

Evaluation of the fermentation process in the production of Colombian monofloral meads

Evaluación del proceso fermentativo en la producción de hidromieles monoflorales colombianas

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Abstract

The aim of this research was the optimization of Colombian meads using monofloral honey samples of Eucalyptus (*Eucalyptus globulus* Labill.), Encenillo (*Weinmannia tomentosa* L.f.) and mataraton (*Gliricidia sepium* (Jacq.)), obtained in the areas of Villanueva - Casanare, Paipa - Boyacá and Mariquita - Tolima, Colombia as the development of a new product with added value. In first place, the evaluation of the physicochemical properties of the raw material (honey) was carried out, as well as the pollen analysis to confirm its nature. A discontinuous (batch) system was used at room temperature with 22eBrix musts and three levels of yeast (0.30, 0.40 and 0.60 g.L⁻¹) of the genus *Saccharomyces bayanus*. During the fermentation process, the transformation of honey sugars, volatile and total acids in the musts was evaluated, using a Sigmoidal-Logistic mathematical model. For the measurement of ethanol and carbon dioxide production, the kinetics were adjusted to the Sigmoidal-Slogistic mathematical model with logarithmic interaction by Levenberg Marquart, allowing to assess each of the variables related to the consumption and production of compounds during the exponential phase of yeast growth. The most relevant results showed a decrease in soluble solids, during the fermentation process, from $22,2 \pm 0,40$ to $9,10 \pm 0,05$ eBrix. The ethanol fraction in the musts evolves with the increase of yeast, for mead it was in the range of $8,34 \pm 0,22$ to $11,29 \pm 0,33$ g.L⁻¹. For the evaluation of kinetics, the OriginPro2016 statistical package was used. The evolution of carbon dioxide showed a higher reaction rate in the musts with higher levels of yeast, from $17,4 \pm 0,06$ to $20,8 \pm 0,70$ g.L⁻¹ accumulated during the 11 days of fermentation. The final product was evaluated in terms of ethanolic fraction, soluble solids, total acidity, volatile and carbon dioxide.

Keywords: Apiarian agroindustry, ethanolic fraction, fermentation, reaction kinetics, soluble solids, total acidity.

Resumen

El objetivo de esta investigación fue la optimización de hidromieles colombianas usando muestras de mieles monoflorales de Eucalipto (*Eucalyptus globulus* Labill.), Encenillo (*Weinmannia tomentosa* L.f.) y Mataratón (*Gliricidia sepium* (Jacq.) Walp.), obtenidas en las zonas de Villanueva -(Casanare), Paipa- (Boyacá) y Mariquita-(Tolima), Colombia, como desarrollo de un nuevo producto con valor agregado. Se realizó en primera instancia, la evaluación de las propiedades físicoquímicas de la materia prima (miel), así como el análisis polínico de la misma para confirmar su naturaleza. Se utilizó un sistema discontinuo (Batch) a temperatura ambiente con mostos de 22eBrix y tres niveles de levadura (0,30, 0,40 y 0,60 g.L⁻¹) del género *Saccharomyces bayanus*. Durante el proceso fermentativo, se evaluó la transformación de los azúcares de la miel, ácidos volátiles y totales en los mostos, usando un modelo matemático Sigmoidal-Logístico. Para la medición de la producción de etanol y dióxido de carbono, la cinética se ajustó al modelo matemático Sigmoidal-Slogístico con interacción logarítmica de Levenberg Marquart, permitiendo valorar cada una de las variables relacionadas con el consumo y producción de compuestos durante la fase exponencial del crecimiento de las levaduras. Los resultados más relevantes permitieron observar un descenso de los sólidos solubles, durante el proceso de fermentación, desde $22,2 \pm 0,40$ a $9,10 \pm 0,05$ eBrix. La fracción de etanol en los mostos evoluciona con el incremento de levadura; para las hidromieles estuvo en el rango de $8,34 \pm 0,22$ a $11,2 \pm 0,33$ g.L⁻¹. Para la evaluación de la cinética, se usó el paquete estadístico OriginPro2016. La evolución de dióxido de carbono mostró una mayor velocidad de reacción en los mostos con niveles más altos de levadura, desde $17,4 \pm 0,06$ a $20,8 \pm 0,70$ g.L⁻¹ acumulado durante los 11 días de fermentación. El producto final fue evaluado en términos de la fracción etanólica, sólidos solubles, acidez total, volátil y dióxido de carbono.

Palabras clave: Acidez total, agroindustria apícola, cinética de reacción, fermentación, fracción etanólica, sólidos solubles.

Introduction

Apiculture in Colombia is an agricultural activity oriented to the management of bees of the genus *Apis*, honey and pollen are harvested, the extraction of propolis, royal jelly and wax in low quantities is carried out. Most of the small producers are rural with great difficulties in production that prevent production with quality, volume, periodicity, timeliness and at low costs.

The mead is undoubtedly the oldest fermented drink and recognized in different cultures and human civilizations, however at present the market is restricted only to Eastern Europe, contains 8% -18% (v / v) of ethanol. Its value as a refreshing drink and as a health tonic has made it possible to resume the properties attributed to it in another time. Honey fermentation can be used to produce different varieties of mead, sherry, sparkling wine and fruit-honey wines that can have different flavors depending on the floral source and type of honey used in the preparation of the product; which are enhanced with the incorporation of additives and new types of yeast used in the process (Gupta & Sharma, 2009).

The composition of the honeys defines the quality of the final product (Mendes-Ferreira *et al.*, 2010). In the product, invigorating properties are still recognized due to the residue of unfermented sugars and the fraction of ethanol present in the body of the drink; the presence of antioxidants confers a special value to the mead that positions them in the market of products with added value (Ramalhosa, Gomes, Pereira, Dias, & Estevinho, 2011). The conventional fermentation process takes several months to complete and the use of yeast as starter cultures is necessary (Pereira *et al.*, 2013; Pereira *et al.*, 2009). Nowadays, the production of meads represents a possible economic alternative to beekeepers who intend to obtain new value-added products.

Alcoholic fermentation is an anaerobic process carried out by yeasts and some families of bacteria (Jackson, R. S., 2008). Salamanca & Beltran (2015), establish that carbohydrates (mono and disaccharides) are transformed into ethanol and carbon dioxide, resulting in the reduction equivalents of the compounds NADH/NAD⁺ and NADHP/NADP⁺ and high energy phosphate bonds, ATP. Similarly, it can be considered as an oxidation process where a complex molecule is transformed into a simpler one, releasing energy and generating a final product. Chemical energy is derived from a phosphorylation process, by transferring electrons leading to the production of an oxidized organic compound.

Regarding the origin of honey, meads can have a wide range of aromas and flavors, due to the use of additives, mixture of musts, types of yeast during the fermentation period and aging time. Despite the recognition of the conditions necessary for the elaboration of mead, the technological aspects of the elaboration have faced the problem of scaling, going from productions of 1,0 to 20 L. In these conditions, maximum specific growth rates of the order of 0,045 and 0,038 h⁻¹ have been observed (Gomes, T. Barradas, C., Dias, T., Morais, J.S., & Ramalhosa, E. 2015).

The production of mead is a process that requires time to present the consumption of honey sugars, the evolution of acidity and the transformation of compounds such as ethanol and carbon dioxide (CO₂). The main objective of many producers of this drink is to reduce the fermentation time and maintain the final characteristics of the product. The use of different amounts of nitrogen, according to European legislation for grape wines, (300 mg.L⁻¹) as diammonium phosphate or ammonium sulfate that allow you to reduce transformation times by eleven days. But despite the use of cellular activators, the development of the process is not as expected, because the entire substrate is not consumed, suggesting that honey has compounds with the ability to inhibit its growth. (Mendes-Ferreira *et al.*, 2010).

Aspects related to the kinetics of the process are unknown, the lack of controls and monitoring of the fermentation process brings as a consequence, the lack of uniformity in the final products and incomplete or excessive fermentations which tend to be accompanied by unpleasant aromas and flavors. The objective of this research has focused on the optimization of monofloral meads of Eucalyptus (*Eucalyptus globulus* Labill.), Encenillo (*Weinmannia tomentosa* L.f.) and mataraton (*Gliricidia sepium* (Jacq.) Walp.), optimizing the proportion of water, honey and yeast to be entered in a discontinuous system (Batch) at room temperature.

Materials and Methods

Samples

In this work, samples of honey from *Apis mellifera* L. (Hymenoptera: Apidae), benefited in biogeographical areas of tropical humid forest (bh-T; 350 m.a.s.l. 2640 mm.year⁻¹ of precipitation; 27eC), in the town of Villanueva (5e 16 16.2' LN; 71 59'06.25' LO) and San Sebastián de Mariquita (bh-T; 480 m.a.s.l. 1811 mm.year⁻¹ of precipitation and 28eC), (5e 14.22'65' LN; 74e 55.54'09')

LO) were used in the departments of Casanare and Tolima, Colombia, respectively. A third sample was benefited in rural area of the municipality of Paipa (5e 47.03' 74" LN; 73e09.00'. 16" LO), (7bh-mb7;

2525 m. s. n. m. 944 mm.year⁻¹ of precipitation; 13eC) in the Vereda de la Bolsa – Paramo de Paipa, Department of Boyacá, Colombia (Figure 1).



Figure 1. Apiarian aspects and specific botanical flora to produce monofloral honeys

Yeast

A widely used wine yeast strain of the genus *Saccharomyces bayanus* VR 44 was used in the production of alcoholic beverages and wines produced nationally and internationally (Lot KR-13001038) of the brand Springer Oenologie® of the company FERMENTIS®. This variety is characterized by having a good adaptability and quick start of fermentation in the must. Its fermentation temperature ranges from 10eC to 40eC with a high alcohol tolerance power and low nitrogen requirements.

Characterizations

Harmonized methods of analysis of honey for moisture parameters (Xw, g.100g⁻¹); reducing sugars (XR fructose, glucose and sucrose) g.100g⁻¹, total (AT,) lactonic (AL) and free (AL) acidity me.K⁻¹; hydroxymethyl furfural (HMF, mg.K⁻¹); color (CIELab and Pfund); water activity (aW) electrical conductivity (C.E. mS.cm⁻¹); diastase index (ID) and palinological verification study of floral origin were applied in the evaluation of honey (Figure 2).

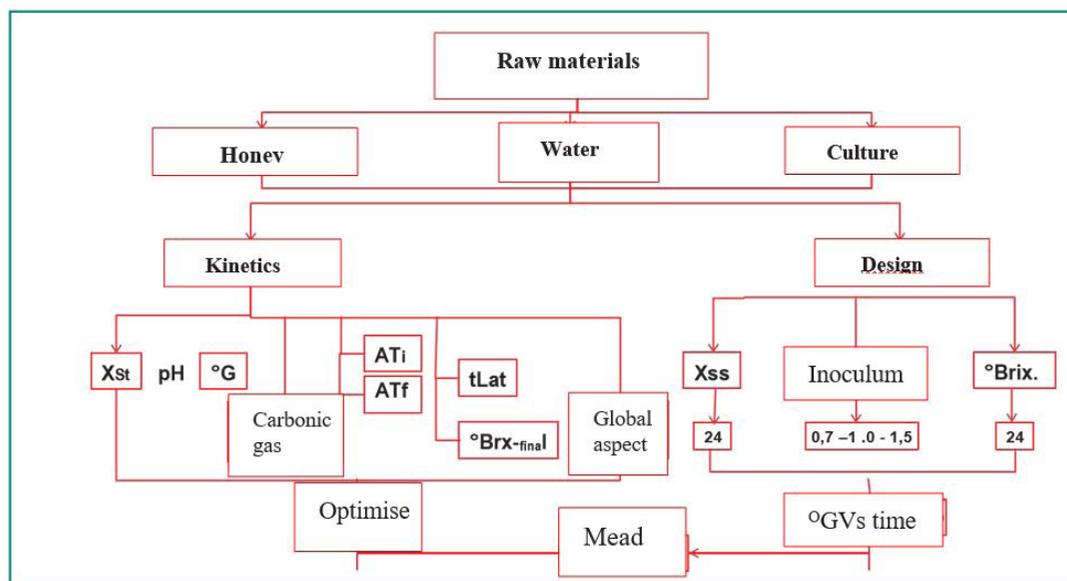


Figure 2. Kinetics and design of the Colombian mead making process

Fermentations

For the fermentation process using a discontinuous batch system at 35eC 1000 ml reactors were used. For the preparation of

the musts Colombian monofloral honeys of Encenillo (*Weinmannia tomentosa* L.f.) (EC) and Matarratyn (*Gliricidia sepium* Jacq.) with an initial concentration of 22eBrix. 35eC. The musts were treated with sodium metabisulfite at 100 ppm

and pasteurized at 63°C for three minutes. It was inoculated with *Saccharomyces bayanus* as the microorganism responsible for the fermentation process and enriched with monobasic ammonium phosphate to initiate the fermentation process (Figure 3).

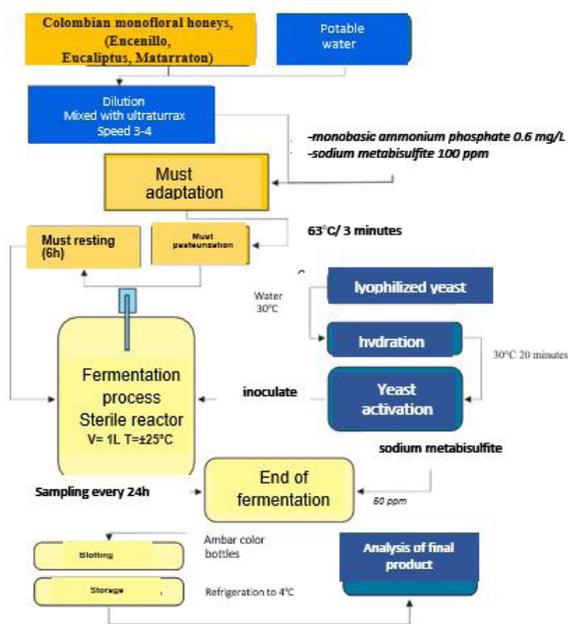


Figure 3. Flowchart of the production process of standardized meads

Kinetic Model

The transformation of honey sugars (glucose and fructose) in the musts used in the production of encenillo, eucalyptus and mataratyn meads, with the transformation of soluble solids, volatile and total acids, conforms to a sigmoidal-Logistic model (Equation 1).

Equation 1. Sigmoidal Logistic mathematical model for the kinetic behavior of soluble solids, Brix, and total and volatile acidity in the production of Colombian monofloral meads.

$$Y = \frac{A_2 - A_1}{1 + \left(\frac{X}{X_0}\right)^p} + A_1$$

Where:

A1 and A2 correspond to the initial and final values of the parameters, (X₀) is the mean value, (X) is the parameter value at time (t) and (p) is a pre-exponential factor specific to the model. For the case of ethanol and carbon dioxide transformation in the working musts from monofloral honeys, a sigmoidal-Slogistic1 model with Levenberg Marquart logarithmic interaction is fitted (Equation 2).

Equation 2. Sigmoidal Slogistic1 mathematical model for transformation in mead kinetics for ethanol and carbon dioxide.

$$Y = \frac{a}{1 + e^{-k(x-x_c)}}$$

Where:

a: Corresponds to the amount of carbon dioxide accumulated during the process, (X_c) the amount of CO₂ produced in the middle of the process, (X) is the CO₂ produced at any time during the process and (k) is a coefficient typical of the model. The formation of metabolites of yeast activity (ethanol and acid components), in the reaction medium. Additionally, it should be noted that it is presented in three phases with a slight increase at the beginning of the process and with a marked effect in an intermediate phase and a slight decrease at the end of the process (Salinas, 2010; Salamanca & Beltrón, 2015).

Data analysis

For the analysis of the kinetics of the samples of encenillo, eucalyptus and mataratyn musts, the data were organized in a completely random 3*3*1 factorial arrangement (DCA) with three replicates for the different treatments, the factors being the concentration of yeast (0,30; 0,40 and 0,60 g.L⁻¹) and concentration of the must (22eBrix). The experimental unit corresponds to a reactor with a volume of one litre, 27 units being valued.

The results were processed statistically by an analysis of variance at 5% of statistical significance for the physicochemical variables of pH, consumption of soluble solids (eBrix), evolution of total and volatile acidity, transformation of ethanol and carbon dioxide with the statistical software Statgraphics Centurion XVI version 16.1.03. Likewise, for the kinetics of the fermentation process, the OriginPro2016 statistical package version b9.3.226 was used.

Results and discussion

The properties of honeys vary according to its botanical and geographical origin. The moisture content of the honeys used as raw material for the preparation of the mead (Table 1), are in the range 19,7 and 20,7% w/w, being greater in matarraton, in that of encenillo is 20,4. Results very similar to those reported by in monofloral honeys. The pH and total acidity show significant differences between treatments (P<0,05), this is due to the presence of organic acids that become an important antimicrobial factor, with gluconic acid being the highest concentration.

Table 1. Physico-chemical characterisation of monofloral honeys of encenillo, eucalyptus and matarratón used for the production of meads.

Parameters	Units	Encenillo	Eucalyptus	Matarratón
Water activity	Aw	0,61 ± 0,02	0,57 ± 0,01	0,60 ± 0,01
S. total solubles	(g.100g ⁻¹)	79,6 ± 0,10	80,3 ± 0,30	79,1 ± 0,50
IR Refractive Index	-	1,4926 ± 0,04	1,4932 ± 0,02	1,4853 ± 0,01
Humidity	(g.100g ⁻¹)	20,0 ± 0,10	19,7 ± 0,30	20,1 ± 0,40
Density	(g.mL ⁻¹)	1,394 ± 0,01	1,416 ± 0,02	1,463 ± 0,01
C.E.	mS.cm ⁻¹	0,52 ± 0,01	0,45 ± 0,01	0,21 ± 0,02
pH	-	4,02 ± 0,02	3,73 ± 0,02	3,20 ± 0,05
Free acidity	(meq.K ⁻¹)	38,1 ± 0,70	42,2 ± 0,50	28,1 ± 0,30
Lactonic A.	(meq.K ⁻¹)	8,40 ± 0,10	1,20 ± 0,17	2,00 ± 0,10
Total acidity	(meq.K ⁻¹)	46,3 ± 0,10	43,4 ± 0,50	30,1 ± 0,30
Ashes	(g.100g ⁻¹)	0,28 ± 0,01	0,15 ± 0,39	0,04 ± 0,01
Sugar. Reducers	(g.100g ⁻¹)	69,5 ± 0,60	72,4 ± 0,10	69,5 ± 0,20
Diastase Index (DN)	-	6,32 ± 0,43	11,4 ± 0,56	12,7 ± 0,47
Tabouret Index	-	10,40	9,30	8,10
HMF content	mg.K ⁻¹	13,3 ± 0,45	6,38 ± 0,01	3,29 ± 0,01
Glucose.	mg.K ⁻¹	27,1 ± 0,48	34,7 ± 0,19	29,5 ± 0,81
Fructose	mg.K ⁻¹	42,4 ± 0,32	36,4 ± 0,27	40,0 ± 0,12
Sucrose	mg.K ⁻¹	9,81 ± 0,12	11,2 ± 0,37	10,1 ± 0,24
L	Luminance	58,1	67,0	56,1
a*		18,4	9,70	1,7
b*		81,8	69,0	47,3
USDA	-	(50-84)	(85-114)	(50-84)
Colour	-	Light amber	Amber	Light amber

Fermentation process

Alcoholic fermentation is an anaerobic process carried out by yeasts that transform sugars into ethanol and carbon dioxide (Jackson, 2008). These yeasts used as a pure culture initiator (starter) require an adaptation process that is based on the characteristics of the must (pH, substrate, viscosity, dissolved oxygen content and acidity).

In the treatments of the encenillo musts at 0.30; 0.40 and 0.60; the pH and the soluble solids evolve according to the consumption of the substrate by the yeasts. The pH is kept between 2.97 ± 0.02 and 3.23 ± 0.02 with a slight drop during the first three days of fermentation in each of the treatments and stabilizing on the sixth day of fermentation (Figure

4). Eucalyptus musts exhibit similar behavior in their pH to other samples. However, the process begins with a higher pH and this evolves from 3.26 ± 0.04 to 3.68 ± 0.04 stabilizing nine days after the process. In the case of Matarratyn musts, they range from 3.15 ± 0.01 to 3.29 ± 0.02 , being the treatments at 0.30 g.L^{-1} of yeast, which reached a higher value.

The transformation of honey sugars (glucose and fructose) in the musts used in the production of Encenillo, Eucalyptus and Matarratyn meads is adjusted to a sigmoidal-Logistic model with statistical significance ($\text{Prob} > F$), of $4,07 \times 10^{-13}$ when the amount of yeast is $0,30 \text{ g.L}^{-1}$ of $2,15 \times 10^{-11}$ and $1,65 \times 10^{-12}$ to $0,40$ and $0,60 \text{ g.L}^{-1}$ (Figure 4).

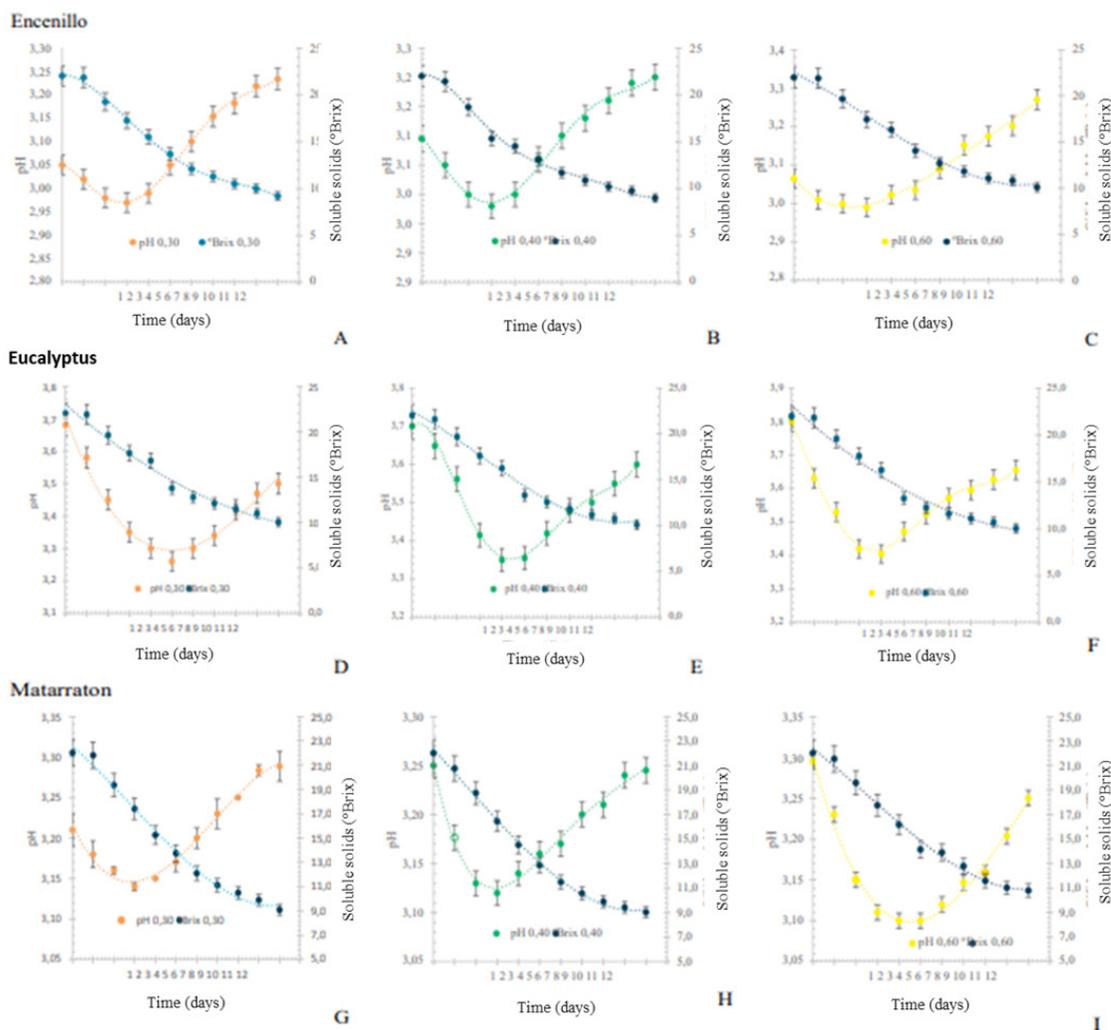


Figure 4. Evolution of pH and soluble solids in the Encenillo musts of meads (A-C). Eucalyptus (D-F) and Matarraton (H-I) at 22°Brix and yeast levels in the musts of 23 0,30-0,40-0,60g.L⁻¹

During the evolution of sugars consumed during the fermentation process, the treatments T1 (0.30g.L⁻¹) (7.40 ± 0.80) for EC; T1 (0.30g.L⁻¹) (8.90 ± 1.00) for EU and T2 (0.40g.L⁻¹) (7.30 ± 0.13) for MT, are those that showed a greater consumption of solids during kinetics. The acidity of the mead is represented in all the acids present in the honey. Its initial value in the samples is of the order of (26.62 ± 0.235; 27.53 ± 0.271 and 27.87 ± 0.004 meq.L⁻¹) for MEC; (24.70 ± 0.171; 27.41 ± 0.432 and 25.87 ± 0.309 meq.L⁻¹) for MEU and (23.85 ± 1.173; 27.71 ± 0.085 and 28.83 ± 0.001 meq.L⁻¹) for MMT being recurrent with the needs of the mead process and similar to those reported by Ojeda de Rodríguez, Sulbarón de Ferrer, Ferrer & Rodríguez, (2004) in the state of Lara, Venezuela.

Under the indicated process conditions in each of the monofloral honey musts, they have an alcoholic strength (°G) between 8.66 ± 0.14 and 11.6 ±

0.77 °G. The fraction of ethanol in musts evolves with the increase of yeast, managing to work on a wide range of substrates including mono-, di-, and oligosaccharides, ethanol, acetate, lactate and glycerol, glucose being the main and preferred source of carbon, transforming it into ethanol through its assimilation, reaching yields of between 80% and 90% during the process similar to those worked by (Pereira *et al.*, 2009), (Salinas *et al.*, 2010), (Mendes-Ferreira *et al.*, 2010), (Blanco & Quicazan, 2012), (Salamanca & Beltrón, 2015).

The production of ethanol occurs in the three treatments and evolves to 8.81 ± 0.28 for 0.30 g.L⁻¹ of yeasts; 9.50 ± 0.20 with 0.40 g.L⁻¹ and 11.0 ± 0.33 with 0.6 g.L⁻¹ for Encenillo; 8.34 ± 0.22 for 0.30 g.L⁻¹ of yeasts; 9.17 ± 0.34 with 0.40 g.L⁻¹ and 9.85 ± 0.31 with 0.6 g.L⁻¹ for eucalyptus and 9.02 ± 0.74 for 0.30 g.L⁻¹ of yeasts; 10.3 ± 0.33 with 0.40 g.L⁻¹ and 11.2 ± 0.33 with 0.6 g.L⁻¹ for

Matarratyn, demonstrating that the mead with Matarratyn being the best performing. 0,60 g.L⁻¹ of yeast produced the highest amount of alcohol during fermentation, with treatment 3 of

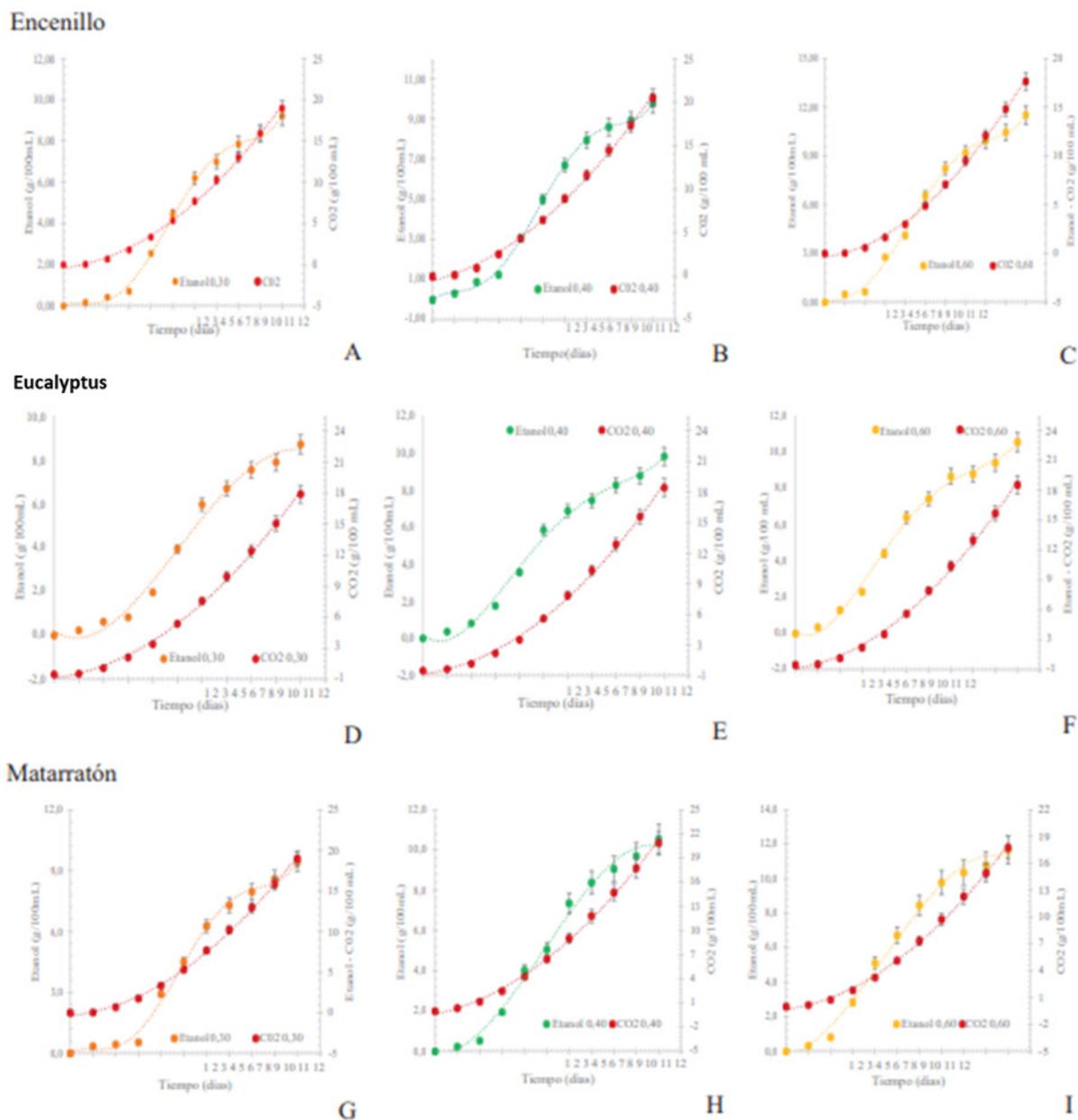


Figure 5. Transformation of ethanol and CO₂ during the fermentation process into monofloral mead musts

During the fermentation process of the must, a large amount of CO₂ is produced that is lost in the next stages of the process. The presence in the final product improves the perceptions of freshness and acidity, reduces sweetness, intensifies bitterness and astringency and can cause a sharp sensation for this type of drink. The CO₂ production for the used meads is between 17.4 ± 0.06 and 20.8 ± 0.17 g.L⁻¹ accumulated during the 11 days of process (Figure 5).

In fermentation processes, the acidity mainly comes from the degradation of sugars as a product of yeast metabolism, from the phosphorylation of glucose to glucose-6-phosphate, isomerization to fructose-6-phosphate and to the formation of glyceraldehyde that promotes the formation of glyceric acid to pyruvic acid and the final evolution of ethanol and carbon dioxide through the pathway of Embden-Meyerhof-Parnas (EMP). The speed in the three types of musts

presents significant differences between treatments (Pv 0.088 F 33,66) being higher in the T2EU treatment in Eucalyptus compared to Encenillo and Matarratyn. Meanwhile, in the formation of ethanol no significant statistical differences are perceived, but in the Matarratyn T3MT musts the production speed is $0,310 \pm 0,004$, which is greater than that observed in T3EU and T3EC, for eucalyptus and Encenillo respectively. Regarding the transformation of carbon dioxide statistically, there are no significant differences, it being found that the treatments with Eucalyptus honey TEU presented greater speed of change compared to the other treatments. This behaviour is due to the nature of the samples.

Final physicochemical parameters

Mead is an alcoholic beverage based on honey, water and fermentative crops (yeast). (Salinas, 2010). This drink contains a minimum of 7% ethanol and other compounds such as sugars, acids, vitamins and antioxidants, among others. Its composition largely depends on the biogeographical origin of the honey. Pereira, Dias, Andrade, Ramalhosa & Estevinho, (2009). The final contents of total solids were between 9.05 ± 0.071 and 10.50 ± 0.460 for all treatments being very similar to those reported by Roldán, Van Muiswinkel, Lasanta, Palacios & Caro (2011). The pH ranged from 3.22 ± 0.021 to 3.66 ± 0.004 , with Eucalyptus honey treatments having the highest value compared to the other samples (Table 2).

Table 2. Final parameters for the Colombian monofloral meads of Encenillo, Eucalyptus and Matarratón

Meads										
Parameters	Units	Encenillo			Eucalipto			Matarratón		
		T1EC	T2EC	T3EC	T1EU	T2EU	T3EU	T1MT	T2MT	T3MT
SST	g/100g	9,63±0,601	9,05±0,071	10,2±0,141	10,1±0,106	10,1±0,035	10,1±0,071	9,12±0,028	9,10±0,071	10,5±0,460
Densidad	g/MI	1,288±0,51	1,298±0,42	1,299±0,81	1,268±0,08	1,275±0,65	1,281±0,24	1,281±0,17	1,289±0,23	1,293±0,54
pH	pH	3,24±0,005	3,22±0,021	3,26±0,008	3,51±0,007	3,61±0,007	3,66±0,004	3,29±0,004	3,25±0,011	3,25±0,007
Acidez total	meq/L	50,1±0,008	50,2±0,008	53,2±0,009	49,2±0,001	49,8±0,003	51,8±0,023	50,9±0,005	53,3±0,003	55,7±0,004
A. volátil	meq/L	22,11±0,01	24,17±0,01	24,80±0,01	23,72±0,01	24,50±0,01	26,30±0,01	22,20±0,97	23,60±0,01	26,61±0,01
Etanol	Mg.L	9,21±0,03	9,76±0,01	11,51±0,01	8,68±0,03	9,79±0,02	10,53±0,01	9,43±0,04	10,53±0,04	11,65±0,02

The parameters of total and volatile acidity were extensively evaluated during the kinetics of the process where the Matarratyn musts had a greater number of acidic compounds that were reached at the end of the exponential phase with values between 53.3 ± 0.003 and 55.7 ± 0.004 . The transformation of sugars into ethanol was between 8.68 ± 0.03 and 11.65 ± 0.02 , clearly evidencing that the greater the amount of yeast, the better the alcohol yield.

Conclusions

Research has shown that the greater the number of microorganisms, the greater the efficiency of the process. However, it cannot be abused with the concentration of cells during the start of fermentation because unpleasant conditions are generated in the final product associated with a high acidity of the mead. The research carried out is a contribution to the process of diversification of hive products in Colombia, with mead being an alcoholic beverage that is presented as another alternative to the use of beekeeping products

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