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Elaboration of germinable bioplastic based on corn olot

Elaboración de bioplástico germinable a base de olote de maíz

MORENO-RODRIGUEZ, Bertha María†*, RODRIGUEZ-DE LA CRUZ, Sofia Alejandra, LOYA-, ESCALANTE, María Teresa and DARÍO-RAMOS, Jazmín Elizabeth

Tecnológico Nacional de México / ITS de Poza Rica. México.

ID 1st Author: *Bertha María, Moreno-Rodríguez* / **ORC ID:** 0000-0002-0598-7524, **CVU CONAHCYT ID:** 243865

ID 1st Co-author: *Sofia Alejandra, Rodríguez-de la Cruz*/ **ORC ID:** 0009-0003-0329-2651, **CVU CONAHCYT ID:** 1014943

ID 2nd Co-author: *María Teresa, Loya-Escalante* / **ORC ID:** 0000-0003-1515-4312, **CVU CONAHCYT ID:** 635849

ID 3rd Co-author: *Jazmín Elizabeth, Darío-Ramos*

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Abstract

The present work was developed within the facilities of the Instituto Tecnológico Superior de Poza Rica, said research work aims to develop a germinable bioplastic based on corn cob, which will reduce environmental contamination, generating a biodegradable and germinable product at the same time. time. The elaboration of the bioplastic was carried out taking into account the methodology described by Guzmán (2013) using cob powder instead of corn starch and with an additional input, gelatin. In this way, 10 tests were carried out, starting from procedure 1 in which 5 tests were carried out, from which it is concluded that the prototypes presented curves and breaks in their structure, and have even reduced their dimensions. Likewise, for procedure 2, 3 tests are carried out where it is obtained that if there has been a resistance to perforation (there is no fracture) and there has been a decrease in its size.

Bioplastic, Corn Cob, Biodegradable

Resumen

El presente trabajo se desarrolló dentro de las instalaciones del Instituto Tecnológico Superior de Poza Rica, dicho trabajo de investigación tiene como objetivo desarrollar bioplástico germinable a base de olote de maíz, mismo que permitirá reducir la contaminación ambiental, generando un producto biodegradable y germinable al mismo tiempo. La elaboración del bioplástico se llevó a cabo teniendo en cuenta la metodología que describe Guzmán (2013) utilizando el polvo de olote en lugar de almidón de maíz y con un insumo adicional, la grenetina. De este modo se llevaron a cabo 10 pruebas, partiendo del procedimiento 1 en el que se realizaron 5 pruebas, de las cuales se concluye que los prototipos presentaron curvas y rompimiento en su estructura, incluso se han reducido en sus dimensiones. Así mismo para el procedimiento 2 se realiza 3 pruebas en donde se obtiene que si se ha presentado una resistencia a la perforación (no hay fractura) y se ha presentado una disminución en su tamaño.

Bioplástico, Olote de maíz, Biodegradable

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† Researcher contributing as first author.

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Introduction

Plastic is a material that has multiple applications and is an important part of different industries, for example, in the food industry where plastics are used for food packaging or for the creation of plastic utensils better known as disposable plastics. These, as the name suggests, are disposable and therein lies the problem that most of these disposables are only used for 20 minutes or less and are quickly discarded and have a long decomposition time. Plastic disposables represent a big environmental problem that we should be concerned about, if a change is not made now there will be very serious problems such as the contamination of aquifers and soil contamination, to mention a few. These problems are due to the fact that past generations have not been more careful with this type of plastic, and this is where our work arises, we seek to reduce this environmental impact and our product is germinable, this means that we can plant the product and later a plant will come out which will be in accordance with the environment that surrounds it. With this we will be able to reduce the use of disposable plastics.
With the above mentioned, the research and development work was carried out to obtain a biopolymer that is made from corn stover and which has other elements that make up it and that make it possible to be planted and not generate damage to the land.

Increasing the consumption of bio-based type A plastics can help to reduce the dependence on oil for the manufacture of plastic products, since oil is a limited resource that will tend to increase in price. On the other hand, disposal by incineration (waste to energy) results in green energy, since the CO2 expelled into the atmosphere was previously consumed by plants, so we could talk about an almost neutral carbon footprint. On the other hand, biodegradable plastics (type B) have advantages only in certain fields of application. For example, in agricultural mulch films, waste bags and packaging. Other applications where biodegradability makes sense are agricultural aids, such as clips used in tomato harvesting. Such parts can be disposed of together with waste and green waste more easily than clips made of non-degradable plastics.

According to the United Nations Environment Programme (UNEP), the global production of plastics has increased 20 times over the last 50 years. In that period, around 320 million tonnes were produced, dumping 13 million tonnes into the seas and oceans, of which a large number sank, or were left floating on beaches, causing environmental and economic damage that transcends borders and affects more than 700 marine species [4]. In the national context, Mexico produces more than seven million tonnes of plastic per year; of which 48% is single-use plastic, and only 6.07% is recycled. [4]. Meanwhile, disposable cutlery takes 400 years to degrade, the straw 100, the cup 65-75, and the bag 55 [] The pollution generated by disposable plastics affects more than 100,000 marine animals and causes the death of one million birds a year, as well as damaging human health Gareli (2020). It is worth noting that Greenpeace conducted a study showing the impact of microplastics on commercially popular fish in the Gulf of California, the Gulf of Mexico and the Mexican Caribbean. It is worth mentioning that 20% of the 755 fish had plastic in their stomachs. A total of 2,718 microplastics were found, the region with the greatest impact was Veracruz with 96% of contaminated fish and 1,865 pieces found; on the other hand, La Paz represents 21% of affected species and 110 pieces were found. These figures are alarming for the health of aquatic organisms and therefore also for fishing activity, which could be affected [4].

Due to the global environmental problem, it is important to consider a sustainable alternative to replace the use of petroleum-based plastics, which have a great environmental impact. Biopolymers fulfil the purpose of reducing this problem, as they are characterised by their ability to degrade quickly, as well as having properties similar to those of traditional plastics, and can be applied in a wide range of industries such as food packaging, surgery, pharmaceuticals, etc. [1].

Thus, we asked ourselves whether it is possible to produce a germinable bioplastic based on corn stover, which contributes to reducing environmental pollution, generating a biodegradable and germinable product at the same time.

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Thus, one of the objectives is the production of biopolymers for the manufacture of disposable products.

Development

Bioplastics

Biopolymers are defined as a variety of macromolecules, produced by biological systems, such as animals, plants or microorganisms. They can be chemically synthesised, but their polymeric units must be derived from biological systems such as amino acids, sugars, lipids, etc. (Tharanathan, 2003).

In general, natural biopolymers come from four main sources:

- Animal origin (collagen/gelatin).

- Marine origin (chitin/chitosan).

- Agricultural origin (lipids, fats, hydrocolloids, proteins and polysaccharides).

- Microbial origin (polylactic acid (PLA) and Polyhydroxyalkanoates (PHAs).

The development of biodegradable plastics from organic sources such as starch derivatives, polylactic acid and cellulosic polymers, represent a more environmentally friendly option than those obtained from petroleum, resulting in increased social awareness of the environmental problems generated by plastics (Demirbaş, 2007; Nath, Dixit, Bandiya, Chavda, & Desai, 2008).

Characteristics of bioplastics

Bioplastics are biodegradable and/or bio-based materials. Bio-based polymers are produced using renewable resources. It simply refers to plastic made from plant or other biological material instead of petroleum. It is also often called bio-based plastic.

It can be made from polylactic acids (PLA) found in plants such as corn and sugar cane, or it can be made from polyhydroxyalkanoates (PHA) made from microorganisms [7].

Bioplastic materials have similar properties to conventional plastics, and can be stored in a similar way and processed in conventional machines, but the big difference is that they are biodegradable and environmentally friendly.

Industrial applications and properties

Bioplastics are divided into:

A) Plastics from renewable sources such as corn, sugar cane or even agricultural waste.

B) Biodegradable plastics. Some bioplastics are both renewable and biodegradable, but not all bioplastics are biodegradable. [8]

Advantages and disadvantages of using biodegradable plastics

The benefits of bioplastics include:

- Most of them are biodegradable, so they contribute to the care of the planet by producing less waste.

- They come from 100 percent renewable raw materials and less energy is needed for their production.

Disadvantages:

- With the large-scale production of bioplastics, other problems could arise, such as the availability and rising prices of food derived from maize and wheat, as most of them are currently made from these elements.

- However, bioplastics are an ideal option for reducing the use of plastics and for the care of our planet.

Methodology of the experiment

The methodology to be followed is the scientific method, where experimentation is the basis with which to find the correct formula to obtain the desired results, it is worth mentioning that experimentation is a quantitative method, therefore we involve quantities to carry out the project.

ISSN: 2410-3993

Inputs and equipment to be used

The inputs used for the creation of the prototype are:

- 5g dried Olote (powdered)
- 1/2 ear of corn
- 1/4 litre of water
- 17ml distilled water
- 1.7ml glycerine
- 3ml vinegar
- 7g of grenetin
- 3ml additional 3ml distilled water
- 1 seed

The equipment required is:

- Knife
- Blender
- Sieve
- Tray
- Scales
- Syringe
- Measuring cup
- Containers
- Metal spoons
- Saucepan

Flowchart of bioplastic processing

Flow diagram for the production of pulverised corncob

Home

Hydrate 7 g of grenetin with 3 ml of distilled water and mix until both elements are incorporated.

Place the mixture in a bain-marie and whisk continuously until it becomes liquid, set aside for a few minutes.

In another pot, place 17 ml of distilled water together with 5 g of the corn powder, stirring constantly until homogenised and taking care that it does not exceed 70°C.

Then add 1.7 ml of glycerine with constant stirring, noting a change in the consistency of the mixture.

Add 3 ml of vinegar while continuing to mix, until no more vapour is visible in the mixture.

Finally, add the grenetin and continue mixing until the suspension is homogeneous.

Once this process is finished, it is poured into the moulds and the seed is placed in the moulds.

The previously filled moulds are placed strategically and then secured with elastic netting.

Finally, for drying, the cutlery is exposed to the sun for 5 days, after which time the bioplastic obtained is removed from the mould.

End

Figure 1 Obtaining pulverised corncob

Flow diagram for the production of the biopolymer.

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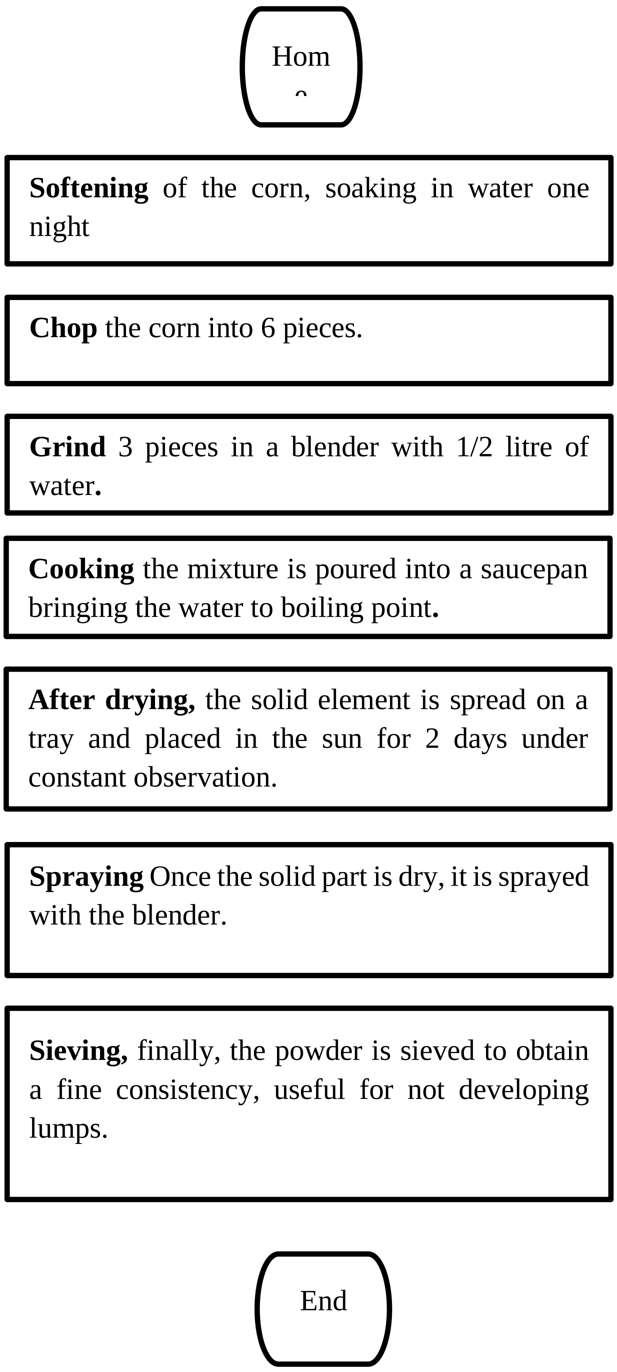


Figure 2 Obtaining the polymer

Obtaining pulverised corncob

The production of the dried and pulverised corncob was carried out in nine stages: softening, chopping, wet milling, cooking, suspension filtration, drying, pulverising and sieving.

- Softening: In order to facilitate chopping, the three olotes are soaked in water overnight.

- Chopping: The olote is chopped into 6 pieces.

- Grinding: Only 3 pieces of the olote are placed in the blender with 1/4 litre of water, a thick mixture with lumps will be obtained.

- Cooking: Pour the mixture into a saucepan and keep stirring constantly over medium heat. When it has reached boiling point, turn off the cooker.

- Filtration: The previously cooked mixture is placed in a sieve while it is still hot. Through this process, the solid part of the suspension is removed, while the liquid part can be left to cool and then poured over the plants.

- Drying: The solid element is spread on a tray and placed in the sun for 2 days, under constant observation.

- Pulverisation: Once the solid part is dry, it is pulverised using a blender.

- Sifting: Finally, the powder is sifted to obtain a fine consistency, which is useful to avoid lumps.

Bioplastic production

The elaboration of the bioplastic was carried out taking into account the methodology described by Guzmán (2013) using corn stover powder instead of corn starch and with an additional input, grenetin.

- To begin, hydrate the grenetin, add 7g with 3ml of distilled water and mix until the elements are incorporated.

- Place the mixture in a bain-marie and whisk continuously until it becomes liquid. Set aside for a few minutes.

- In another pot, place the 17 ml of distilled water together with 5 g of the corn powder, stirring constantly until homogenised and making sure that the temperature does not exceed 70°C at all times.

- Subsequently, 1.7 ml of glycerine is added dropwise with constant stirring, noting a change in the consistency of the mixture.

- Add the 3 ml of vinegar while continuing to stir, until no more vapour is visible in the mixture.

- Add the previously hydrated grenetin and continue mixing until the suspension is homogeneous.

- At the end of this process, it is poured into the mould and the seed is placed in it.

- The previously filled moulds are placed strategically and then secured with elastic netting.

- Finally, for drying, the cutlery is exposed to the sun for 5 days, after which time the bioplastic obtained is removed from the mould.

Experimentation

Olote: It was hydrothermally treated to modify its recalcitrant form and obtain a solid fraction composed mainly of cellulose and lignin, in addition to a soluble fraction rich in xylose. Lignin in combination with low glycerol content favours intermolecular interactions and as the plasticiser content increased, intra-molecular interrelationships were favoured. Its brown pigmentation and lumpy texture to the touch contributed to its appearance.

Distilled water: It is the main solvent for the formation of natural polymers, its contribution is its capacity for synthesis by means of its exposure to heat, combining the reagents used in a homogeneous way to obtain the final mixture.

- Glycerin: Contains plasticising properties due to its ability to reduce the interaction of hydrogen bonds. It also provides the bioplastic with flexibility and tensile strength.

- White vinegar: Provides stability to the substance, contains plasticising properties and helps to maintain its functionality in the time scale of its expected durability. It performs an important preservative action thanks to its degree of acidity, this aspect slows down the growth of microorganisms, although it does not eliminate them.

- Grenetin: Increases the rigidity of the bioplastic by solidifying it. The granules swell, absorbing up to 10 times their weight, then the temperature rises to dissolve the swollen particles and form the solution. This solution gels when cooled to room temperature in this case.

- Seed: Add to the bioplastic the characteristic of germinability, as the seed degrades it can take its rightful place in the soil; it is with the help of the other reagents that the soil will be nourished to receive and germinate the plant.

Evidence

To obtain the ideal prototype, two procedures were applied with variable inputs and quantities in order to have more options and to determine which result was of better quality. It should be noted that from procedure number two, the last test recorded was the one chosen. The details and results of the tests are presented below:

- Procedure 1.

The procedure used is to include all the ingredients mentioned below in a saucepan, place over high heat and mix all the ingredients with a spoon, when half of the lumps disappear, reduce the intensity of the heat (low). Continue mixing. This stage is finished when the lumps are completely dissolved. Finally, the mixture is poured into moulds and left to dry for 5 days.
Note: For the procedure with grenetin, the first step is to dissolve it in water and then place the dissolved mixture in a water bath until it is free of lumps. At the end of this process, the suspension is added to the other ingredients in the saucepan.

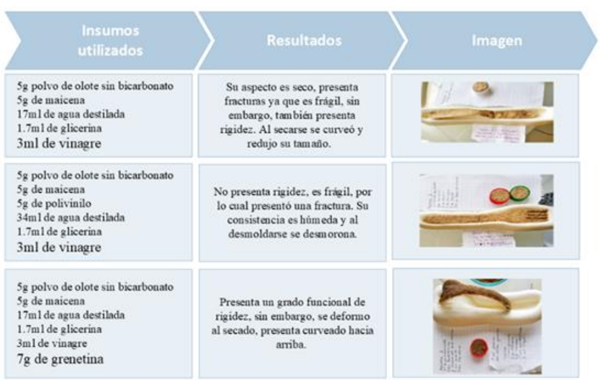
Insumos utilizados	Resultados	Imagen
20g de polvo de olote con bicarbonato 158ml de agua destilada 11g de glicerina 15g de vinagre blanco	Presenta una consistencia húmeda y arenosa, no se observa compacta ni rigida	
20g de polvo de olote con bicarbonato 20g de maicena 158ml de agua destilada 15g de agua destilada 15g de vinagre blanco	Al tacto presenta endurecimiento; se observa compacta y flexible, se observa una reducción de su tamaño original y fracturas.	
20g de polvo de olote con bicarbonato 7g de maicena 7g de polivinilo 158ml de agua destilada 15g de agua destilada 15g de vinagre blanco	Su consistencia es húmeda, arenosa, no compacta ni rigida. Al desmoldarse se desmorona	
20g de polvo de olote con bicarbonato 140ml de agua destilada 10g de bicarbonato 140g de agua destilada 15g de vinagre blanco 7g de grenetina	Presenta muy poca rigidez, es frágil al tacto y como resultado se desmorona.	
20g de polvo de olote con bicarbonato 20g de maicena 140ml de agua destilada 10g de bicarbonato 140g de agua destilada 15g de vinagre blanco 7g de grenetina	La consistencia que presenta es medianamente rígida, consta de altos niveles de flexibilidad. Se redujo de su tamaño original y la prueba se observa grumosa.	

Figure 3 Results of procedure 1

- Procedure 2.

The procedure used in the following section is what we consider to be the ideal procedure, the methodology can be found in the experimentation section.

Remark: In case of not using grenetin, the initial step is omitted.



Insumos utilizados	Resultados	Imagen
5g polvo de olote sin bicarbonato 5g de maicena 17ml de agua destilada 1.7ml de glicerina 3ml de vinagre	Su aspecto es seco, presenta fracturas ya que es frágil, sin embargo, también presenta rigidez. Al secarse se curveó y redujo su tamaño.	
5g polvo de olote sin bicarbonato 5g de maicena 5g de polivinilo 34ml de agua destilada 1.7ml de glicerina 3ml de vinagre	No presenta rigidez, es frágil, por lo cual presentó una fractura. Su consistencia es húmeda y al desmoldarse se desmorona.	
5g polvo de olote sin bicarbonato 5g de maicena 17ml de agua destilada 1.7ml de glicerina 3ml de vinagre 7g de grenetina	Presenta un grado funcional de rigidez, sin embargo, se deformo al secado, presenta curveado hacia arriba.	

Figure 4 Results of procedure 2

The tests presented below are those that were tied to the mould with elastic mesh to prevent deformation during drying, and were carried out as follows:

Figure 5 Use of elastic netting

Insumos utilizados	Resultados	Imagen
5g polvo de olote sin bicarbonato 5g de maicena 17ml de agua destilada 1.7ml de glicerina 3ml de vinagre 7g de grenetina	Presenta un buen grado de rigidez, al secado se redujo su tamaño y se mantuvo en el molde sin deformación alguna. Sin embargo, su aspecto es muy seco y es un poco frágil.	
5g polvo de olote sin bicarbonato 17ml de agua destilada 1.7ml de glicerina 3ml de vinagre 7g de grenetina	Presenta reducción al secado, consta de un grado funcional de rigidez y se mantuvo en el molde sin deformarse.	

Figure 6 Results with elastic mesh.

Results

Once the experimentation process was carried out, 10 tests were carried out, starting from procedure 1 in which 5 tests were carried out, from which it was concluded that the prototypes presented curves and breakage in their structure, and even reduced in their dimensions.

Likewise, for procedure 2, 3 tests are carried out in which it is obtained that if there has been a resistance to perforation (no fracture) and a decrease in the size of the perforation (no fracture) and a decrease in the size of the perforation.

With the implementation of elastic meshes, the best results are obtained in the tests covered with the following characteristics: greater resistance to fracture, maintains its original size and does not present a deformation in its structure.

- Qualitative characteristics: Its brown pigmentation stands out, in addition, it has a functional level of rigidity as it does not fracture when manual force is applied, it has a basic but useful design with room for improvement.

- Quantitative characteristics: The weight of the cutlery is 16g, which shows that it is light to use, its dimensions are 13.5cm high and 3.2cm wide on the widest side and 0.8cm on the narrowest side, an average length useful for its operation, the thickness of the cutlery is 0.6cm, which guarantees its comfort when used.

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- Composition: The bioplastic is made only from environmentally friendly inputs, furthermore, they significantly benefit the earth. The elements used are not harmful to health. The composition of the disposable utensils seeks to be germinable due to the seed inside and biodegradable due to the inputs used, these last two features continue to be examined, as the results will be obtained after their decomposition time has elapsed.

- Quality: They have quality in terms of resistance, rigidity, lightness, functionality, composition, procedure, ecological inputs and goodness for the soil. We continue to examine biodegradability and germinability, as well as looking for improvements in texture, ergonomics and design.

Discussion

There are several proposals at international, Latin American and national level that show various sustainable alternatives to replace disposable plastics to counteract environmental pollution [5], from the University of Curtin, Malaysia, presents an article on the potential of lignocellulose fibre from corn waste, as reinforced bioplastic components, an alternative source of reinforcements to other natural fibres for bioplastic composites. On the other hand, in Peru, the author Dante Arturo Martin Guerrero (2019) from the University of Piura, carried out a project on the design of the production process of biodegradable trays from corn starch, carrying out experimental tests where the resistance, permeability, hardness, perforation, temperature and biodegradability of the product were evaluated, the expected result was obtained, the appearance of the tray is pleasant for the customer and environmentally friendly. In the national context, students from the Autonomous University of Querétaro proposed "Boltsiri", a project to design a bioplastic obtained from corn and other agro-industrial components. According to Mónica Citlalli García (2018), leader of the project, the purpose is to offer a sustainable and ecological alternative that meets the mechanical and resistance characteristics of plastic to reduce degradation time and thus counteract the impact generated by disposable plastic bags.with a ratio of quantities and units. For example, write "Temperature (K)", not "Temperature/K".

Conclusion

The final evaluations with regard to the experimentation in the elaboration of the roofing allowed to recognise in some way some important points in the work with biopolymers based on corn stover as a sustainable alternative in the production of inputs for the service industry; these points can eventually be considered as areas of opportunity for a better definition of the prototype according to the demands of quality and efficiency.

From this perspective, the pulverisation process considered nine stages from the first stage, among which softening, chopping, grinding and pulverisation were decisive to make the raw material sufficiently ductile. Subsequently, in the production of the bioplastic that was governed by certain guidelines of the methodology of Guzmán (2013), several attempts had to be made in order to give the right consistency to the utensil; reagents such as polyvinyl, grenetin and glycerin were relevant to test the degree of rigidity and flexibility of the bioplastic. On the other hand, tests with and without bicarbonate also contributed to a better drying and consistency.

Therefore, the results observed allowed us to detect those qualitative parameters (pigmentation, rigidity and basic design) and quantitative parameters (weight and lightness, ergonomic dimensions and a comfortable thickness) that would finally lead to the creation of a cutlery based on environmentally friendly inputs and with a biodegradability still subject to assessment according to its decomposition time; the seed inserted inside the utensil would finally seek to blend organically with the soil and germinate profitably.

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