RESEARCH ARTICLE

Determination of factors involved in the rejection of bananas (*Musa acuminata*) intended for international commercialization

Jesus R. Melendez* Alberto Peñalver, Paola Pincay Figueroa, Nelly L. Pulgar, Mayra Cayos

Faculty of Technical Education for Development, Universidad Catolica de Santiago de Guayaquil, Ecuador

*Correspondence: Jesus R. Melendez, jesus.melendez@cu.ucsg.edu.ec, Address: Av. Pdte. Carlos Julio Arosemena Tola, Guayaquil 090615, Ecuador. Tel: +593 04 222-2024

Received: 13/03/2020

Accepted (Online first): 01.04.2020

Vol./Issue/Year: 1(1), 2020

Competing interests: Author(s) stated no compete of interest.

Edited by Lowy A. Daniel; Bence Mátyás

Grant information: This study was funded by Universidad Catolica de Santiago de Guayaquil.

Copyright 2020 © The Author(s). This is an Open Access article under the CC-BY 4.0 license published by Dama Research Center limited a private company limited by shares organized and existing under the laws of Hong Kong, with its head office located at Room 409, Beverley Commercial Centre, 87-105 Chatham Road South, Tsim Sha Tsui, Kowloon- Hong Kong and company number: 2875213.

How to cite: Melendez et al.. "Determination of factors involved in the rejection of bananas (*Musa acuminata*) intended for international commercialization" DRC Sustainable Future 2020, 1(1): 48-53, DOI: 10.37281/DRCSF/1.1.6

ABSTRACT

Rendering production and trade more sustainable can be accomplished via promoting innovation and sustainable business models. This paper addresses sustainable production and international trade in the banana agro-export sector of Ecuador. This activity provides millions of dollars in income, but with this development, a series of quality standards have been established to enter the competitive export system. These criteria contributed to establishing good post-harvest production and management practices that guarantee optimal banana and plantain production. The objective of this study is to determine the factors involved in the rejection of bananas (*Musa acuminata*) intended for international commercialization. Our methodology considered the design modality of non-experimental transactional research, using a quantitative approach. Methodological design was developed in three phases at Finca 6 Hermanas, located in the Barraganete sector of the San Juan parish in the Pueblo Viejo canton of the Los Ríos Province, Ecuador. Results highlight that 79.55 % of reasons for banana rejection are abiotic factors (damage, dry latex, scar, insect damage, broken neck, and overgrowth), while biotic factors (twins, diseases, and short finger) cause 20.45%. Over the 6-week duration of our investigation the average rejection was 6,361 fingers and 1,269 kg. The analysis of variance turned out to be significant for variable 1 (biotic and abiotic). In this case the null hypothesis (H_0) is rejected; with the criterion of $p\text{-value} < 0.0001$ and $F(9; 45) = 2.10$, $F = 13.17 > F_{\text{critical}}$. For variable (2) "work weeks", H_0 is accepted for $p\text{-value}$ of 0.7694 and $F(5; 45) = 2.4$. As $F = 0.51 < F_{\text{critical}}$, one can conclude, that with a significance level of 5% the null hypothesis is accepted. It is also established that these figures enable strategies that systemically mitigate the damages via correcting the causes that lead to the deterioration of banana and, by this, increase the economic gains of commercialization.

Keywords: export, dessert bananas, Ecuador, *Zingiberales*, *Musaceae*

1. Introduction

According to data provided by the Central Bank of Ecuador (CBE), Ecuador is among the main banana producers and exporters worldwide, banana turnover is 32% of global business and within the group consisting of agriculture, aquaculture, and fishes its contribution to the Gross Domestic Product (GDP) in 2016 was 7.7% (INEC, 2017) and 3.84% for the individual contribution in the group (CBE, 2017a). Within the economic context, bananas are in a group of non-oil export-traditional trade. This dynamic sector is based on the following results, where it is evident that the total non-oil exports recorded in January 2017 were USD 991.1 million, 14.5% greater (USD 125.2 million) as compared to the first month of 2016 (USD 865.8 million). recorded an increase in volume (metric tons) of 14.2%, over the above time frame (CBE, 2017b). For the group, where bananas and plantains are considered, traditional non-oil exports totaled USD 590.4 million, a value greater by 13.6% (USD 70.9 million) than that recorded in January 2016. In the meanwhile, non-traditional sales reached USD 400.7 million i.e., 15.7% (USD 54.4 million), more than sales made in the same period of 2016. However, the behavior evidenced in non-oil and traditional products from January 2015 to January 2017, reached a monthly average FOB value of USD 534.1 million, the share of the goods that make up this group was as follows: banana and plantain (43.8 %), shrimp (37.8%), cocoa and processed cocoa (12.2%), tuna and fish (3.9%); coffee and processed coffee (2.3%) (CBE, 2017b).

Other data provided by the governing body of Ecuador established that the Non-Oil Trade Balance decreased its deficit (4.7%) as compared to the same time period in 2016, going from USD 210.7 million FOB to USD 200.9 million FOB, this means that non-oil exports increased from 865.8 to 991.1 million FOB (CBE, 2017b).

Total values were released for the non-oil and traditional exports sector; specifically for banana and plantains these reached in 2016 and 2017 a total production (thousands of MT) of 562 m TM and 668 m TM, respectively, together with a unit price for the same period of 443.5 and 457.3 USD / MT, this represented an increase of 3.1% of the unit value (CBE, 2017b) in these two years. Nevertheless, this business item generates significant income for the country, owing to its significant volume of marketing, which makes it the main export product and a source of foreign currency that currently exists in the country (Maridueña, 2018).

This economic activity is extremely important, since 180,336,000 hectares are dedicated nationwide to banana cultivation; this was revealed by the 2016 report of the Central Bank of Ecuador (CBE, 2017a). The Ecuadorian banana sector exported the majority of

bananas to the European Union 30%, followed by Russia 21%, and the United States 18% (CBE, 2017a).

Given its economic importance for the development of the country, banana production is subjected to rigorous agronomic and phytosanitary management (Joshi *et al.*, 2019). Diseases, such as black Sigatoka (*Mycosphaerella fijiensis*) and banana streak virus are commonly controlled with significant spendings (Gaviria and Cayón, 2008). Likewise, pre and post-harvest management is essential for generating fruit with high quality (Gomes *et al.*, 2020). For the same reason, pre and post-harvest management is very important for generating fruit with excellent quality. Also, the quality of the soils is also important (Mendoza *et al.*, 2020) and its multifaceted soil functions must be protected (Jakab, 2020) along with proper waste management (Bottani *et al.*, 2019). Nonetheless, it has been common to observe morphological defects in the fingers and hands of the fruit, which are of abiotic, or biotic nature. These have negative economic repercussions on banana production (Carvajal *et al.*, 2015).

Abiotic damages are caused by climatic conditions, such as extreme temperatures, excess or deficiency of water, light or nutrients, compact soil, drought, stagnation of water and/or adverse cultivation practices (Fernando, *et al.*, 2020). Other damages may result from long-term interaction between the plant and one or more causes, such as lack of space for optimal root growth, and the presence of chronic levels of air or water contaminants (Sánchez Castañeda, 2017).

According to González *et al.* (2006), other associated factors that affect rejection can encompass biotic problems (Black Sigatoka, Nematodes, Black Weevil, Virosis, etc.), abiotic (drought) and technological issues (low densities, irrigation, nutrition, pest control, etc.). Effects of these negative factors can worsen by the total planted area; should only 60% of the cultivated surface not have access to technology, low yields will be obtained (Instituto Nacional de Investigaciones Agropecuarias [INIAP], 2020).

These consequences associated with the decrease and loss of significant quantities of banana prior to its commercialization determine the objectives of this study to identify the critical factors, which affect the economic profitability of bananas (*Musa acuminata*) for export in the post-harvest stage. Our methodology considered the transactional non-experimental research design, with a quantitative approach. Three phases were established for the evaluation of observed phenomena: Phase (1): Parametric evaluation of quality, Phase (2): Quantitative evaluation of discarded fruit; Phase (3): Quantitative evaluation of the economic loss because of discard. Results were subjected to statistical tests (standard deviation and analysis of variance) to determine the relationship between the variables.

2. Methods

2.1 Location of the study.

Our investigation was carried out at Finca 6 Hermanas, located in the Barraganete sector of the San Juan parish in the Pueblo Viejo Canton of the Los Ríos Province, Ecuador (Figure 1).

Figure 1. Satellite view of the 6 sister farms

2.2 Type of research

This investigation is performed according to a non-experimental research design, by sampling fruits during the post-harvest process, to describe variables and analyze their incidence and interrelations (Villafuerte, 2017). The investigative scope can be found in the exploratory, descriptive level of our research. Our research approach is quantitative, by applying a deductive method (Palella and Martins, 2012).

2.3 Experimental Design

Development by three phases were established.

Phase 1: Parametric evaluation of the quality, to obtain the first sample, a 2.5-kg tray or container and sizes of 86 cm x 68 cm was taken, for depositing 50 rejected fingers. Three repetitions were made, of which 10 fingers were chosen for each tray, adding a total of 30 fingers selected at random to qualify them and determine the cause of their rejection. Similar sampling was done every week after each process fruit shipment, over 6 weeks.

Phase 2: Quantitative evaluation of the discard: variables of interest in the selected samples were evaluated.

Phase 3: Quantitative evaluation of the economic loss. Economic production of weekly boxes was established, and the weight in kg, both of the production for export and of the discard. Once the weight of rejection was determined, the loss per boxes was calculated and by this, the economic loss and percentage of discard relative to the total production of the packing plant.

2.4 Presentation of results

Results are listed in tables of contents the followings being highlighted: (i) Parametric evaluation of quality, (ii) The number of discarded banana fingers is quantified by process area, (iii) Percent distribution of critical factors present in fruit samples. (iv) Economic losses due to discard, and (v) Statistical tests for checking the validity of hypotheses of this study (see Table 1). Analysis of variance and Tukey tests are considered. Infostat®. 2019 version was used as the statistical software.

Table 1. Hypothesis formulation.

Hypothesis	Description
H_0	Critical factors (variables 1a) * do not affect the desired quality of banana destined for international commercialization.
H_1	Critical factors (variables 1a) do affect the desired quality of banana destined for international commercialization.
H_0	Critical factors “work-week” (variables 2a) ** do not affect the desired quality of the banana destined for international commercialization.
H_1	Critical factors “work-week” (variables 2a) ** do affect the desired quality of banana destined for international commercialization.

* Variable 1a represents damage of biotic and abiotic origin.

** Variable 2a represents the “work weeks” involved in obtaining samples.

3. Results and discussion

3.1 Stage 1: Determination of critical factors

The main causes of rejection are listed in Table 1 of Results. In this study, the variable “damage” was the most frequent factor of rejection, 38.18% of rejected fruit being affected by it, secondly, dry latex is found affecting 12.27% of the fingers, thirdly, dry latex which was observed in 10.45% of the evaluated fingers, the rest of the factors presented figures less than 10% (see Table 2).

Table 2. Percent distribution of critical factors

Critical Factors	Percentage (%)
Spoil	38.18
Dry latex	12.27
Scar	10.45
Damage / Insects	9.55

Critical Factors	Percentage (%)
Broken neck	9.09
About grade	8.18
Twins	5.00
Short finger	3.18
Diseases	3.18
Low grade	0.91
Total	100.00

3.2 Quantification of discarded fingers in the Postharvest process

In the post-harvest process, a significant amount of banana fingers were discarded, with its distribution is shown in Table 3.

Table 3. Fingers discarded in the Postharvest process.

Week	Pool 1	Pool 2	Packaging	Total
1	800	200	6	1006
2	1000	167	8	1175
3	875	100	9	987
4	920	103	5	1028
5	995	202	6	1203
6	852	100	10	962
Total (%)	85.59	13.72	0.69	6361

3.3 Average losses

When quantifying the economic loss, calculations yield 1.2% of total production. Taking into account that the 15.87 kg/box of bananas is currently quoted on the market at 5.50 USD, it is estimated that the loss generated over the 6 weeks of investigation was rejection a total of 79.96 boxes, which represents a total economic loss of 439.78 USD, equivalent to 73.29 USD weekly loss.

Table 4. Discard weight in the Post-harvest process

Week	Discarded product weight (K)
1	201
2	234
3	198
4	204
5	240
6	192
Total Discarded	1269

3.4 Hypothesis Check: Analysis of Variance.

Table 5 lists a summary of statistical results.

Table 5. Statistical data

Variables / Factors	Total Discard	Average Arithmetic	Error EE	Significance
Mellizos	11	1,83	1,01	NS
Over-graduate	18	3,00	1,18	NS
Under-Graduate	2	0,33	0,21	NS
Short finger	7	1,17	0,48	NS
Insect damage	21	3,50	0,85	NS
Disease	7	1,17	0,48	NS
Broken neck	20	3,33	0,80	NS
Dry latex	27	4,50	1,26	NS
Scar	23	3,83	1,01	NS
Spoilage	84	14,00	1,98	**

Analysis of variance turned out to be significant for variables (1), a p-value < 0.0001 was obtained. If $\alpha = 0.05$, then the critical point, which delimits the acceptance and rejection zone of the null hypothesis (H_0) is $F(9; 45) = 2.10$. Since $F = 13.17 > F_{critical}$, it is concluded that with a 5% significance level one should reject the null hypothesis (H_0). In the second case, evaluation made to the number of "workweeks" yielded a p-value of 0.7694, and the evaluation criteria were $F(5; 45) = 2.4$. As $F = 0.51 < F_{critical}$, and for a significance level of 5% the null hypothesis is accepted, equivalent to no difference between the number of bananas produced and the weeks evaluated (see Table 6).

Table 6. Variance Analysis Chart (SC type III)

FV	SC	IG	CM	F	p-value
Model	827.67	14	59.12	8.65	<0.0001
Variables	810.33	9	90.04	13.17	<0.0001
Work weeks	17.33	5	3.47	0.51	0,7694
Error	307.67	45	6.84		
Total	1135.33	59			

The posteriori test shows that for variables that measure the rejection factors, an ex post test was applied, the Tukey test with $\alpha = 0$; this produced a DMS = 5.92, indicating that the difference between treatments is only

due to the level of rejection, which corresponds to the variable called “spoilage”. The analysis of the residuals did not show noncompliance with the assumptions of the theoreticians of the applied statistical technique (see Table 7).

Table 7. Results of Tukey test. Averages with a common letter are not significantly different ($p>0.01$).

Test: Tukey. Alfa = 0.01 DMS = 5.92194				
Error:	6.8370	gl:	45	
VARIABLES	Average	n	E.E	
Low-grade	0.33	6	1.07	A
Disease	1.17	6	1.07	A
Finger-short	1.17	6	1.07	A
Twins	1.83	6	1.07	A
Overripe	3.00	6	1.07	A
Broken neck	3.33	6	1.07	A
Insect damage	3.50	6	1.07	A
Scar	3.83	6	1.07	A
Latex-dry	4.50	6	1.07	A
Spoilage	14.00	6	1.07	

4. Conclusions

This study allows to get familiar with the main factors involved in the rejection of bananas that are destined for export. According to the obtained results, there is a distribution of factors according to the percentages obtained.

There are biotic factors (twins, diseases) and abiotic factors (damage, dry latex, scar, insect damage, broken neck, over grade, low grade, short finger) that generate a high percentage of discard and, therefore, a great economic loss. Most non-exportable quality banana results from damage, scarring, dry latex, damage/insects, and broken neck. All these can be attributed to poor care of the field personnel or falls, mishandling of employees and additional falls that may occur when banana is removed from the plant. Participation of managers ((Melendez *et al.*, 2018a)) and employees ((Melendez, Malvacias Escalona and Almeida, 2018b)) in executing strategies for post-harvest management plays an important role in a better care of the product intended for export. Situation that has increased a greater adherence to compliance with corporate social responsibility ((Melendez and Gracia, 2019c)).

Factors that directly affect banana loss are divided into two groups, the first representing 79.55% of cases, comprising damage, dry latex, scars, damage/insects, and a broken neck, while 20.45% of losses are a consequence of per grade, low grade, and diseases.

Out of the recorded total loss of 1,269 kg fruit, 1,009 kg are directly related to the first five key factors, while 253 kg are included in the group of main factors. These values lead to developing strategies that mitigate damage in a systemic manner, by correcting each of the causes that generate that factor.

Finally, these results will allow agricultural banana producers to develop new strategies that improve banana quality in the supply chain that will sustain the export process and, thus, increase the exportable quantity and the greater inflow of foreign currency to the country.

References

- Bottani, E.; Vignali, G.; Mosna, D.; Montanari, R. Economic and Environmental Assessment of Different Reverse Logistics Scenarios for Food Waste Recovery. *Sustain. Prod. Consum.* **2019**, 20, 289–303. <https://doi.org/10.1016/j.spc.2019.07.007>.
- Carvajal, J. C. P.; Jaramillo, J. S.; Castaño, A. G. Guidelines for a Rehabilitation Model for Banana Packing Plants from the Integration of Environmental Variables and Human Factors. *Procedia Manuf.* **2015**, 3, 6190–6197. <https://doi.org/10.1016/j.promfg.2015.07.916>.
- Central Bank of Ecuador (CBE). Información Estadística Mensual; CBE, Ecuador, **2017a**.
- Central Bank of Ecuador (CBE). Evolución de la balanza comercial; BCE: Subgerencia de Programación y Regulación, Ecuador, **2017b**.
- Fernando, I.; Fei, J.; Stanley, R.; Rouillard, V. Evaluating Packaging Performance for Bananas under Simulated Vibration. *Food Packag. Shelf Life*, **2020**, 23, 100428. <https://doi.org/10.1016/j.fpsl.2019.100428>.
- Gaviria, P. A.; Cayón, G. Efecto de *Mycosphaerella fijiensis* sobre la fisiología de la hoja de banano. *Agr. co.* **2008**, 26. <http://www.scielo.org.co/scielo.php?scrip>
- Gomes, H. de O.; Menezes, J. M. C.; da Costa, J. G. M.; Coutinho, H. D. M.; Teixeira, R. N. P.; do Nascimento, R. F. Evaluating the Presence of Pesticides in Bananas: An Integrative Review. *Ecotoxicol. Environ. Saf.* **2020**, 189, 110016. <https://doi.org/10.1016/j.ecoenv.2019.110016>.

González, E. M. Manejo Integrado de Plagas. Manual Práctico; Centro Nacional de Sanidad Vegetal (CNSV): Cuba, **2006**.

Instituto Nacional de Investigaciones Agropecuarias (INIAP). Retrieved from <http://www.iniap.gob.ec/pruebav3/banano-platano-y-otras-musaceas/>. (accessed on March 13, 2020).

Instituto Nacional de estadística y censos (INEC). Panorama Laboral y Empresarial del Ecuador. INEC: Ecuador, **2017**.

Jakab, A..“The ammonium lactate soluble potassium and phosphorus content of the soils of north-east Hungary region: a quantifying study” *DRC Sustainable Future*. **2020**, 1(1), DOI: 10.37281/DRCSF/1.1.2

Joshi, A.; Kalauni, D.; Tiwari, U. Determinants of Awareness of Good Agricultural Practices (GAP) among Banana Growers in Chitwan, Nepal. *J. Agric. Food Res.* **2019**, 1, 100010. <https://doi.org/10.1016/j.jafr.2019.100010>.

Maridueña L, Ángel. Efecto De La Apertura Comercial en el Crecimiento Económico. La Estructura Productiva, El Empleo, La Desigualdad y La Pobreza En El Ecuador (1960-2015). *Cuestiones Económicas* **2018**, 27.

Melendez, J. R.; Perez Pupo, I.; Garcia Vacacela, R.; Piñero Pérez, P. Strategic Factors in the Context of Project Management: Management Perspectives. *Espacios* **2018a**, 39 (39).

Melendez, J. R.; Malvacias Escalona, A. M.; Almeida, A. Importance of the Participation of the Employee in the Execution of Projects: Management Perspectives. *Espacios* **2018b**, 39 (14), 21.

Melendez, J. R.; Gracia, G. E. Theoretical Perspective of Corporate Social Responsibility in the Managerial Scenario: Shared Implications between the Company-Stakeholders. *Espacios* **2019c**, 40 (10), 1–14.

Mendoza, B.; Guananga, N.; Melendez, J. R.; Lowy, D. A. Differences in Total Iron Content at Various Altitudes of Amazonian Andes Soil in Ecuador. *F1000Research* **2020**, 9, 128. <https://doi.org/10.12688/f1000research.22411.1>.

Stracuzzi, P.; Feliberto, M.P. Metodología de la Investigación cuantitativa; (3rd ed.); Fondo Editorial de la Universidad Pedagógica Experimental Libertador: Caracas, **2012**.

Sánchez Castañeda, J. Mercado de Productos Agrícolas Ecológicos En Colombia. *Suma Negocios*, **2017**, 8 (18), 156–163. <https://doi.org/10.1016/j.sumneg.2017.10.001>.

Villafuerte, C. Manual metodológico para el investigador científico. Biblioteca virtual de Derecho, Economía y Ciencias Sociales: www.eumed.net/libros/2010e/816/, 2017.

Linked Preprint:

Melendez et al. Determination of factors involved in the rejection of bananas (*Musa acuminata*) intended for international commercialization. *DRC Preprints* **2020**, DOI: 10.37281/Preprints/2