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Physical characteristics of biopolymers obtained from cereal starch biomolecules

Caracteristicas físicas de biopolímeros obtenidos a partir de biomoléculas de almidón de cereales

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Abstract

Natural biopolymers have been of great help, due to the versatility of their mechanical, biodegradable and biocompatible properties. They have been adapted for different uses. In the present work the elaboration on a laboratory scale of biopolymers of cereals Zea mays, Sorghum and Triticum is shown, the obtaining of the starch biomolecules by means of alkaline extraction [1], edible chemical modifiers such as citric, tartaric and ascorbic acid were used, glycerin as plasticizer and distilled water for hydration. Eleven experiments E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11 were carried out under two drying conditions: room temperature and a Felisa oven at 30±1°C for 24 hours. Experiments E1, E2, E3, E4, E7 were made with biomolecules extracted from the starch of the three cereals mentioned, using citric acid as a chemical modifier and experiments E5, E6, E8, E9, E10 and E11 were carried out with standardized starch. tartaric acid and ascorbic acid in order to compare the stability in its macromolecular matrix of the biopolymers. Concluding that the chemical modifier that provides better physical characteristics such as miscibility in biopolymers was citric acid compared to the use of tartaric acid and ascorbic acid. In addition, it was observed that the less molecular weight of starch biomolecules are used and stability at a temperature of 30 ± 1°C for 24 hours, a stable, cohesive and flexible biopolymer macromolecular matrix is obtained as shown in experiments E3, E4, E7 and E11.

Biopolymers, Macromolecular, Biocompatibility

Resumen

Los biopolímeros naturales han sido de gran ayuda, debido a la versatilidad de sus propiedades mecánicas, biodegradables y biocompatibles. Se han adecuado para diferentes usos. En el presente trabajo se muestra la elaboración a escala laboratorio de biopolímeros de cereales Zea mays, Sorghum y Triticum, la obtención de las biomoléculas de almidón mediante extracción alcalina [1], se utilizó modificadores químicos comestibles como son ácido cítrico, tartárico y ascórbico, como plastificante glicerina y para la hidratación agua destilada. Se realizaron once experimentos E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, en dos condiciones de secado, temperatura ambiente y horno Felisa a 30±1°C por 24 horas. Los experimentos E1, E2, E3, E4, E7 se elaboraron con biomoléculas extraídas de almidón de los tres cereales mencionados, usando ácido cítrico como modificador químico y los experimentos E5, E6, E8, E9, E10 y E11 se realizaron con almidón estandarizado, ácido tartárico y ácido ascórbico con la finalidad de comparar la estabilidad en su matriz macromolecular de los biopolímeros. Concluyendo que el modificador químico que aporta mejores características físicas como miscibilidad en los biopolímeros fue el ácido cítrico a comparación del uso del ácido tartárico y ácido ascórbico. Además, se observó que entre menos peso molecular de biomoléculas de almidón se usen y estabilidad en la temperatura de 30± 1°C por 24 horas se obtiene una matriz macromolecular de biopolímero estable, cohesiva y flexible como muestran en los experimentos E3, E4, E7 y E11.

Biopolímeros, Macromolecular, Biocompatibilidad

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Introduction

Biopolymers are produced by living organisms and are considered sustainable materials as they are biodegradable, such as plants, animals or microorganisms, and are synthesised by processing enzymes that link building blocks such as amino acids, hydroxylated fatty acids and polysaccharides to form high molecular weight molecules. Starch is the main energy reserve polysaccharide in plants, consisting of glucose chains with a linear (amylose) or branched (amylopectin) structure [2]. Starch granules have amorphous and crystalline regions. The crystalline region has a high degree of organisation and is mainly composed of amylopectin, while the amorphous region is rich in amylose and has less organisation [3]. These polymers are derived directly by fermentation or by polymerisation with chemical modifiers, causing degradation upon contact of the material with an aqueous medium; the penetration of water into the polymer matrix causes swelling, breaking of intermolecular hydrogen bonds, hydration of the molecules and finally, hydrolysis of the unstable bonds.

In the starch gelation process, it occurs in a narrow temperature range that varies depending on the source of the starch. The uncoiling of the molecules and the thermal mobility of the molecules due to swelling cause the crystallinity to decrease, breaking the structure. The behaviour of the mixture will depend on the concentration and level of water absorption by the starch. When gelatinisation occurs, the swollen starch granules occupy the empty spaces. Viscosity increases with temperature until the granules fragment, disintegrate and dissolve, leading to a decrease in viscosity. At high starch concentration, when a thermoplastic starch is to be obtained, the behaviour is different. The higher the stiffness, the higher the resistance due to the collision between the swollen granules, which generates a high viscosity [4]. Against this background, different biopolymers were produced from alkaline extraction [1] to obtain starch biomolecules from Zea mays, Sorghum and Triticum and to observe the characteristics of their macromolecular matrix with the following characteristics their macromolecular matrix with different chemical modifiers giving way in the future to designate unique properties that make them irreplaceable for certain applications, such as elastomers, rubbers, polypropylenes, thermoplastics, etc.

Methodology

Zea mays, *Sorghum* and *Triticum* cereals were collected from Celaya Guanajuato. Grinding was carried out with a 1 HP Fumasa MN-80 nixtamal mill. The result of the grinding was weighed to obtain 1± 0.1 kg. The sieving was carried out using the HIGHTOP flour sieve at 100 microns. The acid extraction of cereal starch biomolecules followed the methodology and its modifications of Yamamoto et al 1973 [1]. It started with a hydration of the flour of the three cereals, then two alkaline washes controlling the hydrogen potential and after the washes the neutralization was corroborated and then centrifuged at 3000 rpm for 20 min. at a temperature of 25 ± 0.1° C. Drying of the starch at 35± 0.3° C for 48 hours. Eleven biopolymer experiments were prepared following the methodology and modifications of Yamamoto et al 1973 [1]. from starch biomolecules of *Zea mays*, *Sorghum* and *Triticum*. Table 1

	E1	E2	E3	E4	E7
	% (p/v), (p/p) y (v/v)				
Ad	Biomoléculas de cereales				
AZ	20 ± 0.1	20 ± 0.1	5 ± 0.1	5 ± 0.1	2.5 ± 0.1
AS	20 ± 0.1	20 ± 0.1	5 ± 0.1	5 ± 0.1	2.5 ± 0.1
AT	20 ± 0.1	20 ± 0.1	5 ± 0.1	5 ± 0.1	2.5 ± 0.1
H2Od	64± 0.01	64± 0.01	75± 0.01	75± 0.01	76± 0.01
Ac	10 ± 0.1	10.± 0.1	12.4± 0.02	12.4± 0.02	12.8± 0.02
G	6 ± 0.3	6± 0.2	7.6± 0.01	7.6± 0.01	7.6± 0.01
T °C	*	**	*	**	**

	E5	E6	E8	E9	E10	E11
	% (p/v), (p/p) y (v/v)					
Ad	Biomoléculas estandarizadas					
AE	20 ± 0.1	20 ± 0.1	5 ± 0.1	5 ± 0.1	5 ± 0.1	5.2 ± 0.1
H2Od	62.5± 0.1	62.5± 0.1	75± 0.1	75± 0.1	76± 0.1	76± 0.1
Ac	–	-	-	-	-	13± 0.1
Aa	-	10.4± 0.02	12.5± 0.02	-	-	-
At	10.4± 0.1	-	-	12.5± 0.02	12.8± 0.02	-
G	6.2± 0.01 *	6.2± 0.01 **	7.5± 0.01 *	7.5± 0.01 *	5.12± 0.01 **	5.6± 0.02 **

Triticum in triplicate. Ad (Additive) AZ (*Zea mays* starch), AS (*Sorghum starch*), AT (T*ritucum* starch) AE (Starch standardised as control), Ac (Citric acid), Aa (Ascorbic acid), At (Tartaric acid), G (Glycerine H20d (Distilled water), Biopolymer drying conditions. Room temperature 24 hr (*) and 30 ± 0.1°C 24 hr. Felisa Fe-293ad oven (**)

Table 1 Elaboration of eleven biopolymers from starch *biomolecules of Zea mays, Sorghum and Triticum in triplicate*
Source: Own elaboration

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Results

Figure 1 shows the biopolymers obtained from the eleven cereal experiments using Zea mays, Sorghum, Triticum and standardised starch biomolecules. The colours of the biopolymers are pearly white, dark brown and light brown to brown, the pigment is caused by the carotenoid content of the cereals, but depends on the percentage of carotenoids in each cereal and the molecular weight content of the starch biomolecule used in the different biopolymers. The experiments with the lowest molecular weight such as E7 show lighter colours compared to the other experiments. In experiment one and two, the same molecular weights of starch biomolecules, chemical modifiers, moisturiser, plasticiser and a different drying process were used, as shown in table 1, observing that by maintaining a stable temperature during the 24 hours, it provides better stability in its macromolecular matrix with cohesive resistance, as well as hydration avoiding breakage in its matrix compared to experiment 1, which was dried at room temperature with a dehydration and breakage behaviour.

Experiment E3, E4 followed the same technique using low molecular weights derived from the previous result, changing the drying E3 room temperature and E4 stable temperature. Observing a radical change in clarification, its stable macromolecular matrix without ruptures, temperature stability plays an important role showing a similar characteristic to a commercial polymer. Experiment E7 improved its characteristics by reducing its molecular weight table 1, obtaining a better result in its miscibility, stable macromolecular matrix and flexibility upon mould release.Experiments E5, E6, E8, E9, E10, E11 were carried out with different molecular weights derived from the previous results. standardised starch biomolecule was used as a control to observe the behaviour of tartaric acid and ascorbic acid. In the experiment E5 was carried out with high molecular weight and as a chemical modifier tartaric acid dried at room temperature where it presents a prominent macromolecular matrix, at the beginning it was soft and when it was tempered, it returned to its rigid state similar to a thermoplastic, these are characterised by their cross-links between molecular chains that only break when heated to excessive temperature, which causes the degradation of the polymer.

Experiment E6 was under the same weight conditions as E5, using tartaric acid and with stable temperature for 24 hours, it can be observed that it shows a soft and malleable characteristic. E8 and E9 were carried out with the same molecular weights and the same drying conditions but different chemical modifiers, obtaining better results in miscibility and stability of its molecular matrix when tartaric acid was used. With these results, finally, it was decided to work with acid modifiers such as tartaric acid E10 and citric acid E11, which were the ones that presented the best behaviour to compare the conditions that have been obtained so far according to molecular weights and drying, for this reason a better physical characteristic comparable to crystalline polypropylene polymers was obtained.

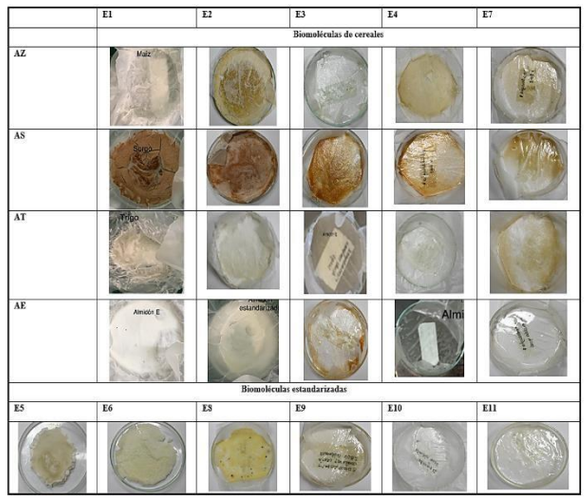

Figure 1 Biopolymers of cereal biomolecules. Biopolymers of starch biomolecules from Zea mays, Sorghum and Triticum using the three cereals. E1, (Experiment 1) Ad (Additive) AZ (Zea mays starch), AS (Sorghum starch), AT (Triticum starch) AE (Standardised starch as control), AE (Standardised starch as control)

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Conclusions

The biomolecules extracted from cereals Zea mays, Sorghum, Triticum presented cohesive macromolecular matrix; which gives them good mechanical properties that could be measured in the future such as adhesion and flexibility [6].

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Considering amylose as a starch component, it is the one that provides the three-dimensional network that will form the macromolecular matrix, therefore, the lower the molecular weight used, the better the adhesion and the better the flexibility at the end of the drying process, improving the detachment from the mould. In addition, its retrogradation is less, so the properties will not change with respect to time. The chemical modifications of citric acid in the acid hydrolysis of the biopolymers improve the miscibility and flexibility. The molecular weights to be used in biopolymers can change the physical characteristics and orient them to different classifications similar to commercial polymers such as thermoplastics, polypropylenes etc.

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