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PRODUCTION OF BIOPLASTIC FROM POTATO STARCH

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ABSTRACT

Due to their diverse properties, plastic materials are used in numerous sectors. It is possible to produce different articles and plastic objects with reduced costs, being more accessible to the population. Conventional plastics are obtained from petroleum-derived raw materials, a non-renewable resource in which their extraction and refining process cause major environmental impacts. The production of plastic reaches a level of approximately one hundred and forty million tons per year, and the disposal of these materials is increasing, generating a high rate of waste and leading to an increase of pollution since the decomposition of these materials lasts about five hundred years old. Conventional plastics can be replaced by bioplastics, a material obtained from renewable raw materials such as potatoes, cassava, maize, and which, when disposed of under favorable conditions, decomposes faster, as during its degradation process at least one step occurs. Through the metabolism of organisms present in the environment. Starch has been widely used in the production of biodegradable packaging, so the objective of this work was to produce a biodegradable bioplastic from the potato starch. Potato starch, glycerin, hydrogen peroxide, distilled water, and commercial agar were used to produce the bioplastic. Bench-scale bioplastics had good organoleptic characteristics, similar in appearance to a conventional plastic obtained from petroleum. The thickness, moisture content, and solubility of the bioplastics were analyzed, as well as their fruit preservation capacity. The samples produced were rigid and with good resistance.

Keywords: *Plastics, Bioplastics, Starch*

1. INTRODUCTION

Plastic is an organic and synthetic polymer, solid in your final stage as a finished product, and at some point, in its production phase was turned to fluid, suitable for molding by the actions of heat and pressure (Piatti e Rodrigues, 2005). Most of the industrial plastic materials have petroleum as raw material, a non-renewable natural source (Telles, 2011). Among the most used plastics, it is possible to highlight the polypropylene (PP), high density polyethylene (HDPE) and low density (LDPE). Currently, 140 million tons of plastic are produced per year, distributed between different products. This number is related to the easy processing and low cost of this material (Oliveira, Lacerda, Alves, Santos, Oliveira, and Batista, 2012; Macedo, 2015).

Plastic is a material of difficult compaction, which can lead to waste accumulation in the environment, also compromising the decomposition of other organic materials. Plastic material is resistant to fungi and bacteria, resulting in a slow degradation. In direct contact with the environment, it can take around 100 thousand years to be decomposed. Most of its waste is discarded at dumps and landfills, leading to concern around the disposal process (Machado, 2011; Franchetti, Marconato, *2006*).

In Brazil, approximately 25 thousand ton of plastic packing are discarded every day, which compose 20% of all waste produced, and 80% of these plastic packings are used only once before going to thrash (Ministério do Meio Ambiente, 2016).

Due to the great environmental impact caused by the use of plastic products, in the past years has been studied alternative routes to obtain plastics made by renewable sources, such as bioplastics. This material is similar to conventional plastic, though its degradation time is much shorter, showing to be a much more ecological option (Rodríguez, 2012; Moreno-Bustillos, Humarán-Sarmiento, Báez-Valdez, Báez-Hernández and León-Villanueva, 2017).

The bioplastics have physical and chemical properties similar to conventional plastics, but its degradation can take from 18 to 20 months, reducing the time in contact with the environment. This process is a result, mainly, by the action of microorganisms like fungi, bacteria, and naturally occurring algae (Santos, 2014; Giordani; Oliveira, 2014).

The term bioplastic refers to all plastic material containing organic raw material, but the fact of the raw material being organic does not necessarily indicate that the material will be biodegradable. The bioplastics are the ones that degrade easily through the the composting process or water-soluble bioplastics, which which can have its degradation process started by the air humidity (ABES, 2016; Valero-Valdivieso, Ortegón, Uscategui, 2013).

Several researches about the production of bioplastics using natural and renewable raw materials like castor oil, sugar cane, beets, lactic acid, corn, soya protein, potato, and cassava starch are being realized around the world.(Telles, 2011; Giordani; Oliveira, 2014). In proper conditions (Temperature, humidity, and oxygen availability), the degradation of biopolymers leads to disintegration with non-toxic and not dangerous waste(Fonseca, 2014).

The bioplastics can be extracted straight from biomass, like cellulose and starch, produced by natural or genetic modified microorganisms like PHA, PHAB and TPS, obtained from bio-intermediators like polylactic acid/PLA, Green PET/PlantBottle®, biodegradable plastics obtained from conventional plastics additives like Ecoflex/Ecovio from BASF and conventional plastics produced by renewable raw materials like polyethylene obtained from sugar cane ethanol (Prandella, 2006; Correa, 2018).

Many biopolymer applications depend on their properties, such as; mechanical, thermic, gas, and water vapor barriers. The biopolymers have properties similar to conventional polymers. They can be used to produce every type of package (trays, cups, bottles, monolayer films, laminates, composites, etc.) using the same processing step, as long as adjusted according to its properties (Coltro, Sarantópoulos, Jesus Jr, 2005).

Starch is an abundant raw material present in nature that possesses a relatively low cost, has been used in biodegradable packing production, thus being studied as a replacement for petroleum, due to the fact of being renewable, biodegradable source and toxin less, making possible food applications (Fakhouri, 2009). In 2011, starch mixtures were responsible for 11,3% of produced bioplastics, but due to the increase in research around this topic, this number may increase (Priendniece, Spalvins, Ivanovs, Pubule, Blumberga, 2017).

Due to these characteristics, this project seeks the study and production of a biodegradable bioplastic made from white potato starch and evaluate its physical and chemical properties.

2. EXPERIMENTAL SECTION

The bioplastics were produced using potato starch, glycerin, hydrogen peroxide, distilled water, and commercial agar.

In a blender, it was added 530 grams of washed potatoes and 500 mL of distilled water, according to Pinto (2016). The obtained material was strained and kept at rest for approximately 10 minutes, to separate the starch by decantation. The extracted starch was divided into two portions of 5.6 grams each. The portions were solubilized in 25 mL of distilled water.

The bioplastic was obtained by two different methods, Almeida, Almeida and Miranda Leite (2014) and Santos (2013): on the first, it was added 1 mL of glycerin; 1.12 grams of commercial agar and 1 mL of hydrogen peroxide at 35%. On the second, the reaction order was modified, adding 1 mL of hydrogen peroxide, 1 mL of glycerin, and 1.12 grams of commercial agar. other mixtures were heated to 60 ºC, being stirred by a glass rod until boiling point. Posteriorly, the mixtures were transferred to a Styrofoam tray and stayed in an incubator for 2.4 hours at 40 ºC.

It was observed visible changings on the sample characteristics like color, aspect, hardness, texture, and odor. The determination of humidity of the produced materials was made in triplicates. For each produced bioplastic, it was removed 3 samples of approximately 2 cm^2, which were weighted and placed in an incubator for 24 hours at 105 ºC (Silva, 2011). The humidity was obtained using Equation 1:

$$h = \frac{(mi - mf)}{mi} * 100\% \qquad (Eq. 1)$$

Where *h* is the humidity percentage, *mi* is the initial mass and *mf* the final mass after drying.

The solubility determination was made in duplicates. For each bioplastic, a sample of 2 cm^2

was obtained and placed in an incubator for 24 hours at 105 ºC. Then, the sample was weighted (*mi*) and placed inside a beaker with 10 mL of distilled water for 24 hours at 25 ºC. Posteriorly, the bioplastic was placed in the incubator for 24 hours at 105 ºC to dry. The sample was weighted, obtaining the final mass (*mf*) (Silva, 2011). Thus, it was possible to determine the mass loss (*pm*) by solubilization, using equation 2:

$$pm = \frac{(mi - mf)}{mi} \quad (\text{Eq. } 2)$$

Where *pm* is the mass loss, *mi* the initial mass obtained in the first weighting and *mf* the final mass. The bioplastic film thickness was measured using a caliper rule. Controlling the film thickness, it is possible to evaluate the homogeneity of these materials, the repeatability of its properties measurements, and validate the comparison between different films (Silva, 2011).

To evaluate the barrier properties, it was used apple slices wrapped with bioplastic and placed at room temperature. In order to compare, one slice was wrapped in commercial plastic (petrol based), and one slice was not wrapped, used as the negative control. The samples were analyzed and compared after 5 days (Silva, 2011).

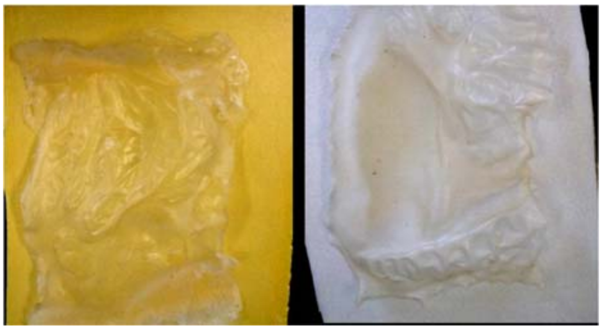
3. RESULTS AND DISCUSSION:

The produced bioplastics presented a rigid aspect, with no cracking, odorless, and colorless. These characteristics were also observed in bioplastics produced previously, also using potato starch as raw material (Almeida, Almeida, and Miranda Leite, 2014).

Both samples presented consistent films with a certain flexibility. This characteristic was obtained because of the presence of glycerin, which increases the mobility of macromolecular chains. This aspect was also observed by Neves and his colleagues in 2013, where bioplastics were produced from potato peel. The high stability and clear aspect are associated with the presence of hydrogen peroxide, since, with the starch oxidation, it is possible to modulate its properties and increase its usage (Brites, 2013).

The firmer appearance presented by the bioplastics is due to the high concentration of amylose. According to Santana (2013), the ratio between amylose and amylopectin affects the bioplastics morphology, a high amylose concentration leads to more homogeneous films, with better mechanical and barrier properties while a high amylopectin concentration leads to separation, with more fragile films.

Image 1 presents the produced bioplastics. The bioplastic 1 showed to be more similar to the conventional plastic, due to its lower thickness.



(a) **(b)**

Image 1: *Produced Bioplastics**(a)** Bioplastic 1**,** **(b)** Bioplastic 2.*

Source: Author.

The thickness determined by direct measurement, using a caliper rule, was 0.04 mm for bioplastic 1 and 0.052 for bioplastic 2. This variation can be related to the way how the bioplastic was spread onto the Styrofoam surface. Since the mixture presents a high viscosity after the heating step, the molding step showed to be difficult.

According to Vasconcellos (2014), a conventional polypropylene (PP) film has a thickness around 0.03 mm. Thus, it is possible to state that the produced bioplastics had a similar thickness to petroleum-based polymers. During the film production, it was observed that films with higher thickness had problems during the drying step, with no film formation.

The produced bioplastics dried correctly because of the thin thickness obtained. The average humidity of the bioplastics was 25.34% and 26.18%, respectively. These values are within the limit set by cassava starch bioplastics, which varies from 14.58% to 51.61% (Santos, 2013). It is possible to compare these values because of the similar humidity range obtained for both cassava and potato starch-based bioplastics. Tough, studies say that the humidity concentration must be 10% maximum, so the film presents good barrier properties (Silva, 2011).

The water solubility is one of the properties that characterize a good biodegradable film. A low water solubility characterizes a good bioplastic (Junior, 2009). The solubility index of the produced bioplastics was 26.1% for bioplastic 1 and 23.6% for bioplastic 2. The potato starch and glycerin films showed solubility values of around 31.7% (Wang, Jin, & Yuan, 2007). The bioplastics presented a good resistance, which can be related to the low solubility index in comparison to the studies in potato starch bioplastics.

The produced bioplastics presented a good degradability in comparison to conventional plastics. This result can be seen in studies made by Azevedo, Almeida e Santos (2017), where was used several natural polymers, among them the potato starch.

The use of bioplastic as food coating was analyzed using apple slices. It was used: (a) A slice wrapped in bioplastic 1, (b) a slice wrapped in bioplastic 2, (c) a slice wrapped in conventional plastic, petroleum-based, and (d) a fourth sliced used as a negative control, with no coating. Image 2 is possible to observe the aspect of the slices after 5 days.

(a) (b) (c) (d)

Image 2:*Apple slices after 5 days of exposure.*

Source: Author.

Image 2 showed that the better coating was made by conventional plastic. This indicates that the barrier property of the conventional plastic is better than the bioplastics. This also can be related to the high humidity found in the produced bioplastics. The air humidity, associated with the bioplastic humidity affected the fruit conservation, even when compared with the negative control. It is possible to observe that the bioplastic 2 conserved the apple slice better than bioplastic 1. Bioplastic 2 presented a lower solubility index than bioplastic 1, which could have influenced the difference in conservation between the two bioplastics.

At research made by Silva (2011), similar results were founded for bioplastics produced from pine cone starch, where three apples, one coated with the biofilm, one with conventional plastic and negative control, were evaluated. Inthe experiment, it was also observed that the conventional plastic had better results in comparison to the bioplastic, which was explained by the good permeability to ethylene by the conventional plastic, fundamental factor to fruit conservation.

4. CONCLUSIONS:

In this work, it was produced a bioplastic of white potato starch. The produced bioplastic presented good organoleptic characteristics, with similar aspects to a conventional plastic made of petroleum.

During the research, it was observed that the determination of the film thickness has great importance due to the fact that a high thickness does not allow a good film formation. The thickness obtained in this work was considered satisfactory since it was similar to polypropylene films.

The humidity concentration presented in the biofilms was considerate high, where the films with the best barrier properties for water and air possess a low humidity index, around 10%. The produced biofilms presented a rigid aspect, with good resistance, which is associated with the low water solubility index presented by the biofilms.

In the future, it is suggested the realization of permeability studies, to increase the bioplastics properties in food conservation. Mechanical tests, like tensile, stress.

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