



Quality of 'Ubá' mangos from harvest to receipt by the processing plant

Érica Granato Faria Neves¹, Afonso Mota Ramos², Gilberto Bernardo de Freitas³, Túlio Reis Teixeira⁴, Maria Emília Rodrigues Valente⁵, Erick Ornellas Neves⁶, Marcela Zonta Rodrigues⁷

¹ Department of Food, Universidade Federal de Ouro Preto, Campus Universitário, Morro do Cruzeiro, s/n. ZIP CODE: 35400-000, Ouro Preto, MG, Brasil.

efgranato@yahoo.com.br

² Department of Food Technology, Universidade Federal de Viçosa, Campus Universitário, s/n. ZIP CODE: 36570-000, Viçosa, MG, Brasil. Phone (31) 3899-1849 Fax: (31) 3899-2208 .

amramos@ufv.br

³ Plant Science Department / Fruit Growing Sector, Universidade Federal de Viçosa, Campus Universitário, s/n. ZIP CODE: 36570-000, Viçosa, MG, Brasil.

bernardo@ufv.br

⁴ Department of Food Technology, Universidade Federal de Viçosa, Campus Universitário, s/n. ZIP CODE: 36570-000, Viçosa, MG, Brasil.

tulioreisvrb@gmail.com

⁵ Department of Food Technology, Universidade Federal de Viçosa, Campus Universitário, s/n. ZIP CODE: 36570-000, Viçosa, MG, Brasil.

millaeal2003@yahoo.com.br

⁶ Department of Food Engineering, Universidade Federal de São João del Rei (DEALI/UFSJ), Rod. MG-424, km 47. ZIP CODE: 35701-970, Sete Lagoas / MG – Brasil.

neves@ufs.edu.br

⁷ Department of Food Technology, Universidade Federal de Viçosa, Campus Universitário, s/n. ZIP CODE: 36570-000, Viçosa, MG, Brasil.

marcela_vrb@yahoo.com.br

ABSTRACT

Fruit quality is extremely important for the processing *factory*. This study aimed to evaluate the physical, chemical and microbiological characteristics of 'Ubá' mangos at harvest, after ripening, upon receipt by the processing plant and during storage to identify points where physical damages and microbial contamination of fruits most likely occur after harvest. Microbiological analyses of aerobic mesophilic microorganisms and coliforms were performed at 35 °C and 45 °C. The physical and chemical characteristics evaluated included moisture (MOI), total titratable acidity (TTA), total soluble solids (TSS) content, pH, reducing sugars (RS), total sugars (TS), average weight, transversal (TD) and longitudinal diameters (LD), external peel coloration and the pulp colour. The results of the microbiological analyses of mango revealed that the ripening shed is a point of contamination of fruits. The microbial load increases considerably at this point and continues developing during transportation. The physical and chemical analyses conducted on the mangos showed that the fruits are within the standards established by law and are suitable for the production of pulp and derivatives such as juices and nectars.

Indexing terms/ Keywords: characterization; physico-chemical; microbiology; post-harvest contamination.

Academic Discipline: Food Science and Technology of Fruits

SUBJECT CLASSIFICATION Food Science

INTRODUCTION

Currently, fruit is one of the most competitive segments of the Brazilian agricultural sector. Fresh fruit and its derivatives show an upward trend in exports. The sector's potential stems from an increase in consumption in both internal and external markets. The increasing consumption of fruits worldwide is one of the factors that signal favourable opportunities for Brazilian fruit growing. Brazil, which is the third largest fruit producer in the world behind China and India, has been gradually expanding its participation in the world trade of fresh fruits and derivatives (Vilela and Moreira, 2008)²⁵.

The region of Zona da Mata of Minas Gerais contains several factory, which prepare fruits produced in the region. Among the currently marketed fruit products, 'Ubá' mangos are well accepted by processing plant because of their colour characteristics, flavour and texture and their acceptance by domestic and foreign markets (Ramos et al., 2005)²².

The climate throughout much of the Zona da Mata of Minas Gerais is appropriate for the cultivation of mango trees that is it exhibits well-defined dry and rainy seasons. This climate has led to the region becoming an important producing centre for mangos, including organic fruits. During the period of floral differentiation and flowering, the climate exhibits dry, mild temperatures, while during the formation and filling phase of the fruits, the temperatures and precipitation increase, allowing a satisfactory production of fruits without the need for intensive cultivation.



Because of these ideal climatic conditions, in 2005 and 2006, a portion of the fruit produced in the region received organic certification, which was promoted by the processing plant in the region. Of the many the municipalities located in the Zona da Mata of Minas Gerais, Guidoal stands out for its 'Ubá' mango production. Family farmers who have cultivated the fruit sell their production to the juice and pulp processing plant in the region. Although together they produce an impressive volume of organic mangos, these producers currently market their fruits as conventional because the region's processing plants do not process organic fruit (Ramos et al., 2010)²⁰.

'Ubá' mangos are usually harvested manually; harvesters climb trees and shake the branches or use a bamboo stick to throw down all the fruits of certain plant when they are "at the colour-turning stage". Before the fruits are thrown down, many producers cover the ground beneath the canopy of plants with straw mats to protect the fruits from the fall. The fruits remain on the mats until the latex, which comes off the stalk after the harvest, dries. Next, the fruits are collected in boxes and taken to a shed to complete their ripening. In the shed, the boxes are stacked and covered with mats and plastic sheeting to complete their ripening in a natural way or using smoke. After complete ripening, which occurs approximately five to seven days later, the fruits are removed from the shed and transported to the processing plant (Neves, 2010)¹⁸.

The fruits produced in the Zona da Mata of Minas Gerais need to be handled appropriately to ensure their physical and health qualities. Proper post-harvest management of fruits promotes quality improvement and reduces losses. The ability of farmers to provide fresh raw material at the appropriate degree of ripening and free from microbiological contamination and defects is important for improving the quality of fruits cultivated in the region (Ramos et al., 2007)²¹.

In this context, this study evaluated the physical, chemical and microbiological characteristics of 'Ubá' mangos at harvest, after ripening, upon receipt by the processing plant and during storage to identify points at which physical damage and microbial contamination of fruits after harvest could occur.

MATERIAL AND METHODS

Experimental design and samples collecting of mango

From harvest to loading dock by the processing plant

The experiment was conducted using a completely randomised 4x3 factorial design with three replicates. The first factor was site and the second factor was point along the production chain: field (immediately after harvest when fruits were already in the boxes), shed (during the ripening of fruits) and loading dock by the processing plant.

'Ubá' mango samples were collected during the 2008-2009 harvest during the months of largest fruit production on four sites located within the municipality of Guidoal in Minas Gerais. The fruits underwent microbiological, physical and chemical analyses.

At a site identified as P4, samples were collected in the field to perform the ripening of fruits under appropriate conditions to evaluate their health aspects and their microbiological and physical-chemical characteristics. The fruits were stored in plastic boxes and transported to the Fruit Growing Sector (FGS) at the Plant Science Department of Universidade Federal de Viçosa. To ripen the fruits, the boxes were stacked and the fruits were covered with paper sheets and canvas. After 5 days, the fruits were ripe, and samples were collected to perform the analyses. The boxes of fruit were transported to the fruit processing plant at the Department of Food Technology at the Universidade Federal de Viçosa. Samples of the mangos were again collected upon arrival.

For microbiological evaluation of the fruits, three samples were collected in the field, three others in the ripening shed and three upon loading dock the processing plant; each sample consisted of 5 mangos for a total of 36 samples and 180 mangos. All fruits were placed in polyethylene bags sterilised in an autoclave at 121 °C for 20 minutes and transported in cold boxes on ice to the laboratory.

For physical and chemical evaluations, three samples were collected at the same three points in the chain as above, but each sample was composed of 15 mangos, and there were a total of 36 samples and 540 mangos. The mangos were randomly selected, and their pulp was removed for analyses conducted in duplicate.

All fruits were transported to and analysed at the Science Laboratory of Products of Fruits and Vegetables, Department of Food Technology, Universidade Federal de Viçosa.

After receipt by the processing plant

Upon receipt by the factory, trucks carrying fruit shipments usually stay on the docks of the processing plant until the fruits are processed. Sometimes equipment failures occur that can stop the processing for up to several days.

To evaluate the effect of storage time on microbial counts and physical and chemical properties that reduce the quality of the raw material, samples of 'Ubá' mangos from three sites that were ripened at the FGS were collected upon arrival at the processing plant and were analysed at three points: upon receipt by the plant (time 0) and 24 and 48 hours later.

The experiment used a split-plot design with the four harvest sites as four levels (sites 1, 2, 3 and 4) with three replicates and the storage time as subplots at three levels (0, 24 and 48 hours).

For microbiological, physical and chemical analyses, three samples were collected upon arrival at the processing plant and at 24 and 48 hours after arrival for a total of 36 samples. For microbiological analysis, each sample consisted of five fruits totalling 180 mangos, which were placed in polyethylene bags, sterilised in an autoclave at 121 °C for 20 minutes, and transported in cold boxes to the laboratory. For physical and chemical evaluations, each sample consisted of 15 fruits totalling 540 mangos from which the pulp was removed to perform the physical and chemical analysis in duplicate.

Microbiological analysis performed in mango

To perform the microbiological analyses, 0.1% peptone water was added to the sterile bags containing each sample (5 mangos), at an amount dependent upon the weight of each bag containing the samples. The mangos were washed by manually shaking the bag for five minutes. Aliquots of the solution peptone water, which washed fruit, were diluted at 10^0 , 10^{-1} and 10^{-2} . Petrifilm™ plates were inoculated with 1.0 mL aliquots of the different dilutions.

Standard counts of aerobic mesophilic bacteria and coliform were conducted at 35 °C for all samples according to the methods of the Association of Official Analytical Chemists (AOAC, 2005)². Microbiological analyses of coliforms were performed at 45 °C according to the methods of the Association Française de Normalization (AFNOR)¹.

Physical and chemical analysis of mangos

The mangos were weighed using a precision scale (Welny, model W15). The transverse and longitudinal dimensions were determined using a digital calliper (Mitutoyo brand, model IPM / E 103). The peel and pulp colouration was determined using a portable colorimeter (model CR10, Minolta brand in the CIELAB system, through direct reading of the coordinates "L*", "a*" and "b*").

Moisture was determined by heating subsample at 105 °C to a constant weight; the pH was determined using a calibrated digital pH meter (Tenopon brand, model MPA 210); the total soluble solids content (TSS) was determined by direct reading of a refractometer ABBE (model WYA - 2S); total titratable acidity (TTA) was determined by titration, and the result was expressed as a percentage of citric acid; total and reducing sugars were determined by titrimetry with Fehling's reagent. All analyses were performed using the methods described by the Institute Adolfo Lutz (2008)¹⁵. The TSS / TTA ratio was determined by calculation.

Statistical analyses

The results of the microbiological, physical and chemical analyses of 'Ubá' mangos from farm to factory were analysed using an analysis of variance with comparisons by Duncan's test at a significance level of 5%. A regression analysis relating the analyses conducted on mangos after receipt by the factory to storage time was performed. Statistical analyses were performed using the statistical programme SAS (*Statistical Analysis System* - SAS Institute Inc., North Carolina, USA), licensed by the Universidade Federal de Viçosa.

RESULTS AND DISCUSSIONS

Microbiological evaluation of 'ubá' mango from harvest to loading dock in the processing plant

To study the interaction between the different sites where samples were collected and the points of the production chain, an analysis of variance (ANOVA) was conducted on the data obtained from the microbiological analysis. The summary of the ANOVA is described in Table 1.

Table 1 - Summary of analysis of variance of the microbiological characteristics of 'Ubá' mango from harvest to loading dock in the processing plant

FV	GL	Mean Square		
		(SC)	(C35)	(C45)
Sites (PROP)	3	0.2156 ^{ns}	1.3089*	0.4411 ^{ns}
Local (LC)	2	1.4687*	3.2950*	0.6459*
PROP * LC	6	0.1586 ^{ns}	0.4823 ^{ns}	0.2178 ^{ns}
Error	24	0.1758	0.2667	0.1555

* Significant at 5% of probability

ns = non-significant at 5% of probability.

SC = Standard count of aerobic mesophilic microorganisms.

C35 = Coliforms at 35 °C.

C45 = Coliforms at 45 °C.



There were no significant effects of site on the SC, C35 or C45 at any point in the production chain.

Because the interaction with site was not significant (Table 1), the three time points in the production chain were compared with each other using an ANOVA followed by Duncan's test at a 5% probability level. The results for SC, C35 and C45 are shown in Table 2.

Table 2 - Average of logarithm of count of microorganisms regarding mangoes analyzed at each point of the production chain

Production Chain	SC	C35	C45
Farm	3.86 a	1.19 a	0.66 a
Shed	4.41 b	2.21 b	1.12 b
Receipt	4.52 b	1.90 b	0.91 b, a

Means followed by at least one letter in the column do not differ by Duncan test at 5% probability.

SC = Standard count of aerobic mesophilic microorganisms.

C35 = Coliforms at 35 ° C.

C45 = Coliforms at 45 ° C.

Table 2 shows that mangos, both upon receipt by the factory and in the ripening shed, had higher SC and differed significantly at the farms, which had a lower average. Thus, the ripening shed is an important point of contamination of the fruits. The microbial load increases considerably in the shed and continues to develop during transportation. At harvest, many fruits are exposed to the soil and are transported in wooden boxes to the ripening shed. In the shed, fruits are stored in the same wooden boxes and covered with straw mats and plastic sheeting.

The straw mats, wooden boxes and the conservation status and hygiene of sheds are important factors in the contamination of mangos. Covering fruits with straw mats or plastic sheeting results in a significant increase in the respiration of fruits and, consequently, increased temperature and humidity of the environment, which favours microbial growth on the surface of fruits. At the sites visited, the structure of the ripening sheds is precarious. The boxes of fruit are in direct contact with the soil because most sheds have earth floors and no walls, and the boxes are not sanitised. No pest control (rodents and insects) is conducted, and domestic animals roam freely within the sheds.

The ripening sheds also have higher average C35 and C45, than does the farm (Table 2). Most orchards in the region are in "backyards", where there are domestic animals (dogs, chickens and pigs), and many producers use the orchards to graze animals, primarily cattle and horses. Contact with the soil and with the hands of harvesters are potential sources of microbial contamination for fruits. In the ripening shed, these microorganisms find a favourable environment for their proliferation.

Despite several contamination points for mangos, the results obtained for C 45 at the farm, in the sheds and upon receipt by the factory show that 'Ubá' mangos are within the standards established by legislation (Brasil, 2001)⁷. The Resolution RDC nº 12, January 2, 2001, the Ministry of Health, has set the microbiological standards for coliforms at 45 °C is on fresh mangos at 2.69 log UFC/g (Brasil, 2001)⁷.

Care during harvest and post harvest is necessary to improve the sanitary quality of fruit and reduce losses. Hygienic care and prevention of contamination are fundamental to the conservation of fruits. The Technical Regulation on Hygienic-Sanitary Conditions and Good Manufacturing Practices for Producers/Industries of Foods says that the methods and procedures for harvest and post-harvest shall not constitute a potential danger to or cause contamination of the product (Brasil, 2002)⁶. The higher the microbial load is and the more damaged the fruits are, the greater the loss of fruits and the more rigid the process of cleaning and disinfecting fruits should be. Processing plant may reject loads if the fruits arrive badly worn or contaminated. The producers' loss in these cases is high because they have already performed the work of harvesting, ripening and transporting the fruit.

Evaluation of the microbiological characteristics of 'ubá' mangos up to 48 hours after receipt by processing plant

To study the effect of storage time after mangos are received by processing plants on the microbiological quality of fruits, an analysis of variance (ANOVA) was conducted to verify the existence of significant effects between Sites and Time. The summary of ANOVA is described in Table 3.

Table 3 - Summary of analysis of variance (ANOVA) of the microbiological characteristics of 'Ubá' mango upon receipt by the processing plant.

FV	GL	Mean Square		
		SC	C35	C45
Sites (PROP)	3	0.4855*	5.1537*	1.3798*
Error a	8	0.1036	0.1364	0.2389
Time (TP)	2	0.2036*	0.1665 ^{ns}	0.4741 ^{ns}
PROP * T	6	0.0298 ^{ns}	0.1000 ^{ns}	0.0576 ^{ns}
Error b	16	0.0385	0.2235	0.1825

* Significant at 5% of probability

^{ns} non significant, at 5% of probability

SC - standard count of aerobic mesophilic microorganisms

C35 - Coliforms at 35 °C

C45 - Coliforms at 45 °C

The ANOVA (Table 3) indicates no significant interaction between PROP * TP for the SC, C35 or C45. Therefore, a linear regression between the variables measured and the storage time at the factory was conducted. A first-order model was tested. The selection of model was performed using the analysis of lack of adjustment of the experimental data at a 5% significance level by examining the coefficient of determination (R^2). The behaviour of the SC, C35 and C45 levels over time is shown in Figure 1.

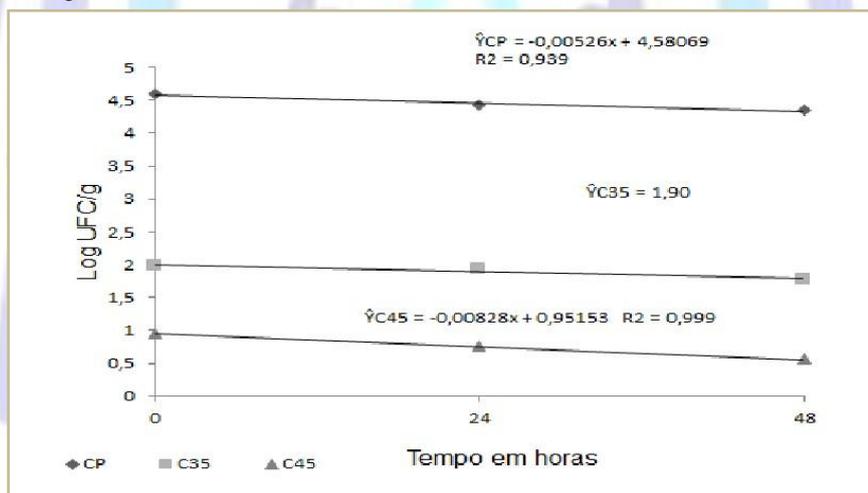


Figure 1 - Variation in the standard count of aerobic mesophilic microorganisms (SC), coliforms at 35 °C (C35) and coliforms at 45 °C (C45) of mangos analysed within 48 hours upon receipt by the processing plant.

The regression analysis showed a significant effect of time on the SC and C45, but not in C35.

The linear equations obtained for SC and C45 showed good adjustment with the results of the analysis over time; the lack of adjustment was not significant at the 5% probability level and had a coefficient of determination (R^2) of 0.939 (SC) and 0.999 (C45).

Storage time of up to 48 hours after receipt of fruits by a factory does not cause large changes in microbial counts on fruit surfaces.

Physical and chemical evaluation of 'ubá' mango harvest to loading dock in the processing plant

To study the interaction between the different sites where samples were collected and the points of the productive chain, an analysis of variance (ANOVA) of the data obtained from physical and chemical analysis was conducted (Table 4).



Table 4 - Summary of the analysis of variance (ANOVA) of the physical and chemical characteristics of weight, transversal diameter (TD), longitudinal diameter (LD), moisture (MOI), pH, total titratable acidity (TTA), total soluble solids (TSS), reducing sugars (RS), total sugars (TS) and Ratio (TSS /TTA) of 'Ubá' mango from harvest to loading dock in the processing plant.

FV	G L	Mean Square									
		Weight	TD	LD	MOI	pH	TTA	TSS	RS	TS	Ratio
Sites (PROP)	3	102.77*	0.07*	0.15 ^{ns}	17.59*	0.16*	0.21 ^{ns}	4.64*	7.56 ^{ns}	38.08*	267.65*
Local (LC)	2	434.64*	0.19*	0.21 ^{ns}	3.06*	4.17*	7.79*	492.38*	180.24*	2323.15*	4567.45*
PROP * LC ^{ns}	6	49.62 ^{ns}	0.01 ^{ns}	0.05 ^{ns}	0.31 ^{ns}	0.09 ^{ns}	0.22 ^{ns}	0.38 ^{ns}	9.28 ^{ns}	13.69 ^{ns}	111.63 ^{ns}
Error	24	659.02	0.01	0.12	0.60	0.04	0.09	0.58	4.23	6.20	76.02

^{ns} Non-significant at 5% of probability

* Significant at 5% of probability

From the ANOVA, there was no significant effect of the interaction PROP * LC in the physical and chemical parameters studied. Therefore, an analysis of variance followed by a Duncan test at 5% probability was performed on the physical and chemical characteristics comparing the three points in the production chain among themselves. The results are described in Table 5.

Table 5 - Physical and chemical characteristics of mangos analysed on the farm, in the ripening shed and upon loading dock by the processing plant

	Farm	Shed	Processing plant
Weight, g	108.64 a	102.11 b	97.16 b
Transversal diameter (TD), cm	5.36 a	5.16 b	5.14 b
Longitudinal diameter (LD), cm	7.15 a	6.97 a	6.89 a
External peel coloration of fruit			
L	51.27	54.49	55.95
a*	-10.09	0.12	4.25
b*	34.81	38.94	43.52
Pulp colour			
L	66.21	55.90	55.24
a*	-1.26	11.04	11.19
b*	39.10	39.77	39.13
Total soluble solids (TSS), °Brix	6.92 b	17.71 a	18.29 a
Total titratable acidity (TTA), % lactic acid	1.96 a	0.58 b	0.42 b
Ratio (TSS /TTA)	3.53 c	30.53 b	43.47 a
pH	3.20 b	4.15 a	4.29 a
Moisture (MOI)	83.11 a	82.64 a	82.09 a
Reducing Sugars (RS) (g/100 g glucose)	3.10 b	5.95 a	6.53 a
Total Sugars (TS) (g/100 g glucose)	4.99 b	12.73 a	12.91 a

Mean values followed by at least one letter do not differ in a Duncan's test at 5% probability.



The ripening shed and loading dock by the factory exhibited lower values for weight and differed significantly from the values observed at the farm, which had a higher average. During ripening, fruits lose moisture, which explains the loss in weight. According to Ramos et al. (2005)²², fruits intended for industrial processing should be medium-sized, which corresponds to a mass of 100-150 g.

The mean values obtained for TD and LD were close to those found by Faraoni et al. (2009)¹¹. Taken together, these parameters represent the size of fruit, and their relationship is associated with the form of the fruit. Their measurement is important for products destined for fresh consumption and it is only useful in products for processing in some cases, such as the manufacture of jams (Chitarra and Chitarra, 2005)¹⁰.

The colour of fruit is an important attribute of quality in products intended for processing because it contributes to a good appearance and influences the product's acceptance by the consumer. The average colour values found for L*, a* and b* on the surface of fruits show that the peel has yellowish-green colour at harvest. The values for the parameters a* and b* were negative and positive, respectively, indicating a green and yellow tint, respectively, to the skin of the fruit at harvest. After ripening, the values of a* and b* were higher than at harvest. The values for the parameters of a* were positive after ripening and upon receipt by the processing plant, indicating that the skin of the fruit exhibits a yellow tint.

The variables L, a* and b* for pulp indicate that the product has a yellowish-green colour at harvest and yellow-orange after ripening and receipt by the processing plant. The fruit at harvest had negative of a* and b*, a negative result, indicating green tint for pulp. The values for the parameters of a* and b* after ripening and in receipt in the factory were positive and higher than the harvest, indicating that the pulp of mango shows yellow and orange tint. The positive values found for pulp after ripening, indicating that the product has characteristic colour of pulp of 'Ubá' mango. Benevides (2006)⁴ found, for pulp of 'Ubá' mango, values of L (57.99), a* (15.91) and b* (49.11), which were close to those found in this study, which correspond to yellow and orange colour. In the pulp of mangos, positive b* values are mainly due to the presence of carotenoids, the main pigments found in mangos. Carotenoids are, in general, pigments of yellow to orange in colour (Chitarra and Chitarra, 2005)¹⁰. According to Pinto et al. (2002)¹⁹, the colour of skin and pulp of mango is yellow.

For factory, fruits with high soluble solids content result in higher yields at processing. The average TSS for mangos analysed were close to those values found by Galli et al. (2008)¹³ and Silva et al. (2009)²³. At the ripening shed and upon receipt by the factory, the mangos exhibited higher values for TSS, differing statistically from the farm, which had a lower average. Sothornvit and Rodsamran (2008)²⁴ observed that the increase in soluble solids in mangos could be attributed to the ripening of the fruits.

The values of TTA, pH and Ratio (TSS /TTA), as described in Table 5, for 'Ubá' mangos in the shed and upon receipt by the processing plant are close to those values found by Benevides et al. (2008)³. The Ratio (TSS /TTA) is widely used to evaluate the sensory quality of fruit, showing the degree of balance between these two components (Chitarra and Chitarra, 2005)¹⁰. The acidity is attributed to organic acids, primarily citric acid, which is dissolved in fruit cells.

Similar results to those described in Table 5 for mangos analysed at the farms were observed by Megale (2002)¹⁷ in green mangos, *Palmer cultivar*, for pH (3.6) and moisture (83.74%). The fruits examined in the shed and upon receipt had MOI values close to those found by Fontes (2002)¹², who found moisture of 79.95% for the 'Ubá' mango.

The sugars present in fruits are responsible for their sweetness and sugar content increases with ripening. The total and reducing sugar content in samples in the shed and upon receipt, as described in Table 5, are similar to results reported by Faraoni et al. (2009)¹¹ for reducing (5.00%) and total (10.5%) sugars. According to Hulme (1971)¹⁴, among the six mango varieties studied ('Haden', 'Keitt', 'Irwin', 'Zill', 'Sensation' and 'Kent'), the content of reducing sugars was between 3.4% and 5.3%, and total sugars were between 4.8% and 9.9% in green mangos.

During maturation, many chemical changes occur, resulting in sensitive alterations in the characteristics such as colour, flavour and aroma. The initial characteristic change is the degradation of chlorophyll, as well as the synthesis of other pigments that produce changes in colour. This change is followed by the synthesis of sugars and a reduction in acidity. During ripening, there is a sharp decline in organic acid content because these acids are being widely used as substrates in the respiratory process or transformed into sugars (Chitarra and Chitarra, 2005)¹⁰.

The main sugars present in fruits are fructose, glucose and sucrose. The disaccharide sucrose is the main non-reducing sugar, while glucose and fructose are the main reducing sugars. In general, fruits contain more reducing sugars than sucrose (Brecht et al., 2010)⁹. During ripening, there is an increase in the reducing sugars content. The ratio of the different types of sugars is an important attribute of quality, because the sugars differ in degree of sweetness; fructose has a greater sweetness level than sucrose, which is greater than glucose. The ripening process promotes an increased content of sugars, which is primarily attributed to the hydrolysis of reserve carbohydrates accumulated during fruit growth in the plant, thereby resulting in the production of total sugars (Bezerra, 2009)⁵.

As shown in Table 5, the ripening shed and the receipt by processing plant differed statistically from the farm in terms of total titratable acidity, total soluble solids, pH, reducing sugars and total sugars. The results confirm the changes that occur in mangos during ripening. Lebrun et al. (2008)¹⁶ analysed the mangos varieties 'Cogshall', 'Kent' and 'Keitt' immediately after harvest when the fruits were still green and again after ripening. The results for values of pH and total soluble solids increased, and total titratable acidity values decreased with the ripening of fruit. The results indicate that fruit exhibits a reduced acid content and increased solids after ripening.

The Technical Regulation for Identity and Quality Standards for Mango Pulp (Brasil, 2000)⁸ establishes physical and chemical parameters, such as a pH between 3.30 and 4.50, minimum total soluble solids at 20 °C of 11.0 °Brix, a



minimum total acidity of 0.32 g/100 g of citric acid, and maximum total sugars of 17.0 g/100 g. The processing plant of the Zona da Mata of Minas Gerais establish additional physical-chemical criteria for 'Ubá' fresh mangos (Table 6) to standardise them for processing pulp and juice.

Table 6 - Physical-chemical parameters established for 'Ubá' mango intended for processing, set by the factory in the Zona da Mata of Minas Gerais

	Minimum	Maximum
pH	3.70	4.30
Total soluble solids (° Brix)	14.00	20.00
Total titratable acidity (g citric acid/100 g pulp)	0.50	0.80
Total soluble solids/total acidity (<i>ratio</i>)	17.80	40.00

Source: Benevides et al. (2008)³

The physical and chemical analysis performed on 'Ubá' mangos showed that they are within the standards established by legislation (Brasil, 2000)⁸. As for the specifications established by the factory itself (Table 6), it was found that the mangos have pH, total soluble solids and total titratable acidity suitable for the production of mango pulp and its derivatives, such as juices and nectars.

Evaluation of physical and chemical characteristics of 'ubá' mango until 48 hours upon receipt by the processing plant.

Initially, an analysis of variance (ANOVA) was performed to verify the existence of a significant effect of the PROP*TP interaction. The effect of the PROP*TP interaction was not significant at 5% probability for the physical and chemical parameters studied (Table 7). Therefore, these characteristics were regressed against time.

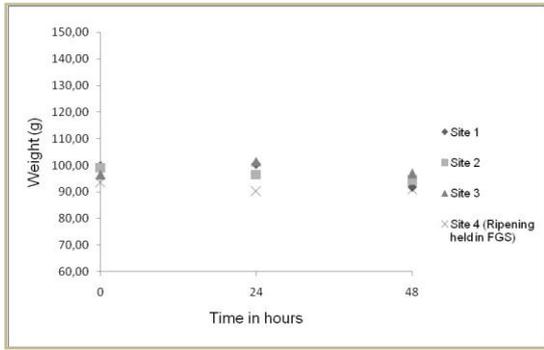
Table 7 - Summary of the analysis of variance (ANOVA) of the physical and chemical characteristics of weight, transversal diameter (TD), longitudinal diameter (LD), moisture (MOI), pH, total titratable acidity (TTA), total soluble solids (TSS), reducing sugars (RS), total sugars (TS) and *Ratio* of 'Ubá' mangos upon receipt by the processing plant.

FV	GL	Mean Square									
		Weight	TD	LD	MOI	pH	TTA	SST	RS	TS	<i>Ratio</i>
Sites (PROP)	3	82.47 _{ns}	0.0285 _{ns}	0.1502 _{ns}	18.46 *	0.5359 *	0.0228 *	6.34 *	0.0559 _{ns}	0.36 ^{ns}	141.59 *
Error a	8	70.61	0.0096	0.0402	0.69	0.0051	0.0015	0.53	0.06178	0.17	7.39
Time (TP)	2	53.40 _{ns}	0.0106 _{ns}	0.0686 *	2.42 *	0.0739 *	0.0093 _{ns}	0.84 *	2.6597 *	29.83 *	73.59 ^{ns}
PROP * TP	6	21.14 _{ns}	0.0065 _{ns}	0.0156 _{ns}	0.46 ^{ns}	0.0031 _{ns}	0.0043 _{ns}	0.43 ^{ns}	0.0673 _{ns}	1.32 ^{ns}	21.28 ^{ns}
Error b	16	20.98	0.0046	0.0104	0.66	0.0159	0.0035	0.20	0.1045	0.54	43.44

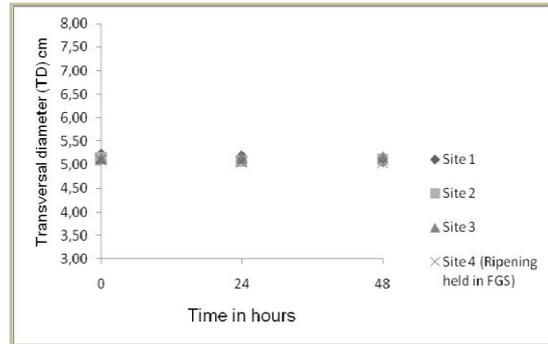
^{ns} Non-significant at 5% of probability

* significant at 5% of probability

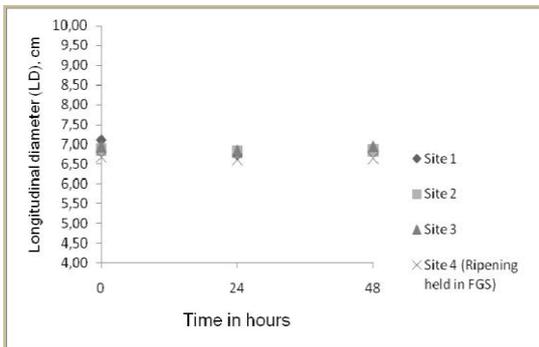
Thus, for the physical and chemical parameters analysed, a linear regression models as a function of time was performed, which tested the first-order models. The choice of model was determined from an analysis of lack of adjustment with the experimental data at a 5% significance level by evaluating the coefficient of determination (R^2). The weight of the transversal diameter (TD) and longitudinal (LD), moisture (MOI), pH, total titratable acidity (TTA), total soluble solids (TSS), reducing sugars (RS), the total sugars (TS) and the *ratio*, over time, are shown in Figure 2.



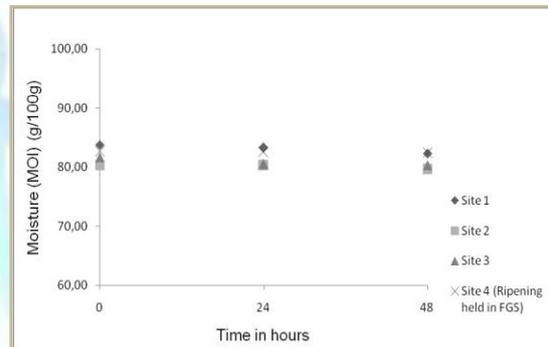
(a)



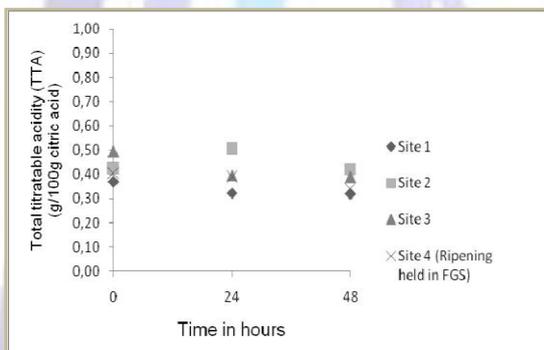
(b)



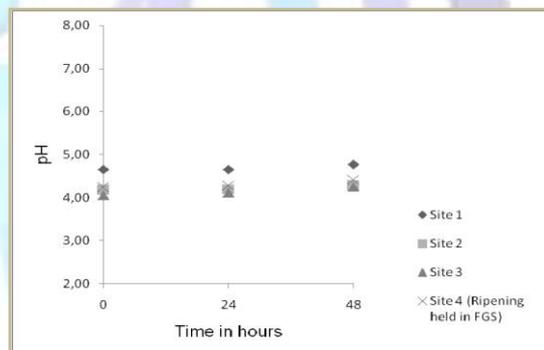
(c)



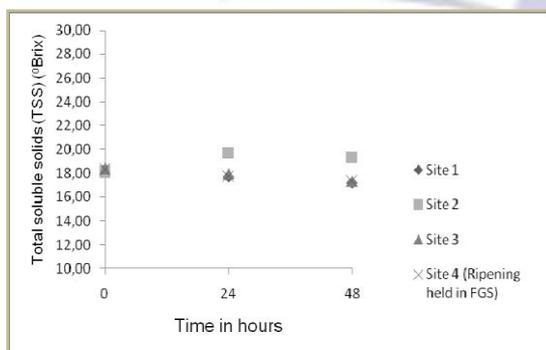
(d)



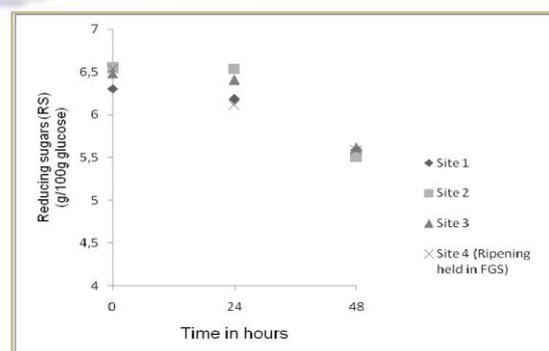
(e)



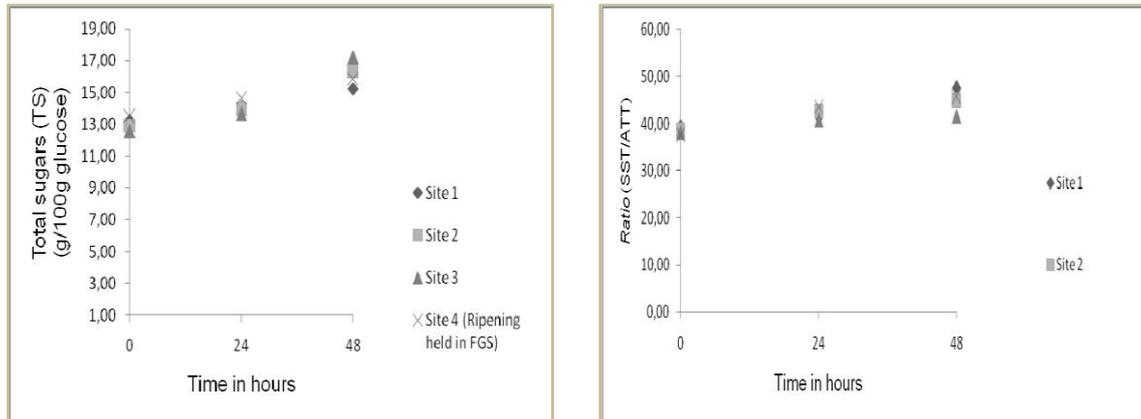
(f)



(g)



(h)



(i)

(j)

Figure 2 - Variation in the physical and chemical parameters of mangos analysed in different sites within 48 hours upon receipt by the processing plant: a) Weight b) Transversal diameter (TD), c) Longitudinal diameter (LD) d) Moisture (MOI) e) pH f) Total titratable acidity (TTA) g) Total soluble solids (TSS) ; h) Reducing sugars content (RS); i) Total sugars content (TS); j) TSS / TTA (*Ratio*).

In the regression analysis, there was no significant effect in weight, TD, LD, MOI, pH, TTA, TSS, RS and *Ratio* over time upon receipt by the processing plant.

There was a significant effect of time for TS. Initially, the average obtained for TS was 16.16. Over time, the total sugar content of mango showed a slight decrease, eventually reaching 13.07. This finding suggests that the fruits respire, oxidising sugars to obtain energy. The linear equation obtained presented a good adjustment of the results of physical and chemical analysis over time; the lack of adjustment was not significant at the 5% probability level, and the coefficient of determination (R^2) was 0.945.

The averages of the physical and chemical analyses performed up to 48 hours after receipt of mangos by in processing plant are presented in Table 8.

Table 8 - Physical and chemical characteristics of the mangos analysed up to 48 hours upon receipt by the processing plant.

ANALYSES	Time (hours) Average \pm SE		
	0	24	48
Weight (g)	97.16 \pm 2.85	93.50 \pm 5.11	97.15 \pm 2.69
Transversal diameter (TD), cm	05.16 \pm 0.06	05.12 \pm 0.06	05.10 \pm 0.05
Longitudinal diameter (LD), cm	06.90 \pm 0.17	06.75 \pm 0.10	06.84 \pm 0.14
Moisture (MOI) (g/100 g)	82.11 \pm 1.47	81.65 \pm 1.50	81.17 \pm 1.41
pH	04.28 \pm 0.26	04.31 \pm 0.24	04.43 \pm 0.23
Total titratable acidity (TTA) (g/100 g citric acid)	0.42 \pm 0.05	0.40 \pm 0.08	0.37 \pm 0.05
Total soluble solids (TSS) ($^{\circ}$ Brix)	18.26 \pm 0.13	18.32 \pm 0.95	17.81 \pm 1.02
Reducing sugars (RS) (g/100 g glucose)	6.47 \pm 0.05	06.31 \pm 0.19	05.58 \pm 0.01
Total sugars (TS) (g/100 g glucose)	16.16 \pm 0.40	14.08 \pm 0.42	13.07 \pm 0.81
Ratio (TSS /TTA)	43.47 \pm 0.88	45.80 \pm 1.29	48.13 \pm 2.53

SE: Standard error

The *Ratio* is commonly used to evaluate fruit flavour. The balance between these two components allows us to evaluate the sensory quality of fruit. According to the parameters described in Table 3, the factory in the region of Zona da Mata of Minas Gerais have established quality standards for 'Ubá' mango pulp for the value of this ratio of 17.80-40.00. The *Ratio* analyses performed on 'Ubá' mangos indicate that fruits had higher values than the standards set by the processing plant upon arrival at the processing plant.



CONCLUSIONS

The sheds used to ripen 'Ubá' mangos are important points of contamination for the fruit. The microbial load increases at this chain point and continues to develop during the transportation. Despite the lack of appropriate techniques for post-harvest, the analysis of 'Ubá' mangos from harvest to loading dock by the processing plant revealed that the fruits are within the microbiological, physical and chemical standards established by Brazilian legislation.

The storage of mangos for up to forty-eight hours upon receipt by the processing plant does not cause large changes in the microbiological, physical and chemical quality of fruits.

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