Physical, chemical and microbiological changes in mango varieties when cryopreserved using solar energy

Abstract

Fruits and vegetables are highly perishable living tissues that maintain their metabolic activity even after harvest. This study aimed to monitor the changes of physicochemical and microbiological parameters of two varieties of mango (*Valencia* and *Camerounaise*) during conservation in a photovoltaic cold room. The mangoes were stored at 10-12°C with a relative humidity of 80-90% for 3 weeks (*Valencia*) and 7 weeks (*Camerounaise*). Mango samples were taken every week for analyses. The physicochemicaland microbiological parameters of mangoes were determined using standard methods. Results showed an increase in the reducedsugar content of mangoes (3.12±0.01-4.79±0.02 % for the *Valencia* variety and 3.01±0.08-6.22±0.02 % for the *Camerounaise* variety). The water content of the mango remained practically constant (85.42% to 85.40%) for the *Valencia* variety. However, an increase was observed for the *Camerounaise* variety (86.26±0.00-87.29±0.03 %). The titratable acidity of mangoes decreased(1.07±0.03-0.67±0.01 %) and their Brix level increased (9.8±0.01-16.20±0.01 % for the *Valencia* variety and 8.00±0.00-13.50±0.14 % for the *Camerounaise* variety). The maximum relative mass loss observed was 8.25% for the *Camerounaise* variety. Regarding the microbiological analyses, the results showed a reduction in total flora and yeast and mold loads during storage. Storage in a solar cold room of fresh mangoes picked at physiological maturity and pretreated in accordance with good hygiene practices, delays the ripening process, inhibits the proliferation of surface microorganisms, preserves the physicochemical characteristics and extends the shelf life of the mangoes. Preserved mangoes are of good quality.

Keywords: Mango varieties, photovoltaic solar cold room, preservation, physico-chemical and microbiological parameters.

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1. Introduction

The mango, fruit of the mango tree, is a drupe of 7 to 12 cm in diameter, more or less flattened laterally, which has a characteristic odor when ripe. Mango is also a climacteric fruit, ripening after harvesting. It is a fruit rich in carbohydrates, mineral salts and other

bioactive substances such as carotene, vitamins C, B1, B2 and phenolic compounds [1]; [2]. In Burkina Faso, it is the most important fruit crop, and is therefore considered the "first national fruit" [3]. Like other fruits and vegetables, mango is highly perishable due to its high-water content [4]. Its preservation at room temperature remains difficult. Preservation techniques have been developed to delay the deterioration of mangoes and increase their shelf life. These include cold storage. Cold is the first food preservation technique that preserves the original qualities of the foodstuff [5]. Indeed, refrigerated storage is a well-established and widely used technology for storing horticultural crops worldwide [6]; [7]; [8]. However, this technology remains inaccessible to growers in developing countries like Burkina Faso because of the high cost of electricity. The development of infrastructures using the sun as an energy source is an alternative for promoting refrigerated storage in these countries. With this in mind, a photovoltaic solar cold room has been designed at the Energy Department of the Institut de Recherche en Sciences Appliquées et Technologies (DE/IRSAT, Burkina Faso) for the preservation of highly perishable fruits and vegetables, in this case, mango [9].The objective of the present work was to evaluate the effectiveness of this photovoltaic solar cold room by following the evolution of the physicochemical and microbiological parameters of mangoes during storage.

2. Materials and Methods

2.1. Description of the photovoltaic solar cold room

The photovoltaicsolar cold room used was previously described by Compaoré *et al.[*9]. It is a 32 m^3 chamber connected to an air-cooled compressor/condenser unit located inside a technical room along the east wall of the cold store. The cold store is supplied with electrical power by a 5 KWp mini photovoltaic system. This power is supplied by 20 modules of 250 Wp each, grouped into two strings, one of 12 modules and the other of 8 modules. Two 5 KVA hybrid inverters supply the two cooling units. An energy storage system consisting of 24 batteries, each rated at 2V-500Ah, ensures continuity of power supply at night and on days with little sunshine.

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Figure 1: Overview of the interior of the storage room with mangoes

2.2. Mangoes varieties

The mangoes of the *Valencia* and *Camerounaise*varieties, collected respectively in Dédougou and Bobo-Dioulasso (Burkina Faso) were used.

2.3. Mango sampling, preparation and storage

A quantity of 500 Kg of mangoes of the *Valencia* variety was picked at physiological maturity directly in the orchard of the Catholic Nuns in Dédougou and transported to the Energy Department of IRSAT (Ouagadougou) for conservation trials. These mangoes were used for the first conservation experiment running from 24/05/17 to 13/06/17. Before storage in the cold room, the mangoes were washed with neutral soap, rinsed thoroughly with drinking water, then placed in 24 crates weighing 19 kg each and placed on 6 pallets inside the cold room. The *Camerounaise*variety was used for the second and third preservation experiments. These experiments took place respectively from 14/06/17 to 02/08/17, and from 07/06/18 to 26/07/18. For each experiment, 2 tons of mangoes were acquired at physiological maturity from Société Nouvelle Ranch du Koba based in Bobo-Dioulasso and transported to the Energy Department of IRSAT (Ouagadougou). The mangoes were processed in the same way as previously described, then packed in 500 cartons, with 8 mangoes per carton. The cartons were arranged on 6 pallets, in two columns facing the evaporators in the solar cold room. 30 cartons of mango were kept at room temperature in a control room. The temperature of the cold storage room was 10-12°C, while that of the ambient room was 30-35°C.

2.4. Preparation of mangoes for Physicochemical and microbiological analyses

Samples of 3 to 5 mangoes were taken each week for physicochemical and microbiological analyses. The mangoes werecollected under aseptic conditions (hand disinfection with 70°C ethanol), placed in sterile stomacher bags and transported to the laboratory. For physico-

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chemical analysis, the mangoes are peeled and pulped; the pulp is pureed using a stainless-steel blender. The puree obtained was placed in plastic pots and kept in the freezer prior to analysis.

2.5. PhysicochemicalanalysesMethods

2.5.1. Water content

Water content was determined by drying 5 g of mango puree in an oven at 105°C, in accordance with AFNOR standard [10].Water content was calculated using the following equation:

$$\%\,(water) = \frac{M_0 - M}{M_0} * 100$$

M0 = initial sample weight

M = final sample weight

2.5.2. pH and titratable acidity

pH and titratable acidity were determined by direct measurement and titration respectively, using the AFNORmethod [11]. A 5 g suspension of mango puree in 25 ml of distilled water was subjected to magnetic stirring. After 1 h of agitation, the pH was measured using a pH meter previously calibrated with pH 4 and pH 7 buffer solutions. The suspension was then centrifuged at 5000 g for 5 min. The supernatant was collected and titrated with 0.1 N NaOH in the presence of phenolphthalein. Titratable acidity was expressed in g of citric acid per 100 g of pulp by the following equation:

$$titrable\ acidity = \frac{N * V * V_T}{V_p * P_E} * 0.070 * 100$$

N= NaOH normality

V=Volume of Na OH required for titration.

V_T=Total volume of solution to be titrated

V_P=Draw volume

P_E=Test sample

0.070= Conversion factor for citric acid

2.5.3. Brix degree

The brix degree of the mango samples was determined by the standardized refractometric method[12] using a digital refractometer (Bellingham Stanley). The mango Puree was placed on the refractometer lens and the Brix value read directly on the screen.

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2.5.4. Reducing sugars

Reducing sugars were determined by the 3-5 dinitrosalicyclic (DNS) spectrometric method [13]. Reducing sugars were extracted from a 1.5 g test sample of mango puree using distilled water heated to 60°C. To 5 ml of the extract, 1 ml of DNS reagent was added and the mixture was incubated in a boiling water bath for 15 min, then rapidly cooled. To this mixture, 3.5 ml of distilled water was added and the absorbance was read using a spectrophotometer (JENWAY). The reduced sugar contentwas determined using a D-glucose standard curve.

2.6. Microbiological analyses

Microbiological analyses consisted of enumerating the total aerobic mesophilic flora, yeasts and molds present on the surface of whole mangoes. The stock solution and dilutions were prepared in accordance with EN ISO 6887 standard [14] (**Table 1**).

Table 1: Standards for microbiological parameters analyses

Germes dénombrés	**Methods**	Culture media	**Incubation**
Total aerobic mesophilic flora	(ISO 4833, 2013) [15]	Plate Count Agar (PCA)	72 ± 3 h at 30°C
Yeasts and molds	(ISO 21527, 2008)[16]	SABOURAUD chloramphenicol	3 - 5 days at 25°C

2.7. Statistical analysis of data

Data were entered intoMicrosoft Excel 2010 and then processed using XLSTAT softwareversion 2016.02.27444. Statistical analysis consisted of calculating means, standard deviations and analysis of variance (ANOVA) using the Fisher LSD test at a significance level of 5%.

3. Results and discussion

3.1. Evolution of physicochemical and microbiological parameters in*Valencia* mango variety

The physico-chemical parameters of the Valencia variety mangoes during storage are presented in Table 1.

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3.1.1. Water content

Moisture content of*Valencia* samples during refrigerated storage ranged from 85.39% to 86.28% over the three weeks of storage (**Table 2**). Thus, despite a slight sawtooth fluctuation, the water content of Valencia mangoes remained almost constant. A slight increase was observed after one week's storage (86.28%). The relative humidity of 85-90% in the refrigerated warehouse kept the water content of the mangoes relatively constant and prevented dehydration, which would depreciate the quality of the mangoes. According to Sawadogo-Lingani [17], water content decreases from young fruit (90%) to ripe fruit (84%) and during storage. Water content is important for fruit preservation during storage and influences spoilage mechanisms. Emongor and Ramagonono[18] reported that the optimum storage relative humidity for mango ofthe Kent variety was between 90 and 95%.

3.1.2. Soluble dry matter or Brix degree

In our storage monitoring, the percentage of soluble dry matter or Brix degree varied from 9.80% at the start of storage (T0) to 16.3% after 3 weeks of storage (S3), reflecting ripening during storage. In contrast, the same variety kept at room temperature gave a Brix level of 15.23% after one week's storage week of storage (**Table 2**). The soluble dry matter content of the *Amélie* mango, for example, is around 10% in young fruit and reaches 16% in ripe fruit [17] These results show that the ripening process of mangoes in a cold room, set at a temperature of 10°C-12°C, slows down, thereby increasing shelf life.

3.1.3. pH and titratable acidity

The pH and acidity of *Valencia* variety mangoes during cold storage areshown in **Table 2**. The pH ranged from 3.30 at the start to 4.11 after 3 weeks of storage. The pH of the control sample, left at room temperature, increased from 3.30 to 3.98 within one week of storage. The ripening process is slowed by refrigerated storage at 10-12 °C compared to storage at room temperature at 30-35 °C.

During storage, the titratable acidity of *Valencia* mangoes dropped from 1.07 g citric acid / 100 g at the starting (T0) to 0.67 g citric acid / 100 g at the end of storage (S3) (Table 1). The titratable acidity of the sample left at room temperature decreased from 1.07 to 0.70 g citric acid / 100 g, after one week of storage. Sawadogo-Lingani[17] reported that the titratable acidity of *Amelie* variety mangoes decreased during the ripening phase and storage and that the ripe mango had an acidity of 0.64 % and a pH of 4.20, whereas unripe fruit has an acidity of approximately 2.15 % with a pH of 3.35.Malundo*et al*[19] and(Vásquez-Caicedoet

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al[20]have also reported that titratable acidity and pH influence fruit carbohydrate/acid balance, which is a quality attribute and an indicator of fruit maturity.

3.1.4. Reducing sugar content

The reducing sugar content of *Valencia*variety mangoes stored in the solar cold room (10-12°C) for 3 weeks varied from 3.12% (T0) to 4.79% (S3) and from 3.12% (T0) to 3.63% (S1) for the sample left at room temperature (30-40°C) for one week (**Table 2**). It has been reported that during mango ripening, reducing sugars appear at the expense of starch [17]. Their level intensifies and it is from values around 5% that the mango presents a softening and a fairly appreciable sweet taste; the content in ripe mango is around 5.28% [17]. This suggests that cold storage slows down the ripening process and increases shelf life compared with storage at room temperature. The quality of the mangoes was not affected.

3.1.5. Evolution of microbiological characteristics in *Valencia* mango variety

The results of the enumeration of the surface microflora of mangoes of the *Valencia* variety are given in **Table 3**. Microbial loads decreased from $5.6x10^5$ CFU to $2.5x10^4$ CFU and from 4.4 $x10^4$ to less than 40 CFU respectively for total mesophilic aerobic flora and yeasts and molds.

The results show a reduction in surface microflora during storage in the solar cold room, where temperatures recorded were 10 °C to 12°C. The values obtained for total aerobic flora and yeasts and molds comply with sanitary quality requirements, which indicate limit values of $<10^6$ CFU [21].

3.2. Evolution of physicochemical and microbiological parameters in*Camerounaise*variety

Tables 4 a and b below show the evolution of the physico-chemical parameters of the *Camerounaise*variety during storage monitoring in the cold room for experiment 1 and experiment 2 respectively. As a reminder, the first experiment was carried out from 14/06/17 to 02 /08/17 while the second experiment took place from 07/06/18 to 26/07/18. Both experiments involved two tons of mangoes each.

3.2.1. Water content

The evolution of the water content of mangoes stored in a refrigerated atmosphere was similar for both experiments. In the 1st experiment, water content remained almost constant despite a slight sawtooth fluctuation, from the 1st week (86.26%) to the 3rd week of storage (86.51%), then increased to 87.14% in the fourth week. The moisture content obtained at week 7 was

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87.29% (**Table 4 a**). The same trend was observed in the second experiment (**Table 4 b**). This moisture uptake would no doubt be due to an accumulation of water vapor in the warehouse; the relative humidity of the refrigerated warehouse which was 85-90% and also to the temperature of 10-12°C which slows down respiration, ethylene production and action as well as the activity of microorganisms and insects. Emongor and Ramagonono [18] stated that mangoes should be stored at temperatures between 10 and 16°C depending on cultivar, growing conditions and maturity at harvest. Other authors such as Watanawan *etal*[22] recommend a storage temperature of between 5-15°C for 2-3 weeks depending on variety and stage of ripeness. For the control sample left at room temperature, the water content varied from 86.30 to 87.81% after one week's storage in the first experiment. The water content results obtained in the 2nd experiment are similar to those obtained in the 1st experiment. Appiah *et al*[23] obtained an increase in water content ranging from 79.75% to 83.11% during the ripening of the *Keit*t mango variety kept at 30-33°C. These authors attributed this result to the hydrolysis of polysaccharides into simple sugars, which could increase the osmotic transfer of moisture from the skin to the flesh. The moisture content results of the present study are superior to those reported byAppiah *et al.*[23]

3.2.2. Soluble dry matter or Brix degree

The values of soluble dry matter or Brix degree of the *Camerounaise*variety obtained during storage in the cold room during the 1st experiment (**Table 4a**), varied from 8% at the start of storage (1st week), to 13.40% at the 2nd week of storage. These values remained almost constant from the 3rd to the 7th week of storage. During the 2nd experiment, Brix values also remained constant (**Table 4 b**). These results indicate a maturation process of the *Camerounaise* variety during storage.

Brix values for the control sample varied from 8 to 13.35% in one week in both experiments (**Table 4a and b**). As with the *Valencia* variety, the ripening process is slowed down when the mangoes are kept in refrigerated storage at a temperature of 10-12°C.

3.2.3. Acidity and pH

The pH values of the *Camerounaise*variety (**Table 4 a**) showed virtually no change from the 1st week of storage (pH = 3.56) to the 6th week (pH = 3.58) during the 1st storage experiment in the solar cold room at a temperature of 10-12°C. However, a relative variation was observed in pH (3.80) at week 7 of storage. During the 2nd experiment, the pH values obtained also remained virtually constant from week 1 to week 6, while at week 7 a slight

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increase in pH (3.79) was observed (**Table4b**) as had been observed during the 1st experiment.

The pH values of the control sample left at room temperature 30-35°C varied from 3.56 at the beginning of the week to 4.02 at the end. The temperature of 30-35°C has an influence on pH evolution. At this temperature, the mango's physiological processes are accelerated (ethylene production, respiration, ripening, softening, etc.).

In contrast to pH values, which remained almost constant, a drop in the acidity in stored mangoes was observed from 1.05 at the start of the experiment (t0) to 0.67 at the end of the experiment (S7) for both experiments. In general, the titratable acidity of mangoes decreases during storage. The decrease in acidity corresponds to a gradual ripening of the mangoes. This evolution of titratable acidity is in line with the results found by Sawadogo-Lingani[17] andFréhaut[24].

3.2.4. Reducing sugars

The reduced sugar content of the *Camerounaise*variety varied from 3.01% to 6.19% during the 1st experiment (**Table 4 a**). The same variations were observed in reducing sugar values in the 2nd experiment (**Table 4b**), highlighting a ripening process. The values for reducing sugars in mangoes stored in cold storage for seven weeks in the 2 experiments (6.19% and 6.22%) and the value for reducing sugars in mangoes stored for one week at room temperature (5.62%) are similar to the value for reducing sugars (5.53%) found by Kamenia *et al.* [25].

3.2.5. Evolution of microbiological characteristics in*Camerounaise*variety

The results of the surface microflora enumeration (**Table 5**) indicate that the total aerobic flora and yeast and mold loads on mangoes of the *Camerounaise* variety were generally maintained satisfactory for total aerobic flora (103-105 CFU) and for yeast and mold (102 - 102 CFU), in relation to quality requirements (N<106). Values comply with sanitary quality requirements (N<106).

4. Conclusion

This study tested the performance of a solar-powered cold room for mango preservation, using two varieties (Valencia, Cameroon) and evaluating the evolution of certain parameters. Changes in pH, titratable acidity, Brix level and reducing sugars revealed a slower ripening process for mangoes during refrigerated storage than during storage at room temperature. Keeping mangoes in solar-powered refrigerated storage set at 10°-12°C inhibits the

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development of surface microorganisms and improves mango shelf life. The time spent in the solar-powered cold store did not affect the quality of the mangoes, according to the results obtained. The solar cold room enables good mango preservation for at least 3 to 7 weeks, depending on variety and degree of ripeness. The preservation in the solar cold room of fresh mangoes picked at physiological maturity and pre-treated in accordance with good hygiene practices should be promoted among stakeholders (producers, distributors, processors) to reduce post-harvest losses. Optimization work should be carried out to control the relative humidity in the warehouse to avoid condensation of water vapor.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscript.

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Competing interests

Authors have declared that no competing interests exist.

References

[1] Masibo, M. & Qian, H. (2008). Major mango polyphenols and their potential significance to human health. Comprehensive Reviews in Food Science and Food Safety, 7(4), 309–319. https://doi.org/10.1111/j.1541-4337.2008.00047.x

[2] Sawadogo-Lingani, H. & Traoré S. A. (2002). Chemical composition and nutritional value of the Amélie mango (Mangifera indica L.) from Burkina Faso. Journal of Sciences Vol.2 No.1, 35-39.

[3] Kanté-Traoré, H., Sawadogo-Lingani, H., Seogo, I., Kabore, D. & Dicko, M. H. (2017). Mango processing processes and level of knowledge of quality standards by production units in Burkina Faso. International Journal of Biological and Chemical Sciences, 11(1), 195-207. https://doi.org/10.4314/ijbcs.v11i1.16

[4] Kanté-Traoré, H. (2019). Valorization of mango varieties produced in Burkina Faso: Biochemical, biotechnological and nutritional aspects. Unique Doctoral Thesis, defended on October 14, 2019; Doctoral School of Sciences and Technology; Joseph KI-ZERBO University, Burkina Faso. 170 p https://doi.org/10.13140/RG.2.2.27000.06407.

[5] Commère, B. & Billiard, F. (1999). "The cold chain in the food industry". Engineering techniques, F 3 230. 18 p.

[6] Chakraverty, A., Mujumdar, A. S., & Ramaswamy, H. S. (Eds.). (2003). Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices (1st ed.). CRC Press. https://doi.org/10.1201/9780429294211

[7] Chaudhary, P.R., Jayaprakasha, G. K.,Ron Porat., Bhimanagouda S. Patil. (2014). Low temperature conditioning reduces chilling injury while maintaining quality and certain bioactive compounds of "Star Ruby" grapefruit. FOOD CHEMISTRY, 153, pp. 243–249. https://doi.org/10.1016/j.foodchem.2013.12.043.

[8] Singh, R.K.P., Satapathy, K.K.(2006). Performance evaluation of zero energy cool chamber in hilly region, AgrEngg Today. 30 pp. 5-6

[9] Compaore, M. C. R., Sanogo, O., Yamba, K., Ouédraogo, O., &Bathiébo, D. J. (2019). Evaluation of the thermal profile of a solar photovoltaic cold room loaded with mangoes. International Journal of Engineering Sciences & Research. Technology, 8(8) 31-44, ISSN: 2277-9655 DOI: 10.5281/zenodo.3365383.

[10] United Nations (2003) 'Revision of the master standard for dried and dried fruits: determination of the water content of dried fruits, Specialized Section for the Standardization of Dried and Dried Products (Fruit) Fiftieth Session, Geneva, June 24-27, 2003, p. 5.

[11] AFNOR (French Standardization Association): NF V05 101 (1974). Products derived from fruits and vegetables - Determination of titratable acidity, p. 4.

[12] ISO 2173. (2003). Products derived from fruits and vegetables - Determination of soluble dry residue - Refractometric method, p. 8.

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[13] Miller, G. L. (1959). Use of Dinitro salicylic Acid Reagent for Determination of Reducing Sugar', Analytical Chemistry, 31(3), pp. 426–428. https://doi.org/10.1021/ac60147a030.

[14] EN ISO 6887-1, (1999). Microbiology of food and animal feeding stuffs - Preparation of test samples, initial suspension and decimal dilutions for microbiological examination - Part 1: General rules for the preparation of the initial suspension and decimal dilutions.

[15] ISO 4833. (2013). Microbiology of the food chain Horizontal method for the enumeration of microorganisms Part 1: Counting colonies at 30 °C by the deep plating technique, p. 9.

[16] ISO 21527-1. (2008). Microbiology of foods Horizontal method for the enumeration of yeasts and molds Part 1: Colony counting technique in products with water activity greater than 0.95, p. 9.

[17] Sawadogo-Lingani, H. (1993). Technological development of the Amélie mango variety from Burkina Faso: control of physicochemical parameters for better stabilization of transformation products. Postgraduate doctoral thesis Biochemistry Microbiology, University of Ouagadougou, Burkina Faso, 164p

[18] Emongor, V.E. and Ramagonono, G. (2019). Storage Temperature Influences Postharvest Quality of Wild Plum (Ximmenia Americana L.) Fruit. Ghana Journal of Science, 60(2), pp. 1–10. https://doi.org/10.4314/gjs.v60i2.1.

[19] Malundo, T. M. M., Shewfelt, R. L., Ware, G. O. & Baldwin, E. A. (2001). Sugars and Acids Influence Flavor Properties of Mango (Mangifera indica). Journal of the American Society for Horticultural Science. 126 (1), 115-121.

[20] Vasquez-Caicedo, A. L., Neidhart S. and Carle R. (2004). Postharvest ripening behavior of nine Thai mango cultivars and their suitability for industrial applications. ActaHorticulturae.

645, 617-625.

[21] CECMA (2009) Committee on the development of microbiological criteria in foods. Quebec.

[22] Watanawan, C., Wasusri, T., Srilaong, V., Wongs-Aree, C. andKanlayanarat, S. (2014). Near infrared spectroscopic evaluation of fruit maturity and quality of export

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Thai mango 155(*Mangifera indica* L. var. *Namdokmai*). International Food Research Journal 21, 1073–1078.

[23] Appiah, F., Kumah, P., & Idun, I. (2011). Effect of ripening stage on composition, sensory qualities and acceptability of *keitt* mango (*mangiferaindica* L.) chips. African Journal of Food, Agriculture, Nutrition and Development, 11(5). https://doi.org/10.4314/ajfand.v11i5.70439

[24] Fréhaut, G. (2001). Study of the biochemical composition of mango (*mangiferaindica* l. cv early gold) according to its stage of maturity. Dissertation, Compiegne University of Technology (UTC), 65p.

[25] Kameni, A., Mbofung, C. M., Ngnamtamb, Z., Doassem, J. & Hamadou, L. (2003). Ability to dry the fruits of some varieties of mango trees grown in Cameroon. Fruits, 58(2), 89–98. https://doi.org/10.1051/fruits:2002039.

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Table2: physico-chemical parameters for mangoes of the *Valencia* variety.

Shelf life (Week)	Parameters monitored									
	At room temperature (30-35 °C)					In cold room (10-12 °C)				
	Water content (%)	pH	Titratable acidity (g of citric acid/100 g)	Degree Brix (%)	Reducingsugars (%)	Water content (%)	pH	Titratable acidity (g of citric acid/100 g)	Degree Brix (%)	Reducingsugars (%)
T0	85.42±0.13^{a}	3.30±0,02^{a}	1.07±0.03^{g}	9.8±0.1^{b}	3.12±0.01^{b}	85.42±0.13^{a}	3.30±0.02^{a}	1.07±0.03^{g}	9.8±0.1^{b}	3.12±0.01^{b}
S1	85.29±002^{b}	3.98±0.03^{jh}	0.7±0.0^{a}	15.23±0.06^{e}	3.63±0.02^{e}	86.28±0.02^{b}	3.41±0.01^{b}	1.02±0.03^{efg}	11.76±0.06^{c}	3.32±0.02^{c}
S2						85.39±0.06^{a}	3.93±0.00^{h}	0.77±0.16^{g}	15.4±0.1^{e}	3.56±0.03^{d}
S3						85.40±0.22^{a}	4.11±0.01^{j}	0.67±0.01^{a}	16.2±0.1^{a}	4.79±0.02^{h}

Values with different letters on a row are significant at $P < 0.05$

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Table 3: Results of mango surface flora enumeration

Shelf life	**Microbiological parameters**	
(Week)	Total mesophilic aerobic flora (UFC*)	Yeasts and molds (UFC*)
T0	$5.6x10^5 \pm 2.3x10^4$	$4.4x10^4 \pm 3.8x10^3$
S1	$4.2x10^3 \pm 1.9x10^4$	$5.5x10^1 \pm 5.0$
S2	$9.2x10^4 \pm 4.7x10^4$	$2.1x10^2 \pm 1.1x10^3$
S3	$2.5x10^4 \pm 8.9x10^4$	Moins de 40

*****Average number of surface germs counted on the entire surface of two mango samples analyzed separately.
Values with different letters on a row are significant at $P < 0.05$

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Table4a : Changes in Physicochemical parameters of the *Camerounaise* variety during the 1st conservation monitoring experiment (14/06 to 02/08/2017).

Shelf life (Week)	Paramètres analysés									
	A la Température ambiante (30-35°C)					En chambre froide (10-12°C)				
	Water content (%)	pH	Titratable acidity (g of citric acid/100 g)	Degree Brix (%)	Reducingsugars (%)	Water content (%)	pH	Titratable acidity (g of citric acid/100 g)	Degree Brix(%)	Reducingsugars (%)
T0	86.30±0.00^{cd}	3.56±0.01^{def}	1.05±0.01^{fg}	8.00±0.00 ^{a}	3.01±0.08^{a}	86.30±0.00^{cd}	3.56±0.01^{def}	1.05±0.01^{fg}	8.00±0.00^{a}	3.01±0.08^{a}
S1	87.810±0.00^{h}	4.02±0.10^{i}	0.86±0.02^{bc}	13.35±0.07^{d}	5.62±0.03^{i}	86.00±0.11^{b}	3.50±0.04^{cde}	1.00±0.03^{fg}	9.70±0.14^{b}	3.71±0.03^{e}
S2						86.82±0.08^{f}	3.50±0.01^{cdef}	0.97±0.06^{defg}	13.40±0.00^{d}	4.00±0.05^{f}
S3						86.49±0.01^{de}	3.49±0.01^{cd}	0.99±0.01^{efg}	13.40±0.14^{d}	4.62±0.03^{g}
S4						87.14±0.07^{g}	3.47±0.00^{bc}	0.89±0.00^{cd}	13.55±0.07^{d}	5.37±0.01^{i}
S5						87.20±0.01^{g}	3.50±0.01^{cdef}	0.95±0.01^{cdef}	13.35±0.07^{d}	6.08±0.02^{k}
S6						87.25±0.02^{g}	3.58±0.02^{f}	0.89±0.02^{cd}	13.45±0.07^{d}	6.18±0.01^{l}
S7						87.29±0.03^{g}	3.80±0.02^{g}	0.67±0.00^{a}	13.5±0.14^{d}	6.19±0.02^{l}

* Values with different letters on a row are significant at $P < 0.05$

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Table4b : Evolution of the physico-chemical parameters of the *Camerounaise* variety during the 2nd experiment of conservation monitoring in the solar cold room (07/06 to 27/07/2018).

Shelf life (Week)	Paramètres analysés									
	A la Température ambiante (30-35°C)					En chambre froide (10-12°C)				
	Water content (%)	pH	Titratable acidity (g of citric acid/100 g)	Degree Brix (%)	Reducingsugars (%)	Water content (% m/m)	pH	Titratable acidity (g of citric acid/100 g)	Degree Brix (%)	Reducingsugars (%)
T0	86.26±0.05^{c}	3.56±0.01^{def}	1.05±0.00^{fg}	8.00±0.00^{a}	3.06±0.02^{ab}	86.26±0.05^{c}	3.56±0.01^{def}	1.05±0.00^{fg}	8.00±0.00^{a}	3.06±0.02^{ab}
S1	87.78±0.04^{h}	4.03±0.08^{i}	0.86±0.03^{bc}	13.35±0.07^{d}	5.62±0.03^{i}	86.11±0.26^{bc}	3.49±0.05^{cd}	0.98±0.03^{efg}	9.65±0.21^{b}	3.71±0.02^{e}
S2						86.79±0.12^{f}	3.50±0.02^{cde}	0.95±0.01^{cdef}	13.40±0.00^{d}	3.99±0.07^{f}
S3						86.51±0.04^{e}	3.46±0.03^{bc}	0.96±0.00^{cdefg}	13.40±0.14^{d}	4.62±0.02^{g}
S4						87.16±0.03^{g}	3.47±0.00^{bc}	0.94±0.00^{cde}	13.50±0.00^{d}	5.35±0.02^{i}
S5						87.21±0.02^{g}	3.50±0.01^{cd}e	0.89±0.00^{cd}	13.40±0.00^{d}	6.09±0.02^{k}
S6						87.25±0.03^{g}	3.57±0.01^{ef}	0.88±0.01^{bcd}	13.4±0.0^{d}	6.19±0.02^{i}
S7						87.27±0.01^{g}	3.79±0.03^{g}	0.71±0.02^{a}	13.45±0.07^{d}	6.22±0.02^{l}

* Values with different letters on a row are significant at $P < 0.05$

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Table5 : Results of surface microflora analyses on *Camerounaise* variety (1st experiment).

Temps de conservation (Semaine)	Paramètres microbiologiques analysés	
	Flore aérobie totale (UFC*)	Levures et moisissures (UFC*)
t0	$1,1x10^5 \pm 1.7x10^3$	$1,7x10^4 \pm 8.4x10^3$
S1	$1,3x10^5 \pm 1.9x10^4$	$2,4x10^4 \pm 5.5x10^1$
S2	$2,7x10^5 \pm 1,1.10^4$	$4,6x10^4 \pm 3.8x10^1$
S3	$7,8x10^5 \pm 1.7x10^4$	$7,9x10^2 \pm 2.2x10^2$
S4	$1,7x10^5 \pm 1.7x10^3$	$5,6x10^2 \pm 0.0$
S5	Nd	$1,1x10^3 \pm 1.1x10^2$
S6	$5,5x10^4 \pm 9.3x10^3$	$3,2x10^3 \pm 1.1x10^3$
S7	$3,2x10^3 \pm 1.2x10^3$	$6,2x10^3 \pm 2.3x10^3$

* average number of surface germs counted on the entire surface of two mango samples analyzed separately.

Values with different letters on a row are significant at $P < 0.05$

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