

Draft Genome Sequence of the Xanthan Producer *Xanthomonas campestris* LMG 8031

Jochen Schmid,^a Christopher Huptas,^b Mareike Wenning^b

Chair of Chemistry of Biogenic Resources, Technical University of Munich, Straubing, Germany^a; Chair for Microbial Ecology, Technical University of Munich, Freising, Germany^b

Here, we report the draft genome sequence of *Xanthomonas campestris* LMG 8031, for which nearly no genetic information is available, despite its good xanthan-producing properties. We performed an Illumina-based sequencing approach of LMG 8031. The genome revealed a 5.0-Mb chromosome having 4,434 coding sequences and a G+C content of 65%.

Received 8 August 2016 Accepted 20 August 2016 Published 27 October 2016

Citation Schmid J, Huptas C, Wenning M. 2016. Draft genome sequence of the xanthan producer *Xanthomonas campestris* LMG 8031. *Genome Announc* 4(5):e01069-16. doi:10.1128/genomeA.01069-16.

Copyright © 2016 Schmid et al. This is an open-access article distributed under the terms of the [Creative Commons Attribution 4.0 International license](https://creativecommons.org/licenses/by/4.0/).

Address correspondence to Jochen Schmid, j.schmid@tum.de.

The plant pathogenicity of xanthomonads is mainly based on exopolysaccharide production, which supports adhesion to enable plant penetration, as well as preservation against environmental stress factors such as desiccation or plant protection compounds (1–5). Next to its natural function, xanthan as a highly viscous exopolysaccharide obtained industrial relevance due to its excellent rheological behavior (6, 7). By now, several strains of *Xanthomonas campestris* have been sequenced with a focus on plant pathogenicity: *X. campestris* ATCC 33913 (8), *X. campestris* 8004 (9), *X. campestris* Xca5 (10), *X. campestris* CN14, CN15, and CN16 (11), *X. campestris* 17 (12), as well as *X. campestris* CFBP 1869 and CFBP 5817 (13). Genome sequencing approaches were also performed with a focus on xanthan production: *X. campestris* B100 (14), *X. campestris* JX (15), and *X. campestris* ATCC 13951 (16). To further enhance insights into xanthan biosynthesis of *Xanthomonas* strains with a high production capacity for xanthan, we hereby present the genome of the xanthan-producing strain LMG 8031.

For the determination of the genome sequence of *X. campestris* LMG 8031 we extracted genomic DNA by use of the DNeasy blood and tissue kit (Qiagen, USA) on a culture grown overnight, according to the manufacturer's protocol (17). Preparation of a library having an average insert size of approximately 750 nucleotides (nt) (IS1) was done as described elsewhere (18). Sequencing was performed on the Illumina MiSeq platform with v3 chemistry. Sequencing data were trimmed and quality-controlled using the NGS QC Toolkit version 2.2.3 (19). High-quality read pairs (2 × 175 nt) were visually inspected using FastQC version 0.11.4 (20) prior to assembly with SPAdes version 2.5.1 (21) applying the *k*-mer combination <21, 33, 55, 77, 99, 127>. The resulting draft genome assembly comprised 50 contigs with an *N*₅₀ of 352,468 nt and an assembly size of 5,017,935 nt. Genomic G+C content was 65.09%. With 586,326 high-quality read pairs used for genome assembly, the theoretical sequencing depth is close to 41-fold. Genome annotation was carried out on the RAST server (22, 23), which detected 4,434 coding sequences in 465 subsystems and 55

RNA genes. Additionally, an amount of 20 GGDEF domain-containing proteins were identified manually.

These data will enhance the genomic information of xanthan biosynthesis and facilitate more detailed and comparative analyses of xanthan production and genomic sequences. The xanthan cluster shows an identity of 98% to the biosynthesis operon of strain ATCC 33193 and 99% for *X. campestris* B100, as well as *X. campestris* JX on the nucleotide level.

Accession number(s). This whole-genome shotgun project has been deposited at DDBJ/ENA/GenBank under the accession number [MBDP00000000](https://www.ncbi.nlm.nih.gov/nuclink/MBDP00000000). The version described in this paper is the first version, MBDP01000000. Strain LMG 8031 is available from the BCCM/LMG Bacteria Collection (Ghent, Belgium) and from the CIRM–Collection Plant Associated Bacteria/CIRM-CFBP under the accession numbers LMG 8031 and CFBP 1121, respectively.

FUNDING INFORMATION

The project benefited from the financial support of a Max Buchner Scholarship (DECHEMA) awarded to Jochen Schmid.

REFERENCES

- De Pinto MC, Lavermicocca P, Evidente A, Corsaro MM, Lazzaroni S, De Gara L. 2003. Exopolysaccharides produced by plant pathogenic bacteria affect ascorbate metabolism in *Nicotiana tabacum*. *Plant Cell Physiol* 44:803–810. <http://dx.doi.org/10.1093/pcp/pcg105>.
- Kakkar A, Nizampatnam NR, Kondreddy A, Pradhan BB, Chatterjee S. 2015. *Xanthomonas campestris* cell–cell signalling molecule DSF (diffusible signal factor) elicits innate immunity in plants and is suppressed by the exopolysaccharide xanthan. *J Exp Bot* 66:6697–6714. <http://dx.doi.org/10.1093/jxb/erv377>.
- Leigh JA, Coplin DL. 1992. Exopolysaccharides in plant–bacterial interactions. *Annu Rev Microbiol* 46:307–346. <http://dx.doi.org/10.1146/annurev.mi.46.100192.001515>.
- Soto MJ, Domínguez-Ferreras A, Pérez-Mendoza D, Sanjuán J, Olivares J. 2009. Mutualism versus pathogenesis: the give-and-take in plant–bacteria interactions. *Cell Microbiol* 11:381–388. <http://dx.doi.org/10.1111/j.1462-5822.2008.01282.x>.
- Yun MH, Torres PS, Oirdi M, Rigano LA, Gonzalez-Lamothe R, Marano MR, Castagnaro AP, Dankert MA, Bouarab K, Vojnov AA.

2006. Xanthan induces plant susceptibility by suppressing callose deposition. *Plant Physiol* 141:178–187. <http://dx.doi.org/10.1104/pp.105.074542>.
6. Hublik G. 2012. Xanthan, p 221–229. In *Polymer science: a comprehensive reference*. Elsevier, Amsterdam, The Netherlands.
 7. Jeanes A, Pittsley JE, Senti FR. 1961. Polysaccharide B-1459: A new hydrocolloid polyelectrolyte produced from glucose by bacterial fermentation. *J Appl Polym Sci* 5:519–526. <http://dx.doi.org/10.1002/app.1961.070051704>.
 8. Da Silva AC, Ferro JA, Reinach FC, Farah CS, Furlan LR, Quaggio RB, Monteiro-Vitorello CB, Van Sluys MA, Almeida NF, Alves LM, do Amaral AM, Bertolini MC, Camargo LE, Camarotte G, Cannavan F, Cardozo J, Chambergo F, Ciapina LP, Cicarelli RM, Coutinho LL, Cursino-Santos JR, El-Dorry H, Faria JB, Ferreira AJS, Ferreira RCC, Ferro MIT, Formighieri EF, Franco MC, Greggio CC, Gruber A, Katsuyama AM, Kishi LT, Leite RP, Lemos EGM, Lemos MVF, Locali EC, Machado MA, Madeira AMBN, Martinez-Rossi NM, Martins EC, Meidanis J, Menck CFM, Miyaki CY, Moon DH, Moreira LM, Novo MTM, Okura VK, Oliveira MC, Oliveira VR, Pereira HA, Rossi A, Sena JAD, Silva C, de Souza RF, Spinola LAF, Takita MA, Tamura RE, Teixeira EC, Tezza RID, Trindade dos Santos M, Truffi D, Tsai SM, White FF, Setubal JC, Kitajima JP. 2002. Comparison of the genomes of two *Xanthomonas* pathogens with differing host specificities. *Nature* 417: 459–463. <http://dx.doi.org/10.1038/417459a>.
 9. Qian W, Jia Y, Ren S.-X, He Y.-Q, Feng J.-X, Lu L.-F, Sun Q, Ying G, Tang D.-J, Tang H, Wu W, Hao P, Wang L, Jiang B.-L, Zeng S, Gu W.-Y, Lu G, Rong L, Tian Y, Yao Z, Fu G, Chen B, Fang R, Qiang B, Chen Z, Zhao G.-P, Tang J.-L, He C. 2005. Comparative and functional genomic analyses of the pathogenicity of phytopathogen *Xanthomonas campestris* pv. *campestris*. *Genome Res* 15:757–767. <http://dx.doi.org/10.1101/gr.3378705>.
 10. Bolot S, Guy E, Carrere S, Barbe V, Arlat M, Noël LD. 2013. Genome sequence of *Xanthomonas campestris* pv. *campestris* strain Xca5. *Genome Announc* 1(1):e00032–12. <http://dx.doi.org/10.1128/genomeA.00032-12>.
 11. Bolot S, Roux B, Carrere S, Jiang B.-L, Tang J.-L, Arlat M, Noël LD. 2013. Genome sequences of three atypical *Xanthomonas campestris* pv. *campestris* strains, CN14, CN15, and CN16. *Genome Announc* 1(4): e00465–13. <http://dx.doi.org/10.1128/genomeA.00465-13>.
 12. Liu Y.-C, Wang S.-C, Yu Y.-J, Fung K.-M, Yang M.-T, Tseng Y.-H, Tsai S.-F, Sun HS, Lyu P.-C, Chou S.-H. 2015. Complete genome sequence of *Xanthomonas campestris* pv. *campestris* strain 17 from Taiwan. *Genome Announc* 3(6):e01466–15. <http://dx.doi.org/10.1128/genomeA.01466-15>.
 13. Bolot S, Cerutti A, Carrère S, Arlat M, Fischer-Le Saux M, Portier P, Poussier S, Jacques M.-A, Noël LD. 2015. Genome sequences of the race 1 and race 4 *Xanthomonas campestris* pv. *campestris* strains CFBP 1869 and CFBP 5817. *Genome Announc* 3(5):e01023–15. <http://dx.doi.org/10.1128/genomeA.01023-15>.
 14. Vorhölter FJ, Schneiker S, Goesmann A, Krause L, Bekel T, Kaiser O, Linke B, Patschkowski T, Rückert C, Schmid J, Sidhu VK, Sieber V, Tauch A, Watt SA, Weisshaar B, Becker A, Niehaus K, Pühler A. 2008. The genome of *Xanthomonas campestris* pv. *campestris* B100 and its use for the reconstruction of metabolic pathways involved in xanthan biosynthesis. *J Biotechnol* 134:33–45. <http://dx.doi.org/10.1016/j.jbiotec.2007.12.013>.
 15. Tao F, Wang X, Ma C, Yang C, Tang H, Gai Z, Xu P. 2012. Genome sequence of *Xanthomonas campestris* JX, an industrially productive strain for xanthan gum. *J Bacteriol* 194:4755–4756. <http://dx.doi.org/10.1128/JB.00965-12>.
 16. Wibberg D, Alkhateeb RS, Winkler A, Albersmeier A, Schatschneider S, Albaum S, Niehaus K, Hublik G, Pühler A, Vorhölter F.-J. 2015. Draft genome of the xanthan producer *Xanthomonas campestris* NRRL B-1459 (ATCC 13951). *J Biotechnol* 204:45–46. <http://dx.doi.org/10.1016/j.jbiotec.2015.03.026>.
 17. Qiagen. 2006. DNeasy blood & tissue handbook. <https://www.qiagen.com/de/resources/resourcedetail?id=6b09dfb8-6319-464d-996c-79e8c7045a50&lang=en>.
 18. Huptas C, Scherer S, Wenning M. 2016. Optimized Illumina PCR-free library preparation for bacterial whole genome sequencing and analysis of factors influencing *de novo* assembly. *BMC Res Notes* 9:269. <http://dx.doi.org/10.1186/s13104-016-2072-9>.
 19. Patel RK, Jain M. 2012. NGS QC toolkit: a toolkit for quality control of next generation sequencing data. *PLoS One* 7:e30619. <http://dx.doi.org/10.1371/journal.pone.0030619>.
 20. Andrews S, Fast QC. 2014. A quality control tool for high throughput sequence data. <http://www.bioinformatics.babraham.ac.uk/projects/fastqc>.
 21. Bankevich A, Nurk S, Antipov D, Gurevich AA, Dvorkin M, Kulikov AS, Lesin VM, Nikolenko SI, Pham S, Pribelski AD, Pyshkin AV, Sirotkin AV, Vyahhi N, Tesler G, Alekseyev MA, Pevzner PA. 2012. SPAdes: a new genome assembly algorithm and its applications to single-cell sequencing. *J Comput Biol* 19:455–477. <http://dx.doi.org/10.1089/cmb.2012.0021>.
 22. Aziz RK, Bartels D, Best AA, DeJongh M, Disz T, Edwards RA, Formsma K, Gerdes S, Glass EM, Kubal M, Meyer F, Olsen GJ, Olson R, Osterman AL, Overbeek RA, McNeil LK, Paarmann D, Paczian T, Parrello B, Pusch GD, Reich C, Stevens R, Vassieva O, Vonstein V, Wilke A, Zagnitko O. 2008. The RAST server: rapid annotations using subsystems technology. *BMC Genomics* 9:75. <http://dx.doi.org/10.1186/1471-2164-9-75>.
 23. Overbeek R, Olson R, Pusch GD, Olsen GJ, Davis JJ, Disz T, Edwards RA, Gerdes S, Parrello B, Shukla M, Vonstein V, Wattam AR, Xia F, Stevens R. 2014. The SEED and the rapid annotation of microbial genomes using subsystems technology (RAST). *Nucleic Acids Res* 42: D206–D214. <http://dx.doi.org/10.1093/nar/gkt1226>.