Asian Journal of Chemistry; *Vol. 34, No. 11 (2022), 2813-2816*

ASIAN JOURNAL OF CHEMISTRY

https://doi.org/10.14233/ajchem.2022.23698

Evaluation of Antioxidants in Byproduct from Bananas: Dominico (*Musa sapientum* L.) and Maqueño (*Musa balbisiana* L.) as Quality Criteria

Angelica Tigre-León[1], Deysi Guanga-Chunata[1], Rolando Zabala Vizuete[2] and Favian Bayas-Morejón[1,*]

[1]Centro de Investigación y Desarrollo Biotecnológico, Departamento de Investigación y Vinculación, facultad de Ciencias Agropecuarias, Universidad Estatal de Bolívar, CP: 020150, Guaranda, Ecuador
[2]Facultad de Recursos Naturales, Escuela Superior Politécnica de Chimborazo (ESPOCH), Riobamba, Ecuador

*Corresponding author: E-mail: fbayas@ueb.edu.ec

Received: 27 March 2022; *Accepted*: 30 May 2022; *Published online*: 19 October 2022; AJC-20990

In this work, the antioxidants of the two varieties of bananas *viz*. dominico (*Musa sapientum* L.) and maqueño (*Musa balbisiana* L.) were evaluated. Three factors were considered before the determination of antioxidant activity *i.e.* variety of banana, type of antioxidant and amount of antioxidant. The same conditions were also considered for citric acid and ascorbic acid in the amounts of 13, 15 and 17 mg/Kg; evaluated in the 36 experimental units. According to the obtained results, the best type of antioxidant is citric acid, which indicated that the T5 treatment is the one that presents the best results in the processed products. In addition, in this treatment a lower amount of antioxidant is used at a rate of 15 mg/Kg. It was established that they were complied with the minimum parameters established in the Codex Standard for Bananas (Plantain) Codex Stan 205-1997. The studied bananas were also complied with the microbiological parameters as established in the Ecuadorian technical standard NT INEN 1529-10. The definitive can be established that this product is fit for human consumption.

Keywords: Bananas, Oxidation, Preservative, Antioxidant, Shelf life.

INTRODUCTION

In Ecuador, bananas have been a crop of increasing socio-economic significance, since it exports bananas about 30% of total world exports. Currently, Ecuador is the second largest global exporter of bananas. Its use is a relevant aspect of food security and has progressively become a source of foreign exchange and employment for producers. Ecuador generates a revenue of $ 1.9 billion dollars in foreign exchange and of another $ 90 million dollars in taxes to the state through banana cultivation, which leads to creating millions of jobs [1].

The country's production is carried out in 20 provinces of the territory. The coast of this country contributes with 89% of the national production, whereas the Sierra with 10% and the Amazonic region contributes with 1%. The provinces with the maximum production on the coast include Los Ríos and Guayas with 35% and 32% of total production, respectively [2]. The warm regions of Cañar, Bolívar, Pichincha, Santo Domingo de los Tsachilas and Loja provinces contribute to 3.8%, 1.8%, 1.6%% 1.4% and 0.8% of production, respectively. Remaining provinces afford a lower production than the reported ones.

Generally, antioxidants undergo the oxidation and prevent the phenolics, flavonoids and carotenoids compounds found in fruits and vegetables from oxidizing. Thus, prevent quinone polymerization and results in the pigment formation without altering the flavours of foods/vegitable and are safe [3]. However, antioxidants affect the properties of foods and are added to food to prevent oxidation in various products since several foods undergo an undesirable coloration when they come in contact with oxygen. Different antioxidants are available depending on their action mechanism, however, their use depends on the type of food industry. In this work, antioxidants activity of two varieties of bananas *viz*. dominico (*Musa sapientum* L.) and maqueño (*Musa balbisiana* L.) were evaluated, in order to acquire the quality criterion at the State University of Bolivar, Ecuador.

EXPERIMENTAL

The present research work was performed in the Faculty of Agricultural Sciences Laboratory, the State University of Bolivar. In this investigations the descriptions of the studied bananas *viz*. dominico (*Musa sapientum* L.) and maqueño (*Musa balbisiana* L.) are given in Table-1. A completely randomized design (DCA) was developed in a tri-factorial arrangement 2*2*3, with 3 repetitions.

TABLE-1
FACTORS UNDER STUDY OF THE RESEARCH

Factor	Code	Description
Banana variety	A	a1 = Dominico; a2 = Maqueño
Antioxidant type	B	b1 = citric acid; b2 = ascorbic acid
Amount of antioxidant	C	c1 = 13 mg/Kg; c2 = 15 mg/Kg; c3 = 17 mg/Kg

Materials: Raw materials were obtained as a bunch from the parish San Luis de Pambil-Guaranda (Ecuador). The morphological selection (bananas without physical damage) and microbiological selection (bananas without the presence of mould) were conducted followed by manual washing and peeling were performed. Afterwards, weighed 250 g of raw material was precisely cut to 2 to 3 mm thickness. In 200 mL plastic trays, the pieces of the two types of bananas were placed and covered with the prepared antioxidant solutions. The antioxidant solutions (citric acid and ascorbic acid) were prepared in concentrations of 13, 15, and 17 mg/kg with 100 mL of distilled water. Finally, the pieces were stored in polystyrene bags.

Analysis on raw materials: The maturity state was studied through visual inspection by using a colorimetric scale based on a numerical assessment [4].

Brix: The content of soluble solids or sugars was estimated through refractometry.

Titrable acidity: Titrable acidity was measured using a titration method by employing a standardized 0.1 N NaOH as reported in the Ecuadorian technical standard NTE INEN 381: 86 [5].

Hydrogen potential (pH): The products' acidity level was estimated using a potentiometer through direct immersion in the sample. This procedure was performed according to the Ecuadorian technical standard NTE INEN 389: 86 [6].

Microbiological analysis: The microbiological cultures were evaluated at 22-25 ºC by using petrifilm type sowing plates to study the presence of mould and yeast by employing a medium containing yeast extract, glucose, mineral salts and plate count technique according to the Ecuadorian technical standard NTE INEN 1529 -10: 98 [7].

Analysis of the finished product

Enzymatic browning: This procedure was performed according to the spectrophotometer method at 1 min intervals. The increase in the absorbance of a mixture of the enzymatic solution and chlorogenic acid as substrate was reported.

Statistical analysis: The analysis of variance (ADEVA) was used to determine the differences between the treatments developed in this study. According to data, the means were compared to determine the optimal treatment.

RESULTS AND DISCUSSION

Hydrogen potential (pH): Table-2 presents the values acquired from pH measurements conducted for different treatments. The same values were used for the analysis after 8 days of first test. The findings are comparable with the results of Dávila, who reported the pH of 5.6-5.8, acidity of 0.0050-0.0072 g/L and sugar content of 4.8-5.0% [8]. These values indicated that the experimental measurements performed satisfied the minimum chemical quality for parameters established for this product type. Similarly, the present results are in agreement with the Codex Standard for Bananas [9].

TABLE-2
pH VALUES MEASURED IN THE DIFFERENT TREATMENTS

Treatments	Code	Means	Treatments	Code	Means
1	$A_1B_1C_1$	5.98	7	$A_1B_2C_1$	5.85
2	$A_1B_1C_2$	5.88	8	$A_1B_2C_2$	5.90
3	$A_1B_1C_3$	5.86	9	$A_1B_2C_3$	5.91
4	$A_2B_1C_1$	5.75	10	$A_2B_2C_1$	5.92
5	$A_2B_1C_2$	5.80	11	$A_2B_2C_2$	5.94
6	$A_2B_1C_3$	5.80	12	$A_2B_2C_3$	5.93

Determination of acidity (g/L): According to ADEVA, the P values corresponding to factor B (type of antioxidant) show statistical significance, indicating that the types of antioxidants influence the acidity of bananas subjected to different treatments. Similarly, the P value for factor C (type of antioxidant) indicates that the antioxidant amount influences the acidity of bananas subjected to different treatments (Table-3).

After the comparison of mediums, the T5 treatment was considered the optimum for studying the antioxidant agents of bananas. When 15 mg/Kg of citric acid was applied to Maqueño banana, the product characteristics can be preserved according to the minimum quality parameters.

TABLE-3
ANALYSIS OF VARIANCE FOR THE EXPERIMENTAL ACIDITY RESPONSE

Variation source	Df	Sum of squares	Middle squares	Reason-F	Value-P
Factor A: Variety banana	1	0.000015210	0.0000152	127.18	0.9860
Factor B: Type of antioxidant	1	0.000002668	0.0000026	22.31	0.0437*
Factor C: Quantity antioxidant	2	0.000004461	0.0000022	18.65	0.0012**
Repetitions	2	0.000001102	0.0000005	4.610	0.0613
Interaction AB	1	0.000006760	0.0000068	56.52	0.0719
Interaction AC	2	0.000006132	0.0000031	25.63	0.0534
Interaction BC	2	0.000000987	0.0000004	4.130	0.0830
Interaction ABC	2	0.000010232	0.0000051	42.78	1.3210
Residue	22	0.000002631	0.0000001	–	–
Total	35	0.000050182	–	–	–

*Significant difference; **Highly significant difference

TABLE-4
ANALYSIS OF VARIANCE FOR THE EXPERIMENTAL RESPONSE DEGREES BRIX

Variation source	Df	Sum of squares	Middle squares	Reason-F	Value-P
Factor A: Variety banana	1	0.029469	0.029469	2.76	0.0106*
Factor B: Type of antioxidant	1	0.114469	0.114469	10.74	0.1400
Factor C: Quantity antioxidant	2	0.283172	0.141586	13.28	0.2620
Repetitions	2	0.107639	0.053819	5.05	0.0571
Interaction AB	1	0.107803	0.107803	10.11	0.436
Interaction AC	2	0.110872	0.055436	5.20	0.1420
Interaction BC	2	0.027539	0.013769	1.29	0.2949
Interaction ABC	2	0.011506	0.005753	0.54	0.5905
Residue	22	0.234561	0.010662	–	–
Total	35	1.027030	–	–	–

*Significant difference

TABLE-5
ANALYSIS OF VARIANCE FOR THE EXPERIMENTAL ENZYMATIC BROWNING RESPONSE

Variation source	Df	Sum of squares	Middle squares	Reason-F	Value-P
Factor A: Variety banana	1	0.0087111	0.00871111	6.11	0.0217*
Factor B: Type of antioxidant	1	0.0036401	0.00364011	2.55	0.1243
Factor C: Quantity antioxidant	2	0.0064607	0.00323036	2.27	0.1274
Repetitions	2	0.0028050	0.00140253	0.98	0.3898
Interaction AB	1	0.0071684	0.00716844	5.03	0.3530
Interaction AC	2	0.0056990	0.00284953	2.00	0.1594
Interaction BC	2	0.0159011	0.00795053	5.58	0.1100
Interaction ABC	2	0.0084893	0.00424469	2.98	0.0717
Residue	22	0.0313649	0.00142568	–	–
Total	35	0.0902399	–	–	–

*Significant difference

Determination of Brix degree: The P values of factor A (banana variety) exhibits a significant variation over the Brix degrees with the 95% confidence level. This finding indicates that the two types of bananas have different sugar concentrations, which affects their Brix degrees during different treatments. From the mean comparison, the T5 treatment is optimum for antioxidant agents present in Maqueño and Dominico bananas. The application of citric acid (15 mg/Kg) to Maqueño bananas preserves the product characteristics, satisfying the established the minimum quality parameters in relation to Brix degrees (Table-4).

Determination of enzymatic browning: A statistical difference exists in enzymatic browning at the confidence level of 95% because the P value of A (0.0217) is < 0.05. This result shows that the both types of bananas (dominico and maqueño) affect enzymatic browning. The mean comparison results showed that the optimum treatment was T5 with the code a1b1c2, which corresponds to banana + citric acid + 15 mg/kg (Table-5). To obtain an enzymatic browning value of 0.0914, the enzymatic browning of a product must be 0.0910-0.0925, as reported by Morales *et al*. [10].

Microbiological studies: The study was performed at 36 experimental units, considering day 3 and 6 of treatment as reference (Table-6).

TABLE-6
ANALYSIS OF MOLDS AND YEASTS CARRIED OUT ON THE BANANAS EVALUATED ON DAY 3 OF TREATMENT

Treatment	Code	3 days	6 days	Unit	Rank
1	a1b1c1	< 10	< 10	CFU	
2	a1b1c2	< 10	25	CFU	
3	a1b1c3	< 10	364	CFU	
4	a2b1c1	< 10	348	CFU	
5	a2b1c2	< 10	102	CFU	
6	a2b1c3	< 10	205	CFU	2X102 CFU
7	a1b2c1	< 10	47	CFU	
8	a1b2c2	< 10	22	CFU	
9	a1b2c3	< 10	35	CFU	
10	a2b2c1	< 10	75	CFU	
11	a2b2c2	< 10	< 10	CFU	
12	a2b2c3	< 10	25	CFU	

The Ecuadorian technical standard NTE INEN 1529-10 presents the minimum criterion for parameters, which must be obeyed by food products. Bananas satisfy this requirement; therefore, in relation to yeasts and moulds, the colony-forming units (CFU) limit is 2×10^2 CFU. The results acquired after 6 days of the treatment indicated that microbiological parameters for all 36 experimental units showed variations because the evaluated samples have variable microbiological levels. For the optimum T5 treatment, no contamination was observed because the values presented were within the established range of 2×10^2 CFU. The observed values were 53, 102 and 148 CFU.

Conclusion

The antioxidant agents exhibited a catalytic impact of browning reactions in bananas, thus preventing effects, including rancidity, discoloration and nutrient loss. Among the studied varities of Banana, Maqueño (*Musa balbisiana*

L.) is better than then Dominico (*Musa sapientum* L.), since it better preserve the physical, microbiological, chemical, and sensory characteristics, moreover, citric acid is the best antioxidant as compared to ascorbic acid.

ACKNOWLEDGEMENTS

The authors thank Universidad Estatal de Bolívar for the financing of this project.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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