Original Research Paper Engineering

Evaluation of two types of antioxidants in the process of obtaining flours of tropical fruits *Ananas comosus* (Pineapple), *Musa paradisiaca* (bananas), *Mangifera indica* L. (handle), for agro-industrial use

Jose Vicente Villarroel Bastidas Faculty of Engineering Sciences, State Technical University of Quevedo (UTEQ), Quevedo, Rivers EC.120501, Ecuador

Sandro Darío Guerra Faculty of Engineering Sciences, State Technical University of Quevedo (UTEQ), Quevedo, Rivers EC.120501, Ecuador

Lui Gabriel Pico Saltos Faculty of Engineering Sciences, State Technical University of Quevedo (UTEQ), Quevedo, Rivers EC.120501, Ecuador

Leonardo Arturo Baque Mite Faculty of Engineering Sciences, State Technical University of Quevedo (UTEQ), Quevedo, Rivers EC.120501, Ecuador

Luciana Coello León Faculty of Engineering Sciences, State Technical University of Quevedo (UTEQ), Quevedo, Rivers EC.120501, Ecuador

ABSTRACT *This research attempts to obtain flour fruits Ananas comosus (Pineapple), Musa paradisiaca (Williams banana), Mangifera indica L. (handle Tommy) that meet or resemble the requirements of flour for human consumption established by the standard INEN, through the application of antioxidants (ascorbic acid and citric acid), and different temperatures of dehydration (65°C and 70°C). Was raised as an objective: to evaluate the types of antioxidants in the process of obtaining flours of tropical fruits Ananas comosus (Pineapple), Musa paradisiaca (Williams banana), Mangifera indica L. (handle Tommy). In addition establecercuál of antioxidants ascorbic acid 0.07% and citric acid 0.2% controls the oxidation in the conservation of the meal, and establish at what temperature 65°C and 70°C is adequate in the dehydration of the fruit. In this investigation was applied a factorial design randomized complete blocks AxBxC which corresponds to twelve treatments with two replicas gives a total of twenty-four treatments. The studied factors were: as a factor to (types of antioxidants, factor B (temperatures of dehydration) and C factor (types of fruit). For the trials were selected fruits , proceeded to washing, peeled and chopped the same in slices to then be immersed in solutions of (0.07% of ascorbic acid 0.07% Sodium metabisulphite) and (0.2% citric acid and 0.07% Sodium metabisulphite) during fifteen minutes, and then proceed to dehydrate at temperatures of 65°C and 70°C, once the dehydration of dried fruits were sprayed, to determine the effects that produce the twenty-four treatments the following variables were evaluated: pH, °Brix, acidity, humidity, ashes, microbiological analysis (molds and yeasts and total coliforms). The results indicate that the banana immersed in citric acid and dehydrated at 70°C reflected a flour with better results.*

KEYWORDS : oxidation, dehydration, temperatures, humidity.

Introduction

The consumption of tropical fruits and derived products is of great importance for human health in accordance with the latest reports of the World Health Organization, due to the contribution of nutritional compounds and non-nutritive (F. Millan & Ramirez, 2012). There is at present a large amount of raw material of rejection, which subjected to an agro-industrial processing this has led to the realization of this research with the aim to obtain a value added of fruits such as bananas, pineapple and mango, since they are the fruits of increased production in the area of influence of the State Technical University of Quevedo.

These tropical fruits due to their high fiber content will be assessed through the process of elaboration of flour, subjecting them to different times and temperatures of dehydration, applying different antioxidants and a preservative to prevent the enzymatic browning of the product and thus obtain the flour of better physical, chemical and microbiological.

Some products that have been obtained after the industrial processing of fruits have been classified as sources of fiber, it has been confirmed that the presence of fiber in fruits and vegetables has positive effects of great importance in health by virtue of its properties (Ramírez & Pacheco de Delahaye, 2009).

The dehydration or drying of the fruits are to eliminate the majority of water contained in these, eliminating a part of the water, which prevents the development of microorganisms (Eligio, Guerra, & Sauri, 2014). The purpose of this research project is to obtain a quality product that meets the requirements of flour, taking as a reference the quality parameters of the rules INEN of flours.

Materials and Methods

The physical and chemical analyzes were performed with the materials and equipment available in the Laboratory of Chemistry and the Biotechnology Laboratory of the State Technical University of Quevedo (79º 28' 30" West, 1 6' S). A factorial design was randomized complete blocks (ABC) as a factor in (types of antioxidants, factor B (temperatures of dehydration) and C factor (types of fruit). For this research were used fruits like pineapple, banana and the handle of the city of Quevedo. Altitude: 74 m.a.s.l. Length: 79° 27'00" or Latitude: 1°02' 00" S

Average temperature: 20 to 35 °C that belongs to the province of the rivers. The analyzes were carried out in duplicate in each treatment.

Process of obtaining of flour of tropical fruits

Collected the different types of fresh fruit (pineapple, banana and mango) in the same state of maturity, for a correct selection of fruits are found their physico-chemical features, the same should not present mechanical damage., washed fruits in order to eliminate any impurities, peeling is performed manually moving the bark and the seeds for the pulp, the pulp of the fruit was the cut in slices, to

ease the process of dehydrated, this immersion was conducted in solutions of (0.07% of ascorbic acid and 0.07% Sodium metabisulphite) and (0.2% citric acid and 0.07% Sodium metabisulphite) during 15 minutes with The order to avoid the enzymatic browning and the development of micro-organisms (bacteria, molds and yeast) in the final product,

The pulps were dehydrated at temperatures of 65°C and 70°C in order to extract the greatest amountd of water, is spray for smaller particles, forming the flour, was stored in airtight covers of plastic in a cool and dry environment to prevent moisture from entering the environment toward the product.

Physicochemical and microbiological analyzes

The pH is a measure that expresses the degree of acidity or alkalinity in a food remain vital to control bacterial growth pH values in food goes from 1 and 14, is considered to be the value 7 as pH neutral if this level is above is known as alkaline, taking into consideration that the majority of pathogenic microorganisms grow between a pH of 5 and 8 [5]. The Brix measure the total percentage of sucrose present in a food, a solution of 25 °Brix contains 25 grams of sucrose per 100 grams of liquid, in other words there are 25 grams of sucrose and 75 grams of water in the 100 grams of a solution [6]. The titratable acidity is an indicator that expresses the total content of free acids in an array, the same that is expressed as the percentage of the predominant acid of the matrix [7]. The determination of moisture is one of the most important techniques with greater use in the processing, control and conservation of the food, since most of the food products have a majority content of water [8]. The ashes are a analytical term that is equivalent to the inorganic residue that remains after ash organic matter, usually are not the same inorganic substances present in the original food, due to losses by volatilization or to the chemical interactions between the constituent [9]. The fungi and yeasts are widely distributed in the environment can be found as normal flora of a food, or as contaminants in equipment bad sanitized some species of fungi and yeasts are useful in the preparation of some food, but they can also be the cause of the breakdown of other food [10].

Statistical Analysis

For the analysis of data is carried out trials for normality and homogeneity of variance using the Kolmogorov-Smirnov tests and Levene, respectively. An ANOVA was used to determine statistical differences between the variables measured in the experiment. Finally performed the test post hoc comparison of multiple ranges Tukey HDS. Set a level of significance of $p < 0.5$. Statistical analyzes were performed with the statistical program StatGraphics v. 16.1.

Results and Discussion

Types of antioxidants (ascorbic acid and citric acid)

In regard to the factor to (types of antioxidants) were determined values of pH 4,30 (a_0) (ascorbic acid), to 4.14 () (citric acid)a_1, these values are below (5,820 ± 0.150) reported by (Marcano & Salazar de Marcano, 2011) In his study The Yam Flour *(Dioscorea alata)*, a potential ingredient in the elaboration of bakery products, due to two factors that intervene in the lowering of the pH the first by the type of fruit and the second the antioxidant that applied in this case as referred to at the beginning of the discussion.

In regard to °Brix values were observed (a_0) (ascorbic acid), 7.53 () (citric acid) 7.35 which are below (a_18.9±0.7) that makes reference (Guzmán, Calandri, Orrabalis, & Gorostegui, 2013) In his study functional parameters and glucose content in flours obtained from ripe fruit of "chañar" *(Geoffroea decorticans)* of the arid and semi-arid zone of the province of Formosa, the difference is between the two investigations by acids applied that it took fruits in state semimaduras the same that have lower values of °Brix before reaching its final state of maturation.

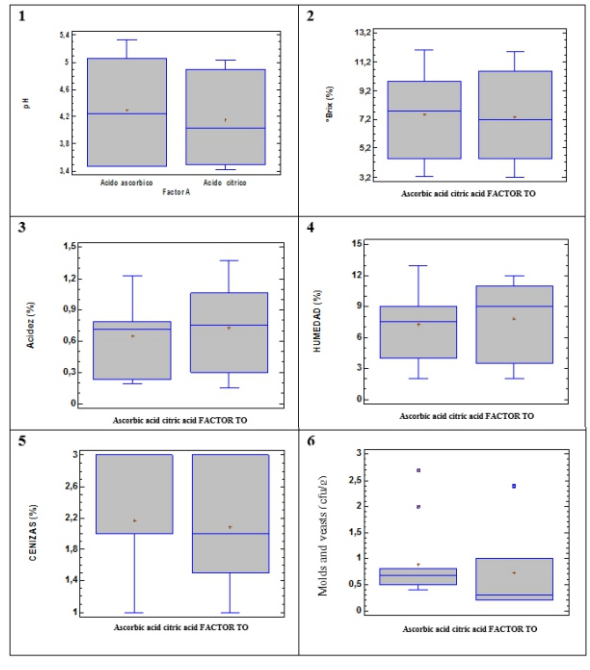
In regard to the acidity values were of (a_0) (ascorbic acid), 0.65 () (citric acid) 0.73 which () is lower and () higher than (a_1 a_0 a_1 0,676 ± 0.031), values exposed by (Marcano & Salazar de Marcano, 2011) In its investigation the yam flour (Dioscorea alata), a potential ingredient in the elaboration of bakery products, the difference that presents the values of acidity is given because the flour in the research cited used a tuber by which has a different percentage of acidity of a tropical fruit.

With regard to the Moisture values were obtained of 7.25 (a_0) (ascorbic acid) to 7.83 () (citric acid) These are less (14.06) exposed by a_1 (Ramirez & Villa, 2015) In his study obtaining squash flour by the drying process of food, to get similar values in the moisture content of the flour indicates that the implementation of the two antioxidants helped to inhibit the enzymatic browning and therefore the moisture.

In which corresponds to Ashes EC gave values of 2.16 (a_0) (ascorbic acid) to 2.08 () (citric acid), these are above a_1(1.509 ± 0.038) reported by (Marcano & Salazar de Marcano, 2011), in its study The Yam Flour (Dioscorea alata), a potential ingredient in the elaboration of bakery products, this is due to the larger number of minerals are present in the fruits that were used in this research.

For microbiological analyzes in molds and yeasts were obtained 0,894 values (a_0) (ascorbic acid) to 0,730 () (citric acid) These values are below () established by $a_1 5 \times 10^2$ *UFC/g* (NTE INEN 0616, 2006), wheat flour requirements, the presence of molds and yeasts could be given due to the pH of the flours as these are able to grow in lower pH values to those who can grow other microorganisms.

Graph No. 1: Results of the mean difference between ascorbic acid and citric acid of the significance test Tukey ($p<0.05$). 1.- pH (DS); 2.- °Brix (DS); 3.- Acidity (DS); 4.- Moisture (DS); 5.- Ash; 6.- molds and yeasts (DS).



Temperatures of dehydration (65°C and 70°C)

With regard to factor B (temperatures of dehydration) were determined pH values 4.24 (b_0) (65°C), to 4.20 () (70°C) b_1These values are below 5.32 reported by (Hernández & Blanco, 2015) In his study Evaluation of carrot powders obtained by dehydration by forced air at different temperatures, the temperatures applied in the dehydration process influenced the pH of the flour because there was a decrease of water.

In regard to the degrees Brix values were observed of 8.33 (b_0) (65°C), 6.55 () (70°C), which are below (b_1 8.9±0.7) reported by (Guzmán, Calandri, Orrabalis, & Gorostegui, 2013) In his study

functional parameters and glucose content in flours obtained from ripe fruit of "chañar" *(Geoffroea decorticans)* of the arid and semi-arid zone of the province of Formosa, this is due to the temperature of dehydration they were subjected to the fruits which produced concentration of sugars.

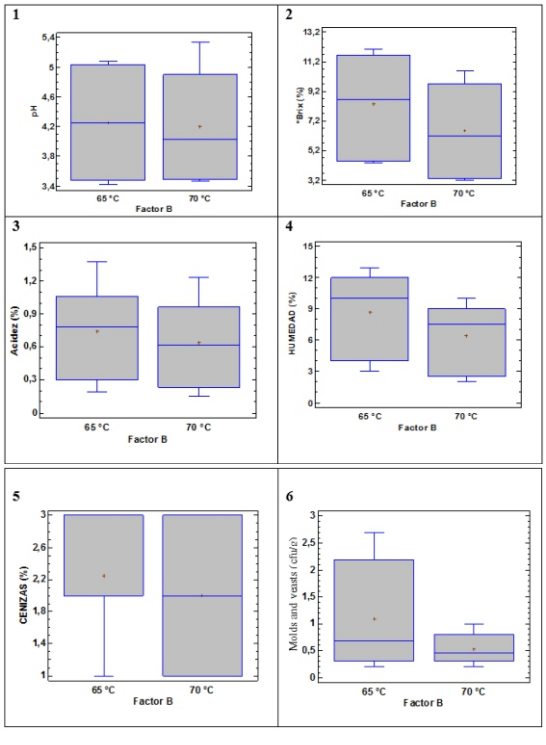
With regard to the acidity was appreciated values of 0.74 (b_0) (65°C), to 0.63 () (70°C), in which () presented higher values and () values below (b_1 b_0 b_1 0,676 ± 0.031) exposed by (Marcano & Salazar de Marcano, 2011) In its investigation the yam flour *(Dioscorea alata)*, a potential ingredient in the elaboration of bakery products, could be this difference due to the variation of temperatures so that there is less moisture at 70°C, the same as that obtained a percentage of heartburn more low.

With regard to moisture is showed the values of 8.66 (b_0) (65°C), 6.41 () (70°C), $b_1$which are below 10.65 reported by (Hernández & Blanco, 2015) In his study Evaluation of carrot powders obtained by dehydration by forced air at different temperatures, were presented percentages of moisture minors by the temperatures were higher than those used in the research cited.

With regard to ashes showed values of 2.25 (b_0) (65°C), to 2.0 () (70°C), $b_1$these values are below (2.74) of the Reported By (Ramirez & Villa, 2015) In his study obtaining squash flour by the drying process of food, these values are an important factor since it by the fact of being a little flour refined has greater contribution of minerals.

In the microbiological analyzes molds and yeasts were obtained values of 1.09 (b_0) (65°C), to 0.53 () (70°C), these are below () established by b_1 5 x 10^2 *UFC/g* (NTE INEN 0616, 2006), wheat flour requirements, these temperatures helped favorably in the obtaining of flour because there is not a further proliferation of molds and yeasts.

Graph No. 2: Results of the mean difference between 65°C and 70°C in the significance test of Tukey (p<0.05). 1.- pH (DS); 2.- °Brix (DS); 3.- Acidity (DS); 4.- Moisture (DS); 5.- Ash(DS); 6.- molds and yeasts (DS).



Types of fruits (pineapple, banana and mango)

With regard to the C factor (types of fruit) were determined values of pH 4,13 (c_0) (Pineapple), 5.08 () (bananas) and $c_1$3.45 (c_2) (Handle) These values are below (5,820 ± 0.150) reported by (Marcano & Salazar de Marcano, 2011) In his study The Yam Flour *(Dioscorea alata),* a potential ingredient in the elaboration of bakery products, is due to the fact that the flour that was obtained from fruits have a low pH which reflects to compare with another type of flour.

In regard to the °Brix values were observed in 9.98 (c_0) (Pineapple), 3.85 (c_1) (bananas) and 8.48 () (handle) which () (pineapple) is greater while () (bananas) and () (handle) are lower than (c_2 c^0 c_1 $c_2$8.9±0.7) reported by (Guzmán, Calandri, Orrabalis, & Gorostegui, 2013) In his study functional parameters and glucose content in flours obtained from ripe fruit of "chañar" *(Geoffroea decorticans)* of the arid and semi-arid zone of the province of Formosa, there was an increase in the concentration of sugars in the final product due to the dehydration process to which they were subjected the fruits.

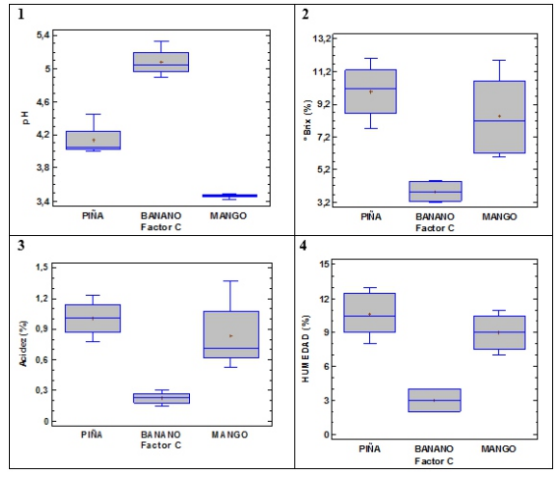
In regard to the acidity values were 1.0 (c_0) (Pineapple), 0.22 (c_1) (bananas) and 0.83 () (handle), c_2 these are higher than (0.003) reported by (Ramirez & Villa, 2015) In his study obtaining squash flour by the drying process of food, the difference is due to the fact that the percentage of acidity obtained in the research cited is low as it used a vegetable unlike tropical fruits that show a percentage of acidity higher.

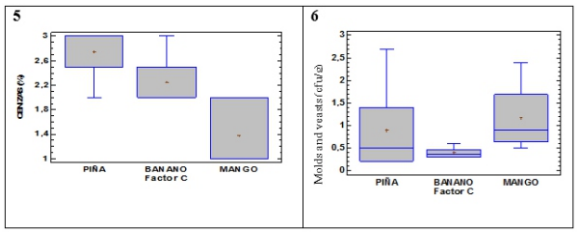
With regard to moisture is showed the values of 10.62 (c_0) (Pineapple), 3.0 (c_1) (bananas) and 9.0 (c_2) (handle), are below (10.65) reported by (Hernández & Blanco, 2015) In his study Evaluation of carrot powders obtained by dehydration by forced air at different temperatures, this difference occurs because the pineapple and mango have greater amount of water so that the moisture percentage was high in the banana to be a fruit with a large amount of fiber and little water obtained a percentage of humidity less.

With regard to ashes the values obtained were 2.75 (c_0) (Pineapple), 2.25 (c_1) (bananas) and 1.375 (c_2) (handle), which (c_2) (handle) is lower, while () (pineapple) and () (bananas) are higher than (c_0 c_1 1.509 + 0.038) reported by (Marcano & Salazar de Marcano, 2011) In his study The Yam Flour (*Dioscorea alata),* a potential ingredient in the elaboration of bakery products, flours obtained with percentages of ashes different by the contents of minerals and nutrients present in the raw materials used.

In the microbiological analyzes molds and yeasts were obtained values of 0.88 (c_0) (Pineapple), 0.38 (c_1) (bananas) and 1.16 (c_2) (handle), these are below () established by 5 x 10^2 *UFC/g* (NTE INEN 0616, 2006), wheat flour requirements, the values obtained were low due to the moisture content of the flour not allowed greater proliferation of molds and yeasts.

Graph No. 3: Results of the mean difference between the fruits, pineapple, banana and mango of the significance test of Tukey (p<0.05). 1.- pH (DS); 2.- °Brix (DS); 3.- Acidity (DS); 4.- Moisture (DS); 5.- Ash(DS); 6.- molds and yeasts (DS).





Conclusions

The concentrations of the antioxidants acted in a way favorable to the process of obtaining the flour. The temperature of dehydration that presented the best results in the process of dehydration of fruits for the obtaining of flour (70°C).

The banana is the most appropriate fruit in the elaboration of flour because it provided the best results in the studied variables (° Brix, acidity, humidity and microbiological analysis).

References

1. Arriagada, F. G. (Julio de 2007). INFOEXPLORA REGIÓN DE LA ARAUCANÍA. Obtenido de El Refactometro.
2. Becerá, S. M., Pereira, A. G., & otros, y. (2013). Evaluación de la calidad de la fruta bomba (Carica papaya L.) variedad Maradol roja deshidratada utilizando el método de deshidratación osmótica (DO). Revista Ciencias Técnicas Agropecuarias.
3. Botero V., M. L., Ricaurte A., S. C., Monsalve G., C. E., & Rojano, B. (Abril de 2007). Capacidad reductora de 15 frutas tropicales. Redalyc, XIII(33), 295.
4. Cafaro, T. A., & Serra, H. M. (2007). Ácido ascórbico: desde la química hasta su crucial función protectiva en ojo. Acta Bioquímica Clínica Latinoamericana, 41(4).
5. Camacho, A., M.Giles, A.Ortegón, M.Palao, & O.Velázquez., B. y. (2009). Técnicas para el Análisis Microbiológico de Alimentos. Obtenido de Método para la cuenta de mohos y levaduras en alimentos.
6. Chavarrías, M. (2013). El pH de los alimentos y la seguridad alimentaria.
7. Eligio, M. V., Guerra, C. P., & Sauri, M. E. (27 de Junio de 2014). Elaboración de Polvos a Base de Frutas Aromáticas para su Aplicación en la Panifi cación. Faculatad Nacional De Agronomia Medellín, 67(2), 257.
8. Elmadfa, I., Muskat, E., & Fritzsche, D. (2009). Tabla de Aditivos Los Números E. . Barcelona, España : Hispanno Europea S.A.
9. F. Millan, & Ramirez, J. (13 de 07 de 2012). Diseño de un texturizado multisápido a base de frutas tropicales y biopolímeros de algas. Dialnet, 12(2), 189.
10. Fernández, H. Z. (2004). Análisis Químico de los Alimentos. Obtenido de Instituto de Farmacia y Alimentos Universidad de La Habana .
11. Goyenola, G. (junio de 2007). Guía para la utilización de las Valijas Viajeras. Obtenido de Red de Monitoreo Ambiental Participativo de Sistemas Acuáticos RED MASPA.
12. Guzmán, C., Calandri, E., Orrabalis, C. J., & Gorostegui, H. (2013). Parámetros funcionales y contenido de glucosa en harinas obtenidas de fruto maduro de "chañar" (Geoffroea decorticans) de la zona semiárida y árida de la provincia de Formosa. Redalyc(22).
13. Hernandez, A. G. (2010). Tratado de Nutrición: Composición y Calidad Nutritiva de los Alimentos (Vol. 2). Médica Panamericana.
14. Hernández, R. R., & Blanco, G. D. (2015). Evaluación de polvos de zanahoria obtenidos por deshidratación por aire forzado a diferentes temperaturas. Scielo, 33(4).
15. Laneri, J. L., & Casas, R. (2001). MANUAL DE PROCEDIMIENTOS PARA EL CONTROL MICROBIOLOGICO DE ALIMENTOS. Asunción , Paraguay.
16. Marcano, M., & Salazar de Marcano, E. (2011). LA HARINA DE ÑAME (Dioscorea alata), UN INGREDIENTE POTENCIAL EN LA ELABORACIÓN DE PRODUCTOS DE PANADERÍA. Redalyc.org, 23(2).
17. Maupoey, P., Díaz, M., & et all. (2001). Utilización de técnicas combinadas de deshidratación en la preparación de nuevos productos de frutas. Dialnet (Alimentaria: Revista de tecnología e higiene de los alimentos)(320).
18. Montoya, C. G., Ospina, C. O., Mesa, N. S., Cano, C. M., Arias, M. L., García, P. G., … Rojano, B. (2009). Actividad antioxidante e inhibición de la peroxidación lipídica de extractos. Redayc, 8(6), 520.
19. Moreno, M., & et al, .. (2007). Efecto del ácido cítrico sobre la madurez del tomate de árbol. Revista de la Facultad de Agronomía, 24(2).
20. NTE INEN 0616. (2006). Harina de trigo. Requisitos.
21. Nucci, L. S. (24 de abril de 2013). Análisis de prefactibilidad para el procesamiento de frutas tropicales en el Atlántico. Economicas CUC, 34(1), 155.
22. Orberá, R. T. (jul-sep de 2004). Acción perjudicial de las levaduras sobre los alimentos. Revista Cubana de Salud Pública, 30(3).
23. Ospina, I. D. (11 de 2010). Ficha Tecnica Metabisulfito De Sodio Grado Alimenticio. Medellin - Colombia.
24. Pelaes, J. M. (2013). HARINAS Y DERIVADOS, FECULAS Y ALMIDONES. Innovacion y Experiencias Educativas(60).
25. Pereira, A. G., & et al. (2013). Análisis comparativo de la cinética de deshidratación Osmótica y por Flujo de Aire Caliente de la Piña (Ananas Comosus, variedad Cayena lisa). Revista Ciencias Técnicas Agropecuarias, 22(1).
26. Pereira, A. G., Becerá, S. M., Gómez, A. H., Lázaro, M. G., & Valdés, D. F. (2013). Análisis comparativo de la cinética de deshidratación Osmótica y por Flujo de Aire Caliente de la Piña (Ananas Comosus, variedad Cayena lisa). Revista Ciencias Técnicas Agropecuarias, 22(1). Obtenido de http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2071-00542013000100011&lng=es&tlng=es.
27. Péres, C. (2011). Plátano: beneficios y propiedades. Natursan.
28. Proecuador. (Julio de 2011). Perfil de fruta tropicales frescas y procesadas en Chile. Inteligencia Comercial e Inversiones, 1.
29. Ramírez, A., & Pacheco de Delahaye, E. (Abril de 2009). PROPIEDADES FUNCIONALES DE HARINAS ALTAS EN FIBRA DIETÉTICA OBTENIDAS DE PIÑA, GUAYABA Y GUANÁBANA. Redalyc , 34(4), 293.
30. Ramirez, R. E., & Villa, Q. A. (Mayo de 2015). Obtención de harina de zapallo por el proceso de secado de alimentos. SCielo, 5(9).
31. Rastian, Z., Mehranian, M., Vahabzadeh, F., & Sartavi, K. (Diciembre de 2007). Antioxidant activity of extract from a brown alga, Sargassum boveanum. African Journal of Biotechnology, 6 (24).
32. Roberto, R. C., Antolín, Y. D., & Aurelio, L. S. (2012). Estudio de rendimiento de harina de lúcuma a partir del fruto fresco. redalyc.org, 15(1).
33. Robledo, J. D. (2004). descubre los Frutos Exoticos. Madrid: ediciones Norma, Parque Europolis, V 16B, 28230 Las Rozas (Madrid).
34. Sánchez, J. E., Ortiz, M. I., Aguilar, Á. R., & Aguilar, R. G. (2015). ELABORACIÓN DE HARINA A BASE DE LA CORTEZA DE MELÓN Y SANDÍA. Revista cientfica Horizonte empresarial, 2(1).
35. Sinchi, I. A. (2008). Colombia: frutas de la Amazonia. (D. P. Rodríguez, Ed.)
36. Torres-González, M. P., Jiménez-Munguía, M. T., & Bárcenas-Pozos. (2014). Harinas de frutas y/o leguminosas. Departamento de Ingeniería Química, Alimentos y Ambiental, Universidad de las Américas Puebla.
37. UNAM. (2007). FUNDAMENTOS Y TECNICAS DE ANALISIS DE ALIMENTOS .
38. Valencia, L. (2012). DETERMINACIÓN DE ACIDEZ TOTAL EN PRODUCTOS DE FRUTAS Método potenciométrico Sección Química de Alimentos y Nutrición.
39. Writer, C. (s.f.). eHow en español .
40. Zamora S, J. D. (Marzo de 2007). ANTIOXIDANTES: MICRONUTRIENTES EN LUCHA POR LA SALUD. Revista Chilena de nutrición, 34.