The Genus Lysinibacillus: Versatile Phenotype and Promising Future

Kayath Aimé Christian1,2, Voudhibio Mbozo Alain Brice1, Mokémiabeka Saturnin Nicaise1, Kaya-Ongoto Moïse Doria1, Nguimbi Etienne1

1Laboratoire de Biologie Cellulaire et Moléculaire (BCM), Faculté des Sciences et Techniques, Université Marien NGOUABI, BP. 69, Brazzaville, République du Congo

2Institut national de Recherche en Sciences Exactes et Naturelles (IRSEN), Brazzaville, Congo

Abstract: This critical mini review aims to summarize the current status of the genus Lysinibacillus research, and discusses several challenges in order to open new vision for future development. The wonderful world of bacteria does not even more reach surprises in the scientific community. Every year several bacterial species are discovered from a lot of sources and areas for their phenotypic diversities, therapeutic aspects, industrial and biopharmaceutical interest. Since ten years twenty six Lysinibacillus species were discovered with several exciting characteristics.

Keywords: Lysinibacillus spp., Lysinibacillus louembei, versatile phenotype, promising future, bacteriocins

1. The Genus Lysinibacillus

Initially designated as Bacillus spp, the genus Lysinibacillus are Gram positive, ubiquitous, motile, aerobic or facultative anaerobic belonging to the family Bacillaceae of the phylum Firmicutes. Nomenclature was proposed for the first time by Ahmed et al. (2007). The genus Lysinibacillus is consistently characterized by rod-shaped bacillithat form endospores (Ahmed et al., 2007) with an A4a (L-Lys–D-Asp) cell-wall peptidoglycan type (Zhu et al., 2014; Zhu et al., 2015). Menaquinone MK-7 is the most predominant respiratory lipoquinone system among the genus Lysinibacillus, and major polar lipids found are diphosphatidylglycerol, phosphatidylglycerol and ninhydrin-positive phosphoglycolipid (Zhu et al., 2014).

At the time of drafting this review and together with Lysinibacillus louembei, a novel spore-forming bacterium isolated from NtobaMbodi which is an alkaline fermented leaves of cassava from the Republic of the Congo (Ouoba et al., 2015), the genus Lysinibacillus contains twenty-six species (26). This number includes validate resultsand published namesin LPSN-bacterio-net (http://www.bacterio.net/lysinibacillus.html) and NCBI (http://www.ncbi.nlm.nih.gov/) (Table 1).

Table 1: List of genus Lysinibacillus

<table>
<thead>
<tr>
<th>Species</th>
<th>Reference</th>
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<tbody>
<tr>
<td>L. Manganicus</td>
<td>(Liu et al., 2013)</td>
</tr>
<tr>
<td>L. Tabaci folii</td>
<td>(Duan et al., 2013)</td>
</tr>
<tr>
<td>L. Halotolerans</td>
<td>(Kong et al., 2014)</td>
</tr>
<tr>
<td>L. Composti</td>
<td>(Rifat Hayat et al., 2015)</td>
</tr>
<tr>
<td>L. Pakistanensis</td>
<td>(AHMED et al., 2014)</td>
</tr>
<tr>
<td>L. Varians</td>
<td>(Zhu et al., 2014)</td>
</tr>
<tr>
<td>L. Fluoroglycenilyticus</td>
<td>(Cheng et al., 2015)</td>
</tr>
<tr>
<td>L. Alkaliphilus</td>
<td>(Zhao et al., 2015)</td>
</tr>
<tr>
<td>L. Acetophenoni</td>
<td>(Azmatunissa et al., 2015)</td>
</tr>
<tr>
<td>L. Louembei</td>
<td>(Ouoba et al., 2015)</td>
</tr>
<tr>
<td>L. Cresolivorans</td>
<td>(Ren et al., 2015)</td>
</tr>
<tr>
<td>L. Xyleni</td>
<td>(Begum et al., 2016)</td>
</tr>
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2. The Versatile Phenotype of the Genus Lysinibacillus

Bioremediation Interest

Among the genus Lysinibacillus, L. sphaericus is the most documented. Many of the topics running through this genus are talking about Biopesticide, Bioremediation and antimicrobial peptide. Some bacterial species of the genus Lysinibacillus were recently the subject of whole genome sequencing such as L. sphaericus, strain C3–41 and B1–CDA (Zheng et al., 2008; Rahman et al., 2016), and Lysinibacillus varians strain GY32 (Zhu et al., 2015). L. sphaericus is an attractive biological insecticide. Biotechnology efforts are being made and elaborated to optimize and to maximize its toxicity and manufacturing techniques (Berry, 2012; Allievi et al., 2014). The protein responsible for the biopesticide effect isa binary toxin considered as biolarvicide that has been used worldwide for mosquito surveillance and especially against larvae from the Culex pipiens complex and Anopheles spp. (Regis et al., 2001; Schlein and Muller, 2015). In addition, binary toxins of L. sphaericus IAB872 have been detected for anticancer activity against human lung cancer cell line A549 (Luo et al., 2014). According to World Health Organization (WHO), this is the most common cause of cancer death in men after breast cancer in women.
This genus *Lysinibacillus* has been tested for potential bioremediation use in research including the ability to utilize heavy different metal for their metabolism such as nickel, iron and manganese compounds (Doutorelo et al., 2014; Prithviraj et al., 2014; Barboza et al., 2015) and metalloid including arsenics (Rahman et al., 2014). It was reported that *L. sphaericus* G1 (Bafana et al., 2015) and *L. fusiformis* are able to clean up industrial effluent and areas contaminated with mercury (Gupta et al., 2012). *L. sphaericus* was showed with mercuric reductase activity (Bafana et al., 2015) and flavin-free NADH azoreductase for decreasing toxicity for nitro-aromatic compounds (Misal et al., 2014). These biochemical advantages allow bacteria for metal tolerance (Lozano and Dussan, 2013). *Lysinibacillus* sp. KMK-A and *L. fusiformis* ZC1 can reduce highly chromate (He et al., 2011; Chaudhari et al., 2013). Furthermore it was also demonstrated that *L. sphaericus* DMT-7 isolated from diesel contaminated soil can desulfurize dibenzo thiophene (DBT) (Bahuguna et al., 2011).

*L. fusiformis* produces biosurfactants, *Biosurfactants* were characterized on the basis of their emulsifying properties with petrol, diesel, mobil oil and petrol engine oil (Kumar G, Kumar R, Sharma A., 2015).

The use of microorganisms to biodegrade polymers have been boosted with notable interest because the chemical and physical disposal methods used pollutants and cause many problems the environmental areas. Consortium culture of *Lysinibacillus* and one of the most common species of the genus *Aspergillus* degrade plastics. *L. xylinus* and *Aspergillus* *niger* in soil have been showed biodegradation plastics of low-density polyethylene (LDPE) (Esmaeili et al., 2013). In addition biodegradation of ethanethiol and dichloromethane was observed by using *L. sphaericus* RG-1 and wh22 strains (Wu et al., 2009; Wan et al., 2010).

Nitrilases (EC 3.5.5.1) are prompting significant importance in discovering a novel microorganism capable of hydrolyzing biotechnologically nitriles. *L. boronitolerans* was recently identified for nitrilase activity (Muluka et al., 2016). Nitriles are highly toxic, mutagenic, and carcinogenic due to their cyano group (Chen et al., 2009). *L. boronitolerans* could be the good model to degrade nitrile in order to generate a broad range of useful amides, carboxylic acids, and other groups for several industrial and biotechnological applications, including the synthesis of industrially important carboxylic acids and bioremediation of cyanide and toxic nitriles (Chen et al., 2009; Howden and Preston, 2009).

**Biotechnological Dreams**

*L. sphaericus* CCM 2177 well known as mesophilic microorganism produces SbpA, a surface (S)-layer protein, which after secretion completely covers the cell surface with a crystalline array exhibiting square lattice symmetry. These features on solid supports represents appropriate apparatus for genetically engineering to create a versatile self-assembly system for the development of a functionalized nanoarrays for nanobiotechnological applications (Badelt-Lichtblau et al., 2009).

*Caenorhabditis elegans* is a small worm that represents a model organism in molecular biology; it allows many studies among others apoptosis and cellular aging embryonic development. *L. sphaericus* was showed to extended longevity and robust early-stage development of *Caenorhabditis elegans* (Go et al., 2014).

High technology research with *L. fusiformis* has been demonstrated for the operating performance of a biotrickling filter. In fact filter associated *L. fusiformis* can remove high-loading gaseous chlorobenzene (Li et al., 2014). Wastewaters from a variety of industrial processes have been treated in trickling filters. Using biotrickling filter associated with *L. fusiformis* could represent big challenges for the bioremediation of wastewaters.

**Pathogenicity of Genus Lysinibacillus**

Besides all features discussing up on molecule biosynthesis, bioremediation and biocatalysts, the genus *Lysinibacillus* often regarded as environmental contaminants was isolated in the clinical microbiology laboratory. Its potential to cause human disease has been documented (Castagnola et al., 2001; Wenzler et al., 2015). Although Clinical relevant infections with *Lysinibacillus* sp. are still uncommon, a rare case of severe sepsis due to *L. fusiformis* and *L. sphaericus* was reported. *L. sphaericus* was demonstrated to cause 2% episodes of bacteremia in children with cancer or those undergoing bone marrow transplant (Wenzler et al., 2015).

**Bacteriocins secretion**

The multidrug resistance bacteria pose serious problems for the treatment of bacterial diseases. Antimicrobial peptides such as bacteriocins or bacteriocins-like molecules could be a comfortable solution to remedy the resurgence of antibiotics. Bacteriocins could also be important in food preservation. The genus *Lysinibacillus* produces a broad range of antimicrobial bacteriocins against foodborne bacterial and fungal pathogens, isolated from fruits and vegetable waste (Ahmad et al., 2014; Ahmad and Khan, 2015). The sequencing of complete genome of *L. sphaericus* (strain C3-41) and *L. fusiformis* (strain ZC1) have been showed to contain gene encoding for bacteriocins (B1HTL7LYSSC, B1HTX2LYSSC and B1HS6LYSSC) and (D7WSU89BACI) respectively with activity against *Listeria* (Zheng et al., 2008).

*L. louembe* isolated from a traditional fermented food of Congo Brazzaville was also postulated to produce bacteriocins-like molecules. This novel exciting bacterium with unusual phenotypic, biochemical and genotypic characteristics has been tested for the ability to kill pathogenic bacteria such as *Samonella, staphylococcus* and *shigella*. This means that this bacterium could be also a candidate for probiotic features (personal communication) (Ouoba et al., 2015). Excepting for classical lipids met in genus *Lysinibacillus*, two unknown lipids were identified this means that *L. louembe* may contain new clusters gene encoding new enzymes which could be biochemically involved in the biosynthesis and the selection of lipids.
3. Conclusion and Promising Research

The possibility for achieving novel bacteria with commercially desirable antibacterial activities and other biocatalyst molecules for interest may offer excellent bait for promising future. To contribute to sustainable development the genus Lysinibacillus could play a vital and undeniable role in their ability to biodegrade plastics. In the very close future, scientific research could be addressed toward the sequencing of many Lysinibacillus species such as L. Louembeiigenome. Researches could be oriented to experiment growing conditions according to different culture media. The optimization of growth (pH, temperature), the ability to tolerate and/or degrade hydrocarbons and ability to secrete the biosurfactants and to biosynthesize biocatalysts molecules will be experienced.

4. Acknowledgments

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5. Conflict of interest

There is no conflict of interest.

References


