Data Article

Dataset describing ethanol and 1,2-propanediol production by a stenothermal moderately thermophilic anaerobe, Clostridium strain AK1

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Abstract

The dataset details the fermentation of D-glucose, L-rhamnose, and L-fucose and their end-product formation by the moderate thermophile Clostridium strain AK1 (DSM 18778) as related to the work described in "Propanediol from L-rhamnose using the moderately thermophilic Clostridium strain AK1" [1]. The influence of culture conditions on end product formation from D-glucose and L-rhamnose by AK1 was investigated in batch culture. Strain AK1 was cultivated at initial substrate concentrations varying from 0 to 60 mM and initial pH values varying from 4.5 to 8.5. Additionally different cultivation temperatures (30–65 °C), the influence of liquid-gas phase ratio as well as different phosphate concentrations on growth were investigated.

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Specifications Table

| Subject area                        | Biology          |
|------------------------------------|------------------|
| More specific subject area         | Microbiology     |
| Type of data                        | Table            |
| How data was acquired               | GC-FID, Perkin Elmer Clarus 580 |

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GC-TCD, Perkin Elmer Autosystem XL
UV-Visible Spectroscopy, Bioscreen C (GrowthCurves Ltd, Finland) and
Shimadzu UV-1800 UV-Visible Spectrometer

Data format Raw
Experimental factors Substrate, growth temperature, initial substrate concentration, initial
pH, liquid-gas phase ratio, initial phosphate concentration
Experimental features Data shows fermentation products from D-glucose, L-rhamnose, and
L-fucose under different culture parameters. Major end products
being ethanol (from glucose) and 1,2-PD from L-rhamnose. L-fucose
was not fermented.
Data source location University of Akureyri, Akureyri, Iceland
Data accessibility Data is included in this article
Related research article Ingvadottir et al. [1]

Value of the data

• The data presents ethanol and 1,2-propanediol fermentation from a stenothermal moderately
thermophilic anaerobe isolated from a geothermal feature in Iceland.
• This data set could be of value for comparing fermentation yields and the impact of key culture
parameters on ethanol and 1,2-propanediol producing microorganisms.
• Could be used as a reference organism for studying an overlooked environmental niche (moderate
temperature hot springs).

1. Data

Clostridium strain AK1 ferments D-glucose and L-rhamnose with ethanol and 1,2-propanediol
(1,2-PD) being the major end-products, respectively (Table 1). Table 2 shows the influence of tem-
perature on the fermentation of D-glucose and L-rhamnose while the effect of pH from pH 4.8 to 7.8 is
shown in Table 3. The impact of liquid-gas phase ratio in culture bottles on D-glucose and L-rhamnose
fermentation is summarized in Table 4. D-Glucose and L-rhamnose degradation on various initial
phosphate concentrations resulted in the same end-product formation as before as summarized in
Table 5.

2. Experimental design, materials and methods

2.1. General methods

Yeast extract was obtained from Difco. L-Fucose was obtained from Dextra (Reading, UK). All other
reagents were obtained from Sigma-Aldrich. Nitrogen gas was acquired from AGA and contained less
than 5 ppm O2.

2.2. Microorganism and cultivation

Clostridium strain AK1 (DSM 18778) was isolated from the laboratory of the authors as described in
[2] and reobtained from Deutsche Sammlung von Mikroorganismen und Zellkulturen (DSMZ). Strain
AK1 was cultivated in serum bottles using the in Basal Mineral (BM) medium prepared as previously
described [3]; BM consisted of (per liter): NaH2PO4 · 2H2O 3.04 g, Na2HPO4 · 2H2O 5.43 g, NH4Cl 0.3 g,
NaCl 0.3 g, CaCl2 · 2H2O 0.11 g, MgCl2 · 6H2O 0.1 g, yeast extract 2.0 g, resazurin 1 mg, trace element
solution 1 mL, vitamin solution (DSM141) 1 mL, and NaHCO3 0.8 g. The trace element solution con-
sisted of the following on a per liter basis: FeCl2 · 4 H2O 2.0 g, EDTA 0.5 g, CuCl2 0.03 g, H3BO3, ZnCl2,
Table 1
Effect of initial substrate concentration (10 to 60 mM) D-glucose, L-fucose, and L-rhamnose by *Clostridium* strain AK1 (DSM 18778). Values represent the average ± standard deviation of triplicates.

| Substrate (mM) | Sugar consumed (%) | Analyte (mmol L⁻¹) |   |   |   |   | Ethanol Yield (%) | 1,2-PD Yield (%) | Carbon balance (%) |
|---------------|--------------------|---------------------|---|---|---|---|-------------------|------------------|-------------------|
|               |                    | Ethanol             | Acetate | Butyrate | 1,2-PD | Lactate | H₂ | OD₆₀₀ nm | pH | Ethanol | 1,2-PD | Carbon balance |
| Control (0)   | ND                 | 2.95 ± 0.10         | 1.82 ± 0.10 | < 0.20 | < 0.20 | 0.20 ± 0.10 | 1.80 ± 0.10 | 0.09 ± 0.01 | 6.9 ± 0.1 | ND | ND | ND |
| D-Glucose (10)| 88.9 ± 1.1         | 11.00 ± 0.40        | 6.10 ± 0.64 | 0.28 ± 0.07 | < 0.20 | 0.45 ± 0.20 | 8.29 ± 0.23 | 0.26 ± 0.01 | 6.8 ± 0.1 | 55.0 | 0.0 | 104.6 |
| (20)          | 94.9 ± 2.4         | 23.71 ± 3.23        | 11.20 ± 1.93 | < 0.20 | < 0.20 | 1.48 ± 0.36 | 10.49 ± 3.57 | 0.33 ± 0.02 | 6.6 ± 0.2 | 59.2 | 0.0 | 97.5 |
| (40)          | 89.6 ± 3.3         | 38.66 ± 1.19        | 10.48 ± 0.29 | < 0.20 | < 0.20 | 2.72 ± 1.44 | 20.45 ± 0.70 | 0.35 ± 0.01 | 5.8 ± 0.1 | 48.3 | 0.0 | 73.9 |
| (60)          | 47.0 ± 3.4         | 36.69 ± 0.81        | 9.71 ± 0.28 | < 0.20 | < 0.20 | 6.27 ± 1.04 | 20.30 ± 1.13 | 0.37 ± 0.02 | 5.8 ± 0.1 | 30.6 | 0.0 | 96.6 |
| L-Fucose (10) | 0.0 ± 0.0          | 2.11 ± 0.22         | 1.34 ± 0.26 | < 0.20 | < 0.20 | 0.20 ± 0.30 | 0.93 ± 0.37 | 0.08 ± 0.02 | 6.9 ± 0.1 | ND | 0.0 | ND |
| (20)          | 0.0 ± 0.0          | 1.04 ± 0.17         | 0.53 ± 0.34 | < 0.20 | < 0.20 | 0.20 ± 0.30 | 0.64 ± 0.24 | 0.07 ± 0.01 | 6.9 ± 0.1 | ND | 0.0 | ND |
| (40)          | ND                 | ND                  | ND | ND | ND | ND | ND | ND | 0.0 | ND | ND |
| (60)          | ND                 | ND                  | ND | ND | ND | ND | ND | ND | ND | 0.0 | ND | ND |
| L-Rhamnose (10)| 80.1 ± 2.2         | 2.20 ± 0.03         | 3.50 ± 0.32 | < 0.20 | < 0.20 | 6.60 ± 0.75 | 1.21 ± 0.23 | 0.17 ± 0.01 | 7.1 ± 0.2 | 22.0 | 66.0 | 79.0 |
| (20)          | 74.9 ± 0.8         | 2.03 ± 0.07         | 6.59 ± 0.04 | 0.83 ± 0.12 | 12.20 ± 0.37 | < 0.20 | 2.40 ± 0.15 | 0.19 ± 0.02 | 6.9 ± 0.1 | 10.2 | 61.0 | 82.8 |
| (40)          | 59.9 ± 1.2         | 1.90 ± 0.15         | 17.68 ± 0.35 | 1.05 ± 0.21 | 22.13 ± 3.21 | < 0.20 | 4.71 ± 0.42 | 0.30 ± 0.01 | 6.2 ± 0.1 | 4.8 | 55.3 | 95.4 |
| (60)          | 34.9 ± 2.8         | 1.54 ± 0.21         | 12.80 ± 1.01 | 0.80 ± 1.01 | 21.62 ± 2.88 | < 0.20 | 3.15 ± 0.72 | 0.27 ± 0.04 | 6.0 ± 0.3 | 2.6 | 36.0 | 82.5 |
Table 2
Effect of cultivation temperature on fermentation of selected sugar (20 mM) by *Clostridium* strain AK1 (DSM 18778). Values represent the average of triplicates with standard deviation shown as error bars.

| Substrate | T (°C) | Sugar consumed (%) | Analyte (mmol L\(^{-1}\)) | Ethanol | Acetate | Butyrate | 1,2-PD | Lactate | H\(_2\) | OD\(_{600\ nm}\) | pH | Ethanol Yield (%) | 1,2-PD Yield (%) | Carbon balance (%) |
|-----------|-------|-------------------|--------------------------|---------|--------|----------|--------|---------|-------|-------------|----|----------------|----------------|------------------|
| D-Glucose | 30    | 37.0 ± 2.1        | 6.89 ± 1.31             | 5.53 ± 0.87 | < 0.20 | < 0.20 | 0.10 ± 0.10 | 0.22 ± 0.28 | 0.13 ± 0.05 | 6.8 ± 0.1 | 17.2 | 0.0           | 87.5            |
| D-Glucose | 35    | 35.1 ± 3.8        | 7.10 ± 0.59             | 4.21 ± 0.14 | < 0.20 | < 0.20 | 0.40 ± 0.10 | 0.05 ± 0.03 | 0.11 ± 0.06 | 7.0 ± 0.2 | 17.8 | 0.0           | 85.2            |
| D-Glucose | 40    | 34.1 ± 1.3        | 6.31 ± 0.49             | 4.48 ± 0.34 | < 0.20 | < 0.20 | 0.50 ± 0.10 | 0.59 ± 0.16 | 0.23 ± 0.03 | 6.9 ± 0.1 | 21.4 | 0.0           | 84.7            |
| D-Glucose | 45    | 33.3 ± 0.9        | 8.54 ± 2.57             | 4.56 ± 0.71 | < 0.20 | < 0.20 | 0.60 ± 0.23 | 2.87 ± 0.73 | 0.24 ± 0.05 | 6.8 ± 0.1 | 21.4 | 0.0           | 99.4            |
| D-Glucose | 50    | 96.0 ± 1.3        | 29.40 ± 2.67            | 9.10 ± 0.47 | < 0.20 | < 0.20 | 1.55 ± 0.17 | 9.65 ± 0.67 | 0.20 ± 0.02 | 6.6 ± 0.2 | 73.5 | 0.0           | 104.8           |
| D-Glucose | 55    | 93.9 ± 2.2        | 27.56 ± 2.02            | 9.40 ± 1.14 | < 0.20 | < 0.20 | 1.87 ± 0.28 | 10.04 ± 0.67 | 0.36 ± 0.02 | 6.7 ± 0.2 | 68.9 | 0.0           | 103.8           |
| D-Glucose | 60    | 0.0 ± 0.0         | 1.35 ± 0.23             | 1.03 ± 0.80 | < 0.20 | < 0.20 | 0.43 ± 0.10 | 0.02 ± 0.00 | 0.12 ± 0.01 | 6.8 ± 0.1 | < 0.5 | 0.0           | ND              |
| D-Glucose | 65    | 0.0 ± 0.0         | 1.23 ± 0.06             | 1.16 ± 0.03 | < 0.20 | < 0.20 | 0.30 ± 0.10 | 0.19 ± 0.27 | 0.12 ± 0.01 | 6.7 ± 0.0 | < 0.5 | 0.0           | ND              |
| L-Rhamnose| 30    | 0.0 ± 0.0         | 1.97 ± 0.08             | 2.32 ± 0.11 | 0.67 ± 0.76 | 0.29 ± 0.25 | < 0.20 | 0.83 ± 0.10 | 0.07 ± 0.01 | 6.9 ± 0.1 | 9.9  | 1.5           | ND              |
| L-Rhamnose| 35    | 15.5 ± 2.3        | 2.08 ± 0.23             | 2.02 ± 0.15 | 0.54 ± 0.11 | 0.20 ± 0.10 | < 0.20 | 0.36 ± 0.14 | 0.11 ± 0.03 | 6.9 ± 0.0 | 10.4 | 1.0           | 86.8            |
| L-Rhamnose| 40    | 19.0 ± 1.3        | 1.97 ± 0.01             | 2.21 ± 0.05 | 0.87 ± 0.30 | 0.97 ± 0.16 | < 0.20 | 0.82 ± 0.08 | 0.15 ± 0.01 | 6.9 ± 0.1 | 19.7 | 4.9           | 90.6            |
| L-Rhamnose| 45    | 27.0 ± 2.2        | 2.19 ± 0.43             | 2.00 ± 0.30 | 2.02 ± 0.29 | 2.83 ± 0.70 | < 0.20 | 2.16 ± 0.30 | 0.14 ± 0.01 | 6.8 ± 0.1 | 21.9 | 14.2          | 102.4           |
| L-Rhamnose| 50    | 66.0 ± 2.8        | 3.29 ± 0.16             | 8.89 ± 0.28 | 1.54 ± 0.35 | 9.72 ± 0.71 | < 0.20 | 2.81 ± 0.35 | 0.13 ± 0.01 | 6.9 ± 0.2 | 32.9 | 48.6          | 94.6            |
| L-Rhamnose| 55    | 60.5 ± 1.2        | 3.29 ± 0.24             | 10.04 ± 1.76 | 1.12 ± 0.15 | 7.22 ± 0.63 | < 0.20 | 2.39 ± 0.54 | 0.13 ± 0.02 | 6.8 ± 0.1 | 32.9 | 36.1          | 94.2            |
| L-Rhamnose| 60    | 0.0 ± 0.0         | 1.43 ± 0.19             | 0.80 ± 0.20 | 1.83 ± 0.57 | 0.32 ± 0.24 | < 0.20 | 0.02 ± 0.00 | 0.13 ± 0.01 | 7.0 ± 0.1 | 10.4 | 1.6           | ND              |
| L-Rhamnose| 65    | 0.0 ± 0.0         | 1.35 ± 0.04             | 0.55 ± 0.02 | 0.48 ± 0.06 | < 0.20 | < 0.20 | 0.03 ± 0.01 | 0.12 ± 0.02 | 7.2 ± 0.1 | 13.5 | 0.0           | ND              |
| Substrate        | Initial pH | Sugar consumed (%) | Analyte (mmol L⁻¹) | OD₆₀₀ nm | pH   | 1,2-PD Yield (%) | 1,2-PD Yield (%) | Carbon balance (%) |
|------------------|------------|--------------------|-------------------|----------|------|------------------|------------------|--------------------|
| D-Glucose        | 4.5        | 0.0 ± 0.0          | 2.30 ± 0.30       | < 0.20   | 0.33 ± 0.04 | 1.40 ± 0.02 | 0.09 ± 0.03 | 4.2 ± 0.3 | 5.8  | 0.0 | ND   |
| D-Glucose        | 4.8        | 7.0 ± 0.6          | 16.5 ± 2.06       | 11.03 ± 1.49 | 0.20 | 1.10 ± 0.10 | 11.86 ± 3.70 | 0.50 ± 0.03 | 4.4 ± 0.0 | 41.3 | 0.0 | 94.3 |
| D-Glucose        | 5.1        | 7.2 ± 0.9          | 16.19 ± 0.66      | 10.42 ± 0.40 | 0.20 | 1.40 ± 0.13 | 9.29 ± 0.09 | 0.49 ± 0.02 | 4.7 ± 0.2 | 65.4 | 0.0 | 98.6 |
| D-Glucose        | 5.5        | 9.0 ± 1.3          | 26.15 ± 2.20      | 12.12 ± 0.12 | 0.20 | 1.30 ± 0.18 | 8.83 ± 1.09 | 0.46 ± 0.02 | 5.1 ± 0.1 | 65.4 | 0.0 | 104.0 |
| D-Glucose        | 5.9        | 9.0 ± 1.2          | 21.82 ± 1.48      | 12.95 ± 0.40 | 0.20 | 1.90 ± 0.21 | 9.55 ± 1.56 | 0.44 ± 0.03 | 5.6 ± 0.1 | 54.5 | 0.0 | 101.8 |
| D-Glucose        | 6.7        | 9.7 ± 0.4          | 34.62 ± 1.60      | 14.15 ± 1.28 | 0.20 | 1.44 ± 0.30 | 8.30 ± 1.25 | 0.34 ± 0.02 | 6.6 ± 0.2 | 86.6 | 0.0 | 108.9 |
| D-Glucose        | 7.2        | 9.2 ± 1.5          | 24.34 ± 2.77      | 12.81 ± 0.72 | 0.25 ± 0.01 | 1.40 ± 0.25 | 8.91 ± 0.13 | 0.37 ± 0.02 | 6.8 ± 0.1 | 60.9 | 0.0 | 105.6 |
| D-Glucose        | 7.8        | 9.38 ± 1.4         | 27.45 ± 1.50      | 14.68 ± 1.10 | 0.34 ± 0.00 | 1.00 ± 0.10 | 8.43 ± 0.50 | 0.33 ± 0.06 | 7.5 ± 0.1 | 68.6 | 0.0 | 105.5 |
| D-Glucose        | 8.5        | 0.0 ± 0.0          | 2.10 ± 0.22       | 1.00 ± 0.08 | < 0.20 | 0.20 ± 0.10 | 1.20 ± 0.04 | 0.11 ± 0.03 | 8.3 ± 0.2 | 5.3  | 0.0 | ND   |
| L-Rhamnose       | 4.5        | 0.40 ± 0.06        | 1.20 ± 0.03       | 0.10 ± 0.01 | 0.80 ± 0.10 | < 0.20 | 0.20 ± 0.07 | 0.07 ± 0.04 | 4.1 ± 0.1 | 2.0  | 4.0 | ND   |
| L-Rhamnose       | 4.8        | 52.1 ± 0.19        | 1.74 ± 0.19       | 1.03 ± 0.82 | 1.60 ± 0.23 | 6.46 ± 0.84 | < 0.20 | 3.01 ± 0.73 | 0.14 ± 0.06 | 4.5 ± 0.2 | 8.7  | 32.3 | 103.5 |
| L-Rhamnose       | 5.1        | 66.0 ± 0.7         | 3.07 ± 0.45       | 10.92 ± 0.53 | 2.10 ± 0.22 | 7.63 ± 0.84 | < 0.20 | 3.05 ± 0.70 | 0.14 ± 0.02 | 4.8 ± 0.1 | 15.4 | 38.2 | 97.8 |
| L-Rhamnose       | 5.5        | 77.5 ± 0.5         | 0.94 ± 0.97       | 12.99 ± 1.54 | 2.00 ± 0.30 | 9.22 ± 1.46 | < 0.20 | 3.22 ± 0.86 | 0.16 ± 0.03 | 5.1 ± 0.2 | 4.7  | 46.1 | 87.6 |
| L-Rhamnose       | 5.9        | 71.5 ± 1.1         | 1.24 ± 0.13       | 10.72 ± 0.25 | 1.90 ± 0.23 | 8.42 ± 1.57 | < 0.20 | 2.49 ± 0.76 | 0.13 ± 0.02 | 5.4 ± 0.2 | 6.2  | 42.1 | 84.5 |
| L-Rhamnose       | 6.7        | 77.0 ± 1.5         | 2.22 ± 0.46       | 15.10 ± 0.84 | 1.30 ± 0.26 | 10.38 ± 1.19 | < 0.20 | 3.48 ± 0.84 | 0.16 ± 0.04 | 6.3 ± 0.1 | 11.1 | 51.9 | 98.4 |
| L-Rhamnose       | 7.2        | 61.5 ± 2.2         | 1.33 ± 0.14       | 10.10 ± 0.30 | 1.00 ± 0.30 | 8.49 ± 0.16 | < 0.20 | 2.73 ± 0.21 | 0.19 ± 0.01 | 6.9 ± 0.2 | 6.7  | 42.5 | 89.1 |
| L-Rhamnose       | 7.8        | 56.1 ± 3.0         | 0.94 ± 0.30       | 10.60 ± 1.99 | 1.50 ± 0.22 | 7.54 ± 1.79 | < 0.20 | 2.32 ± 0.55 | 0.21 ± 0.01 | 7.3 ± 0.1 | 4.7  | 37.7 | 98.6 |
| L-Rhamnose       | 8.5        | 0.9 ± 0.3          | 0.40 ± 0.00       | 1.00 ± 0.05 | 0.20 ± 0.05 | 0.70 ± 0.03 | < 0.20 | 0.23 ± 0.02 | 0.98 ± 0.06 | 8.4 ± 0.1 | 2.0  | 3.5 | ND   |
| Substrate  | L-G ratio | Sugar consumed (%) | Analyte (mmol L⁻¹) | Ethanol | Acetate | Butyrate | 1,2-PD | Lactate | H₂ | OD₆₀₀ nm | pH | Ethanol Yield (%) | 1,2-PD Yield (%) | Carbon balance (%) |
|------------|-----------|-------------------|--------------------|---------|---------|----------|--------|---------|----|----------|----|------------------|------------------|--------------------|
| D-Glucose  | 0.09      | 96.1 ± 1.5        | 22.20 ± 3.02       | 14.10 ± 1.69 | 0.25 ± 0.10 | < 0.20 | 1.71 ± 0.65 | 2.40 ± 0.20 | 0.37 ± 0.01 | 6.4 ± 0.2 | 55.5 | 0.0           | 101.8            |
| D-Glucose  | 0.34      | 97.3 ± 0.8        | 26.42 ± 4.81       | 11.50 ± 0.74 | < 0.20 | < 0.20 | 2.63 ± 0.13 | 6.40 ± 1.23 | 0.35 ± 0.01 | 6.3 ± 0.1 | 66.1 | 0.0           | 106.1            |
| D-Glucose  | 1.00      | 97.0 ± 0.3        | 24.04 ± 2.60       | 11.90 ± 0.93 | < 0.20 | < 0.20 | 4.46 ± 0.69 | 18.51 ± 1.75 | 0.35 ± 0.01 | 6.4 ± 0.1 | 60.1 | 0.0           | 106.3            |
| D-Glucose  | 2.12      | 96.0 ± 1.5        | 26.11 ± 1.33       | 9.20 ± 0.36 | < 0.20 | < 0.20 | 1.34 ± 0.47 | 12.89 ± 0.37 | 0.34 ± 0.02 | 6.1 ± 0.1 | 65.3 | 0.0           | 97.5             |
| D-Glucose  | 5.62      | 95.0 ± 1.3        | 26.92 ± 2.56       | 10.00 ± 0.49 | < 0.20 | < 0.20 | 0.79 ± 0.18 | 41.62 ± 1.21 | 0.34 ± 0.01 | 6.2 ± 0.2 | 67.3 | 0.0           | 101.3            |
| L-Rhamnose | 0.09      | 67.5 ± 1.4        | 1.23 ± 0.62        | 9.23 ± 2.71 | 1.83 ± 0.65 | 12.19 ± 1.96 | < 0.20 | 0.34 ± 0.07 | 0.19 ± 0.01 | 6.8 ± 0.1 | 6.2 | 61.0          | 97.4             |
| L-Rhamnose | 0.34      | 53.0 ± 3.4        | 3.65 ± 0.44        | 5.87 ± 0.38 | 1.42 ± 0.99 | 6.16 ± 0.45 | < 0.20 | 0.80 ± 0.54 | 0.18 ± 0.02 | 6.8 ± 0.0 | 18.2 | 30.8          | 87.4             |
| L-Rhamnose | 1.00      | 42.5 ± 1.8        | 1.11 ± 0.08        | 5.84 ± 0.15 | 1.15 ± 0.06 | 7.06 ± 0.31 | < 0.20 | 2.46 ± 0.02 | 0.16 ± 0.01 | 6.9 ± 0.2 | 6.0 | 35.3          | 96.0             |
| L-Rhamnose | 2.12      | 50.0 ± 2.2        | 3.86 ± 0.58        | 5.52 ± 0.13 | 2.28 ± 0.02 | 6.35 ± 0.48 | < 0.20 | 4.29 ± 0.41 | 0.16 ± 0.02 | 6.8 ± 0.1 | 19.3 | 31.8          | 101.5            |
| L-Rhamnose | 5.62      | 52.5 ± 1.3        | 1.68 ± 0.35        | 6.66 ± 0.35 | 0.81 ± 0.11 | 9.66 ± 2.29 | < 0.20 | 9.67 ± 1.79 | 0.15 ± 0.01 | 6.8 ± 0.2 | 8.4 | 48.3          | 93.4             |
### Table 5

Effect of initial phosphate concentration on fermentation of selected sugar (10 mM) by *Clostridium* strain AK1 (DSM 18778). Values represent the average of triplicates with standard deviation shown as error bars.

| Substrate      | Phosphate concentration (mM) | Sugar consumed (%) | Analyte (mmol L⁻¹) | OD₆₀₀ nm | pH | Ethanol Yield (%) | 1,2-PD Yield (%) | Carbon balance |
|----------------|------------------------------|-------------------|---------------------|----------|----|--------------------|-------------------|-----------------|
|                | Ethanol | Acetate | Butyrate | 1,2-PD | Lactate | H₂ |                 |                  |                 |
| D-Glucose 0    | 75.1 ± 2.1 | 7.52 ± 1.13 | 3.14 ± 0.12 | < 0.20 | < 0.20 | 3.16 ± 0.40 | 3.16 ± 0.70 | 0.06 ± 0.02 | 6.7 ± 0.1 | 37.6 | 0.0 | 95.0 |
| D-Glucose 0.01 | 90.1 ± 1.0 | 11.01 ± 0.36 | 3.13 ± 1.45 | < 0.20 | < 0.20 | 2.93 ± 1.69 | 4.35 ± 0.81 | 0.07 ± 0.02 | 6.6 ± 0.2 | 55.1 | 0.0 | 96.4 |
| D-Glucose 0.05 | 96.9 ± 0.3 | 12.59 ± 1.01 | 4.15 ± 0.46 | < 0.20 | < 0.20 | 2.61 ± 0.84 | 6.08 ± 1.28 | 0.09 ± 0.02 | 6.5 ± 0.1 | 63.0 | 0.0 | 101.0 |
| D-Glucose 0.10 | 98.8 ± 0.6 | 12.84 ± 1.60 | 4.28 ± 0.60 | < 0.20 | < 0.20 | 2.79 ± 0.59 | 5.21 ± 0.35 | 0.09 ± 0.02 | 6.6 ± 0.2 | 64.2 | 0.0 | 101.4 |
| D-Glucose 0.25 | 95.0 ± 0.7 | 12.24 ± 1.27 | 4.03 ± 0.29 | < 0.20 | < 0.20 | 2.54 ± 0.52 | 6.06 ± 1.01 | 0.09 ± 0.03 | 6.5 ± 0.1 | 61.2 | 0.0 | 100.5 |
| D-Glucose 0.50 | 97.9 ± 2.0 | 12.50 ± 1.33 | 4.11 ± 0.43 | < 0.20 | < 0.20 | 3.21 ± 0.47 | 6.26 ± 1.32 | 0.09 ± 0.02 | 6.4 ± 0.2 | 62.5 | 0.0 | 102.4 |
| D-Glucose 1    | 93.2 ± 1.2 | 10.94 ± 0.99 | 4.12 ± 0.25 | < 0.20 | < 0.20 | 3.18 ± 1.00 | 5.62 ± 1.11 | 0.090 ± 0.03 | 6.3 ± 0.1 | 54.7 | 0.0 | 99.5 |
| D-Glucose 5    | 95.0 ± 1.2 | 10.89 ± 1.01 | 4.16 ± 0.55 | < 0.20 | < 0.20 | 3.31 ± 1.25 | 6.93 ± 1.93 | 0.10 ± 0.02 | 6.3 ± 0.1 | 54.4 | 0.0 | 97.9 |
| D-Glucose 15   | 90.2 ± 0.5 | 11.23 ± 0.97 | 4.21 ± 0.44 | < 0.20 | < 0.20 | 2.06 ± 0.12 | 6.89 ± 0.42 | 0.19 ± 0.10 | 6.2 ± 0.1 | 56.2 | 0.0 | 98.8 |
| D-Glucose 25   | 61.0 ± 3.4 | 5.92 ± 0.86 | 3.48 ± 0.08 | < 0.20 | < 0.20 | 2.14 ± 0.73 | 4.48 ± 1.26 | 0.27 ± 0.06 | 6.0 ± 0.2 | 29.6 | 0.0 | 97.3 |
| L-Rhamnose 0   | 56.0 ± 2.6 | 4.09 ± 0.33 | 3.66 ± 0.18 | 0.73 ± 0.37 | 2.02 ± 0.36 | < 0.20 | 2.84 ± 0.53 | 0.05 ± 0.01 | 6.9 ± 0.0 | 40.1 | 20.2 | 100.2 |
| L-Rhamnose 0.01| 61.2 ± 2.0 | 3.61 ± 0.19 | 3.12 ± 0.34 | 1.18 ± 0.03 | 1.91 ± 0.43 | < 0.20 | 2.43 ± 0.32 | 0.06 ± 0.01 | 6.9 ± 0.1 | 36.1 | 19.1 | 90.1 |
| L-Rhamnose 0.05| 59.3 ± 1.3 | 3.69 ± 0.24 | 2.99 ± 0.17 | 1.31 ± 0.05 | 1.78 ± 0.38 | < 0.20 | 2.67 ± 0.33 | 0.06 ± 0.01 | 7.0 ± 0.2 | 36.9 | 17.8 | 93.8 |
| L-Rhamnose 0.10| 54.2 ± 1.7 | 3.46 ± 0.13 | 2.82 ± 0.16 | 1.23 ± 0.07 | 1.56 ± 0.22 | < 0.20 | 2.06 ± 0.26 | 0.06 ± 0.01 | 6.9 ± 0.2 | 34.6 | 15.6 | 95.4 |
| L-Rhamnose 0.25| 53.4 ± 2.1 | 3.41 ± 0.12 | 2.87 ± 0.09 | 1.12 ± 0.13 | 1.66 ± 0.08 | < 0.20 | 2.02 ± 0.19 | 0.06 ± 0.01 | 6.8 ± 0.1 | 34.1 | 16.6 | 95.9 |
| L-Rhamnose 0.50| 57.1 ± 2.5 | 3.58 ± 0.05 | 3.56 ± 0.16 | 0.91 ± 0.37 | 2.19 ± 0.65 | < 0.20 | 2.56 ± 0.33 | 0.05 ± 0.01 | 6.8 ± 0.1 | 35.8 | 21.9 | 97.8 |
| L-Rhamnose 1   | 53.8 ± 1.1 | 3.25 ± 0.27 | 3.08 ± 0.09 | 1.07 ± 0.08 | 1.89 ± 0.40 | < 0.20 | 2.28 ± 0.43 | 0.06 ± 0.01 | 6.8 ± 0.2 | 32.5 | 18.9 | 95.8 |
| L-Rhamnose 5   | 53.0 ± 1.5 | 3.38 ± 0.43 | 3.01 ± 0.32 | 0.99 ± 0.01 | 1.84 ± 0.45 | < 0.20 | 2.07 ± 0.31 | 0.06 ± 0.01 | 6.7 ± 0.1 | 33.8 | 18.4 | 96.3 |
| L-Rhamnose 15  | 57.3 ± 1.2 | 3.77 ± 0.15 | 3.35 ± 0.24 | 1.05 ± 0.07 | 2.05 ± 0.60 | < 0.20 | 2.36 ± 0.11 | 0.03 ± 0.003 | 6.7 ± 0.1 | 37.7 | 20.5 | 98.9 |
| L-Rhamnose 25  | 43.4 ± 2.5 | 2.70 ± 0.30 | 2.22 ± 0.77 | 1.06 ± 0.05 | 1.28 ± 0.18 | < 0.20 | 1.96 ± 0.16 | 0.22 ± 0.07 | 6.8 ± 0.0 | 27.0 | 12.8 | 96.7 |
MnCl$_2$ × 4 H$_2$O, (NH$_4$)$_2$Mo$_7$O$_{24}$, AlCl$_3$, CoCl$_2$ × 6 H$_2$O, NiCl$_2$, and 0.05 g Na$_2$S × 9 H$_2$O 0.3 g, and 1 mL of concentrated HCl. The carbon source concentration 20 mM unless stated otherwise. The medium was prepared by adding the buffer to distilled water containing resarzurin and boiled for 10–15 min until pink and cooled to ambient temperature under a stream of nitrogen (< 5 ppm O$_2$). The mixture was then transferred to serum bottles using the Hungate technique [4,5] and autoclaved for 60 min. All other components of the medium were added separately through filter (0.45 μm) sterilized solutions. All experiments were conducted at 50 °C and at pH of 7.0 with a liquid-gas (L-G) ratio of 1:1 unless specifically stated otherwise. In all cases, growth experiments were performed in triplicate without agitation.

2.3. Effect of initial substrate concentration

To investigate the effect of different initial glucose and rhamnose concentrations on growth the strain was cultivated at 10, 20, 40 and 60 mM of each sugar.

2.4. Effect of pH on fermentation end products

To investigate the effect of pH on growth the strain was cultivated at pH ranging from pH 4.0 to 9.0 with 0.5 pH unit intervals. End products were determined after 5 days of incubation.

2.5. Effect of temperature on fermentation end products

To investigate the effect of temperature on growth the strain was cultivated at 35 °C to 65 °C in 5 °C intervals. End products were determined after 5 days of incubation.

2.6. Effect of liquid-gas phase ratio

Strain AK 1 was cultivated in serum bottles (57 mL nominal volume) were filled with either 4.5, 13.4, 26.5, 36.0, or 45.0 mL of BM medium to give L-G values of 0.09, 0.34, 1.00, 2.12, and 5.62, respectively.

2.7. Effect of initial phosphate concentration

Phosphate-free yeast extract was prepared according to the method described by [6] and used for the preparation of phosphate-free BM. The phosphate concentration of the resultant yeast extracted was verified colorimetrically and was below the limit of detection of the assay. Strain AK1 was cultivated on 10 mM of either D-glucose or L-rhamnose with phosphate added from syringe-filtered stock bottles. Phosphate concentrations ranging from 0 (control) and 0.01 mM to 25 mM were investigated.

2.8. Analytical methods

Hydrogen, volatile fatty acids and alcohols were quantified by gas chromatography as described earlier [2]. D-Glucose was quantified using the anthrone method [7] with the modifications described by previously [8]. Methylpentoses and 1,2-PD were analysed using colorimetric methods [9,10] modified for microplates as described earlier [8]. Lactic acid was quantified using the method of [11] with modification; Briefly, 50 μL of sample was placed in a 1.5 mL Eppendorf tube, followed by the addition of 300 μL of concentrated sulfuric acid and incubated in a water bath (100 °C) for 10 min. After cooling to RT, 5 μL of 4% (w/v) CuSO$_4$ reagent were added followed by 10 μL of 1.5% (w/v) p-phenylphenol in 95% (v/v) ethanol. The mixture was vortexed and allowed to incubate at room temperature for 30 minutes. 300 μL of sample was then transferred into a microtiter plate and read at 570 nm against a water blank. Phosphate concentrations were determined spectrophotometrically according to Olsen and Summers [12] in microtiter plates read in a Bioscreen C.
Optical density was measured at 600 nm with a Shimadzu UV-1800 UV-Visible spectrophotometer with cuvetted ($l = 1$ cm) against a water blank.

**Transparency document. Supporting information**

Transparency data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2018.08.088.

**References**

[1] E.M. Ingvadottir, S.M. Scully, J. Orlygsson, Production of (S)-1,2-propanediol from L-rhamnose using the moderately thermophilic costridium strain AK1, Anaerobe 54 (2018) 26–60. http://dx.doi.org/10.1016/j.anaerobe.2018.07.003.

[2] J. Orlygsson, S.R.B. Baldursson, Phylogenetic and physiological studies of four hydrogen-producing thermoanaerobes, Icel. Agric. Sci. 20 (2007) 93–105.

[3] M. Sveinsdottir, S.R.B. Baldursson, J. Orlygsson, Ethanol production from monosugars and lignocellulosic biomass by thermophilic bacteria isolated from Icelandic hot springs, Icel. Agric. Sci. 22 (2009) 45–58.

[4] R.E. Hungate, A roll tube method for cultivation of strict anaerobes, in: J.R. Norris, D.W. Ribbons (Eds.), Methods in Microbiology, Academic Press, New York, 1969, pp. 117–132.

[5] T.L. Miller, M.J. Wolin, A serum bottle modification of the Hungate technique for cultivating obligate anaerobes, Appl. Microbiol. 27 (1974) 985–987.

[6] K. Tran-Din, G. Gottschalk, Formation of D(-)-1,2-propanediol and D(-)-lactate from glucose by Clostridium sphenoides under phosphate limitation, Arch. Microbiol. 142 (1985) 87–92.

[7] D. Aminoff, W.W. Binkley, R. Schaffer, R.W. Mowry, Analytical methods for carbohydrates, in: W. Pigman, D. Horton, A. Herp (Eds.), The Carbohydrates - Volume IIB, 2nd ed., Academic Press, London, 1971, pp. 739–808.

[8] E.M. Ingvadottir, S.M. Scully, J. Orlygsson, Evaluation of the genus of Caldicellulosiruptor for production of 1,2-propanediol from methylpentoses, Anaerobe. 47 (2017) 86–88.

[9] Z. Dische, L.B. Shettles, A specific color reaction of methylpentoses and a spectrophotometric micromethod for their determination, J. Biol. Chem. 175 (1948) 595–603.

[10] L.R. Jones, Colorimetric determination of 1,2-propanediol and related compounds, Anal. Chem. 29 (1957) 1214–1216.

[11] K.A.C.C. Taylor, A simple colorimetric assay for muramic acid and lactic acid, Appl. Biochem. Biotechnol. 56 (1996) 49–58.

[12] S.R. Olsen, L.E. Sommers, Phosphorous, in: P.L. Page, R.H. Miller, D.R. Keeney (Eds.), Methods of Soil Analysis, 2nd ed., Soil Science Society of America, Inc, Madison, 1982, pp. 403–430 (Agronomy Series No. 9).