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Time and temperature for roasting breadfruit seed with couverture chocolate

Tiempo y temperatura para la torrefacción de la semilla de fruta de pan con chocolate de cobertura

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Abstract

The research was carried out at the Bromatology and Rumination Laboratory of the "La María" Experimental Farm, where the effect of varying the time and temperature of roasting breadfruit (*Artocarpus altilis*) with couverture chocolate was evaluated by means of physical-chemical, microbiological and sensory analyses. A completely randomized design with bi-factorial arrangement was used to compare the mean values. The data were performed using free software. For the physicochemical measurements pH, titratable acidity, °Brix, moisture, dry matter, ash, inorganic matter, crude fiber, total nitrogen, ethereal extract and energy, a multivariate analysis by principal components (PCA) was applied and for the sensory analysis a cluster analysis (Ward Cluster Method) was performed to structure and highlight the treatments with the best organoleptic characteristics, represented by a dendrogram. The bromatological analysis of the roasted breadfruit for the variables pH, humidity, dry matter, ash, organic matter and energy did not show statistical significance. In the sensory analysis, there was no statistical significance according to Tukey ($p \leq 0.05$), for the attributes of the breadfruit (roasted) with couverture chocolate, but T3 obtained the highest preference index with 53%.

Keywords: *Artocarpus altilis*, torrefaction, quality, feed

Resumen

La investigación se desarrolló en el Laboratorio de Bromatología y Rumiología de la Finca Experimental “La María” fueron evaluados el efecto de la variación del tiempo y temperatura de torrefacción de la fruta de pan (*Artocarpus altilis*) con chocolate de cobertura, mediante análisis físico-químicos, microbiológico y sensorial. Se empleó un diseño completamente al azar con arreglo bi factorial se utilizó para comparar los valores medios. Los datos realizaron utilizando el software libre. Para las mediciones físico-químicas pH, acidez titulable, °Brix, humedad, materia seca, cenizas, materia inorgánica, fibra bruta, nitrógeno total, extracto etéreo y energía, se aplicó un análisis multivariado por componentes principales (ACP) y para el análisis sensorial se realizó un análisis de conglomerados (Método de Ward Cluster) para estructurar y evidenciar los tratamientos con mejor características organolépticas, representado por un dendrograma. El análisis bromatológico de la fruta de pan torrefactada para las variables pH, humedad, materia seca, cenizas, materia orgánica y energía no se encontraron significancia estadística. En el análisis sensorial no existió significancia estadística según Tukey ($p \leq 0,05$), para los atributos de la fruta de pan (torrefactada) con chocolate de cobertura, pero el T3 obtuvo el mayor índice de preferencia con 53%.

Palabras clave: *Artocarpus altilis*, torrefacción, calidad, alimento

Introduction

In Ecuador, breadfruit is very abundant in warm and humid climates, and is found in home orchards in the Amazon and coastal areas, bearing fruit for long periods of the year, but its production is not exploited. The use of the fruits in human food allows obtaining food with low costs, considering that more than 70% of the fruit production of this tree is lost due to low demand. The use of promising species makes it possible to supply the food needs of the population and is also a source of commercialization. (Carrasco, 2010) .

Artocarpus altilis, commonly known as "breadfruit" or breadfruit tree, is a perennial plant native to the Pacific islands. (Campos, 2013) is a perennial plant native to the Pacific islands that moved and became naturalized in the tropical zones of the planet and is cultivated by a small number of farmers during several months of the year. (Carrasco, 2010) . It has a height ranging between 8 and 20 m, produces a fruit of 10 to 20 cm wide, is used for human or animal consumption for its richness in energy compounds, although it is poor in protein. (Valdivia & Álvarez, 2003) .

Quality evaluations carried out on fruits in the experimental field of the National Center for Agricultural Research (CENIAP), show that their average weights range between 2 and 3 kg, finding fruits of 8 kg. The proportion of the fruit at physiological maturity is approximately 59% pulp, 37% skin and 4% seeds, these measure 2 to 4 cm long and 1.25 to 2 cm wide, white and without ripples, with between 100 and 500 seeds in a single fruit, although the number of seeds varies, the weight being around 7 g (Piña *et al*, 2010).

Chocolate and its derivatives, such as coatings, are very popular due to their sensory characteristics. The transformation involves different stages, including obtaining the liquor of suitable particle size, followed by conching, which is the central point for obtaining the coating. (Bejarano & Calderón, 2006) . It is characterized by a high cocoa butter content. It can be black, milk or white. The coating is used because it is easy to handle and to make the product shiny. (Velasteguí, 2010) .

In the city of Quevedo breadfruit is normally consumed, cooked in desserts, a large part of the population is still unaware of the wide variety of food uses that can be obtained from the breadfruit seed, it is important to promote this fruit as its investment is minimal and it is also economical to grow this fruit because its production is good and its nutritional content is also good, which is why it will be characterized by physicochemical and microbiological analysis of the seed and the sensory acceptability of breadfruit (roasted) with chocolate coating.

Materials and methods

The research was carried out in the Laboratory of Bromatology and Ruminology of the Experimental Farm "La María" belonging to the Faculty of Livestock Sciences of the State Technical University of Quevedo, located at km 7 ½ of the road Quevedo - El Empalme, San Felipe, canton Mocache, province of Los Ríos. Between the geographical coordinates of 01 ° 06 ' south latitude and 79 ° 29 ' west longitude at an altitude of 120 meters above sea level with an average temperature of 25.8 °C.

Physical-chemical analysis

Table 1 shows the references of the laboratory test methods for each physicochemical variable.

Table 1. *Methods and references for physicochemical laboratory analysis. FCP - UTEQ. 2018.*

Analysis	Method - Reference
pH	Potentiometer (NMX - F - 317 - S - 1978)
Titratable acidity	Sodium hydroxide solution (NMX - F - 102 - S - 1978)
°Brix	Brixometer
Moisture or heat loss	Gravimetry (NMX - F - 083 - 1986)
Dry matter or total solids	Difference (Calculation)
Ash or inorganic matter	Gravimetry (NMX - F - 066 - S - 1978)
Organic matter	Difference (Calculation)
Crude fiber	Acid and alkaline digestion (NOM - F - 90 - S - 1978)
Total nitrogen or crude protein	Kjeldahl (NOM - F - 68 - S - 1980)

Ether extract or crude fat Acid hydrolysis (NMX - F - 427 - 1982)

Energy Calorimetry

Microbiological analysis

Table 2 shows the references of the laboratory test methods for each microbiological variable.

Table 2. *Methods and references for microbiological laboratory analysis. FCP - UTEQ. 2018.*

Analysis	Method - Reference
Mesophilic aerobes	NTE INEN 1529 - 5: 2006
Total coliforms	NTE INEN 1529 - 7: 1990
Fungi and yeasts	NTE INEN 1529 - 10: 1998

Sensory analysis

The sensory analysis was based on determining the effect of time and temperature variation in the roasting process on the main properties of breadfruit (roasted) with couverture chocolate. A descriptive test (sensory profile) and a five-level interval scale (1 slightly, 2 moderately, 3 quite a lot, 4 very much and 5 extremely) were used to measure the attributes assigned to each property. In addition, an affective test (acceptance) was applied to establish the preferred treatment by the judges.

Experimental procedure

A selection was made, observing that they were free of alterations. Subsequently, 443.2 g of breadfruit were weighed for each treatment, giving a total of 1772.8 g to be used in the research. was then rinsed with potable water in order to eliminate impurities adhering to the raw material, leaving it to drain for a few minutes on a clean, dry surface.

The breadfruit was placed in an aluminum tray and taken to the forced-air oven (Table 3). At the end of the roasting time, the aluminum tray was removed and allowed to cool to room temperature. Subsequently, they were shelled and wooden sticks were inserted into each fruit. They were kept in airtight bags for physicochemical and microbiological analysis. For sensory analysis, the covering phase was continued.

Table 3. Breadfruit roasting factors FCP - UTEQ. 2018

Time min	Temperature °C
20	160
30	180

The chocolate was melted in a stainless steel container in a water bath at 50 °C for 5 minutes, the breadfruit was submerged in the chocolate and the coating was applied, allowed to cool on an aluminum foil, and then placed in airtight bags for preservation and storage at room temperature.

Statistical analysis

A completely randomized design with a bi-factorial arrangement was used to detect differences, with four treatments, considering roasting times and temperatures, with five replications, each experimental unit will be constituted by 62 g. Tukey's test ($p \leq 0.05$), (Pedroza *et al.*, 2016), was used to compare the mean values. The data performed using free software.

For the physicochemical measurements pH, titratable acidity, °Brix, moisture, dry matter, ash, inorganic matter, crude fiber, total nitrogen, ethereal extract and energy, a multivariate analysis by principal components (PCA) was applied, which allowed comparing the interdependence of metric variables and evidencing the adequate graphic representation of the variability of the data in a table of n observations and p columns or variables.

For the sensory analysis, a cluster analysis (Ward Cluster Method) was performed to structure and highlight the treatments with the best organoleptic characteristics, represented by a dendrogram corresponding to the grouping according to their differences or similarities.

Result

Physicochemical analysis of breadfruit

Table 4 shows the values recorded in the bromatological analysis of breadfruit, which correspond to;

Table 4. Bromatological analysis values of breadfruit. FCP - UTEQ. 2018.

Parameters	Breadfruit
pH	6,02
Titratable acidity	0,35%
°Brix	
Moisture or heat loss	69,05%
Dry matter or total solids	30,95%

Ash or inorganic matter	3,38%
Organic matter	96,62%
Crude fiber	4,50%
Total nitrogen or crude protein	9,60%
Crude fat or ether extract	11,75%
Energy	255.25 kcal/100 g

Physicochemical analysis of roasted breadfruit

In the ANDEVA analysis of the pH variable of the roasted breadfruit (Table 5), there was no statistical significance for the effect of the interactions between the time and temperature factors. T1 and T2 presented differences with mean values of 6.57 and 6.56, respectively, compared to T3 and T4 with mean values of 6.44 and 6.45. According to Riaño (2013), in the effect of the humidity of raw coffee on the properties of roasted coffee, he reports a pH value of 4.95, which is lower than those found in this research. Meanwhile Bonilla (2014), in the evaluation of roasting and development of milk chocolate from cocoa (*Theobroma cacao L.*) Trinitario variety, shows values between 5.03 and 5.27 pH, being lower than those recorded, which may be due to the composition of cocoa beans versus breadfruit.

Table 5. Effects of time and temperature interactions on physicochemical analyses FCP - UTEQ, 2018

	pH (H+)	Acidez titulable (%)	°Brix (%)	Humedad o pérdida por calentamiento (%)	Materia seca o sólidos totales (%)	Cenizas o materia inorgánica (%)	Materia orgánica (%)	Fibra bruta (%)	Nitrógeno total o proteína bruta (%)	Extracto etéreo o grasa bruta (%)	Energía (kcal/100 g)
Interacciones A*B: Tiempo por temperatura											
T1 (20 min / 160 °C)	6,57 b	0,33 b	2,16 d	54,24 b	45,76 a	1,21 a	98,78 a	1,57 a	9,60 a	2,55 b	4121,91 a
T2 (20 min / 180 °C)	6,56 b	0,27 a	1,42 b	53,13 b	46,87 a	1,26 a	98,74 a	2,46 b	11,23 b	2,44 ab	4174,04 a
T3 (30 min / 160 °C)	6,44 a	0,26 a	1,16 a	53,16 b	46,84 a	1,22 a	98,78 a	2,31 b	13,02 d	2,32 a	4749,43 b
T4 (30 min / 180 °C)	6,45 a	0,35 c	1,66 c	51,11 a	48,89 b	1,26 a	98,74 a	1,57 a	12,16 c	2,82 c	4785,87 b
Promedio	6,51	0,3	1,6	52,91	47,09	1,24	98,76	1,98	11,5	2,54	4457,81
C.V. (%)	0,64	3,52	3,95	2,03	2,28	5,18	0,06	7,55	0,25	3,41	1,55

In the ANDEVA analysis of the variable titratable acidity of the roasted breadfruit (Table 5), <statistical significance was found for the effect of the interactions between the time and temperature factors. The highest titratable acidity rating was obtained for T4 with 0.35%, while the lowest rating was for T3 with 0.26%. According to Castaño & Torres (1997), in the characterization of roasted coffee from coffee perforated by CBB, they obtained titratable acidity values in a range between 0.81 and 1.1%, being higher than those recorded in the research.

Alegría (2015), in the evaluation of treatments prior to the cocoa bean roasting process for the design of the cocoa paste (*Theobroma cacao* L.) production area, recorded values that fluctuated between 8.91 and 5.10 meq/100 g, being higher than those obtained in the present study. It is also indicated that titratable acidity measures the content of organic acids, while pH determines the ions that are present in the solution and therefore may or may not be related to each other.

Buenaventura & Castaño (2002), in the study of the influence of altitude on the beverage quality of coffee samples of ecotype 206B in Colombia, obtained values that were in a range between 2.05 and 2.35%, being a little high, due to the fact that they followed patterns established by the Cenicafe cupping panel and not those corresponding to very light roasting and medium grinding, these values being higher than those registered in the present investigation, but with the exception of T1.

On the other hand, the average values obtained in the present investigation are close to those of (Castaño & Torres, 1997) in the characterization of roasted coffee from coffee perforated by borer, who registered a value of 1.78% of °Brix.

In the ANDEVA analysis of the roasted breadfruit moisture variable (Table 5), no statistical significance was observed for the effect of the interactions between the time and temperature factors. However, T4 showed a difference with an average value of 51.11%, compared to T1, T2 and T3 with mean values of 54.24, 53.13 and 53.16%, respectively. The highest moisture value was obtained by T1 with 54.24%, while the lowest value was for T4 with 51.11%.

These values differ from the results of Sánchez *et al* (2007), in the study of the hydrodynamics of coffee (*Coffea arabica* L.) in a fluidized bed, who recorded values that ranged between 1.68 and 2.60% moisture, also indicating that the moisture of the bean is lost in the first minutes of the roasting process, and it may be that the loss of moisture is governed by internal conditions of the bean, because it is only a matter of time and temperature rather than air speed. Corroborating with Riaño (2013).

According to Tukey ($p > 0.05$) for the dry matter variable (Table 5), no statistical significance was observed for the effect of the interactions between the time and temperature factors. However, T4 presented the highest average with 48.89%, compared to T1, T2 and T3 with values of 45.76, 46.87 and 46.84% respectively, with an overall mean of 47.09% and a coefficient of variation of 2.28%.

According to Bratschi *et al*, (2012), in the chemical characterization of soybean grain subjected to different deactivation treatments 2: roasting effect, they recorded a range between 94.1 and 94.6% of dry matter, being higher values than those shown in the present research. Furthermore, they do not coincide with those of Lon-Wo *et al*. (2002) in the study of extrusion, roasting or sun-drying of legume grains, who obtained values of 90.53 and 94.32% dry matter for mucuna and canavalia, respectively.

In the analysis of variance for ash (Table 5), no statistical significance was determined for the effect of the interactions between time and temperature. All treatments were equal with averages of 1.21, 1.26, 1.22 and 1.26%, respectively. The highest ash value was obtained by

T4 with 1.26%, while the lowest value was obtained by T1 with 1.21%, an overall mean of 1.24% and a coefficient of variation of 5.18%.

These values are lower than those obtained by Álvarez *et al.*, (2007), in the physical and chemical characterization of fermented, dried and roasted (150 °C for 30 minutes) cocoa beans grown in the region of Cuyagua, Aragua State, who recorded values between 2.86 and 3.32% ash. Coinciding with the findings of Alves *et al.*, (2008), on the in vitro iron availability of soybeans roasted by different treatments, who obtained between 4.44 and 4.81% ash.

According to Tukey ($p \geq 0.05$) of organic matter of roasted breadfruit (Table 5), there was no statistical significance for the effect of interactions between time and temperature. All treatments were equal with mean values of 98.78, 98.74, 98.78 and 98.74%, respectively. The highest valuation of organic matter was recorded for T1 and T3 with 98.78%, while the lowest valuation was for T2 and T4 with 98.74%, an overall mean of 98.76% and a coefficient of variation of 0.06%.

According to Chávez *et al.*, (2000) in the incidence of roasting on the nutritional value of supplemented germinated and non-germinated flours, they recorded a content of 98.07 and 98.16% organic matter in roasted barley and lentils, respectively, which are lower than those determined in the present investigation.

In agreement with Lares *et al.*, (2012), in the study of the effect of roasting on the physical and physicochemical properties, proximal composition and fatty acid profile of cocoa bean butter from the state of Miranda - Venezuela, who obtained a content of 97.04 and 96.94% organic matter, which were lower than those recorded in the experimental research.

In the ANOVA-1 for crude fiber of roasted breadfruit (Table 5), statistical significance was determined for the effect of the interactions between time and temperature. T1 and T4 showed differences with averages of 1.57%, compared to T2 and T3 with values of 2.46 and 2.31%, respectively. The highest crude fiber value was recorded by T2 with 2.46%, while the lowest value was shared by T1 and T4 with 1.57%, an overall average of 1.98% and a coefficient of variation of 7.55%.

Quintero *et al.*, (2014) in the characterization of a toasted tortilla made with corn (*Zea mays*) and seaweed (*Ulva clathrata*) as a prospective functional food, obtained a content of 3.4%, constituting a good source of soluble fiber and carotenoids, but defying the value recorded in the research.

According to Díaz (2014) in the study of the effects of altitude on the quality of roasted coffee (*Coffea arabica* L.) produced in the municipalities of Buesaco and La Unión - Nariño, belonging to Ecotope E - 220 A, he obtained a range of values less than or equal to unity, leaving the factorial structure of the respective analysis, being lower than those recorded in the experiment.

In the ANDEVA analysis of the total nitrogen variable of the roasted breadfruit (Table 5), statistical significance was indicated for the effect of the interactions between the time and temperature factors. The highest total nitrogen value was obtained by T3 with 13.02%, while

the lowest value was obtained by T1 with 9.60%, an overall mean of 11.50% and a coefficient of variation of 0.25%.

According to Lon - Wo *et al*, (2002) in the study of extrusion, roasting or sun-drying of tropical legume grains. Technical note, they recorded values of 25.52 and 26.78% for mucuna and canavalia, respectively, being higher than those of the present research.

Lozano *et al*, (2008) in their study of pinole of high nutritional value obtained from cereals and legumes, recorded values that are close to those obtained in this research, ranging between 10.12 and 15.55% crude protein. They also indicate that an optimal combination of cereals with legumes improves the quantity and quality of protein without detracting from the palatability of the feed.

For ethereal extract of roasted breadfruit (Table 5), statistical significance was established according to Tukey ($p \leq 0.05$) for the effect of interactions between the time and temperature factors. T4 presented a difference with an average value of 2.82% compared to T1, T2 and T3 with average values of 2.55, 2.44 and 2.32%, respectively. The highest ethereal extract valuation was recorded by T4 with 2.82%, while the lowest valuation was for T2 with 2.32%, an overall mean of 2.54% and a coefficient of variation of 3.41%.

According to Álava (2016) on the time - temperature effect of roasting fine aroma cocoa on its physicochemical and organoleptic characteristics, it obtained an average of 53.1% fat content, being a higher value than that recorded in the research. Agreeing with Lares *et al*, (2012) in the study of the effect of roasting on the physical, physicochemical properties, proximal composition and fatty acid profile of cocoa bean butter from Miranda State - Venezuela, who showed values of 46.27 and 45.42% crude fat for fermented and sun-dried beans, and fermented, sun-dried and roasted beans respectively.

In the analysis of variance for energy (Table 5), no statistical significance was found for the effect of the interactions between time and temperature. T1 and T2 showed differences with averages of 4121.91 and 4174.04 kcal/100 g respectively, compared to T3 and T4 with mean values of 4749.43 and 4785.87 kcal/100 g respectively. The highest energy valuation was obtained by T4 with 4785.87 kcal/100 g, while the lowest valuation was for T1 with 4121.91 kcal/100 g, an overall mean of 4457.81 kcal/100 g and a coefficient of variation of 1.55%.

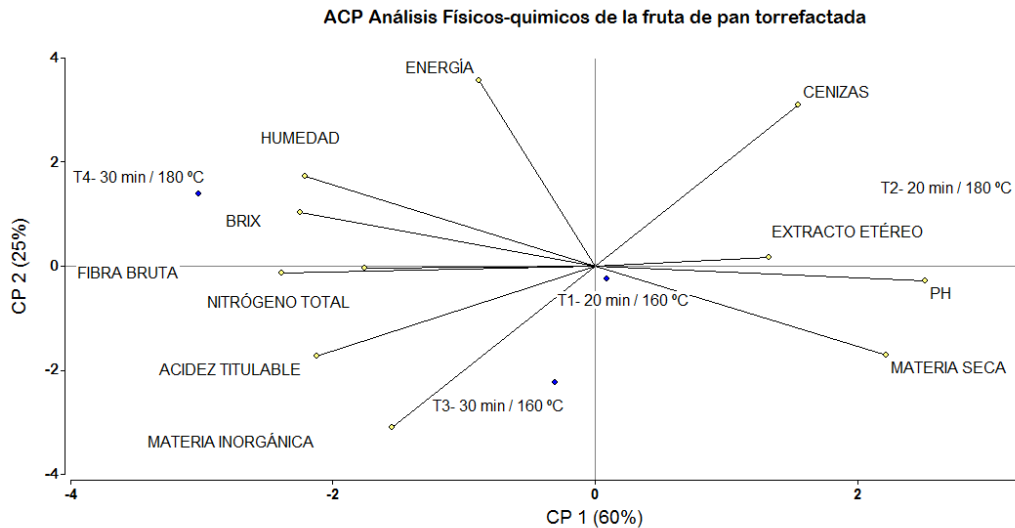


Figure 1. Principal component analysis (PCA) of physical-chemical analyses of roasted breadfruit.

Figure 1 shows the PCA, in which the points corresponding to the breadfruit roasting are explained, the first CP 1 explains 60% of the total variation; the second CP 2 explains 25% of the variation, which as a cumulative proportion represents 85% of the existing variation.

It could be observed that T4 (30 min/180°C) of torrefaction, presents a greater association with moisture, °Brix, crude fiber and nitrogen, while T13 (30 min/160°C) presents a clear inclination towards organic matter and titratable acidity; T1 (20 min/160°C) and T2 (20 min/180°C) have a tendency towards the variables ethereal extract, dry matter and energy.

Microbiological analysis

In the ANDEVA analysis of the mesophilic aerobic variable of the roasted breadfruit (Table 6), statistical significance was established for the effect of the interactions between the time and temperature factors. T1 and T3 presented differences with average values of 4.37×10^6 y 5.18×10^6 cfu/g, respectively, compared to T2 and T4, with mean values of 1.14×10^6 y 1.38×10^6 cfu/g, respectively. The highest mesophilic aerobic value was obtained by T3 with 5.18×10^6 cfu/g.

Table 6. Effect of time-temperature interactions on the mesophilic aerobic variable in roasted breadfruit. FCP - UTEQ. 2018.

Mesophilic aerobes (cfu/g)	
A*B interactions: Time per temperature	
T1 (20 min / 160 °C)	4,37 x10 ⁶ c
T2 (20 min / 180 °C)	1,14 x10 ⁶ b
T3 (30 min / 160 °C)	5,18 x10 ⁵ a
T4 (30 min / 180 °C)	1,38 x10 ⁶ b
Average	1,85 x10 ⁶
C.V. (%)	9,98
s.e.	**

cfu/g= Colony forming units per gram.C.V.= Coefficient of variation.

s.s.= statistical significance (n.s.= not significant, *=significant and **=very significant).

Quintero *et al*, (2014) in the characterization of a toasted tortilla made with corn (*Zea mays*) and seaweed (*Ulva clathrata*) as a functional food prospect, obtained a product with a content of less than 10 cfu/g in the samples of corn tortilla and added tortilla, differing to the results of the present research.

The difference between the experimental results and the requirements of the Salvadoran standard NSO 67.31.02.04 for roasted coffee beans and roasted ground coffee, where it indicates that the maximum permissible index to identify the acceptable level of quality is 2000 cfu/g.

Total coliforms, fungi and yeasts

The presence of total coliforms was not observed. A comparison with the requirements of the Salvadoran standard NSO 67.31.02.04 for roasted coffee beans and roasted ground coffee shows that it agrees with the data obtained in the present experiment, where there should be no presence of this type of microorganisms.

In the ANDEVA analysis of the variable of fungi and yeasts of the roasted breadfruit (Table 7), statistical significance was found for the effect of the interactions between the time and temperature factors. The highest fungi and yeast titer was obtained at T1 with 6.71 x10⁴ cfu/g, while the lowest was for T3 with 1.03 x10⁴ cfu/g. The experimental value differs from the requirement for fungi and yeasts of the Salvadoran standard NSO 67.31.02.04 for roasted coffee beans, the maximum permissible index to identify the acceptable level of quality is 200 cfu/g, which is higher than that obtained.

Table 7. Effect of interactions between the time and temperature factors on the variable fungi and yeasts of roasted breadfruit. FCP - UTEQ. 2018.

Fungi and yeasts (cfu/g)*	
Interactions A*B: Time by temperature	
T1 (20 min / 160 °C)	6,71 x10 ⁴ ab
T2 (20 min / 180 °C)	1,36 x10 ⁴ a
T3 (30 min / 160 °C)	1,03 x10 ⁴ a
T4 (30 min / 180 °C)	1,42 x10 ⁴ b
Average	5,82 x10 ⁴
C.V. (%)	11,27
s.e.	

Data transformed to root of $n + 0.5$ (coefficient of variation).

cfu/g= Colony forming units per gram.C.V.= Coefficient of variation.

s.s.= statistical significance (n.s.= not significant, *=significant and **=very significant).

Sensory analysis

For the light brown color attribute according to Tukey ($p > 0.05$), there was no statistical significance between treatments. T4 obtained the highest average value of 3.00, while T1 presented the lowest value of 1.94, which corresponds to scale 3 (fairly). As with the creaminess attribute, no statistical significance was demonstrated. T1 recorded the highest average value of 3.53, while T3 showed the lowest value of 2.41, an overall average of 3.01, where the aforementioned value corresponds to the scale of 3 (quite a lot).

Hasbún *et al.*, (2009) in the study of physical-chemical properties and quality parameters for industrial use of four potato varieties, obtained a product that showed less darkening with a tendency to a yellow tone, being different from breadfruit, which is due to the fact that the roasting process is related to the content of reducing sugars.

For the breadfruit odor attribute, no statistical significance was demonstrated, T4 obtained the highest average value of 2.71, while T1 presented the lowest value of 2.18, corresponding to scale 3 (quite a lot) and a coefficient of variation of 8.25%. The same occurred for the burned attribute, and no statistical significance was demonstrated. T2 registered the highest average value of 1.29, while T1 showed the lowest value of 0.65, where the aforementioned value corresponds to the scale of 1 (slightly) and a CV of 11.92%.

Magro (2015) in the physicochemical, proximal chemical and sensory characterization of pre-baked flour from germinated flaxseed (*Linum usitatissimum*) by autoclaving and roasting, obtained values of 3.87 and 4.57 whose qualification corresponds to the scale 4 (fair) and 5

(good) respectively, This was found to be acceptable in comparison with the roasted breadfruit, due to the thermal process applied, which was roasting, since this process allows the formation of compounds mostly of the pyrazine type.

For the breadfruit taste attribute, according to the Tukey test ($p>0.05$), there was no statistical significance between treatments. T2 obtained the highest mean value of 3.06, while T1 and T3 had the lowest value of 2.35, an overall mean of 2.57, where the above-mentioned value corresponds to scale 3 (quite a lot) and a coefficient of variation of 8.65%.

For the chocolate attribute, according to Tukey's test ($p>0.05$), there was no statistical significance. T1 recorded the highest mean value of 3.41, while T2 showed the lowest value of 2.65, an overall mean of 3.01, where the above-mentioned value corresponds to the scale of 3 (quite a lot) and a coefficient of variation of 8.60%.

Chávez *et al*, (2000) in the incidence of roasting on the nutritional value of supplemented germinated and non-germinated flours, obtained as the best treatment mixture 1, which corresponds to 80% roasted barley flour + 15% roasted lentil flour + 5% roasted sweet corn flour, chosen for its better taste and acceptability despite its lower amino acid content. For the fragmentable attribute, according to Tukey's test ($p>0.05$) (Figure 2), no statistical significance was demonstrated. T3 obtained the highest mean value of 2.35, while T1 presented the lowest value of 1.59, an overall mean of 2.01, where the aforementioned value corresponds to scale 2 (moderately) and a coefficient of variation of 10.07%.

For the hardness attribute (Figure 2), there was no statistical significance between treatments. T1 recorded the highest mean value of 3.65, while T2 showed the lowest value of 2.88, an overall mean of 3.31, where the above-mentioned value corresponds to the scale of 3 (quite a lot) and a coefficient of variation of 7.84%.

Hasbún *et al*, (2009) in the study of physical-chemical properties and quality parameters for industrial use of four potato varieties, obtained a crunchy product, indicating that crunchiness is related to total solids content, which differs from the texture of breadfruit.

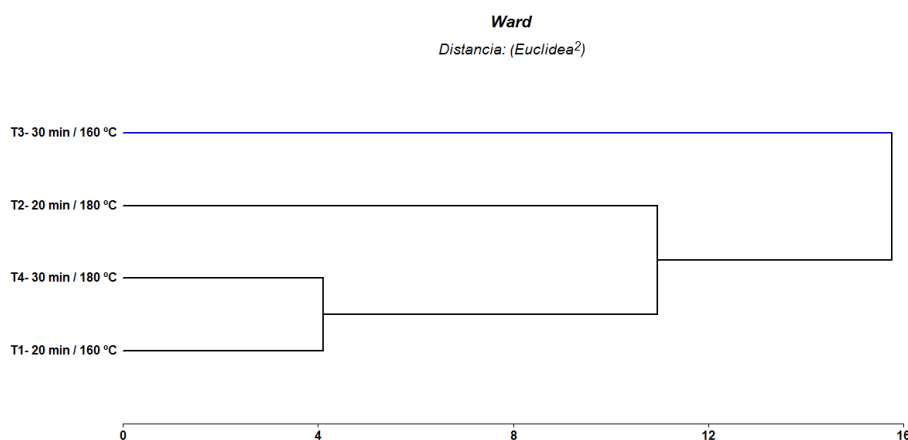


Figure 2. Similarity dendrogram of the sensory analysis of roasted breadfruit FCP-UTEQ 2018.

When evaluating the sensory properties (color, odor, taste and texture) of breadfruit (roasted) with couverture chocolate, it was determined that T3 obtained the highest preference index of 53%, while T2 registered the lowest preference value of 12%.

Conclusions

The bromatological analysis of the roasted breadfruit for the variables pH, moisture, dry matter, ash, organic matter and energy found no statistical significance, while the variables acidity, fiber, total nitrogen and ethereal extract were found to be statistically significant.

According to the microbiological evaluation, the values obtained are not in accordance with the Salvadoran standard NSO 67.31.02.04 for roasted coffee beans and ground roasted coffee, due to the conditions of the roasting process and place of development for the corresponding analysis. Based on the sensory analysis, there was no statistical significance for the sensory attributes of breadfruit (roasted) with chocolate coating, but T3 obtained the highest preference index of 53%, while T2 registered the lowest preference value of 12%. The product had a creamy interior color, predominant breadfruit odor, chocolate flavor and hard texture.

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