Chapter 4 / Capítulo 4

Turning Research into Reality as a Contribution to Transforming Society

Hacia la materialización de la investigación como aporte a la transformación de la sociedad

Diana Paola Navia-Porras and Héctor Samuel Villada-Castillo

Abstract

Coordinating University, Company, and State is an important challenge that should be seen as a means of increasing competitiveness and productivity in society. The Science and Technology of Biomolecules of Agro-industrial Interest research group (Cytbia) at Universidad del Cauca is one of the stakeholders involved in generating knowledge in the field of biodegradable packaging and is the leading figure in the creation of a spin-off in a bid to turn the innovations that have been developed into reality.
This chapter examines different aspects of the developments and challenges related to the innovations obtained.

Keywords: coordination, biodegradables, biocontainers, innovation, materials.

Resumen

La articulación entre la Universidad, la Empresa y el Estado es un reto importante que debe ser considerado como estrategia para el incremento de la competitividad y productividad de las sociedades. En este contexto, el grupo de investigación Ciencia y Tecnología de Biomoléculas de Interés Agroindustrial (Cytbia) de la Universidad del Cauca forma parte de los actores involucrados en el proceso de generación de conocimiento en el campo de los empaques biodegradables, y es protagonista de la creación de una *spin-off*, como apuesta a la materialización de las innovaciones desarrolladas.
Este capítulo examina aspectos relacionados con los desarrollos y desafíos de las innovaciones obtenidas.

Palabras clave: articulación, biodegradables, bioenvases, innovación, materiales.

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Introduction

The current processes of globalization, involving a large number of societal changes, have generated a series of transformations in the socioeconomic structure that necessarily affect education and, as one of its fundamental organizations, the university. This has seen the knowledge and information society organized in new ways, and all stakeholders involved, especially researchers, must adapt in order to fulfill their potential. It is therefore important to highlight the relevance of the university in human development and, essentially, in the training of students, researchers, and innovative professionals whose key challenge is to participate in the transformation of society. For this reason, it is increasingly appropriate to conduct research into sensitive subjects, that is, in matters that are truly important for the outside world and that target real problems in society.

Knowledge appropriation and the transfer of technology are matters of great importance that must be consolidated in research projects and proposals, as the knowledge generated should be transferred to the necessary organizations in order for it to be successfully applied. There is no use in academia producing ideas and products (prototypes, products, processes) if their success is limited to an oral presentation of the work undertaken; coordination with external stakeholders such as the company and the State is vital for industrial and social development. Once knowledge has been transmitted, it will be appropriated and used to achieve the desired objective.

The University-Company-State (UCS) relationship, which commonly appears in different fields of knowledge, can be reduced to University-Society (US), as the company and the State form part of society. This US link, however, must be strengthened by keeping academia up to date with society's needs so that training and constructive processes can address pertinent issues, with the aim of implementing strategies that allow the stakeholders involved to positively influence society. Accordingly, the primary strategy is to strengthen proactive contact between the two parties.

The Cytbia research group at Universidad del Cauca has been working in collaboration with entities such as the Ministry of Agriculture and Rural Development and the Regional Center of Productivity and Innovation in Cauca (CREPIC), conducting research into biodegradable materials based on starch resources (Navia & Villada, 2012). Currently, these developments are being taken up by other research groups in southwest Colombia, such as Universidad de San Buenaventura, Cali campus, and Universidad del Valle, with the involvement of highly inventive and collaborative human talent in these processes. Nevertheless, a valuable element

of this work, and one of the medium-term goals of the groups and institutions involved, is to form a company. The aim is to translate the different innovations undertaken by these universities and private institutions into initiatives, which become effective when they are disseminated in society.

Background and experiences

The annual increase in consumption of plastic made from fossil fuels is a global issue, as the disposal of these products has a negative impact on the environment, mainly due to their accumulation in landfills (Souza et al., 2012, p. 110). Many researchers worldwide are therefore directing their efforts towards the study and creation of bioplastics using natural resources such as albumin, collagen, glucose, carboxymethyl cellulose, chitosan, chitin, and starch (Tharanathan, 2003). Given that packaging represents 40% of annual global plastic production (which exceeds 250 million tons) (Chiellini, 2008, p. 4), biopackaging obtained from starch sources represents an attractive alternative in this field of research. Due to the major production of cassava in the Cauca department, the Cytbia research group considered its use as the raw material for different developments; however, the physiochemical properties of the raw materials used to produce these products present certain disadvantages such as fragility, rigidity, and instability with regards to moisture in final products due to incompatibility (Tserki, Matzinos, Kokkou, & Panayiotou, 2005, p. 965), affecting their performance.

Creating bioplastics with starchy raw materials requires the incorporation of additives such as plasticizers, stabilizers, and reinforcing materials that help reduce the stability problems of the finished product caused by the characteristics of the raw materials used. The research conducted has therefore incorporated the use of added natural fibers to reinforce the plastic materials, aiding the functional properties of the final product, while conserving the biodegradable nature of the packaging (Navia, 2011).

Indeed, many research projects have investigated the use of fibers and have reported benefits in terms of increased resistance and reduced fragility of the materials discussed here (Luna, Villada & Velasco, 2009; Nirmal, Singh, Hashim, Lau, & Jamil, 2011; Kalia, Kaith & Kaur, 2009; Nam, Ogihara, Tung, & Kobayashi, 2011). Likewise, the use of coverings compatible with the packaging contributes to reducing the adsorption of moisture in the biopackaging, and this increased resistance could make the material suitable for various applications in food and non-food areas. While the current work of the Cytbia group has evaluated the response to moisture of bioplastics obtained through different additives (coupling agents, fats from natural sources), in subsequent studies it has also looked at creating coverings

with other biopolymers such as hydrocolloids and amphiphilic structures, which help reduce moisture gain.

In terms of the use of fibers, especially those obtained from fique (*Furcraea sp.*), it is worth noting not only the advantages of biodegradability and compatibility with the bioplastics developed, but also the alternative provided when using them in packaging, given that the Cauca region is one of the main areas in Colombia where this vegetable fiber is produced and agro-industrialized.

In terms of the technological offerings for cassava and its production chain, there is a lack of strategic data that would allow the identification of technological innovations, monitoring of information related to opportunities for negotiating the aforementioned offerings, and the characterization of clients interested in supporting new developments. In this sense, a need has been identified for appropriate tools and methodologies, such as "competitive intelligence," in order to optimize knowledge gathering and analyze information on opportunities for implementing technological and innovative processes, as well as identifying the sectors with the greatest medium- and long-term potential for establishing the respective plans for taking new technological proposals and developments to market. This would undoubtedly facilitate UCS coordination, encouraging the realization of innovations that, due to their positive impact on society, are tangible indicators of progress in knowledge generation. Although the Cytbia research group is developing joint proposals with other organizations such as CREPIC to strengthen this aspect of the first part of the cassava agro-industrial chain, the State must also get involved, either with financial or operative resources, in order to achieve integration in the chain and, consequently, of the information and knowledge generated around it.

Another consideration is the multi-disciplinary integration needed to ensure that the developments and innovations produced are successful. This is the case for the various research groups that have given their support to achieve the goals set in relation to biodegradable plastic materials. The work has involved collaboration of professionals in the fields of materials engineering, industrial automation engineering, business administration, economics, chemistry, biology, and food engineering, among others. Each has contributed from their area of expertise with the agro-industrial engineers leading the projects and the studies of the Cytbia group on the subject of biodegradable materials.

All of this points to the need to unite research efforts focused on obtaining bioplastics in order to allow agro-industry to take advantage of resources available in the region, to contribute to making implicit production chains more dynamic, and to benefit the environment through the products produced. The Cytbia group's aim in the area of biodegradable packaging is to find products that, in addition

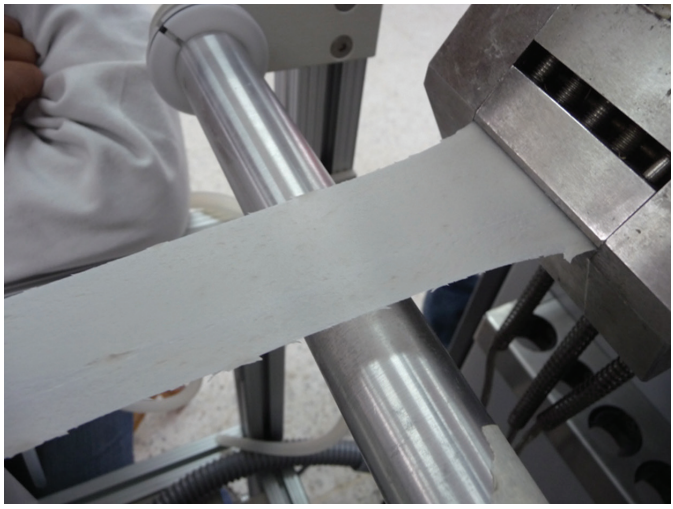
to meeting the requirement of biodegradability, have the functional specifications needed to become useful and technically competitive materials, supporting the social aspect associated with cassava's production chain and its technological offering. Thus, it has become a priority for the different stakeholders in this production and research initiative to create companies that can validate innovative technical and scientific developments.

Programs and projects

In 2008, the program titled "The use of products and by-products of cassava (*Manihot esculenta* Crantz) in developing biodegradable packaging," designed by Universidad del Cauca and CREPIC, was put forward in the "National call for co-funding research programs and projects, technological development, and innovation for the agricultural sector through production chains," offered by the Ministry of Agriculture and Rural Development (MADR). It consisted of the following projects:

- Production and characterization of flexible, biodegradable films using single-screw extrusion based on cassava starch, plasticizer, and PLA. During the project, flexible plastics (see Figure 4.1) were developed with different technical characteristics. These plastics could be used to protect flowers or in the packaging of food products for export.

Figure 4.1 Flexible film based on cassava starch obtained by extrusion



Source: Cytbia group archives, Unicauca.

- Production and characterization of biodegradable thermoformed packaging based on cassava flour, fique fiber, and plasticizer. This research study has seen the development of materials molded by thermocompression, such as semi-rigid trays (see Figure 4.2), which could be used for packaging certain types of food.

Figure 4.2 Semi-rigid tray based on cassava flour created through thermocompression

Source: The authors.

Both research initiatives began with CREPIC bringing together cassava producers and processors, who began the organizational process working independently and in isolation; consequently, it became clear that the lack of information and communication was causing inefficiency in the participants' activities. With the creation of the Morales Association of Cassava Producers (Asyumor) in the cassava-producing section of the production chain, and the Cauca Association of Starch Extractors (Asoraca) in the cassava-processing section, the characterization of cassava varieties in the projects was facilitated and, in turn, producers received training in their handling.

The raw material for both projects was obtained thanks to the integration of producers and starch extractors, and it was processed and converted in the research center (Universidad del Cauca), led by the Cytbia research group. It should be made clear that there are two phases in processing the raw material: The first takes place in the starch extraction plants, where the starch and flour are obtained from cassava roots; the second occurs in the laboratory, where bioplastics are produced through the thermoplastification of the cassava flour and starch.

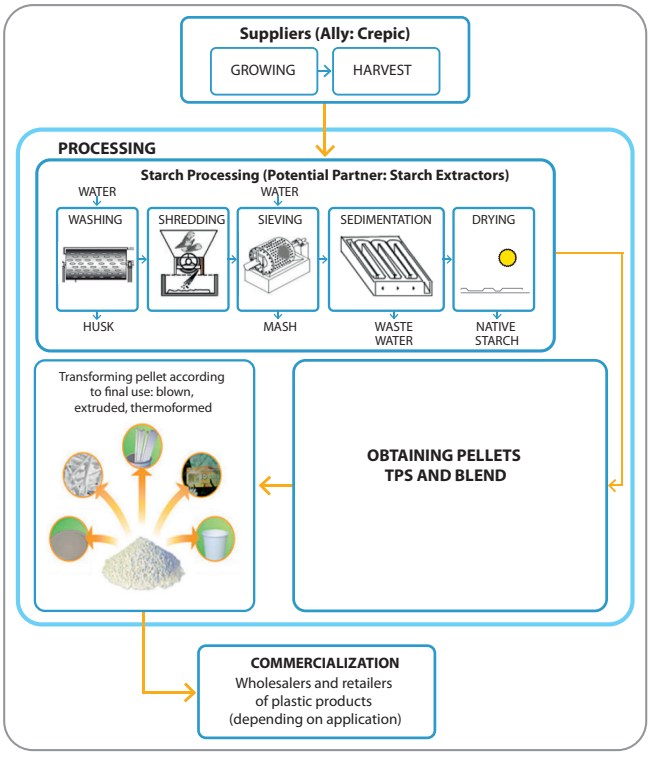
In the second phase of processing the raw material, an intermediate product is produced (thermoplastic matrix), which is later combined with other additives to obtain the extruded film or laminate that is subsequently blown to form the bag

and the tray molded by thermocompression. The processes and products were also implemented on an industrial scale; in other words, the protocols carried out in the laboratory were repeated in a company from the plastics sector in order to validate the quantities of materials and additives, as well as the conditions and variables of the process on a larger scale. This was followed by a process of technology transfer, thereby closing the research cycle (see Figures 4.3 and 4.4).

Spin-off

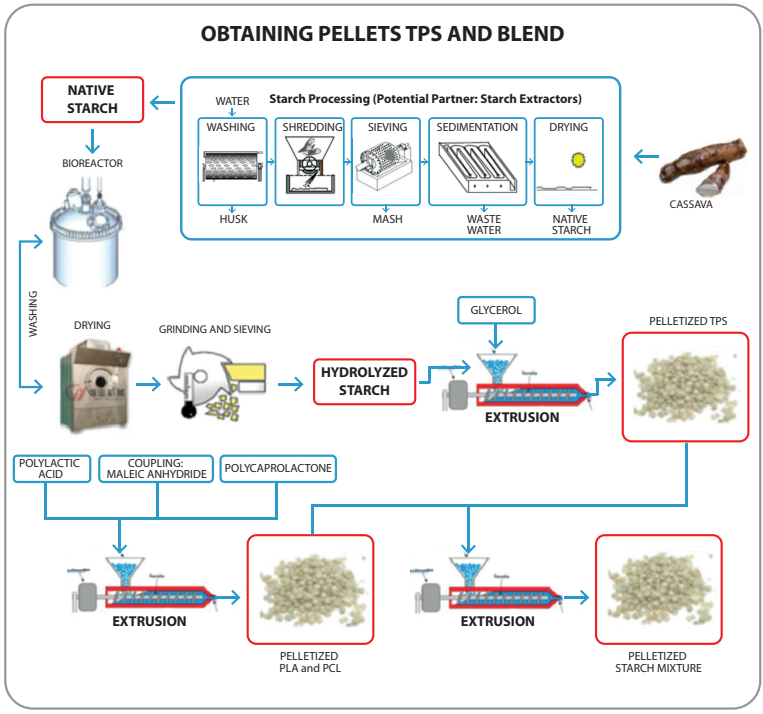
The goal of the research program mentioned above centers on developing biodegradable packaging that provides benefits for different parts of the cassava agro-industrial chain. The program includes a social component, and this translates into the work carried out with producers and starch extractors. They are the leading figures in the primary production section of the chain, and their involvement is of major importance as they provide the raw materials used in the research initiatives.

Figure 4.3 Biopolymer development from cassava starch



Source: Cytbia group archives, Unicauca.

Figure 4.4 Development of biopolymers

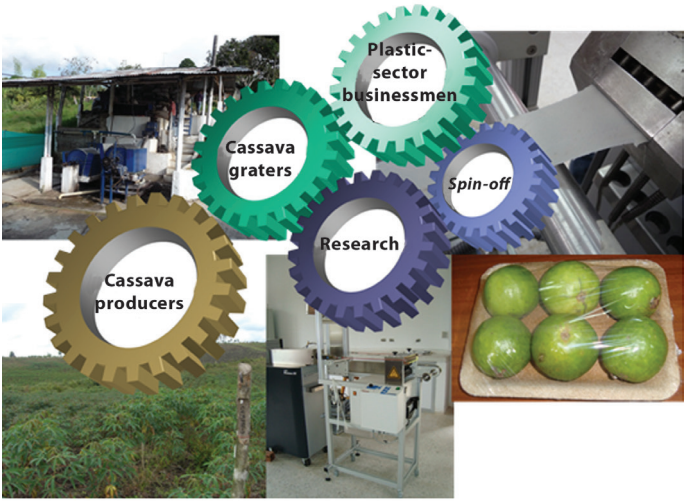


Source: Cytbia group archives, Unicauca.

Another part of the chain is processing, which occurs with the involvement of undergraduate and postgraduate students, teachers, and experts, who, thanks to their knowledge, have facilitated the creation of flexible and semi-rigid bioplastic materials from starch and cassava flour respectively.

The final part of the chain is commercialization, allowing the products obtained to be applied in different areas of food and non-food agro-industry. It is in this last section of the chain that the different stakeholders seek to contribute to the execution of innovation by creating a spin-off, as shown in Figure 4.5.

Figure 4.5 Creating a spin-off in biodegradable packaging



Source: The authors.

In this context, Universidad del Cauca and CREPIC jointly presented the project titled "Corporation Center for Technological Development and Innovation in Biodegradable Packaging (CCDTieb)," financed by Colciencias. This spin-off aims to become the main driver of scientific, social, and business activity associated with biodegradable packaging within the areas of the Cauca department, southwest Colombia, and the country. Coordinating these two institutions with others in the region will allow the spin-off to establish a framework for strategic collaboration. This is vital for providing an environment in which solid scientific and technological projects of national and international importance can transform part of the territory through a comprehensive social model based on the innovation and sustainable development of environmentally-friendly plastics.

The set of scientific and academic disciplines brought together by the CCDTieb will cover a wide spectrum including agro-industrial, food, chemical, environmental, agricultural, forest, materials, physical, and electronic engineers, as well as business administrators, economists, lawyers, and experimental sciences professionals, each of whose contributions are valuable in these types of initiatives. Accordingly, the CCDTieb's activity will cover an essential part of the agricultural and industrial plastic production sector, stimulating the southwest region of the country. The CCDTieb will therefore take an active role in the change of the economic and productive model, a change which must be faced in the coming years in the field of biodegradable packaging.

The CCDTieb will operate within the guidelines of both institutions that start this project to create a public-private company, but as the center progresses, other institutions may become part of the project. Universidad del Cauca is one of the higher education institutions that focuses the greatest amount of human resources on training in academic, scientific, and technological fields. Specifically, it is the most active in southwest Colombia.

CREPIC, meanwhile, is a private institution that includes Universidad del Cauca, the Cauca Chamber of Commerce, the Cauca Departmental Government, and the Cauca branch of the National Association of Colombian Businesses (ANDI). This regional center was established twelve years ago and operates in various parts of the agricultural sector. CREPIC works jointly with other institutions in the Cauca department (both private and public), and at the national level on research projects. It is committed to the creation and development of the CCDTieb due to its history and involvement in the field of bioplastics research, as well as the global interest in environmentally-friendly packaging. Among others, CREPIC is also a key player in the cassava chain in different research, development, and innovation processes, which will help strengthen the first sections of the chain, such as the primary producers of cassava, the starch extractors, and those in the plastics industry.

Universidad del Cauca and CREPIC have attempted to share human talent and the potential derived from all areas of knowledge within both organizations. This is done to guarantee a coexistence model in which respect for and harmony with the environment are compatible with the most advanced technology and with innovation in the field of biodegradable packaging.

The CCDTieb works towards excellence and national and international cooperation in line with the following statement: "The sum of abilities and the complementary strategic aggregation of Universidad del Cauca and CREPIC with other research and innovation entities in the region and country." The CCDTieb was thus created to give continuity to the program and maintain the capacity achieved so far via different research results, as well as continuing training and maintaining human resources, both in the Cytbia research group at Universidad del Cauca and in the entities that over time have joined the program and are working jointly with it.

Additionally, creating a spin-off with the results obtained so far will boost the competitiveness of the cassava agro-industrial chain in the medium term. In this way, the bolstering of business, the different academic and research activities, and the training and strengthening of human resources that the region and country need in the field of environmentally-friendly packaging will impact and positively transform the external environment.

Knowledge generation

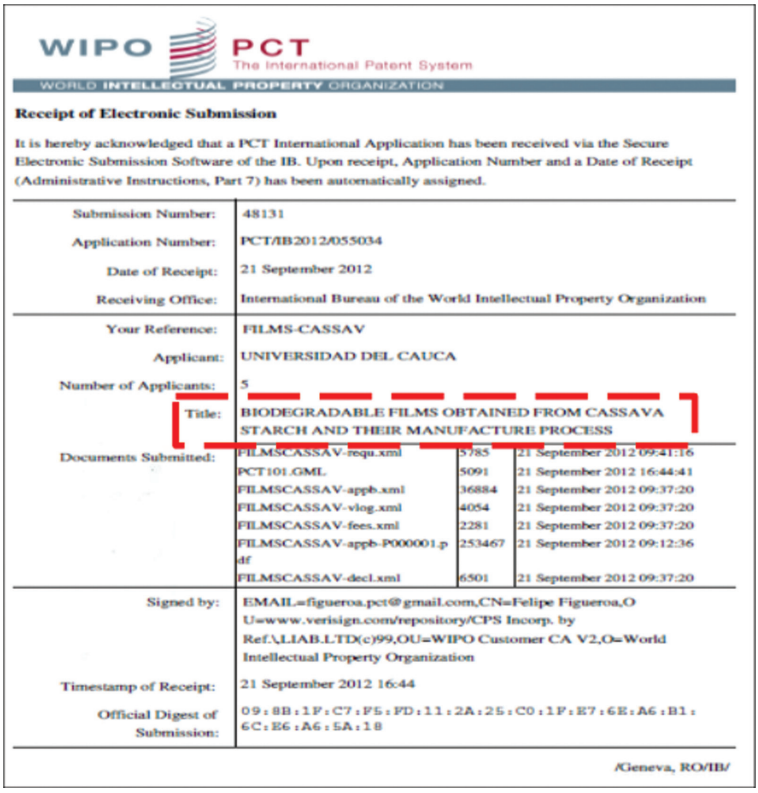
The previously mentioned research projects conducted within the "Use of products and by-products of cassava (*Manihot esculenta* Crantz) in developing biodegradable packaging" program have led to the registering of four inventions that are under intellectual property protection in countries such as Colombia, Brazil, and the U.S. The objective is to seek licensing in these countries once the different procedures for technology transfer and legalization of the inventions begin.

Figure 4.6 shows one of the protection procedures in Colombia, registered with the Superintendency of Industry and Commerce (SIC). Figure 4.7 shows confirmation of the procedures carried out with the World Intellectual Property Organization (WIPO), based in Geneva, Switzerland. Both figures relate to the registration of the flexible film project (see Figure 4.1), similar to the registration for the semi-rigid project (see Figure 4.2), which is not presented here.

Figure 4.6 Patent procedure for biodegradable film and packaging made from cassava, registered with SIC

Source: Cytbia group archives, Unicauca.

Figure 4.7 Patent procedure for flexible film, WIPO, Switzerland



WIPO PCT
The International Patent System
WORLD INTELLECTUAL PROPERTY ORGANIZATION

Receipt of Electronic Submission

It is hereby acknowledged that a PCT International Application has been received via the Secure Electronic Submission Software of the IB. Upon receipt, Application Number and a Date of Receipt (Administrative Instructions, Part 7) has been automatically assigned.

Submission Number:	48131		
Application Number:	PCT/IB2012/055034		
Date of Receipt:	21 September 2012		
Receiving Office:	International Bureau of the World Intellectual Property Organization		
Your Reference:	FILMS-CASSAV		
Applicant:	UNIVERSIDAD DEL CAUCA		
Number of Applicants:	5		
Title:	BIODEGRADABLE FILMS OBTAINED FROM CASSAVA STARCH AND THEIR MANUFACTURE PROCESS		
Documents Submitted:	FILMSCASSAV-requ.xml	5785	21 September 2012 09:41:16
	PCT101.GML	5091	21 September 2012 16:44:41
	FILMSCASSAV-appb.xml	36884	21 September 2012 09:37:20
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/Geneva, RO/IB/

Source: Cytbia group archives, Unicauca.

Conclusions

The consolidation of the program through a spin-off that integrates research, development, and innovation (RDI) and coordinates the different sections of the cassava production chain (Producers-Starch Extractors-Research Centers or Universities and the Plastics Industry) could contribute to the transformation of society by transferring technology from innovative research areas—as in the case of "packaging and biodegradable materials"—with specific applications in generating new knowledge. Likewise, from a business, academic, and research point of view, it could contribute to professional training, offering a foundation for undergraduate and postgraduate students looking to carry out technological research, innovation, and development projects, and thus forming a model of innovation for the Cauca department and the country.

State support in applying competitive intelligence in agro-industrial chains for products prioritized by the national government could be an alternative means of promoting the implementation of technological processes and innovations resulting from the research conducted by Colombian academia.

Collaboration between different disciplines, professionals and members of research groups, institutions, and entities in the production sector is the major goal towards which higher education institutions should work in order to consolidate, secure, and stimulate UCS coordination, with the aim of creating a positive impact on society.

Glossary

- Amphiphilic: molecule whose structure contains a hydrophilic and a hydrophobic part
- Bioplastics: plastic material obtained using biological raw materials
- Chitin: polymer present in the cell wall of most species of fungi and algae, and in the exoskeletons of insects and crustaceans
- Chitosan: polymer obtained through the deacetylation of chitin
- Commodity: raw material produced by humans or widely available in nature
- Extrusion: process whereby a polymer is melted and homogenized using a block or die to obtain a product in the form of a plate, film, or tube (Osswald, Baur, Brinkmann & Schimachtenberg, 2006, p. 294)
- Spin-off: term referring to the creation of companies from pre-existing organizations
- Starch extractors: rural agro-industry where the starch contained in cassava roots is extracted, generally via wet milling
- Starchy: related to starch, containing starch or similar to it
- Thermocompression: during this process a polymer is placed in the cavity of a mold (female) and heat and pressure is applied (male mold) to solidify or cure the polymer, which takes on the form of the cavity (Vincent, Álvarez & Zaragoza, 2006)
- Thermoformed: process by which a thermoplastic sheet or film is heated to a specific temperature for a specific amount of time to take on the form of the mold used (Osswald et al., 2006)
- Thermoplastics: polymers that have acquired the characteristics of plastic due to the action of temperature and plasticizers

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