Article

Effect of using different types of avocado oil in the production of gelatin-based biopolymers Bloom 300

Efecto del uso de diferentes tipos de aceite de aguacate en la elaboración de biopolímeros a base de grenetina Bloom 300

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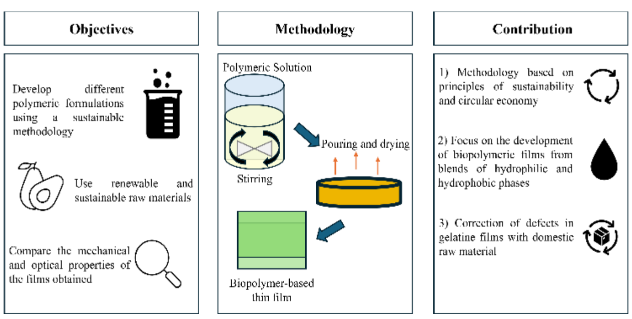
Abstract

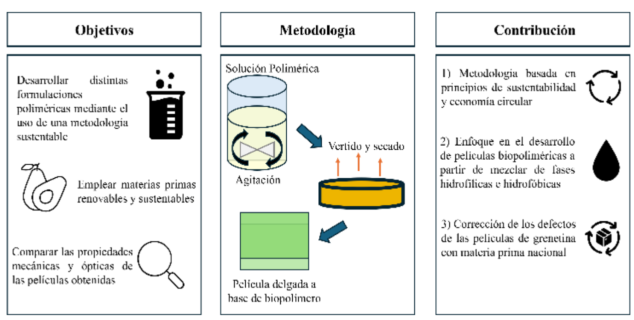
Derived from the high demand in the use of polymers for the preservation or transportation of various products, the need to replace them with environmentally friendly materials arises, thus emerging biopolymers. In the present work, different biopolymers were developed made with avocado oil [commercial, extra virgin and natural], 300° Bloom gelatine and glycerine as a plasticizer. In order to analyse the homogeneity of the plasticized biofilms, they were characterized by UV and infrared, evaluating their absorption, as well as the transmittance in the visible range, in addition the effect of wettability was analysed by measuring the angle of contact on the surface of the biopolymers and by using a thermobalance, the percentage of solids was measured after 90 minutes of exposure. The results showed a good performance, highlighting the films made with Bloom type gelatine and natural oil maintains the best properties.



Biodegradable, Biopolymer, Film

Resumen

Derivado de la alta demanda en el uso de polímeros para la preservación o transportación de diversos productos nace la necesidad de sustituirlos por materiales amigables con el ambiente surgiendo de esta manera los biopolímeros. En el presente trabajo se desarrollaron diferentes biopolímeros fabricados con aceite de aguacate [comercial, extra virgen y natural], grenetina 300° Bloom y como plastificante glicerina. Con la finalidad de analizar la homogeneidad de las biopelículas plastificadas se caracterizaron mediante UV e infrarrojo evaluando su absorción, así como la transmitancia en rango visible, además se analizó el efecto de la humectabilidad mediante la medición del ángulo de contacto sobre la superficie de los biopolímeros y mediante el uso de termobalanza se midió el porcentaje de sólidos después de 90 minutos de exposición. Los resultados mostraron un buen desempeño, destacando las películas elaboradas con grenetina tipo Bloom y aceite natural mantiene las mejores propiedades.



Biodegradable, Biopolímero, Película

Area: Promotion of frontier research and basic science in all fields of knowledge.

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Introduction

Made up of a long chain of repeat units [monomers], polymers are structures with high molecular weights due to their macromolecules [Rudin & Choi, 2025] Polymers have become a fundamental part of everyday life due to their use in the manufacture of various objects and materials.

The excessive use of these materials has made waste disposal increasingly complicated, so efforts to revolutionize waste replacement are receiving significant attention [Nair, Sekhar, Nampoothiri, & Pandey, 2017]

One of the alternatives to reduce the use of synthetic polymers is the production of *"biopolymers",* biodegradable plastics produced from monomers of biological origin, synthesized by microorganisms or derived from animal or plant biomass [Nair et al., 2017]

The aim has been to generate materials with the ability to form thin films on a surface that come from agro-industrial by-products such as fruits and vegetables, for example, avocado [*Persea americana*]. [Santamaría Juárez, 2025]

Avocado oil represents a vegetable input that stands out for its outstanding physicochemical properties thanks to its high content of fatty acids [oleic acid], tocopherols and carotenoids. It is used in various applications, has excellent dermatological properties, within gastronomy it has good thermal stability and a mild flavor. The extraction to obtain it can be by various methods, some of them are by solvents, heat pressure or cold pressing, depending on the final application since with the latter method the sensory and bioactive compounds are better preserved. [Woolf et al., 2009]

The factors that directly influence the yield of the extraction are the ripeness of the fruit, the climatic conditions of cultivation, the processes and care after its harvest. The obtaining of oil usually comes from fruits rejected for marketing for human consumption, making it a sustainable strategy, although compared to other vegetable oils its commercial volume is limited. [Woolf et al., 2009]

As mentioned, the extraction process significantly influences the quality of the oil and its chemical profile [Flores et al., 2019]

Cold Press Method

Ideal for the production of extra virgin oil due to the preservation of antioxidants since heat is not applied, it has a low yield, but improves the bioactive profile.

Ultrasound-assisted aqueous extraction

It improves efficiency without chemical solvents as it uses waves to release lipids, the oil obtained has a high content of fatty acids and phenolic compounds.

CO_2 extraction

This method has two variants, the first is supercritical CO_2; The oil obtained contains high bioactive compounds, high oxidative stability, uses carbon dioxide as an ecological solvent but its highest efficiency is found at pressures of 400 bar. The second subcritical CO_2; The oil produced has greater clarity, the content of triacylglycerides and fatty acids is improved, and it also has a lower melting point.

Enzymatic extraction

It improves performance by up to 25% and is a potential method in case of integrating a sensitive compound, enzymes such as pectin or cellulose are used.

Organic solvent extraction

One of the most common methods is Soxhlet which uses mixtures of chloroform and methanol, the oil obtained contains fewer antioxidants, but the fatty acids are preserved, in some cases hexane is used for the formation of specific compounds, but a post-process chemical control is necessary.

Depending on the extraction method, there are multiple technological applications for avocado oil such as the synthesis of structured lipids, the formation of food nano emulsions or the production of biodegradable polymers, becoming very versatile. [Flores et al., 2019]

Within the literature, there have been works by different researchers that directly use the pulp of fruits such as apples [Rojas-Graü et al., 2007], Barbados cherries [Azeredo, Miranda, Rosa, Nascimento, & de Moura, 2012] as film-forming solutions, obtaining potential results in various applications.

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Another example is overripe banana pulp has been investigated as a potential raw material for the production of biodegradable films using plasticizers such as glycerol and pectin as a binder. The biopolymers showed a significant increase in elongation when glycerol was significantly added, but the resistance was reduced, so a greater amount of pectin was added. [Martelli, Barros, & Assis, 2014]

The mango pulp was used for the production of biopolymers reinforced with cellulose nanofibers, the incorporation of the reinforcement increased the mechanical resistance and the elastic modulus by the formation of an internal fibrillar network. Due to the components of the pulp [pectin and starch], plasticizers and binders were not added, however, the materials obtained by their mechanical characteristics are a strong candidate for application in food packaging. [Azeredo et al., 2009]

In the case of avocados, the potential of pulp residues for the production of biodegradable polymeric films has been analyzed. Glycerol was incorporated as a plasticizer additive, cassava starch and microcrystalline cellulose as reinforcement, the characterization shows that by adding starch and glycerol the biopolymers reach an elongation of up to 13.9% and a resistance of 2.70 MPa. [Dalle Mulle Santos et al., 2016]

The incorporation of agro-industrial waste in the production of biopolymers has generated a wide field of research, so taking into account the research already carried out, this work presents the production of biopolymers based on the use of proteins such as gelatin with a plus by increasing their Bloom degrees [standardized measure of the resistance to deformation of a gelatin gel], glycerol as a plasticizer and avocado oil as a film-forming solution.

Methodology

For the elaboration of the biopolymers, a solution of 300° Bloom gelatin was prepared in a ratio of 1:8 in distilled water, then glycerin was constantly added while it was in agitation; Once the solution is homogenized, add avocado oil [commercial, extra virgin and natural] without stopping the agitation.

The solution is poured into a metal mold to let dry. Once the biopolymers are dried, they are carefully unmolded and stored tightly.

Box 1

Table 1

Nomenclature of biopolymer samples according to the oil used

Content	Nomenclature
Grenetin Bloom + Commercial Avocado Oil	BC
Grenetin Bloom + extra virgin avocado oil	BEx
Grenetin Bloom + Natural Avocado Oil	BN

By the basic method of casting, a statistic of the thickness of each biopolymer was performed, as well as the infrared and ultraviolet blocking rate, as well as the visible light transmission of each of the films, they were also characterized by stereoscopy, the contact angle was measured and the percentage of solids in a thermobalance was quantified after 90 minutes at a temperature of 112°C.

Results

A total of three biopolymers were made by varying the type of avocado oil, as can be seen in Figure 1 the BC and BEx samples are transparent, while BN has a greenish-yellow coloration that is attributed to the natural oil content as it did not go through any clarification or washing process.

Box 2

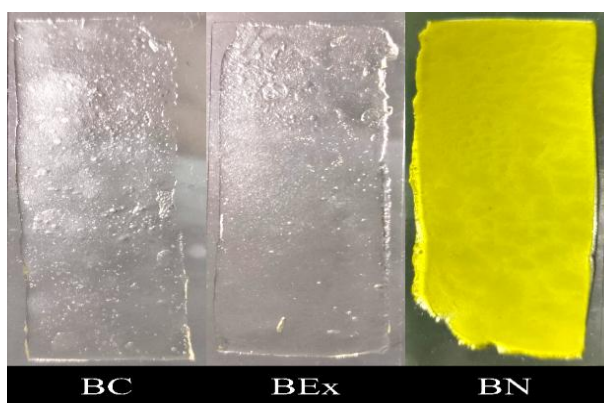

Figure 1

Biopolymer films made with 300° Bloom gelatin and avocado oil

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Each one was measured 10 times on each side, adding up to a total of 40 measurements to form a statistic of the thicknesses, in table 2 it is observed that the biopolymers range from 0.5 to 1 millimeter in thickness on average, in addition to the value of the standard deviation BEx is the most uniform sample.

Box 3

Table 2

Statistical data on the thickness of biopolymers

Sample	Media [mm]	Standard deviation
BC	0.527	0.208
BEx	0.757	0.100
BN	1.09	0.156

Figure 3 shows a graph of boxes where it is observed that the greatest variability in thicknesses is present in BC, while BEx had a homogeneous behavior and BN exhibits an intermediate behavior.

Box 4

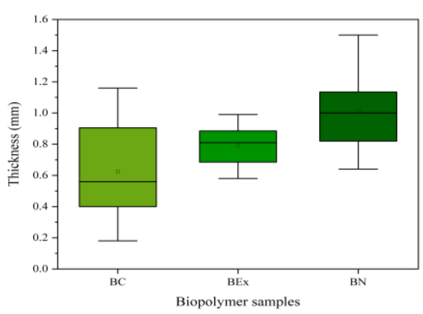

Figure 3

Graph of the variation in the thicknesses of biopolymers with different avocado oils

It was possible to observe that on the surface of the biopolymers there was an excess of avocado oil, each of the samples was characterized by stereoscopy at 40x.

Box 5

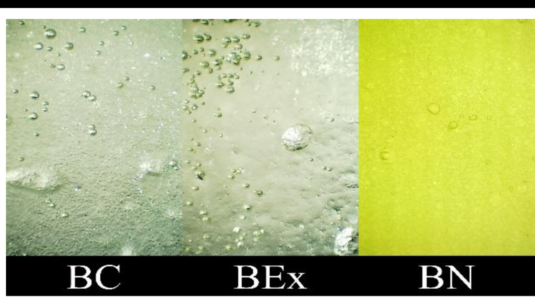

Figure 4

Biopolymer surface using 40x stereoscope

As can be seen in Figure 4, the surface contains small bubbles from the manufacturing process due to magnetic agitation for homogenization, however, the BN sample had a considerably smaller amount.

Due to the shades exhibited by the three samples, the rejection rate for Uv and IR and the level of transmittance of visible light were characterized.

As shown in table 3 the BN sample shows high values for Uv and IR rejection, however, the visible light transmission is low, it can be attributed to the opacity that the sample presents since the natural avocado oil gave the biopolymer a green/yellow color that does not allow visible light to pass through freely.

Box 6

Table 3

Values obtained from the characterization of Uv and IR rejection and visible light transmission

Sample	Rejection		Visible transmission
	Uv	IR	
BC	86.1 %	83.2%	14.6%
BEx	60.3 %	46.7%	54.7%
BN	99.7%	95.3%	4.6%

The BEx sample presented lower values compared to the other two samples, however, it has the higher value in the transmission of visible light, this can be attributed to the fact that the extra virgin oil is almost completely free of all the impurities of its extraction in addition to carrying out a clarification process. The contact angle of each of the samples was measured, showing a hydrophilicity phenomenon with values less than 90°.

Box 7

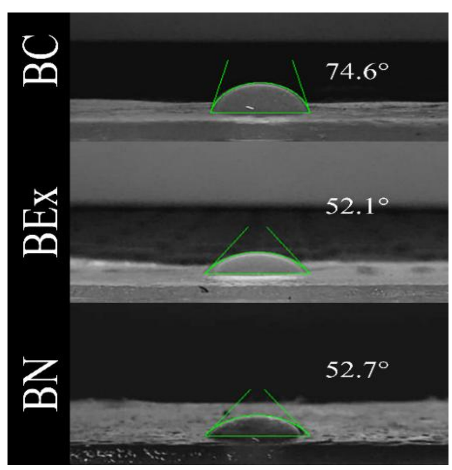

Figure 5

Contact angle of biopolymers

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Figure 5 shows that the BC sample has the highest contact angle of the 3 samples with 74.6°.

Figure 6 shows the graph of the change in the percentage of solids in the BN sample since residue was observed on its surface after the drying process.

Box 8

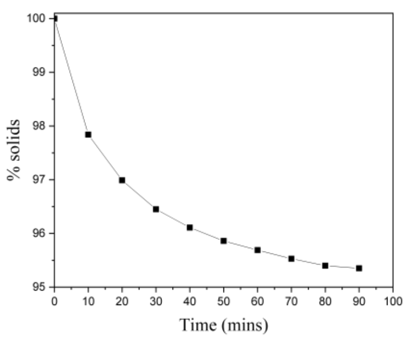

Figure 6
Graph of the change in the percentage of solids in the BN sample over 90 minutes at a temperature of 112 °C.

The test on the thermobalance began with a portion of the sample weighing approximately 5 g, at the end of the test the weight was reduced by 4.65%, obtaining a weight of 4.7 g.

Box 9

Figure 7
Biopolymer after thermobalance test

As a result of the test on the thermobalance, a change in color was obtained in the biopolymer as shown in Figure 7, lighter areas on the surface and a reduction in the sample size are observed.

Conclusions

Natural biopolymers have the advantage of being available, biodegradable and biocompatible, thus contributing to ecological safety.

The biopolymers made with gelatin with 300 degrees Bloom, glycerol and avocado oil showed a homogeneous surface, but contained air bubbles inside that were visible to the naked eye, likewise their thicknesses range from 0.5 to 1 mm presenting variations in their ends.

The significant rejection of Uv and IR is exhibited by the BN sample, however, it does not have a good transmittance for the visible range.

The contact angles are below 90°, being hydrophilic. The change in the percentage of solids decreases by only 4.65% so the biopolymer does not have a considerable loss of mass.

The type of oil influences the morphology and transparency of biopolymers.

Conflict of interest

The authors declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that would have appeared to influence the article reported in this article.

Authors' contribution

Nolasco-Arizmendi, Víctor Alfredo: Experimentation, characterization, analysis of results, conceptualization, writing.

Rodríguez-Espíndola, Gerardo Daniel: Writing.
Melo Máximo Dulce Viridiana: advice, characterization, analysis of results, conceptualization.

Melo-Máximo, Lizbeth: Project advice, conceptualization, characterization and analysis of results.

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Background

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Basic

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Support

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