





Manufacture of Syringes made of Natural Polymers Derived from Avocado Seed

*Fabricación de jeringas a partir de polímeros naturales
derivados de la semilla de aguacate*

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ABSTRACT

This project aims to develop a biodegradable syringe to reduce plastic waste pollution, especially in sectors like healthcare and livestock production. The premise is to study the avocado seed through processes like grinding, decantation, drying, and mixing to create an environmentally friendly biopolymer plastic. Current syringes are made of non-biodegradable and non-recyclable plastic materials, worsening pollution due to their handling and hazardous nature. In contrast, our product can be disposed of in landfills, degrading within 180 days without causing contamination. This approach offers a sustainable alternative to conventional plastics, which are challenging to control, recycle, and separate due to their properties.

Keywords: Biodegradable Syringe, Avocado Seed, Bio-based Material, Common Polymers, Avocado Starch Blends, Decantation.

RESUMEN

Este proyecto busca desarrollar una jeringa biodegradable para reducir la contaminación por desechos plásticos, especialmente en sectores como la salud y la producción pecuaria. La premisa es estudiar la semilla de aguacate mediante procesos como el molido, decantación, secado y mezclas, para crear un biopolímero plástico amigable con el medio ambiente. Las jeringas actuales están hechas de materiales plásticos no biodegradables y no reciclables, lo que agrava la contaminación debido a su difícil manejo y peligrosidad. En cambio, nuestro producto podrá ser desechado en vertederos, donde se degradará en un plazo de 180 días, sin generar contaminación. Este enfoque ofrece una alternativa sostenible frente a los plásticos convencionales que, por sus propiedades, son difíciles de controlar, reciclar y separar.

Palabras Claves: Jeringa Biodegradable, Semilla de Aguacate, Material Biobasado, Polímeros Comunes, Mezclas del Almidón de Aguacate, Decantación.

1. INTRODUCTION

According to Rodríguez [1], around 1.4 million tons of plastic materials are produced annually in Colombia, including polypropylene, PVC, polystyrene, and low-density polyethylene, among others. The plastic products industry processes more than 1.3 million tons each year, producing a wide variety of items such as packaging, containers, pipes, automotive parts, and toys. Of the total, 54% of consumed plastics are used for packaging, utilized in food, hygiene, cleaning, industrial products, and lubricants.

The use of plastics is widespread across virtually all industrial and economic sectors. In the agricultural sector, low-density polyethylene is the most widely used material, although PVC and EVA copolymers are also employed in greenhouses. These materials are used in the cultivation of fruits, vegetables, and flowers. In the automotive sector, polypropylene dominates due to its excellent properties and cost-effectiveness. In construction, PVC makes up 60% of the plastics used, primarily in the manufacture of pipes and fittings, followed by polyethylene and polyurethanes. Polypropylene accounts for 51% of the plastics used in industrial parts, with polyester being the second most used plastic.

Given the environmental impact of plastics, alternatives such as bioplastics have been investigated. These biodegradable materials are derived from renewable sources. Biopolymers, made from agricultural waste, cellulose, or starch, have properties comparable to conventional plastics but are more sustainable. For example, polyethylene (PE) and polyethylene terephthalate (PET) bioplastics possess identical properties to their traditional versions and are recyclable, contributing to a reduced carbon footprint.

A fully biodegradable and compostable bioplastic has been developed from avocado seeds. The result is Biocom, a thermoplastic resin for the manufacture of biodegradable and compostable products, along with Bioblend, an additive that accelerates the decomposition of materials such as polyethylene, polypropylene, PVC, polystyrene, and cellulose polymers. Approximately 1.5 kilograms of avocado seeds are required to produce one kilogram of bioplastic, although this amount varies according to the characteristics of the final product. The resulting products can degrade within a period of six months to five years, compared to conventional plastics, which can take between 100 and 1,000 years to decompose [2].

2. METHODOLOGY

According to Mahecha [1], previous studies conducted by the Polymer and Adhesives Research Group (GIPA) showed that, after dehydrating, grinding, and sieving the avocado seed, its protein content is approximately 3.7%. This data indicates that it is a good source of soluble and insoluble fiber (19%) and is rich in starch, with more than 60%, making it an interesting compound for those exploring renewable sources of polymers.

2.1. Phase 1: Obtaining starch from avocado seeds

The extraction of starch from the avocado seed is an essential step for the production of biodegradable syringes and other sustainable products that aim to reduce the use of traditional plastic materials in medical applications (Figure 1). This phase is developed in six main stages:

- **Seed collection:** The process begins with the collection of avocado seeds, which will serve as the starch source.

- **Seed cleaning:** The collected seeds undergo a cleaning process to remove any external residue (pulp or cuticle) that could affect the quality of the starch.
- **Seed grating:** Once clean, the seeds are grated or crushed, breaking them down into smaller particles. This step facilitates starch extraction in later stages.
- **Starch decantation from the seed:** The grated material is subjected to a decantation process, which separates the

starch from other seed components, yielding a purer extract.

- **Decanted starch:** The decanted starch is collected and prepared for its final transformation.
- **Starch powder:** In this final stage, the decanted starch is dried and turned into powder, completing the extraction process and obtaining the starch in an optimal form for use in the manufacture of biodegradable products.

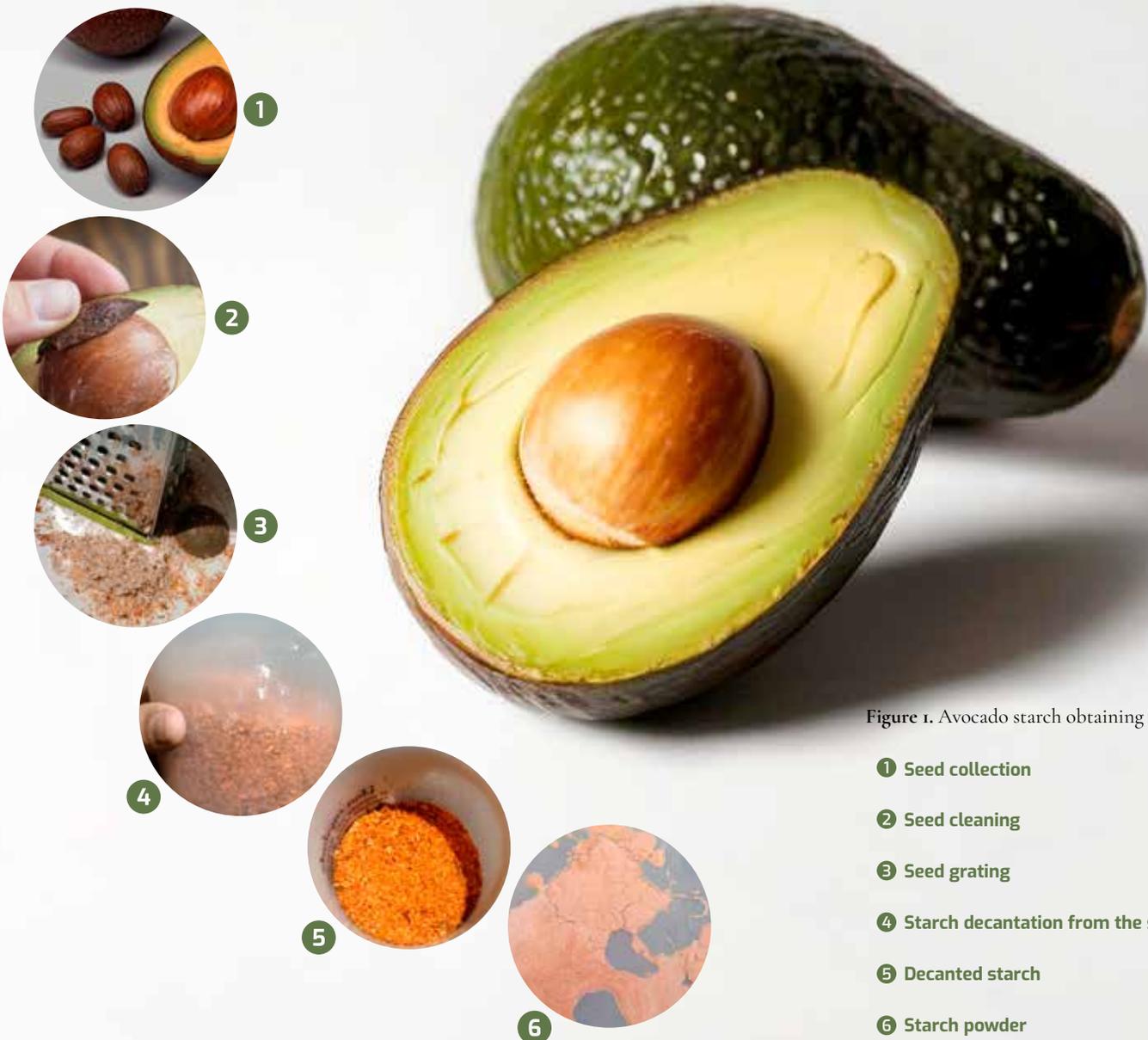


Figure 1. Avocado starch obtaining process

- 1 Seed collection
- 2 Seed cleaning
- 3 Seed grating
- 4 Starch decantation from the seed
- 5 Decanted starch
- 6 Starch powder

2.2. Phase 2: Mixture of avocado seed starch to inject

In Figure 2, the mixing process to obtain an injection material based on avocado seed starch can be seen, composed of the following elements:

- **Polymer:** Represented in a yellow oval at the top.
- **Avocado starch:** Represented in a green oval in the center.
- **Binder:** Represented in a light blue oval at the bottom.

The combination of these three elements results in “Phase 2,” the material that will be used for injections, aimed at achieving an optimal mixture for the creation of biodegradable products.

2.3. Phase 3: Injection of test tubes in different proportions

Different test specimens were prepared using varying proportions of polymer and starch. These included 40% polymer with 60% starch, 50% polymer with 50% starch, and 60% polymer with 40% starch.

Figure 3 shows the test specimens corresponding to the proportions of 70% polymer with 30% starch, 80% polymer with 20% starch, and 90% polymer with 10% starch.

These proportions reflect different configurations of the material that will undergo physical and mechanical tests in the next phase to evaluate their performance.



Figure 2. Proportional mixing process



Figure 3. Proportional mixing combinations

2.4. Phase 4: Physical and mechanical tests

To understand the material's strength and ductility, the following tests were developed:

- **Aging Chamber:** Allows samples to be exposed alternately to cycles of ultraviolet light and condensation, with controlled temperature.
- **Bending Test:** Measures the behavior of materials subjected to a simple load.
- **Impact Test (Charpy and Izod):** These are short-duration tests that provide information on the behavior of materials or components when subjected to impact loads.
- **Hardness Test:** Evaluates a material's resistance to permanent deformation by penetrating it with a harder material.
- **Tensile Test:** Involves applying axial stress to a specimen until it breaks. The strain rate must be low to avoid distorting the results, measuring the force and extension of the specimen.
- **Fatigue Test:** Determines the resistance of a part subjected to cyclic loads, where fatigue occurs when the loads are below the material's critical breaking point.
- **Wear Test:** Measures changes in conditions caused by friction. The result is obtained from deformation, scratches, and notches on the surfaces in contact.

2.5. Phase 5. Conclusions

2.5.1 Results

In the context of the project, Table 1 corresponds to the schedule or list of key activities for developing biodegradable material from avocado seed starch. These activities include tasks ranging from market research to the formulation and testing of the material, evaluating its performance, costs, and degradation processes.

2.5.2. List of customer requirements

The following list describes the features that customers would like to find in the product:

- Material used for the barrel (avocado seed starch).
- Material used for the plunger (avocado seed starch).
- The syringe must not have leaks.
- It should be ergonomic.
- It must provide safety.
- The packaging should be easy to open.
- It should comply with hygiene standards.
- The boxes must meet the printed unit specifications.
- It should not pose an environmental risk.
- Proper functionality.
- The measurement scale on the barrel should be legible.
- Low cost.
- The manufacturing date should be legible.
- Sufficient installed capacity to meet projected production units.
- Short degradation period (less than 180 days).

Table 1. Results of the activity. Project monitoring and evaluation

ACTIVITY	PERCENTAGE (%)
Market research.	90
Consult advertisements.	100
Papers resources.	100
Step-by-step process of decanting the seed to obtain the biopolymer.	100
Obtaining avocado seeds.	100
Monitoring of a injected part, then leaving it in the environment to see its degradation time.	50
Go to specific sites for aging chamber testing.	20
Make mixtures of avocado seed starches, varying the polymer percentages.	80
Mechanical and organoleptic tests..	20
Cost study of materials for the manufacture of the product.	90
Identify the competition to compare product costs.	90
Marketing study by areas and locations.	50

Table 2a. Description monetary value of the project

DESCRIPCION	VALOR MONETARIO
Mano de obra preparación del proyecto	\$1.228.800 se utilizan 4 personas, 4 horas a la semana durante 3 meses.
Transporte	camión de acarreo de 1 ton \$20.000
Almacenamiento de la materia prima por mes	\$200.000
Proceso	<p>Todo se hace por kilos horas o unidades minuto</p> <p>1. triturado, rayado o molido de la materia (mortero o licuadora) \$25.000</p> <p>2. mezclado de la materia con agua hervida o filtrada \$ 7.000</p> <p>3. Secado de la materia prima (pepa) ya triturada, al sol o en un horno. \$40.000</p> <p>4. granular o pulverizar la materia ya deshidratada. (licuadora o molino casero). \$6.000</p>
Inyección	
Máquina	Usando moldes de probeta e inyectora durante un día (800\$ KW/HR inyectora de 30 KW/HR). \$192.000
Polímero	Valor de 1 kilo \$6.500
Catalizador	Valor de 30 c.c \$5.000
Total	\$1.730.300

Table 2b. Description monetary value of the project

Descripción	VALOR
Mano de obra	\$ 1.228.800
Transporte	\$ 20.000
Almacenamiento	\$ 200.000
Proceso	
Rayado	\$ 25.000
Agua	\$ 7.000
Secado	\$ 40.000
Pulverizado	\$ 6.000
Inyección	
Maquina	\$ 192.000
Polímero	\$ 6.500
Catalizador	\$ 5.000
Total	\$ 1.730.300

2.5.3. Cost study

Tables 2a and 2b summarize the project costs and mention additional resources required to carry it out.

3. CONCLUSIONS

To produce one kilogram of bioplastic, approximately 1.5 kilograms of avocado seeds are required, although this figure varies depending on the desired final characteristics of the product. The resulting products can degrade within a period ranging from six months to five years, depending on their final application, with minimal environmental impact.

This initiative aims to promote circular bioeconomy commitments by generating materials that are more environmentally friendly and facilitating better waste management. According to World of Statistics [1], Mexico

leads global avocado production with 2,442 million tons, followed by Colombia (979,000), Peru (777,000), and Indonesia (669,000).

Ramos [2] points out that the efficient use of waste generated by the agro-industry has attracted global interest, as it seeks to obtain alternative chemicals and proteins through sustainable technologies and closed systems, contributing to environmental preservation.

According to a study by the National Planning Department (DNP) [3], approximately 10,000 kilograms of avocado are wasted in Corabastos out of an average purchase of 400,000 kilograms, representing a 10% loss of the total fruit.

Monsalve and Ramos [4] state that “this avocado waste not only represents losses for the marketing organizations but also has a negative environmental impact due to the way the fruit unfit for sale is disposed of.”

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