EXTRUSION CHARACTERIZATION OF STARCH BIOPOLYMERS FOR ADDITIVE MANUFACTURING APPLICATIONS

César Bacca (1), Ernesto Córdoba (2), Bibiana Vallejo (3)

1. MEng, Dep. Eng. Mechanics and Mechatronics, UNAL, Colombia; 2. Prof. Dep. Eng. Mechanics and Mechatronics, UNAL, Colombia; 3.Prof. Dep. Pharmacy, UNAL, Colombia

Thematic Nucleus: Extrusion process, 3D Printing and Biomaterials

Introduction

Additive manufacturing, also referred to as 3D Printing, is currently at the forefront of processes for obtaining customized products, due to its low costs and accessible design, being possible to innovate in sustainable materials such as gelatinized starch, and adapted in additive manufacturing platforms, with applications in food [Escalante-Aburto, 2016] and biomedical industries [Koski, 2018]. Some publications have defined the scopes of gelatinized starch to form geometric shapes by extrusion additive manufacturing techniques [Fallahi, 2016], and also highlight the effect of rheology in the process [Xie, 2009].

In this research, were studied the basic requirements of the experimental platform, focused on identifying the extrusion rate, speed and diameter of the extruded material, with respect to the effect of the extruder speed and the different mixtures of biopolymers obtained: type of starch (cassava and corn), percentage of starch, glycerin and water, with the purpose of identifying the interaction of the material with the parameters of the extrusion process.

Methods

For the development of the tests, has implemented an extruder WASP, with a 0.84 mm nozzle, adapting a PVC reservoir tank, with a capacity of 500 c.c. with an internal piston driven at a pressure of 0.3 MPa. For each of the tests was adjusted three speed levels of the extruder screw (36.9, 18.5 and 9.6 RPM), controlling the motor by means of a microcontroller.

Were used mixtures of corn and cassava starches, at a ratio of 20% and 25%, and two levels of glycerin (0% and 15%, with respect to the dry base content), bringing the starch to its gelatinized state.

To determine the extrusion rate, the material is weighed at the extruder outlet, during a specific period of time. The speed of the extruded material is analyzed using the Tracker software, over a 10 mm stroke (Figure 1). And the diameter of the extruded material is obtained by placing a stereomicroscope, positioning the objective parallel to the material output (Figure 2).

Results

In the determination of the extruded diameter, it was found that the cassava starch blends presented a larger diameter of 1.19 mm, compared to corn starch of 0.78 mm, due to the swelling effect presented by starches with a high amylopectin content with respect to the amylose value (polysaccharides that make up the starch structure), which is why cassava starch presents a higher diameter [Zdanowicz, 2016]. This condition may also explain the difference found between the extrusion speed of the corn (1111.1 mm/min) and cassava blends (411.7 mm/min), or the difference between the extruded material rates of the blends (Corn: 0.671 g/min and Cassava: 0.419 g/min).

Discussion

By means of the experimental platform adapted in the present experimental research, it was possible to determine three relevant parameters for the adaptability of the extrusion system and the starch biopolymer material, to a robotic platform with 8DOF of additive manufacturing, being of great importance the extruder output speed to determine the speed range to be programmed in the extruder head, the amount of material supplied, and finally with the diameter the distance between trajectories (lateral gap) or between layers (vertical gap) can be adjusted, and in this way make a better distribution of the material..

Figures

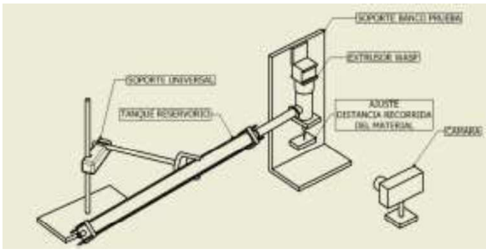

Figure 1. Experimental scheme to determine the speed of extruded material

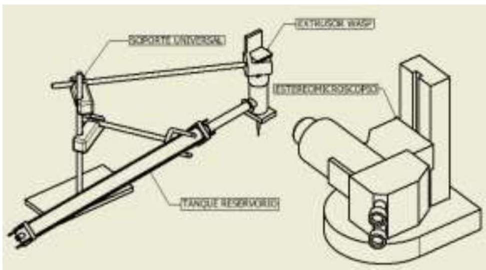

Figure 2. Experimental scheme to determine the diameter of the extruded material

References

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