Year 2 Study- De la Raiz al Remedio:

Engineering Fiber-Gauze Infused with Traditional Mexican Plants

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Advanced Research Methods

by

[redacted]

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ABSTRACT

Medication is one of the greatest inventions made by humanity that is often lifesaving. Although medicine is beneficial for those who need it, the cost of it can be expensive. This can be dangerous, especially for developing countries that can't even buy slightly cheaper alternatives that work less effectively. This research aims to engineer and formulate a cost-effective and practical alternative for gauze and antibiotics using traditional Mexican plants.

This research was conducted by the following methods: First, Yerba de Manso leaves, Maguey leaves, and Cempasuchil are collected. After they were placed in a jar with ethanol for a week. To get the extract, I used a rotary evaporator and as soon as the ethanol was separated from the extracts, a Centri Fuge was used to get the Cempasuchil extract. With the rest of the Maguey leaves, they were beaten then boiled for 15-20mins until no longer hard. After beating each leaf then the pulp was removed by cutting vertical lines with a fork/knife. To remove remaining pulp, soak into water until all debris is cleaned off. With the dry fiber, braid into a gauze like strand.

Based on results the gauze can absorb more than twice its size with extract. Based on the antibacterial tests, both Cempasuchil and Yerba de Manso showed significant results when its concentration was 40% and 60% and a continuous diffusion rate. This means that the fiber-gauze is an effective alternative.

RATIONALE

Since the beginning of time bacteria, disease, and death have been a part of the world. One being the starting catalyst to the other. Bacteria was and still are some of the deadliest organisms to exist. Throughout the ages, humans have fought to survive as well as expand their knowledge. The only hope for their survival was whatever humans had around them. Herbal medicine has been around way before recorded history. According to Science News Today, this early form of treatment paved the way for modern medicine that we all know of today. Even so, around the world herbal medicine has been engraved in some countries not only for its low cost but for its cultural significance. This research aims to engineer effective a fiber-gauze infused with plant extract that works against bacteria at a low cost using Mexican plants used in traditional medicine.

BACKGROUND RESEARCH

Raices Ancestrales: The Origens of Modern Medicine

Herbal medicine presents itself in many different forms, especially depending on where it is practiced. This form of treatment also has many names such as: curanderismo, herbalism, and ayurveda. As different as their names may be they all share the same tool of treatment. Herbal medicine is the practice of using plants for medicinal purposes. Aside from plants, roots, leaves, flowers, and seeds were also used as such.

Long before recorded history, humans have used Herbal medicine as a form of treatment. According to mountsinai.org, medicinal plants have been in use as early as 3,000 BCE. All

around the world medicinal plants have been used for similar purposes to other countries. An example of herbal medicine is Mexicans, especially pre-Colombian civilizations which include the Mayan and Aztec people.

Barriers to Care: Antibiotic Access and Workplace Risks

While antibiotics are the most used medication out there, they can be quite expensive. These medications can treat injuries before they become life-threatening. On average antibiotics cost from $8 to $40, but name brands could cost up to $200 according to bettercare.com (April 11, 2025). Of course, the price can depend on the pharmacy, dosage, insurance, and brand.

According to U.S Bureau of Labor Statistics, Hispanics make up about 8.2% of the employed U.S. workforce. The most common job where injuries occur for Hispanics is construction. Falls, slips, cuts, even scraps could become a problem if not treated. Some of these injuries could be fatal, producing a large percentage of deaths for Hispanics in the workforce compared to other workers.

Addressing Wound Infections: Battling the Invisible Enemy

Bacterial Infections often happen from neglect of a wound/injury. Using antibiotics that aren't effective can worsen the issue as well. These infections can range in effects on the body from delayed healing to the amputation of the limb or area. A common type of bacteria found in injuries is E. coli. This bacterium is spread by coming in contact with feces or waste of any kind. Especially by not maintaining hygiene like the cleaning of hands, this bacterium can enter

injuries and become a problem. E. coli strains have been known to become resistant to multiple drugs, this becoming more common.

Curando con Plantas: From Folk Wisdom to Herbal Healing

Yerba de Manso is a plant native to Southwestern North America that has been recognized for its healing abilities. This plant is anti-inflammatory, antimicrobial, and has antioxidants. Known as Lizard Tail in America, it was traditionally used by indigenous communities for the many properties it was seen to have.

The Maguey plant, otherwise known as Agave, is famous for making alcohol. Not only can it be used to make tequila, but it can also be eaten, and used for fabric etc. This versatile plant is quite popular in Mexico. Aside from all of its benefits, the Maguey plant may contain medicinal benefits. It contains soap-like properties, can be anti-fungal, antiseptic, and anti-inflammatory.

Cempasuchil is one of the most popular flowers in Mexico. This flower is used for Day of the Dead, which represents the bridge between life and dead. This iconic flower had a tie with medicinal and religious practices long ago as well as used to promote menstruation and an aid to urination. The properties its believed to have are anti-bacterial, anti-inflammatory, and containing antioxidants.

YEAR 1 STUDY

The results showed that Yerba remains significant after doing the alpha adjustment.

Treatments	T-Statistic	P-Value	Bonferroni Significant	Interpretation
Yerba	-6.99121	2.30E-05	TRUE	Significant
Orange	1.956835	0.078849	FALSE	Not Significant
Cinnamon	-1.64751	0.127693	FALSE	Not significant

Yerba de Manso showed 100% effectiveness against e. coli as an ointment and an extract unlike orange leaf and cinnamon extracts and ointments where results varied widely.

STATEMENT OF THE PROBLEM

General Problem: This research aims to investigate and engineer effective antibiotic alternative being a fiber-gauze infused with extracts that prevent bacteria growth using Mexican plants used in traditional medicine.

Specific Problem:

To be more specific, this research answered these following questions:

1. What plant extract prevents bacteria growth, Yerba de Manso or Cempasuchil ? If so, which one is more effective?
2. Can an effective fiber-gauze infused with the traditional Mexican plant extract be engineered to fight off bacteria?

VARIABLES OF STUDY

Hypothesis: During pre-colonization times the roots of modern medicine began to sprout. It has been recorded that Aztecs might have been more advanced for their time than most believe. As the 'warrior people' they knew a thing or two about the treatment of wounds. Dressing the wounds with agave sap for example. Even today, these plants are used for their healing properties. Yerba de Manso, Maguey, and Cempasuchil have been found to contain anti-bacterial and anti-inflammatory properties while being used in Aztec treatments. This research aims to engineer and formulate anti-bacterial alternatives using these plants as well as fiber-gauze to prevent bacteria growth.

Independent Variable: Yerba de Manso, Maguey, and Cempasuchil Extracts

Dependent Variable: Growth of Bacteria

Constants: Type of Bacteria, Ingredients, Fiber, Amount of Extracts

METHODS

This part of the experiment includes materials and procedures that will be utilized during this experimentation:

Formulating and Extracting Traditional Plants

Yerba de Manso leaves, Maguey leaves, and Cempasuchil flowers were collected. Before extraction, they were cleaned using bleach and a sterile cotton swab, then placed in a jar. Each plant was placed in separate jars with ethanol for a week until visible color change occurred. (Figure 1)

Figure 1. Extracting Yerba de Manso with ethanol (Image Taken by student)

After a week, the extract was drained to separate the debris. To separate the extract and ethanol, it was placed in a rotary evaporator going at 100RPM at 60 degrees. Once dripping of the ethanol stops in a separate flask connected to the device, the extract is pure and free of ethanol content. To get pure cempasuchil extract, it was placed in a Centri Fuge and timed for 1 minute. The extract was taken and placed into its jars/tube and put away properly for later use.

Engineering Fiber-gauze

The remaining Maguey/Agave leaves were pounded with a wooden stick to allow the fibers to separate. Once flat enough, each leaf was boiled for 15-20 minutes until no longer hard and stiff. Due to the heat of the leaves, tongs were used to hold down the leaves, once again they were pounded with a wooden stick to separate even more. While using the tongs to hold down the leaves, vertical lines were cut to allow the fibers to come out. After allowing the cut fiber to cool off, remove large chunks of pulp from the fibers.

Figure 2. Agave Fiber being cleaned and separated (Image Taken by student)

Then the fibers were soaked in hot water to remove any remaining debris. Over a week the water will be changed to clean the fibers completely (Figure 2). With the clean fibers, they were dried for a day then braided fibers to make bigger strands. The strands were then put together in a gauze like strand.(Figure 3)

Figure 3. Fiber prototype (Image Taken by student)

STATISTICAL ANALYSIS

The data was collected and analyzed using MS excel to get the absorbency rate, zone of inhibition, R^2 value, diffusion release, and Higuchi analysis. The data collected shows the zone of inhibition and the effectiveness of extracts and fiber-gauze.

Potential Risks and Safety Precautions

Potentially hazardous substances. The live bacterial sample tube of E. coli was ordered from Carolina Biological with a Biosafety Level 1.

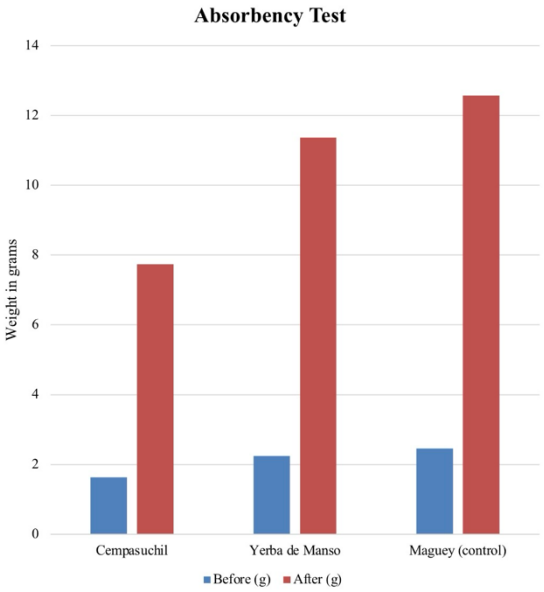
Site of experimentation and biological containment. The experiment was conducted within the science classroom with all people following safety guidelines. The laboratory sink and countertop were utilized in performing the experiment. Petri dishes were kept closed all throughout the experimentation to avoid contamination. A digital incubator was used to control the temperature for the growth of the bacteria.

Procedures to minimize risk. The researcher used PPE (gloves, mask, goggles, and laboratory coat) in performing the antimicrobial test. Petri dishes were kept sealed at all times. The laboratory sinks and the countertop were sanitized before and after the experimentation.

RESULTS

Part 1: Absorbency Test

$$\text{Percent Absorbency} = \frac{\text{After} - \text{Before}}{\text{Before}} \times 100$$

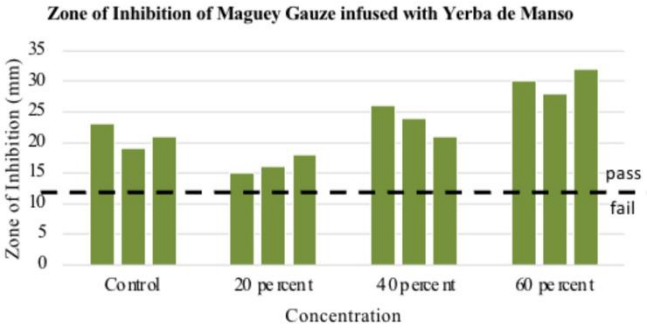


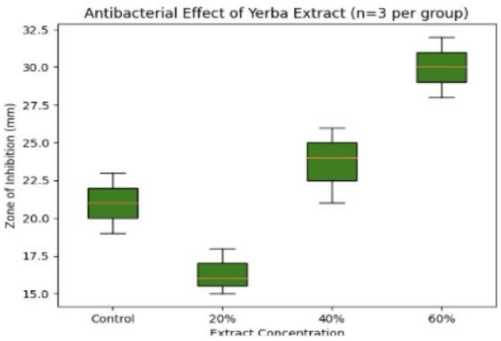
Graphs were made by student

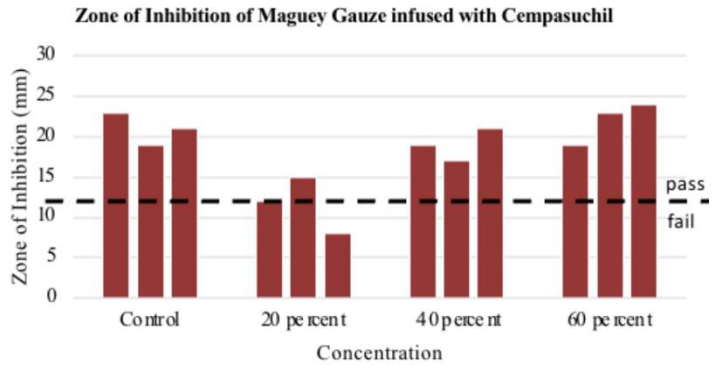
A gauze was soaked in an extract then weighted after to see how much each fiber absorbed. The formula above was used to measure the percentage of absorbency.

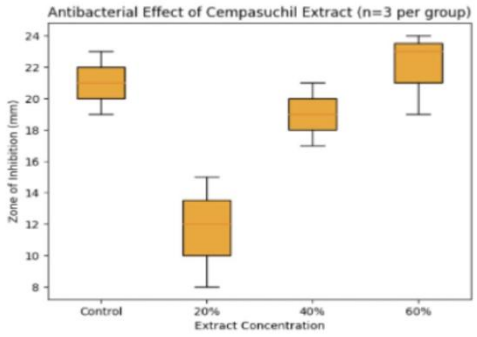
- The gauze before the Cempasuchil was 1.63g and 7.74g after, absorbing 375%.
- The gauze before Yerba was 2.24g and 11.37g after, absorbing 407%.
- The gauze before Maguey was 2.46 and 12.57 after, absorbing 411%.

Part 2: Antibacterial Testing of Plant Infused Gauze





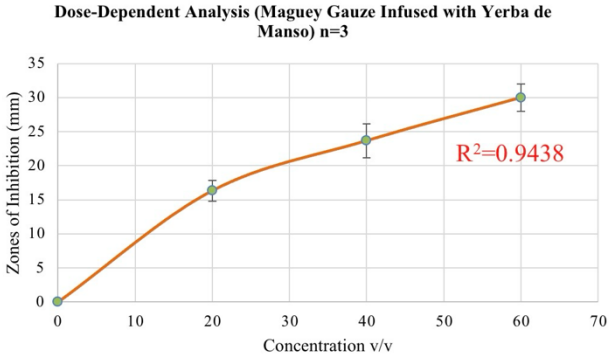


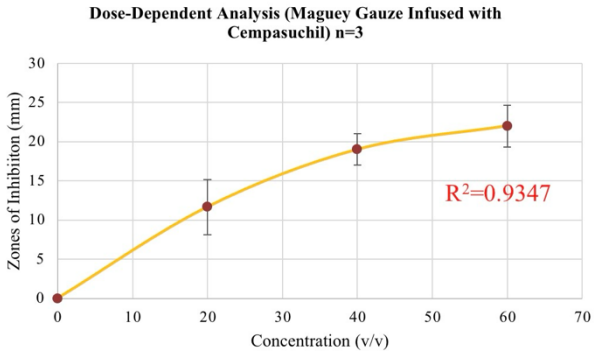


Graphs were made by student

Both plant extracts showed antibacterial activity when infused into maguey gauze. Yerba de Manso demonstrated a stronger and more consistent dose-dependent effect, with inhibition zones increasing from 20% to 60% concentration. Cempasuchil showed weaker activity at lower concentrations but improved at 60%. Overall, higher extract concentrations produced greater bacterial inhibition, with Yerba de Manso performing better than cempasuchil. *(Note: Amoxicillin was used as a positive control)*

Part 3: Dose-Dependent Analysis





Graphs were made by student

Both plant extracts showed a clear dose-dependent antibacterial effect, with inhibition zones increasing as extract concentration increased. Yerba de Manso demonstrated a slightly stronger and more consistent response, as reflected by a higher R^2 value. The high R^2 values for both extracts indicate a strong correlation between concentration and antibacterial activity. (Note saline solution was used as a negative control, 0%)

Part 4: Diffusion Release Analysis Using ImageJ Program

Calculate the Area of the Paper

The paper was 90mm, and to calculate the area, I used the radius (45mm) and used the area of a circle formula

$A = \pi r^2$ $A = \pi(45mm)^2$

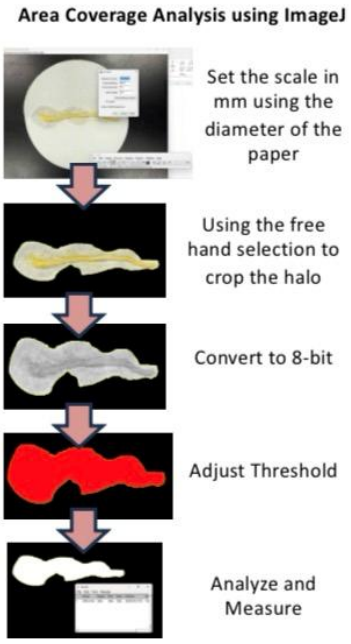
A= 6362 mm

To find the percent area coverage, I used this formula:

$$\%\text{Area released} = \left(\frac{\text{Halo area}}{\text{Total filter paper area}}\right) \times 100$$

Yerba de Manso		
Time (min)	Halo Area (mm)	%
0	0	0
5	876	13.8
10	1632	25.7
20	3212	50.5
30	5043	79.3

Cempasúchil		
Time (min)	Halo Area (mm)	%
0	0	0
5	754	11.9
10	1336	21.0
20	3014	47.4
30	4879	76.7



Graphs and pictures were made by the student

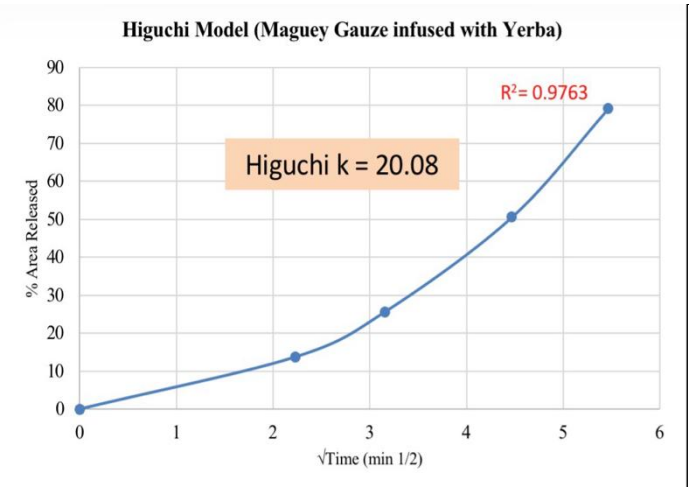
The diffusion release of the plant extracts from the maguey gauze was analyzed using ImageJ by measuring the halo area formed on a 90 mm filter paper over time. The halo area was converted into percent area released using the total filter paper area. Both Yerba de Manso and Cempasuchil showed a steady increase in percent area over time, indicating continuous diffusion of the extracts from the gauze.

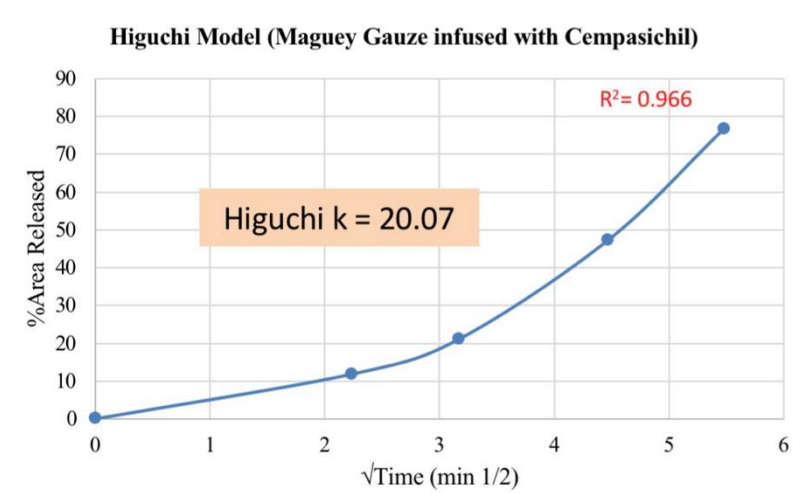
Part 5: Higuchi Drug Release Analysis

I used the Higuchi model because it helps determine whether the plant extract is released from the maguey gauze through a diffusion-controlled process, which is typical for porous natural fiber wound dressings. To do this, I used this formula:

$$Q = k_h\sqrt{t}$$

Q = cumulative amount or percent released
$\mathbf{k_h}$ = Higuchi constant (release rate constant)
t = time
√t = square root of time





Graphs were made by the student

Both extracts showed a strong fit to the Higuchi model ($R^2 \approx 0.97$), indicating that the release from the maguey gauze is primarily diffusion-controlled. The similar Higuchi constants (~20) suggest that both plant extracts diffuse from the gauze at nearly the same rate.

DISCUSSION AND CONCLUSION

Does the fiber-gauze work effectively?

- Based on my results, the fiber-gauze absorbs more than twice its original weight, making it effective in absorbing extracts/liquids as well as showing continuous diffusion rates.

Does it prevent bacteria growth?

- Based off the antibacterial tests, both Cempasuchil and Yerba de Manso showed significant results when

After conducting my research, I found out that fiber from Maguey could be used to make a fiber-gauze. Using traditional Mexican plant's extract can be an effective way to prevent bacteria growth in wounds.

Importance/Significance of the Study

My results provide a cost-effective alternative to modern medicine. This is evidence that traditional medicine can be used against disease/bacteria to better the health of communities in need that are already used to these methods.

Future Plans and Possible Applications

For future research I plan to:

- Continue research on traditional plants as solutions for communities in need.
- Engineer Cost-effective treatments for those that can't afford expensive treatments.
- Work and study with others in this field of study.

Acknowledgment

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