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ASSESSMENT OF THE EFFICIENCY OF THE MUCILAGE OF THE COFFEE AS COAGULANT ORGANIC, FOR THE REMOVAL OF TURBIDITY. CONSIDERING THE PH OPTIMUM AND OPTIMAL DOSE

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Abstract: The prevailing need of satisfy the demand of water for use and consumption human with a approach sustainable Make necessary look for new alternatives for the removal of the turbidity in this matrix environmental.
By it former, he present job seeks assess the efficiency of the mucilage of the coffee as coagulant organic, for the removal of turbidity. considering the pH and optimal dose. By testing jars and determining the concentration of mucilage of coffee, with samples collected to leave of methods of extraction different. Being he pH 11 and 12 are optimal for removal with the optimal dose of 10 and 20 ml of coffee mucilage as a coagulant. It is proven that the organic coagulant from coffee mucilage is an effective and viable option for the removal of turbidity in the synthetic water, reaching removal efficiencies of 91.38% for a pH of 12 and 90.99% for a pH of eleven.
Keywords: Coagulant organic, mucilage of coffee, treatment of water, removal of turbidity.

INTRODUCTION

JUSTIFICATION

In Mexico, the coffee industry is important for national development, since it is a generating source of income. jobs and foreign exchange for the country, as well as for the conservation of biodiversity. (CEDRSA, 2019). With the Ministry of Agriculture and Rural Development, Mexico occupies 11th place in terms of world production of coffee.

Within the coffee production process, there are two methods to obtain the final product, the dry method and he method wet (Prada, 2014), in set, during all the process productive, only it takes advantage of the 5% of the weight of the fresh fruit for the final preparation of the drink and 95% constitute the organic waste they contain different chemical compositions. (Nuván and Rojas, 2018) These organic waste is composed of the pulp and the mucilage of the fruits extracted, additionally, they add as waste the fruits of the coffee that by diverse factors as its quality or maturity they cannot be considered for the final production.

According to Mazille and Spuhler, regardless of the nature of the treated water and the integral system of treatment applied, generally, he includes the process of coagulation-flocculation as pretreatment (before of the sand filtration) or as a post-treatment step after sedimentation (in sand treatment plants), centralized waters).

Due to the above and taking into consideration, that both Mexican and foreign companies continue in the search for improve productive and industrial processes to make them sustainable and generate the least impact on the environment, the This research work seeks to provide a possible alternative using coffee mucilage for the removal of turbidity of waters like a coagulant natural organic.

GOALS OF WORK

To evaluate the efficiency of coffee mucilage as an organic coagulant for the removal of turbidity, considering the pH optimal and optimal dosage.

BACKGROUND

One of the needs of every society is to be able to guarantee hygiene and sanitation services for the population. as well as providing water for human use and consumption that is clean, safe, affordable and continuous. (UN, n.d.) That is why the microbiological, chemical and organoleptic aspects must be considered in the quality of this vital liquid. (World Health Organization, 2011)

A of the characteristics physical and organoleptic to consider for the acceptance of the population is the turbidity, already that In addition to being an aesthetic criterion, it can directly or indirectly indicate the presence of

some harmful constituent. in water. (National Water Commission, sf, p. 25). Turbidity or turbidity in surface waters is due to the presence of suspended, colloidal and dissolved matter (Trussell et al., 2012) present from the processes erosive, the particles that generate this characteristic, which are also known as colloids, have a size no way from 1nm to 1mm. (CONAGUA p. 27)

The importance in the removal of are particles of agreement to (Trussell et to the., 2012) relapses in that: to) reduce the quality of the water by the turbidity, b) can have agents infectious as virus, bacteria and others microorganisms contents in colloids, which can be protected from disinfection reactions (CONAGUA p.27), and that c) some components such as toxic metals can be found adsorbed in said particles.

Continuous monitoring of turbidity in water is important because it is a regulated parameter in the framework legal Mexican and additionally works as mechanism of control in the efficiency of the processes of treatment, as well as the quality of the treated effluent. (CONAGUA, p.68). The Official Mexican Standard NOM-127-SSA1-2021 that establishes the permissible quality limits for water for human use and consumption, which indicates that for the By 2023, the turbidity of water for the population must have a maximum of 4.0 Nephelometric Turbidity Units (UNT), changing this maximum permissible limit (LMP) to 3.0 UNT starting of the year following.

Inside of the treatment of waters in water treatment plants, he system of clarification conventional is one of the further used, through which the flow to be treated passes through filters or grates to retain large solids, Subsequently, the remaining solids are colloidal in nature, so they are in suspension. Are Particles cannot be removed due to their size, minimum sedimentation velocity and electrical superficial charge, generally negative that they possess. (NF Gray, 2005)

The process used most important for the removal of these solids is the coagulation-flocculation, the which consists in the addition of compounds chemicals, inducing he contact coagulant-matter in suspension, with the aim of destabilizing the said matter by promoting the generation of aggregates and adsorption of dissolved constituents, to favor sedimentation and its subsequent removal. (CONAGUA, sf.; Barreto Pardo et al., 2022; Organization world of the Health, 2011; Hendricks, 2006; Trussel et al., 2012)

This process has two important phases: a) the appropriate choice of coagulant, depending on the nature of the particles, the dose of coagulant and the necessary pH correction to achieve a high removal efficiency and b) generate contacts between the chosen coagulant and the particles present in the water for the formation of flocs. (Hendricks, 2006; N.F. Gray, 2005)

Considering the above, a jar test must be performed to obtain an optimal coagulation process. flocculation. This test allows the measurement and control of the effects of the dose of coagulant used and the pH, in different combinations where he has to of measure the turbidity and he pH of the water supernatant. (NF Gray, 2005)

The coagulants mainly used are inorganic, compounds by you go out metallic of aluminum either iron, but due to environmental problems - generation of high volumes of treatment sludge with toxic characteristics - (Barreto Pardo et al., 2022 taken from Abebe, et al., 2016) and to health - assimilation of aluminum in the body, due to its solubility, being associated with neurological diseases such as Alzheimer's (NF Gray, 2005; Barreto Brown et to the., 2022) that potentially they can trigger this guy of agents chemicals, the natural coagulants are

presented as an environmentally viable and economically feasible alternative for turbidity removal. (Manzo Garrido, 2023)

Some of the benefits of natural coagulants are related to their low cost, the availability that They present their biodegradability, as well as the possibility of revalorizing waste from existing production chains.

COFFEE

He system of benefit of the coffee is he process of transformation of the fruit either cherry of the coffee, in the product that after of the toasted and ground, enters to the chain of the consumer final. Inside of this process of benefit, he generates different results by products of the coffee, that, of not being managed, treaties either ready of manner suitable, could trigger an impact negative to the environment. The main organic byproducts according to (Samoaya Toledo et. al, 2014 taken from ANACAFE) of this process are:

1.- Coffee pulp, the largest volume byproduct, representing 56% of the volume of the fruit (Samayoa Toledo et to the. 2014). With a large organic load, so it can be used as organic fertilizer or for composting. 2.- Mucilage, coagulant natural selected for the present job of investigation, which he will address in he pulled apart next. 3.- Aguamiel, liquid byproduct (waste water) of the pulping and washing process, so its characteristics depend of these two processes. 4.-Parchment loose (husk) this by-product, No It represents risk contaminant within the benefit wet.

The mucilage or mesocarp of coffee is a layer of translucent tissues composed of water, sugars and substances pectic acid that acts as a hydrogel, which is located between the pulp and the shell of the seed (Barreto Pardo et al., 2022; Puerta Quintero and Arias, 2011) this is revealed when the grain is pulped and its removal is necessary to facilitate the process of dehydration, drying and conservation of the quality characteristics of the coffee parchment. (IICA, 2010)

The characterization of this byproduct has been the object of study of different investigations carried out by several authors. In the **Board 1,** they observe the compositions obtained in the results of sayings jobs, for his application in different purposes industrial.

Removing coffee mucilage immediately after pulping is complicated, due to the hydrogel properties that it possesses due to pectic substances. (Peñuela Martínez et al., 2011) Therefore, in the conditions current of the industry, the removal of the mucilage for the benefit of the coffee, he makes by some of the two following methods: a) Mechanical removal (demucilaginator) b) Removal by natural fermentation. (Quintero and Arias, 2011; IICA, 2010; Samayoa Toledo, 2014)

Work has been carried out applying coffee mucilage as a natural coagulant to remove turbidity in water, such as that reported by Barreto Pardo et al., 2022, where they mention two types of mucilage coagulants from coffee obtained by different methods, the first from a mixture of aqueous mucilage generated in a coffee plant benefit and the second, of a solution using a particulate material of the mucilage after a treatment thermal of the first solution. The results show that the two coagulants follow a trend, although They present different removal efficiencies. The first coagulant extracted from coffee mucilage removed 65% of the turbidity, with an optimal dose of 300 mg/L. By other side, he second coagulant had a removal between 30% - 39%. In none is reported pH optimum for the coagulation.

Additionally, in the work of Cendales Arévalo et al., 2016, multiple jar tests were carried out comparing the efficiency of inorganic coagulants (ferric chloride) against coffee mucilage with two extraction

methods, a of manner watery, the which No got remove turbidity and other with a solution saline that presented a removal 29% with a dose of 120 mg/L. The low efficiencies reported were potentially generated by the lack of pH variation when doing jar tests, when performing them with a range of 7 to 8 pH units. For the said evidence, the dose employees were in the rank of 20-240 mg/L.

MATERIAL AND METHODOLOGY

He performed a visit to field, where he collected mucilage of coffee in two benefits coffee growers, that they use methods of removal of the mucilage different. Sayings benefits, belong to two municipalities of the state of Veracruz, as he observed in **Figure 1** : Benefit in Teocelo, with coordinates 19.37901° N, 96.96861° W where it is removed using a demucilaginator (mechanical removal), and Ixhuacán de los Reyes, with coordinates 19.30855° N, 97.00900°, where removal occurs by fermentation and subsequent washing. The two sampled benefits cultivate and they produce coffee of the *Coffea arabica species* with altitudes of 1,250 meters above sea level for Ixhuacán de los Reyes and 1, 335m.a.s.l. for the benefit in Theocelus.

Nomenclature keys were assigned for the development of the experimental phase as follows, "Mec" for the mechanical removal sample, which had a storage time in the mill tank of three days, when moment of the take of sample. For the second benefit, sampled in two points different of the process, "Fer" in the drain valve of the fermentation process unit with one day of storage in said tank, for the second "Fer2" the sampling he water used for he washed of the grain of coffee fermented, with the intention of know the efficiency of this liquid waste, bliss solution had a total fingers day of fermentation.

Additionally, coffee cherries are collected to obtain a mucilage sample in the laboratory. This sample presented fruits of sizes, varieties and colorations different. The pulp of seven kilograms of manner manual in the laboratory, getting the grain with the mucilage in a weight of three kilograms, later added 4 liters of water for its fermentation for 24 hours and finally be filtered out.

The experimental phase in the laboratory begins with the filtering of the aqueous samples collected in the field and prepared in the laboratory with a sieve of number 8 (2.36 mm) to separate large solids from mucilage of the coffee and to have samples without pollutants that affect the efficiency of the organic coagulant.

With base in the bibliographic revision, he proceeds to determine the concentration of mucilage in the samples collected in field, following the methodology made by Cendales et to the. 2016:

1. He weighs in a balance analytics (OHAUS, Galaxy 160) 3 capsules of porcelain to weight constant, attached to the Rule Official Mexican PROY-NOM-211-SSA1-2002, by each sample.

2. They add twenty ml of mucilage in each capsule and subsequently, he introduces the oven, with a constant temperature of 105° C, during 24 hours.

3. Once the capsule samples have been dehydrated, they are removed from the oven and allowed to cool in a desiccator to weigh the capsules and obtain the total solids. And thus, know the concentration of mucilage by liter of each sample.

To determine the efficiency of the mucilage of coffee as coagulant organic, he applies the technique of the proof of jugs, first determining the optimal pH with which there is better removal of solids, then determining the optimal dose of mucilage in ml.

1. The preparation of the water synthetic it implies add 0.5 grams of kaolin by each

liter that he has of drinkable water and shake mix in a grill shaker (StableTemp, Cole-parmer) at a speed of 500 rpm.

2. He measures 900 ml of water synthetic in the test tubes and he pours in glasses of precipitates of a liter **(Phipps** & Bird, Model PB-700 Jar tester).

3. He adjusts the apparatus of jugs to a speed of 100 rpm for subsequently add the dose of mucilage in cups of precipitate, giving rise to the mix fast that has a duration of one minute.

4. Subsequently, he changes to a mix slow, adjusting the speed to 40 rpm during fifteen minutes.

5. Once the mixing time has elapsed, operation is stopped by lifting the mixing paddles, allowing the flocs to settle for 15 minutes, to extract a sample of the supernatant and carry out the reading of turbidity with the turbidimeter (HACH, 2100N Turbidimeter).

Two jar tests are performed, one to determine the optimal pH and another for the optimal dosage. For samples taken in field, He makes a set of two evidence by each sample, while that for the extraction of mucilage made in laboratory, he makes to the three, six and eight days of fermentation.

For the optimal pH, 40 ml of coffee mucilage is prepared following the recommended methodology Cendales et al. 2016, since it reports a higher percentage of solids removal. The test was done with pH from 5 to 12. To reduce the worth of the pH, He uses acid hydrochloric (HCl), while that for increase he pH HE uses hydroxide of sodium (NaOH).

The second jar test consists of determining the greatest solids removal efficiency by varying the volume of coagulant with the identified optimal pH. Volumes ranging from 10 ml of mucilage to arrive to a volume of 70 ml, with intervals of 10 ml. between each one.

For the determination of efficiency removal is used the following equation:

$$\%\ removci\ or\ n = \frac{\text{Initial UNT} - \text{UNT final}}{\text{UNT initial}} * 100 \quad \text{Equation (1)}$$

Where
UNT: Nephelometric Unit Turbidity

RESULTS AND DISCUSSION

CONCENTRATIONS OF MUCILAGE

Table **2** shows the different concentrations according to the way in which the mucilage was extracted. different days after collecting the sample. 4 columns are observed, which represent the mechanical method "Mec", the fermentation done by hand in the field "Fer" and "Fer2" and the artisanal extraction done in the laboratory "Lab."

The "Fer" and "Lab" samples have approximate values even though the fermentation time is one week. difference. Therefore, it can be interpreted that the days of fermentation do not affect the concentration of total solids, without however, it infers that he method of extraction is he that influences.

The sample "Mech" It represents the extraction by half of the demucilaginator, where He detaches he mucilage of the grain without pass by a process of fermentation.

The days of fermented are due to the storage, with these results, he reaffirms that he method of extraction influences in the concentration of solids totals of mucilage, but not necessarily in the removal of turbidity.

The "Fer2" sample presents the lowest concentration compared to the "Fer" and "Lab" samples that share characteristics of extraction, this due to the dilution by the water washed.

WATER SYNTHETIC AND VARIATION PH

The conditions of the water to be treated

according to the described methodology were on average: initial turbidity of 625 UNT and a pH of 7.82. Without the addition of no other compound further that he kaolin previously mentioned.

For the case of the pH of mucilage of the coffee, he presents as a half acid with the days of fermentation, without changes considerable, staying within a rank of 4.03 - 3.38 for the first 8 days.

pH OPTIMUM

In the jar tests carried out with the selected mucilage samples, the results of the **Figure 2** where it is observed that, within the 5 tests, the trend is that as the pH of the solution increases, the removal percentage behaves in a similar way, increasing. That is, the mucilage of Coffee as a coagulant depends on the fermentation variables and the extraction method.

The trend lines allow us to point out that the coagulant sample with the lowest efficiency is that of "Mec", he can attribute to the low concentration of solids that presented.

The second lowest efficiency belongs to the "Fer" sample. This indicates that although the concentration of solids in the mucilage (Table 2), the change of the composition chemistry due to the days of fermentation affects in the efficiency of its use as a coagulant.

In the results obtained for the Lab 3 and Lab 6 samples, it is observed that the behavior of both in a range of neutral pH, is different by almost 10% removal, but as the different jars for the samples, trends removal are practically the same, approaching a 80% of effectiveness.

Analyzing only specific results, the Lab 3 sample was the one that presented the best efficiency, being up to of 91.8%, followed by Lab 6 (89.77%) and Lab 8 (89.45%), where in all samples the optimal pH obtained was of 12.

The best result in removal efficiency for optimal pH tests, according to the trend lines, he got with the sample of the laboratory for the proof made to 8 days of fermentation (Lab 8). This could indicate that the days of fermentation are the variable further determinant for the efficiency of the mucilage of coffee as coagulant.

OPTIMAL DOSE

Analyzing **figure 3**, a similar level can be noted in all the tests with a concentration of 20 ml for the different days of fermentation. He observed that he percentage of removal fluctuates by the themselves values in the following order of agreement with the days of fermentation 88.27%, 89.40%, 91.00% and 85.07% for the values of pH of eleven and for the percentages of removal in the pH of 12 are from 91.34%, 88.97% and 85.02%.

The difference in percentages for the 2 pH values turns out to be minimal, it can be observed with the tests "Lab-6" that its difference is 2.5% to 5% removal, this being a small value for a pH unit. With these results show that coffee mucilage is presented as an organic coagulant option and not increases the turbidity as reported by Cendales et al., in his work of the 2016.

Of the same manner, the changes with the dose of 10 to 20ml of mucilage of coffee they can result little ones, already that the difference is a maximum of 5% removal. The best removal percentages are found with values of 20 ml of coffee mucilage with a removal percentage of 91.34% at pH 12. With a pH of 11 it turns out that the better percentage of removal gets with the same dose of mucilage of coffee.

According to the results obtained and in comparison, with Barreto Pardo et al., in their 2022 work, it is demonstrated that determination of the Optimum pH turns out to be predominant for a better removal of turbidity.

It is observed that the removal percentages remain within a ±5% range, with changes in

the days of fermented, he kind of extraction and dose used.

CONCLUSIONS

The efficiency of coffee mucilage as an organic coagulant for turbidity removal was evaluated. considering the pH and optimal dose, where the results obtained present a good turbidity removal efficiency for the characteristics of the water synthetic.

The efficiency of the mucilage of the coffee as coagulant natural for the removal of turbidity, is influenced mainly due to its fermentation time. On the other hand, the mucilage extraction method is not an influencing variable. This could be beneficial for its application in different coffee-growing areas, regardless of the process of benefit.

There are areas of opportunity to improve the efficiency of this coagulant, defining whether there is a relationship between the planting altitude and removal efficiency; the maturity of the harvested fruit; the species and variety of coffee or the mix with a chemical agent coagulant.

ANNEXES (TABLES AND FIGURES)

Braham and Bressani taken of Nadal (1959)	Braham and Bressani(1978)	Door and Rivers (2011)
Water - 84.2%	Pectic substances totals 35.80%	Carbohydrates 85.5%
Protein - 8.9%	Total Sugars ½ - 45.8%	Proteins 9.3%
Sugar - 4.1%	Reducing sugars -30.0%	Ashes 4.3%
Acid Pectic - 0.91%	Sugars No Reducers - 20.0%	Acids (Lactic) 1.7%
Ashes 0.7%	(Cellulose + Ash) -17.0%	Alcohol (Ethanol) 1.2%
		Lipids 1.2%

Board 1. Composition of Mucilage of Coffee.

(Own elaboration, 2023) *OK to different authors

	Mec		FerFer2Lab	
Days	9	7	7	2
Concentration (g/L)	8.47	34.48	6.69	33.65

Board 2. Concentration of Mucilage coffee in samples collected

Mech: Mechanic. Fer: Fermented 1. Fer2: Fermented 2. Lab: Laboratory. (Own elaboration, 2023)

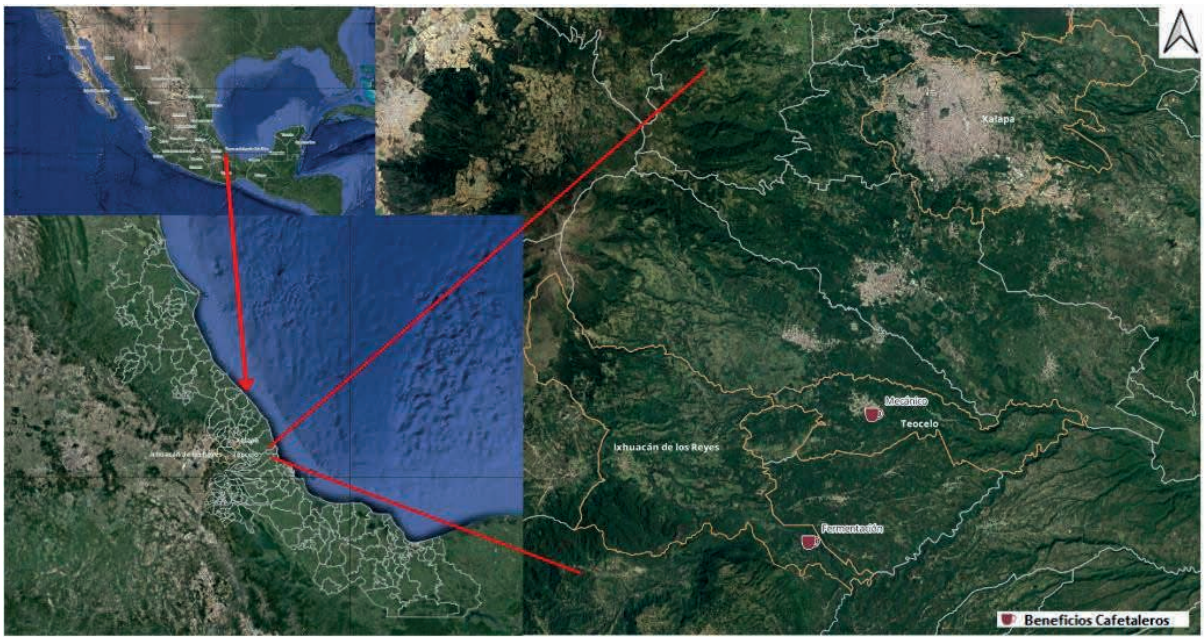

Figure 1. Site Location Map *(*own creation, 2023). *You can see the image in the upper left corner of Mexico, expanding the limits and municipalities of the state of Veracruz towards the lower zone. The enlargement on the right indicates the municipalities of Theocelus and Ixhuacan of the Kings, demarcations to where belong the benefits visited.*

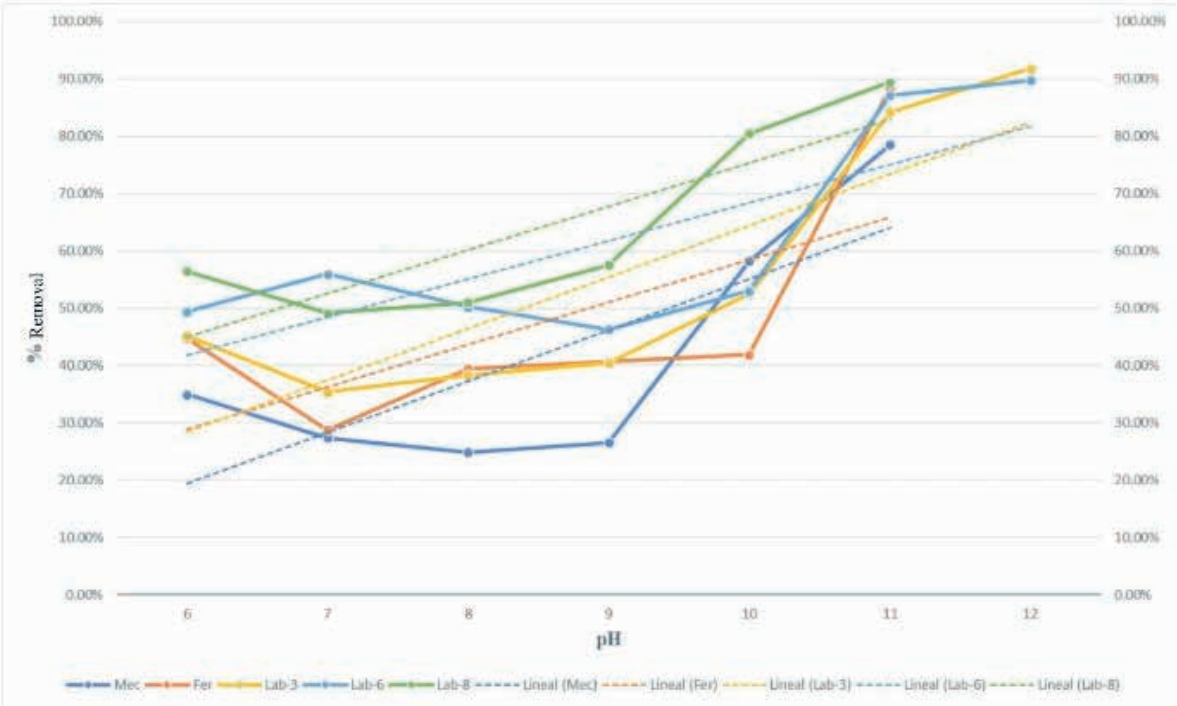

Figure 2. Efficiency of the percentage removal with regard to the pH optimum (Own elaboration, 2023).

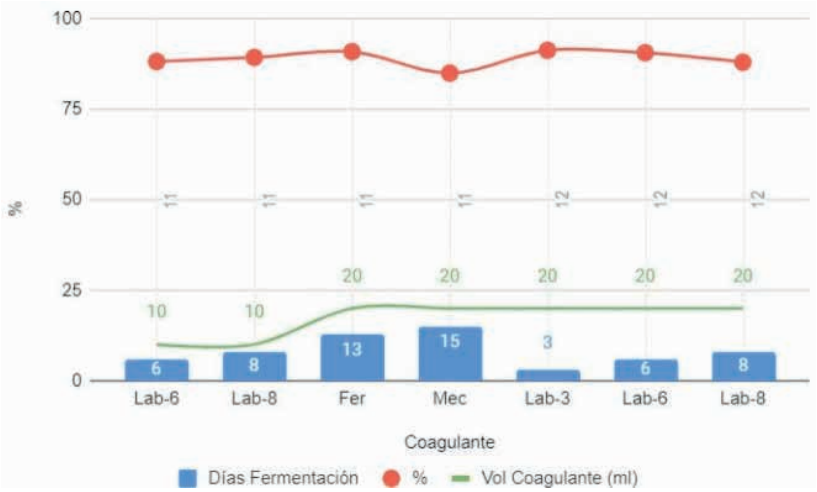

Figure 3. Percentage of removal, of agreement to the coagulant used. *It indicates the days of fermentation in the columns, the volumes used of coagulant, So as he pH optimum of each proof (In vertical)* (Own elaboration, 2023).

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