Exploiting biodegradable waste: challenges for today's environment

Explotación de residuos biodegradables: desafíos para los entornos actuales

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Abstract

This study is presented with the objective of analyze the potentialities of biodegradable waste produced in the agro-food industry, as a viable alternative to create a circular economy that derives benefits for all humanity. the study is based on a qualitative methodological approach, supported by the review of literature; therefore, it is considered at an epistemological level that is framed within the interpretative paradigm. In terms of the procedure used, it was investigated in different academic databases on the most recent scientific publications that provide guidance on the best practices being implemented in the sector of biodegradable waste use. Documents from recent years are included in both English and Spanish, in order to cover the greatest number of reflections and findings of the authors. The analysis of the publications indicates that there is an important area of opportunity for the development of initiatives that consider the use of biodegradable waste, generated from the different activities of the agro-industrial sector. The main challenges to reach this goal, undoubtedly, are related to investment in technology, assessment of economic and financial viability and human awareness to promote a paradigm shift to improve collection at source.

Keywords

Biodegradable waste, agro-industrial sector, use, biorefineries, enviromental.

Resumen

Este estudio se presenta con el objetivo de analizar las potencialidades de los desechos biodegradables producidos en la industria agroalimentaria, como una alternativa viable para crear una economía circular que genere beneficios para toda la humanidad. el estudio se basa en un enfoque metodológico cualitativo, respaldado por la revisión de la literatura; por lo tanto, se considera a nivel epistemológico que se enmarca dentro del paradigma interpretativo. En términos del procedimiento utilizado, se investigó en diferentes bases de datos académicas sobre las publicaciones científicas más recientes que brindan orientación sobre las mejores prácticas que se están implementando en el sector del uso de desechos biodegradables. Los documentos de los últimos años se incluyen en inglés y español, con el fin de cubrir la mayor cantidad de reflexiones y hallazgos de los autores. El análisis de las publicaciones indica que existe un área importante de oportunidad para el desarrollo de iniciativas que consideren el uso de residuos biodegradables, generados a partir de las diferentes actividades del sector agroindustrial. Los principales desafíos para alcanzar este objetivo, sin duda, están relacionados con la inversión en tecnología, la evaluación de la viabilidad

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económica y financiera y la conciencia humana para promover un cambio de paradigma para mejorar la recolección en la fuente.

Palabras clave
Residuos biodegradables, sector agroindustrial, uso, biorefinerías, ambiental.

Introduction

There are many initiatives around the world that have set their sights on developing processes that make it possible to take advantage of the numerous wastes generated by man in all the productive activity he carries out (Gottinger, 2018). The current problems regarding elements such as plastic and other types of hazardous waste, including batteries and lighting fixtures with polluting elements, are only part of the many difficulties faced by the academic and scientific community, as part of the effort to find sustainable solutions that impact in the short and medium term (Boetzkes, 2019).

For this reason, given the disproportionate production of goods and the accelerated and unnecessary consumption of human beings, there are environmental effects that have a negative impact on public health and natural resources of the planet (Sarkis and Zhu, 2018). Depending on what was said by Severo, Guimarães y Dorion (2018), the consequences of these acts are not only having an immediate impact on ecosystems, but are also putting at risk the sustainability of future generations. By virtue of this, the incorporation of policies that orient towards circular economies that contribute to the reuse of the great quantity of materials that are discarded is an urgent need that must be addressed using the most creative and innovative methods. Jiménez, Cabarcas y Hernández (2019).

Specifically, in the agro-industrial sector, there is a high potential for reuse of food, due to its ease of decomposition, such as residues of fruits, vegetables, animal excreta and liquids (Hasanudin, 2019). These in turn can be converted into useful by-products that would significantly reduce the impact generated on the earth and encourage a new ecological industry. According to AlQattan, *et al.,* (2018), today technology and advances in agricultural production make it possible to incorporate numerous techniques in order to reduce man's environmental footprint on the planet and produce benefits such as energy.

These methods include composting, natural waste degradation treatments, recycling, and biorefineries, which become alternative solutions to the problems that affect the quality of life, and put this and future generations at risk due to unjustifiable human waste. For Mondelli, Bruijnincx y Sels (2019), biorefineries are an option for the reduction of environmental pollution, different researches are directed to the development of projects and works whose components collaborate in the search for the improvement of properties of resources such as biomass, to put them at the service of the human being in substitution of harmful and irrecoverable fuels, it is important to take them into account due to the wealth of global biodiversity, as a raw material.

The high potential that exists in Agra-industry with respect to the proper management of waste generated from productive activities, shows a clear opportunity for related sectors interested in developing products derived from the transformation of materials such as remains of fruits, vegetables, pruning of grass and trees, excreta of animals such as livestock, biodegradable liquids derived from cheese production, among others. In this way, by encouraging companies to take these elements as input to create new products, an effective response would be given to the environmental and economic (Jiménez, Cabarcas y Hernández, 2019).

The efficient management, applied of biodegradable waste, would reduce processes of high contamination, and would be a cost-benefit contribution, in the industry, especially in the pharmaceutical, beauty, food, whose residues would represent the raw material of work, in addition to the incentive of the preservation of earth resources by the material that is recycled again (Baltrėnas and Baltrėnaitė, 2018). In countries whose economies are developing, the shortfalls in the use of these materials are even greater, given that they do not have the appropriate technology and training to enable them to reach an optimum level of reuse and recycling. Therefore, there is great concern about advancing processes that guarantee a transformation as soon as possible.

Faced with the questioning of the academic community regarding the actions to be taken promptly in order to reverse an unhelpful scenario in environmental matters, it is important to analyze the current situation of biodegradable waste that can be reused, depending on the amount generated and the impact produced, especially in Latin American countries in which there are no evident significant advances compared to other regions such as Europe or the United States (Banco Mundial, 2018). Likewise, when evaluating the normative framework present in Colombia, it is possible to provide the reader with a general outline related to the fulfillment of certain parameters and guidelines emanating from State institutions.

Due to the above, it is necessary to deepen the study of techniques that can be used in the recovery of biodegradable resources, their characteristics and current panorama of use, in addition to knowledge of the rules governing the generation of products such as fertilizers, biomass, among others, which will be studied. Consequently, the article presents the current state of biodegradable waste management at a global level, some of the most relevant methods in this area and a characterization of the different types of waste that can be reused in other processes.

Theoretical framework

In this section, the importance of sustainability within the international framework is analyzed. In this sense, several studies comment on how training in educational environments generates an important impact on the sustainable culture of society (Gomez, 2018).

Therefore, it is considered that in Colombia there is currently an important process to get me to be a nation based on sustainability in the framework of meeting the objectives for the year 2030 (Moreno, López, & Oqueña, 2018). There are clear differences between the positions and the practical reality of sustainability in the countries because in some cases there are extremely significant advances while in others there is a delay or nonexistence of the aforementioned (Rueda, 2018).

Methodology

The article is based on a qualitative approach, the purpose of which is to approach phenomena of interest without resorting to numerical methods to explain them. This idea is also proposed by Gehman *et al.,* (2018) those who maintain that qualitative methodology has emerged under the guidelines of the interpretive paradigm with the purpose of giving greater flexibility to the researcher, especially in areas with social impact, where it is required to analyze reality beyond measurements, on the other hand, (Gibs, 2018) maintains that the changing condition of observable facts and the high complexity that comes represented by the interaction of multiple factors, makes necessary the application of techniques that facilitate an analysis from a critical and reflexive point of view.

Qualitative methods have been widely employed in the study of the diversity of problems, which include components and dimensions that can hardly be approached on the basis of a single position to achieve understanding (Flick,

2018). For this reason, in the case of the present article, the environmental problem that is currently being experienced has innumerable causes and consequences, therefore, it is important to explore the possible solutions based on the greatest number of theoretical perspectives made as contributions in the literature.

In addition to the above, the documentary design served to explore recent publications framing, the use of biodegradable waste and its benefits. For Dennis and Wixom (2018) the techniques used in this methodology facilitate the collection, organization and analysis of data and information from secondary sources, without the need to apply sampling methods specific to statistics and the quantitative approach.

For this reason, some of the academic databases and repositories were extensively revised in order to compile articles and reports from internationally recognised bodies containing relevant information on the progress made in the management of biodegradable waste. Among the main references used are Emerald, Scielo, Redalyc, Elsevier, Scopus, among others. The results were organized in a documentary matrix that allowed their evaluation and analysis taking into account the most significant bibliographic data, contributions and conclusions.

A set of keywords associated with topics such as: biodegradable waste, circular economy, agro-industrial, economic development, environmental impact, techniques and regulations were used as search criteria. Likewise, the articles published in the last five years were selected, both in English and Spanish, in order to obtain the greatest variety of theoretical postulates from authors coming from different latitudes. This allowed triangulating information and enriching it through the author's analysis, constituting an opportunity to strengthen the knowledge developed in this subject.

Results

Current situation of Biodegradable Waste

Latin America contains 1.3 million tonnes of waste per year, of which 46% is equivalent to organic waste. Methodologies are required that stimulate not only recycling, but promote clean production, these practices must be enforced in companies whose processes generate incentives to increase waste. There are other waste disposal methodologies, such as incineration, here there is no classification, and in the process, harmful effects are generated to the environment, such as methane gas and carbon dioxide, pollution of the ecosystem, therefore, there is no better alternative than recycling, for example, mechanical, which includes in industrial processes, within the chain, the reuse of bags, furniture, waste, among others. Waste from livestock processes, such as manure, are fermented and used as fertilizers, without negative effects on the environment (Chávez, 2016).

In Panama, there is little literature on the fate of its solid waste. However, the figures denote the existence of 73 landfills in the country. The calculated daily estimate of waste is 2600 tons of which 45% is organic waste. If you analyze the landfill Patacón, handles 60% of waste in the capital, whose composition of solid waste is 45% of organic waste from companies in the food sector (see figure 1). This represents a high percentage, and it is not understandable that it ends up inside a sanitary landfill, on the contrary, it should be used with the help of technology and entrepreneurs as raw material in the conformation of new products (Franco, 2016).

Lima, Peru contains within Law 27314, three types of waste, including household, commercial and industrial. According to the information, Lima has inadequate waste management. This, for lack of habit in the recycling, a problem found in the population is, that the local authority or mayors, do not even have defined in their programs a plan that encourages

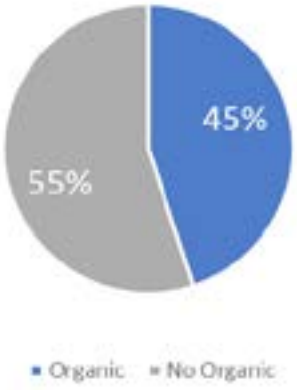

Figure 1. Composition of waste generated in Panama

Source: Own elaboration, 2019

the classification of waste in organic and inorganic, this further complicates the availability of products usable from the use of recyclable waste (Bustamante, 2014).

In review of other countries of the Middle East, Turkey, generates approximately 26 million tons of waste per year, according to the statistical basis of the country, of this total, 20 million correspond to biodegradable waste, which generates a strong environmental, economic problem in parallel with the growth of its population, these disadvantages are greater in the large cities of the country. Although it is true, if there are management programs, however, in practice, there is no control and cooperation between the institutions designed to take care of the environment, responsible for technical and financial management (Salihoglu *et al.,* 2018).

Although it is true, if there are management programs, however, in practice, there is no control and cooperation between the institutions designed to take care of the environment, responsible for technical and financial management. Normative references include, for example, the definition of the quantities of fertilizers applied in small batches, determination of soluble potassium, phosphorus, nitrogen, sulfur, and other fertilizer chemical compounds (ICONTEC, 2011a).

Other processes, such as labeling of fertilizer products are found in standards such as NTC 40, which contemplates recommendations, use and handling of the product, precautions, observations, and other indications that generate product reliability to the consumer and good practices (ICONTEC, 2011b). Standard NTC 5167 describes organic fertilizer as a solid product obtained from animal, vegetable or urban waste. Its parameters include certain humidity conditions that depend on the type of waste used, for example, for animal by-products percentages less than 20% and vegetable by-products of 35%, pH, density, heavy metals, all these variants must be characterized following the guidelines established by the standard.

The studies carried out by Lesmes (2018) for the treatment of organic waste composting at the Colombian School of Engineering Julio Garavito, applet parameters established by NTC 5167. The composting process is defined by the standard as the aerobic oxidation of materials in a stage of minimum maturation, to then become suitable for use in agriculture (ICONTEC, 2011a). The products had their respective characterization and composition analysis by AGRILAB S.A.S a specialized laboratory, for fruit and vegetable residues, here were evaluated variables such as humidity, where samples were obtained that met the requirement of humidity of 23 and 28%, pH from 6.25 to 8.67% that fits within an interval between 4 and 9% as the standard requires (Lesmes, 2018). It is important to know the techniques and processes that can be used for the use of non-hazardous and biodegradable waste, these are described in Figure 2.

According to the information shown in figure 2, the different processes that can be used to generate reusable products represent biological processes such as worm farming, used in the breeding of earthworms, and generate vermicomposting, used in crops, it should be noted that the Californian worm is consumed for hu-

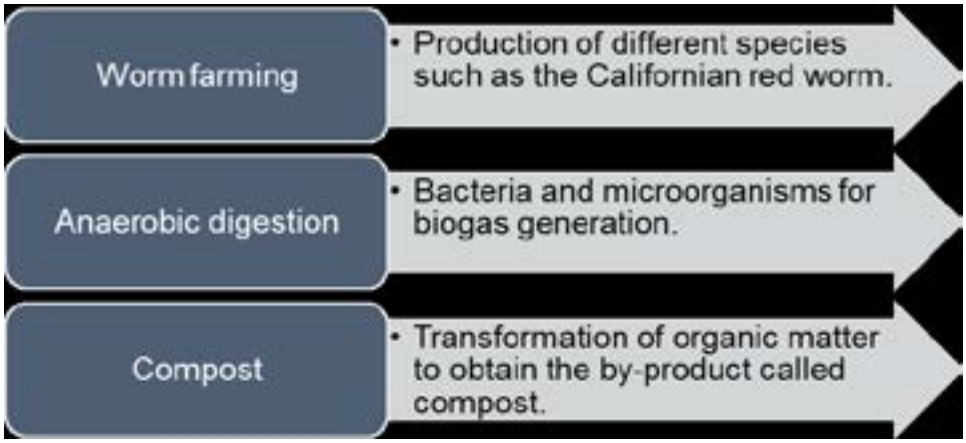

Figure 2. Techniques and processes for the use of biodegradable waste with biological processesç
Source: Own elaboration, 2019

man consumption, which makes this processing a good business. Anaerobic digestion that uses microorganisms for the decomposition of organic waste and generation of biogas, in rural projects and construction of biodigestors, these microorganisms can be homoacetogenic bacteria, reducing sulfate, and methanogenic arches.

Composting is a process used to obtain natural fertilizer, compost, by-product, is used in the urbanization of parks, crops and as a nutrient for plants and animals. As there are other processes and chemical terms such as combustion, gasification, liquefaction, pyrolysis, and physicochemicals such as fermentation, these and other industrial processes that science and technology work in their daily work in search of new knowledge (ICONTEC, 2006). The physicochemical processes are specified in figure 3.

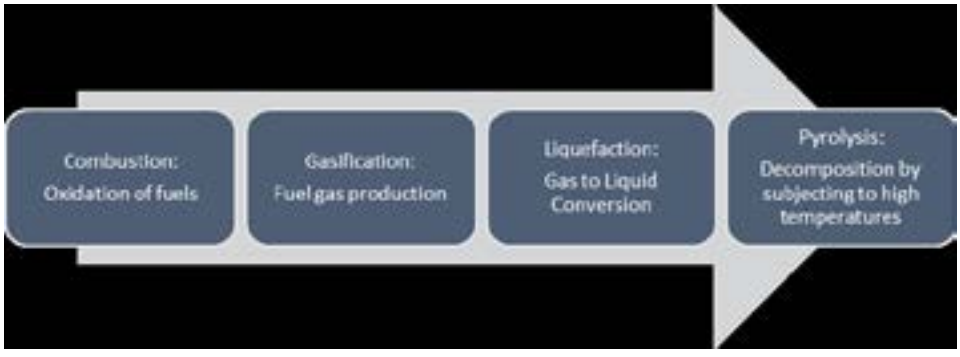

Figure 3. Techniques and processes for using biodegradable waste with thermochemical procedures
Source: Own Elaboration, 2019

According to figure 3, four thermochemical processes are described that collaborate in the reuse of biodegradable wastes. These are subjected to thermal treatments to change their properties, including the temperature factor. Generally, the combustion processes where solid waste is used are for the production of steam, destined for renewable generation, such as electricity, motive and thermal energy. Gasification includes the production of biogas, suitable for heating, chemical products such as synthesis gas, hydrogen, transport and electricity, lique-

faction for the production of liquid fuels and, finally, the pyrolysis process used in the generation of charcoal.

In the Colombian Technical Guide 53-7, the types of residues that can be reused again and that techniques of exploitation can be carried out according to the agricultural, industrial, domestic, commercial activity are consigned (ICONTEC, 2006). Figure 4 shows the by-products derived from these and many more processes aimed at using the raw material generated from biodegradable waste.

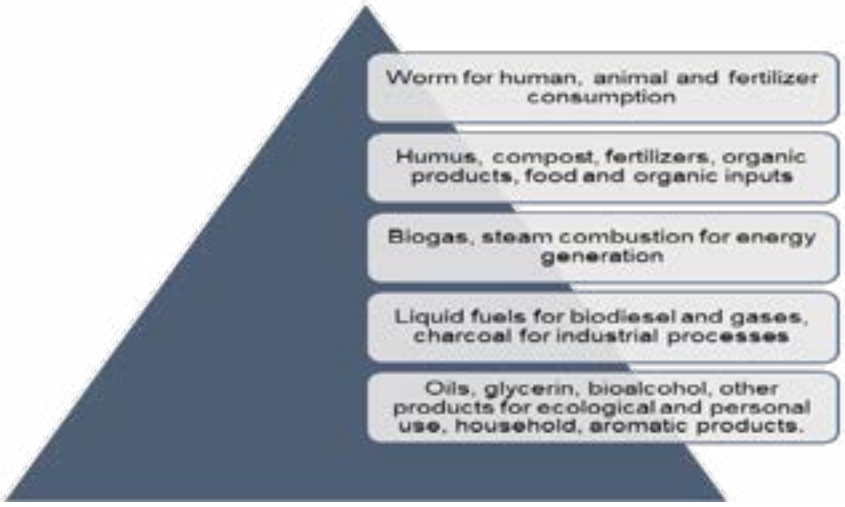

Figure 4. By-products obtained from the use of waste for biodegradable use
Source: Own elaboration, 2019

According to the information shown in figure 3, the by-products of the processes shown in figure 2 can be observed, destined for food, fertilizers, fertilizers, energy generation and other inputs for personal and industrial use that were included. The list can be further extended taking into account that human beings still have a long way to go in the scientific field and that they have not yet fully exploited for the solution of the appropriate destination of the waste.

According to Pacheco's study (2017), the electric energy market consumes 70% of fossil fuels such as coal, oil and derivatives, natural gas, which are dangerous. Biomass can become a useful alternative for small engines that serve locations isolated from a national energy grid systems. This is the case of Brazil, whose problem, generated by the difficult and challenging geographical conditions of the Amazon, cannot be connected to the grid. Three types of waste feasible in energy sector ventures in the Brazilian Amazon, are generated from crops of cassava, banana, rice, pineapple, corn and soybeans (Pacheco, 2017). It is important to have a clear understanding of the types of biomass generated by nature, which represent the basic raw material in the processing of biodegradable waste. These are represented by Figure 5.

According to figure 4, biomass are classified according to its physical state, the solid biomass, mostly used represents branches, straw, crowns, leaves, pomace from different plants, liquid biomass, considers the use of vegetable oils for biodiesel production others, such as ethanol, which uses raw material such as starch, cellulose and sugar. Gaseous biomass, which uses wastes of agricultural origin, derived from birds, cattle, pigs, agriculture. (Pacheco, 2017).

Biomass, becomes an attractive resource,

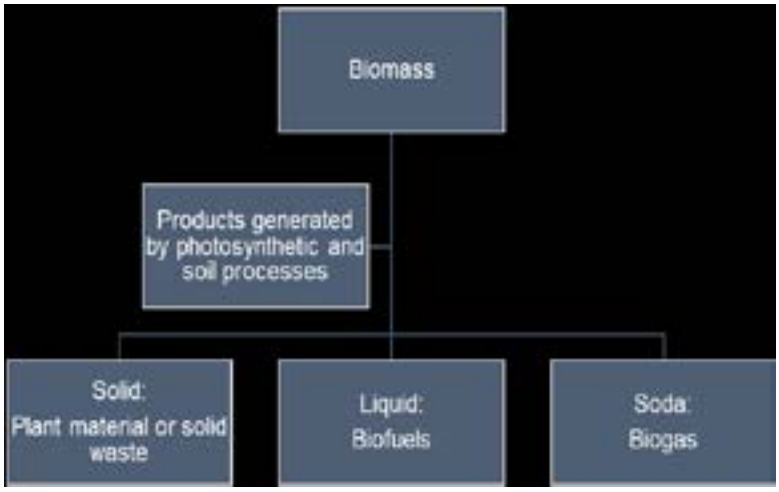

Figure 5. Types of Biomass
Source: Own preparation, 2019

whose potential must be developed, Countries such as India have developed 10.5% of their energy, through renewable resources, of these, 13% has been through biomass. The country has considered the inclusion of new policies and strategies to increase this value in its energy matrix with processes such as biogas and biodiesel (Kumar *et al.,* 2015).

Lithuania, a European country, is researching agricultural strategies to increase the viability of the performance of the energy sector on farms, through the use of bogus, whose production in 2006 obtained a significant growth compared to previous years, equivalent to 2 tons of oil. This alternative, they consider it favorable for the replacement of parts of the traditional fuel, in processes for the generation of energy and heat in the country (Katinas *et al.*, 2019).

Colombia, in search of alternatives for environmental improvement that promote good practices, including the treatment of solid waste, has set goals for 2018, such as, for example, that 20% of the waste produced be reused. However, not even 17% of the forecast has been reached, which generates the need for incentives and projects that promote activities such as recycling and/or reuse of resources (see figure 6). There is a notable difference with the countries of the European Union, whose exploitation capacity is 67% of the waste generated by the population (Peñaranda et al., 2017).

In relation to the by-products generated by the agro-industrial sector, many can be used again, one of them is glycerol, obtained from animal and vegetable fat, which acts as an energy biodiesel, whose benefits include lower costs than bioethanol in its production stage. Among other products, there are bioplastics, which replace synthetic ones, whose characteristics are non-toxic and biodegradable.

Vegetable waste, whose production in Colombia is relatively high, such as coffee, can be used to generate biofuel, so the available energy of 1/ha/year is equivalent to 513 gallons of gasoline. Rice residue is used in concrete additives. Citrus residues, such as peel, seeds, pulp that can go to the garbage, are viable for the pharmaceutical and cosmetic industries, for the production of aromas, oils, fiber, cleaning products, and others. Even the poultry, take advantage of the product residues in animal concentrates (Peñaranda *et al.,* 2017).

Waste such as grape marc represents approximately 20% of the product, its production is approximately nine million tons per year,

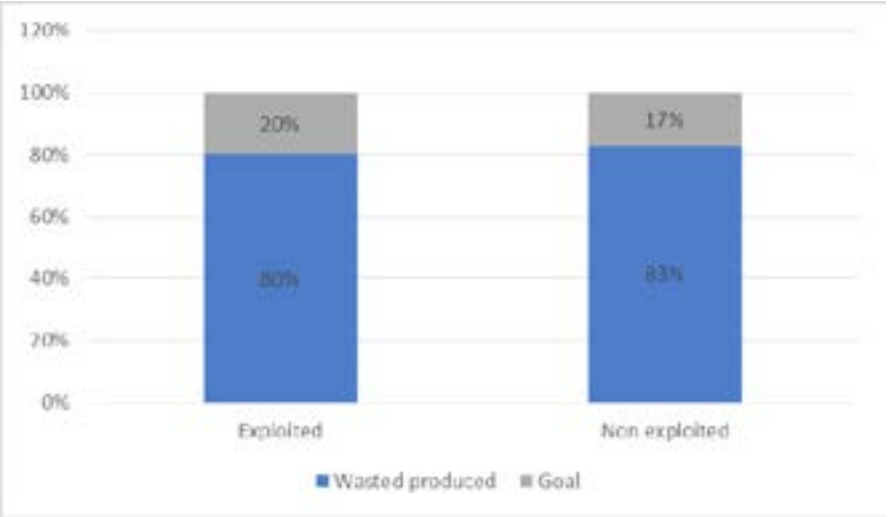

Figure 6. Percentage of waste recovery
Source: Own Elaboration, 2019

what can be done with this residue? Many by-products include ethanol for use as biofuel, tartrates used as antioxidants in the food industry, others as citric acids, oils, fibers, which can be reused in commonly used products (Álzate, Jiménez y Londoño, 2011). Products such as coconut shells become materials of interest whose high lignin value is useful in the generation of phenolic compounds that are substitutes for petroleum (Cabrera *et al.*, 2016).

The potato, leader product in departments like Boyacá, Cundinamarca and Antioquia, presents many alternatives in the increase of use of its components. In Bogota, the destiny of the potato processing residues brought with it, the search of alternatives for their reduction. Among these, the use of starch for the generation of products destined for animals. There are figures that 88.9% of the potato is used for potato chips, 4% precooked, 3.5% canned potato and 0.4% dehydrated, which denotes the high power of industrial trade for the processing of snacks and snacks (Prada, 2012).

Another undertaking that projects viability are the cellulose packaging, as opposed to situations presented by packaging such as Tetrapack, which takes more than 100 years to degrade, all, only for the increase of the useful life for example of a juice that can be made naturally and with more nutrients. In Bogota, the solid residues of the marketplaces were studied, which responds to high opportunity of execution of packages as disposable plates, boxes, baskets, bags of paper, sheets of paper, cone of crispeta, separators of books, through stem of banana, stems, petals of flowers, cogoño of pineapple, among others. In the studies of Velandia and Valencia (2015), prototypes are found that inspire new ventures in other cities of the country (Velandia y Valencia, 2015).

Findings

The application of three essential words such as: reduction, reuse and recycling, should be carried out in all households, as well as the payment of bills, taxes and so on. The collection system of each country must be re-evaluated in order to take measures to solve the waste generated. In Panama, where according to the bibliography 45% of waste is organic, it can not only be highlighted as a raw material in the sector of production of physical by-products of consumption due to its biodegradability, but can

be included within the energy matrix in the potentialization of new electrical energy projects with biomass. Among other uses of biodegradable products in everyday life are, for example, corn starch for bag production, ecological dishes based on banana leaves, pigments based on turmeric, soybean wax, bipesticides, natural detergents, cosmetic products, food products, and others that require human creativity, aimed at developing friendly products.

Chemical engineering provides the tools that study the characteristics and physical and chemical structure of biodegradable elements, their studies, and scientific research in general, should be supported with greater continuity by governments, for the management of clean processes. All the sectors involved in the conservation of the environment in the country should rethink the projection of a manual of good practices, supported by solid government policies that require the expansion of clean production, and that require households to use recycling as any basic activity, is the responsibility of society in general, the contribution to the problem of inadequate waste management that increases proportionally with the population, over the years.

The establishment of a regulatory framework to properly manage the different types of waste generated in the country is overwhelming evidence of the concern that exists in the authorities that direct the State, whose purpose is to align with the global demands that are emerging in environmental matters. From this point of view, to advance in the creation of productive projects focused on the use of biodegradable waste is not only an economic opportunity, but also a mechanism to solve the great ecological problems that humanity currently faces.

This will be possible with the accompaniment of technology, which every day finds more efficient methods to respond to environmental challenges, likewise, education and training as a fundamental pillar of development, can help raise awareness of human consumption style, which is doing so much damage today. In view of the above, it is concluded that the agro-industrial sector has a high potential for the development of projects involving the transformation of organic waste into raw material for other processes, thus, it is possible to achieve a circular economy that supports the progress of emerging economies and also provide a viable solution to reduce the impact of human activity on the environment. It is hoped that this research will deepen the understanding of other types of waste materials in order to create new uses for these materials.

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