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Accelerated Ripening of Mangoes in the Commune of Man

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Abstract: The ripe look and quality of mango are market requirements. Faced with the demands, some sellers use accelerated mango ripening methods to sell their stock quickly. Like these, the sellers of the city of Man use a method of rapid ripening of mangoes with the ashes of cooked wood. The main objective of this study is to evaluate the influence of this accelerated ripening method on the organoleptic quality of mangoes (Mangifera indica) in the city of Man. The harvested mangoes were sprinkled with cooked wood ashes, packed and kept in a dark place in the laboratory. Physical and biochemical analyzes were determined. The analyzes revealed rapid ripening of the treated mangoes (2 to 3 days) whereas the untreated mangoes ripen between 5 and 8 days. During storage, we noticed losses in mass, firmness, dry matter, starch content and phenolic compounds but on the other hand an increase in soluble dry extract, pH, reducing sugar content, the transfer of the green to dark red skin color of stored mangoes. This method used makes it possible to obtain mangoes which ripen quickly and of good organoleptic quality.

Keywords: Mangoes, Keitt, Kent, Wood Ash, Accelerated Ripening, Man

1. Introduction

Mango is a tropical fruit appreciated for its taste and nutritional qualities due to its high vitamin A content [28] It is a delicate fruit, very sensitive to post-harvest losses [12]. The mango is consumed in the ripe state in the form of dessert and salad [6]. Its maturation process begins on the tree and continues after harvest: harvested too early, the mango crumples without really ripening; harvested too late, its shelf life will be too limited to withstand transport over long distances [12]. Mango production all over the world is ensured by a multitude of small growers [24]. In Côte d'Ivoire, around five thousand producers produce mangoes and nearly 90% of national production is provided by small growers (around 7,000) [23, 21]. Côte d'Ivoire is the third supplier of the European market and the first African country exporting mangoes. Mango is the third fruit exported by the country behind bananas and pineapples [21]. However, out of a production of approximately 1,800,000 tonnes per year, sales difficulties linked to the narrowness of the domestic market, consumer demand and fruit diseases cause the rotting of nearly 40% of the production [8]. Indeed, the quality and appearance of mangoes on the markets are criteria for choosing them. It is therefore essential to know whether the aptitude for conservation and the marketing techniques used will guarantee a correct final quality, capable of both meeting market requirements and facing up to competition [24]. Some vendors, faced with market demands, use traditional ripening methods to sell their unripe mangoes. Indeed, some mangoes, well adorned with yellow and red nuances, are hard as "stone". No doubt, these mangoes need a little boost to ripen a little faster [28]. The main objective of this study is to evaluate the influence of traditional ripening (use of wood ashes) on the organoleptic quality of mangoes (Mangifera indica) in the city of Man. This will specifically be:

1) Sprinkle the ashes of the cooked wood on the mangoes, wrap the mangoes in plastic bags and store the packages obtained in a dry and dark place,
2) Appreciate the effect of this accelerated ripening method on the organoleptic quality of mangoes.

2. Materials and Methods

2.1. Plant Material

The plant material used is mango (Mangifera indica). These are two varieties of mango: Kent and Keitt from the fields or plots of the city of Man which were the subject of our study. The mangoes used are 120 days old after flowering and harvested in February 2021 in the fields or plots of certain farmers who have given their agreement for the picking of these.

Geographical Location of the City of Man

This study was conducted in the town of Man. The city of Man is located in the west of Côte d'Ivoire, at latitude 7° 24' North and longitude 7° 33' West. This city is bounded to the north and west by the city of Biankouman and Danané, to the south by Bangolo (Figure 1). It is a mountainous and forested area with a mountain climate, a long rainy season and a short dry season favoring the formation of dense forest.

Figure 1. *Geographical location of the city of Man.*

2.2. Methods

2.2.1. Sampling

The experiment took place with 200 mangoes of the Mangifera indica variety harvested from 20 mango trees due to 10 mangoes per mango tree in the city of Man. The mango trees of the Mangifera indica variety chosen were distributed in five zones of the city of Man, namely the north, the south, the west, the east and the center of the said city. In each zone, there are 4 mango trees chosen from a field or plot. All the fruits were harvested in substantially the same ripening stage (green) during the 2021 mango season. Physical data was collected on each mango in the sample. The processed mangoes were stored in the black plastic bags. A quantity of 5 mangoes sprinkled with wood ash was put in each plastic bag and 5 other mangoes that had not undergone treatment were exposed to room temperature. A total of 150 mangoes were sprayed with wood ash and another 50 unsprayed mangoes were stored at room temperature.

2.2.2. Traditional Ripening Process

The mangoes were ripened according to a traditional method used by most mango vendors in the city of Man and its surroundings. Unripe and very green mangoes are sprinkled with wood ash. The processed mangoes are kept in black plastic bags and tied. These obtained packets are kept in a dry and dark place in the house. This method is described according to the following flowchart:

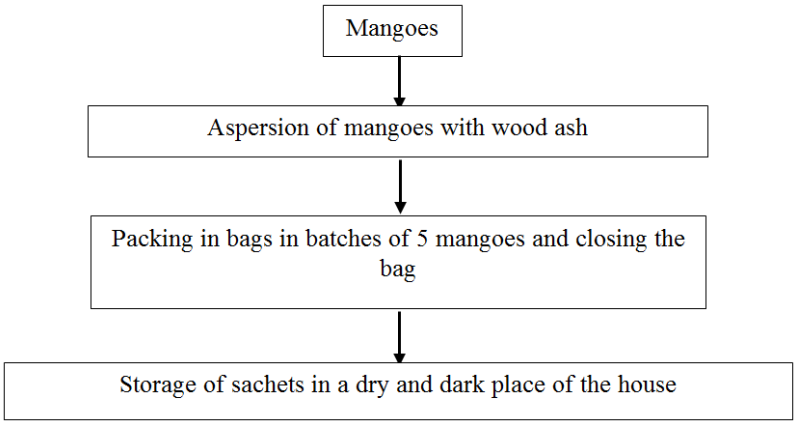

Figure 2. *Traditional wood ash ripening method for mangoes.*

2.2.3. Analytical Methods

(i). Determination of Physical and Biochemical Characteristics

The skin color of mangoes was determined by the method of [16] based on visual and touch assessment methods**.** The mass of each mango was determined by weighing on a scale (Berkel: minimum capacity 100 g and maximum capacity 100 kg). The firmness of the mango pulp was determined using a penetrometer according to the method described by [19]. The soluble dry extract is measured by refractometry on the mango juice, using a hand refractometer WYT 4 Grosseron precision l°Brix. The pH is measured on the undiluted juice using a SCHOTT GERÂDE pH-meter CG 818 pH probe. The water and dry matter content of mangoes is determined according to the AACC method [1]. The starch content is determined according to the AFNOR standard [2]. The extraction of total sugars was done according to the method described by [17] and the dosage of reducing sugars were made according to the method described by [11]. The determination of total phenols was done by the method of [15].

(ii). Statistical Analyzes

The analysis of the physical and biochemical parameters was carried out using the XLSTAT 7.5.3 EXCEL software. The comparison of the means was made according to Duncan's test at the 5% threshold.

3. Results and Discussion

3.1. Physical Characteristics of the Mangoes Used

The physical characteristics of the mangoes used are recorded in Table 1.

Green lifetime

Treated and untreated mangoes have different green lifespans. Untreated mangoes have twice the green life of treated mangoes. The green life of untreated mangoes is between 5 and 8 days while those of treated mangoes are between 2 and 3 days. Both Kent and Keitt processed mango varieties have the same green life of 2-3 days. The untreated ones also have the same green life between them of between 5 to 8 days.

The difference between the green lifespans of treated and untreated mangoes would be linked to the strong heat produced by packing the mangoes and to the action of wood ash on the action of ethylene (a hormone that promotes maturation of climacteric fruits). Indeed, the passage from the mature state to the ripe state of the mango is manifested by a resumption of respiratory activity as brief as it is intense and a strong release of ethylene [9, 29]. These phenomena characterize the climacteric crisis. This climacteric respiration during fruit ripening has a great impact on shelf life since this phenomenon draws on metabolic reserves [14]. Also, the higher the temperature of the fruit, the greater the metabolic activities [5, 22]. During the ripening process, chloroplasts are transformed into chromoplasts, chlorophyll is degraded, carotenoids accumulate and the color of the fruit changes from green to red [3].

Mass and firmness

The masses of the treated Keitt and Kent mangoes are lower than those of the untreated mangoes of the same species at the 5% threshold. The masses of treated mangoes are between 508.6 ± 1.4 and 533.2 ± 1.5 g while those of untreated mangoes start from 570.6 ± 1.8 g to 596.6 ± 1.7g.

This mass loss between treated and untreated mangoes was observed by [14]. This mass loss would be linked to the loss of water from the mango cells which affects the shape and mass of the mangoes.

The firmnesses of the treated mangoes are lower than those of the untreated mangoes at the 5% threshold. The firmnesses of the treated mangoes are between 1.6 ± 0.5 to 1.8 ± 0.1 N while those of the untreated mangoes are between 2.3 ± 0.3 and 2.4 ± 0.1 N.

The difference in firmness between treated and untreated mangoes would be linked to the high heat produced by the packaging of the fruit. Indeed, the heat stimulates the synthesis of ethylene which in turn causes a disorganization of the walls [7]. The disorganization of the cell walls which occurs during ripening appears to be the preponderant factor in the modification of the texture, essentially in the softening of fruits during ripening [7].

Table 1. *Physical characteristics of the mangoes used.*

	Green life (d)	Skin color	Mass of mango (g)	Firmness (N)
Kent Processed Mangoes	2-3[a]	Dark red	533,2 ± 1,5[c]	1,6 ± 0,5[g]
Untreated Kent Mangoes	5-8[b]	Green	596,6 ± 1,7[d]	2,3 ± 0,3[h]
Keitt Processed Mangoes	2-3[a]	Dark red	508,6 ± 1,4[e]	1,8 ± 0,1[g]
Untreated Keitt Mangoes	5-8[b]	Green	570,6 ± 1,8[f]	2,4 ± 0,1[h]

Values in the same column followed by different letters show significant differences ($p<0.05$). Each value is the mean of the results obtained over 5 determinations ± standard deviation of this mean.

3.2. Biochemical Characteristics of the Mangoes Used

The results of the biochemical characteristics of the mangoes studied are recorded in Table 2.

The Dry Extracts of treated mangoes are higher than those of untreated mangoes at the 5% threshold. The Dry Extracts of treated mangoes are between 19.2 ±0.4 and 20.1 ± 0.1°Brix while those of untreated mangoes are between 8.6 ±0.8 and 9.6 ± 0, 5°Brix.

The difference observed between the Dry Extracts of treated and untreated mangoes would be linked to ripening. Indeed, during the maturation of mangoes, the Dry Extract increases [10, 13, 26, 27]. The increase in Dry Extract would be linked to the hydrolysis of starch which releases reducing sugars [10].

The pH values of treated mangoes are acidic and higher than those of untreated mangoes at the 5% threshold. The pH values of the treated mangoes are between 4.4 ± 0.1 and 4.6 ± 0.5 while those of the untreated mangoes are between 3.3 ± 0.3 and 3.5 ± 0.7 would be linked to the hydrolysis of starch which releases reducing sugars [10].

The increase in the pH of the treated mangoes would be linked to the rapid ripening of the mangoes caused by the heat produced. Indeed, during the ripening of mangoes, the pH increases [10, 26].

The dry matter content of treated mangoes is higher than that of untreated mangoes at the 5% threshold. The dry matter contents of the treated mangoes are between 24.7 ± 0.4 and 25.5 ± 0.4 g/100 g DM whereas those of untreated mangoes are between 21.3 ± 0.1 and 21.8 ± 0.2g/100g MS.

The difference in the dry matter of the mangoes would be linked to the rapid ripening caused by the heat produced during the treatments. Indeed, the dry matter of mangoes increases during ripening [10, 13].

The starch contents of treated Kent (0.5 ±0.1 g/100 g DM) and Keitt (0.4 ± 0.3 g/100 g DM) mangoes are lower than those of the same untreated Kent varieties (1.2 ± 0.2 g/100 g DM) and Keitt (1.1 ± 0.1 g/100 g DM).

The difference in starch content between treated and untreated mangoes was also observed by Sawadogo (1993, [10, 13, 26]. These authors observed a hydolysis of the starch of mangoes during their maturation.

The sugar content of treated mangoes is higher than that of untreated mangoes at the 5% threshold. The reducing sugar contents of the treated mangoes are between 32.8 ± 0.8 mg/100 g DM and 33.2 ± 0.5 mg/100 g DM. However, the reducing sugar contents of untreated mangoes oscillate between 22.9 ± 0.2 mg/100 g DM and 23.2 ± 0.4 mg/100 g DM.

The difference between the levels of reducing sugars would be linked to the hydrolysis of the starch [10, 26]. Indeed during the hydrolysis of the starch, the reducing sugars accumulate in favor of the starch content which decreases.

The total phenol contents of treated mangoes are lower than the contents of untreated mangoes. The total phenol contents of treated mangoes vary between 35.8 ± 0.7 and 36.4 ± 0.2 mg/100 g DM while those of untreated mangoes vary between 49.8 ± 0.4 and 50.3 ± 0.5 mg/100 g DM.

The difference between the total phenol contents of treated and untreated mangoes would be linked to the rapid ripening of the treated mangoes. Indeed, the total phenol content of mangoes decreases during ripening [16].

Table 2. *Biochemical characteristics of the mangoes used.*

	Soluble Solids (°Brix)	pH	Dry matter content (g/100g DM)	Starch content (g/100g DM)	Reducing sugar content (mg/100g DM)	Total phenol content (mg/100g DM)
Kent Processed Mangoes	20,1±0,2[a]	4,4±0,1[c]	25,5±0,4[e]	0,5±0,1[g]	33,2 ± 0,5[i]	36,4±0,2[k]
Untreated Kent Mangoes	9,6±0,5[b]	3,3±0,3[d]	21,3±0,1[f]	1,2±0,2[h]	23,2 ± 0,4[j]	50,3±0,5[l]
Keitt Processed Mangoes	19,2±0,4[a]	4,6±0,5[c]	24,7±0,4[e]	0,4±0,3[g]	32,8 ± 0,9[i]	35,8±0,7[k]
Untreated Keitt Mangoes	8,6±0,8[b]	3,5±0,7[d]	21,8±0,2[f]	1,1±0,1[h]	22,9 ± 0,2[j]	49,8±0,4[l]

Values in the same column followed by different letters show significant differences ($p<0.05$). Each value is the mean of the results obtained over 5 determinations ± standard deviation of this mean.

4. Conclusion

The method of accelerated ripening of mangoes with wood ash allowed us to observe a rapid reduction in the green life of mangoes, loss of mass, firmness, dry matter, starch and phenolic compound content but on the other hand an increase in soluble dry extract, pH, reducing sugar content, change in skin color from green dark red. This ripening method influences the biochemical parameters of stored mangoes and is of interest for accelerating the ripening of mangoes. This ripening method can be recommended to the authors of the

mango sector for the rapid flow of mangoes.

5. Recommendation

This method of rapid ripening of mangoes must now be part of the recovery solutions for the mango sector in Côte d'Ivoire and around the world.

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