Approach to knowledge of the microbial bioprospecting in Venezuela

Abstract
This exploratory research was based on the review of the proceedings of the Annual Convention of the Venezuelan Association for Science Advance (AsoVAC) between 2002 and 2017 about the investigations realized in native microorganisms with biotechnological potential. In this regard, the researchers from Venezuelan universities and scientific institutions have developed lines of research to address the subject on the biotechnological utilization of microorganisms. The results indicate that the University of Oriente has the biggest contribution with respect to the evaluation of the photosynthetic microorganisms for the aquaculture food production and the biotechnologically important metabolites production. On the other hand, non-photosynthetic microorganism investigations have been directed especially to study their applicability in agrobiotechnology as biofertilizers and biocontrol agents; likewise they are candidates for the bioremediation of polluted terrestrial and aquatic ecosystems by petroleum hydrocarbon, an area very investigated by researchers at the University of Zulia due to oil exploitation that takes place within its area. Another topic of interest that stands out is the study in thermophilic and psychrophilic bacteria by the researchers from the University of Carabobo and the University of Los Andes, respectively.

Keywords: native microorganisms, microbial biotechnology, Venezuela, food biotechnology, agrobiotechnology, environmental biotechnology, proceedings of the AsoVAC

Introduction
The structural and functional diversity of microorganisms has allowed them to colonize a wide variety of environments in all terrestrial geography by deploying various essential adaptation mechanisms and processes for the functioning of ecosystems, mainly through their participation in the biogeochemical cycles, an activity linked to the fertility of soils and aquatic ecosystems; however, it is necessary to solve methodological limitations and knowledge gaps about the microbial regulation of global biogeochemical cycles. Moreover, they are natural controllers of pathogens and other harmful microorganisms to human health, plants and animals populations; and to continue adding benefits, its role in the mitigation of greenhouse gases and in regulating the planet climate associated with the recycling of atmospheric gases. In this sense, it has been noted that the importance of microorganisms has not been taken into account in predictive climate models suggesting for this purpose the development and application of molecular techniques to get to know the metabolic diversity that enable to assess mitigation strategies for greenhouse gas emissions.

On the other hand, the search for life beyond Earth scenarios has become one of the goals of science considering that this would be represented by very simple shapes such as the microorganisms. This assessment has as starting point, the presence of microorganisms in extreme environments on Earth whose conditions have also been found in other planets of the solar system. However, the exploration and investigation of the microbiodiversity in our planet continues being of interest in different types of ecosystems whose spectrum has increased thanks to the new technologies. This exploration has been focusing more on genetic potential which possess the microorganisms for biotechnological use in different scientific and technological areas. In this regard, Venezuelan researchers have explored the habitat diversity in the country carrying out studies on isolation and evaluation of the microbial potential for biotechnological purposes obtaining promising results for several years. This search comprises natural and anthropic environments some of whom have been subjected to a high degradation by chemical pollution or to the effects of climate change; nevertheless, these contaminated environments have become new sources of microorganisms with important metabolic functions for the bioprocesses development of environmental and industrial interest.

These investigations not only represent a scientific contribution to biotechnology and ecological knowledge of the Venezuelan microbiodiversity, they also represent a valuable genetic bank deposited in the strain collections which become more and more precious as environmental degradation is increased because, consequently, many beneficial species disappear. In this way, it was made an exploratory study as an approximation of the knowledge in this area based on the review of the proceedings of the Annual Convention of the Venezuelan Association for Science Advance (AsoVAC) between 2002 and 2017 about the research on photosynthetic and non-photosynthetic native microorganisms with biotechnological potential.

General scenario
The Annual Convention of the AsoVAC started in 1950 and it has as objective the dissemination of scientific, socio-humanistic and technological knowledge of Venezuela. In this sense, is a multidisciplinary event with several genres of presentation such as forums, round tables, courses, symposiums, seminars, conferences and presentations (oral and poster), latter being which meet the greatest number of work presented and published as abstracts in the
printed and digital memories of the congress. This event is organized each year in a distinct country city with the participation of different Venezuelan universities and scientific institutions, this fact can influence a greater presence of those institutions geographically next to the place of the Convention. However, in recent years certain happenings have hindered the organization of this Convention which in some cases forced to do it simultaneously in different cities as it was the case for the years 2014 and 2017. There is also a decrease in participation in this convention (Figure 1).

![Figure 1](image.png)

**Figure 1** Works presented in the Annual Convention of AsoVAC (■) and in the Venezuelan Congress of CTI (●). The proceeding 2010 is not available.

In this context, the results extracted from the proceedings of the Annual Convention of the AsoVAC show that biotechnological investigations have focused on four main areas: firstly, the industrial biotechnology, specifically with application in the food industry. Secondly, the environmental biotechnology dominated research on bioremediation of petroleum hydrocarbon polluted environments (PH), followed by agricultural biotechnology with the production of biofertilizers and biocontrol agents. Finally, the biotechnology in human health has few jobs in diagnosis and production of bioactive substances among other studies, although this area can share research with food biotechnology on functional foods and nutraceuticals (Table 1).

| Researchs | Works |
|-----------|-------|
| Food biotechnology | 23 FM, 21 NFM, 04 FM, 10 NFM |
| Biomass production (SCP) | 23 FM, 05 NFM, 04 FM, 01 NFM |
| Fermented foods production | 07 FM, 01 NFM |
| Probiotics | 09 FM, 07 NFM |
| Food conservation | 01 NFM |
| Food and drug biotechnology: metabolites production | 30 FM, 53 NFM, 03 FM, 12 NFM |
| Enriched biomass | 25 |
| Bioactives compounds | |
| Bacteriocins (food conservation) | 04 NFM |
| Pharmacological use | 05 FM, 11 NFM, 01 FM, 02 NFM |
| Enzymes | 29 FM, 05 NFM |
| Biosurfactants | 05 FM, 01 NFM |
| Others | 04 FM, 02 NFM, 03 NFM |
| Environmental biotechnology | 36 FM, 28 NFM, 08 FM, 21 NFM |
| Heavy metals biosorption | 13 FM, 07 NFM |
| Bioremediation: | |
| Hydrocarbon biodegradation | 08 FM, 25 NFM, 18 |
| Pesticides biodegradation | 02 FM |
| Wastewater treatment | 12 FM, 01 NFM, 02 NFM |
| Ecotoxicological studies | 03 |
| Others (biodegradation) | 01 NFM, 01 |
| Energetic and mining biotechnology | 02 FM, 11 NFM, 01 FM, 09 |
| Biofuel production | 02 FM, 02 NFM, 01 FM, 07 NFM |
| Improvement of oil | 03 FM, 01 NFM |
| Bioremediation and improvement of oil | 04 |
| Bioleaching | 02 FM |
| Bioelectricity generation | 01 |
| Agricultural biotechnology | 32* NFM, 104* |
| Biocontrol agents | 16 FM, 54 |
| Biofertilization | 15 FM, 46 |
| Microbial culture collections | 01 NFM, 06 |
| Others | 04 FM, 05 NFM, 03 NFM, 04 NFM |

*It include integrated studies on biocontrol and biofertilization agents.

In the same way, the proximity to places with high oil activity generating a significant contamination of soils and waters offer to LUZ the opportunity to carry out studies on indigenous microbial potential (photosynthetic and non-photosynthetic) to degrade PH, its derivatives and heavy metals, including ecotoxicological studies (15.2%). While the UDO has principally explored the marine photosynthetic biodiversity as food and drug resource (6.6%) (Table 2).
group of research of the Laboratory of Molecular Microbiology and Biotechnology (Biology Department, Faculty of Sciences, University of Los Andes (ULA), Merida State) has explored the microbiodiversity of the Sierra Nevada glaciers in this city with very promising results in the isolation of psychrophilic bacteria as a novel source of bioactive compounds and biofertilizers of soils; this microbial group may be threatened by climate change that has affected Andean Mountain systems (Table 3).  

In general, the papers presented at the Annual Convention of the AsoVAC have applications in different biotechnological areas concentrating most of the works on bioremediation, on agricultural and food production (Table 1). Moreover, many of the organisms studied are natives of different Venezuelan ecosystems; of the total of presented research, the studies on isolation and evaluation of indigenous microorganisms represent 83.3%, the photosynthetics 38.4% and the non-photosynthetics 44.9%, the work done with bacterial strains predominate in the second group (39.6%).

By contrasting these results with those obtained in the Venezuelan Congress of Science, Technology and Innovation between 2012 and 2014 (event organized by the National Centre of Science, Technology and Innovation (ONCTI)), it can see important differences in the institutional presence: 38.4% of the work corresponds mostly to joint investigations between various institutions; however, in this group stand out the participation of the National Institute for Agricultural Research (INIA) with 12.4% of the studies, this entity is attached to the Ministry of the Popular Power of Agriculture and Lands. In this regard, INIA researchers share the authorship of his works mainly with those pertaining to the faculties of Agronomy of the UC, LUZ, UCLA, UNEFM and UNET, highlighting studies in the area of biocontrol and biofertilization with the use of commercial and native microorganisms (Tables 1 & 2). Additionally, the INIA has a microbial culture collection and production of bio-inputs.

This scientific work has generated a significant amount of biotechnology information which has involved the preservation of microorganisms in different types of collections, usually administered under the criteria established by the same participating researchers in their respective research units, invaluable spaces of preservation of genetic material for different purposes, often academics. In this way, the UDO has the collection of permanent cultivation of microalgae in the Aquaculture Laboratory of the Oceanographic Institute of

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**Table 2** Participating institutions in the congress of AsoVAC (2002–2017) and CTI (2012–2014). It includes the total works on biotechnology of autochthones and commercial microorganisms

| Institutions | Microorganisms | Total | Microorganisms | Total |
|--------------|----------------|-------|----------------|-------|
| F            | NF             |       | F              | NF    |
| LUZ          | 25.4           | 9.4   | 34.8           | 4.9   | 2.7 | 7.6 |
| UC           | 12.7           | 12.7  | 1.1            | 2.2   | 3.2 |
| UDO          | 8.2            | 1.6   | 9.8            | 1.6   | 2.7 | 4.3 |
| UCV          | 7.0            | 7.0   | 14.6           | 14.6  |
| ULA          | 6.2            | 6.2   | 2.7            | 2.7   |
| USB          | 5.3            | 5.3   | 0.5            | 0.5   |
| UNEFM        | 2.5            | 2.5   | 1.1            | 6.0   | 7.0 |
| IDEA         | 2.1            | 2.1   | 4.3            | 4.3   |
| UCLA         |                |       | 4.9            | 4.9   |
| UNET         |                |       | 3.8            | 3.8   |
| INIA         |                |       | 6.5            | 6.5   |
| Others       | 5.3            | 14.3  | 19.6           | 2.2   | 38.4 | 40.5 |

F, Photosynthetics; NF, Non-photosynthetics.

In the case of the U.C, researchers from the Chemistry and Biology departments of the Faculty of Science and Technology (FACYT) took advantage of thermal springs at Las Trincheras (Carabobo State) to isolate and study several thermophilic bacteria with potential for the production of valuable enzymes for industrial use. Similarly, the

**Table 3** Extremophile microorganism sources in Venezuela with biotechnological potential

| Microorganisms                | Researchs                                      |
|-------------------------------|-----------------------------------------------|
| **Thermophile Bacteria**      |                                               |
| Bacillus stearothermophilus    | Production of exochitinases, endoglucanasas, lipases, amylases and proteases; improvement of oil |
| Bacillus sp.                  | Production of proteases                       |
| Brevibacillus brevis          | Production of xylanases                       |
| Geobacillus pallidus          | Production of xylanases (β-xylodidase)        |
| Geobacillus stearothermophilus | Production of β-xylodidase, amylases and cellulases |
| Sulfur-reducing thermophile bacteria | Bioremediation and improvement of oil         |
| Non specified strain Gram+   | Production of alkaline phosphatase            |
| Psychrophile and psychrotolerant Bacteria | Isolation, identification and characterization |
| Actinobacteria and Proteobacteria       |                                              |
| Janthinobacterium, Iodobacter and Duganella | Production of violacein (biological activity) |
| Pseudomonas                   | Inorganic phosphate solubilizing, production of the phytohormone indol-acetic acid and antimicrobial compounds, detection of siderophores |

This work has generated a significant amount of biotechnology information which has involved the preservation of microorganisms in different types of collections, usually administered under the criteria established by the same participating researchers in their respective research units, invaluable spaces of preservation of genetic material for different purposes, often academics. In this way, the UDO has the collection of permanent cultivation of microalgae in the Aquaculture Laboratory of the Oceanographic Institute of

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Venezuela; similarly, LUZ has the collection of microalgae from the Laboratory of Photosynthetic Microorganisms (Biology Department, Faculty of Experimental Sciences, Zulia State). The Venezuelan Center for Microorganisms Collection (CVCM) is recognized at the national level belonging to the Institute of Experimental Biology (IBE) of the UCV whose services include the deposit and conservation of microbial strains of researchers who request it; this center is registered and is governed by the performance standards established by the World Federation for Culture Collections (WFCC) and it belongs also to the Latin American Federation for Culture Collections.

**Photosynthetic microorganisms**

**Food production**

The studies leading to the search of photosynthetic and non-photosynthetic microorganisms have brought great findings on two important topics in microbial ecology such as biodiversity and metabolic activity in natural and anthropic environments. In this way, biotechnology has taken advantage of the different microbial metabolic strategies optimizing the culture processes among which the biomass production is priority for different purposes (Table 1). On this aspect, the valuation of the photosynthetic microorganisms as food source has included studies on growth kinetics under different physicochemical and nutritional conditions to optimize the enriched biomass production with proteins, lipids (especially polyunsaturated fatty acids), pigments and carbohydrates (exopolysaccharides) that improve their food quality. To this objective several species of microalgae and cyanobacteria usually intended as a source of live food for marine or freshwater organisms under cultivation (fishes, crustaceans and molluscs) has been evaluated (Table 4). In this way, biotechnology has taken advantage of the different microbial metabolic strategies optimizing the culture processes among which the biomass production is priority for different purposes (Table 1). On this aspect, the valuation of the photosynthetic microorganisms as food source has included studies on growth kinetics under different physicochemical and nutritional conditions to optimize the enriched biomass production with proteins, lipids (especially polyunsaturated fatty acids), pigments and carbohydrates (exopolysaccharides) that improve their food quality. To this objective several species of microalgae and cyanobacteria usually intended as a source of live food for marine or freshwater organisms under cultivation (fishes, crustaceans and molluscs) has been evaluated (Table 4). Among the most studied are the salt beds of Araya (Sucre State) and Coche (Nueva Esparta State) in the northeast of Venezuela; then include the salt beds Las Cumuragüias (Paraguán Peninsula, Falcon State) and Las Peonias (Zulia State). Several strains of *D. salina* and *D. viridis* have been isolated from these environments, however, the first is the more attractive species due to its ability to produce carotenoid pigments of food and pharmaceutical interest. Among the cyanobacteria with these properties is *Phormidium* sp., *Oscillatoria* Limnothrix* sp.*, *Spirulina* subsalsa and Nostoc strains some of which are cultivated around the world (Table 4). In this way, the photosynthetic microorganisms become an excellent source of beneficial functional foods for human and animal consumption because they can synthesize bioactive substances in addition to their nutritional properties.

The Venezuelan coasts offer interesting hypersaline systems, which constitute microhabitats of special scientific interest since they can grow on natural, degraded or contaminated soils.

**Table 4** Investigations carry out on photosynthetic microorganisms: food and drug biotechnology

| Cyanobacteria | Microalgae |
|---------------|------------|
| **Food production** |  |
| Marine ecosystems: Chaetoceros sp., *Chlorella* sp., *Skeletonema* sp., Tetraselmis sp., *T. chuii*, *T. tetratelehe*, *T. tetrathele* | marine ecosystems: *Chaetoceros* sp., *Chlorella* sp., *Skeletonema* sp., *Tetraselmis* sp., *T. chuii*, *T. tetratelehe*, *T. tetrathele* |
| Hypersaline environments: *Dunaliella salina*, *D. viridis* | Hypersaline environments: *D. salina*, *D. viridis* |
| Freshwater: *Chlorella* sp., *Ceratocystis* sp., *C. vulgaris*, *Pseudokirchneriella subcapitata* | Savannas: *D. salina* |
| *Pseudokirchneriella subcapitata* | Savannas: *D. salina* |
| Source not specified: *Anabaena* sp., *Nostoc* sp. *Spirulina* platensis, *S. Subsalsa*, *Synechococcus* sp. | Source not specified: *Anabaena* sp., *Nostoc* sp. *Spirulina* platensis, *S. Subsalsa*, *Synechococcus* sp. |
| Enriched biomass production |  |
| Marine ecosystems: *Limnothrix* sp., *Oscillatoria* sp., *Phormidium* sp. | Marine ecosystems: *Chlorella* sp., *Rhodosorus marinus* |
| Source not specified: *Nostoc* sp., *Synechococcus* sp., *Synechocystis minuscula* | Hypersaline environments: *D. salina*, *D. viridis* |
| Bioactive compounds production | Savannas: *D. salina* |
| Marine ecosystems: *Limnothrix* sp., *Oscillatoria* sp., *Phormidium* sp. | Savannas: *D. salina* |
| Source not specified: *Nostoc* sp., *Spirulina* subsalsa | Source not specified: *Nostoc* sp., *Spirulina* subsalsa |

*In this work the scientific names of the species were maintained as they appear in the abstracts of the AsoVAC Convention. Some of these have changed, for example, *Selenastrum capricornutum* was modified to *Pseudokirchneriella subcapitata*.*

On the other hand, the production of enriched biomass with metabolites of agrifood, cosmetic, clinical or pharmaceutical interest increases the value added of this organism group. On this subject, investigations have been focused mainly on evaluating the production of bioactive substances that are especially pigments carotenoids and the phycobiliproteins. In this sense, *Dunaliella salina* (halotolerant microalgae from salty lagoons), is a source of vitamin A and the cause of the coloration in the red flamingo (*Phoenicopterus ruber*). Moreover, the phycobiliproteins has been used in immunosays and fluorescent microscopy for diagnostics and biomedical research. Among the cyanobacteria with these properties is *Phormidium* sp., *Oscillatoria* Limnothrix* sp.*, *Spirulina* subsalsa and Nostoc strains some of which are cultivated around the world (Table 4). In this way, the photosynthetic microorganisms become an excellent source of beneficial functional foods for human and animal consumption because they can synthesize bioactive substances in addition to their nutritional properties.

The Venezuelan coasts offer interesting hypersaline systems, which constitute microhabitats of special scientific interest since they can grow on natural, degraded or contaminated soils.
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Fermentation products
Pretreated urban paper (acid hydrolysis).
Agroindustrial byproducts
Enzymes
Bioethanol
SCP-enriched biomass
Pretreated mesocarp orange (Citrus sinensis) (acid hydrolysis)
SCP-enriched biomass for animal food
SCP-enriched biomass for animal food
SCP-enriched biomass

Microalgae
Freshwater: Chlorella sp.
Source not specified: Scenedesmus sp.
Freshwater: Chlorella sp.
Chlorella sp.
Port of Lanchas: Chlorella sp.
Source not specified: Synechococcus sp.
Oil pit: Chlorella sp. and Chlorococcus sp. (mixed culture)
Oil pit: Chlorella sp.
Source not specified: Synechocystis sp.
Chlorella sp.

Table 5 Investigations carry out on photosynthetic microorganisms: environmental biotechnology

Cyanobacteria

Microalgae

Metal heavy biosorption
Marine ecosystems: Limnothrix sp., Oscillatoria sp., Phormidium sp.
Source not specified: Pseudanabaena sp.
Bioresistance
Marine ecosystems: Limnothrix sp.
Source not specified: Synechococcus sp.
Microbial mats of coastal sediments polluted by petroleum hydrocarbon: Microalgae: Chlorella, Scenedesmus, Merismopedia, Chlamydomonas, Ankistrodesmus and Nitzschia. Cyanobacteria: Spirulina, Anabaena, Oscillatoria, Westellopsis, Synechocystis and Synechococcus
Wastewater treatment
Source not specified: Synechocystis sp.
Freshwater: Chlorella sp.
Source not specified: Scenedesmus sp.
Floating aquatic plant system: Scenedesmus sp. y Chlorococcus sp.
Constructed wetland: Chlorophyta sp. and Staurosnesis sp.

Macrophyte-based constructed wetland: Cyanobacteria: Oscillatoria sp., Microcystis sp. Arthospira sp., Synechocystis sp. Microalgae: Kirchneriella lunaris, Chlorella sp., Scenedesmus sp., Nodulica sp., Nitzschia sp., Euglena sp. and Trachelomonas sp., photosynthetic bacteria Thiopedia sp
Ecotoxicological studies
Marine ecosystems: Chaetoceros sp., Tetraselmis muelleri
Hypersaline environments s: D. salina
Oil pit: Chlorella sp.

Biofuel production
Marine ecosystems: Chaetoceros sp., Chlorella capsulata, Skeletonema sp., Tetraselmis sp.
Hypersaline environments: D. Salina

Another consideration is that mixed and axenic cultures of cyanobacteria and microalgae are particularly beneficial in systems of wastewater treatment for its ability to remove nitrogen and phosphorus compounds, so the understanding of its dynamics is valuable information for the management and design of these systems. In addition, Scenedesmus sp. can be used with a dual purpose: on the purification of wastewater from food industry that constitute at the same time an appropriate culture medium for the production of protein-rich biomass as a source of food (Table 5). Photosynthetic microorganisms

Food production
Unlike the photosynthetic microorganisms, the non-photosynthetic shows greater diversity in its application. Although they are also used as food source, studies conducted for the production of single-cell protein (SCP) include the development of enriched products with microbial biomass usually using submerged fermentation of organic wastes or byproducts of low or no commercial value as carbon and energy source. The utilization of these wastes tends to be a common practice in the obtaining of biomass from non-photosynthetic microorganisms. However, they generally are pretreated before being used as fermentation substrates depending on their nature; particularly the lignocellulosic residues are predigested with organic solvents, acid or enzymatic hydrolysis that release fermentable sugars for the metabolites production or to enhance the digestibility of the biomass obtained for animal feed (Table 6).

Table 6 Utilization of industrial byproducts as fermentation substrates

| Microorganisms (source) | Agroindustrial byproducts | Fermentation products |
|-------------------------|---------------------------|-----------------------|
| Hot springs: Geobacillus stearothermophilus | Paper, napkins, ground grass | Enzymes (1) |
| Commercial: Saccharomyces cerevisiae ATCC-4921. Mosto de uvas: S. cerevisiae LGBM-26. | Pretreated urban paper (acid hydrolysis). | Bioethanol (2) |
| Source not specified: S. cerevisiae | Pretreated mesocarp orange (Citrus sinensis) (acid hydrolysis) | SCP-enriched biomass for animal food (3) |
| Source not specified: Thermotolerant yeasts | Pretreated Pinus radiata wood chips (organosolv-enzymatic hydrolysis) | Bioethanol (4) |
| Poultry manure: Nocardia sp. EP3-MC3 | Integral wastes of orange (Citrus sinensis) not pretreated | SCP-enriched biomass (5) |

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Agroindustrial byproducts

- Proteins, xylanases, simple sugars
- Bioactive compounds production (antibacterians)
- Proteases
- 134 protein hydrolysates, bacteriocins production (control of Lactobacillus casei)
- Bioactive compounds production (Antimicrobial agents)
- SCP-enriched biomass, carotenoids and Keratinases

Table 7: Investigations realized on non-photosynthetic autochthones microorganisms: food and drug biotechnology

| Microorganisms (source)        | Agroindustrial byproducts | Fermentation products                  |
|-------------------------------|---------------------------|----------------------------------------|
| Cocoa husks (ANM-1)           | Proteins, xylanases, simple sugars | Enzymatic aditives for monogastric diet (CMCases, 1,4-β-endoglucanases) |
| Corn grains and sunflower seeds, respectively: Aspergillus niger ANM-1, A. niger ANG () | Hydrolysis of bovine, ovine and caprine whey proteins by proteases of A. niger | 1,4-β-endoglucanases and fermentable sugars |
| Banana peel (Musa sapientum)  |                          | SCP-enriched biomass, carotenoids and proteases |
| Bristles and hairs of pig     |                          | Protein hydrolysates, N-acetyl-glucosamine and chitosan for animal food and pharmaceutical industry |
| Proteo-chitinous wastes of the shrimp industry |                          | Proteases |
| Feathers and pig’s hairs (keratin), shrimp wastes (chitin) |                          | Carotenoid |
| Poultry wastes: Kocuria rosea |                          | Keratinases |

Lactic acid bacteria (LAB)

LAB have been used in the manufacture of processed dairy products and cheeses for the production of organic acids, bacteriocins (antimicrobial proteins), components of the flavor or as probiotics (Table 7). In addition, Lactobacillus casei has the ability to hydrolyze casein, an activity which makes it a potential source of proteases. In order to expand the applications of this group of bacteria, Zambrano and Maldonado isolated and characterized autochthonous bacteria to produce a mature cheese (cheddar) obtaining favorable results.

On the other hand, bacteriocins have shown potential to inhibit or slow the growth of pathogenic microorganisms present in some foods. Thus, the investigations have been directed to the pursuit of these bacteriocins in the Enterococcus genus as a response to the growing rise of antibiotic-resistant bacteria. With this aim, several species of bacteria have been isolated and evaluated from milk and cheese.

Studies on functional foods supplemented with probiotics are also two of the most widely used microbial groups in the food industry, particularly in the production of dairy products, whose aspects to be considered include evaluation of the methods of counting. In this sense, Biomon et al. assessed the incorporation of Lactobacillus fermentum isolated from guayanes cheese in the food rations for rats in order to determine the effect on the development of salt-sensitive hypertension in these animals. The results showed that this bacterium may act as a probiotic in the alternative treatment of hypertensive patients.

Yeasts

Yeasts have wide application not only in the preparation of fermented foods and beverages but also in the production of biomass by its nutritional characteristics and probiotic effect for animal consumption. For example, oenology is a highly relevant biotechnology area so that the yeasts are given special attention. For this purpose, Medina et al. isolated and evaluated the sugarcane (Saccharum officinarum) must yeasts of the Zulian region obtaining tolerant strains to high temperatures and concentrations of sugars and ethanol, desirable features in the selection of strains--initiating the fermentation (Table 7).

Table 7: Investigations realized on non-photosynthetic autochthones microorganisms: food and drug biotechnology

| Microorganisms (Sources) | Researches |
|--------------------------|------------|
| Milk and cheese from buffalo (Bubalus bubalis): bacteriocinogenic lactic acid bacteria (LAB): Aerococcus viridans, Enterococcus faecium, E. faecalis, Pedicoccus acidilactici | Bacteriocins production |
| Foods: E. faecalis | Bacteriocins production (control of Staphylococcus) |
| Artisanal white Cheese: E. faecalis | Bacteriocins production (control of Listeria monocytogenes) |
| Guayanes cheese: Lactobacillus fermentum (LAB) | Probiotic |
| Fermented sugarcane juice (Saccharum officinarum): Candida intermedia, C. tropicalis, Dekkera anomala, Kluyveromyces marxianus, Pichia anomala, P. fermentans, P. guilliermondii, Torulaspora delbrueckii y Zygasccharomyces fermentati/Z. cadi | Fermented beverages elaboration |
| Fermented cacao (Theobroma cacao): acetic acid bacteria: Acetobacter cibinogensis, A. cerevisiae y A. estaminus | Cacao fermentation |
| Mangrove roots (Rhizophora mangle): Penicillium sp., P. citrinum, Aspergillus niger, Trichoderma viride, Syncephalastrum racemosum, A. ochraceus | Bioactive compounds production (Antimicrobial agents) |
| Soil: Streptomyces sp. | Bioactive compounds production (antibacterians) |
| Endophytic fungi: Xylaria spp. | Bioactive compounds production (Antimicrobial agents) |

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Production of bioactive metabolites

The non-photosynthetic microorganisms produce a wide range of bioactive substances with different functions; however, a larger number of investigations have been made with the purpose of finding antimicrobial compounds as consequence of the increasing rate of antibiotic resistance which demand new drug products to combat them. In this sense, the isolation and characterization of new microbial strains producing these metabolites is an important and attractive area for research, especially the study of the actinomycetales traditionally known as an important antibiotic source very abundant in the soil which can isolate, just as marine and endophytic fungi with antibacterial and antifungal activities (Table 7).  

Production of enzymes

Non photosynthetic mesophile microorganisms constitute an important source of enzymes of wide application in the chemical, textile, paper, food and pharmaceutical industry. Enzymatic applications include the sugars production mainly from cellulosic wastes for the further fermentation and conversion in biofuels, organic acids, antibiotics and other enzymes (Table 6); on the other hand, the whey is an important byproduct from cheese manufacture due to the presence of bioactive peptides (antihypertensive, antioxidant, antithrombotic, immunomodulatory, antibacterial), which can be utilized as functional ingredient in the food or pharmaceutical industry through the employ of microbial proteases.

In this sense, the commercial and native species of the *Aspergillus* genus have been very studied; such is the case of the production of glucose oxidase from *Aspergillus niger* whose applications include preparation of glucose assay kits and the development of antioxidant additives in the food preservation. This enzyme is industrially used, so the studies leading to the optimization of culture media to improve its production is one of the objectives of research. *A. niger* is also a producer of Hydrolase (β-1,4-Endoglucanases, α-amylases, glucoamylases, xylanases and phytase) that can be incorporated in the monogastric animal diets as enzymatic additives to improve their feed conversion (Table 6).

Agroforestry applications

Biofertilization and biocontrol are important biotechnological applications in the agricultural sector. Both biotechnological processes bring significant benefits to agriculture since it means the decline in the application of chemical inputs highly polluting for the environment or harmful to human health; likewise, it represents a contribution to agroecological practices with emphasis on sustainable agriculture. In this sense, the use of commercially known and native microorganisms in important crops from the production and consumption point of view around the world has been research (Table 8).

### Table 8 Investigations realized on non-photosynthetic autochthones microorganisms: agrobiotechnology

| Microorganisms (sources) | Researches |
|-------------------------|------------|
| Soils: *Bacillus thuringiensis* | Pest biocontrol, chitinases production |
| Cacao plantation: Entomopathogenic fungi | Pest biocontrol |
| Rhizosphere: wild strain *Pseudomonas fluorescens* | Biocontrol and biofertilization (glucolic acid production) |
| Soil and rabbit manure: diazothrophics bacteria phylogenetically related with *Burkholderia vietnamiensis* and *Paenibacillus sabina* | Nitrogen fixation |
| Root nodules of *Calopogonium* sp.: *Rhizobium* sp. | Nitrogen fixation, inorganic phosphate solubilizing and auxins production |
| Rhyzosphere and roots of rice plants (*Oryza sativa*): Plant growth-promoting bacteria | Nitrogen fixation inorganic phosphate solubilizing |
| Bog-iron ore: *Pantoea*, *Burkholderia*, *Serratia*, *Ralstonia* y *Enterobacter* | Nitrogen fixation inorganic phosphate solubilizing |
| Rhyzospheric soil and roots of wild and cultivated plants: plant growth-promoting bacteria (Gram-negatives) | Degraded forest recovery |
| Rhyzospheric soil and roots of dry forest plants: *Arbuscular mycorrhize*: *Glomus*, *Acaulospora*, *Scutellospora* y *gigaspora* | |

### Biopesticides

*Bacillus thuringiensis* (producer of cry toxins) and *Beauveria bassiana* are the most known and used species, they are employed in several countries including Venezuela for the control of insect pests of agricultural crops as well as of those considered biological and mechanical vectors of human and animal public health interest. In this sense, strains adapted to the conditions of the Venezuelan tropics have been isolated and selected. On the other hand, several rhizobacteria of wild and cultivated plants interact with various microorganisms exhibiting chemical defense mechanisms such as the production and excretion of glucan and 2-cetogluconic acids that acidify the soil and in this way they inhibit the growth of pathogenic microorganisms with the additional advantage of dissolving the inorganic phosphorus of soil.  

### Biofertilizers

Rhizobacterial and endophytic microorganisms have shown several benefits in addition to protection against pathogens, such as the production of the plant growth-promoting substances and the supply of essential nutrients. In the latter case, the fixation of atmospheric nitrogen, inorganic phosphate solubilizing and production of siderophores stand out; for this reason, the study of plant growth promoting strains is relevant to the soil fertility so the formulation and application of inoculants with these characteristics could optimize the nutritional capacity of them and promote the ecological agriculture.

Among the different food items produced in Venezuela, legumes and cereals such as the rice (*Oryza sativa*) and the corn (*Zea mays*) are very important for its nutritional value. Additionally,
legumes are interesting fodder; as a result, some researchers have prioritized the pursuit of plant growth-promoting bacteria whose most known and studied species belong to the *Rhizobium* genus, an endosymbiotic bacteria associated to the radical structures of legumes, crops that enrich the nitrogen content of soil, thus increasing its fertility. With this interest, Venezuelan researchers have explored the microbiodiversity associated with the rhizosphere and roots of these crops finding several strains that expand the spectrum of this kind of agrobiotechnology local resource as a source of inoculants.

### Environmental biotechnology

The bioremediation of polluted environments with xenobiotic compounds especially by petroleum hydrocarbon is one of the most important biotechnological applications of microorganisms in environmental matters; as a consequence, the aromatic compounds acquire relevance because they are partially responsible for the low biodegradation of hydrocarbons, in addition to being highly recalcitrant, carcinogenic and mutagenic compounds persisting in contaminated environments. Like this, photosynthetic and non-photosynthetic microorganisms are equally important in the environmental recovery, however, the first have been studied for their potential on the heavy metals biosorption while the latter are evaluated for the bioremediation by their ability to biodegrade hydrocarbons and their derivatives (Table 9). Despite this capability, microalgae may be sensitive to these chemicals pollutants in aquatic environments which affect the growth and pigment synthesis, reason for which they are used to carry out ecotoxicological studies (Table 5).

#### Table 9 Investigations realized on non-photosynthetic autotrophs microorganisms: environmental and mining biotechnology

| Microorganisms (sources) | Researchs |
|--------------------------|-----------|
| Agricultural soils and coal mining activity soils: degrading pesticides bacteria (*DDT* and parathion) | Bioremediation |
| Oil pit: (1) Gram-negative strains: *Pantoea agglomerans*, *Sphingobacterium thalophilum*, *Actinobacillus* sp. (2) Gram-negative mixed bacterial culture | Bioremediation |
| Soils by PH: (1) *Pseudomonas* sp. (2) *Bacillus* sp., *P. aeruginosa*, *Bacillus* sp., *P. aeruginosa* | Biosurfactants production |
| Polluted Soils/sediments by PH: (1) *Staphylococcus* spp., *Micrococcus* spp. (2) *P. alcaligenes* | Bioremediation |
| Polluted Waters by PH: (1) *Serratia*, *Alcaligenes*, *Vibrio*, *Aeromonas*, *Pseudomonas*, *Morococcus*, *Acinetobacter*, *Flavobacterium*, *Enterobacter*, *Cronobacter* (2) *Escherichia* coll. (3) Bacteria sulfurreductors: *Desulfuvibrio desulfuricans*, *D. vulgaris*, *D. termitidis*. (4) *Pseudomonas* aeruginosa, *P. stutzeri*, *P. fluorescens*, *P. syringae* | Bioremediation |
| Hydrocarbon mixture wastes: Consortium: *Pseudomonas* sp. and *Serratia* sp. | Bioremediation |
| Polluted Environments by PH, white rot and biterness of Aloe vera: *Aspergillus oryzae*, *A. nidulans* y *A. versicolor* | Bioleaching |
| Iron ore associated microflora: *Aspergillus niger* HNA-I | Bioleaching |

*DDT*, dichlorodiphenyltrichloroethane.

Hydrocarbonoclastic bacteria have shown that they can be used not only in bioremediation processes but also as agents of improvement of the properties of heavy or extra-heavy oil (viscosity, density, and API grades) to optimize its extraction, transport and refining, and hence obtain high economic benefits; in this case, an alternative involves the utilization of thermophilic enzymes for its greater stability at high temperatures. Moreover, the improvement may include the use of sulfur-reducing bacteria to eliminate the sulphur present in the oil that is released during its combustion in the form of highly pollutant sulfur dioxide which is one of the components in acid rain.

## Bioremediation

Hydrocarbons biodegradation is usually accompanied by the production of surfactants that emulsify these hydrophobic substrates improving its bioavailability and consequently the contact between the bacteria and the oily phase; the best known surfactants were obtained from soils, sediments and water contaminated with oil from Lake Maracaibo (Zulia State), however, it can also be produced by the bacteria of the *Bacillus* genus when grow in soluble substrates.

One of the objectives includes the study of catabolic routes of some aromatic compounds in species such as *Pseudomonas putida*; this information is useful for the microbial consortia design in the bioremediation processes development of hydrocarbon polluted environments which involves strains producing biosurfactants as *P. aeruginosa*. The utilization of these bacterial or fungal consortia (natural or artificial) in bioremediation processes tends to be more efficient in the degradation of hydrocarbons than the axenic cultures.

In the same line of investigation, some authors have explored contaminated waters and soils by petroleum in Zulia State in search of aromatics-degrading bacteria and resistance to heavy metals (mercury, chromium, cadmium and nickel) in order to determine its potential for bioremediation. However, despite having obtained promising results, is also cause for alarm because isolates including important pathogenic species for man with implications for public health which have shown resistance to antibiotics.

On the other hand, it was evaluated the use of sulfur-reducing bacteria for the recovery of environments contaminated by industrial effluents which contain high concentrations of toxic sulfates to living organisms; this alternative have ecological advantages and low cost. Studies for the evaluation of these bacteria include *Desulfuvibrio desulfuricans*, *D. vulgaris* and *D. termitidis* isolated from Maracaibo Lake which additionally can remove heavy metals. With the same aim, González & Wilkesman determined the oxygenase activity to degrade dibenzothiophene as carbon and energy source in thermophilic strains isolated from the hot springs at Las Trincheras.

## Mining: bioleaching

The high content of phosphorus in iron ore (>0.08%) raises industrial costs for its dephosphorization in obtaining high quality derivatives; as a result, it produce large amounts of ore rejected producing an important environmental liability. In this sense, may be...
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applicable biotechnology alternatives that consist of iron ore leaching to reduce the phosphorus content using axenic cultures of *Aspergillus niger* HNA-1 isolated from the iron ore associated microflora (Table 9).\(^\text{177}\)

**Conclusion**

Documentary search based on the AsoVAC memories is an approach to the research lines developed by the Venezuelan investigators on bioprospecting; thus, it underestimates the work in microbial biotechnology carried out by some institutions,\(^\text{18}\) especially in non-photosynthetic microorganisms. In this regard, the consultation of other documentation sources demonstrates this investigative work, for example, Institutional Repository Saber ULA\(^\text{184}\) where it can find information published by researchers of the Laboratory of Microbial Biotechnology (Faculty of Sciences). In general, papers in microbial biotechnology of the AsoVAC Convention between 2002 and 2017 have applications in different areas concentrating most of the studies on the environmental biotechnology, agricultural and food production.

In this sense, the agroecological crop management should be the most immediate potential application through the formulation of biocontrol and biofertilization supplies considering that food production is a priority area for Venezuela and due to the indigenous microbial richness found in the country that can replace imported commercial sources. Within this priority area, the implementation of photosynthetic organism cultures is feasible as live or processed food destined to aquaculture or for human consumption; this practice would directly benefit existing populations along the Venezuelan coasts. In addition, photosynthetic organisms have added value as a source of important bioactive substances and functional foods.

On this aspect, there are few algae-producing countries in Latin American to obtain products for commercial purposes, but Venezuela is not one of them;\(^\text{18}\) however, in this country there is a large volume of information about indigenous photosynthetic microorganisms that offers the opportunity to evaluate more ambitious projects within the bioeconomy, such as the biorefineries in which microalgae and cyanobacteria biomass can integrally be utilized under matter and energy cyclic flows that generates small amounts of waste and gaseous emissions; in fact, it can promote the mitigation of greenhouse gases when attaching the production processes to the CO\(_2\) biofixation. Nevertheless, this work has big economic, technological and legal challenges.\(^\text{186,187}\)

In terms of the legal challenges to the development of certain biotechnology areas, the obtaining of transgenic organisms is one of them. In this context, the article 9 of the law of seeds of Venezuela prohibits “the production, import, marketing, distribution, release, use, multiplication and entry of transgenic seeds”.\(^\text{188}\) Consequently, this regulation sets limits to biotechnology research, particularly in the agricultural field which has led to differing views between the Venezuelan investigators, both in favor and against GMOs.\(^\text{189}\) However, the research of Goglielmo-Croquer et al.,\(^\text{190}\) prior to the adoption of this law in which assessed the genetic improvement of coffee (*Coffea arabica*) through the introduction of the gene cry1ac (endotoxin) of *B. thuringiensis* to confer resistance to the pest *Leuconota coffeella* does not contradict the opinion of some investigators who are in favor of the GMOs development from Venezuelan native materials.\(^\text{191}\)

Finally, biotechnology applications have several implications in environmental decontamination, one of which involves the use of agroindustrial wastes of low or no commercial value for production of protein-rich foods intended for animal consumption. On the other hand, despite numerous investigations on the use of microorganisms on bioremediation of petroleum hydrocarbon polluted environments, more studies are required for its implementation, especially in the biosecure consortia design. However, in aquatic environments such as Maracaibo Lake, it adds the pollution with industrial, hospital and domestic waste water, a source of pathogens to man requiring additional controls as well as the recovery with hydrocarbonoclastic microorganisms.

Climate change together with the general deterioration of the terrestrial and aquatic ecosystems by pollution are altering the microbial community structure-function relationships and destroying beneficial populations to give way to those harmful to humans and other forms of life on Earth.\(^\text{4,3}\) This microbial loss also affects biotechnology opportunities to reduce the richness of this resource which has to develop important biological processes. This scenario reveals the importance of microbial collections which constitute an important resource for the research development giving them as Emerson and Wilson say “a home to the microbial diversity”.

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**Conflicts of interest**

The author declares that there is no conflict of interests regarding the publication of this review article.

**References**

1. Mesquita BR, Nobrega DM, Araujo WL. Microbial interactions: ecology in a molecular perspective. *Brazilian Journal of Microbiology*. 2016;47:86–98.
2. Rouk J, Bengston P. Microbial regulations of global biogeochemical cycles. *Frontiers in Microbiology*. 2014;5:1–3.
3. Panizzon JP, Pilz HL, Knaak N, et al. Microbial diversity: relevance and relationship between environmental conservation and human health. *Brazilian Archives of Biology and Technology*. 2015;58(1):137–145.
4. Pajares S, Souza V. Microorganismos para controlar el cambio climático? *Oikos*. 2013;8:19–21.
5. Martins Z, Cottin H, Kotler JM, et al. Earth as a tool for astrobiology. A European perspective. *Space Sci Rev*. 2017;209:43–81.
6. Piñero-Bonilla J. Importancia biotecnológica de la microbiodiversidad. Los nuevos cazadores de microbios. *Revista Venezolana de Ciencia y Tecnología de Alimentos*. 2013;4(2):284–317.
7. Subbarán A, Espina K, García M, et al. Resistencia a los antimicrobianos de *Pseudomonas* spp. aisladas de muestras de agua del Lago de Maracaibo. *LV Convención Anual de la AsoVAC*. 2005. p. 147.
8. Gabaldón AJ. El cambio climático y sus posibles efectos sobre Venezuela. *Humanidad del Sur*. 2008;(4):13–32.
9. Asociación Venezolana para el Avance de la Ciencia. 2018.
10. Freites L, Lodeiros C, Guevara M, et al. Experiencias en el cultivo de organismos marinos en el Golfo de Cariaco. *Venezuela Saber*. 2012;24(1):5–24.
11. Andrade A, Contreras ML. Biochemical characterization of exochitinases produced by thermophilic bacteria. *LV Annual Convention of the AsoVAC*. 2004. 180 p.
12. Torquati E, Contreras LM. Study and characterization of endo-glucanases produced by *Bacillus steaerotherophilus*. *LV Annual Convention of the AsoVAC*. 2004. 44 p.
Approach to knowledge of the microbial bioprospecting in Venezuela...

13. Tapizquen M, Contreras LM, Wilkesman J. Analysis of lipase activity from thermophiles using zymographic techniques. LXIX Annual Convention of the AsoVAC. 2009.

14. Fernández M, Wilkesman J. Multiple determination of exoenzymes from thermophilic microorganisms by zymogramme. LXIII Annual Convention of the AsoVAC. 2013. p. 31–32.

15. Gómez F, Contreras L, Wilkesman J. Biodegradation of xenobiotic aromatic compounds using thermophiles isolated from the Las Trincheras thermal waters. LVII Annual Convention of the AsoVAC. 2006. 131 p.

16. Belmonte F, Amaíz L, Contreras LM. Compatibility of a thermophilic protease of Bacillus sp. with detergents. LV Annual Convention of the AsoVAC. 2005. 59 p.

17. Quintero D, Velasco Z, Valbuena O, et al. Identification of total xylanase activity in thermophilic bacteria at the Las Trincheras Thermal Center, Carabobo State. LXIV Annual Convention of the AsoVAC. 2006. p. 45–46.

18. Quintero D, Velasco Z, Valbuena O, et al. Purification and characterization of a thermostable β-xylanase produced by the thermophilic bacterium Geobacillus pallidus. LV Annual Convention of the AsoVAC. 2006. 46 p.

19. Zambrano M, Velasco Z. Partial purification of a xylanase from the thermophilic bacterium Geobacillus pallidus. LVIII Annual Convention of the AsoVAC. 2008. 72 p.

20. Graterol H, Contreras LM. Activity, stability and structure relationship in the β-xylanase XynB, of Geobacillus stearothermophilus. LXI Annual Convention of the AsoVAC. 2011. 5 p.

21. Méndez M, Andrades A, Rodríguez G, et al. Characterization and partial purification of amylases from a thermophilic bacterium isolated from the Las Trincheras Thermal Center, Carabobo State. LXV Annual Convention of the AsoVAC. 2006. p. 46.

22. Torquati E, Contreras L. Production of cellulolytic enzymes and degradation of waste by Geobacillus stearothermophilus. LXIII Annual Convention of the AsoVAC. 2013. 31 p.

23. Daza R, Valbuena O, Pereira J, et al. Sulforreductive bacteria in thermal waters of Las Trincheras, Carabobo State. LIX Annual Convention of the AsoVAC. 2003. 188 p.

24. González K, Wilkesman J. Determination and standardization of oxygenase activities present in thermophilic strains. LVII Annual Convention of the AsoVAC. 2007. 395 p.

25. Storaci V, Kurz L, Wilkesman J. Purification and characterization of an alkaline phosphatase type activity produced by thermophilic bacteria. LIV Annual Convention of the AsoVAC. 2004. 3 p.

26. Rondón J, Gómez W, Ball MM, et al. Diversity of cultivable bacteria present in an Andean glacier of the Sierra Nevada, Mérida-Venezuela. LXIV Annual Convention of the AsoVAC. 2014. 432 p.

27. Rengifo M, Ball M, Balcázar W, et al. Isolation, characterization and identification of psychrophilic bacteria producing violacein-like pigments from glacial ice. LXIV Annual Convention of the AsoVAC. 2014. 463 p.

28. Balcázar W, Ball M, Rengifo M, et al. Dissolution of inorganic phosphates mediated by psychrophilic bacteria, isolated from glacial ice in the Venezuelan Andes. LXIV Annual Convention of the AsoVAC. 2014. 462 p.

29. National Observatory of Science, Technology and Innovation. I Venezuelan Congress of Science, Technology and Innovation. 2012.

30. National Observatory of Science, Technology and Innovation. II Venezuelan Congress of Science, Technology and Innovation. 2013.

31. Diamont D. Reactivation and preservation of the fungal strain of the mycology laboratory of the INIA-CENIAP. I Venezuelan Congress of Science, Technology and Innovation. 2012. 39 p.

32. National Institute of Agricultural Research. 2018.

33. Bermúdez J, Lodeiros C, Morales E. Production of biomass of the marine microalga Chroomonas sp., Depending on the pH, luminous intensity and salinity. Bulletin of Marine and Coastal Research. 2002;(31):167–185.

34. Reviakina V, Panizo MM. Catalog of the Venezuelan Center for Microorganism Collections. Journal of the Venezuelan Society of Microbiology. 2013;53:169.

35. Vera A, Morillo K, Montes S, et al. Discontinuous cultivation of Chlorella sp. in a medium based on Acacia macracantha gum. Preliminary phase. LII Annual Convention of the AsoVAC. 2002. 65 p.

36. Moronta R, Mora R, Morales E. Chlorella sorokiniana microalgae response to pH, salinity and temperature in axenic and non axenic conditions. LII Annual Convention of the AsoVAC. 2002. 184 p.

37. Cabrera MI, Fernández J. Growth rate and filtration rate of Brachionus plicatilis fed Chlorella sorokiniana under laboratory conditions. LIII Annual Convention of the AsoVAC. 2003. 70 p.

38. Brito D, Milani N, Pereira G. Growth of freshwater microalgae Chlorella vulgaris, in two Guillard culture media and a commercial nitroforsk fertilizer. LV Annual Convention of the AsoVAC. 2005. 27 p.

39. Brito D, Milani N, Pereira G, et al. Filtration rates and ingestion of Simeonchephalus vetulus (Crustacea: Cladocera) fed with Chlorella vulgaris and Selenastrum capricornutum. LVI Annual Convention of the AsoVAC. 2006. 7 p.

40. Brito D, Brito R, Pereira G. Evaluation of the filtration and ingestion rates of Dendrocephalus spartaenovae (Crustacea: Anostraca: Thamnocephalidae) fed with a monoculture of microalgae. LVII Annual Convention of the AsoVAC. 2007. 17 p.

41. Brito D, Brito R, Pereira G. Survival of Dendrocephalus spartaenovae (Crustacea: Anostraca: Thamnocephalidae) fed with the microalga Chlorella vulgaris. LIX Annual Convention of the AsoVAC. 2009.

42.omba E, Vera P, Rosales-Looiza N, et al. Production of Chlorella sp. And Anabaena sp at different concentrations of nitrogen for food purposes. LXIII Annual Convention of the AsoVAC. 2013. p. 34–35.

43. Loreto C, Morales E. Productivity of the cyanobacterium Anabaena PCC7120 in semicontinuous cultures. LII Annual Convention of the AsoVAC. 2002. 184 p.

44. Vera P, Rosales N, Morales E. Productivity of cyanobacteria Anabaena sp. and Nostoc UAM308 under different concentrations of nitrogen. LXIII Annual Convention of the AsoVAC. 2013. 4 p.

45. Rosales N, Morales E. The semicontinuous cultivation system increases the daily biomass production of the cyanobacterium Synechococcus sp. LVI Annual Convention of the AsoVAC. 2002. 186 p.

46. Vásquez A, Guevara M, Lodeiros C. Growth and biochemical composition of four autochthonous strains of the genus Dunaliella isolated from Venezuelan salinas. LIV Annual Convention of the AsoVAC. 2004. 1 p.

47. Tovar I, Yegres F, Richard-Yegres N. Salina “Las Cumaráguas”: physicochemical analysis and study of microalgae and fungi. Paraguana, Falcón State. LVI Annual Convention of the AsoVAC. 2006. 79 p.

48. Parra J, Torres R, González H, et al. Pilot cultivation of Spirulina platensis in photobioreactor. LV Annual Convention of the AsoVAC. 2005. 25 p.

49. Velásquez A, Rosas J, Cabrera T, et al. Effect of diet, light and temperature on the population growth of the copepod Apeycyclops diastis Kiefer, 1956 (Copepoda, Cyclopoidae). LV Annual Convention of the AsoVAC. 2005. 25 p.

50. Barrera K, Guevara M, Cortez R, et al. Microalgae pasta as alternative food for cladocero Daphnia magna. LXIV Annual Convention of the AsoVAC. 2014. 350 p.
51. Vallejo N, Guevara M, Lodeiros C. Influence of light intensity and culture media on growth and fatty acid profile of native microalgae Chaetoceros sp. and Tetraselmis sp. under semicontinuous culture system. LVI Annual Convention of the AsoVAC. 2006. 8 p.

52. Rosales N, Zambrano H, Andrade C, et al. Use of fish meal and shrimp exoskeleton for the cultivation of the diatom Chaetoceros sp. LIX Annual Convention of the AsoVAC. 2009.

53. Vásquez-Suárez A, Guevara M, González M, et al. Growth and biochemical composition of Skeletonema sp. LAEPI-37 depending on the irradiance and the culture medium. LVII Annual Convention of the AsoVAC. 2007. p. 2–3.

54. Morales E, Andrade C, Vera A, et al. Mixed cultivation of diatoms Navicula sp. And Nitzchia sp. for the production of pigments and lipids. LIX Annual Convention of the AsoVAC. 2009.

55. Pica Y, Ronco A, Díaz MC. Chronic toxicity assay with Selenastrum capricornutum (Pseudokirchneriella subcapitata) algae by the cell enumeration method based on the use of Neubauer hemocytometer. In toxicological tests and water quality evaluation methods. Standardization, intercalibration, results and applications. In: Castle G, editor. IDRC, IMTA, Canada; 2004. p. 80–93.

56. Dubois E, Guevara M, Lodeiros C, et al. Influence of saline stress on population parameters and the production of pigments in a Dunaliella salina strain from Coche saline, Nueva Esparta State, Venezuela. LII Annual Convention of the AsoVAC. 2002. 5 p.

57. Dubois E, Guevara M, Romero L, et al. Cultivation of two strains of Dunaliella salina from the northeastern coast of Venezuela under semicontinuous regime. LIV Annual Convention of the AsoVAC. 2004. 2 p.

58. Romero I, Guevara M, D’Armas H, et al. Standardization of extraction methods, separation and quantification of β-carotene produced by a strain of Dunaliella salina, isolated from Coche, Venezuela. LIII Annual Convention of the AsoVAC. 2003. 40 p.

59. Romero L, Guevara M, Dubois E, et al. Influence of stressful culture conditions on the population parameters and biochemical composition of a Dunaliella salina strain (LAEPI-21) from car saline. Venezuela. LV Annual Convention of the AsoVAC. 2004. 2 p.

60. Guevara M, Lodeiros C, Gómez O, et al. Evaluación de la carotenógenesis de cinco cepas de Dunaliella sp. aisladas de lagunas hipersalinas de las costas venezolanas y cultivadas a dos intensidades luminosas y elevada salinidad. LV Convenio Anual de la AsoVAC. 2004. 2 p.

61. Cáceres L, Jonte L, Ortega J, et al. Nutrient concentration and salinity modulate the biochemical composition of two strains of the microalgae Dunaliella viridis. LVII Annual Convention of the AsoVAC. 2007. 115 p.

62. Rosales N, Jonte L, Bermúdez J, Morales E. Lipid content of the cyanobacterium Synechococcus sp. in response to various cultivation parameters. LII Annual Convention of the AsoVAC. 2003. 177 p.

63. Jonte L, Rosales N, Bricheco B, et al. Growth of Synechocystis miniscus cyanobacteria in response to various culture parameters. LII Annual Convention of the AsoVAC. 2003. p. 177–178.

64. Ortega J, Mora R, Bricheco B, et al. Growth and production of pigments, proteins and exopolysaccharides of the marine cyanobacterium Limnothrix in relation to irradiance and nitrate. LIII Annual Convention of the AsoVAC. 2003. 178 p.

65. Vásquez-Suárez A, Lernus N, Guevara M, et al. Growth and biochemical composition of the cyanobacteria Limnothrix sp. and Phormidium sp. depending on the salinity and concentration of nitrate. LVII Annual Convention of the AsoVAC. 2007. 24 p.

66. Ortega J, Rosales, N, Cáceres L, et al. Discontinuous and fed cultures of the marine cyanobacterium Limnothrix sp. for the production of metabolites of commercial interest as a function of nitrate concentration. In the LVII Annual Convention of the AsoVAC. 2007. 131 p.

67. Bermúdez J, Cheng-Ng R, Villasni T, et al. Influence of the renewal rate and unilateral-bilateral irradiance on the biomass production of the microalga Chlorella sp. in semi-continuous crops. LIII Annual Convention of the AsoVAC. 2003. 190 p.

68. Jonte L, Fuenmayor G, Escribuela A, et al. Influence of irradiance on the growth and biochemical composition of the marine cyanobacterium Oscillatoria sp. LIV Annual Convention of the AsoVAC. 2005. 57 p.

69. Rosales N, Jonte L, Rodríguez S, et al. Effect of the interaction of salinity, nitrate and irradiance on the growth and production of pigments of the cyanobacterium Phormidium sp. LIX Annual Convention of the AsoVAC. 2009.

70. Molina L, Machado M, Mora R, et al. Biochemical composition of the Rhodosorus marinus microalga according to the concentration of nutrients in discontinuous cultures. LVII Annual Convention of the AsoVAC. 2007. 115 p.

71. Moreno C, Rovar M, Urban T, et al. Biochemical composition and biological activity of the cyanobacterium Phormidium sp. cultivated at different intensities of light. LIV Annual Convention of the AsoVAC. 2004. 3 p.

72. Rivas R, Ortega J, Fuenmayor G, et al. Study of the biological activity of hydrosoluble fractions of marine cyanobacteria Limnothrix sp. and Oscillatoria sp. LIV Annual Convention of the AsoVAC. 2005. 57 p.

73. Cheng-Ng R, Pons H, Morales E. Immunomodulatory effects of the cyanobacterium Spirulina subalsa. LV Annual Convention of the AsoVAC. 2005. 109 p.

74. Cheng-Ng R, Rosales N, Pons H, et al. Immunomodulatory and cytotoxic effect of extracts of cyanobacteria. LVII Annual Convention of the AsoVAC. 2007. 307 p.

75. Rosales N, Jonte L, Morales E. Production of phycobiliproteins from discontinuous cultures of two strains of the cyanobacterium Nostoc. LVI Annual Convention of the AsoVAC. 2006. p.140–141.

76. Cortez R, Guevara M, Vásquez A, et al. Influence of oil on the growth of two microalga in northeastern Venezuela. LVII Annual Convention of the AsoVAC. 2007. 22 p.

77. Mago K, Rangel J, Cortez R, et al. Population growth of Venezuelan marine microalgae and its possible use for the production of biodiesel. LXI Annual Convention of the AsoVAC. 2011. 18 p.

78. Vásquez-Patiño E, Guevara M, Lodeiros C, et al. Oil removal capacity by Synechococcus sp. LIX Annual Convention of the AsoVAC. 2007. 227 p.

79. Bricheco B, Castaheda J, Díaz L, et al. Growth of Chlorella sp. And Chlororococcus sp. in the presence of oil. LIX Annual Convention of the AsoVAC. 2009.

80. Bricheco B, Díaz L, Zambrano H, et al. Microalgae and cyanobacteria associated with microbial mats present in petrol sediments. LX Annual Convention of the AsoVAC. 2009.

81. Hernández D, Albargue D, Morales E, et al. Effect of diesel on autochthonous microalga (Chlorella sp.) Isolated from the Puerto de Lanchas on Isla de Toas. LXIII Annual Convention of the AsoVAC. 2013. 79 p.

82. D’Lima W, Portillo J, Parra Y, et al. Biosorption of iron by the cyanobacterium Limnothrix sp. LVIII Annual Convention of the AsoVAC. 2008. 125 p.

83. D’Lima W, Portillo J, Parra Y, et al. Biosorption of nickel by biomass Limnothrix sp. evaluated by atomic absorption spectrophotometry with flame. LIX Annual Convention of the AsoVAC. 2011. p. 23–24.

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DOI: 10.15406/jabb.2019.06.00168
85. Portillo J, D’Lima W, Parra Y, et al. Biosorption of Ni (II) by the cyanobacterium Oscillatoria sp. immobilized in calcium alginate beads. LVIII Annual Convention of the AsoVAC. 2008. 138 p.

86. Rojas A, Elkhouri H, Pena A, et al. Influence of the concentration of biomass and initial concentration of the metal in the biosorption of lead by the dry biomass from Oscillatoria sp. LXII Annual Convention of the AsoVAC. 2011. 24 p.

87. Rojas A, Corner M, Hill Y, et al. Optimization of the contact time and the pH in the biosorption of lead by the dry biomass of Oscillatoria sp. LXII Annual Convention of the AsoVAC. 2011. 24–25.

88. Bracho Y, Marquez E, Elkhouri H, et al. Removal of Cu in the biomass of Pseudanabaena sp., immobilized in calcium alginate. LXII Annual Convention of the AsoVAC. 2012. 433 p.

89. Marquez E, Elkhouri H, Corner M, et al. Optimization of the parameters that influence the biosorption of zinc by the biomass of Pseudanabaena sp. LXII Annual Convention of the AsoVAC. 2012. 431 p.

90. Elkhouri H, Marquez E, Rincon M, et al. Influence of pH, contact time and concentration of biomass in the biosorption of copper by the free biomass of Phormidium sp. LXII Annual Convention of the AsoVAC. 2012. 430 p.

91. Machado M, Mora R, Gonzalez M, et al. Photosynthetic microorganisms associated with a constructed wetland, in the presence of the macrophyte Typha domingensis. LVII Annual Convention of the AsoVAC. 2007. 203 p.

92. Ramirez M, Andrade C, Araujo G, et al. Evaluation of phytoplankton associated with wastewater treatment systems that use aquatic plants. LXII Annual Convention of the AsoVAC. 2012. 229 p.

93. Andrade C, Cárdenas C, Vera A, et al. Use of discontinuous cultures of the microalgae Scenedesmus sp. as a tertiary wastewater treatment. LVII Annual Convention of the AsoVAC. 2007. 210 p.

94. Moronta R, Ortega J, Mora R, et al. Autotrophic, mixotrophic and heterotrophic growth of Chlorella sp. Microalgae, depending on pH and salinity. LI Annual Convention of the AsoVAC. 2002. 184 p.

95. Andrade C, Cárdenas C, Araujo I, et al. Use of microalgae Chlorella sp. for the treatment of urban wastewater. LII Annual Convention of the AsoVAC. 2002. 185 p.

96. Andrade C, Chacon C, Cárdenas C, et al. Removal of nitrogen and phosphorus from urban wastewater by the microalgae Chlorella sp. LII Annual Convention of the AsoVAC. 2003. p. 176–177.

97. Rivas K, Guevara M, Vallejo N, et al. Ability to remove ammonium from synthetic wastewater by a strain of Chlorella sp. isolated from fish culture lagoons. LV Annual Convention of the AsoVAC. 2005. 88 p.

98. Jonte L, Guabea L, Cárdenas C, et al. Urban wastewater from a system of stabilization ponds for the cultivation of cyanobacterium Synechocystis sp. LII Annual Convention of the AsoVAC. 2002. 185 p.

99. Bricelio B, Andrade C, Vera A, et al. Residual fishers as an alternative source of nutrients for the production of the microalgae Scenedesmus sp. LIX Annual Convention of the AsoVAC. 2009.

100. Torquati E, Contreras L. Production of cellulolytic enzymes and degradation of waste by Geobacillus stearothermophilus. LXIII Annual Convention of the AsoVAC. 2013. 31 p.

101. Medina J, Rivera J, Aranaga V, et al. Conversion of urban waste paper to ethanol by integration of physiochemical and biological processes. LXII Annual Convention of the AsoVAC. 2012. 292 p.

102. Loaiza L, Rivas B, De Silva A, et al. Optimization of the acid hydrolysis of mesocarp residues of the creole orange (Citrus Sinensis L. Osbeck) for obtaining biomass of Saccharomyces cerevisiae. LX Annual Convention of the AsoVAC. 2011. 87 p.

103. Rivas B, Loaiza L, Alvaruez S, et al. Obtaining biomass of Saccharomyces cerevisiae using residues of the creole orange mesocarp (Citrus Sinensis (L.) Osbeck). LXI Annual Convention of the AsoVAC. 2011. 84 p.

104. Araque E. Optimization of the organo-solvent pretreatment for the production of bioethanol from lignocellulosic materials. LX Annual Convention of the AsoVAC. 2009.

105. Piñero-Bonilla J, Rivas N. Isolation of a cellulolytic strain of Nocardia sp. LV Annual Convention of the AsoVAC. 2004. 177 p.

106. Piñero-Bonilla J, Diaz I. Submerged fermentation of orange waste using a Nocardia sp. LX Annual Convention of the AsoVAC. 2009.

107. Dominguez G, Bertsch A, Matute S, et al. Selection of Aspergillus niger isolates for the bioconversion of cocoa husk in products of industrial interest. LXI Annual Convention of the AsoVAC. 2011. 16 p.

108. Matute L, Bertsch A, Dominguez G, et al. Cellulolytic activity in microbial cultures in solid and submerged state for obtaining and characterizing enzymatic additives. LXI Annual Convention of the AsoVAC. 2011. 16 p.

109. Alvarado C, Guerra M, Gomez–Ruiz JA. Antihypertensive and antioxidant activity of cow, sheep, and goat whey proteins hydrolysed with Aspergillus oryzae proteases. LXI Annual Convention of the AsoVAC. 2011. 70 p.

110. Rodriguez D, Bertsch A, Diaz I, et al. Cellulase activity of Aspergillus niger in crops with banana waste. LVII Annual Convention of the AsoVAC. 2007. 132 p.

111. Bertsch A, Diaz I, Bernal C, et al. Use of by-products from the meat industry: pig bristles and hairs for the production of metabolites of bacterial origin. LV Annual Convention of the AsoVAC. 2005. 55 p.

112. Bertsch A, Diaz I, Coello N. Kokuria rosea: a shrimp chitin-degrading bacterium. LV Annual Convention of the AsoVAC. 2004. p. 41–42.

113. Bernal C, Bertsch A, Coello N. Proteolytic activity of the Kokuria rosea strain. LV Annual Convention of the AsoVAC. 2004. 42 p.

114. Coello N, Lugo M, Bernal C, et al. Kokuria rosea as a microbial source of carotenoid pigments. LIII Annual Convention of the AsoVAC. 2003. 47 p.

115. Bernal C, Coello N. Purification and characterization of a keratinolytic activity of Kokuria rosea. LIII Annual Convention of the AsoVAC. 2003. 47 p.

116. Citti R, Criado R, Gutierrez J, et al. Antimicrobial activity and genetic characterization of bacteriocinogenic lactic acid bacteria isolated from milk and buffalo cheeses from Venezuela. LVII Annual Convention of the AsoVAC. 2007. 478 p.

117. Citti R, Cintas L, Criado R, et al. Biodiversity of the isolated microflora of Venezuelan buffalo milks and cheeses and identification of structural genes that produce bacteriocinogenic lactic acid bacteria (BAL). LXI Annual Convention of the AsoVAC. 2011. 70 p.

118. Gonzalez L, Reyes G, Medina J, et al. Antimicrobial activity of bacteriocins obtained from Enterococcus faecalis isolated from food. LXIII Annual Convention of the AsoVAC. 2013. p. 77–78.

119. Vargas G, Lucci E, Rodriguez M. Characterization of an antimicrobial compound produced by Enterococcus faecalis isolated from artisan cheese. LV Annual Convention of the AsoVAC. 2015. 136 p.

120. Biomun R, Bdz E, Del Castillo J, et al. Effects of Lactobacillus fermentum on the development of essential arterial hypertension in salt sensitive rats. LXVI Annual Convention of the AsoVAC. 2016. 59 p.
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122. Medina J, González L, Reyes G, et al. Identification of non-Saccharomyces yeasts associated with sugarcane musts by restriction analysis of rDNA. LXIII Annual Convention of the AsoVAC. 2013. 74 p.

123. Medina J, González L, Reyes G, et al. Potentiality of yeasts from the Zulia region as fermentation initiators: tolerance to physicochemical factors. LXIII Annual Convention of the AsoVAC. 2013. p. 75–76.

124. Marcano I, Lucci E, Rodríguez M. Isolation and characterization of acetic acid bacteria present in the fermentation of Cacao variety Caranero. LXVI Annual Convention of the AsoVAC. 2016. 57 p.

125. D’Armas H, Castillo I, Malave N. Chemical analysis of fungal extracts isolated from mangrove roots Rhizophora mangle. LV Annual Convention of the AsoVAC. 2005. 332 p.

126. D’Armas H, Castillo I, Malave N, et al. Bioactivity of extracts of fungi isolated from mangrove roots Rhizophora mangle. LV Annual Convention of the AsoVAC. 2005. 53 p.

127. Moreno S, Taddei A, Rosas-Romero AJ, et al. Preliminary chemical study and antibacterial activity of a strain of Streptomyces sp. from the Edo. Sucre. LVII Annual Convention of the AsoVAC. 2007. 60 p.

128. Mogollón I, Moreno S, Taddei A, et al. Analysis of the organic extracts and the antimicrobial activity of Xylaria spp. LXI Annual Convention of the AsoVAC. 2011. 50 p.

129. Lamarino M, Hernández S, Hurtado D, et al. Obtaining an extract with proteolytic activity from the Lactobacillus casei culture in an unconventional medium. LXII Annual Convention of the AsoVAC. 2012. 210 p.

130. Zambrano I, Maldonado R. Isolation and characterization of laetic fermenters of autochthonous origin for use in the manufacture of matured cheese. LXVI Annual Convention of the AsoVAC. 2016. 21 p.

131. Rodríguez I, Zambrano M. Feasibility of L. reuteri probiotic and existing starter cultures in a fermented dairy drink during its shelf life. LVII Annual Convention of the AsoVAC. 2007. 366 p.

132. Ávila O. Comparison of the conventional method and the PetrofilmTM technique for the counting of lactobacilli in yogurt. In the LV Annual Convention of the AsoVAC. 2005. 149 p.

133. Pérez I, Peñuela A, Rodríguez C, et al. Methodologies for the counting of strains of bifidobacteria present in yoghurt-type dairy products. LV Annual Convention of the AsoVAC. 2007. 393 p.

134. Arrieta D, Pérez ML, Ascaino E, et al. Effect of yeast culture Saccharomyces cerevisiae 1026 and selenium on the hepatotoxicity of aflatoxin B1 in broiler chickens. LV Annual Convention of the AsoVAC. 2005. 206 p.

135. Zoghi N, Ojeda L, Camargo H, et al. Isolation of enzymes for the production of a reagent for measuring glycaemia. LV Annual Convention of the AsoVAC. 2005. p. 58

136. Ojeda L, Noguera N, Pérez L, et al. Potential use of an extract of the enzymes glucose oxidase and catalase of Aspergillus niger as an antioxidant food additive. LIX Annual Convention of the AsoVAC. 2009.

137. Noguera N, Ojeda L, Triana-Alonso FJ. Recovery of glucose oxidase from Aspergillus niger in acid culture broths. LIX Annual Convention of the AsoVAC. 2009.

138. Noguera N, Ojeda L, Zoghi N, et al. Production of glucose oxidase from Aspergillus niger grown in fertilizer-based medium. LXII Annual Convention of the AsoVAC. 2007. 119 p.

139. Velásquez I, Noguera N, Ojeda L, et al. Thermal stability of a crude glucose oxidase extract. Pasteurization conditions. LXII Annual Convention of the AsoVAC. 2012. 378 p.

140. Carmona A, Núñez M, Bullé M. Evaluation of Bacillus thuringiensis strains native to Venezuela against Plutella xylostella. LII Annual Convention of the AsoVAC. 2002. 63 p.

141. Bullé M, Carmona A. Isolation and characterization of native strains of Bacillus thuringiensis with potential for the control of insect pests in agriculture. LII Annual Convention of the AsoVAC. 2002. 63 p.

142. Santana M, Moccia C, Ronai G. Isolation and identification of strains of Bacillus thuringiensis from samples collected in cassava plantations. LIII Annual Convention of the AsoVAC. 2003. 11 p.

143. Moccia C, Santana MA. Standardization of the isolation method of thuringiensis Bacillus strains from sandy soils collected in cassava plantations. LIII Annual Convention of the AsoVAC. 2003. 188 p.

144. Ochoa G, Moccia C, Santana MA. Detection of Cry and Cyt genes and their products in Venezuelan Bacillus thuringiensis strains. LV Annual Convention of the AsoVAC. p. 2004. 40 p.

145. Gillis A, Santana MA. Isolation and characterization of strains of Bacillus thuringiensis from the Guayana region. In the LVII Annual Convention of the AsoVAC. 2006. 132 p.

146. Romero A, Santana, MA. Isolation and characterization of Bacillus thuringiensis with chitinolytic activity from soil samples of the National Park “Henri Pittier”. LXVI Annual Convention of the AsoVAC. 2016. 58 p.

147. Rojas T. Inventory of entomopathogenic fungi in the cacao plantation of Choroni, Aragua State. In the LII Annual Convention of the AsoVAC. 2002. 178 p.

148. Rondón J, Ball M, Yarzabá L. Effect of gluconic acid produced by Pseudomonas fluorescens CHA0 on Colpodia steinii, a natural predator of the rhizosphere. LXII Annual Convention of the AsoVAC. 2012. 286 p.

149. Armadoa A, Quesada E, García P, et al. Study of nitrogen fixation capacity of microorganisms isolated from soil and organic fertilizer from western Venezuela. LVII Annual Convention of the AsoVAC. 2007. 378 p.

150. Arzolay Y, Toro M, Guevara P, et al. Bacteria of the genus Rhizobium associated with nodules of the legume Calopogonion sp., in savanna soils of the Guarico State. LXII Annual Convention of the AsoVAC. 2012. 137 p.

151. Arzolay Y, Toro M, Guevara P. Molecular characterization by TP-RAPD of populations of endosymbiotic Rhizobium bacteria of Calopogonion sp., Native legume of Edo. Guarico in the LXII Annual Convention of the AsoVAC. 2012. 175 p.

152. Moronta-Barrios F. Bacteria promoting plant growth isolated from the rhizosphere and roots of rice plants. In the LXIV Annual Convention of the AsoVAC. 2014. 20 p.

153. Sulbarán-Mora M, Pérez-Pérez E, Ball M, et al. Study of the solubilizing capacity of two bacterial strains isolated from iron deposits in the Guayana region (Venezuela). LVII Annual Convention of the AsoVAC. 2006. 136 p.

154. Jürgensen C, Ball M, Yarzábal A. Isolation and characterization of phenotypic variants of a bacterial strain with solubilizing capacity of mineral phosphates. LVII Annual Convention of the AsoVAC. 2006. 137 p.

155. Pérez-Pérez E, Sulbarán-Mora M, Ball M, et al. Study of solubilizing bacteria of mineral phosphates isolated from limonitic crusts in Bolivar State (Venezuela). LIII Annual Convention of the AsoVAC. 2006. 138 p.

156. Reyes I, Álvarez L, El-Ayoubi H, et al. Selection and evaluation of growth promoting rhizobacteria in paprika and corn. LVII Annual Convention of the AsoVAC. 2007. 117 p.

157. Reyes I, Valery A. Effect of soil fertility on the microbiota and the promotion of maize growth under inoculation. LVII Annual Convention of the AsoVAC. 2007. 116 p.

158. Mimbela I, Carpiñero S. Presence of arbuscular mycorrhizae in native species of tropical dry forest in the town of Chiguana, Sucre State, Venezuela. LVII Annual Convention of the AsoVAC. 2006. 71 p.

Citation: Piñero–Bonilla J. Approach to knowledge of the microbial bioprospecting in Venezuela. J Appl Biotechnol Biog. 2019;6(1):1–14.

DOI: 10.15406/abb.2019.06.00168
159. Tortolero L, Cazorla D, Morales P, et al. Effects of thermal stress on in vitro germination of 13 native isolates of the entomopathogenic fungus Beauveria bassiana. LVII Annual Convention of the AsoVAC. 2007. 403160 p.

160. García ID, Troisi R, Moronta-Barrios F. Isolation of endophytic bacteria with a view to the formulation of rice biofertilizers. LXIV Annual Convention of the AsoVAC. 2014. 91 p.

161. Medina-Ramírez G, Castro D, Molina L, et al. Tolerance to heavy metals of microorganisms capable of detoxifying media supplemented with dichloro diphenyl trichloroethane (DDT). LVI Annual Convention of the AsoVAC. 2006. p. 49–50.

162. Castro D, Duarte R, Rivas R, et al. Evaluation of the growth of parathion-tolerant microorganisms in the presence of heavy metals and antibiotics. LVI Annual Convention of the AsoVAC. 2006. 50 p.

163. García-Petit M, Rosales N, Díaz L, et al. Growth of Pantoea agglomerans K3 in kerosene. LVII Annual Convention of the AsoVAC. 2007. 388 p.

164. García-Petit M, Rosales N, Díaz L, et al. Growth of Sphingobacterium thalophilum K2 isolated from an oil pit in a petroleum derivative. LVII Annual Convention of the AsoVAC. 2007. 389 p.

165. García-Petit M, Rosales N, Díaz L, et al. Growth of Actinobacillus sp. H7 in a hydrocarbon compound. LVII Annual Convention of the AsoVAC. 2007. 390 p.

166. Díaz L, García M, Rosales N, et al. Growth of a mixed culture of bacteria in the presence of kerosene and isolated from an oil pit, Zulia State, Venezuela. LVII Annual Convention of the AsoVAC. 2007. p. 25.

167. Martínez E, Pérez A, Ledesma A. Emulsifying capacity of Pseudomonas sp. isolated from soils impacted by hydrocarbons. LIII Annual Convention of the AsoVAC. 2003; 185 p.

168. Morán E, Ledesma A. Production of biosurfactants by Pseudomonas aeruginosa and selection of a culture system. LV Annual Convention of the AsoVAC. 2005. 146 p.

169. Morán E, Ledesma A. Production of biosurfactants by Bacillus sp. and selection of a culture system. LV Annual Convention of the AsoVAC. 2005. 146 p.

170. Díaz L, Melo P, Dupontt J, et al. Comparison of the growth of Pseudomonas alcaligenes LDA19 in anthracene and naphthalene by plate count and epifluorescence microscopy. LV Annual Convention of the AsoVAC. 2005. 145 p.

171. Espina k, Melo P, Rincon N, et al. Resistance to metal ions and degradation of hydrocarbons by bacteria isolated from oil contaminated environments, Cabimas Municipality, Zulia State. LV Annual Convention of the AsoVAC. 2005. 147 p.

172. Querales L, Caraballo L, Bracho M, et al. Presence of strains of Escherichia coli degrading naphthalene, anthracene and phenanthrene in four beaches of Zulia State. LV Annual Convention of the AsoVAC. 2005. 154 p.

173. García M, Bracho M, Romero M. Resistance to heavy metals by sulfate-reducing bacteria (SRB). LV Annual Convention of the AsoVAC. 2005. 252 p.

174. Jousse S, Rejas A. Isolation, characterization and identification of microorganisms with the capacity to grow in the oil phase of petroleum media. LVII Annual Convention of the AsoVAC. 2007. 133 p.

175. Yegres F, Hill J, Petit K, et al. Biotransformation of aromatic polycyclic hydrocarbons by fungi of the genus Aspergillus. LXII Annual Convention of the AsoVAC. 2012. 224 p.

176. Delvasto P, Balleser A, García-Balboa C, et al. Biomejoramiento de iron ore rejected for its high phosphorus content. LXII Annual Convention of the AsoVAC. 2012. 202 p.

177. Acosta V, Buitrago E, Liceit B, et al. Bioaccumulation of cadmium in the microalgae Tetraselmis muellieri. LV Annual Convention of the AsoVAC. 2004. 69 p.

178. Morales E, Díaz L, Rodríguez S, et al. Effect of cadmium on the growth of Chlorella sp. isolated from an oil pit, Zulia State, Venezuela. LIX Annual Convention of the AsoVAC. 2009.

179. Machado J, Naranjo L, Jumar M, et al. Bioprocessing of aromatic hydrocarbons. LV Annual Convention of the AsoVAC. 2005. 58

180. Bravo C, Labrador H, Wilkesman J. Biodegradation of extra-heavy crude Carabobo and its fractions of saturated, aromatic, resins and asphaltenes (SARA) by thermophilic bacteria. LVII Annual Convention of the AsoVAC. 2007. 384 p.

181. De Sisto A, Ilzins O, Machado JG, et al. Molecular identification of a potential bioremediation activity in soils contaminated with heavy crude. LV Annual Convention of the AsoVAC. 2005. 59 p.

182. Caraballo L, Querales L, Bracho M. Determination of microbial growth on anthracene in microtiter plates. LV Annual Convention of the AsoVAC. 2005.157 p.

183. University of Los Andes. 2018. Repositorio Saber ULA.

184. Martinez L D, Ramirez LG. Current status of companies producing microalgae for food and food supplements in Latin America. Venezuelan Journal of Food Science and Technology. 2017;8(2):130–147.

185. Giraldo-Calderón ND, Romo-Buchelly RJ, Arbeláez-Pérez AA, et al. Microalgae biorefineries: applications and emerging technologies. DYNA. 2018;85(205):219–233.

186. Henry G, Pahun J, Trigo E. The bioeconomy in Latin America: development opportunities and implications of policy and research. FACES. 2014;1(42–44):125–141.

187. Bolivarian Republic of Venezuela. Law of seeds. Official Gazette of the Bolivarian Republic of Venezuela, No. 6207 Extraordinary. 2015.

188. Morán T. Venezuela without transgenic crops. University time. 2016.

189. De Guglielmone-Croquer Z, Hermoso L, Menéndez-Yuffá A. Introduction of the cry1ac gene of B. thuringiensis for resistance to the leafminer in Coffea arabica cv. Catimor through biobalistics. LV Annual Convention of the AsoVAC. 2006. 52 p.

190. Emerson D, Wilson W. Giving microbial diversity a home. Nat Rev Microbial. 2009;7(11):758.

Citation: Piñero–Bonilla J. Approach to knowledge of the microbial bioprospecting in Venezuela. J Appl Biotechnol Bioeng. 2019;6(1):1–14.
DOI: 10.15406/jabb.2019.06.00168