Complete Genome Sequence of the Methanogen Methanoculleus bourgensis BA1 Isolated from a Biogas Reactor

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Methanoculleus bourgensis BA1, a hydrogenotrophic methanogen, was isolated from a laboratory-scale biogas reactor operating under an elevated ammonium concentration. Here, the complete genome sequence of M. bourgensis BA1 is reported. The availability of the BA1 genome sequence enables detailed comparative analyses involving other Methanoculleus spp. representing important members of microbial biogas communities.

Frequently, members of the genus Methanoculleus were described as playing an important role in different biogas reactor systems (1, 2). In particular, the species Methanoculleus bourgensis was found to be dominant in several biogas systems. Moreover, different studies described the prevalence of M. bourgensis in reactors performing syntrophic acetate oxidation (SAO) under high ammonium concentrations (3–5), indicating the importance of this methanogen in corresponding communities. Isolation and/or cocultivation of M. bourgensis, together with acetate-oxidizing bacteria (4, 6) such as Clostridium ultunense (7), led to the assumption that syntrophic association may play an important role for members of the genus Methanoculleus. Bioaugmentation involving Methanoculleus spp. in coculture with SAO bacteria was discussed as a feasible approach to shorten the adaptation period of digesters operating under high ammonium/ammonia concentrations (3, 8).

The objective of this work was to sequence the methanogen M. bourgensis BA1 (9) originating from a Swedish lab-scale continuous stirred tank reactor (37°C) operating under an elevated ammonium concentration (6.4 g l⁻¹ NH₄⁺ N) and utilizing alfalfa silage for methane production. Furthermore, the availability of the M. bourgensis BA1 genome sequence and insights into its predicted metabolic capabilities provide reference points for comparative analyses comprising other methanogenic species of Archaea from biogas communities.

Strain BA1 was isolated as described previously (9, 10). The 16S rRNA gene sequence analysis classified the isolate as a member of the species M. bourgensis with 99% sequence identity to the 16S rRNA gene of strain MS2T (11). Genomic DNA of strain BA1 was isolated using the Qiagen blood and tissue kit and sequenced applying the paired-end protocol on an Illumina MiSeq system. The 2,155,212 reads obtained, accounting for 565,780,211 bp of sequence information, were de novo assembled using the GS de novo assembler version 2.8 software. The assembly resulted in 14 scaffolds comprising 48 contigs. An in silico gap closure approach (12) was applied to close all gaps between contigs and circularize the genome. The complete BA1 chromosome has a size of 2,551,189 bp, featuring a GC content of 60.89%. Annotation of the genome sequence was performed within the annotation system GenDB version 2.0 (13) and resulted in the detection of 2,528 protein-coding sequences, 45 tRNA genes, and one rrr operon.

Interpretation of the M. bourgensis BA1 genome sequence revealed that all genes required for hydrogenotrophic methanogenesis were identified. Moreover, genes encoding a formate transporter (fdhC) and a formate dehydrogenase operon (fdhA-B) for growth on formate as an alternative methanogenic substrate were found. Since strain BA1 was isolated from a habitat rich in ammonium/ammonia, genes involved in nitrogen metabolism were analyzed. Similar to the type strain M. bourgensis MS2T (11, 14), the BA1 genome encodes neither a methylammonium permease nor the putative archaeal ammonium uptake system Amt predicted to transport NH₄⁺. The missing ammonium transporter may indicate an adaptation of the strain to environments rich in ammonium/ammonia. Furthermore, strain BA1 harbors genes encoding different potassium transporters and a glycine betaine/proline transport system that may contribute to cumulative solute accumulation as response to high osmolality.

Nucleotide sequence accession number. This whole-genome shotgun project has been deposited in the EMBL/GenBank database (EBI, NCBI) under the accession number LT549891 (Study ID: PRJEB13327).

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