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Research Article

# Isolation and Characterization of a New *Streptomyces* strain LG10 from an Unexploited Algerian Saharan Atlas

**Saïd Belghit[1,2], Omrane Toumatia[2,3], Mahfoud Bakli[4], Boubekeur Badji[2], Abdelghani Zitouni[2], Florence Mathieu[5], Laura Smuleac[6], Noureddine Bouras[1,2]***

[1]*Département de Biologie, Faculté des Sciences de la Nature et de la Vie et Sciences de la Terre, Université de Ghardaia, Ghardaïa, Algeria*
[2]*Laboratoire de Biologie des Systèmes Microbiens (LBSM), Ecole Normale Supérieure de Kouba, Alger, Algeria*
[3]*Agro Pastoralism Research Center (APRC) Djelfa, Algeria*
[4]*Département des Sciences de la Nature et de la Vie, Faculté des Sciences et Technologie, Université Belhadj Bouchaib d'Ain Temouchent, Ain Temouchent, Algeria*
[5]*Laboratoire de Génie Chimique, Université de Toulouse, CNRS, Toulouse, France*
[6]*Banat's University of Agriculture Science and Veterinary Medicine "King Michael I of Romania", Faculty of Agriculture,119 Calea Aradului, 300645, Timisoara, Romania*

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**Abstract**
An actinobacterial strain named LG10 was isolated from a Saharan Atlas soil (Laghouat, Algeria). The aerial hyphae were yellowish-white on all culture media with *rectiflexibiles* spore chains, suggested that this bacterium attached to *Streptomyces*. Furthermore, LG10 contained chemical characteristics that were diagnostic for the genus *Streptomyces*, such as the presence of LL-diaminopimelic acid isomer (LL-DAP) and glycine amino acid. The hydrolysates of whole-cell included non-characteristic sugars. Comparative analysis of the 16S rDNA sequence displayed a similarity level of 100% with *Streptomyces puniceus* NRRL ISP-5058$^T$. The antimicrobial activity of the LG10 strain was better in the culture medium MB5. *Streptomyces* strains are good sources of bioactive compounds with multiple biological activities.

**Keywords:** isolation, soil, taxonomy, *Streptomyces*, Saharan Atlas.

## Introduction

Actinobacteria are particularly interesting for the production of bioactive substances such as antibiotics. Indeed, it has been estimated that more than 45% of antimicrobial products are secreted by actinobacteria [1]. Majority of these compounds were produced by *Streptomyces* [2]. Previous studies have indicated the richness of actinobacteria in Algerian Sahara [3, 4], and it has been reported that many isolates from these soils were producers of interesting biological activities [5, 6]. In this work, we report the taxonomy of a *Streptomyces* strain labelled LG10 originated from a Saharan Atlas sample.

## Material and Methods

### *Isolation of the actinobacterial strain*

In our study, the aim is to isolate and identify actinobacteria that have antimicrobial bioactivities. Therefore, we have used six soil samples collected from different sites of Algeria. Based on morphological characteristics, 175 isolates of actinobacteria including 123 *Streptomyces* were purified and studied for their antimicrobial activities. After screening of all these strains, 28 of them have showed an interesting antagonistic

* Corresponding author: **Noureddine Bouras, Email:** noureddine_bouras@yahoo.fr
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microbial activity. Among these isolates, the actinobacterium LG10 was isolated using chitin-vitamins agar medium [7], from a sample collected from Laghouat (33°48′N, 2°52′E) in the north edge of the Algerian Sahara (Saharan Atlas). Penicillin (25 µg/mL) and cycloheximide (50 µg/mL) were supplemented to culture medium to avoid bacterial and fungal development, respectively. The Petri dishes were incubated at 28°C for 21 days.

***Taxonomic study***

***Phenotypical, chemical and physiological characterization***

Cultural and morphological characteristics were explored using the method of Shirling and Gottlieb [8], on various ISP (International *Streptomyces* Project) media, nutrient agar and Bennett medium [9].

For the chemical analysis, the isolate was cultivated on ISP-2 broth medium at 28°C for 96 hours. Determination of the diaminopimelic acid isomerism was realized depending to the methods of Becker *et al.* [10], The constitution of whole-cell sugars were identified as mentioned by Lechevalier and Lechevalier [11] and phospholipids were defined corresponding to the method Minnikin *et al*. [12]. Fifty-eight (58) tests were evaluated as reported by Locci [13].

***DNA extraction, PCR amplification and sequence study***

DNA extraction of pure isolate LG10 was done following to the method of Liu *et al.* [14]. The amplification of 16S rDNA was performed as reported by Belghit *et al.* [15]. The PCR product was purified and then sequenced by the Company of MilleGen (Toulouse, France). The 16 rDNA sequence obtained was matched with those available in EzBioCloud database [16]. A phylogenetic tree was constructed using MEGA version 6.0 package [17] as described by Lu *et al.* [18].

***Impact of some culture media on antimicrobial activity***

In order to determine the best culture medium for antimicrobial activities production, ten culture media were examined. Two standard media: ISP2 medium (MA0) composed of malt extract, yeast extract, agar; and Bennett medium (MB0) composed of glucose, casein peptone, meat extract, yeast extract and agar. Eight derived media as following: MA1 (ISP2 without glucose), MA2 (ISP2 without malt extract), MA3 (ISP2 without yeast extract), MB1 (Bennett without meat extract), MB2 (Bennett without yeast extract), MB3 (Bennett without glucose), MB4 (Bennett without casein peptone) and MB5 (Bennett without meat and yeast extracts). The antagonistic activities were highlighted by the double layer technique [19]. Actinobacterium LG10 was seeded inside a circle diameter of 10 mm in the middle of the Petri dish containing one of the agar media mentioned above. After 8 to 14 days of incubation at 28 °C, the cultures (3 replicates for each medium) were flooded with 3 mL of semi-solid ISP2 medium (10 g/L of agar) previously inoculated with the target microorganism (*Candida albicans* IPA200 or *Bacillus subtilis* ATCC 6633). Petri dishes re-incubated at 28 °C and the diameter of the inhibition zones was determined in mm (including the diameter of the seeded isolate) after 1 day for *Bacillus subtilis* and 2 days for *Candida albicans*.

**Results and Discussion**

***Phenotypic traits, chemical and physiological characteristics***

The cultural characteristics are shown in (Table 1). A good growth was exhibited by the strain LG10 on ISP2, ISP3, ISP4, Bennett and less growth on nutrient agar after incubation period of 14 days at 28 °C. The aerial hyphae were yellowish-white on almost all culture media, with straight and flexuous spore chains containing between 10 and 50 spores. Substrate hyphae were not exhibited fragmentation and it was colored with beige or brown to yellowish brown according to the culture media. The cell-wall of LG10 strain was determined of type IC which consisted of no characteristic sugars composition (ribose, glucose and galactose), and possessed LL-DAP isomer and glycine [20]. The phospholipid profile is of type PII containing phosphatidyl ethanol amine [21]. The physiological characteristics of the LG10 strain are cited in (Table 2). It was able to degrade the carbohydrate compounds used except: adonitol, lactose, arabinose, mannose, ribose, erythritol, melibiose, *myo*-inositol, raffinose, sucrose and sorbitol. It was able to use all amino-acids tested as unique sources of nitrogen except for serine; all organic compounds used except for guanine and all sodium salts except for benzoate and succinate. It was able to grow at pH 5 and pH 9, at 45 °C and at 10% of NaCl, but not at 15% of NaCl, at 60 °C and in the presence of phenol (0.001%), crystal violet (0.05%) or sodium azide (0.001%). The strain was insensitive to all antibiotics utilized (except vancomycin, penicillin and kanamycin). It not produced the melanoid pigments on ISP6 and ISP7 media. Due to its phenotypic traits, physiological and chemical features, the strain LG10 exhibited characteristics that are typical

representatives of the genus *Streptomyces.* Currently, this genus composed of 968 species and 55 subspecies [22].

**Table 1.**

**Cultural characteristics of the strain LG10**

| Medium | Growth[a] | Macromorphology | | | Micromorphology |
|---|---|---|---|---|---|
| | | AM | SM | SP | |
| ISP2 | +++ | yellowish white | beige | None | RF Type, 10 to 50 spores per chain |
| ISP3 | +++ | Yellowish white | Brown | Trace brownish | RF Type, 10 to 50 spores per chain |
| ISP4 | +++ | Yellowish white | Yellowish brown | Trace brownish | RF Type, 10 to 50 spores per chain |
| Bennett | +++ | Yellowish white | Yellowish brown | None | RF Type, 10 to 50 spores per chain |
| Nutrient agar | ++ | White | Light yellow | None | RF Type, 10 to 50 spores per chain |

[a] +++: abundant, ++: moderate, AM: Areal Mycelium, SM: Substrate Mycelium, SP: Soluble Pigments, RF: *Rectus Flexibilis*.

**Table 2.**

**Physiological features of the LG10 strain**

| Test | Result | Test | Result |
|---|---|---|---|
| **Degradation of:** | | Histidine | + |
| Starch | + | Phenylalanine | + |
| Esculine | + | Proline | + |
| Gelatine | + | Serine | − |
| Xanthine | + | **Decarboxylation of sodium salts** | |
| Adenine | + | Pyruvate | + |
| Tyrosine | + | Citrate | + |
| Guanine | − | Acetate | + |
| **Utilization of glucides (1% w/v)** | | Tartrate | + |
| Rhamnose | + | Oxalate | − |
| Mannitol | + | Succinate | − |
| Xylose | + | Benzoate | − |
| Trehalose | + | **Growth in the presence of: (µg/mL)** | |
| Galactose | + | Streptomycin (10) | + |
| Fructose | + | Rifampicin (5) | + |
| Glucose | + | Erythromycin (10) | + |
| Cellobiose | + | Chloramphenicol (25) | + |
| Maltose | + | Penicillin (25) | − |
| Arabinose | − | Kanamycin (25) | − |
| Mannose | − | Vancomycin (5) | − |
| Melibiose | − | **Growth with:** | |
| *Myo*-inositol | − | pH 5 | + |
| Raffinose | − | NaCl (10%) | + |
| Adonitol | − | pH 9 | + |
| Ribose | − | 45 °C | + |
| Sucrose | − | NaCl (15%) | − |
| Sorbitol | − | 60 °C | − |
| Erythritol | − | Sodium azide (0.001) | − |
| Lactose | − | Crystal violet (0.05) | − |
| **Utilization of aminoacids** | | Phenol (0.001) | − |
| Alanine | + | **Melanoid pigments production** | − |
| Arginine | + | **Nitrate reduction** | − |

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***Phylogenetic analysis***

The sequence of 16S rRNA gene (1464 nucleotides) of LG10 strain has been assigned in GenBank under the accession number KC414019. Phylogenetic analysis proved that the isolate LG10 belonged to *Streptomyces* genus. Its taxonomic location in the phylogenetic tree is illustrated in (Figure 1). The comparison of the 16S rRNA gene sequence revealed that strain LG10 is closely linked to *Streptomyces puniceus* NRRL ISP-5058$^T$, *Streptomyces puniceus* NBRC 12811$^T$ and *Streptomyces badius* NRRL B-2567$^T$, sharing a similarity value of 100, 99.93 and 99.86%, respectively. However, the strain LG10 could be distinguished from *S. puniceus* NRRL ISP-5058$^T$ [23] by some morphological and physiological features, like the color of substrate hyphae, production of melanoid pigments and the utilization of some carbohydrate compounds. Thus, the substrate mycelium of strain LG10 was beige on ISP2 medium; however, the substrate mycelium of *S. puniceus* is blue or violet to red-violet according to the culture media. The melanoid pigments were not produced by strain LG10, but *S. puniceus* produces violet or blue pigment in yeast-malt (extracts) agar [24]. The isolate LG10 unlike *S. puniceus* degrades arabinose and rhamnose, but not sucrose and manose [24]. These differences suggested that isolate LG10 could be an original species of *Streptomyces* (despite a similarity level of 100% with *S. puniceus*). Moreover, many studies have shown that strains of *Strptomyces* with high 16S rRNA gene not obligatorily affiliated to the same species [25]. For example, similarity rate of 100% was observed among many sequences of validated species of *Streptomyces*, including *S. rochei* with *S. plicatus*, *S. bellus* with *S. werraensis*, and *S. bobili* with *S. californicus,* etc. [26]. Numerous new species of actinobacteria have been reported from Algerian soils such as *Actinopolyspora righensis* [3], *Prauserella isguenensis* [27], *Saccharothrix tamanrassetensis* [28], *Actinokineospora mzabensis* [29], *Nocardiopsis algeriensis* [30], *Saccharopolyspora ghardaiensis* [31] which reclassified by Moshtaghi Nikou *et al.* [32] as *Salinifilum ghardaiensis*, *Streptosporangium saharense* [33], *Mzabimyces algeriensis* [4] which reclassified by Lai *et al.* [34] as *Halopolyspora algeriensis*, and *Bounagaea algeriensis* [35]. However, *Streptomyces massilialgeriensis* is the only species of *Streptomyces* reported from Algeria [36].

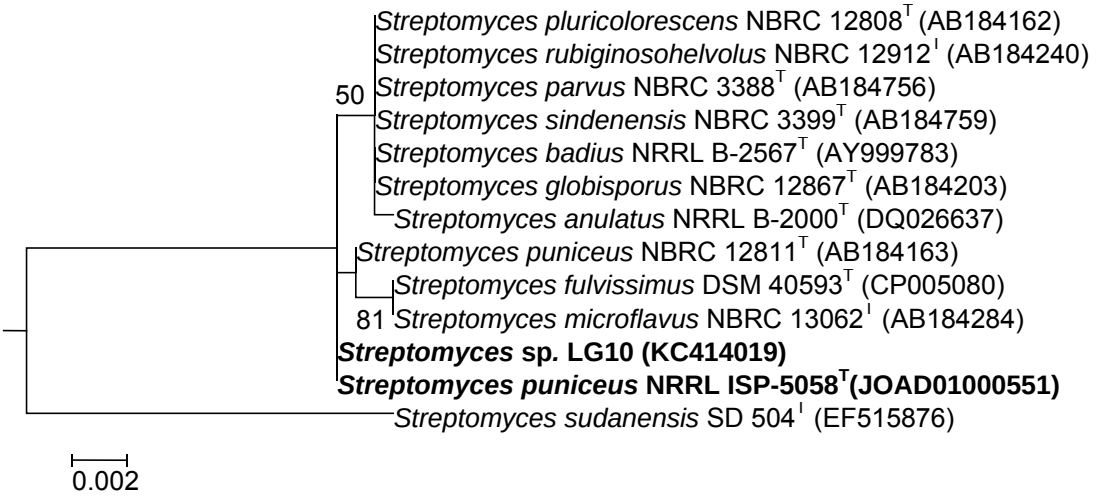



**Figure 1. Phylogenetic tree of the *Streptomyces* sp. LG10 strain**

***Impact of some culture media on antimicrobial activity***

The impact of some culture media on antimicrobial activity of LG10 strain was performed in solid culture media using the double layer technique. The LG10 strain was able to grow and secreted its antibacterial and antifungal activities in all tested media. According to the histogram (Figure 2), the antimicrobial activity of LG10 on derived media from ISP2 medium: MA1, MA2 and MA3 was approximately the same as that obtained with the standard medium MA0 (ISP2). For the biological activity on derived media from Bennett medium, it was clearly that LG10 strain have better antimicrobial activity on the medium MB5 against either *Candida albicans*IPA200 or *Bacillus subtilis* ATCC 6633 (even better than the standard medium Bennett). According to Martín and Demain [37], nutritional sources have an effect on the production of

secondary metabolites. Among these sources, carbon, nitrogen and phosphate strongly affect this production. Furthermore, the lack of these nutritional sources could launch the initiation of antibiotics synthesis by removing the negative effect exerted by these nutrients. Sanchez and Demain [38] reported that the nature and the concentration of some compounds in the culture medium have an eminent influence on the synthesis of biologically active secondary metabolites, among others, in actinobacteria.

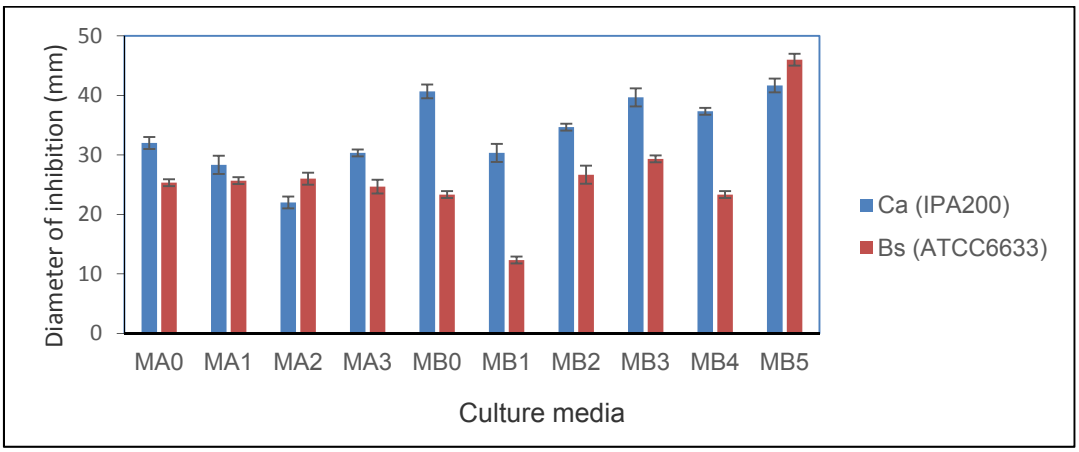



**Figure 2. Bioactivity of the LG10 against the two test strains in the culture media by double layer method**

Ca: *Candida albicans* (IPA 200); Bs: *Bacillus subtilis* (ATCC 6633).
The diameters of inhibition in mm including the diameters of the colonies (10mm) and the data shown are the mean of three independent replicates.

Many new, or already reported, antibiotics have been characterized from new strains of *Streptomyces* isolated from Algeria such as saquayamycines A and C [39], vineomycin A1 and chaetoglobosin A [40], mzabimycins A and B which produced by *Streptomyces* sp. PAL114 [6], oligomycins A and E produced by *Streptomyces* sp. HG29 [5], di-(2-ethylhexyl) phthalate from *Streptomyces* sp. G60 [41], 2,4-di-tert-butylphenol by *Streptomyces* sp. G61 [15], compound AT37-1 produced from *Streptomyces* sp. AT37 [42], actinomycin D by *Streptomyces* sp. IA1 [43] and also by *Streptomyces* sp. GSBNT10 [44], hydroxamic acid-containing antibiotic from *Streptomyces* sp. WAB9 [45], streptazolin produced by *Streptomyces* sp. SRC3 [46], abierixin, nigericin, epinigericin and grisorixin methyl ester secreted by *Streptomyces* sp. SF10 [47], and spectinabilin, undecylprodigiosin and metacycloprodigiosin produced by *Streptomyces* sp.$V_{002}$ [48].

## Conclusions

The strain LG10 was isolated from an Algerian Saharan Atlas soil. The taxonomy study based on morphological, physiological, chemical and 16S rDNA sequencing revealed that this strain belongs to the *Streptomyces* genus and was found that it can be an original species of this genus. Among ten solid culture media, the antimicrobial activities were produced better on the MB5 medium derived from Bennett. Faced with the problem of antimicrobial resistance and a limited number of commercialized antibiotics, actinobacteria could represent a substitution source of bioactive molecules.

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