Original Research Article

Quality and technological properties of dried banana cv. Thap Maeo pre-treated and with osmo-convective dehydration

ABSTRACT

The banana of cv. Thap Maeo is resistant to black sigatoka and yellow sigatoka and Panama disease. The development of banana processing and industrialization technologies in Amazonas is a strategy for conservation, adding value and avoiding post-harvest losses. The objective of this paper is to evaluate the effect of osmotic dehydration and pretreatments on the technological properties and quality of dried banana cv. Thap Maeo. Clusters of banana cv. Thap Maeo were provided by Embrapa Western Amazon and the fruits were submitted to pre-processing: Antioxidant (0.25% ascorbic acid and 0.30% citric), Bleaching (water at 94°C) and Sulphitation (sodium metabisulfite at 0.01%), with and without osmotic dehydration by immersion in sucrose solution (65°Brix/6h) and dried in an oven with air circulation (65°C to constant weight). The obtained products were evaluated for biometric characterization, drying curve, chemical composition, physicochemical characteristics, internal color and external color, and dried banana yield. Banana of cv. Thap Maeo has interesting technological properties for agribusiness, with moderately sweet fruits, low acidity, pulp yield of 80.47%, and caloric value of 92.65 kcal. Bleaching associated with osmotic dehydration and drying in an oven gave the product good Brix/ acidity ratio, softer products, water activity within the standards, better coloring and higher yield. The raisin banana is a viable strategy for adding value and preserving the banana cv. Thap Maeo. Bleaching technology associated with osmotic dehydration to produce dried bananas from cv. Thap Maeo is a strategy for the conservation and added value of bananas*in natura*.

Keywords: Bleaching, color, dried banana yield, osmotic dehydration, prevention of enzymatic browning, water activity.

1. INTRODUCTION

The banana tree cv. Thap Maeo is a variant of Mysore, genomic group AAB, Apple group. This cultivar was selected by Embrapa cassava & fruitsand was distributed to producers in the State of Amazonas by the Institute for Agricultural Development of the State of Amazonas - IDAM, to replace banana trees susceptible to diseases. The cv. Thap Maeo is resistant to black sigatoka and yellow sigatoka and Panama disease, moderately resistant to rhizome drill and nematodes [1] and [2]. Also, it has high size, vegetative cycle of 394 days, big bunch, with Mass of 17 kg, Number of Hands per Bunch of 11, mean of Number of Fruits per Bunch of 164, and yield of 28 t/ha, and has high productivity, high Pulp yield and good characteristics for processing [3] and [4]. Banana crops are very relevant for the agribusiness of the State of Amazonas, because the banana is part of the food base of the Amazonian population, with consumption per capita of 60 kg/year. However, losses can reach 40% of banana production because of inadequate techniques throughout the production chain, which compromise the quality of the product. Another obstacle is the low *in natura*consumption of fruits of some varieties resistant to diseases that are grown in Amazonas [5] which due to changes in flavor of these varieties, result in low acceptance.

The application of techniques such as dehydration increases shelf life and can improve the acceptance of these bananas.

The main purpose of dehydration is to eliminate most water by evaporation with heat application.The reduction of water content by drying and osmotic dehydration results in lower water Activity in food. Low water activity values hinder the action of microorganisms and reduce enzymatic activity.Moreover, kiln dries and osmotic dehydration combined results in many benefits of dried banana as better sensory and nutritional characteristics due to the concentration of constituents [5] and [6]. However, the dried banana offered in the Brazilian market usually has dark color, which is not very approved by consumers. The combined use of pretreatments to prevention the enzymatic browning is the alternative to improve the appearance of dried banana, as the pretreatments: Antioxidant [7], Bleaching [8] and Sulphitation [9]. Thus, the use of techniques may be opportune for agribusiness with the development of banana processing technologies can be strategies for conservation and aggregation of value cv. Thap Maeo to avoid post-harvest losses. In this sense, the objective of this study was to evaluate the effect of osmotic dehydration and pretreatments on the technological properties and of quality of dried banana cv. Thap Maeo.

2. MATERIAL AND METHODS

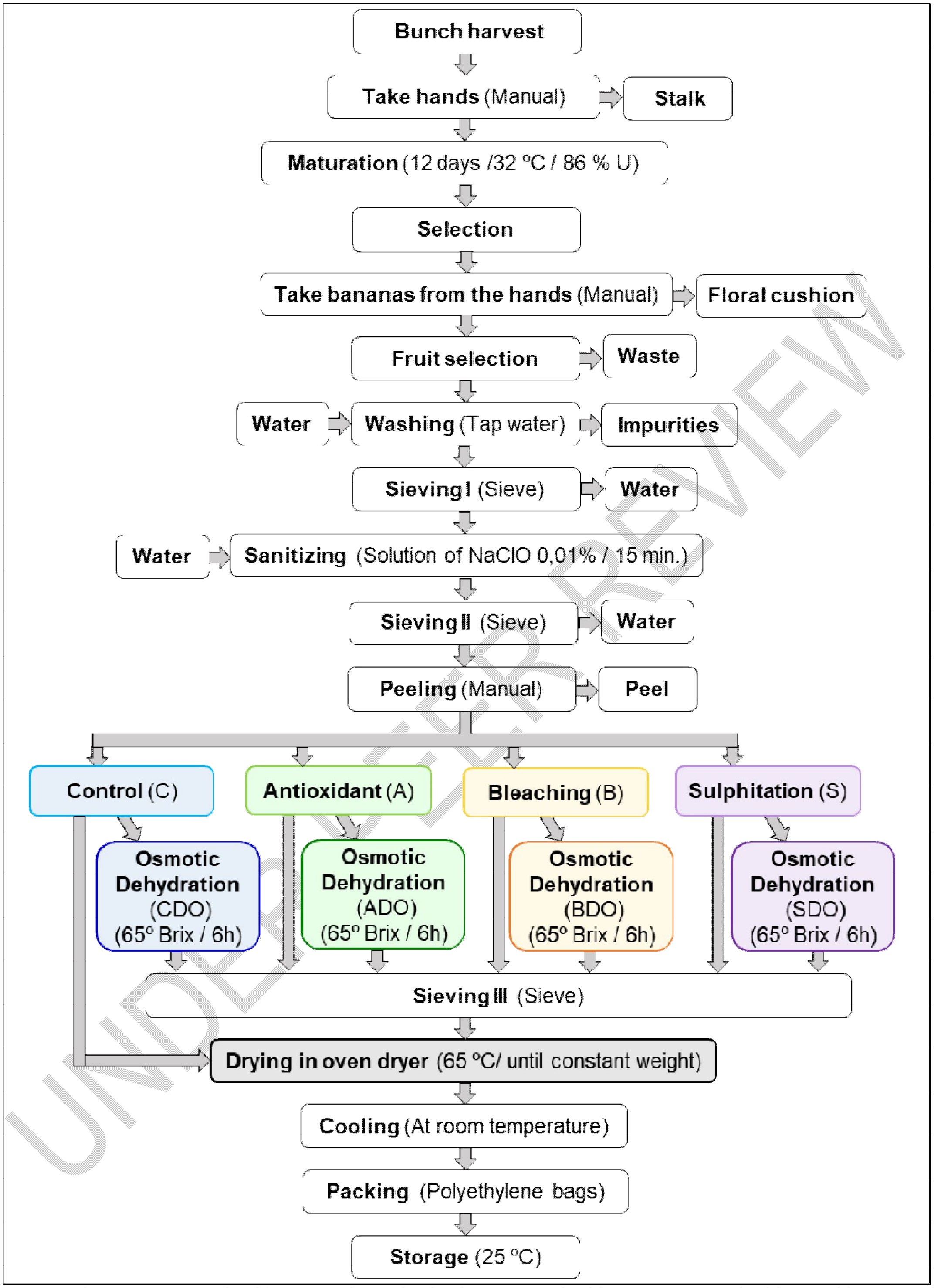
The raw material was obtained from banana trees of the Banana Research Program, of the experimental farm of Embrapa - Brazilian Agricultural Research Corporation – Embrapa Western Amazon,located on highway AM 10, km 29, Manaus, Amazonas. The cultivar Thap Maeo is productive, resistant to pests and diseases, with quality fruits, in addition to having good physicochemical characteristics [4], and for these characteristics was chosen among the cultivars recommended by Embrapa for the State of Amazonas. Bunches were harvested based on the visual criteria of the fruit such as: onset of yellowing of firsthand e o disappearance angular (¾ wide) of the fruit according to the methodology described in [10]. A representative sample of four bunches was collected at 90 days, with fruits at stage three (3). For weighing of buncheswas used graduated scale, Filizola™ model Pluris 15/6 with capacity for 50 kg, and for hands, scale with capacity for 15 kg. These were packed in boxes and immediately transported to the laboratory of biochemistry and post-harvest fruit physiology of the National Institute of Amazonian Research -INPA, Manaus/AM, Brazil.

The hands of bananas were removed manually from the bunches. Then, the hands were placed in polyethylene boxes, at room temperature (± 32 ºC), for ripening and relative moisture of air (± 86%), measured daily by thermo-hygrometer HigroClock™. The fruits in stage three (3), reached Stage Six maturation after 12 days. This stage of maturation is indicated by the color of the peel completely yellow, according to the classification of [10] and [11]. Fruits of bananas were removed from the hands, and discarded the twinned fruits, with floral remains, with mechanical damage, paste and with rot. The biometric characterization was based on the methodology of [4] e modified of [12]. Sixty (60) hands with immature fruits (stage three) were used. The parameters that will be evaluated: Bunch Mass (kg), Number of Hands per Bunch, Hand Mass (kg), Number of Fruits per Bunch, Number of Fruits per Hands, Number of Fruits 2nd Hand, Fruit Mass 2nd Hand (Kg), weight of the Fruit (g), weight of the Pulp (g), weight of the peel (g), Pulp/Peel ratio, Length of Fruit (cm), Length of Fruit Without Peel (cm), Fruit Diameter (mm), Fruit Diameter Without Peel (mm), Pulp (%), Peel (%) and Pulp yield (%). We used a representative sample of 30 fruits from different bunches. For fruit weighing was used on a semi-analytical scale, Mars, model AS2000G. Measurements were performed with the aid of caliper Hélios Stainless, in inch scale, the results expressed in centimeters [13] and[11].

For the processing of dried bananas 20 kg of fruits were used (Figure 1). The fruits were selected without defects, with regular shapes, medium sizes and without irregularities in color. And subsequently,washed in drinking water, sanitizing in 0.01% sodium hypochlorite solution (NaClO) for 15 minutes, rinse and peeling. Separation was performed in four lots for the pretreatments to prevention the enzymatic browning: for pretreatments with antioxidant solution, the fruits were quickly placed in solution with 0.25% ascorbic acid and 0.30% citric acid for five (5) minutes, in proportion of 1:1.5, being 1 L of solution for 1.5 kg of peeled banana, according to the methodology of [7]. In the bleaching, the fruits were peeled and quickly immersed in boiling water (96 ºC), for two (2) minutes and immediate cooling, with immersion with water bath with ice for two (2) minutes and drainage on sieves, according to the methodology of [8]. In sulphitation, the fruits were placed in baskets and immersed in a container containing sodium metabisulfite ($Na_2S_2O_5$), concentration of 0.01% for 40 seconds, using 1 L of solution for 1.5 kg of peeled banana, according to the methodology of [15].

After the pretreatments to prevention the enzymatic browning, the four (4) lots (Control, antioxidant, bleaching and sulphitation), two lots each, being the first batch without osmotic dehydration. The second batch submitted to osmotic dehydration by immersion of the Fruit in sucrose solution at the concentration of 65°Brix for 6 h, in proportion fruit: sucrose solution of 1:2, according to [5]. The treatments were coded as: Control (C), Control with osmotic dehydration (COD), Bleaching (B), Bleaching with osmotic dehydration (BOD), Sulphitation (S), Sulphitation with osmotic dehydration (SOD), Antioxidant (A) and Antioxidant with osmotic dehydration (AOD).To obtain the drying curve of dried banana, the fruits were placed in aluminum pans, separated by treatments and three (3) repetitions, in drying oven Nova ética^{TM} model 420 / 6 D, and dried with forced air circulation, and maintained temperature of 65 ºC to constant weight. The samples of each treatment were weighed at the beginning of drying (every hour) until 2 h of drying, after this period were heavy every 2 h, to constant weight. It was made therevolving of the fruit for uniformization of the removal of water. The weighing was done in semi-analytical scale Marte^{TM}, (capacity of 5 kg), and the results were expressed in grams. Dried banana weight of each treatment was calculated by the difference of the initial weight and final weight. Bananas were placed in medium density plastic bags and stored in temperature of 25 ºC and in a dry and airy place.

Chemical composition of *in natura*banana and dried banana cv. Thap Maeo, analyses were performed in triplicate: The parameters moisture, dry matter, protein, lipids and ash were quantified according to [16]. Moisture (%) and dry matter (%) were determined for drying of the material in drying oven, Nova ética^{TM}, model ETC45, with forced air circulation and temperature of 65 ºC, dry to constant weight. The protein (%) was quantified by the Micro-Kjeldhal method of total Nitrogen, with factor 6.25 for conversion of nitrogen into protein. The lipids (%) were extracted from the dry sample by the Soxhlet, Marconi^{TM}, model MA 1876, using hexane as a solvent. The quantification of ash (%) was obtained by the incineration of the dry and defatted sample in EDG^{TM}, model IP stainless steel, to 550 ºC for five hours. Carbohydrates (%) were calculated by difference. The total fibers were determined from the dry and defatted sample by acid digestion (H_2SO_4 a 0.255 N) and alkaline (NaOH a 0.313 N) in fiber determinator of the brand Tecnal^{TM}, model TE-149, and results were expressed in (%).



C=Control, COD=Control with Osmotic Dehydration, A=Antioxidant, AOD=Antioxidant with Osmotic Dehydration, B=Bleaching, BOD=Bleaching with Osmotic Dehydration, S=Sulphitation, SOD=Sulphitation with Osmotic Dehydration.

Figure 1. Flowchart to obtain dried banana cv. Thap Maeo. Methods for prevention the enzymatic browning and dehydration.National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

The energy value was estimated considering factors four (proteins and carbohydrates) and nine (lipids). The Caloric value respective contents of these nutrients and the results were expressed in Kcal. The phenolic compounds were extracted in water, methanol 100%, and methanol 50% [17] and quantified by Folin-Denis reagent [18]. Tannic acid (20 a 100 $\mu g\ mL^{-1}$). was used to obtain the standard curve. The equation of the straight line was used in the calculations whose results were expressed in mg%. The sugars were extracted at room temperature and quantified by the Somogyi-Nelson method [19], the reducing sugars (%) and total sugars (%) in acid hydrolysis, under heating, and the non-reducing sugars (%) were calculated by difference.

The physicochemical characterization and chemical analysis of the pulps of the Fruit in natura and treatments were performed in samples of different bunches. The pulps were crushed in a food processor. The pH and Total Titrable Acidity (TTA) were determined according to [20]. The pH was determined in pH meter Micronal™, model B 474, previously calibrated with buffer solution, using sample without filtering, obtained from the homogenization of 5 g of pulp and 20 mL of distilled water. Total Titrable Acidity (TTA) performed by titration of the crushed sample and homogenized with 30 mL of distilled water with 0.1 N NaOH solution (standardized) and phenolphthalein as indicator. The results were expressed as percentage of malic acid. Total Soluble Solids (TSS) determined in refractometer Belligran Stanley™ using the liquid phase of the pressing of the sample previously crushed in two layers of gauze, in a filter system under pressure in a syringe. Measurements that were that were not standard temperature (20 ºC) were corrected according to the conversion table of [20] and the results in ºBrix, and the Sugar/acidity ratio (TSS/TTA).The texture of dried banana was determined in texturometer (Texture analyser, of Stable Micro Systems™, model TA-XT2), using the following test method operating conditions: measure of force and compression, distance of 5 mm, pre-test speeds of 2.0 mm/s, of test 2.0 mm/s and after test 5 mm/s with probe SMS P/N, and the results were expressed in Newton (N) [21]. Twelve samples of each treatment were used, in slices of the bananas, with 1cm wide, cut in the central portion of the fruit. Measurements were performed immediately after sample preparation. Each sample was placed on the texturometer in the position that the outer surface was facing the probe. The water activity (Aw) of banana driedwas determined in AquaLab, DecagonTM, by the technique of determining the dew point in encapsulated mirror [22]. The calibration of the equipment, before the readings, was done with standard pure water. The samples were cut into slices of 1 centimeter thickness, to occupy half the height of the reading container.The readings were performed immediately after removal from the package. Dry Banana Yield (DBY%) was calculated by the ratio between 1000g of bananas with peel and the amount of dried banana, of each treatment.

The external color and internal of dried banana was determined by the luminosity parameters (L*) and chromaticity (a* and b*), in colorimeter Spectrophotometer Portable of Sheen Instruments ™, model Micromatch Plus, light source D65 (6500°K), the observation angle of 10 and 30 mm measuring cell aperture, scale L*, a* and b* of the CIELab System, [23], calibration before readings with white and black standard. L* value indicates brightness (L*=0 (black) and L*=100 (white)), a* and b* chromaticity, the data in the coordinates indicate the direction of color, where a* indicates the axis of chromaticity from green (-a) to red (+a) and b* the chromaticity axis from blue (-) to yellow (+). Luminosity and chromaticities of the endocarp were measured in the external parts of whole fruits and inner part of slices. Measurements were performed in triplicate at different points of the same sample and the results expressed in intensity of Luminosity (L*) and chromaticities (a*) and (b*). The experimental design was in a factorial scheme with four pretreatments to prevention the enzymatic browning and two types of dehydration (with and without Osmotic

Dehydration) and three replications. For the comparison of the means, the analysis of variance with F test and the Tukey test at (P< 0,05)probability, R Core Team (2024)[24].

3. RESULTS AND DISCUSSION

In the biometric characterization of the banana of cv. Thap Maeo, it was possible to observe that the values of Bunch Mass were high, considering large bunches (Table 1). These values were higher than those found for cv. Thap Maeo of 15 kg [24], 13.93 kg [26], 17.46 kg [27]. The Number of Hands per Bunch was superior to those found for the cv. Thap Maeo of 12.2 hands [26]. There is a proportionality between Bunch Mass and Number of Hands. According to [28], the cv. Thap Maeo presented greater potential for production of bruches e fruits between twenty genotypes.

Table 1. Biometric characterization of bananas from cv. Thap Maeo. National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

Characteristics	Mean	Standard deviation	Minimum	Maximum	Amplitude
Bunch Mass (kg)	28.38	± 3.4	25.00	31.50	6.50
Number of Hands per Bunch	15.00	± 0.8	14.00	16.00	2.00
Hand Mass (kg)	1.92	± 0.8	0.85	5.90	5.05
Number of Fruits per Bunch	269.00	± 22	247.00	288.00	41.00
Number of Fruits per Hands	19.58	± 7.5	10.00	59.00	49.00
Number of Fruits 2^{nd}Hand	28.75	± 7.5	24.00	40.00	16.00
Fruit Mass 2^{nd}Hand (Kg)	2.84	± 0.7	2.40	3.91	1.51
Weight of the Fruit (g)	102.72	± 9.5	81.48	124.12	42.64
Weight of the Pulp (g)	82.60	± 7.3	67.03	99.32	32.29
Weight of the peel (g)	20.12	± 3.3	14.45	30.67	16.22
Pulp/Peel ratio	4.17	± 0.5	2.99	4.95	1.96
Length of Fruit (cm)	12.00	± 0.5	10.72	12.93	2.21
Length of Fruit Without Peel (cm)	10.64	± 0.5	9.38	12.08	2.70
Fruit Diameter (mm)	36.50	± 0.3	27.40	39.60	12.20
Fruit Diameter Without Peel (mm)	32.80	± 0.2	29.60	35.60	6.00
Pulp (%)	72.17	± 6.3	58.56	86.77	28.21
Peel (%)	27.83	± 6.3	13.23	41.44	28.21
Pulp yield (%)	80.47	± 2.1	74.93	83.20	8.27

Great variation in amplitude was observed between the maximum and minimum values of Hand Mass of 5.05 kg. The Hand Mass was higher than found for cv. Thap Maeo of 1.8 kg [24] and lower to 2.5 kg (14). Hands Mass varied according to the location of the bunch, the first bunch being heavy, and the weight was decreasing proportionally along the cluster to reach the floral cushion. The 2nd hand is the heaviest and with the most fruit. The weight of fruits of the 2nd bunch was higher than that found for cv. Thap Maeo of 1.77 kg [29] and 2.37 kg [13]. The number of fruits per bunch was greater than or found by [27].The Number of Fruits per Hands was higher than found for cv. Thap Maeo of 17 fruits [31] a value close to those 20 fruits [24]. The Number of Fruits 2nd Hand was higher than that found for cv. Thap Maeo of 18.9 fruits [13].The values of Fruits Mass and Pulp Mass values show relatively heavy fruit. This may be due to fertilization and cultural practices that are used by

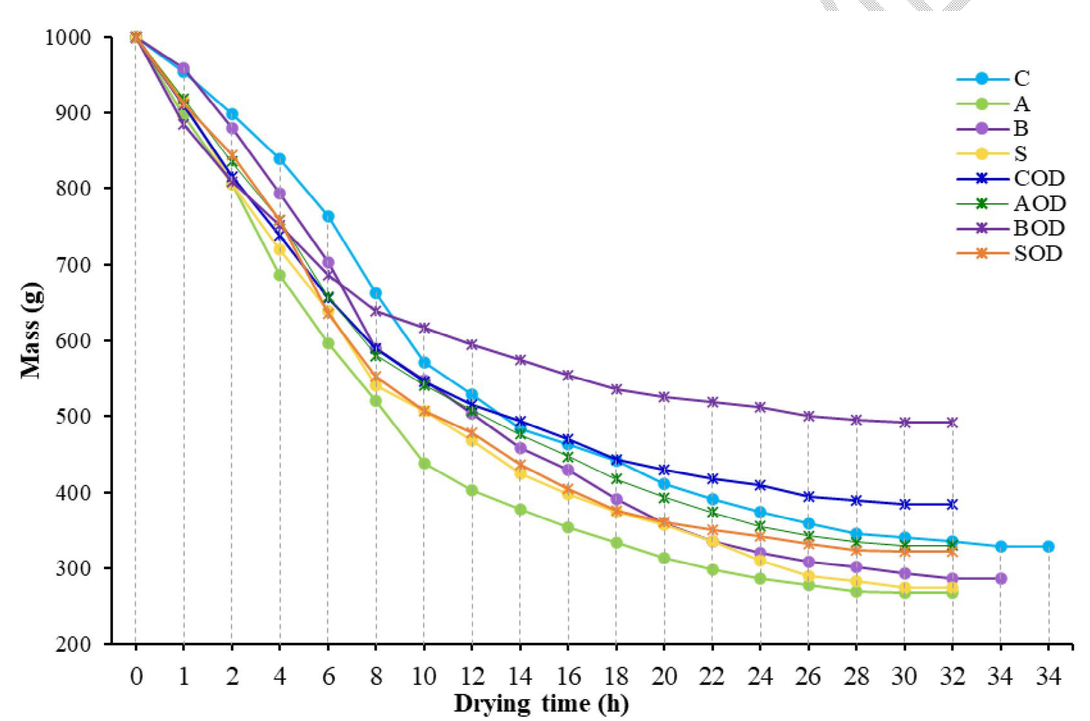
Embrapa. Fruits Mass was superior to that found for cv. Thap Maeo of 67.2 to 94.3 g [31] Pulp Mass was higher than the to that found for cv. Thap Maeo de 56.99 g [31]. A variation of 19.59% was found in relation to Fruits Mass, giving this percentage to the weight of the peel, 20.12 g. Pulp/Peel ratio was close to that found for cv. Thap Maeo of 4.49 g [13] and lower than 5.81 g (13).The values of the Fruit dimension refer to the average fruits, which were classified according to length of the Fruit with peel as belonging to classes 12, by the fruit length being greater than 12 centimeters and less than 15 centimeters (11). The length of the fruits with peel had approximate value cv. Thap Maeo of 11.92 cm [31], from 11 to 13.36 cm [31] and less than 13.47 cm [13]. Length of Fruit without Peel if approximate value 10.64 cm [4]. When evaluating the diameter of the fruits with peel and diameter of the fruits without peel it was observed that the fruits with peel included in the extra gauge category (34 mm), according to classification of [11]. The diameter value of the fruits with peel was lower than that found for cv. Thap Maeo of 36.83 mm, [13]. The percentage of Pulp (P%) was greater than 70% and the percentage of Peel (C%), less than 30%. The pulp yield was considered high, higher than 80%. The value was close to the found for the cv. Thap Maeo of 80.56% (4) and more than 72.58% [27].In the chemical composition and physical and physicochemical characteristics of banana *in natura*of cv. Thap Maeo (Table 2).

Table 2. Chemical composition of the in natura banana cv. Thap Maeo. National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

Parameters	*in natura* banana	
	Mean	**Standard deviation**
Moisture content (%)	79.16	± 1.20
Dry matter (%)	20.84	± 1.20
Carbohydrates (%)	19.08	±1.10
Proteins (%)	4.06	± 0.04
Lipid (%)	0.10	0
Total Fiber (%)	1.50	0
Ash (%)	0.10	0
Caloric Value (Kcal)	92.65	0
pH	4.68	± 0.01
Total Soluble Solid, TSS (ºbrix)	22.00	0
Total Titrable Acidity, TTA (% malic acid)	0.77	0
Sugar/acidity ratio (TSS/TTA)	28.47	0
Total Sugars (%)	8.75	± 0.40
Reducing Sugar (%)	7.15	± 0.60
Non-reducing Sugar (%)	1.62	± 0.20
Phenolic in water (%)	0.06	0
Phenolic in methanol 50% (%)	0.004	0
Phenolic in methanol 100% (%)	0	0

The moisture value higher than found of 75.37% [33] and the authors [32] verified dry matter values of26.65%. The pH value of the pulp is within the average for bananas because it presented value very close to 4.73 [33], 4.72 [32] and greater than 4.18 [34]. Total Titrable Acidity, TTA (% malic acid) of banana *in natura* was more than 0.37% [35], and in [33], 0.59%. The value of Total Soluble Solids (TSS) in the fresh fruit was close to that found by [35], 21.86°Brix, and greater to that found by [34], 20°Brix. The Brix/Acidity ratio shows moderately sweet fruits with low acidity. The values were lower those of [13], 32 and 35. The values of total sugars (%) and reducing sugars (%) were lower than the results found by [34]. The non-reducing sugars (%) were close to [32]. The phenolics contained in the banana*in natura* were extracted in greater quantity in aqueous solution. Protein content (%) was near lower than those found by [36], 4.8%, and the lipid content (%) was lower, 0.17%. The carbohydrate content was higher than that found by [37] for banana of the cv. Silver (15.11%). The banana of cv. Thap Maeo is a source of fiber. And according to [38], the fibers attribute functional properties to food. The caloric value of fresh banana cv. Thap Maeo was 92.65 kcal. The banana of cv. Thap Maeo presents big bunches, high number of fruits, class 12, extra size, medium fruits, moderately sweet, with low acidity, Pulp yield of 80.47%, and caloric value of 92.65 kcal.

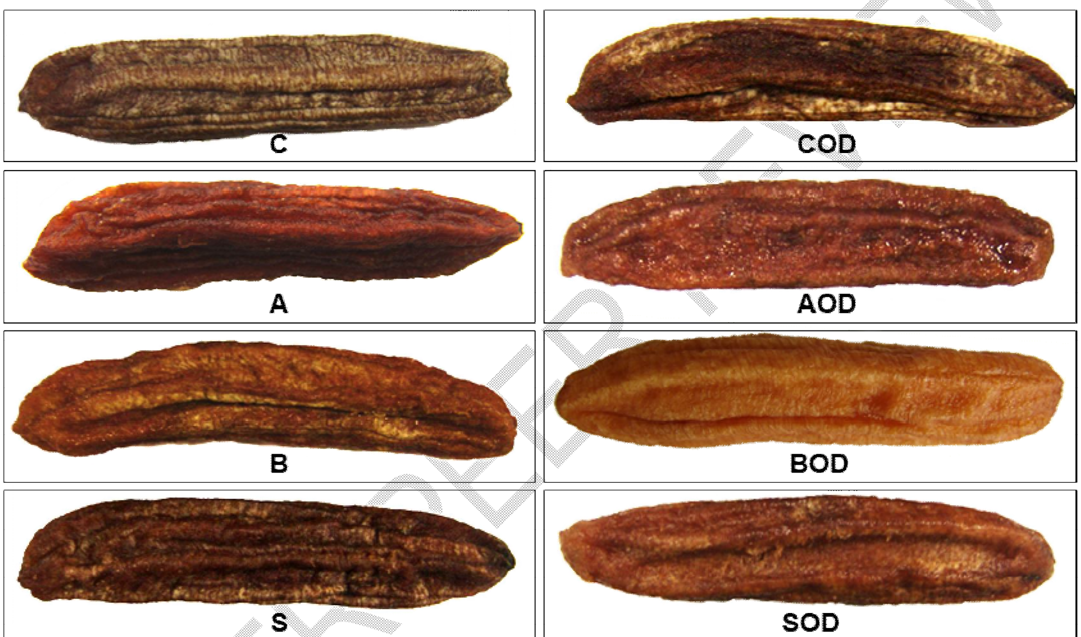
In drying curve (Figure 2), in the first eight hours of drying dried banana occurred weight loss of 40.51% to 59.65%, relative to the initial weight. These results are according to [39] who observed great moisture removal at the beginning of the drying oven process. The bananas were previously submitted to osmotic dehydration, which was faster than the other treatments in the first eight hours. BDO pretreatments were easier to lose water in the first two hours, while CDO, BDO, SDO lost more water in the first six hours.



Control (C), Antioxidant (A), Bleaching (B), Sulphitation (S), Control with osmotic dehydration (COD), Antioxidant with osmotic dehydration (AOD), Bleaching with osmotic dehydration (BOD), Sulphitation with osmotic dehydration (SOD).

Figure 2. Drying curve of dried bananas of cv. Thap Maeo. Methods for prevention the enzymatic browning anddehydration. National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

Treatments with osmotic dehydration were easier to lose water in the first hours due to the sucrose solution residue adhered to the surface of the fruits, which also contains water. The osmotic dehydration facilitates the loss of water in dried banana in drying oven because, in the process of drying, the air conducts heat to the food, causing evaporation of the water, being also the vehicle in the transport of the wet steam released from the food. Thus, a considerable part of the moisture is free on the surface of the banana and thus is easily removed [40].The treatments that had more difficulty losing water mainly in the first eight hours were Control (C) and Bleaching (B). This result can be explained by the greater resistance in internal water loss. According to [40], the differences increase due to internal resistance to moisture transport, as during the drying water interacts with polar groups of constituent molecules. Most treatments had stabilization of dried banana weights with 32 hours in drying oven, however two treatments C and B stabilized the weight after 36 and 34 hours of drying. The drying of dried banana took place at a decreasing rate, in accordance with [41].The times found for drying in over dryer of dried banana at 65°C is proportional to the found drying times used by [40] when using air temperature of 60°C e 70°C, with drying time of 30 h and 36 h, respectively, and with moisture content of 23 to 25%. [39] observed that temperature has a great influence on dry banana drying. It was found in [40], that the



drying curves are important to determine the appropriate drying time for the moisture content within the recommended. According to [42] the banana dried should have moisture content between 20% and 25%. From 8 treatments: 4 pretreatments to prevention enzymatic browning and control (C, A, B and S), and osmotic dehydration (CDO, ADO, BDO and SDO) were produced(Figure 3).

C=Control, COD=Control with Osmotic Dehydration, A=Antioxidant, AOD=Antioxidant with Osmotic Dehydration, B=Bleaching, BOD=Bleaching with Osmotic Dehydration, S=Sulphitation, SOD=Sulphitation with Osmotic Dehydration.

Figure 3. Aspects of dried banana cv. Thap Maeo. Methods for prevention the enzymatic browning and osmotic dehydration.National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

In the chemical composition of the dried banana cv. Thap Maeo significant differences (Table 3), were observed between dehydration treatments for moisture, carbohydrates, ash and caloric value (Table 4). The treatments with osmotic dehydration showed lower values of moisture than the dry treatments in oven dryer.The average moisture (%) differed between the treatments for prevention of enzymatic browning, with lower values in the antioxidant treatments (A and ADO) and Sulphitation (S and SDO).This is due to the loss of water from the fruits to the solution during pretreatments, due to the concentration of solutes of the antioxidant solution (0.25% ascorbic acid and 0.30% citric acid) and sulphitation (0.01% sodium metabisulfite). However, the moisture % of treatments B and BDO did not differ statistically from the treatments C and CDO. Thus, bleaching does not negatively interfere in moisture of the dried banana as the water content absorbed by the fruits during pre-treatments is lost in Drying in oven dryer and osmotic drying.

Table 3. Summary of analysis of variance of chemical composition of dried banana cv. Thap Maeo. Methods for prevention of enzymatic Browning and dehydration.National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

VS	MS					
	Moisture content	**Carbohydrates**	**Proteins**	**Lipids**	**Ash**	**Caloric value**
	(%)					(Kcal)
D.	52.3***	53.104***	0.01402^{ns}	0.000004^{ns}	0.0014***	821.2***
PEB	1.66***	0.6621***	0.1523***	0.00726***	0.00006*	24.08***
D.x PEB	0.28^{ns}	0.3260***	0.00038^{ns}	0.000026^{ns}	0.00003*	5.38***
Error	0.10	0	0.004300	0.000033	0.00001	0.08
CV%	7.55	2.15	4.44	10.28	2.22	2.05
GM	21.36	72.48	3.46	0.29	0.39	306.38
Min.	19.35	70.48	3.16	0.24	0.38	297.36
Max.	23.57	74.29	3.67	0.32	0.40	314.42

*MS=mean squared, VS=variation source; CV%=coefficient of variation; GM=general mean; D.=dehydration; PEB=prevention the enzymatic browning. Significant at the * P<0,05 probability level by F-test, significant at the *** P<0,001 probability level by F-test. ns,no significant at the P<0,05 probability level by F-test.*

The average moisture of the dried banana ranged from 19.35% to 23.57%. These values are within the limit of 25%, established for dried or dehydrated fruits by Resolution-DRC Nº 272/2005 [42]. The transfer of water in the fruit by osmosis to the solution is due to the difference in osmotic pressures of the sucrose solution and the fruit (5). [43] reported the variables that slow down the diffusion speed of water molecules to the osmotic solution, such as the air contained in the fruit tissues, the air adhered to the fruit surface, and the air between the fruits and the sugar solution that obstruct the water transfer path. Most of the fruit water content is in the solutions of sugars, salts, proteins and organic compounds maintained in the cell compartments [44]. The moisture varied as a function of osmotic dehydration, because there was a lower residual moisture at the end of the production process of dried banana with these treatments. The osmotic dehydration at 65º Brix / 6 h, with in drying oven 65 ºC/32 to 34 h, removed from 71.56% to 75.51% of the initial water content of the fruits. These results are within the parameters of [45], which found that osmotic solutions with 70º Brix removed up to 84% of the initial water content of the fruits and osmotic solutions with 60°Brix removed up to 58% of moisture. The moisture values of dried banana for all treatments were close to those found by [7], the value of 20.10% for cv. FHIA 18 and 18.80%, for Country, [46], 19.21%, [47], 22.60% to 22.95%.There are significant differences between dehydration treatments for moisture. The treatments with osmotic dehydration showed lower values of moisture than the dry treatments in oven dryer.

Average moisture (%) differed between the treatments for prevention of enzymatic browning, with lower values in the antioxidant treatments (A and ADO) and Sulphitation (S and SDO).There is interaction between osmotic dehydration and prevention of enzymatic browning for the concentration of carbohydrates for the dried banana. The SDO treatments had the highest mean carbohydrate followed by ACO and BCO. The osmotic dehydration treatments (CDO, ADO, BDO and SDO) had higher averages in relation to dry treatments in a Drying in oven dryer. The osmotic dehydration incorporated sugar in the dried banana due to the osmotic solution. In addition, sugar gain (mass transfer) is related to the intrinsic characteristics of fresh fruits. In addition, the incorporation of sugars was influenced by the prevention of enzymatic browning due to the immersion of bananas in hot water, in the bleaching, and in the antioxidant and sulphitation solutions. The surface water after sieving left the medium less concentrated and attracted the osmotic solution, more concentrated.There was a significant difference between the averages for the treatment of prevention of enzymatic browning for the protein (%) and lipid (%) (Table 4). While treatments B and BDO, presented the lowest average of lipids, treatments SDO and ADO had the highest average protein. The values found were lower than [36] for crude protein in dry banana cv. Thap Maeo. This is due to the bleaching process that in one of the steps uses boiling water (96 ºC) for two minutes. Thus, bananas lost a part of the lipids to the water of Bleaching. The results were higher than that of [36], 0.17% of lipids in dried banana cv. Thap Maeo. Ash contents were influenced by osmotic dehydration and the prevention of enzymatic browning and interaction. The bleaching (B) had the lowest average of ash by loss of minerals contained in the banana, even with rapid submersion in water in white water (2 minutes), this time was sufficient for the solute flow to lead to mineral loss.The fiber contents did not differ between treatments, but the bananas had higher fiber concentration in relation to banana *in natura*, with dehydration. And according to [38] fibers beyond influence in food texture, confer the quality of functional foods.

Table 4. Chemical composition of dried banana cv. Thap Maeo. Methods for prevention the enzymatic browning and dehydration.National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

Parameters	(OD)	Prevention of enzymatic browning									
		(C)		(A)		(B)		(S)		Mean	
Moisture content (%)	Without	23.3	aA	22.0	aA	23.5	aA	22.5	aA	22.9	a
	With	20.1	aA	19.7	aA	20.3	aA	19.4	aA	19.9	b
	Mean	21.7	A	20.9	B	21.9	A	21.0	B		
Carbohydrates (%)	Without	70.5	dA	71.3	aB	70.6	cB	71.3	bB	71.0	b
	With	73.7	dA	74.0	cA	74.3	bA	73.9	aA	74	a
	Mean	72.1	C	72.8	A	72.3	B	72.8	A		
Proteins (%)	Without	3.50	aA	3.64	aA	3.25	aA	3.54	aA	3.48	a
	With	3.44	aA	3.57	aA	3.22	aA	3.50	aA	3.43	a
	Mean	3.47	B	3.43	AB	3.41	C	3.52	A		
Lipids (%)	Without	0.31	aA	0.31	aA	0.24	aA	0.31	aA	0.29	a
	With	0.30	aA	0.31	aA	0.24	aA	0.32	aA	0.30	a
	Mean	0.31	A	0.31	A	0.24	B	0.32	A		
Total Fiber (%)	Without	3.0	aA	3.0	aA	3.0	aA	3.0	aA	3.0	a
	With	3.0	aA	3.0	aA	3.0	aA	3.0	aA	3.0	a
	Mean	3.0	A	3.0	A	3.0	A	3.0	A		
Ash (%)	Without	0.38	bB	0.39	bA	0.38	bB	0.39	bAB	0.39	b
	With	0.40	aB	0.40	aA	0.40	aB	0.40	aAB	0.40	a
	Mean	0.39	BC	0.40	A	0.38	C	0.40	AB		
Caloric value (Kcal)	Without	299	bC	304	bA	298	bD	302	bC	301	b
	With	312	aC	313	aB	311	aC	314	aA	312	a
	Mean	305	B	308	A	304	C	308	A		

OD=Osmotic Dehydration,C=Control, COD=Control with Osmotic Dehydration, B=Bleaching, BOD=Bleaching with Osmotic Dehydration, S=Sulphitation, SOD=Sulphitation with Osmotic Dehydration, A=Antioxidant, AOD=Antioxidant with Osmotic Dehydration.Means followed by equal capital letters in the column do not differ from each other at P<0,05 probability by the Tukey's test. Means followed by equal lowercase letters on the row do not differ from each other at P<0,05 probability by the Tukey's test.

The osmotic dehydration influenced the caloric values of dried banana, with increase in the caloric value of treatments with osmotic dehydration in relation to treatments without osmotic dehydration. Osmotic dehydration (BDO) leads to lower caloric value due to loss of carbohydrates, proteins and lipids in osmotic dehydration. The osmotic dehydration influenced the caloric values of dried banana, with an increase in the caloric value of treatments with osmotic dehydration. There was a significant difference in prevention of enzymatic Browning and the bleaching had the lowest caloric value. This was due to the reduction of lipids in the bleaching.The interaction of osmotic dehydration treatments and prevention of enzymatic browning was significant for caloric value, and treatments with bleaching (B and BDO) had lower caloric values. This was due to the reduction of lipids in bleaching. The dried banana without osmotic dehydration (B) had the lowest caloric value. The osmotic solution increases the caloric value of the treatments by the incorporation of sugars. Accordingly, [5] observed that osmotic dehydration increased caloric value by incorporating soluble solids.

In the physicochemical characterization of dried banana cv. Thap Maeo there was a significant difference in dry matter content (%) in relation to the type of dehydration (Table 5). The sucrose solution influenced the DM (%) of treatments with osmotic dehydration because it was adhered to the surface of the processed fruits and the incorporation of sugar, leading to increased mass(Table 6). There was a significant difference in dry matter content (%) in relation to the type of prevention of enzymatic browning. Among them, the antioxidant treatments (A and ADO) and Sulphitation (S and SDO) had the highest dry matter values, while the control (C and CDO) and bleaching (B and BDO) had the lowest values (Table 7). These last values found were close to those of [44], 76.21% for dried banana cv. Country. In relation to texture, there was a significant difference in relation to osmotic dehydration and prevention of enzymatic browning. The osmotic dehydration that favored products with lower texture, that is, softer. This was due to the interaction of osmotic solution with the surface layers of the fruits causing a type of glaceament. The values of Texture were lower than those found by [7], 7.2 N for dried banana from cv. FHIA 18 and 6.0 N for cv. Country, and by [44], 6.4 N for dried banana fromcv. Country. The treatments CDO, BDO and SDO treatments favored softer products.

Table 5. Summary of analysis of variance of physico-chemical characteristics of dried banana cv. Thap Maeo. Methods for prevention of enzymatic browningand dehydration. National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

VS	MS			
	Dry Matter (%)	**Texture** (N)	**Activity water**	**Dried Banana Yield** (%)
D.	52.303537***	4.2757*	0.008066***	269.742***
PEB	0.1664726**	2.3715*	0.0051000***	63.424***
D.x PEB	0.281915^{ns}	0.0268^{ns}	0.0002778^{ns}	44.805***
Error	0.131646	0,7072	0.0001083	0
CV%	2.05	37.60	5.49	0
GM	78.64	2.65	0.61	24.25
Min.	76.43	1.16	0.57	19.38

Max.	80.65	4.80	0.67	35.58

*MS=mean squared, VS=variation source; CV=coefficient of variation; GM=general mean; D.=dehydration; PEB=prevention the enzymatic browning. Significant at the * P<0,05 probability level by F-test, significant at the *** P<0,001 probability level by F-test. ns,no significant at the P<0,05 probability level by F-test.*

Table 6. Summary of analysis of variance of physico-chemical characteristics of dried banana cv. Thap Maeo.Methods for prevention of enzymatic browningand dehydration.National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

VS	MS			
	pH	**TTA** (% malic acid)	**TSS** (ºBrix)	**TTA/TSS**
D.	0.113438***	1.20154***	591.034***	3325.495837***
PEB	0.097071***	0.07044***	0.006***	104.3721138***
D.x PEB	0.004837***	0.00184***	0.006***	26.315437***
Error	0.000196	0	0	0.000100
CV%	3.06	18.72	8.45	26.77
GM	4.43	1.33	60.00	47.49
Min.	4.17	0.98	55.00	32.65
Max.	4.67	1.69	65.00	66.11

*MS=mean squared, VS=variation source; CV=coefficient of variation; GM=general mean; D.=dehydration; PEB=prevention the enzymatic browning, TTA=Total Titrable Acidity, TSS=Total Soluble Solid, TTA/TSS=Sugar/AcidityRatio. Significant at the *** P<0,001 probability level by F-test.*

There was a significant difference in Activity Water (Aw) in relation to dehydration and the type of prevention of enzymatic browning. The osmotic dehydration that favored products with lower Aw. The BDO treatment favored higher water activity. This is due to the soaking of the fruits in boiling water during bleaching, which facilitated the entry of water. However, the presence of sugar increases the osmotic pressure of the medium thus creating unfavorable conditions for the growth and reproduction of most microorganisms. Although the bleaching provided the highest values of water activity, all treatments were in the range allowed for dehydrated fruits from 0.50 to 0.85 according to [48]. The values of water Activity were lower than those found by [47], from 0.66 to 0.68, [49], from 0.72 with sucrose solution of 65 °Brix, and [6], from 0.74 of water Activity.

Dry Banana Yield DBY (%) considers the mass of bananas *in natura* and the final mass of bananas (Table 6). There was interaction between osmotic dehydration and prevention of enzymatic browning for the concentration of Dried Banana Yield DBY (%) (Table 5). The BDO treatment presented the highest Dried Banana Yield DBY (%). This was due to the incorporation of sugar and sucrose solution adhered to the surface of the dried banana. An increase for DBY (%) was observed of 11.91% in the bleaching (BDO) compared to control (C). The immersion of bananas *in natura*in water during bleaching favored the greater retention of water, in this treatment, compared to the others. The yields of dry banana produced with osmotic dehydration were higher than those found by [7] for cv. FHIA 18, of 28.9 (%). The interaction of treatments was significant for pH.The osmotic dehydration gave slightly more alkaline products, and bleaching, slightly more acidic products, [50] also observed slightly lower pH in mangabas processed with Bleaching. The objective of the Bleaching is the inactivation of browning enzymes. According to [48], the optimum pH for inactivation of the polyphenoloxidase enzyme is at pH close to 4.0. This explains the successful inactivation of the browning enzyme during the Bleaching. The pH values were similar to those of [49].

The interaction of treatments was significant for Total Titrable Acidity (%). The drying in oven dryer presented products with higher Titrable Acidity values, while the antioxidant treatment (A) showed the highest value. This is due to the immersion of bananas in solution with organic acids. According to [48] the use of antioxidants and Bleaching prolong the shelf life of dehydrated products. The values found were similar to those of [7] in cv. FHIA 18, 1.22% of malic acid. The results were higher than those of [51], 0.41% in dried banana of the cv. Plantain, [44], of 0.43% for dried banana of cv. Country, [46], of 0.77% and approximate value of [47], 1.08%. The interaction of treatments was significant for Total Soluble Solids (TSS).

Table 7. Physicochemical analysis characteristics of dried banana cv. Thap Maeo. Methods for prevention the enzymatic browning and dehydration. National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

Parameters	OD	Prevention of enzymatic browning									
		(C)		(A)		(B)		(S)		Mean	
Dry Matter DM (%)	Without	76.7	aA	78.0	aA	76.5	aA	77.5	aA	77.1	B
	With	79.9	aA	80.3	aA	79.7	aA	80.6	aA	80.1	A
	Mean	78.3	B	79.0	A	78.1	B	79.1	A		
pH	Without	4.47	bA	4.38	bC	4.18	bD	4.42	bB	4.36	B
	With	4.65	aA	4.55	aB	4.33	aD	4.48	aC	4.50	A
	Mean	4.56	A	4.47	B	4.26	C	4.45	B		
Total Titrable Acidity TTA (% malic acid)	Without	1.55	aB	1.69	aA	1.48	aC	1.48	aC	1.55	A
	With	1.12	bB	1.26	bC	1.05	bC	0.98	bD	1.09	B
	Mean	1.34	B	1.48	A	1.27	C	1.20	D		
Total Soluble Solid TSS (ºBrix)	Without	55.0	bB	55.1	bA	55.0	bB	55.1	bA	55.0	B
	With	65.0	aA	64.9	aC	64.9	aC	64.9	aB	65.0	A
	Mean	60.0	A	59.8	C	59.8	C	59.9	B		
Sugar/acidity ratio (TSS/TTA)	Without	35.6	bC	32.7	bD	37.3	bB	37.3	bA	35.7	B
	With	57.8	aC	51.4	aD	61.7	aB	66.1	aA	59.3	A
	Mean	46.7	C	42.0	D	49.5	B	51.7	A		
Texture T (N)	Without	2.38	aA	3.86	aA	2.75	aA	3.29	aA	3.07	A
	With	1.45	bA	2.93	bA	2.10	bA	2.41	bA	2.23	B
	Mean	1.91	B	3.40	A	2.43	AB	2.85	AB		
Activity Water (A_w)	Without	0.64	aA	0.60	aA	0.67	aA	0.61	aA	0.63	A
	With	0.58	aA	0.57	aA	0.64	aA	0.58	aA	0.59	B
	Mean	0.61	B	0.59	C	0.66	A	0.60	BC		
Dried Banana Yield DBY (%)	Without	23.7	bA	19.4	bD	20.7	bB	19.8	bC	29.0	B
	With	27.8	aB	23.8	aC	35.6	aA	23.3	aD	38.2	A
	Mean	35.6	B	29.9	C	39.0	A	29.9	D		

OD=Osmotic Dehydration, C=Control, COD=Control with Osmotic Dehydration, B=Bleaching, BOD=Bleaching with Osmotic Dehydration, S=Sulphitation, SOD=Sulphitation with Osmotic Dehydration, A=Antioxidant, AOD=Antioxidant with Osmotic Dehydration.Means followed by equal capital letters in the column do not differ from each other at P<0,05 probability by the Tukey's test. Means followed by equal lowercase letters on the row do not differ from each other at P<0,05 probability by the Tukey's test.

The osmotic dehydration favored the product with higher TSS values, being 10 ºBrix higher than drying in oven dryer, with incorporation of around 18% of sucrose relative to the initial mass of sugar of bananas, and the highest value is the CDO.[45] found that the intake of sucrose in bananas was about 10% of the initial sugar mass of the fruits. The values found were close to [35], 50°Brix in dried banana of the cv. Country, and of [7], of 61.8 Brix for dried banana of the cv. FHIA 18 and 62 Brix for Country, and lower than [37], of 67.61° Brix on dried banana cv. Apple, and [6], of 68.5°Brix in dried banana of the cv. silver, and [49], of 69.95°Brix in dried banana of the cv. dwarf, sucrose solution de 65°Brix, [47], of 72.93°Brix in dehydrated organic banana and [46], of 76.06°Brix. This sucrose incorporation was the same for all treatments until osmotic equilibrium, with the same TSS value of the osmotic solution, 65°Brix. Osmotic balance is a consequence of water loss from the fruit to the solution [43]. [5] observed that sucrose does not diffuse easily through the cell membrane. And [45] observed that the equilibrium value with osmotic solution limits the final water content in the food.

The interaction between treatments was significant for the sugar/acidity ratio (TSS/TTA). The osmotic dehydration favored higher value of (TSS/TTA). for all treatments in relation to treatments drying in oven dryer. These values were influenced by the total soluble solids (TSS). The SDO treatment had the highest value of (TSS/TTA). These values were higher than those of [7], 51.10 for dried banana cv. FHIA 18 and 51.00 for banana cv. Country, and close to those of [47], 67.52 to 68.97, and [51], 88.49 in dried banana cv. Plantain. According to [38] this relationship measures the degree of sweetness in the fruits. The lowest value found was for pretreatments Antioxidant, because it has a higher concentration of organic acids (citric acid and ascorbic acid). Regarding the biometric characterization, chemical composition and physicochemical characteristics the bananas cv. Thap Maeo are very similar to the fruits of cv. Country and cv. FHIA 18 of the silver group. The similarity with other varieties of the apple group has already been verified by [34], when evaluating the post-harvest quality of three cultivars of the apple group.

The osmotic dehydration and prevention of enzymatic browning significantly influenced the color (External) of dried banana, in the colorimetric differences of L*, a* and b*.For the banana it is expected colors ranging from red (chromaticity) to yellow (saturation), with brightness varying according to dehydration method used.When analyzing the dehydrated products, it was found that there was a significant difference for osmotic dehydration and prevention of enzymatic tanning for luminosity L* and saturation b*, while the prevention of enzymatic tanning was significant for luminosity L*, chromaticity a* and saturation b*. (Table 8 and Table 9). The luminosity L* defines the color to be lighter or darker, having as limits black and white. In all treatments the L* values were positive, indicating greater luminosity. With the bleaching, there was inactivation of the tanning enzyme during the process. This gave a higher L* value compared to the other samples and consequently lighter color, because the lower the L* value, the darker the color of the product. This gave a higher L* value compared to the other samples and consequently lighter color, because the lower the L* value, the darker the color of the product. The values were close to [47], for L* for organic banana cv. Country from 35 to 45, and [6], L*=42.35 in the banana cv. Silver. The chromaticity a* (hue) defines the color tone, having as limits the green and red.

Table 8. Summary of analysis of variance of external color and internal color of dried banana cv. Thap Maeo. Methods for prevention of enzymatic browningand dehydration.National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

VS	MS					
	Color (External)			**Color (Internal)**		
	L*	a*	b*	L*	a*	b*
D.	14.664***	6.3654***	30.600***	43.255**	3.800^{ns}	63.148**
PEB	60.148***	18.9431***	40.502***	47.620***	12.129*	41.568**
D.x PEB	0.067	0.1044^{ns}	0.070^{ns}	8.177^{ns}	04.720^{ns}	6.858^{ns}
Error	0.090	0.1214	0.144	3.485	2.431	5.870
CV%	11.76	22.76	40.64	9.55	19.14	22.50
GM	24.88	7.43	6.38	35.63	10.52	16.11

Min.	20.13	5.29	3.39	29.67	6.16	10.44
Max.	29.99	10.94	11.85	41.07	13.50	23.94

*MS=mean squared, VS=variation source; CV=coefficient of variation; GM=general mean; D.=dehydration; PEB=prevention the enzymatic browning. Significant at the * P<0,05 probability level by F-test, Significant at the ** P<0,01 probability level by F-test. Significant at the *** P<0,001 probability level by F-test. ns,no significant at the P<0,05 probability level by F-test.*

Table 9. Color external and internal color of dried banana cv. Thap Maeo. Methods for prevention the enzymatic browning and dehydration. National Institute for Amazonian Research – INPA, Manaus/AM, Brazil.

Parameters		(OD)	Prevention of enzymatic browning									
			(C)		(A)		(B)		(S)		Mean	
Color (External)	L*	Without	22.2	aA	25.1	aA	30.0	aA	25.3	aA	25.7	a
		With	20.7	aA	23.8	aA	28.2	aA	23.6	aA	24.1	b
		Mean	21.4	C	24.5	B	29.1	A	24.5	B		
	a*	Without	6.4	aA	7.6	aA	10.7	aA	7.0	aA	7.9	a
		With	5.5	aA	6.8	aA	9.3	aA	6.1	aA	6.9	b
		Mean	6.0	D	7.2	B	10.0	A	6.6	C		
	b*	Without	4.3	aA	3.8	aA	9.2	aA	3.8	aA	5.3	b
		With	6.5	aA	6.3	aA	11.4	aA	5.8	aA	7.5	a
		Mean	5.4	B	5.1	B	10.3	A	4.8	B		
Color (Internal)	L*	Without	35.2	aA	39.1	aA	40.5	aA	33.1	aA	37.0	a
		With	31.0	aA	34.9	aA	37.4	aA	33.8	aA	34.3	b
		Mean	33.1	B	37.0	A	38.9	A	33.5	B		
	a*	Without	10.5	aA	11.1	aA	11.8	aA	10.3	aA	10.9	a
		With	7.07	aA	11.3	aA	12.3	aA	9.8	aA	10.1	a
		Mean	8.76	B	11.2	AB	12.1	A	10.1	AB		
	b*	Without	16.7	aA	17.8	aA	21.9	aA	14.5	aA	17.7	a
		With	11.6	aA	14.1	aA	17.9	aA	14.4	aA	14.5	b
		Mean	14.2	B	16.0	AB	19.9	A	14.4	B		

OD=Osmotic Dehydration, C=Control, COD=Control with Osmotic Dehydration, B=Bleaching, BOD=Bleaching with Osmotic Dehydration, S=Sulphitation, SOD=Sulphitation with Osmotic Dehydration, A=Antioxidant, AOD=Antioxidant with Osmotic Dehydration.Means followed by equal capital letters in the column do not differ from each other at P<0,05 probability by the Tukey's test. Means followed by equal lowercase letters on the row do not differ from each other at P<0,05 probability by the Tukey's test.

In all treatments the values of a* were positive indicating the color to red. The bleaching influenced the chromaticity a* values, indicating more saturated red. These values are close to those found by [47], chromaticity a* from 9 to 11. Treatments with osmotic dehydration gave lower values of a*, with lower red saturation. However, bleaching favored the coloration of bananas as a higher red saturation than other treatments. Saturation b* (chroma) defines the intensity or purity of chromaticity, having as limits the blue and yellow. In all treatments the b* values were positive indicating the color to yellow more saturated. Treatments with osmotic dehydration gave higher values of b*, with greater red saturation. This coloration is due to the caramelization of sugar on the surface of the product. While the bleaching influenced the values of saturation b*, indicating more saturated yellow. The results of chromaticity b* were similar to those found by [47], chromaticity b* from 20 to 28.The bleaching gave the banana greater values of L*, a* and b* on the outside and inside that attributed better coloring to being more yellow, red and lighter.The osmotic dehydration and prevention of enzymatic darkening significantly influenced the (internal) color of the dried banana, and the COD treatment had the lowest values for luminosity L*, chromaticity a* and saturation b*. Bleaching (B and BOD) and addition of organic acids (A and AOD) were the treatments that most influenced internal coloring, and bleaching favored better coloring compared to other treatments.The coordinate a* represents the combination of green and red showing the brown color resulting from enzyme reactions (phenolases), showing the importance for the study of enzymatic browning[51].

4. CONCLUSION

The osmotic dehydrationgave the dried banana higher values of dry matter, carbohydrates, total soluble solid and brix/acidity ratio, ash, caloric value, and lower water activity, moisture content, lower texture and lowertotaltitrable acidity.Among the processes of prevention the enzymatic browning, bleaching was the best treatment because it gave to the product lower values of lipids, caloric value, dry matter, pH, total titrable acidity, texture (less hard), low moisture content, water activity within standards,high sugar/acidity ratio, highest and yield of dried banana, and higher values of L*, a* and b* on the outside and inside that attributed better coloring being more yellow, red and light.The technology of production dried banana bybleaching with osmotic gave the product good sugar/acidity ratio, best coloring, higher values of carbohydrates, total soluble solid and brix/acidity ratio, ash, caloric value, water activity within standards, and higher dried banana yield. Thus, the use of bleaching technology associated with osmotic dehydration to produce dried bananas from cv. Thap Maeo is a strategy for the conservation and addedvalue of bananas *in natura*.

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