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Effect of Transpiration in Post-Post-State Condition on the Agroindustrial Quality of *Chrysobalanus icaco L* Fruit Variety

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Abstract

The effect of post - harvest transpiration on the agroindustrial quality of the fruit of Chrysobalanus Icaco rosa variety was determined. The methodology followed allowed to find the loss of water for 11 days after its collection and the specific characteristics of color, size and physical appearance, to determine shelf life and its usefulness as raw material. To look at the effect caused by dehydration, a simple linear regression model was fitted using SPSS statistical software to observe, analyze and correlate weight loss as the days elapse over the life of the Icaco fruit. It is evident that for the first four days the most critical in the process of perspiration, being evident by the appearance of wrinkles, moist areas, loss of firmness, wilting, adhesion of the seed to the skin.

Keywords: fruit quality, dehydration, postharvest, perspiration

Introduction

Fruits are a type of food that is widely consumed worldwide, being a source of easy access to energy, vitamins, minerals and dietary fiber, therefore these and their products have a high nutritional value [1]. Currently fruits are being valued, regardless of shape, size or color, in order to determine their specific benefits in the diet, in medicine and also its importance as raw materials that the agroindustrial sector requires for its processing in product finished or in process [2].

Chrysobalanus Icaco is a low-valued native fruit although it is recorded as part of the biodiversity of the unusual flora present on the Colombian Caribbean coast; the natives used it in the preparation of beverages [3], in addition it is used for homemade production of jams, sweets, snacks [4], not to mention the many applications of the tree in general [5], however, as far as fruit management at the mass production level is not recorded no harvest or post-harvest control because it is unknown for the agroindustrial sector.

In spite of the existence of different methods to determine the degree of maturity that allows its collection, among which we can mention, the total soluble solids ratio on acidity titratable [6], as the parameter most used for its determination, the fruit is harvested manually, casually and without any control over the degree of maturity, the external visual characteristic related to the pink coloration of the epidermis being the main indicator of the harvest time, this change is associated to the degradation of chlorophyll and synthesis of other pigments [7], changing the dark green to cream color to finally express the pink color, this change is the most important feature to evaluate the degree of maturity of the fruit informally, in addition to being an indicative for harvest and marketing.

A fundamental aspect to be taken into account in the post-harvest management of Icaco is that it is a non-climacteric fruit [8], which indicates that the fruit is immediately harvested and begins its process of senescence, (not following the ripening process), initiating a series of structural changes and biochemical in fruit [9], among the most notable changes, we can mention; the weight loss caused by transpiration is generated by the difference between the pressure exerted by the steam from the interior of the fruit and the pressure of the surrounding external air [10], whose effect is reflected in the removal of matter in the form of vapor of water, causing weight loss.

The loss of fruit water in the postharvest state, causes its appearance to deteriorate, causing wilting and wrinkling, decrease in firmness, represented in softening due to loss of turgidity, changes in nutritional quality, in addition to a greater susceptibility to certain physiological alterations and / or pathological, as well as hardening at the end by dehydration [6]. The characteristic of the coloration, in the fruits of Icaco, besides marking in a well defined way the time of collection, allows us to verify some physical and chemical changes that the fruit experiences [7, 10].

Therefore, the main objective of this research is to determine the effect of post - harvest transpiration on the agroindustrial quality of the fruit of Chrysobalanus Icaco rosa variety. The process of the effect of transpiration on the fruit of Chrysobalanus Icaco after harvested and its incidence on its useful life. For this, the fruit perspiration process was studied as a quality parameter, which is directly related to weight loss due to dehydration.

Materials and Methods

The fruits of Icaco rosa variety were taken directly from the wild scrubs present on the sandy soil of the Arroyo Grande sector, in the district of Cartagena de indias, Bolívar, located at 10 ° 39'22.6 "north and 75 ° 20'50.1" East, latitude: 10.6563 and longitude: -75.3473.

A sample of 500 fruits was taken randomly directly from the wild scrub, in the laboratory for our analyzes 93 random fruits were selected as the study sample and a test group of 50 fruits was taken, for the identification of organoleptic and for destructive analysis. The fruits selected had a pink coloration in their epidermis, the presence of anthocyanins, non-destructive indicator that determines the state of maturation [11]. The fruits selected did not present bruises, bumps, insect bites, mechanical damages and / or alterations caused by an apparent fungus, since these can affect weight loss as do the storage conditions, among which we can mention the temperature, relative humidity and time of exposure [12], in studies with Mexican plum (*Spondias purpurea L.*). They were then cleaned to remove sand scraps and avoid possible contamination with different scrub fruits.

In the laboratory, the fruits were maintained at an average temperature of 28 ° C and relative humidity (HR) of 72 ± 5%, the selected fruits were initially weighed, labeled with numbers to accurately track weight loss day by day for 11 days, weighing each fruit, using a precision electronic balance with an approximation of 0.001g, until total deterioration of the fruit due to perspiration; the appearance of fruit was also monitored by direct observation during the 11 days, the characteristics observed were wilt, formation of wrinkles and presence of brown color. The quality parameter measured in the fruits was the weight loss by transpiration until the maximum dehydration effect [13], for tomatoes and in some cases the presence of mold.

Equatorial and polar diameters were also recorded, as established two hours after harvest and at the end of the experiment, 11 days after initial weighing. The data obtained related to dehydration were analyzed using the statistical software SPSS version 23 IBM, a descriptive analysis was performed for the statistical procedures corresponding to maximum and minimum values, mean of the variables; weight and dehydration as weight loss. To observe the effect caused by dehydration in the trial, a simple linear regression model was adjusted with the objective of quantifying weight loss as the days elapse, having as dependent variable the weight

of Icaco (Pi) and independent weight the days of dehydration (Di). Calculation of the weight loss in relation to the previous day was calculated by the equation:

$$Pi=Di-Di+1 \quad (1)$$

i, corresponds to the distance between the points in the interval, $1 \leq i \leq 10$

Results and Discussion

Qualitative analysis of the transpiration process

Initially the harvested fruits presented well defined physical characteristics, as they are; skin or smooth skin, pink color easy to identify, shiny surface, peduncle well adhered to the fruit and good turgidity, not having deformation in its structure caused by loss of water retained in the cells, in general, a healthy aspect as can be appreciated in Figure 1a. In relation to the mass of the fruit, a stainless steel knife was used, with which a cut was made to the seed, it was found that the mass is easy to handle and extract, the mass adhered to the seed can be removed by performing a slight pressure on her. This last test was performed with the fruits present in the test group. In addition, based on our observations and experiments, we can state that, less mature or cream colored fruits present mass with greater adhesion to the seed, due to the lack of conversion of starches into sugars, the mass is amarrous, astringent and adheres to the palate, which does not occur with the pulp of the fruits harvested with the bright pink coloration, both produce a pasty mass with water, a technique used to increase its productivity in the elaboration of jam, the pulp changes color in the presence of acid , becoming dark red.

On the second day, the marked turgor in the equatorial zone decreases, which is a consequence of the beginning of the dehydration of the fruit. This process is catalyzed by the average temperature of the laboratory, which can be considered relatively high (28 ºC), causing a greater dehydration, loss of volatile components and denaturation of the proteins14, in terms of color, pink remains very marked as shown in Figure 1b.

On the third and fourth day, it begins to accentuate a change in the initial pink coloration of the fruits, loses brightness and changes its hue to an intense pink, the wilting process begins, which is evidenced by the very marked appearance of wrinkles, follows the dehydration process as shown in Figure 1c. The presence of a shadow on the surface of the fruit was observed, causing a decrease in brightness, changing the pink coloration of the affected place, generating a negative visual impact for the commercialization of the fruit. In fruits with moist areas there is a smell of fermentation, the flesh of the fruit is difficult to recover, therefore a low percentage of recovery, until this point the fruit can still be used for preparations of jelly, fruit liqueur and marmalade, this was evidenced with the test group.

On days 5 and 6, the deterioration area increases, showing more moisture, the fruits to the touch show moisture, the cream coloration begins to accentuate on the peduncle in some fruits, the fruits become soft, the wilt process increases and presence of wrinkles, the presence of the seed is noted. The smell of natural fermentation and the brown color in the inner part of the fruit is accentuated, causing the dark coloration, as shown in Figure 1d. On days 7 and 8, the humidity is very marked, the fruit identified with the initial pink coloration is hard and brown, wrinkled and dry to the touch, the humidity of the deteriorating area presents with mold appearance (white and greenish villi) and putrefaction in the wet areas, increase of black coloration and villi, as shown in Figure 1f.

On days three days late, the fruit is totally dehydrated are dry and hard to the touch, general browning in the interior, the skin changes completely to a dark tonality.

Figure 1 Images of fruits of Icaco, during the first 8 days of study

Quantitative analysis of the transpiration process

Table 1 shows the weight of the fruits of Icaco measured during the 11 days of the experiment, expressed in grams and in Table 2, the values of the different losses taken as weight difference, with respect to the previous day, according to equation 1, for fruits stored at 28 ° C and 72 ± 5% RH.

The fruits present at the time of collection a minimum weight of 10.67 grams and a maximum of 19.85 grams, and on average of 14.76 grams, standard deviation of 2.06 grams approximately, the weight loss increased during the 11 days of observation , arriving at a minimum weight value of 4.72 grams and a maximum of 12.32 grams, average weight at the end of the 11 days of 8.29 grams, showing a marked tendency to decrease the fruit mass; the weight loss coincides with that reported for other non-climacteric fruits [14].

Table 1 Descriptive statistics of weight per day

Day	N	Minimum	Maximum	Average	Offset Typ.
D1	93	10,67	19,85	14,68817	2,060064
D2	93	10,1	18,7	13,86097	1,959567
D3	93	9,56	17,73	13,01763	1,863633
D4	93	9,14	16,94	12,3643	1,795654
D5	93	8,5	16,1	11,73871	1,739567
D6	93	8,05	15,5	11,19366	1,685034
D7	93	7,5	14,9	10,6486	1,644816
D8	93	6,68	14	9,88742	1,616573
D9	93	6,08	13,51	9,4414	1,59612
D10	93	5,48	12,91	8,88645	1,577333
D11	93	4,72	12,32	8,29312	1,564181
N	93				

As for the percentage (% d-1) of weight loss per day as shown in Table 2, for the first day of weighing, the minimum weight loss was 0.39 and a maximum of 1.43 grams, representing 3.6% and 7.25% with respect to initial weight, the average weight loss was 0.83 grams, equivalent to 5.6% of the initial weight, with a standard deviation of 0.19 grams. For the second day, a minimum of 3.4% and a maximum of 7.7% of losses are reported, while for the third day, the minimum represents 2.9% and a maximum of 5.6%, the whole of the first three days, generates a minimum loss of 9.9%, maximum of 20.55%, with an average loss of 17.69%, in graph 1 shows the trend [15]. Referring to fruits that lose more than 3 to 10% of their initial weight, it is lost generates physiological changes that lead quickly to senescence, a well-marked tendency in non-climacteric fruits8, the loss of water is due to the exchange of water between the interior of the fruit and the external environment where it is stored, causing according to FAO, the exit of water as vapor to the atmosphere.

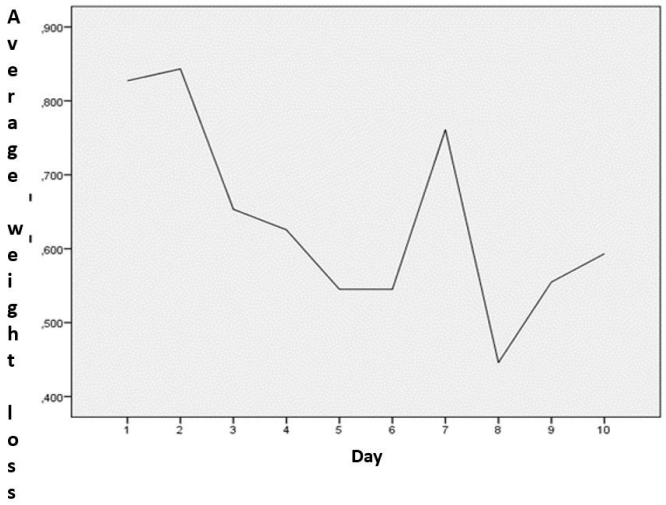
Table 2 Descriptive statistics of weight loss with respect to the previous day

Weightloss	N	Minimum	Maximum	Average	Offset Typ.
P1	93	0,39	1,43	0,8272	0,193354
P2	93	0,35	1,44	0,84333	0,210126
P3	93	0,28	1,00	0,65333	0,148729
P4	93	0,36	0,99	0,62559	0,1533
P5	93	0,25	0,95	0,54505	0,162532

Table 2 (Continued): Descriptive statistics of weight loss with respect to the previous day

P6	93	0,25	0,95	0,54505	0,162532
P7	93	0,28	1,93	0,76118	0,248258
P8	93	0,21	1,09	0,44602	0,127221
P9	93	0	1,32	0,55495	0,191406
P10	93	0,3	1,55	0,59333	0,220466
N valid (according to list)	93				

Graph 1 shows the trend of weight loss according to the previous day, it can be seen that there is no defined trend, the main losses being obtained on the second and first day, with the average weight loss of the second day with respect to the initial 0.8272 grams, with a standard deviation of 0.1933 grams. The greater weight loss in average through dehydration is reflected between the first and third day, this behavior reflects the principle of senescence, characteristic of non-climacteric fruits.



Graph 1 Trend of dehydration of Icaco from the previous day

Until day four the fruit has experienced a minimum cumulative dehydration of 1.02 grams and a maximum of 3.87 grams, which reflects a minimum cumulative loss of 9.55% and a maximum of 19.49%, the average of the losses corresponded to 15.82%, showing the trend to loss of quality and the beginning of the senescence process as reported by Parra (2008) [8], while for day five the minimum loss corresponds to 12.93% and a maximum of 24.44% dehydration of the fruit. Taking into account the results obtained from the measurements of the loss of water by dehydration of the fruit of Icaco until day five after its collection, it is found that

days four and five correspond to the critical period where there is a greater response to the non-climacteric characteristic by the state of initiation of the senescence, losing its quality by dehydration and marking a short time of agroindustrial useful life.

From the sixth day of weighing, the fruit deteriorates at a rate of 27.23%, statistically reaching an advanced stage of senescence according to the simple linear regression model, this loss of water by transpiration produces a marked presence of wilting, wrinkles, as reported Álvarez et al. (2009) [6] in studies with lemon; loss of external red color and gloss of the epidermis; browning of the pulp by contact with oxygen, decrease of the mass by transfer of water to the external environment with loss of its juiciness, leading the fruit to have its skin adhered to the seed by dryness, causing hardening, as expressed by Ruelas et al . (2013) [16], effects clearly identified on the last measurement at the end of day 11. These signs in non-climacteric fruits such as Icaco are due to the hydrolytic action caused by high action of the enzymes that cause the cell death in the fruit, wilting, softening, flaccidity, as well as the reduction of its nutritional value [17].

During post-harvest storage including senescence and fruit decay, the loss for the minimum values corresponded to 55.76%, 37.93% for maximum values and the mean represented in a loss of 37.93%, indicating dehydration due to water loss associated with transpiration, as proposed by Balaguera & Mart (2016) [18].

Model

In Table 3, it is observed that the variation of Icaco weight is explained in 99.5% with respect to the day variable in which the fruit was exposed, in addition, there is a high degree of correlation between the variable weight of the fruit and days (R = 0.997), there is a good fit of the regression line since the typical error of estimation is small. The linear regression model is tested with the calculated value of R2 = 0.995.

Table 3 Summary of the model

Model	R	R^2	R^2correct	Typ. of the estimate	Statistical change				
					Change in R^2	Change in F	$gl1$	$gl2$	Sig. Change in F
1	0,997[a]	0,995	0,994	0,156194	0,995 1756,136		1	9	0,000

Table 4 details the estimate of the weight of Icaco given by the equation = (Weight) ^ = 15,019-0,624 Dia which represents the weight loss, as a function of time (Day), this linear equation is deduced from the values set forth in Table 4; the value (t = -41.906) indicates that there is an inverse relationship, with a significance of 0.000 which is less than 0.005, that is, as the days of exposure increase, the fruit weight

ecreases by 0.624 grams / day (because it is negative slope). This correlation was more noticeable in the first 3 days, since the only post-harvest stage for non-climacteric fruits is senescence or death, after harvesting, the changes that occur during maturation are inhibited, these changes physiological effects are induced by the presence of ethylene, a maturation hormone which decreases its function in this type of non-climacteric fruits [19].

Table 4 Linear regression model for weight loss linear

Model		Non-standardized coefficients		Coefficients typified		
		B	Tip. Error	Beta	t	Sig.
1	Constant	15,019	0,101		148,695	0,000
	Day	-0,624	0,015	-0,997	-41,906	0,000

Conclusion

From the results shown, from their analysis and their discussion, the following conclusions can be drawn on the effect of post-harvest transpiration on the agroindustrial quality of the fruit of Chrysobalanus Icaco pink variety: 1) data collected on the process of transpiration of the fruit of Icaco show a marked decrease of the mass of the fruit, as well as the loss of quality, freshness and useful life of the fruit, until the third day, being useful even for preparations of jelly, fruit liqueur and jam; 2) the loss of water by dehydration causes in the fruit changes in its coloration, brightness, and firmness due to the loss of the turgidity, which affects its possible commercial value, thus controlling the loss of water by transpiration, would be the most logical strategy to lengthen the useful life of this fruit and 3) it is evident that for the first four days the most critical in the process of transpiration, being evident by the appearance of wrinkles, wet areas, loss of firmness, wilting, seed adhesion to the skin.

References

[1] Y.E. Samar, How to achieve a healthy life, *Anales Venezolanos de Nutrición*, **27** (2014), 129-142.

[2] O. Estrada, D. Conde, J. Mendez and A. Cardozo, Chemical constituents from Chrysobalanus venezuelanus, *Biochemical Systematics and Ecology*, **45** (2012), 66-68. https://doi.org/10.1016/j.bse.2012.07.011

[3] A.D. Gonzalez-Delgado and Y.Y. Peralta-Ruiz, Thermodynamic modeling of microalgae oil extraction using supercritical fluids, *Contemporary Engineering Sciences*, **10** (2017), 503-511. https://doi.org/10.12988/ces.2017.7334

[4] M. Ramírez, A. Urdaneta and G. Vargas, Tratamientos con ácido indolbutírico y lesionado sobre el enraizamiento de estacas de icaco (*Chrysobalanus icaco L.*). *Agronomía Tropical*, **54** (2004), 203–218.

[5] P.A.S. White, L.M. Cercato, V.S. Batista, E.A. Camargo, W. De Lucca Jr, A.S. Oliveira, F.T. Silva, T.C. Goes, E.R.A. Oliveira, V.R.S. Moraes, P.C.L. Nogueira, A.M. De Oliveira e Silva, L.J. Quintans-Junior, B.S. Lima, A.A.S. Araújo and M.R.V. Santos, Aqueous extract of *Chrysobalanus icaco* leaves, in lower doses, prevent fat gain in obese high-fat fed mice, *Journal of Ethnopharmacology*, **179** (2016), 92-100. https://doi.org/10.1016/j.jep.2015.12.047

[6] J. Álvarez, J. Galvis and H. Balaguera, Determination of physical and chemical changes during champa fruits maturation (*Campomanesia lineatifolia R. & P.), Fisiología y Tecnología de Poscosecha*, **27** (2009), 253–259.

[7] G. Russo, G. Verdiani and A. Anifantis, Re-Use of Agricultural Biomass for Nurseries Using Proximity Composting, *Contemporary Engineering Sciences*, **9** (2016), 1151–1182. https://doi.org/10.12988/ces.2016.68135

[8] A. Parra and G. Fischer, Ripening and postharvest behavior in the pineapple guava (*Acca sellowiana (O. Berg) Burret*). A review, *Revista Colombiana de Ciencias Horticolas*, **7** (2013), 98–110.
https://doi.org/10.17584/rcch.2013v7i1.2039

[9] B.L. Moreno and Y.A. Deaquiz Oyola, Characterization of physicochemical parameters in blackberry fruit (*Rubus alpinus Macfad*), *Acta Agronómica*, **65** (2016), 130–136. https://doi.org/10.15446/acag.v65n2.45587

[10] J.G. Álvarez-Herrera, X. Rozo-Romero and A.J. Reyes, Effect of ethylene on postharvest behavior of plum fruits (*Prunus salicina* Lindl.) at four stages of maturity, *Revista Colombiana de Ciencias Hortícolas*, **9** (2015), 46-59.
https://doi.org/10.17584/rcch.2015v9i1.3745

[11] P. Benito-Bautista, N. Arellanes-Juarez and M.E. Pérez-Flores, Color and state of maturity of fruit of the husk tomato, *Agronomía Mesoamericana*, **27** (2016), 115–130. https://doi.org/10.15517/am.v27i1.21891

[12] N. Permuy, O. Chaveco, J. González, E. García and N. Hidalgo, Loss of common bean grain in a traditional storage system, *Agricultura Técnica en México*, **34** (2008), 91-100.

[13] I. Domínguez, M.T. Lafuente, P. Hernández-Munoz and R. Gavara, Influence of modified atmosphere and ethylene levels on quality attributes of fresh tomatoes (*Lycopersicon esculentum Mill.*), *Food Chemistry*, **209** (2016), 211-219.
https://doi.org/10.1016/j.foodchem.2016.04.049

[14] Y. García, J. Pérez, A. García and A. Hernández, Determination of Pineapple (*Ananas Comosus*) Quality Properties Cayena Lisa Variety Stored under Environmental Conditions, *Revista Ciencias Técnicas Agropecuarias,* **20** (2011), 62–65.

[15] M. Siddiqui and M. Al-Whaibi, Role of nano-SiO2 in germination of tomato (*Lycopersicum esculentum seeds Mill*.), *Saudi Journal of Biological Sciences*, **21** (2014), 13-17. https://doi.org/10.1016/j.sjbs.2013.04.005

[16] X. Ruelas, M. Reyes, B. Valdivia, J. Contreras, J. Montañez, A. Aguilera, A. Carbó and R. Peralta, Preservation of Fresh and Minimally Processed Fruits and Vegetables with Edible Coatings, *Acta Química Mexicana,* **5** (2013), 31–37.

[17] I. Baldiris-Navarro, Y. Marrugo-Ligardo, C. Severiche-Sierra, J. Jaimes-Morales, W. Fong-Silva, L. Vargas-Ortiz, E. Bedoya-Marrugo, and H. Cohen-Padilla, Delayed Organoleptic Maturation of Tomato Variety Milano (*Lycopersicum esculentum Mill*) Using Giberelina, *International Journal of ChemTech Research*, **10** (2017), 1032-1037.

[18] N. Novizar and M. Reza, The Improvement Lycopene Availability and Antioxidant Activities of Tomato (*Lycopersicum Esculentum, Mill*) Jelly Drink, *Agriculture and Agricultural Science Procedia*, **9** (2016), 328-334. https://doi.org/10.1016/j.aaspro.2016.02.144

[19] E. Martínez, A. Torregroza, A. Torregroza and D. Mogollón, Effect of osmotic-microwave dehydration on physicochemical properties of the mango (*Mangiferea indica L.)* variety Heart, *Agron. Colomb.*, **34** (2016), 1236-1239.

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