Remittances Review
june, 2023
Volume: 8, No: 4, pp. . 998-1009
ISSN: 2059-6588 (Print) | ISSN 2059-6596 (Online)

Received: 11 November 2022 Accepted: 02 February, 2023

DOI: https://doi.org/10.33182/rr.v8i4.70

Production of Bioactive Peptides Through Fermentation of Waste Products from Agribusiness: Review of Scientific Article

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Abstract

The production of by-products or agro-industrial waste has different types of use including new products adding added value to the original products and in environmental conditions. As well as, there are few alternatives that cover the nutritional, social and economic axis to properly take advantage of agro-industrial waste, which causes them to be mismanaged and thus originates sources of contamination of natural resources. Speaking of whey as a waste of agribusiness, in the market it is commonly used as a means to increase milk solids at a minimum cost and, to a lesser degree, to take advantage of certain functional properties of whey proteins, such as free water retention, foaming and thickener (Chacón et al., 2017). In addition, it is practiced in developed countries, in low economies it is characterized by a technological base due to little access control since it offers quality products (Cánovasa et al., 2017). Therefore, in agro-industries fermentation processes allow to obtain products such as: Dairy (cheese, milk, yogurt), which are fermented and rich for a diet I would say. Also, fermentation is considered one of the first processes for food processing that includes the reduction of size, cleaning, cooking and soaking in order to obtain an edible product, since this process helps the modification of products and increase their shelf life.

Keywords: *Bioactive peptides, fermentation, agribusiness.*

Introduction

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The amount of waste from agribusiness is alarming and its inadequate management clearly affects the balance of the environment, therefore, new ways of using such waste have been created (Grande, 2017). During the various industrial processes, a large number of establishments generate waste by-products that start from a wide variety of raw materials, mentioning among them, broken or small seeds, which are rejected by the consumer, defatted flours, or whey derived from milk, which are not contemplated for later use (González, 2018).

Bioactive peptides (PB) are short sequences that are encrypted in food proteins and that, when ingested, are capable of modulating the biological activity of various enzymes in humans, among other effects. PBs have been isolated and characterized from different food sources, such as egg proteins, cereals, fish, among others, however, so far the most investigated are that they come from milk and other dairy products (Nardo, 2017).

Bioactive peptides have been isolated essentially from protein hydrolysates and lactic products modified by bacterial fermentation. It has been shown that protein, regardless of its nutritional quality and functions, can be used for the generation of bioactive peptides, in this way, the use of underutilized proteins or by-products of agro-industrial origin is enhanced (Segura et al., 2014)

In this regard, different investigations have been developed to obtain bioactive peptides using residues from agro-industrial practices, among these examples it is worth mentioning the whey derived from the production of cheeses, which have often appreciated them as a waste of little commercial value and its destination

continues to be one of the most serious problems facing the dairy industry worldwide (Center for Food Research and Development, 2022).

Among the residues that are generally used to obtain PB are the remnants of agro-industrial practices such as the cultivation and processing of vegetables and fruits, residues from the fishing industry, dairy production and maize cultivation (Center for Research in Food and Development, 2022).

The raw material used in agro-industrial processes is subjected to different processes to give it an added value, however, it generates environmental problems due to the high production of waste. Likewise, there are few alternatives that encompass the nutritional, social and economic axis to properly take advantage of agro-industrial waste, which causes them to be mismanaged and thus originate sources of contamination of natural resources (Cury et al., 2017).

The importance of this research lies in the use of by-products of agro-industrial origin, since it has an impact on the conservation of the quality of the environment, this because it considers the development of technologies or methods aimed at a sustainable transformation of natural resources (González, 2018). Thus, the present research seeks to describe the production of bioactive peptides through fermentation of agro-industrial waste products.

The use of waste products from agribusiness is of interest to companies since it is possible to improve the sensory, physical or chemical properties of food, in addition to acquiring new possible applications. As indicated by Grande (2017), agro-industrial residues are suitable substrates for producing enzymes, mainly from solid or submerged fermentation. This leads to a great application

in the manufacturing, food, pharmaceutical and cosmetic industries, among others. Like this

Likewise, the present research is not only important in the field of agribusiness but also in health, because bioactive peptides are natural antioxidants.

Methodology

Type of research

The present research is of bibliographic type, in this type of studies a considerable volume of information is summarized to establish in this way, intertextual relationships, diverse positions before a specific topic and thus synthesize the results. Likewise, bibliographic research has an important role in terms of the advancement of science, because they have a cumulative character of it (Codina, 2020).

Research focus

The study has a qualitative approach, which corresponds to the collection and subsequent analysis of the information obtained, together, it seeks to preserve the systematization, rigor and logic of the information presented, which is typical of scientific research (Borjas, 2020).

Search engines

Among the search engines mentioned are the following scientific databases such as Scopus, Web of Science and Google Scholar.

Inclusion and exclusion criteria Inclusion

I1. Full articles (do not consider abstracts, short articles).

I2. Articles with the keywords: Bioactive peptides, fermentation, agribusiness.

I3. Published articles on the production of bioactive peptides by fermentation.

Exclusion

E1. Articles published before 2017.

E2. Articles in other languages, except English and Spanish. E3. Duplicate items.

Agro-industrial waste

It is defined as a type of biomass due to the processing of organic materials related to the handling of animal products, fruits, plants and vegetables. In addition, they are considered the most important renewable resources to generate products of both social and economic interest (Vargas & Pérez, 2018).

Table 1 Identification of agro-industrial residues

Residue	Main constituents	Origin	Variety
Coconut shell	Dry mesocarp of the Fruit of the coconut tree	Farm the Shepherdess güira de Melena	Red Indian of savanna
Cane straw	Dried cane leaves	Sugar mill	C87-51
Bagasse core	Non-fibrous residue of sugarcane bagasse sugar	Center sugar bowl	C87-51

Note: The image shows some agro-industrial waste. Taken from (García et al., 2022)

This type of waste is produced every day among which, it is mentioned: Leaves, bagasse, bark, seeds, stems, shavings, straws among others, so they are divided into seven groups such as flat oilseeds, cereals, fruits - vegetables, tubers - roots, meats, dairy and maricos. In addition, they are often used for extractions or pretreatments (Rojas, et al., 2019).

For pretreatments, sugars and active compounds are released in biological, chemical, physical media and in combination thereof (Zamakona, 2019). Among the main compounds are hemicellulose and cellulose to be transformed into fermentable sugars (Ambar et al., 2022).

One of the advantages of agro-industrial waste is the production of antioxidant compounds, biofuels, pigments, enzymes, nutraceuticals, carotenoids, microbial oils, dietary fiber, single-cell protein, biodegradable plastics, and nanoparticles (Ibarruri, 2019).

They are also considered as a source of use for bioactive molecules such as phenolic compounds that benefit health due to their antioxidant capacity since, it helps modulate the immune system, reduce the risk of cancer, cardiovascular and degenerative diseases, these are used for pharmaceutical industries or nutraceutical food processing (Vega et al., 2022).

Bioactive peptides

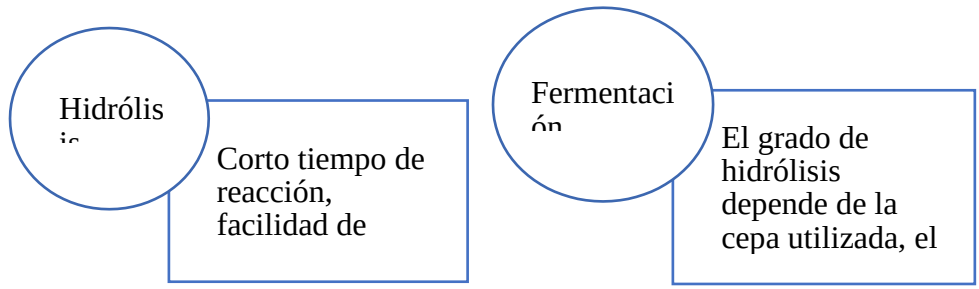
There is an exuberant number of foods that possess nutraceutical properties that are attributed to the products of their proteolytic digestion; these amino acid fragments have a high potential for biological action and are named bioactive peptides (PBA). In addition, the biological action of the peptide is related to the amino acid sequence that constitutes it, and this, in turn, is established by the cleavage points in the predecessor substrate of the peptide by the proteolytic catalyst (Barrero

et al., 2021).

Bioactive peptides are released during enzymatic proteolysis of proteins and also during food processing, such as fermentation, cooking maturation. Bioactive peptides are known for their ability to disable protein-protein interactions due to their small size and specificity. Nature is the major source of bioactive peptides, as plants, fungi, animals, microbes and their products contain several proteins (Mwine et al., 2017).

For the production and processing of bioactive peptides that are derived from food proteins, two methods are commonly known. These are:

Figure 1 *Methods for producing bioactive peptides*



Note: The image shows the most common methods for the production of bioactive peptides. Taken from (Mwine et al., 2017).

Characteristics of bioactive peptides

Whey maintains 55% of the nutrients that milk possesses (Zambrano & Dueñas, 2021). The main characteristics attributed to bioactive peptides derived from whey proteins are antioxidant, opioid, antimicrobial, mineral carrying, antithrombotic, antihypertensive, hypolipidemic and immunomodulatory activities (Chacón et al., 2017).

Uses of bioactive peptides

Speaking of whey as a waste of agribusiness, in the market it is commonly used as a means to increase milk solids at a minimum cost and, to a lesser degree, to take advantage of certain functional properties of whey proteins, such as free water retention, foaming and thickener (Chacón et al., 2017).

Likewise, it has been destined in the field of confectionery, manufacture of syrups used as raw material for different foods due to its sweetening properties, also for all types of beverages due to the low technification of the processes involved and is the origin of common, flavored, fermented and probiotic beverages (Zambrano & Dueñas, 2021).

Fermentation

Fermentation is defined as a biotechnological process to transform the raw material to produce and preserve food, since it is interpreted as the action of taking advantage of the metabolic activity of microorganisms to obtain processed foods (Jiménez et al., 2017).

Solid fermentation

It is characterized by having a minimum moisture content, that is, less than 12%, therefore, solid state fermentation is used for the production of food for both humans and animals, in the same way for fuels, enzymes and degradation of dyes. These products are related to the stationary stage of microbial growth and are manufactured on an industrial scale in order to use them in agriculture and treatment for diseases (Álvarez, 2018).

Likewise, there are secondary metabolites made in liquid fermentation, as a result a more effective method is obtained than solid-state fermentation, since this increases production and energy demand and costs (Balcázar & et al., 2023).

However, solid fermentation has shown the production of products with greater stability due to certain factors such as: Lower energy, small fermenters that allow the process of separation of products.

In the field of biotechnology, solid fermentation is used in bioprocesses such as biotransformation of agricultural residues, biodegradation of toxic compounds and bioremediation, production of surfactants, biofuels; On the other hand, it is mentioned

to alkaloids, enzymes, organic acids, antibiotics among other products (García & et al., 2021).

Figure 2 *Solid-state fermentation*

Note: The image shows compounds related to solid-state fermentation. Taken from (Correa et al., 2018)

In different countries with intensive agriculture, large volumes of agri-food waste are generated, these rich in sugars of easy access and assimilated by microorganisms, for this reason, the waste derived from agribusiness are substrates for the production of compounds through fermentation in solid state, since, when using the residues, they lower the impact of CO2 in the environment generated by CH4 or anaerobic combustion with an increase in the greenhouse effect (Jiménez, et al., 2017)

Types of fermentation

Food fermentation is based on methods and techniques, in which food or other products are taken to a catabolic process under oxidation control by microorganisms, which allows obtaining organic compounds, energy, improved products and various ingredients (Nardo, 2017).

Among the most common types of fermentation are:

Table 2 Types of fermentation

Fermentation	Final compounds	Products obtained
Lactic	It is generated from lactic acid and by various bacteria such as acetate, carbon dioxide and ethanol.	You get yogurt, sauerkraut, cheese, kimchi, kefir.
Acetic	It is generated due to water and acetic acid.	Wine vinegar is obtained and apple, kombucha.
Alcoholic	It is generated by carbon and ethanol.	You get wine, beer, bread and cider.

Note: The image shows the types of fermentation and products obtained. Taken from (Vizcardo & Zavala, 2016)

It is worth mentioning that fermentation processes provide advantages for food companies, among which are mentioned: Manipulation of variables for nutritious foods, as well as improving organoleptic characteristics through the generation of aromas and textures difficult to replicate (Borjas, 2020).

Use or applications of fermentation

The elaboration by fermentation is applied in the cultures of enzymes, microbials, food additives, fragrances, aromas and variety of products that have added value. In addition, it is practiced in developed countries, in low economies it is characterized by a technological base due to little access control since it offers quality products (Cánovasa et al., 2017). Therefore, in agro-industries fermentation processes allow to obtain products such as: Dairy (cheese, milk, yogurt), which are fermented and rich for a diet I would say.

Another of its uses is to transform organic matter based on enzymes, as derived products based on alcoholic fermentation due to its different yeasts, among the elaborated is mentioned: Wines, ciders, beers, distilled beverages; derived from bakery (López et al., 2019).

Fermentation diagrams

There are different fermentation diagrams as in liquid or solid medium:

Figure 3 *Fermentation in liquid or solid medium*

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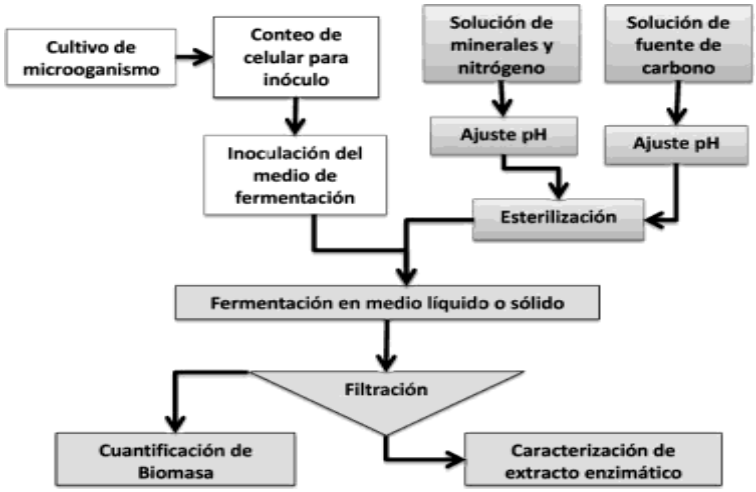
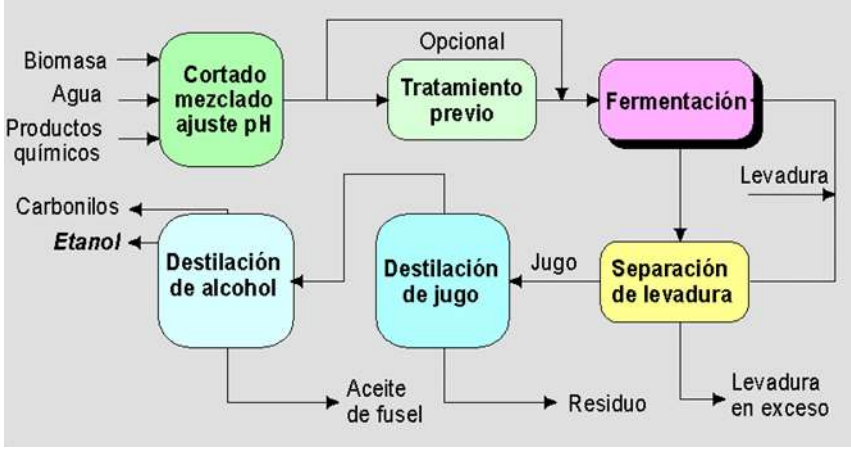


Note: The image shows the fermentation process in liquid or solid medium. Taken from (Balagurusamy, 2017)

The production processes of proteolytic enzymes are described with their process protocol based on purification with the aim of increasing the production of the protein of interest. This fermentation process involves details of parameter control with large volumes.

In addition, a scheme for the process of food fermentation is presented.

Figure 4 *Fermentation for food production*



Note: The image shows the fermentation process to obtain food. Taken from (Arcos, 2023)

Conclusions

Bioactive peptides are essentially isolated from protein hydrolysates and lactic products modified by bacterial fermentation, thus creating new ways of using waste from the dairy industry. Thus, whey, by preserving 55% of the nutrients in milk, has a large number of alternatives for its use, especially from the chemical, food, biomedical and cosmetic industries.

Also, fermentation is considered one of the first processes for food processing that includes the reduction of size, cleaning, cooking and soaking in order to obtain an edible product, since this process helps the modification of products and increase their shelf life.

Recommendations

Carry out further research on the production of bioactive peptides with agro-industrial waste, giving added value to products and minimizing environmental pollution. Thus, knowledge is also generated that can be applied for the benefit of human beings and industry.

It is important that agro-industries use fermentation processes since it is considered as a method of food preservation to improve its digestibility, so consuming them is an adequate way to ingest bacteria and nutrients that benefit health.

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