













Study to obtain Activated Carbon at the laboratory level of the bagasse of the Maguey Pitzometl (*Agave marmorata*) of Zapotitlán Salinas, Puebla





Estudio para obtención de Carbón Activado a nivel Laboratorio del bagazo del Maguey Pitzometl (*Agave marmorata*) de Zapotitlán Salinas, Puebla

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Abstract


The Agave genus has a wide presence in Mexico, where approximately 75% of its total species are located, many of them endemic, as is the case of the Agave marmorata or Maguey Pitzometl, which is present in the Zapotitlán Salinas Puebla Region, which belongs to the Tehuacán-Cuicatlán Biosphere Reserve. Since pre-Hispanic times they have been used as a source of food, drink, construction, ornaments being part of the regional identity, history and culture. Currently, the growing demand for products distilled from Agave such as mezcal and tequila, have led to practices that threaten its natural regeneration. This activity generates large volumes of by-products such as bagasse, both from the maguey leaves that are removed to work only with the pineapple or center of the plant, and from the solid residue of said pineapple itself after subjecting it to the extraction process. The present work shows the results of the study to obtain Activated Carbon at the laboratory level of the bagasse of the Maguey Pitzometl (*Agave marmorata*) of Zapotitlán Salinas, Puebla as an alternative for the management and sustainable use of this by-product.

Resumen

El género *Agave* tiene una amplia presencia en México, donde se albergan aproximadamente el 75% del total de sus especies, muchas de ellas endémicas, como es el caso del *Agave marmorata* o Maguey Pitzometl, que se encuentra presente en la Región de Zapotitlán Salinas Puebla, la cual pertenece a la Reserva de la Biosfera Tehuacán-Cuicatlán. Desde tiempos prehispánicos han sido utilizados como fuente de alimento, bebida, construcción, ornamentos siendo parte de la identidad, historia y cultura regional. Actualmente, la creciente demanda de productos destilados a partir del *Agave* como el mezcal y el tequila, han llevado a prácticas que amenazan su regeneración natural. Esta actividad genera grandes volúmenes de subproductos como el bagazo, tanto de las pencas del maguey que son retiradas para trabajar solo con la piña o centro de la planta, como del residuo sólido mismo de dicha piña después de someterla al proceso de extracción. El presente trabajo muestra los resultados del estudio para obtención de Carbón Activado a nivel Laboratorio del bagazo del Maguey Pitzometl (*Agave marmorata*) de Zapotitlán Salinas, Puebla como una alternativa para la gestión y aprovechamiento sustentable de este subproducto.

Study to obtain Activated Carbon at the laboratory level of the bagasse of the Maguey Pitzometl (<i>Agave marmorata</i>) of Zapotitlán Salinas, Puebla		
Objective	Methodology	Conclusions
To obtain Activated Charcoal from Maguey Pitzometl Bagasse from Zapotitlan Salinas Puebla at laboratory level 	Collection and cleaning of the maguey leaves of the Region under study, obtaining the bagasse, drying, carbonization, activation, washing, drying, grinding, characterization, packaging.	The bagasse of Maguey Pitzometl, which was previously characterized, is a good organic material for the production of activated carbon. Physical and chemical activation was applied using anhydrous potassium carbonate at two concentrations: 40% and 60%.

Bagasse, Activated Carbon, Endemic, By-product, Use

Estudio para obtención de Carbón Activado a nivel Laboratorio del bagazo del Maguey Pitzometl (<i>Agave marmorata</i>) de Zapotitlán Salinas, Puebla		
Objetivo	Metodología	Conclusiones
Obtener Carbón Activado a partir de Bagazo de Maguey Pitzometl de Zapotitlan Salinas Puebla a nivel laboratorio. 	Recolección y limpieza de las pencas de maguey de la Región en estudio, obtención del bagazo, secado, carbonización, activación, lavado, secado, molienda, caracterización, empaclado.	El bagazo de Maguey Pitzometl, el cual se caracterizó previamente, es un buen material orgánico para la producción de carbón activado. Se aplicó activación física y química utilizando carbonato de potasio anhidro a dos concentraciones 40% y 60%.

Bagazo, Carbón Activado, Subproducto, Aprovechamiento

Area: Advocacy and attention to national problems

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Introduction

Plants of the genus *Agave* are widely distributed throughout Mexico, where approximately 75% of all species are found, many of which are endemic, such as *Agave marmorata* or Maguey Pitzometl, native to the Zapotitlán Salinas Puebla region, which belongs to the Tehuacán-Cuicatlán Biosphere Reserve.

Agaves are important components of arid and semi-arid ecosystems (Delgado-Lemus, *et al.*, 2014). In the Tehuacán-Cuicatlán Biosphere Reserve, the survival of this genus is related to various ecological processes of mutualism, where a host plant is required for germination and establishment (Estocapan, 2017). In addition, the flowering of agaves provides food for bats, birds, and insects throughout the year (Rojas Martínez, *et al.*, 1999). The agaves of the Tehuacán Valley have been called a nectar oasis due to the high nutritional quality of their nectar (Ornelas, *et al.*, 200). This characteristic allows nectarivorous bats (Phyllostomidae) to remain permanently in the region (Rojas-Martínez *et al.*, 1999), which in turn play an important role as pollinators and seed dispersers for the columnar cacti of the region, which can be seen on the horizon of the valley.

Agave is a renewable natural resource with multiple applications that has the ability to adapt and grow in arid and semi-arid environments, with important ecological functions such as being a living barrier, soil improver and erosion reducer. The applications of agave and its by-products are receiving both national and international attention in nutrition, biofuels and composite materials.

All components of these plants have attracted interest in researching their potential: leaves, bagasse, fibres, thorns, cuticle, flower and stem, mainly due to their high cellulose content and some bioactive compounds. Álvarez-Chávez, J. *et al.* (2021) present an overview of agave by-products, their nutraceutical value, current applications and processing methods. Among the applications described by these authors, it is noteworthy that agave fibres are used for reinforcement and the production of polymer-based composites due to their thermomechanical properties.

Agave bagasse is considered a promising raw material for biofuels, attributed to its high water efficiency and biomass productivity, as well as its high carbohydrate content. The optimisation of physical and chemical pretreatments, enzymatic saccharification and fermentation are key to biofuel production. Emerging technologies, such as ultrasound, may provide an alternative to current pretreatment processes.

Box 1



Figure 1

Maguey Pitzometl from Zapotitlán Salinas, Puebla

Traditional uses include the production of pulque, mezcal, and tequila from agaves such as *Agave marmorata*. Currently, there is growing demand (CRM, 2020) for both mezcal and tequila, putting strong pressure on the natural resources needed for their preparation and generating a large amount of waste from the respective production processes.

According to Sierra, E. *et al.* (2021), after extracting all the compounds required for the manufacture of spirits from the agave, around 360,000 tonnes of plant waste known as bagasse are obtained each year.

This study addresses the study of an application for obtaining activated carbon from bagasse for its sustainable use in the region of Zapotitlán Salinas Puebla, with the collaboration of the Sembradores de Maguey Pitzometl de Zapotitlán Cooperative Society, Salinas Puebla, S. C. de P. de R. L. de C. V.

It should be noted that activated carbon is a material of great interest due to its important uses, such as those described by [Oblitas-Alcarraz \(2025\)](#) for the removal of the heavy metal cadmium (Cd^{2+}) from aqueous solutions using activated carbon made from eucalyptus (*Eucalyptus globulus*). This study focuses on the use of activated carbon as an absorbent material to remove cadmium from contaminated water, a common problem due to mining and other industrial activities. Similarly, from the thesis by [Peña-Cajan J. \(2025\)](#), it can be concluded that the design of an activated carbon production plant using rice husks is a project that meets the commercial, technological, and economic viability requirements for a city in Peru.

Activated carbon obtained from coconut shells proved to be an efficient alternative in laboratory tests in the thesis by [Maldonado-Vila, K. and Urquiaga-Casahuaman, J. \(2025\)](#), as a low-cost and environmentally sustainable alternative for reducing lead in contaminated water bodies, such as the Rímac River in Peru, contributing to the mitigation of health risks and the fulfillment of SDG 6: Clean water and sanitation.

Undoubtedly, the use of a by-product such as maguey bagasse to obtain activated carbon supports the availability of alternative adsorbent agents to eliminate contaminants, odors, and harmful chemicals in industrial, commercial, and domestic applications within a circular economy.

Methodology to be developed

Collection and cleaning of maguey leaves from the region under study in coordination with the members of the Sembradores de Maguey Pitzometl de Zapotitlán Cooperative Society, Salinas Puebla, S. C. de P. de R. L. de C. V.

Obtaining bagasse for the study, with recovery of the extract for use and exploitation by members of the Sembradores de Maguey Pitzometl de Zapotitlán Cooperative Society, Salinas Puebla, S. C. de P. de R. L. de C. V.

Air drying under aseptic conditions in the Environmental Engineering Laboratory of the National Technological Institute of Mexico/Tehuacán Technological Institute, where the study was continued.

To obtain activated carbon, the tests were carried out in triplicate, where the initial weight of each dry bagasse sample was recorded on an analytical balance, subjected to carbonisation in a muffle furnace at 400°C for 20 minutes, left to cool in a desiccator, and its final weight recorded on an analytical balance. The yield per sample was calculated.

The carbonised samples were pulverised with a mortar and pestle to obtain a homogeneous particle size.

Two activation processes were carried out, obtaining three types of carbon according to the activation method: physical activation and chemical activation with anhydrous potassium carbonate as the activating agent at two levels of 40% and 60% concentration by volume. In this case, the carbon samples were placed in saturation conditions with a contact time of 16 hours, the activating agent was separated by filtration, and the samples were subjected to a second carbonisation in a muffle furnace at 500°C for one hour. Once weighed and cooled, the product obtained is washed with distilled water at 70°C until a pH of 7 (± 0.5) is obtained in the final product, as evaluated with a potentiometer. The product is then dried in an oven at a temperature of 100°C ($\pm 10^\circ\text{C}$) for 48 hours, the final weight is recorded, and the yield is calculated. The samples are then crushed in a mortar with a pestle, and the particle size of the three types of charcoal obtained is determined using 70, 100 and 200 mesh sieves, placed in series from largest to smallest mesh size.

The weight of each sieve is recorded on a grain scale, the weighed sample is placed on the analytical balance in the upper sieve and sifted for 20 minutes, and then the carbon sample residues retained in each sieve are weighed on the analytical balance.

The percentages of carbon retained by each sieve were calculated using the following formula:

$$A_n = \left(\frac{W_1 - W_0}{M} \right) \times 100$$

A_n = Percentage of carbon retained

W_1 = Weight (g) of sieve plus retained carbon sample

W_0 = Weight in grams of the sieve

M = Weight of sample in grams [$\sum(W_1 - W_0)$]

n = Number of sieve used

Results

The Maguey Pitzometl leaves were harvested from plantations belonging to members of the Sociedad Cooperativa Sembradores de Maguey Pitzometl de Zapotitlán, Salinas Puebla, S. C. de P. de R. L. de C. V. Cooperative Society, taking samples of leaves from mature maguey plants with five rosettes of leaves, in order to work with plants of a similar maturity index.

Figure 2 shows the cutting of the clean leaves to obtain the bagasse, work carried out at the facilities of the participating Cooperative Society.

Box 2



Figure 2

Chopping the Maguey Pitzometl

Figure 3 shows the extraction of the juice and bagasse by passing the pieces of stalk through a stainless steel juice extractor in collaboration with the members of the Cooperative Society.

Box 3



Figure 3

Obtaining bagasse from Maguey Pitzometl

The performance results of the activated carbons obtained are summarised in Table 1, reporting the average values of three samples per activation method. The values vary significantly between treatments, mainly because in chemical activation, the washing process to remove excess sodium carbonate and lower the final pH causes a loss of fines.

Box 4

Table 1

Percentage yield of activated carbon production (average values of three determinations by activation method)

Activation	Sample (g)	Carbon obtained (g)	Performance (%)
Physical Activation	30.0077	8.0073	26.6841
Chemical Activation (K ₂ CO ₃) at 40%	35.0001	3.6335	10.3813
Chemical Activation (K ₂ CO ₃) at 60%	35.0005	3.6340	10.3827

The production yield of activated carbon varies greatly depending on process factors, as well as the raw material used and the activation conditions, but values such as 15.43% have been reported in an optimised study based on date palm seeds (Bamerdhah, S., *et al.*, 2025), with a higher yield for physical activation compared to this value, but a decrease with chemical activation. Figure 4 shows the weighing of the carbons obtained to monitor the yield calculation.

Box 5



Figure 4

Weighting on an analytical balance of the activated carbons obtained

Tables 2, 3 and 4 show, respectively, the results obtained from the determination of particle size in the samples of the three types of coal obtained.

Box 6

Table 2

Particle size distribution of activated carbon obtained by physical activation.

N° Tamiz	Retained weight (g)	Percentage retained (%)
70	0.4550	6.4534
100	0.9691	13.7451
200	0.9716	13.7805

The results of particle size tests on activated carbon indicate the percentage by weight of material that is retained or passes through different mesh screens, defining its particle size range.

Box 7

Table 3

Particle size distribution of activated carbon obtained by chemical activation with 40% K_2CO_3

N° sieve	Retained weight (g)	Percentage retained (%)
70	0.2103	3.0010
100	0.6318	9.0159
200	0.7988	11.3990

Generally, a smaller particle size improves the adsorption rate of carbon.

Box 8

Table 4

Particle size distribution of activated carbon obtained by chemical activation with 60% K_2CO_3

N° sieve	Retained weight (g)	Percentage retained (%)
70	0.1008	1.4373
100	0.4012	5.7208
200	0.6038	8.6097

Disclosures

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this paper.

Contribution of authors

López-Vigil, Miriam Silvia: Contributes with the idea of the project, development and organisation of the research.

Gomez-Flores, Nidia Esther: Contributes with collaboration in experimental activities.

Santos-Alvarado, Héctor: Contributed to the data analysis.

Islas-Torres, Héctor: Contributed to the review and editing.

Availability of data and materials

The data analysed during the current study are available from the corresponding author upon reasonable request.

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Abbreviations

CA	Activated Carbon
K ₂ CO ₃	Potassium Carbonate
S.C. de P. de R.	Limited Liability Cooperative
L. de C.V.ANN	Production Company with Variable Capital

Conclusions

Agave marmorata is a species of high biocultural value, with deep ties to the communities where it grows, especially as it is an endemic species that has been present for thousands of years in specific ecosystems in Mexico, such as the Zapotitlán Salinas region in Puebla, which belongs to the Tehuacán-Cuicatlán Biosphere Reserve.

Its long maturation process, which fluctuates between 7 and 10 years, its restricted distribution and the growing demand for its exploitation create a combination of opportunity and risk, as it can be a source of local development but also places it in a vulnerable position if it is not managed sustainably.

This study presents the morphological characterisation of the Maguey Pitzometl of the Zapotitlán region, Puebla, which is one of the most important reservoirs of *Agave marmorata*, contributing to determining its particular morphological, physical and chemical attributes. Salinas, Puebla, which is one of the most important reservoirs of *Agave marmorata*, contributing to the determination of its particular morphological, physical and chemical attributes. In the context of sustainability and the circular economy, the production of activated carbon from agricultural waste such as Maguey Pitzometl bagasse is an alternative of great interest. The yields obtained at the laboratory level by physical activation exceed the values reported by Bamerdhah, S., *et al.*, (2025) using date palm seeds as a source.

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