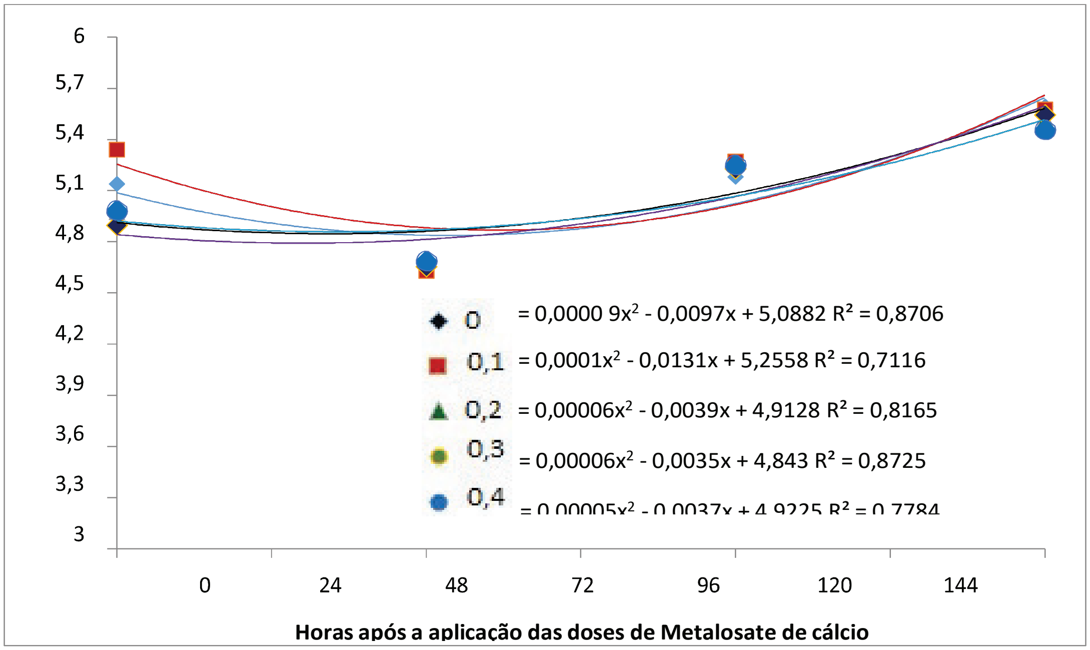

Figure 6. pH readings of banana fruits submitted to doses of Metalosate of calcium in different periods of evaluation. UFMT, Sinop-MT, 2015.

On the other hand, the values of titratable acidity were higher in the control treatment after 48 hours, and remained stable for 96 and 114 hours after the climatization. This fact evidences that untreated (control) fruits presented higher acidity than treated fruits, which may be indicative of the occurrence of some physiological process that may reduce post-harvest quality of fruits. According to Wills et al. (1981), the content of organic acids reduces with fruit maturity, with banana being an exception, where the highest levels of ATT are obtained with fully mature fruits. In bananas the acid that predominates both at the beginning and at the end of its development is malic, which in 'Nanica' bananas can vary from 0.32% when green to 0.51% when ripe (Sgarbieri et al., 1966) .

According to Siqueira (2014), the green banana may have low acidity, and although it increases at the beginning of maturation to a maximum, it slowly decreases in the very mature or senescent fruit. This fall corresponds to the reduction of organic acids in the pulp that begin to be more consumed as a source of energy by breathing than formed.

The results below show that the fruits had relatively low levels of titratable acidity, whose maximum values were slightly higher than 0.4% indicating that

the fruits were not yet fully ripe, meaning that they would have a longer post-harvest shelf life, but maintaining the acidity within the normal levels for cultivation.

Shaftner and Conway (1998) evaluating the effect of the post-harvest application of calcium and the Golden Delicious apple coating types found that treatments with calcium or only the coating of the fruits were less effective than the association of both in the retention the green color of the fruits, the titratable acidity and the firmness of the fruits, and the reduction of respiration and the production of ethylene.

Figure 7. Titratable total acidity of banana fruits submitted to doses of Metalosate of calcium at different evaluation periods. UFMT, Sinop-MT, 2015.

5 CONCLUSIONS

Untreated fruits ripen and senescence early, but do not undergo undesirable changes in total soluble solids, pH and titratable acidity.

The doses of Metalosate® of Ca do not alter the total soluble solids, pH and the titratable acidity of the fruits.

The fruits treated with Metalosate® of Ca remain green for a longer time and maintain the yellow color after maturation.

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