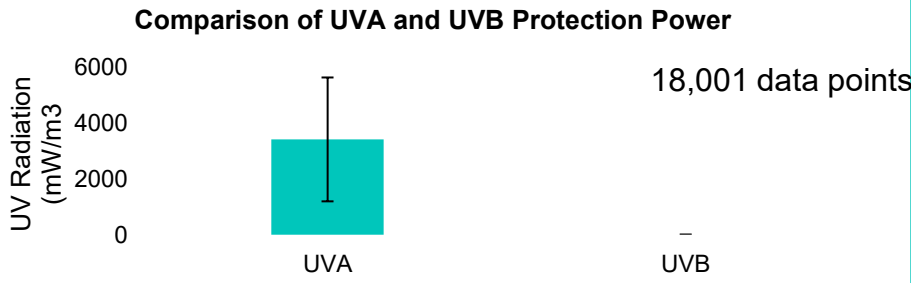
La Flor, el Cactus y el Aceite: Developing a Natural Sunscreen Using Cempasúchil

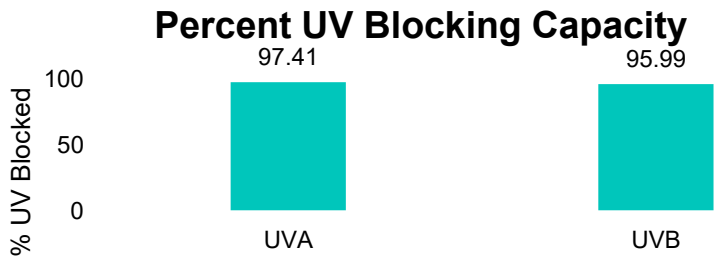
Background Research and Questions

Traditional chemical sunscreens containing oxybenzone protect against UV radiation but often harm marine ecosystems and may disrupt human hormones. While natural alternatives like zinc oxide or antioxidant-rich plants like cempasúchil offer more eco-friendly benefits, they face challenges in maintaining formulation stability and efficacy. Balancing scientific validation with environmental safety remains essential for developing reliable, non-toxic sun protection.

Research Goal: This research aims to formulate a natural sunscreen made of natural ingredients against harmful UV rays.

Data Analysis and Results





Methods

Flower Extraction: Marigold flowers were soaked in a chemical solution for one week.
Nopal Extraction: Diced cactus pads were heated in water for one hour and filtered.
Concentration: Both extracts were concentrated using a rotary evaporator.
Formulation: Extracts were emulsified with natural butters and oils in a warm bath.
Incubation: The mixture was sealed and aged for several days to reach high viscosity.
UV Testing: The product's UVA/UVB protection was measured with a radiation sensor.
Biological Testing: The extract was tested against *Candida albicans* on agar gel.

Discussion and Conclusion

This biosunscreen demonstrates robust, broad-spectrum efficacy by blocking 97.41% of UVA and 95.99% of UVB radiation, providing sustained protection validated across over 18,000 data points. Based on its UVB attenuation, the formula offers an estimated SPF of 25, making it an effective choice for daily sun care. Furthermore, its functional benefits extend beyond UV defense, as it exhibits significant antimicrobial properties by inhibiting 97% of *Candida albicans* growth

In conclusion:
Overall, the biosunscreen exhibited effective UV protection and strong antifungal activity, supporting its potential as a multifunctional natural sunscreen formulation.

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Medicine, Health, and Disease

All photos and graphs were taken/created by the student researcher unless otherwise noted.

Are current sunscreens environmentally friendly?

- Most sunscreens are not environmentally friendly because of their common chemical ingredients.
- Artificial sunscreens often contain chemicals like oxybenzone and octocrylene, which can harm marine life such as corals and fish.
- Artificial sunscreens can accumulate in marine environments and persist for long periods, leading to long-term pollution.

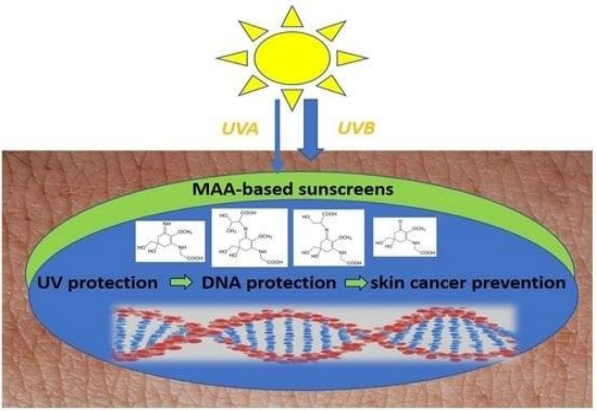
https://www.fortunebusinessinsights.com/sun-care-products-market-103821

https://www.bsac.com/news-and-blog/the-sun-screen-dilemma/

Cempasuchil: Efficacy of Natural Sunblock Agents

https://expansion.mx/tendencias/2024/10/14/que-significado-tiene-la-flor-de-cempasuchil

https://www.mdpi.com/1660-3397/21/4/253



- Cempasúchil is traditionally used in Mexican Día de los Muertos celebrations to guide and honor deceased loved ones.
- Contains antioxidants, anti-inflammatory, and antimicrobial compounds.
- Its name derives from Nahuatl words meaning "twenty" and "flower," referencing its petal abundance and blooming pattern.

- Natural ingredients like zinc oxide, titanium dioxide, and plant-based oils are popular as chemical-free sunscreenoptions due to perceived safety and environmental benefits.
- Formulation stability can be compromised by heat and sunlight, affecting protective efficacy over time.
- Developing reliable natural sunscreens requires a balance of scientific validation, consumer safety, and environmental considerations.

Harmful UV Radiation

https://www.shutterstock.com/search/sunscreen-infographic?dd_referrer=https%3A%2F%2Fwww.google.com%2F

- Sunscreen protects the skin from harmful UV radiation by absorbing or reflecting UV rays, primarily using ingredients like titanium dioxide and avobenzone.
- Its effectiveness against UV-B rays, which cause sunburn, is measured by the Sun Protection Factor (SPF).
- There are concerns about the long-term health effects of certain ingredients, such as oxybenzone, which may act as hormone disruptors.

Difference between UVA and UVB

- **UVA** rays are the aging rays they sneak deep into your skin and cause long-term changes like wrinkles and spots over many years.
- **UVB** rays are the burning rays they hit the surface of your skin and are the main reason you get a painful red sunburn

RESEARCH GOAL

- This research aims to formulate a natural sunscreen made of natural ingredients against harmful UV rays.

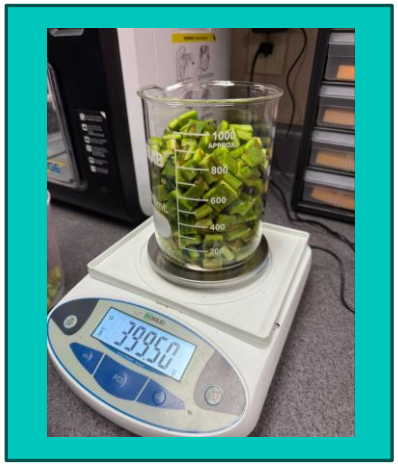
Variables:

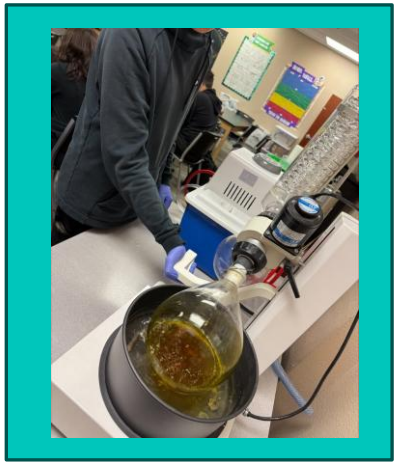
Independent variable: bio susncreen
Dependent Variable: skin exposure to UV lights (UVA, UVB)
Constant value: skin surface, amount UV radiation.

PREDICTION

If the biosunscreen is successfully formulated, then it will significantly reduce UV radiation transmission compared to an untreated control. Additionally, the biosunscreen will inhibit microbial proliferation on exposed surfaces by forming a protective barrier that absorbs and reflects UV radiation.

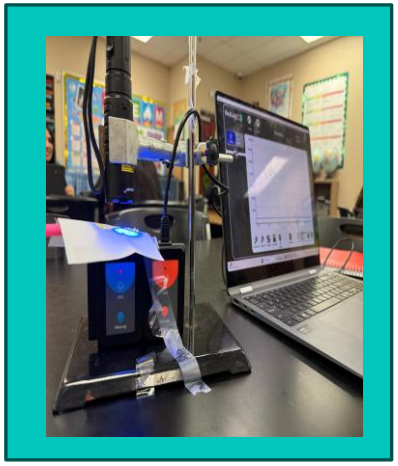
Methods: Preparation and Extraction of Materials





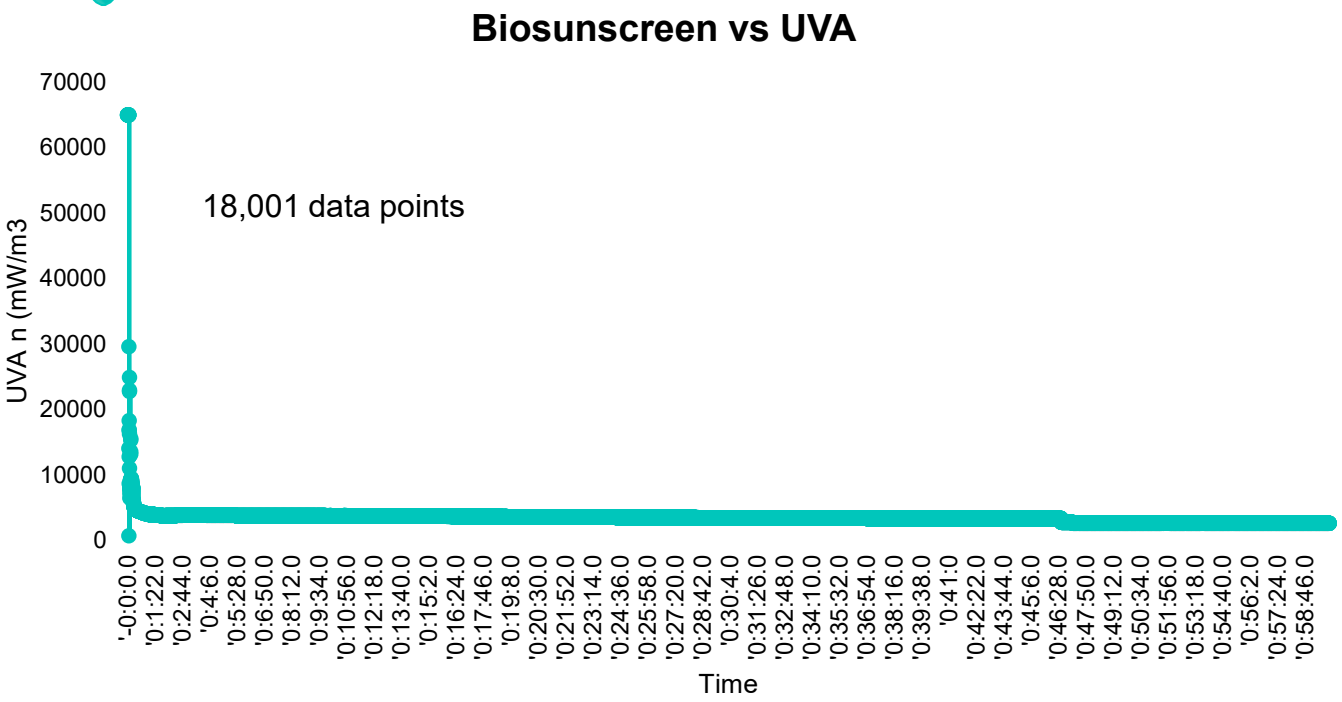
- For the experiment, a dehydrated flower was chosen and immersed in a chemical solution (ethanol) for a week. After the seven-day soaking period, the flower was withdrawn and processed using a rotary evaporator set at 40°C at 100 rpm.
- Nopales, cut into small cubes, were soaked in water and incubated for one hour on a hot plate. Afterward, the resulting liquid extract was separated from the solid cactus material through filtration.

Methods: Preparation of the Biosunscreen Formulation



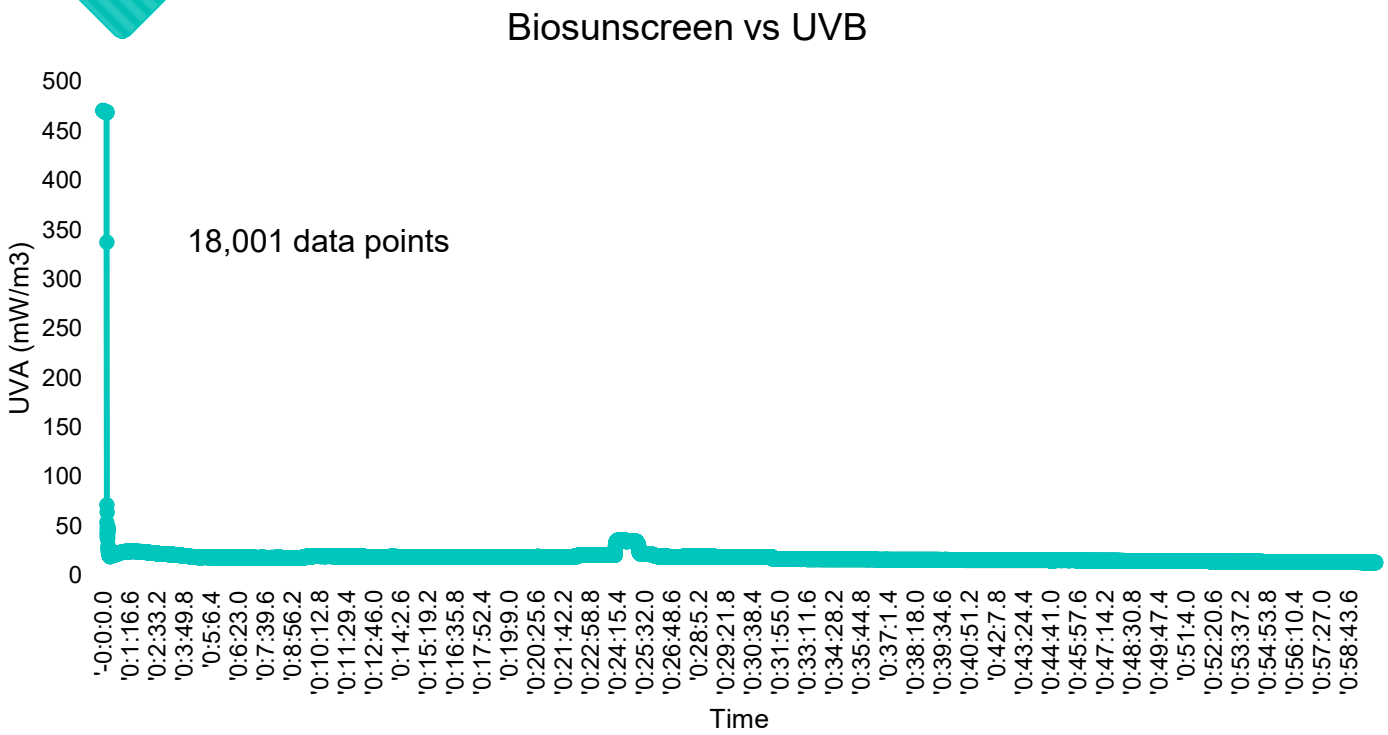
- The preparation involved precisely measuring and mixing ingredients such as shea and tucuma butters, pomegranate and jojoba oils, Vitamin E, nopal and marigold extracts, and a natural preservative, which were homogenized and emulsified with heat until a uniform lipid phase was formed.
- Aging the emulsion for several days to achieve a viscous texture, the sunscreen was tested with UV light and sensors to measure UVA and UVB radiation, and the viscous extract was also streaked onto agar with Candida albicans for further assessment.

Results: Biosunscreen vs UVA



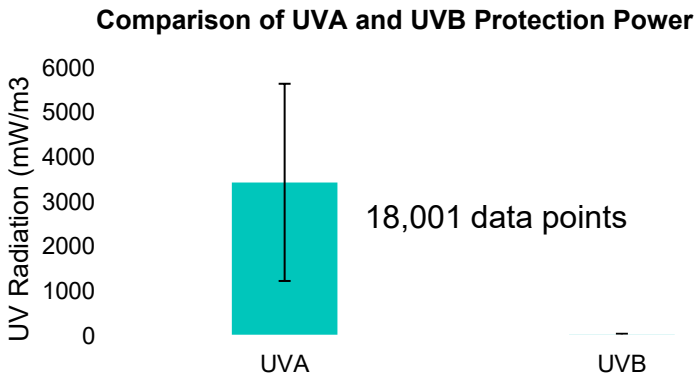
This graph shows UVA intensity measured over 60 minutes after application of the biosunscreen. An initial high UVA reading rapidly decreased and then stabilized at a much lower level, indicating effective UVA attenuation. Across 18,001 data points, the sustained low UVA intensity demonstrates consistent and prolonged UVA blocking by the biosunscreen.

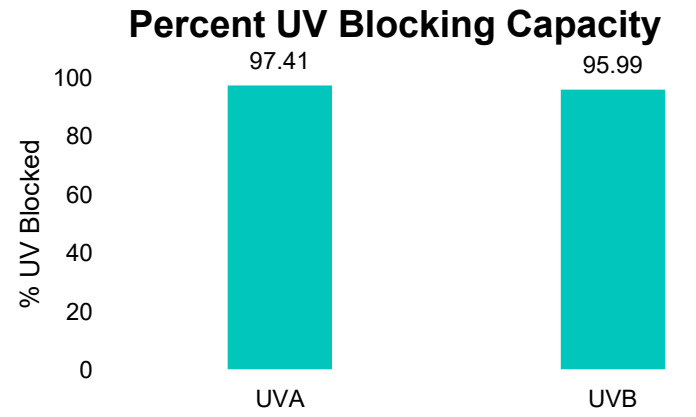
Results: Biosunscreen vs UVB



This graph shows UVB intensity measured over 60 minutes following application of the biosunscreen. UVB intensity dropped sharply from the initial baseline and remained near zero for the duration of the experiment. Across 18,001 data points, the consistently low UVB readings indicate strong and sustained UVB blocking by the biosunscreen.

Results: UV Blocking Power





- Mean transmitted UV intensity was substantially reduced for both UVA and UVB across 18,001 data points, indicating effective ultraviolet attenuation by the biosunscreen.

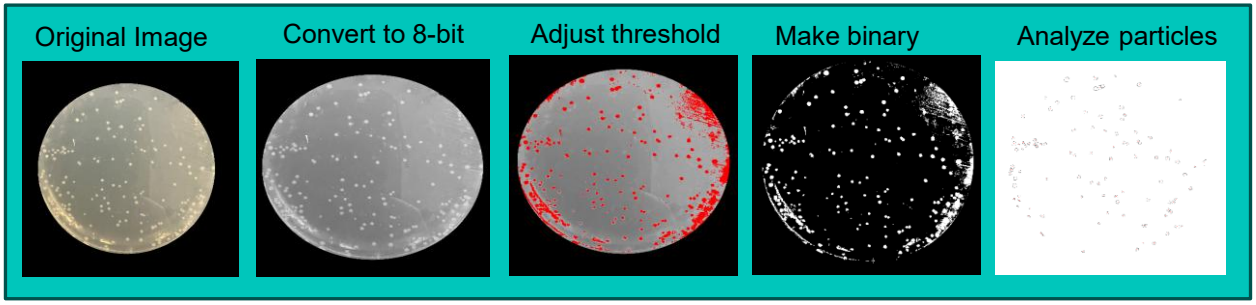
- Percent UV blocking exceeded 95% for both bands, with slightly higher UVA blocking (97.41%) than UVB blocking (95.99%), demonstrating strong broad-spectrum protection.

To calculate the % UV Blocking I used the formula below:

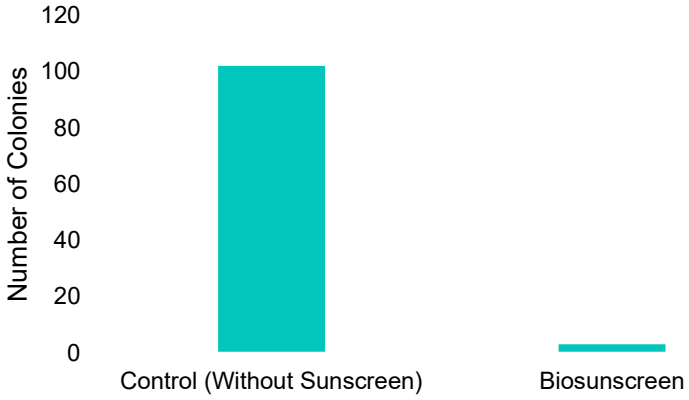
$$\%\ \text{UV Blocking} = \left(1 - \frac{\text{Mean Transmitted Intensity}}{\text{Baseline Intensity}}\right) \times 100$$

Results: Antimicrobial Analysis

Image J Analysis



Biosunscreen vs Candida albicans



The biosunscreen inhibited approximately 97% of *Candida albicans* colony growth compared to the untreated control.

SPF Estimation

To estimate the SPF of the biosunscreen. I considered the UVB blocking power. My biosunscreen was able to blocked about 96% of UVB.

Category	% UVB block	Interpretation
SPF 15	93%	Low–moderate protection
SPF 25	96%	Good daily protection
SPF 30	97%	Standard recommendation
SPF 50	98%	High / extreme protection

The table above is just an estimate, as a standard SPF test must be conducted to be conclusive.

Discussion and Conclusion

Discussion

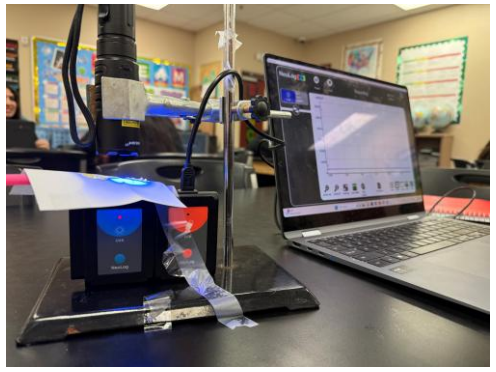
- The biosunscreen demonstrated strong broad-spectrum UV protection, blocking 97.41% of UVA and 95.99% of UVB radiation across 18,001 data points, indicating effective and sustained UV attenuation.
- UVB blocking was used to estimate SPF because SPF is defined by protection against UVB-induced erythema, resulting in an SPF-like estimate of approximately 25, consistent with good daily sun protection.
- Antimicrobial testing showed the biosunscreen inhibited approximately 97% of *Candida albicans* colony growth, suggesting additional protective benefits beyond UV blocking.

Conclusion

Overall, the biosunscreen exhibited effective UV protection and strong antifungal activity, supporting its potential as a multifunctional natural sunscreen formulation.

Future Plans

Future work will include standardized SPF testing (spectral UV-Vis analysis), additional microbial replicates, and formulation optimization to enhance UVA protection and improve reproducibility.



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