María José Marín Domínguez
Colegio Williams
Mexico City
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Before Hunger wins: Chitosan coating as a sustainable food preservation solution in La Guajira, Colombia

La Guajira, Colombia

Food loss and waste represent a critical challenge to global security and economic stability, more than 9.7 millions of tons of food per year are wasted in the Country. in *La Guajira* this loss corresponds critically with the highest index of child malnutrition and poverty (Ramírez, 2023).
In developing regions, the loss of harvest often occurs before food even reaches markets due to lack of infrastructure, high temperatures and limited access to refrigeration. A clear example of this vulnerability is found in *La Guajira*, Colombia (Minvivienda, 2024). A region in Colombia 's north, famous for being the contrast of a tropical desert considered as a tourism destination that meets the Caribbean sea (RTVC noticias, 2024).



Figure 1

Montoya Ardila, D. (2024). La Guajira, un viaje de introspección a una Colombia única. *El Espectador*. https://www.elespectador.com/turismo/la-guajira-un-viaje-de-introspeccion-a-una-colombia-unica/

Furthermore, *La Guajira* is the ancestral home of the Wayúu people,the biggest ethnic group of the country, representing more than 40% of the local population (RTVC noticias, 2024) an indigenous community with perseverance and traditional knowledge. Surviving in an arid environment, they know how to provide essential support for any sustainable intervention.

Eventually, an average family in *La Guajira, Colombia* is under a complex socioeconomic context, presenting strong indigenous presence, structural challenges and a significant poverty state. Families in this region are commonly numerous with an average of 8 or more people living together, specially in rural zones (DANE, 2026). A mostly rural region with 53% of monetary poverty as *Imagen Noticias* said in their report on March 16, 2023.



Figure 2

Make Mothers Matter. (2023, 10 de noviembre). *Exposing the suffering of indigenous mothers and children in Colombia*. https://makemothersmatter.org/exposing-the-suffering-of-indigenous-mothers-and-children-in-colombia/



Figure 3

Prada Céspedes, E. (2018, 29 de noviembre). *La migración wayuu aumenta la presión en La Guajira*. Agenda Propia. https://www.agendapropia.co/articles/la-migracin-wayuu-aumenta-la-presin-en-la-guajira

Due to economic and waste of food problems in La Guajira, the alternatives of food preservation methods seem essential to stop the deterioration caused by microorganisms and enzymes. Its importance it's rooted in guaranteeing health safety, preventing diseases, keeping the nutritional value and reducing waste (DANE, 2024). Although, *La Guajira* community has developed various methods for extending the duration and freshness of their food taking advantage of the arid conditions they live in. One example is sun dehydration for meat and sea products, exposing them to solar radiation and air (Ramírez-Gutiérrez, 2025). Another common method is dehydration by salt taking advantage of the salt resources of the environment, protecting animal

protein from microbial decomposition, also being a practical and functional method with less exposure to outdoors bacterias (Sal Roche, 2019).
Unfortunately, they can't use these methods for their harvests. Lack of refrigeration for food, causes that fruit and vegetables spoil faster before getting to local markets and the consumers (ADR, 2025). This intervention specifically targets highly not-durable crops that are vital for the local economy and nutrition in La Guajira. The little group of harvests that reach the market are sold in a short time reaching only for a few people. This food doesn't last for long periods of time, causing many people to miss the nutrients they require. The most consumed fruits and vegetables such as mangos, papayas, tomatoes and bananas are highly viable for implementing a chitosan dipping method. Chitosan forms a semi-permeable film that regulates gas exchange (O2 and CO2), drastically slowing down the respiration rate and transpiration of these products without suffocating the fabric.

Chitin is a resistant polysaccharide. It's the second most common natural polymer in nature after cellulose. It works like a shield, making the principal structure of insects exoskeletons and the mushroom's cell wall (Clínica Universidad de Navarra, 2023).
It's recognized for being an insoluble fiber and for helping healing wounds, regulating blood sugar levels and aliment for intestinal bacteria.



Figure 4
Elsevier. (2024). *Advances in chitosan-based biomaterials for food preservation and smart packaging applications*. Food Chemistry: X, *24*, Artículo 101477. https://www.sciencedirect.com/science/article/pii/S2590157524004772

The shrimp exoskeleton represents close to 15 % of the total weight, of that dried shells after the desmineralization and deacetylation process with low technology. We can obtain approximately a 20% of powder chitosan to create the dipping solution, scientists recommend use just 2% of chitosan diluted in vinegar (Al-Asadi & Al-Sahlany, 2025).
The mathematical viability of the circular economy model relies on a high efficiency conversion factor. Every 1.0 kilogram of whole shrimp harvested from the community

aquaculture pools yields roughly 150 grams of dry exoskeleton waste (Sanya et al., 2026). Through the low tech green chemicals extraction protocol, this mass produces 30 grams of pure chitosan powder. When dissolved at a standard 2% concentration in diluted acetic acid, it creates 1.5 liters of solution, precisely the volume required to coat and preserve around 100 fresh fruits for transport (approximately 7mL in medium size fruits and 15 mL in big size fruits) having different quantities depending on the fruit or vegetable as shown in the following table. (Romanazzi et al., 2017).

Table 1. Amounts for the implementation of the solution in chitosan

Type of fruit (Lot of units)	Volume solution with the 2% of chitosan (Liters)	Powder chitosan (grams)	Dried shrimp shell (grams)	Shrimp weight (From shrimp farm) (kilograms)
Mango	1.5 L	30 g	150 g	1.00 Kg
Papaya	2.0 L	40 g	200 g	1.33 Kg
Tomate	0.7 L	14 g	70 g	0.46 Kg

Romanazzi, G., Feliziani, E., Baños, S. B., & Sivakumar, D. (2017). Shelf life extension of fresh fruit and vegetables by chitosan treatment. Critical Reviews in Food Science and Nutrition, 57(3), 579–601. https://doi.org/10.1080/10408398.2014.930481

Currently the transportation of fresh produce from agricultural centers to remote Wayuu communities takes between 24 to 72 hours by land (From Bogota or Medellin) or 24 to 48 hours by air.

Due to the complete absence of a refrigerated cold chain and exposure to extreme desert temperatures (often exceeding 35°C), fruits and vegetables suffer a rapid degradation (Magic Tours Editorial, 2026). This leads to severe moisture loss, accelerated microbial growth (such as fungi and mold), and a nutritional decay of up to 40% before reaching the consumers . By applying the chitosan coating, the shelf life is safely extended up to 15 days under ambiental conditions, closing the critical transportation gap (Singh, 2025).

My proposal for fruits and vegetables is the use of edible chitosan coating (Zheng et al., 2026) taking advantage of the sea food (shrimps) that *La Gujira's* ocean offers. Used as a second skin, transparent and edible, that it's applied by drowning fruits and vegetables in a liquid solution. This reduces fruits and vegetables breathing and delays maturation for 15 days without refrigerating (Singh, 2025).

To ensure a steady, sustainable and efficient supply of raw material, the project proposes a circular economy model through a shrimp farm. Instead of only depending on external fishing waste, this integrated system generates local protein for

consumption while systematically capturing all shrimp exoskeletons as a byproduct. This creates a closed bio-economy; the community produces food (shrimps) and simultaneously assures the primary source of chitin required for the preservation coating for fruits and vegetables.

The shrimp exoskeleton is composed of proteins and minerals (calcareous) and chitin. For getting the chitosan, the sample must be purified.
First by desmineralization, the clean and crushed shells are drowned in diluted hydrochloric acid (HCl) in order to remove the calcium the calcium carbonate. Then they must be washed with water until the pH is neutralized. After that, comes the deproteinization, the remaining impurities are treated with sodium hydroxide (NaOH) with moderated heat to eliminate the fixed proteins on the shells, just leaving the chitin. Finally to go through the deacetylation, the chitin is submitted to a concentrated NaOH solution (50%) in high temperatures (90–100◦C). This eliminates the acetyl groups of the molecule transforming it chemically in chitosan, that now is soluble and has antimicrobial properties, just to wash, dry and pulverize. For the dipping mix, the powder is diluted in vinegar, then glycerol is incorporated into the mix. When the mix is homogeneous, fruit can be dipped for 30 to 60 seconds and let dry.(Thangam et al., 2021).

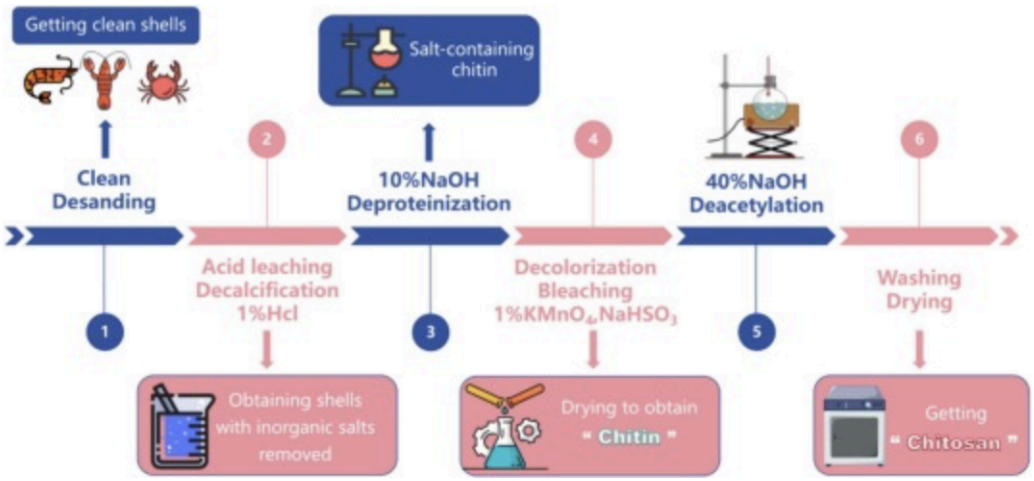

Figure 5
Elsevier. (2024). *Advances in chitosan-based biomaterials for food preservation and smart packaging applications*. Food Chemistry: X, *24*, Artículo 101477. https://www.sciencedirect.com/science/article/pii/S2590157524004772

This proposal will be executed directly within the rural indigenous ranches of *La Guajira*, specifically targeting remote areas near Riohacha. The project will be led by the Wayuu Women Associations, who traditionally manage communal food distribution, serving as the central operators and owners of the localized micro enterprises. To achieve long-term viability, technical training will be delivered free of charge through a strategy according to the SENA (National Learning Service), using

their specialized instructors to build capacity in chemical safety and aquaculture management directly within the territory. This structure ensures full community autonomy, while respecting and preserving the ancestral social fabric of the Wayuu people.
The production process works as a closed-loop bio-economy that completely eliminates the dependence of commercial electric grid.

First the shrimp farm; the meat provides vital proteins, while 100% of the chitin exoskeleton is captured as raw material. These shells are transferred to community low tech biotechnology centers where they follow the chitosan extraction applying green-chemistry.

Executing this pilot work requires a total estimate of $14,400 USD, meticulously distributed across specific operational assets within five strategic categories as the next table presents.

Figure 2. Budgets assignment

Investment of Money	Use
$3500	Installation of the aquaculture unit
$1800	Tanks
$1000	water pumps and aeration and filtration accessories
$700	Initial shrimp larvae stock and organic feed supply
$2000	Low tech lab infrastructure ($1,100 for artisanal thermal)
$900	Hand craft solar concentrators (for desert heat capture)
$1200	$800 vinegar and $400 for vegetable glycerol plasticizers and operator protective equipment.
$1,300	Community training. $600 for Manual printing translated into *Wayuunaiki and $700* for Community deployment and instructor local logistics
$2000	Field testing and contingency fund reserves $1100 for

	post-harvest fruit transport monitoring and tracking metrics, leaving a $900 for other unseen desert operational expenses.

Autoridad Nacional de Acuicultura y Pesca [AUNAP]. (2021). Manual de buenas prácticas de acuicultura de pequeña escala en Colombia. Ministerio de Agricultura y Desarrollo Rural. https://www.aunap.gov.co

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To secure this financial backing, formal capital grant applications will be submitted to *Miniciencias* under their social innovation and ancestral knowledge funding lines, the *Fondo Mujer Emprende* to back the women's micro-enterprise structure, and the international corporate social responsibility funds of *Fundación Cerrejón* and *Ecopetrol*, ensuring a fully funded, structurally secure path toward localized food security.

Unlike commercial technologies that often disregard local customs, a successful preservation method must align with the social fabric of wayúu communities, integrating traditional agricultural practices with appropriate, low-cost biotechnology. Community adoption challenges can only be overcome through participatory methodologies rooted in intercultural dialogue, engaging *La Guajira* community to adopt this method for their local harvest as a current method.

Having the opportunity to participate in spaces like the World Food Prize is not just a privilege, it is a strategic tool for transformation. For students with access to global platforms and scientific knowledge, ignoring massive and terrible issues like food insecurity is choosing silence when we have the voice to act.

I don’t talk about pity, but something I wouldn't want to keep existing and damaging people. If the minds with resources to research, innovate and create do not design solutions, who will? True biotechnology is not meant to stay trapped inside a laboratory, its purpose is to serve humanity and look for everyone's future.

By creating a low tech, circular solution for *La Guajira*, we are proving that youth can bridge the gap between advanced science and ancestral customs. Be aware and care of this global crisis because their future it’s also ours, it’s not just changing their reality, it’s changing the standard of what our generation can achieve with purpose.

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