**Supplementary Information**

A dynamic control strategy to produce riboflavin with lignocellulose hydrolysate in the thermophile *Geobacillus thermoglucosidasius*

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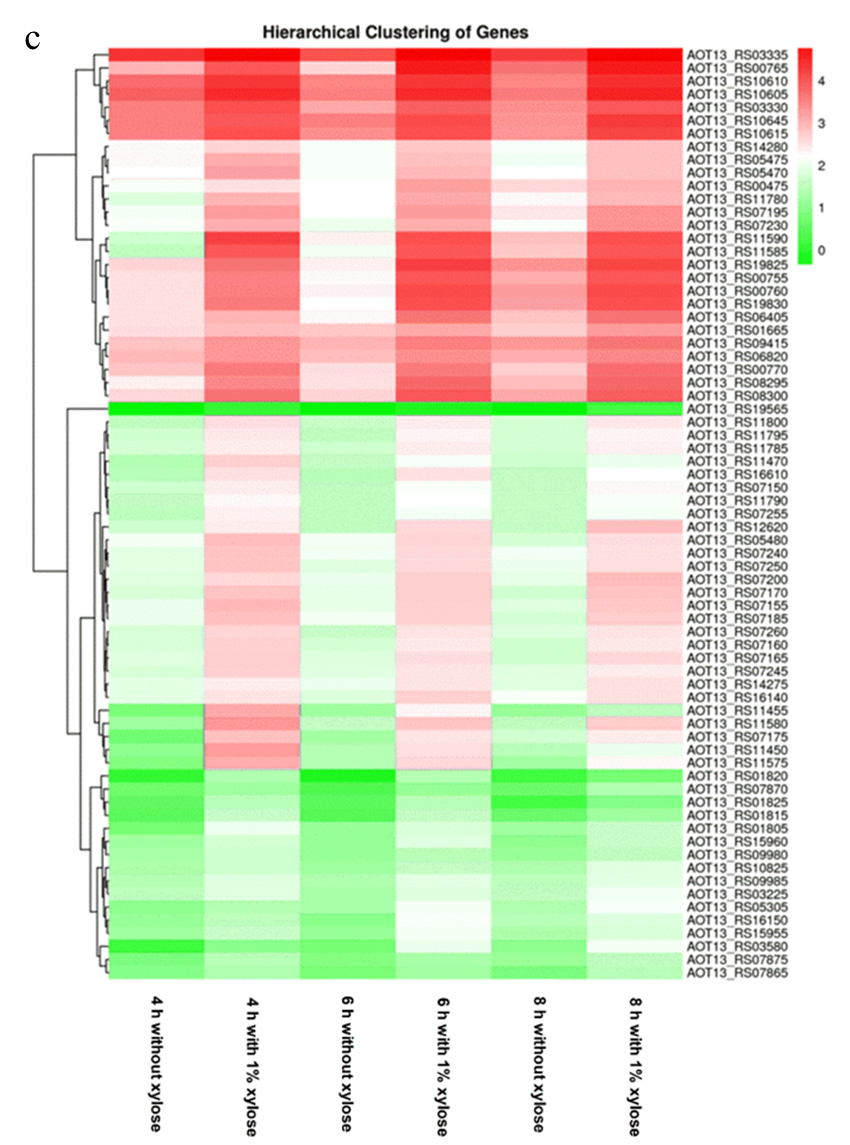
**Supplementary Figures**

**Supplementary Figure 1.**



**Supplementary Figure 1. Utilization of glucose and xylose by *G. thermoglucosidasius* DSM 2542 Rib-Gtg.** **a** Time course of the glucose consumption during the fermentation of DSM 2542 Rib-Gtg in USYE medium supplemented with 1% glucose. **b** Time course of the xylose consumption during the fermentation of DSM 2542 Rib-Gtg in USYE medium supplemented with 1% xylose. Experiments were performed in duplicates. Results were expressed as mean ± SD.

**Supplementary Figure 2.**



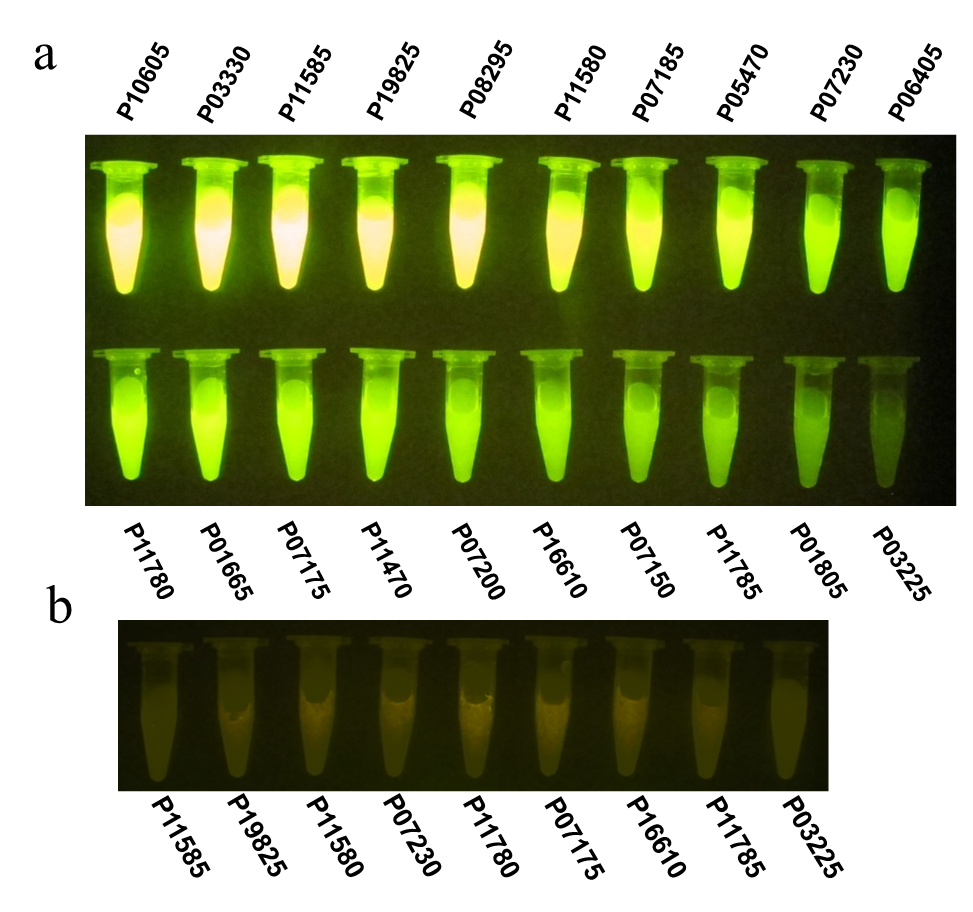
**Supplementary Figure 2. Identification of xylose-inducible and glucose-insensitive promoters.** **a** The growth curves of *G. thermoglucosidasius* DSM 2542 cultured in USYE medium with xylose and without xylose. The cells were collected at 4, 6, and 8 h for whole genome transcriptional analysis. **b** Number of genes activated significantly by xylose in DSM 2542. The Venn diagram indicates the number of genes activated by xylose according to the time-series transcriptome analysis of DSM 2542 cultivated in different conditions. **c** The heat map is generated using the normalized RPKM (reads per kilobase per million mapped reads) values and shows the fold change of the same gene of DSM 2542 from different culture conditions (USYE medium with 1% xylose or without xylose) at three different time points. Red indicates the enhanced expression, and green denotes no significant changes. Scales of expressions are indicated by an integrated color bar at the right.

**Supplementary Figure 3.**



**Supplementary Figure 3. The strengths of the selected 39 putative xylose-inducible promoters indicated by their reads per kilobase per million mapped reads (RPKM) values of downstream genes.**

**Supplementary Figure 4.**



**Supplementary Figure 4. Promoter strengths visualized by GFP fluorescence. a** Strains were cultured in USYE medium with 1% xylose; **b** Strains were cultured in USYE medium with 1% glucose.

**SUPPLEMENTARY TABLES**

**Supplementary Table 1. Genes activated by xylose at three different time points, respectively.** Values are fold change (n-xylose/n, n represents 4, 6 and 8) of gene expression from RNA-seq data (time 1, 2, or 3).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Fermentation for 4 hours** |  | **Fermentation for 6 hours** |  | **Fermentation for 8 hours** |
| Gene ID | Fold change (4-xylose/4) | Gene ID | Fold change (6-xylose/6) | Gene ID | Fold change (8-xylose/8) |
| AOT13\_RS11590 | 7.73 | AOT13\_RS00765 | 6.07 | AOT13\_RS10460 | 3.99 |
| AOT13\_RS11585 | 7.44 | AOT13\_RS11585 | 5.77 | AOT13\_RS12620 | 3.95 |
| AOT13\_RS11460 | 7.22 | AOT13\_RS19830 | 5.69 | AOT13\_RS11585 | 3.83 |
| AOT13\_RS11455 | 7.07 | AOT13\_RS19825 | 5.68 | AOT13\_RS12815 | 3.74 |
| AOT13\_RS11450 | 6.89 | AOT13\_RS00760 | 5.49 | AOT13\_RS11590 | 3.73 |
| AOT13\_RS11575 | 6.74 | AOT13\_RS16160 | 5.44 | AOT13\_RS11580 | 3.66 |
| AOT13\_RS07175 | 6.66 | AOT13\_RS00755 | 5.37 | AOT13\_RS07230 | 3.55 |
| AOT13\_RS11580 | 6.52 | AOT13\_RS11590 | 5.29 | AOT13\_RS07170 | 3.34 |
| AOT13\_RS19505 | 5.05 | AOT13\_RS02945 | 4.87 | AOT13\_RS03580 | 3.31 |
| AOT13\_RS10955 | 4.66 | AOT13\_RS06950 | 4.82 | AOT13\_RS12920 | 3.13 |
| AOT13\_RS12210 | 4.59 | AOT13\_RS01820 | 4.73 | AOT13\_RS10950 | 3.12 |
| AOT13\_RS04580 | 4.44 | AOT13\_RS00825 | 4.69 | AOT13\_RS11575 | 3.11 |
| AOT13\_RS01810 | 4.31 | AOT13\_RS08160 | 4.69 | AOT13\_RS00770 | 3.06 |
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| AOT13\_RS07515 | 3.67 | AOT13\_RS10320 | 3.78 | AOT13\_RS07995 | 2.83 |
| AOT13\_RS11465 | 3.64 | AOT13\_RS08295 | 3.74 | AOT13\_RS00055 | 2.83 |
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| AOT13\_RS14275 | 1.34 | AOT13\_RS06510 | 1.85 | AOT13\_RS09880 | 1.57 |
| AOT13\_RS09420 | 1.32 | AOT13\_RS05000 | 1.85 | AOT13\_RS19810 | 1.56 |
| AOT13\_RS13395 | 1.31 | AOT13\_RS00920 | 1.85 | AOT13\_RS02945 | 1.56 |
| AOT13\_RS16150 | 1.31 | AOT13\_RS00335 | 1.84 | AOT13\_RS00975 | 1.56 |
| AOT13\_RS01050 | 1.31 | AOT13\_RS03430 | 1.84 | AOT13\_RS00830 | 1.56 |
| AOT13\_RS08110 | 1.30 | AOT13\_RS17640 | 1.84 | AOT13\_RS03430 | 1.56 |
| AOT13\_RS10000 | 1.30 | AOT13\_RS02375 | 1.84 | AOT13\_RS12870 | 1.56 |
| AOT13\_RS13390 | 1.29 | AOT13\_RS17795 | 1.84 | AOT13\_RS11180 | 1.55 |
| AOT13\_RS05360 | 1.29 | AOT13\_RS16785 | 1.83 | AOT13\_RS03210 | 1.53 |
| AOT13\_RS14280 | 1.28 | AOT13\_RS02690 | 1.83 | AOT13\_RS00880 | 1.53 |
| AOT13\_RS11025 | 1.28 | AOT13\_RS08730 | 1.83 | AOT13\_RS03630 | 1.53 |
| AOT13\_RS11565 | 1.27 | AOT13\_RS02370 | 1.82 | AOT13\_RS17670 | 1.53 |
| AOT13\_RS06365 | 1.26 | AOT13\_RS16985 | 1.81 | AOT13\_RS07415 | 1.52 |
| AOT13\_RS09980 | 1.26 | AOT13\_RS12520 | 1.81 | AOT13\_RS03325 | 1.52 |
| AOT13\_RS04965 | 1.24 | AOT13\_RS07185 | 1.80 | AOT13\_RS12610 | 1.51 |
| AOT13\_RS19075 | 1.24 | AOT13\_RS09835 | 1.79 | AOT13\_RS03680 | 1.50 |
| AOT13\_RS10645 | 1.23 | AOT13\_RS09160 | 1.79 | AOT13\_RS08725 | 1.50 |
| AOT13\_RS01325 | 1.23 | AOT13\_RS03495 | 1.79 | AOT13\_RS18055 | 1.49 |
| AOT13\_RS15965 | 1.22 | AOT13\_RS05065 | 1.79 | AOT13\_RS02415 | 1.49 |
| AOT13\_RS07865 | 1.21 | AOT13\_RS18870 | 1.78 | AOT13\_RS03530 | 1.49 |
| AOT13\_RS12515 | 1.21 | AOT13\_RS02335 | 1.78 | AOT13\_RS02530 | 1.48 |
| AOT13\_RS00270 | 1.20 | AOT13\_RS17670 | 1.78 | AOT13\_RS18130 | 1.48 |
| AOT13\_RS05395 | 1.20 | AOT13\_RS05500 | 1.77 | AOT13\_RS01255 | 1.48 |
| AOT13\_RS06855 | 1.19 | AOT13\_RS14650 | 1.77 | AOT13\_RS09410 | 1.48 |
| AOT13\_RS13750 | 1.18 | AOT13\_RS15340 | 1.76 | AOT13\_RS02800 | 1.47 |
| AOT13\_RS00475 | 1.18 | AOT13\_RS11170 | 1.76 | AOT13\_RS02420 | 1.46 |
| AOT13\_RS05305 | 1.16 | AOT13\_RS09590 | 1.76 | AOT13\_RS11635 | 1.46 |
| AOT13\_RS15940 | 1.15 | AOT13\_RS07305 | 1.76 | AOT13\_RS05315 | 1.45 |
| AOT13\_RS00285 | 1.14 | AOT13\_RS14645 | 1.76 | AOT13\_RS02790 | 1.44 |
| AOT13\_RS11525 | 1.12 | AOT13\_RS03225 | 1.75 | AOT13\_RS00515 | 1.44 |
| AOT13\_RS06455 | 1.12 | AOT13\_RS14285 | 1.75 | AOT13\_RS16690 | 1.44 |
| AOT13\_RS01665 | 1.12 | AOT13\_RS09415 | 1.74 | AOT13\_RS18065 | 1.43 |
| AOT13\_RS01155 | 1.12 | AOT13\_RS09985 | 1.74 | AOT13\_RS17370 | 1.43 |
| AOT13\_RS19425 | 1.12 | AOT13\_RS07245 | 1.73 | AOT13\_RS08770 | 1.43 |
| AOT13\_RS04860 | 1.11 | AOT13\_RS09915 | 1.73 | AOT13\_RS15955 | 1.43 |
| AOT13\_RS05465 | 1.11 | AOT13\_RS15330 | 1.72 | AOT13\_RS00960 | 1.43 |
| AOT13\_RS07235 | 1.11 | AOT13\_RS02350 | 1.72 | AOT13\_RS12535 | 1.43 |
| AOT13\_RS15330 | 1.11 | AOT13\_RS05480 | 1.72 | AOT13\_RS02805 | 1.42 |
| AOT13\_RS10240 | 1.11 | AOT13\_RS18875 | 1.71 | AOT13\_RS11975 | 1.42 |
| AOT13\_RS02240 | 1.11 | AOT13\_RS01830 | 1.71 | AOT13\_RS02875 | 1.42 |
| AOT13\_RS13420 | 1.10 | AOT13\_RS16245 | 1.70 | AOT13\_RS18885 | 1.42 |
| AOT13\_RS06820 | 1.10 | AOT13\_RS07310 | 1.69 | AOT13\_RS08750 | 1.42 |
| AOT13\_RS06540 | 1.10 | AOT13\_RS03730 | 1.69 | AOT13\_RS17795 | 1.42 |
| AOT13\_RS09885 | 1.09 | AOT13\_RS07255 | 1.69 | AOT13\_RS17010 | 1.41 |
| AOT13\_RS08035 | 1.09 | AOT13\_RS07315 | 1.69 | AOT13\_RS17170 | 1.41 |
| AOT13\_RS10620 | 1.08 | AOT13\_RS02390 | 1.69 | AOT13\_RS02825 | 1.41 |
| AOT13\_RS18385 | 1.08 | AOT13\_RS07275 | 1.68 | AOT13\_RS12540 | 1.41 |
| AOT13\_RS14115 | 1.07 | AOT13\_RS08870 | 1.68 | AOT13\_RS10430 | 1.41 |
| AOT13\_RS14680 | 1.07 | AOT13\_RS14420 | 1.65 | AOT13\_RS14870 | 1.41 |
| AOT13\_RS12835 | 1.06 | AOT13\_RS02365 | 1.64 | AOT13\_RS17835 | 1.41 |
| AOT13\_RS18380 | 1.06 | AOT13\_RS02345 | 1.64 | AOT13\_RS18060 | 1.41 |
| AOT13\_RS03225 | 1.06 | AOT13\_RS06365 | 1.64 | AOT13\_RS12705 | 1.40 |
| AOT13\_RS10160 | 1.06 | AOT13\_RS11470 | 1.63 | AOT13\_RS08505 | 1.40 |
| AOT13\_RS09740 | 1.05 | AOT13\_RS02355 | 1.63 | AOT13\_RS01570 | 1.40 |
| AOT13\_RS14310 | 1.05 | AOT13\_RS09410 | 1.63 | AOT13\_RS18170 | 1.39 |
| AOT13\_RS06650 | 1.05 | AOT13\_RS10645 | 1.63 | AOT13\_RS00315 | 1.39 |
| AOT13\_RS10650 | 1.04 | AOT13\_RS14210 | 1.63 | AOT13\_RS16720 | 1.39 |
| AOT13\_RS06255 | 1.04 | AOT13\_RS02380 | 1.63 | AOT13\_RS08510 | 1.38 |
| AOT13\_RS01160 | 1.03 | AOT13\_RS16800 | 1.63 | AOT13\_RS09915 | 1.38 |
| AOT13\_RS04925 | 1.03 | AOT13\_RS12525 | 1.62 | AOT13\_RS12715 | 1.38 |
| AOT13\_RS14685 | 1.03 | AOT13\_RS02315 | 1.60 | AOT13\_RS08265 | 1.37 |
| AOT13\_RS15335 | 1.03 | AOT13\_RS11140 | 1.59 | AOT13\_RS03080 | 1.37 |
| AOT13\_RS03840 | 1.02 | AOT13\_RS14870 | 1.59 | AOT13\_RS02250 | 1.37 |
| AOT13\_RS10200 | 1.02 | AOT13\_RS02395 | 1.59 | AOT13\_RS01505 | 1.37 |
| AOT13\_RS00280 | 1.02 | AOT13\_RS09565 | 1.58 | AOT13\_RS09985 | 1.37 |
| AOT13\_RS10825 | 1.02 | AOT13\_RS02430 | 1.58 | AOT13\_RS08460 | 1.36 |
| AOT13\_RS18040 | 1.02 | AOT13\_RS02330 | 1.58 | AOT13\_RS02400 | 1.36 |
| AOT13\_RS03655 | 1.01 | AOT13\_RS09290 | 1.58 | AOT13\_RS07240 | 1.36 |
| AOT13\_RS07030 | 1.01 | AOT13\_RS02340 | 1.57 | AOT13\_RS03395 | 1.36 |
| AOT13\_RS06560 | 1.01 | AOT13\_RS07240 | 1.55 | AOT13\_RS08050 | 1.35 |
| AOT13\_RS18375 | 1.01 | AOT13\_RS02305 | 1.55 | AOT13\_RS06320 | 1.35 |
| AOT13\_RS18315 | 1.01 | AOT13\_RS13510 | 1.53 | AOT13\_RS18250 | 1.35 |
| AOT13\_RS12980 | 1.00 | AOT13\_RS02385 | 1.53 | AOT13\_RS10815 | 1.34 |
| AOT13\_RS12510 | 1.00 | AOT13\_RS16915 | 1.53 | AOT13\_RS01545 | 1.34 |
| AOT13\_RS18275 | 1.00 | AOT13\_RS02360 | 1.53 | AOT13\_RS03215 | 1.33 |
| AOT13\_RS03955 | 1.00 | AOT13\_RS03725 | 1.51 | AOT13\_RS01805 | 1.33 |
| AOT13\_RS11190 | 1.00 | AOT13\_RS02320 | 1.50 | AOT13\_RS14210 | 1.33 |
|  |  | AOT13\_RS14410 | 1.50 | AOT13\_RS09835 | 1.32 |
|  |  | AOT13\_RS16620 | 1.49 | AOT13\_RS01555 | 1.32 |
|  |  | AOT13\_RS07760 | 1.49 | AOT13\_RS00335 | 1.32 |
|  |  | AOT13\_RS18705 | 1.49 | AOT13\_RS10620 | 1.32 |
|  |  | AOT13\_RS14275 | 1.49 | AOT13\_RS18700 | 1.32 |
|  |  | AOT13\_RS17015 | 1.48 | AOT13\_RS11455 | 1.31 |
|  |  | AOT13\_RS18880 | 1.48 | AOT13\_RS00340 | 1.31 |
|  |  | AOT13\_RS06820 | 1.47 | AOT13\_RS10715 | 1.30 |
|  |  | AOT13\_RS06910 | 1.47 | AOT13\_RS07280 | 1.29 |
|  |  | AOT13\_RS09910 | 1.47 | AOT13\_RS08080 | 1.29 |
|  |  | AOT13\_RS00950 | 1.46 | AOT13\_RS16055 | 1.29 |
|  |  | AOT13\_RS12685 | 1.45 | AOT13\_RS03015 | 1.29 |
|  |  | AOT13\_RS12695 | 1.44 | AOT13\_RS03730 | 1.29 |
|  |  | AOT13\_RS19565 | 1.44 | AOT13\_RS09980 | 1.28 |
|  |  | AOT13\_RS04980 | 1.44 | AOT13\_RS02540 | 1.28 |
|  |  | AOT13\_RS07350 | 1.44 | AOT13\_RS00740 | 1.27 |
|  |  | AOT13\_RS13665 | 1.43 | AOT13\_RS02395 | 1.26 |
|  |  | AOT13\_RS08865 | 1.42 | AOT13\_RS11605 | 1.25 |
|  |  | AOT13\_RS05950 | 1.42 | AOT13\_RS18175 | 1.25 |
|  |  | AOT13\_RS02325 | 1.40 | AOT13\_RS14415 | 1.25 |
|  |  | AOT13\_RS03270 | 1.40 | AOT13\_RS02410 | 1.25 |
|  |  | AOT13\_RS03060 | 1.40 | AOT13\_RS02795 | 1.25 |
|  |  | AOT13\_RS02310 | 1.40 | AOT13\_RS11185 | 1.24 |
|  |  | AOT13\_RS18165 | 1.40 | AOT13\_RS00345 | 1.24 |
|  |  | AOT13\_RS08260 | 1.39 | AOT13\_RS03725 | 1.24 |
|  |  | AOT13\_RS02810 | 1.39 | AOT13\_RS16050 | 1.23 |
|  |  | AOT13\_RS02830 | 1.39 | AOT13\_RS16830 | 1.23 |
|  |  | AOT13\_RS14655 | 1.38 | AOT13\_RS00475 | 1.23 |
|  |  | AOT13\_RS08255 | 1.38 | AOT13\_RS02405 | 1.22 |
|  |  | AOT13\_RS13735 | 1.34 | AOT13\_RS11540 | 1.22 |
|  |  | AOT13\_RS00880 | 1.34 | AOT13\_RS00330 | 1.22 |
|  |  | AOT13\_RS14790 | 1.34 | AOT13\_RS01550 | 1.22 |
|  |  | AOT13\_RS06800 | 1.33 | AOT13\_RS13430 | 1.21 |
|  |  | AOT13\_RS16920 | 1.33 | AOT13\_RS17780 | 1.21 |
|  |  | AOT13\_RS07865 | 1.33 | AOT13\_RS03155 | 1.21 |
|  |  | AOT13\_RS07270 | 1.31 | AOT13\_RS03500 | 1.20 |
|  |  | AOT13\_RS16725 | 1.31 | AOT13\_RS18310 | 1.20 |
|  |  | AOT13\_RS12315 | 1.31 | AOT13\_RS18705 | 1.20 |
|  |  | AOT13\_RS01255 | 1.31 | AOT13\_RS12330 | 1.20 |
|  |  | AOT13\_RS04595 | 1.31 | AOT13\_RS07285 | 1.20 |
|  |  | AOT13\_RS09315 | 1.30 | AOT13\_RS07875 | 1.20 |
|  |  | AOT13\_RS12530 | 1.30 | AOT13\_RS16980 | 1.19 |
|  |  | AOT13\_RS10820 | 1.30 | AOT13\_RS17685 | 1.19 |
|  |  | AOT13\_RS00340 | 1.29 | AOT13\_RS16615 | 1.19 |
|  |  | AOT13\_RS17800 | 1.29 | AOT13\_RS07290 | 1.19 |
|  |  | AOT13\_RS15775 | 1.29 | AOT13\_RS18695 | 1.18 |
|  |  | AOT13\_RS03230 | 1.28 | AOT13\_RS12580 | 1.18 |
|  |  | AOT13\_RS11480 | 1.28 | AOT13\_RS17360 | 1.18 |
|  |  | AOT13\_RS10170 | 1.28 | AOT13\_RS06820 | 1.18 |
|  |  | AOT13\_RS08960 | 1.26 | AOT13\_RS00455 | 1.18 |
|  |  | AOT13\_RS17020 | 1.26 | AOT13\_RS08075 | 1.17 |
|  |  | AOT13\_RS08860 | 1.26 | AOT13\_RS08920 | 1.17 |
|  |  | AOT13\_RS09165 | 1.25 | AOT13\_RS17675 | 1.16 |
|  |  | AOT13\_RS09155 | 1.25 | AOT13\_RS02390 | 1.16 |
|  |  | AOT13\_RS04925 | 1.25 | AOT13\_RS16150 | 1.16 |
|  |  | AOT13\_RS06795 | 1.25 | AOT13\_RS08045 | 1.16 |
|  |  | AOT13\_RS09170 | 1.25 | AOT13\_RS11100 | 1.15 |
|  |  | AOT13\_RS08085 | 1.25 | AOT13\_RS12570 | 1.15 |
|  |  | AOT13\_RS13390 | 1.25 | AOT13\_RS07895 | 1.15 |
|  |  | AOT13\_RS02400 | 1.25 | AOT13\_RS06515 | 1.15 |
|  |  | AOT13\_RS03800 | 1.24 | AOT13\_RS07050 | 1.15 |
|  |  | AOT13\_RS19535 | 1.24 | AOT13\_RS08785 | 1.15 |
|  |  | AOT13\_RS03805 | 1.23 | AOT13\_RS17665 | 1.15 |
|  |  | AOT13\_RS09135 | 1.23 | AOT13\_RS01145 | 1.14 |
|  |  | AOT13\_RS08965 | 1.23 | AOT13\_RS05945 | 1.14 |
|  |  | AOT13\_RS12625 | 1.22 | AOT13\_RS10635 | 1.14 |
|  |  | AOT13\_RS18865 | 1.22 | AOT13\_RS12680 | 1.13 |
|  |  | AOT13\_RS00840 | 1.22 | AOT13\_RS16985 | 1.13 |
|  |  | AOT13\_RS15425 | 1.21 | AOT13\_RS02350 | 1.13 |
|  |  | AOT13\_RS09150 | 1.21 | AOT13\_RS03085 | 1.13 |
|  |  | AOT13\_RS04805 | 1.21 | AOT13\_RS10700 | 1.13 |
|  |  | AOT13\_RS12515 | 1.20 | AOT13\_RS03240 | 1.12 |
|  |  | AOT13\_RS15475 | 1.20 | AOT13\_RS09355 | 1.12 |
|  |  | AOT13\_RS18115 | 1.19 | AOT13\_RS01295 | 1.12 |
|  |  | AOT13\_RS15345 | 1.19 | AOT13\_RS12180 | 1.12 |
|  |  | AOT13\_RS05990 | 1.19 | AOT13\_RS00620 | 1.11 |
|  |  | AOT13\_RS06825 | 1.19 | AOT13\_RS13595 | 1.11 |
|  |  | AOT13\_RS09115 | 1.18 | AOT13\_RS07470 | 1.11 |
|  |  | AOT13\_RS17750 | 1.18 | AOT13\_RS12080 | 1.11 |
|  |  | AOT13\_RS03235 | 1.18 | AOT13\_RS01575 | 1.11 |
|  |  | AOT13\_RS03005 | 1.17 | AOT13\_RS00925 | 1.11 |
|  |  | AOT13\_RS03220 | 1.17 | AOT13\_RS18630 | 1.11 |
|  |  | AOT13\_RS08010 | 1.17 | AOT13\_RS02385 | 1.11 |
|  |  | AOT13\_RS14685 | 1.17 | AOT13\_RS12770 | 1.10 |
|  |  | AOT13\_RS17835 | 1.17 | AOT13\_RS16165 | 1.10 |
|  |  | AOT13\_RS04560 | 1.17 | AOT13\_RS02370 | 1.10 |
|  |  | AOT13\_RS03500 | 1.17 | AOT13\_RS07860 | 1.09 |
|  |  | AOT13\_RS00885 | 1.17 | AOT13\_RS10625 | 1.09 |
|  |  | AOT13\_RS09980 | 1.15 | AOT13\_RS01175 | 1.09 |
|  |  | AOT13\_RS06830 | 1.15 | AOT13\_RS16140 | 1.09 |
|  |  | AOT13\_RS10825 | 1.15 | AOT13\_RS08965 | 1.08 |
|  |  | AOT13\_RS01570 | 1.15 | AOT13\_RS06815 | 1.08 |
|  |  | AOT13\_RS05965 | 1.15 | AOT13\_RS02245 | 1.08 |
|  |  | AOT13\_RS12030 | 1.14 | AOT13\_RS14085 | 1.08 |
|  |  | AOT13\_RS14290 | 1.14 | AOT13\_RS17800 | 1.08 |
|  |  | AOT13\_RS09145 | 1.13 | AOT13\_RS09600 | 1.08 |
|  |  | AOT13\_RS11020 | 1.13 | AOT13\_RS11470 | 1.08 |
|  |  | AOT13\_RS09175 | 1.13 | AOT13\_RS16795 | 1.07 |
|  |  | AOT13\_RS17560 | 1.12 | AOT13\_RS10165 | 1.07 |
|  |  | AOT13\_RS07875 | 1.12 | AOT13\_RS07310 | 1.07 |
|  |  | AOT13\_RS03115 | 1.12 | AOT13\_RS00805 | 1.07 |
|  |  | AOT13\_RS00555 | 1.11 | AOT13\_RS07215 | 1.07 |
|  |  | AOT13\_RS08245 | 1.11 | AOT13\_RS15995 | 1.06 |
|  |  | AOT13\_RS17370 | 1.11 | AOT13\_RS08255 | 1.06 |
|  |  | AOT13\_RS00345 | 1.11 | AOT13\_RS14680 | 1.06 |
|  |  | AOT13\_RS12035 | 1.11 | AOT13\_RS18230 | 1.05 |
|  |  | AOT13\_RS09120 | 1.11 | AOT13\_RS03495 | 1.05 |
|  |  | AOT13\_RS06920 | 1.11 | AOT13\_RS07035 | 1.04 |
|  |  | AOT13\_RS03530 | 1.11 | AOT13\_RS09415 | 1.04 |
|  |  | AOT13\_RS10190 | 1.10 | AOT13\_RS03180 | 1.04 |
|  |  | AOT13\_RS09600 | 1.10 | AOT13\_RS08455 | 1.04 |
|  |  | AOT13\_RS09215 | 1.10 | AOT13\_RS10630 | 1.04 |
|  |  | AOT13\_RS02645 | 1.10 | AOT13\_RS01170 | 1.03 |
|  |  | AOT13\_RS17860 | 1.10 | AOT13\_RS15775 | 1.03 |
|  |  | AOT13\_RS17565 | 1.10 | AOT13\_RS02355 | 1.02 |
|  |  | AOT13\_RS06980 | 1.09 | AOT13\_RS09315 | 1.02 |
|  |  | AOT13\_RS06515 | 1.09 | AOT13\_RS02375 | 1.02 |
|  |  | AOT13\_RS06350 | 1.09 | AOT13\_RS03195 | 1.02 |
|  |  | AOT13\_RS13385 | 1.09 | AOT13\_RS06410 | 1.02 |
|  |  | AOT13\_RS09180 | 1.09 | AOT13\_RS08870 | 1.02 |
|  |  | AOT13\_RS13410 | 1.08 | AOT13\_RS07785 | 1.01 |
|  |  | AOT13\_RS17580 | 1.08 | AOT13\_RS17690 | 1.01 |
|  |  | AOT13\_RS13395 | 1.08 | AOT13\_RS02365 | 1.01 |
|  |  | AOT13\_RS08250 | 1.07 | AOT13\_RS17640 | 1.00 |
|  |  | AOT13\_RS02240 | 1.07 |  |  |
|  |  | AOT13\_RS19930 | 1.07 |  |  |
|  |  | AOT13\_RS01665 | 1.07 |  |  |
|  |  | AOT13\_RS08805 | 1.07 |  |  |
|  |  | AOT13\_RS02300 | 1.06 |  |  |
|  |  | AOT13\_RS13425 | 1.06 |  |  |
|  |  | AOT13\_RS09210 | 1.06 |  |  |
|  |  | AOT13\_RS15480 | 1.06 |  |  |
|  |  | AOT13\_RS17175 | 1.06 |  |  |
|  |  | AOT13\_RS06595 | 1.06 |  |  |
|  |  | AOT13\_RS03680 | 1.06 |  |  |
|  |  | AOT13\_RS18120 | 1.06 |  |  |
|  |  | AOT13\_RS02555 | 1.05 |  |  |
|  |  | AOT13\_RS18685 | 1.05 |  |  |
|  |  | AOT13\_RS03810 | 1.05 |  |  |
|  |  | AOT13\_RS09260 | 1.05 |  |  |
|  |  | AOT13\_RS18755 | 1.04 |  |  |
|  |  | AOT13\_RS12290 | 1.04 |  |  |
|  |  | AOT13\_RS11570 | 1.04 |  |  |
|  |  | AOT13\_RS05490 | 1.04 |  |  |
|  |  | AOT13\_RS08610 | 1.03 |  |  |
|  |  | AOT13\_RS02275 | 1.02 |  |  |
|  |  | AOT13\_RS00860 | 1.02 |  |  |
|  |  | AOT13\_RS17170 | 1.02 |  |  |
|  |  | AOT13\_RS08615 | 1.02 |  |  |
|  |  | AOT13\_RS05960 | 1.02 |  |  |
|  |  | AOT13\_RS08310 | 1.02 |  |  |
|  |  | AOT13\_RS02765 | 1.01 |  |  |
|  |  | AOT13\_RS13405 | 1.01 |  |  |
|  |  | AOT13\_RS02290 | 1.01 |  |  |
|  |  | AOT13\_RS08265 | 1.00 |  |  |

**Supplementary Table 2. The 71 genes significantly activated by xylose at three different time points.** The data from the heat maps is presented in Supplementary Figure 2c.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **After 4 hours of fermentation** | **After 6 hours of fermentation** | **After 8 hours of fermentation** |
| GeneID | Fold change (4-xylose/4) | Fold change (6-xylose/6) | Fold change (8-xylose/8) |
| AOT13\_RS10610 | 3.48 | 6.05 | 7.29 |
| AOT13\_RS16150 | 2.48 | 11.23 | 2.24 |
| AOT13\_RS10645 | 2.35 | 3.09 | 7.43 |
| AOT13\_RS07875 | 3.71 | 2.18 | 2.29 |
| AOT13\_RS11450 | 118.90 | 11.17 | 3.15 |
| AOT13\_RS07870 | 3.01 | 4.51 | 4.79 |
| AOT13\_RS03335 | 3.59 | 5.26 | 4.15 |
| AOT13\_RS07240 | 6.20 | 2.94 | 2.57 |
| AOT13\_RS07200 | 4.72 | 4.97 | 7.43 |
| AOT13\_RS14275 | 2.52 | 2.80 | 3.70 |
| AOT13\_RS09415 | 2.73 | 3.35 | 2.06 |
| AOT13\_RS15955 | 2.57 | 8.62 | 2.69 |
| AOT13\_RS11800 | 8.53 | 5.19 | 4.07 |
| AOT13\_RS11780 | 11.13 | 6.72 | 4.30 |
| AOT13\_RS08295 | 9.40 | 13.32 | 6.39 |
| AOT13\_RS11795 | 4.36 | 5.40 | 3.05 |
| AOT13\_RS14280 | 2.43 | 3.96 | 4.79 |
| AOT13\_RS10825 | 2.02 | 2.22 | 3.25 |
| AOT13\_RS16140 | 3.23 | 6.31 | 2.12 |
| AOT13\_RS11575 | 107.14 | 12.60 | 8.64 |
| AOT13\_RS00475 | 2.26 | 8.58 | 2.34 |
| AOT13\_RS09985 | 2.84 | 3.34 | 2.58 |
| AOT13\_RS05480 | 5.60 | 3.29 | 5.16 |
| AOT13\_RS07165 | 6.35 | 4.53 | 6.66 |
| AOT13\_RS00770 | 5.50 | 9.34 | 8.35 |
| AOT13\_RS00755 | 8.26 | 41.44 | 6.88 |
| AOT13\_RS07170 | 9.02 | 4.92 | 10.14 |
| AOT13\_RS10605 | 3.25 | 6.91 | 7.00 |
| AOT13\_RS01825 | 6.67 | 7.67 | 4.38 |
| AOT13\_RS07175 | 101.11 | 14.27 | 4.32 |
| AOT13\_RS10615 | 3.30 | 4.39 | 6.05 |
| AOT13\_RS19565 | 3.44 | 2.70 | 4.92 |
| AOT13\_RS05475 | 5.59 | 5.00 | 5.45 |
| AOT13\_RS06405 | 2.85 | 17.83 | 6.21 |
| AOT13\_RS12620 | 4.43 | 9.75 | 15.48 |
| AOT13\_RS15960 | 3.14 | 5.33 | 3.37 |
| AOT13\_RS07195 | 11.46 | 9.57 | 6.74 |
| AOT13\_RS08300 | 9.45 | 15.74 | 5.35 |
| AOT13\_RS11455 | 133.98 | 10.59 | 2.48 |
| AOT13\_RS11790 | 4.31 | 4.28 | 3.27 |
| AOT13\_RS06820 | 2.15 | 2.78 | 2.26 |
| AOT13\_RS07155 | 7.02 | 4.75 | 6.99 |
| AOT13\_RS05470 | 7.04 | 5.68 | 4.13 |
| AOT13\_RS16610 | 9.65 | 9.67 | 3.82 |
| AOT13\_RS11785 | 3.78 | 4.64 | 3.59 |
| AOT13\_RS05305 | 2.23 | 5.55 | 4.94 |
| AOT13\_RS00765 | 8.05 | 67.13 | 7.76 |
| AOT13\_RS03580 | 6.03 | 14.34 | 9.89 |
| AOT13\_RS00760 | 9.37 | 45.05 | 6.28 |
| AOT13\_RS11580 | 91.69 | 13.27 | 12.64 |
| AOT13\_RS01805 | 14.92 | 4.30 | 2.52 |
| AOT13\_RS07255 | 6.47 | 3.23 | 3.02 |
| AOT13\_RS01820 | 15.64 | 26.59 | 3.45 |
| AOT13\_RS07185 | 5.66 | 3.48 | 8.19 |
| AOT13\_RS19825 | 9.50 | 51.39 | 5.69 |
| AOT13\_RS01665 | 2.17 | 2.10 | 3.17 |
| AOT13\_RS01815 | 12.28 | 11.62 | 3.37 |
| AOT13\_RS07865 | 2.32 | 2.52 | 3.69 |
| AOT13\_RS07150 | 4.68 | 3.65 | 4.15 |
| AOT13\_RS07245 | 6.50 | 3.32 | 2.97 |
| AOT13\_RS09980 | 2.39 | 2.22 | 2.43 |
| AOT13\_RS07250 | 6.77 | 4.49 | 3.22 |
| AOT13\_RS19830 | 9.47 | 51.58 | 6.66 |
| AOT13\_RS11590 | 211.77 | 39.18 | 13.27 |
| AOT13\_RS11585 | 173.33 | 54.54 | 14.20 |
| AOT13\_RS07230 | 6.85 | 9.56 | 11.73 |
| AOT13\_RS03225 | 2.08 | 3.36 | 2.98 |
| AOT13\_RS11470 | 15.40 | 3.10 | 2.11 |
| AOT13\_RS07260 | 6.25 | 6.44 | 3.89 |
| AOT13\_RS07160 | 6.63 | 4.12 | 4.54 |
| AOT13\_RS03330 | 3.05 | 4.89 | 3.42 |

**Supplementary Table 3. Operon analysis of 71 xylose activated genes.**

|  |  |
| --- | --- |
| **The activated genes** | **All the genes within the operon** |
| AOT13\_RS10605, AOT13\_RS10610,AOT13\_RS10615 | AOT13\_RS10605, AOT13\_RS10610, AOT13\_RS10615 |
| AOT13\_RS16140, AOT13\_RS16150 | AOT13\_RS16140, AOT13\_RS16145, AOT13\_RS16150 |
| AOT13\_RS10645 | |
| AOT13\_RS07875 | |
| AOT13\_RS11455, AOT13\_RS11450 | AOT13\_RS11450, AOT13\_RS11455, AOT13\_RS11460 |
| AOT13\_RS07865, AOT13\_RS07870 | AOT13\_RS07865, AOT13\_RS07870 |
| AOT13\_RS03330, AOT13\_RS03335 | AOT13\_RS03330, AOT13\_RS03335 |
| AOT13\_RS07240, AOT13\_RS07245, AOT13\_RS07250,  AOT13\_RS07255, AOT13\_RS07260 | AOT13\_RS07240, AOT13\_RS07245, AOT13\_RS07250, AOT13\_RS07255, AOT13\_RS07260 |
| AOT13\_RS07200 | AOT13\_RS07200, AOT13\_RS07205, AOT13\_RS07210 |
| AOT13\_RS14275, AOT13\_RS14280 | AOT13\_RS14275, AOT13\_RS14280, AOT13\_RS14285, AOT13\_RS14290 |
| AOT13\_RS09415 | |
| AOT13\_RS15955, AOT13\_RS15960 | AOT13\_RS15935, AOT13\_RS15940, AOT13\_RS15945, AOT13\_RS15950, AOT13\_RS15955, AOT13\_RS15960, AOT13\_RS15965, AOT13\_RS15970, AOT13\_RS15975 |
| AOT13\_RS11785, AOT13\_RS11790, AOT13\_RS11795, AOT13\_RS11800 | AOT13\_RS11785, AOT13\_RS11790, AOT13\_RS11795, AOT13\_RS11800 |
| AOT13\_RS11780 | |
| AOT13\_RS08295, AOT13\_RS08300 | AOT13\_RS08295, AOT13\_RS08300, AOT13\_RS08305, AOT13\_RS08310 |
| AOT13\_RS10825 | AOT13\_RS10815, AOT13\_RS10820, AOT13\_RS10825 |
| AOT13\_RS11575 | AOT13\_RS11565, AOT13\_RS11570, AOT13\_RS11575 |
| AOT13\_RS00475 | |
| AOT13\_RS09980, AOT13\_RS09985 | AOT13\_RS09975, AOT13\_RS09980, AOT13\_RS09985, AOT13\_RS09990 |
| AOT13\_RS05470, AOT13\_RS05475, AOT13\_RS05480 | AOT13\_RS05470, AOT13\_RS05475, AOT13\_RS05480 |
| AOT13\_RS07150, AOT13\_RS07155, AOT13\_RS07160, AOT13\_RS07165, AOT13\_RS07170 | AOT13\_RS07150, AOT13\_RS07155, AOT13\_RS07160, AOT13\_RS07165, AOT13\_RS07170 |
| AOT13\_RS00765, AOT13\_RS00770 | AOT13\_RS00765, AOT13\_RS00770 |
| AOT13\_RS19825, AOT13\_RS19830, AOT13\_RS00755, AOT13\_RS00760 | AOT13\_RS19825, AOT13\_RS19830, AOT13\_RS00755, AOT13\_RS00760 |
| AOT13\_RS01805, AOT13\_RS01815, AOT13\_RS01820, AOT13\_RS01825 | AOT13\_RS01800, AOT13\_RS01805, AOT13\_RS01810, AOT13\_RS01815, AOT13\_RS01820, AOT13\_RS01825, AOT13\_RS01830 |
| AOT13\_RS07175 | |
| AOT13\_RS19565 | |
| AOT13\_RS06405 | AOT13\_RS06400, AOT13\_RS06405 |
| AOT13\_RS12620 | AOT13\_RS12620, AOT13\_RS12625 |
| AOT13\_RS07185, AOT13\_RS07195 | AOT13\_RS07185, AOT13\_RS07190, AOT13\_RS07195 |
| AOT13\_RS06820 | AOT13\_RS06810, AOT13\_RS06815, AOT13\_RS06820, AOT13\_RS06825, AOT13\_RS06830 |
| AOT13\_RS16610 | |
| AOT13\_RS05305 | |
| AOT13\_RS03580 | AOT13\_RS03565, AOT13\_RS03570, AOT13\_RS03575, AOT13\_RS03580 |
| AOT13\_RS11580 | |
| AOT13\_RS01665 | |
| AOT13\_RS11590, AOT13\_RS11585 | AOT13\_RS11585, AOT13\_RS11590 |
| AOT13\_RS07230 | |
| AOT13\_RS03225 | AOT13\_RS03210, AOT13\_RS03215, AOT13\_RS03220, AOT13\_RS03225, AOT13\_RS03230 |
| AOT13\_RS11470 | AOT13\_RS11465, AOT13\_RS11470, AOT13\_RS11475, AOT13\_RS11480 |

**Supplementary Table 4. The selected 20 promoters with various strengths from the 39 operons.**

|  |  |
| --- | --- |
| Promoters | Sequences (5'-3') |
| P10605 | gaatatcgttttaagatgaagaaatatgtggcggcatttttcgcttccgcaattggaacggcttttggaagatctattgcttgttttttgagataatggaaaatcagtaacaacatgtatggttcagctcttgcaacagttgtttttcactaatatttgttaaatcagtaatttctcaattacttcttctatttgtctttgataaaacttggagccattgatcatcgtctcataggcctctgtttcaactcccatcaagacgcccttttgctttcttttctcccattttcaaaaggtttgatttcaattggagcttttacaaaatcctccccattttcacacccatttttgtattctggacaataaattttttataaaaaatgttaaatatttcgcaattttttatgaaaagattgtgaaatatttcacaaataaaaatattttgctataatgatttatgtaaactggtaaacttatcaagaaaggagttaaaaaatgaa |
| P03330 | tgcagttccgcaaacgcttaagcccggagaaacggcaacaattaacatataaaatgccgctttatccttacagttcatatatttctcttgccttcctgatcttagtggcgattttaatgggctacttcaaagatacacgaatcgcgctcattatcgggccagcttggctcatcttgctcgttgtcgtctattatgcaaaaggcttgcataagcgtcattcttacgcttctgataaaaaaacaagttagcaaaacaaccgctccatccctttttcaggatggagatttttattttttccctccttctttggcttgccatttcttcttcttaatctgttatatatttttatcatcatctaattcatattgttcaacatttcacaaattattcaataatggatagatctaatgatgaaaaaacgtagtattgtatagatgaaagctgttatatacatttttacaaatctgttatataaacagatgcatgggagggaaactgtt |
| P11585 | gaataaatttttatcataaactttgtttgtacactagacaaacaaatttaaccgcattataatttagttgtaagttataaaaatttatggccaatatgaattttagttctatgacactattgtttttcgttgtatttatgatgaatgcttgtggacaggatgttgtaaactgaactgaaatggaagcgttaacaaaaaaggatgtacaggcaggacaagataaaaaataaagataggagctatgatcggcgcccttattatggccagcatcgataatgggatgagcatgatgaacatcgaaaccttttggcaatttattgtaaaaggattgattcttattatcgctgtctggattgatatatcgagtaaaagccgaactaactaattcatcggtgttttgaagattttagttaaaaatgctatttacattttgcgtaaatcccaatcattatgattggtttattctactaataaacatttattaataggaggaatttgcc |
| P19825 | gcggcaaaagcagttgcgcttgtgttgcctgaattaaaaggcaaacttaacggcatggcaatgcgcgtaccaacgccaaatgtgtctgttgtcgaccttgttgcagagctggaaaaagaagtaacggttgaagaagtcaacgcagcattgaaagaagcggcagaaggagaattaaaaggcattttagcttacagcgaagagccgcttgtatcgcgcgactataacggttctactgtatcttcgacaattgatgcgctttcgacaatggttattgaaggaacaatggtgaaagtagtatcttggtacgataacgaaacaggctattctcaccgcgttgttgatcttgcagaatatatcgcatccaaaggcttataattgatgtgattgtgtttatcgcttcatcaagtctataataagaaaatggggagggggagcggggagtgatccccactcctcttcgtttgtcaaaaatcacacaatcaaaaagggggcatagcgcc |
| P08295 | cggcaaattgagcgcgtgaatgaacaatataaaaaactcattgccgctaaccagcggttgaacgaagatacggaaaaatacaataaagagatgaagcgattatctcatattatatggaaataaagtgttttcggcaccaagaggctatattttttgtagcctctttttcttatccgcgaatatgaaacaggtgtaatacaggttttaattaatgtactataacagttttgataaaaaattcacatattataaaaaaataacgttgaatcaaagtaattgacgcataaggaaagaaagtgtaaacttaaaagtgaagatgagagttgtattaatcgaatcagctgaataattgatacagatcttgtaacgcttttttttcatttgcaccgtggaaataagggctgctgttttttattaagattttgggtaaattaatgctgtgtgcatcatgtttacgaatcgctctttattttaaattatgaaaggtagaggtgaataga |
| P11580 | ccagaatattattccggtcaactataaaaacagattttccaacatggaagcagacagttgtgcgccttcctctttcgtggcatgatgctgatgtttcgacaatttacacaaaattacacgactctactaaaggtatactgcatgcggtgggaacgaagctgtaagcatttgatcaggatgtttacggattcaaaaaggcagcttgacatctgcattaactgacaattcatctgaaaactggttgacacgaaaaagcggggctggtacaaaccatttttcgctcttgattctctaaagaagcttcgccagcccctagcttataggccaaacgaagagtgtaggtgcgcagtgccaagagacatgggagggtccggcattataagcgatgcagtgatccatggtgcattacatgtcctctatgaaaactaaatgtaaccgatagtggcagtgaagcgtgcatcgccaatgtaagatatacatatgaagggaggaagaatgcg |
| P07185 | cttggccgcgcgccaaaaggagtcaatgacggcaacggatttgtttttatttcccatatcggggatgtttatccgagcgggctgcttccggtcaaagccggaaacgtccgggaaacgccgctcgcggaaatttaccggaattcgccggttttccaagacttgcgcaaccctgataaatacaaaggaaaatgcggcgtatgcgaattccgctacatttgcggcggttcgcgctcgcgggcgtatgctgtcacgggcgattatttagaaagcgaaccgtattgcatatacattccaaaagcattgcggaaaaagaaaaaacagccattttcgtgaaactggttctcaaacaggagaaccagttttttatgttttgtttcatcatgtgatttttaacaaatatgtgacaccgcgagaatttgtgacaaacatcacaaacattgttttctgatttccgtatgctgaatttagctgcatggctgtaagcaaaaaggaggggtttt |
| P05470 | tgcagaaaggcatcggaaacaacgagcttggcgaaaaagccgaccttgctttccatatggcggtcgctgccgcctcccacaatcccattttagtcagcttaatgaacagcgtatcggaaatgatgatcgaaacaatgcgggaaacgcggcggatttggctgttttccaagcaaacgacaacggaaaagctcctcgaagaacatataaaaattttcaatgccattaaagagaaaaatgccgccgccgcacaagagagaatgcttcagcatttgaccaacgtggagaatgtgcttcataaatatatttattcgcgataagcgtccgctaaaactgccgggcgctttattttactataaaaaagttattgtttttgcaaaattgaataaagtatattttttatcattgaaaatagtatataatgtttataaagtcatcagatgatcagttcacccaatcttttcactgccatagttgatactacttggaagaggggattgaca |
| P07230 | caactagctttgctttgtattcgtataataaaaataaaaaagagaggataggaatgttgcagctgtggaagggctggacagctggaaagcgaaaaccaactgttccaatgccgtttggaagaagtgaagggagaagcggtttgccgaaaaaatggatgtaggtgttgaccgatgggtgatttttgtagaatttagcaaacgattcggcacataaagttgccagcatcattgctttaggcgaattagttgaaagaataaaagaaaaggttgataatatcaatgcataattaagtgaaaattcgcgcgaaatttcttcatcttttcttggacagagaaaggatttcgcaaaatcttcatggcagatagtgagcctgcagccggcaatggtacaggctaaccaaaaaacttgtttggtttaatcgtttgcctgctctgcttgatgcagaaaagaaaaataatggatattacggcagccattaataagaaaaggagagaaaagc |
| P06405 | gagaagcctgtattatttacgtatgatggaaaaacggtgcatcgaaaatatatataaatttgtgacattaagctgctgtgaaagcagcttttttgtttgcatacatttggttttttaatcctttccattgctgtttagtgattattttttatttttttgtataaaatacgagaaaatggttatccgctttgtcgatgatagccattttatttttggaaatttgatccataagtataatgattaaaactatttttacatttataaccgtattaatcatgacaattttgtgacaaacatcacaaattcaccatcttgtcaaagttattttgctatttcttcattgtttgttgataaagtattaagtgcaagaggggttaaaggaggaaaagctgtgtggaaacgtcaagaaaaatggctggtgatagttagttttttagtggcgtttattatgcttctttcgatagttggcagattgttttcataaaaaggaggatgtagcg |
| P11780 | tatcgcaatatttcgaacaccagttgcagaaataaagcatgttgcttccaaatatatgacataaccactttcccataaaaaacgcttaaggccaagattccttaagcgtttttctgtctattgtcattatgatgtccaaaggcagcggcatgggcattagaaagggagcgccatcggggccgccctgcaccaccataaattaatgattgccgggtaggacaaatctataagcatcggcgcaaaatgtcctattcgacgcggaacggatgatccggaagaaaaaagccgccgcattccgttaaacaaatgattgaaatatattaggaaaaacaggagtggtcttttactagataagcgcaagagattgagcatatccggattgataatgtggaatgatctctcaggcagatcttttgcgtgatagtgtgtgatatcgctcacaacgtgtttgcgaaaaacaaggtacaatcatagcaaagaaacaataggagggataaaag |
| P01665 | ctttctgcgggttgatcccatgaacaaaacaaataaatcatattggattagtgtgttttatgttcgtaatcatatcaccatatttatttactgtcaatatcgccgcaaaaatgaatattttttgtcatcttgccgcgcatccgtgcggtgaacttccttgaaatggcttcacatggctgttaaatggcggttttttatggagcgggcgccgtgcagtaggctgccgcgggcagggaggcggccagctggaaaggccggcgcgggtttggtgaaggcctatggatagcttatcagcggaaaaaagcaaaggaaagtgatcaaagcacataagaacatcatgaaaatgaatcagaaaaacaagggagagggaaaatcgccattggcttatgaaggaaggcttcccgtgttaattaatttttaagaatgtctgccgctaatggcgcaaggcgttatgatacaatgaaagtggaaatcatcgaaaagaaagcggggaaaagcgc |
| P07175 | gaaaaaaccggcgtgcggaaacatttcccctgtctgcaaaatcgaaacaatttgttcttttccgttcatatccgttttgtaaattttgatcgttccggaatggatgaaatagacgcgctctaacggatctccttgcataaacacaaacgtccgcggtttataaacgcgcacatgggagatcgatacgagcgattccagttcatgatcggataactcgcggaaaagcggaacatttttcaaccgttctttcatccagccattcgtcattttttcatctccttctgtaattttgacaaaaatgtgacttttgccaatgggaattccttttgccaaaaataaaggggctgcaaggctttccgctatttctatactaccattttatgagtttcttcatatacgagctgtgacataaatcataatatgcgtttgccatgactcacttttttttatttttgtggcgctacaatgagggagaagcaaagataggagggtgatcatgg |
| P11470 | aaaagcggcgcaattatctggaattaaaaccaaacgtgtgacattttgggtgtttgtcaatatgggagtgttggcggcattgtctggtttgattttcgcggctcgcttaaatgcagcgacaccgaaggcagggaatttgtttgaacttgatgcgattgcagcttgctttatcggtggggcgtctgcctacggtggtgttggcacaattagtggagcgattatcggcgggcttgtaatgggggtaataaacaatgggatgtccttgcttggtctgggaattgattggcagcaagcgattaaaggattagtattattagctgcagtagcatttgacatttataataaaaacaaagctgcttagccttcggaagatcgtaatgaaaggaccaagatcaacattgtcttggtcctctttttgcgataaatataatatatacgtacaaataaaaattgttataataaatttactttaatatattatttttaacttgaggtgaact |
| P07200 | cttggccgcgcgccaaaaggagtcaatgacggcaacggatttgtttttatttcccatatcggggatgtttatccgagcgggctgcttccggtcaaagccggaaacgtccgggaaacgccgctcgcggaaatttaccggaattcgccggttttccaagacttgcgcaaccctgataaatacaaaggaaaatgcggcgtatgcgaattccgctacatttgcggcggttcgcgctcgcgggcgtatgctgtcacgggcgattatttagaaagcgaaccgtattgcatatacattccaaaagcattgcggaaaaagaaaaaacagccattttcgtgaaactggttctcaaacaggagaaccagttttttatgttttgtttcatcatgtgatttttaacaaatatgtgacaccgcgagaatttgtgacaaacatcacaaacattgttttctgatttccgtatgctgaatttagctgcatggctgtaagcaaaaaggaggggtttt |
| P16610 | gggaaaaagatccttcgctattaaaaacagtcgtgcaacaccggcgcaattgttttggtgtttatgccaccgtcatcaagacgggagaaattcatgccggtgacgaagtgcatcttttaggttaatggcggcaggatacggacttgtttcggaatatcttaaacaagcaagttcctttcgccgcaaaaatgtaaaagaaagggattcatctgttttttattgacagaaaaactatgttagtttagtatataaactaatgtaatgaaacagaaacagtgattcatttttatgtttgcacatcatcggaggcagaaaagacggggcaacaccgattgaatggggtgcggaatccgcgttggctgtgggcgcttggcggatcataggaaaaagtaaacgtgtgtttgcatatgtcatgtcccagagataaactttttatacagccgctcagaggttgatccgcctgtttaggcggcatactaaaaaggttgcagaaggaatga |
| P07150 | accaagtacagtgccataatccatcaggccatatttttgaaacactgcctgcccgccgataatcgtttcttttgtcatcaacacgtcgccgctttcgctccgcacttctttcgggcgcggcgccatttctttaaaaatccaatacccgccgacaagcagaacggtaaaactgattaaaatcgtaaaaattaatattgatttaaggaaactattttgtgtccgccgttcgggacggaaagacggacgaacggaccgattaacctccatccatgatcaccctcctatctttgcttctccctcattgtagcgccacaaaaataaaaaaaagtgagtcatggcaaacgcatattatgatttatgtcacagctcgtatatgaagaaactcataaaatggtagtatagaaatagcggaaagccttgcagcccctttatttttggcaaaaggaattcccattggcaaaagtcacatttttgtcaaaattacagaaggagatgaaaaa |
| P11785 | acaaataaccaagcgcaaagccaaccgcaaataacgaagaggactcccaagaaatgacaagagcaataatcccccacataacaagcgaatgagtcatgccgcgatggccgaacgcttcttttactttattcgatacgccaaacgaacgccgcccgatgtacgatgtcggctcgtcaatatccggaatcaaactgccgacgacaattcccgccgtatagcttaccgtaaaagaaagcggtgtttgtgccgctgctgttgctcctaatagcaatgacgtaacaatatgactatggtatcgcaaagtgacctcctgcatataaaaattttttctttattatagcacatacaaagaatgtttgttcgttttttatatgttcatactttttcgtcatcgtttgacagatttgtgacagccaaggcaaatgtgacaaaccgcacatctctttattttcattatggctatagtaaaattacacaaattgcgaaaggagtgaaacaaa |
| P01805 | acttttgacaaacgacttcgtcagttcaatcgtcgctgaacagtctgcatcaacgatcatactgttttctttattgaccactaatccgatgaaaaatgctttatattgctgggtaataggattgtttgaaggcgcttttgcgtctccgatgatatatacagtattattctcaaacatgctaatcctccaaccagatacagctattgcgaggggcatttatgatggactcataaatgttgctcgcaatatgtatgttctcttgtttattatactgaatagtaagaaaatagtcgataattacaacttttctagaaatagttctggtatagggataacattcattatggtgtagaaaataaaatcggatttttacacaatttcaaggatgcaaaaataacatcagaaagttaaaatcatttttatttatctacttgtgaattttcgggcattttagtatactatatgtaaccggttacatataaaaatggggacgaatgatg |
| P03225 | ggttagcggcatcacagatttatcgttaaattcgatcgatgtccttactggcattgaaacattaaaaatttgtgttgcttatcgttataaagggaaagtgcttgaagagtttccggcaagtttaaaagtgctggcagaatgtgagccgatttacgaagagctgccaggatggtcagaagatattaccggtgttaagagcttggatgaactgccggctaacgcccgccattatgtggaacgcatttcgcaattaacgggcattccattatcgattttctctgtcggtccagaccgttcgcaaacaaacgttgttcgcagcgtatatgcgtaaaatagcgtaaatagtataataaaagcgtagatgcagcgatgtatctatgcttttctttttgtttcgcctccaattggcaaacggtaatgagtgaattcatttcaataacatgataaattaataatgtacttattttcgattccatcgcaaaggaaggatgtgaaacagg |
|  |  |

**Supplementary table 5. Riboflavin yields of the 27 engineered strains.**

|  |  |
| --- | --- |
| Strains | Riboflavin (mg/L) |
| DSM2542-DCall-SSS | 210.1±4.3 |
| DSM2542-DCall-SMS | 193.5±2.1 |
| DSM2542-DCall-SWS | 166.5±2.6 |
| DSM2542-DCall-MSS | 273.0±3.2 |
| DSM2542-DCall-MMS | 244.2±5.5 |
| DSM2542-DCall-MWS | 210.3±3.7 |
| DSM2542-DCall-WSS | 189.2±2.5 |
| DSM2542-DCall-WMS | 171.6±1.4 |
| DSM2542-DCall-WWS | 153.4±3.0 |
| DSM2542-DCall-SSM | 90.1±1.8 |
| DSM2542-DCall-SMM | 86.7±1.8 |
| DSM2542-DCall-SWM | 83.3±0.5 |
| DSM2542-DCall-MSM | 148.5±1.5 |
| DSM2542-DCall-MMM | 133.4±3.2 |
| DSM2542-DCall-MWM | 126.9±1.1 |
| DSM2542-DCall-WSM | 95.4±2.0 |
| DSM2542-DCall-WMM | 86.4±1.7 |
| DSM2542-DCall-WWM | 82.5±0.7 |
| DSM2542-DCall-SSW | 72.8±1.4 |
| DSM2542-DCall-SMW | 68.4±0.3 |
| DSM2542-DCall-SWW | 63.8±1.4 |
| DSM2542-DCall-MSW | 99.6±2.3 |
| DSM2542-DCall-MMW | 95.2±3.0 |
| DSM2542-DCall-MWW | 79.8±3.0 |
| DSM2542-DCall-WSW | 72.8±1.9 |
| DSM2542-DCall-WMW | 69.6±2.3 |
| DSM2542-DCall-WWW | 53.1±0.9 |

**Supplementary table 6. Riboflavin yields of the three engineered strains using the corn cob hydrolysate as a carbon source.**

|  |  |  |
| --- | --- | --- |
| Strains | Corn cob hydrolysate concentration | Riboflavin (mg/L) |
| DSM2542 Rib-Gtg | 0.5% | 23.0 ± 2.5 |
| DSM2542-DCrib | 0.5% | 51.9 ± 4.0 |
| DSM2542-DCall-MSS | 0.5% | 121.0 ± 8.0 |
| DSM2542 Rib-Gtg | 1.0% | 15.5 ± 1.5 |
| DSM2542-DCrib | 1.0% | 31.0 ± 2.0 |
| DSM2542-DCall-MSS | 1.0% | 69.5 ± 2.5 |

**Supplementary Table 7. Strains and plasmids used in this study.**

|  |  |  |
| --- | --- | --- |
| **Name** | **Relevant characteristics** | **Reference** |
| **Strains** |  |  |
| *E. coli* JM109 | General cloning host for plasmid manipulation | Novagen |
| *E. coli* Top10 | General cloning host | Novagen |
| *Saccharomyces cerevisiae* BJ5464-NpgA | Yeast homologous recombination | 1 |
| *Geobacillus thermoglucosidasius* DSM 2542 |  | CGMCC 1.3473 |
| DSM2542 Rib-Gtg | Overexpression riboflavin gene cluster from *G. thermoglucosidasius* DSM 2542 using *pldh* promoter in *G. thermoglucosidasius* DSM 2542 | 2 |
| DSM2542-n | Controlled the expression of *sfgfp* by selected promoters in *G. thermoglucosidasius* DSM 2542, n indicates RS10605, RS03330, RS11585, RS19825, RS08295, RS11580, RS07185, RS05470, RS07230, RS06405, RS11780, RS01665, RS07175, RS11470, RS07200, RS16610, RS07150, RS11785, RS01805 and RS03225 promoters, respectively | This study |
| DSM2542-DCrib | Overexpression riboflavin gene cluster from *G. thermoglucosidasius* DSM 2542 using RS11585 promoter in *G. thermoglucosidasius* DSM 2542 | This study |
| DSM2542-DCall-ijk | Combinatorial overexpression *prs* gene, purine cluster and riboflavin cluster with various strengths, i, j and k indicate W, M and S, respectively | This study |
| **Plasmids** |  |  |
| XW55 | Ampr, *E. coli*-yeast shuttle expression vector | 1 |
| pUCG3.8-pldh | Kanr, containing *pldh* promoter | Laboratory stock |
| pUCG18-sfgfp | Kanr, containing the *sfgfp* reporter gene | Laboratory stock |
| pUCG18-n-sfgfp | Kanr, derived from pUCG18-sfgfp, n indicates RS10605, RS03330, RS11585, RS19825, RS08295, RS11580, RS07185, RS05470, RS07230, RS06405, RS11780, RS01665, RS07175, RS11470, RS07200, RS16610, RS07150, RS11785, RS01805 and RS03225, respectively. | This study |
| pUCG18-RS11585-Gtribo | Kanr, derived from pUCG18-RS11585-sfgfp, controlling the expression of riboflavin gene cluster of *G. thermoglucosidasius* DSM 2542 by the promoter RS11585 | This study |
| XW55-P15 | Ampr, derived from XW55 | This study |
| p*i*prs-p*j*purine-p*k*riboflavin | Kanr, derived from XW55-P15, combinatorial expression of *prs* gene, purine cluster and riboflavin cluster, *i*, *j* and *k* indicate S, M and W, respectively | This study |

**Supplementary Table 8. Primers and oligonucleotides used in this study.**

|  |  |
| --- | --- |
| Name of the primer | Oligonucleotide sequence (5ʹ−3ʹ) |
| 11585Gtrib-F | aataggaggaatttgccatgcgaaacgatgaacaatatatg |
| 11585Gtrib-R | actcattaggcaccccaggcttacaactcacatttatcc |
| 11585Gtrib-GJ-F | ttggataaatgtgagttgtaagcctggggtgcctaatgag |
| 11585Gtrib-GJ-R | atatattgttcatcgtttcgcatggcaaattcctcctattaat |
| RS10605-F | aacgacggccagtgccaagcttgaatatcgttttaagatgaag |
| RS10605-R | acagctcttcgcctttacgcatttcattttttaactcctttc |
| pUCG18-RS10605-F | aaggagttaaaaaatgaaatgcgtaaaggcgaagagctg |
| pUCG18-RS10605-R | cttcatcttaaaacgatattcaagcttggcactggccgtcgtt |
| RS03330-F | acgacggccagtgccaagctttgcagttccgcaaacgcttaag |
| RS03330-R | cagctcttcgcctttacgcataacagtttccctcccatgcat |
| pUCG18-RS03330-F | atgcatgggagggaaactgttatgcgtaaaggcgaagagctg |
| pUCG18-RS03330-R | cttaagcgtttgcggaactgcaaagcttggcactggccgtcgt |
| RS11585-F | acggccagtgccaagcttgaataaatttttatcataaac |
| RS11585-R | agctcttcgcctttacgcatggcaaattcctcctattaa |
| pUCG18-RS11585-F | ttaataggaggaatttgccatgcgtaaaggcgaagagc |
| pUCG18-RS11585-R | atgataaaaatttattcaagcttggcactggccgtcg |
| RS19825-F | aacgacggccagtgccaagcttgcggcaaaagcagttgcgcttg |
| RS19825-R | cagctcttcgcctttacgcatggcgctatgcccccttt |
| pUCG18-RS19825-F | aaagggggcatagcgccatgcgtaaaggcgaagagctg |
| pUCG18-RS19825-R | caagcgcaactgcttttgccgcaagcttggcactggccgtcgtt |
| RS08295-F | acggccagtgccaagcttcggcaaattgagcgcgtgaatg |
| RS08295-R | cagctcttcgcctttacgcattctattcacctctacctt |
| pUCG18-RS08295-F | aaggtagaggtgaatagaatgcgtaaaggcgaagagctg |
| pUCG18-RS08295-R | cattcacgcgctcaatttgccgaagcttggcactggccgt |
| RS11580-F | acgacggccagtgccaagcttccagaatattattccggtc |
| RS11580-R | tcttcgcctttacgcatcgcattcttcctcccttc |
| pUCG18-RS11580-F | tgaagggaggaagaatgcgatgcgtaaaggcgaagagc |
| pUCG18-RS11580-R | accggaataatattctggaagcttggcactggccgtcg |
| RS07185-F | acgacggccagtgccaagcttcttggccgcgcgccaaaagg |
| RS07185-R | acagctcttcgcctttacgcataaaacccctcctttttgc |
| pUCG18-RS07185-F | aagcaaaaaggaggggttttatgcgtaaaggcgaagagc |
| pUCG18-RS07185-R | ttggcgcgcggccaagaagcttggcactggccgtcg |
| RS05470-F | acgacggccagtgccaagctttgcagaaaggcatcggaaac |
| RS05470-R | agctcttcgcctttacgcattgtcaatcccctcttccaag |
| pUCG18-RS05470-F | acttggaagaggggattgacaatgcgtaaaggcgaagagc |
| pUCG18-RS05470-R | ttccgatgcctttctgcaaagcttggcactggccgtc |
| RS07230-F | acggccagtgccaagcttcaactagctttgctttgtattc |
| RS07230-R | agctcttcgcctttacgcatgcttttctctccttttc |
| pUCG18-RS07230-F | aagaaaaggagagaaaagcatgcgtaaaggcgaagagctg |
| pUCG18-RS07230-R | acaaagcaaagctagttgaagcttggcactggccgtc |
| RS06405-F | acgacggccagtgccaagcttgagaagcctgtattatttacg |
| RS06405-R | cagctcttcgcctttacgcatcgctacatcctccttt |
| pUCG18-RS06405-F | aaaggaggatgtagcgatgcgtaaaggcgaagagctg |
| pUCG18-RS06405-R | cgtaaataatacaggcttctcaagcttggcactggccgtcgt |
| RS11780-F | acgacggccagtgccaagctttatcgcaatatttcgaacac |
| RS11780-R | cagctcttcgcctttacgcatcttttatccctcctattgtt |
| pUCG18-RS11780-F | aacaataggagggataaaagatgcgtaaaggcgaagagctg |
| pUCG18-RS11780-R | gtgttcgaaatattgcgataaagcttggcactggccgtcgt |
| RS01665-F | acgacggccagtgccaagcttctttctgcgggttgatcccatg |
| RS01665-R | cagctcttcgcctttacgcatgcgcttttccccgctttctt |
| pUCG18-RS01665-F | aagaaagcggggaaaagcgcatgcgtaaaggcgaagagctg |
| pUCG18-RS01665-R | catgggatcaacccgcagaaagaagcttggcactggccgtcgt |
| RS07175-F | aacgacggccagtgccaagcttgaaaaaaccggcgtgcgg |
| RS07175-R | cagctcttcgcctttacgcatccatgatcaccctcctatct |
| pUCG18-RS07175-F | agataggagggtgatcatggatgcgtaaaggcgaagagctg |
| pUCG18-RS07175-R | ccgcacgccggttttttcaagcttggcactggccgtcgtt |
| RS11470-F | acgacggccagtgccaagcttaaaagcggcgcaattatctg |
| RS11470-R | cagctcttcgcctttacgcatagttcacctcaagtt |
| pUCG18-RS11470-F | aacttgaggtgaactatgcgtaaaggcgaagagctg |
| pUCG18-RS11470-R | cagataattgcgccgcttttaagcttggcactggccgtcgt |
| RS07200-F | acgacggccagtgccaagcttcttggccgcgcgccaaaagg |
| RS07200-R | cagctcttcgcctttacgcataaaacccctcctttttgctt |
| pUCG18-RS07200-F | aagcaaaaaggaggggttttatgcgtaaaggcgaagagctg |
| pUCG18-RS07200-R | ccttttggcgcgcggccaagaagcttggcactggccgtcgt |
| RS16610-F | acgacggccagtgccaagcttgggaaaaagatccttcgc |
| RS16610-R | agctcttcgcctttacgcattcattccttctgcaacc |
| pUCG18-RS16610-F | aaggttgcagaaggaatgaatgcgtaaaggcgaagagc |
| pUCG18-RS16610-R | agcgaaggatctttttcccaagcttggcactggccgtcg |
| RS07150-F | aacgacggccagtgccaagcttaccaagtacagtgccataatc |
| RS07150-R | cagctcttcgcctttacgcattttttcatctccttctgt |
| pUCG18-RS07150-F | acagaaggagatgaaaaaatgcgtaaaggcgaagagctg |
| pUCG18-RS07150-R | gattatggcactgtacttggtaagcttggcactggccgtcgtt |
| RS11785-F | acgacggccagtgccaagcttacaaataaccaagcgcaaag |
| RS11785-R | agctcttcgcctttacgcattttgtttcactcctttcgc |
| pUCG18-RS11785-F | aaggagtgaaacaaaatgcgtaaaggcgaagagctg |
| pUCG18-RS11785-R | ttgcgcttggttatttgtaagcttggcactggccgtcg |
| RS01820-F | acgacggccagtgccaagcttacttttgacaaacgacttc |
| RS01820-R | agctcttcgcctttacgcatcatcattcgtccccatttttat |
| pUCG18-RS01820-F | ataaaaatggggacgaatgatgatgcgtaaaggcgaagagc |
| pUCG18-RS01820-R | acgaagtcgtttgtcaaaagtaagcttggcactggccgtcg |
| RS03225-F | acgacggccagtgccaagcttggttagcggcatcacag |
| RS03225-R | agctcttcgcctttacgcatcctgtttcacatccttcc |
| pUCG18-RS03225-F | aaggaaggatgtgaaacaggatgcgtaaaggcgaagagctg |
| pUCG18-RS03225-R | tctgtgatgccgctaaccaagcttggcactggccgtcg |
| P15-F | attctactttttgctcccgcgctagcggagtgtatactg |
| P15-R | ttcgagctcggtaccctcgagacaacttatatcgtatgggg |
| XW55-P15-GJ-F | agccccatacgatataagttgtctcgagggtaccgagctcg |
| XW55-P15-GJ-R | agtatacactccgctagcgcgggagcaaaaagtagaatatt |
| JM-F | tggataaatgtgagttgtaagcgctagcggagtgtatactg |
| JM-R | agatcaaaggatcttctcgtgcacccaactgatcttc |
| ZLGJ-F | aagatcagttgggtgcacgagaagatcctttgatcttttc |
| ZLGJ-R | tcaaaatggtatgcgttttgac |
| S-zl-F | atatatagtggatgtgtcaaaacgcataccattttgagaataaatttttatcataaac |
| S-pr-R | atgcaaacaattttaaattatgatgacattcagacatggcaaattcctcctattaat |
| prs-F | atgtctgaatgtcatcataa |
| prs-R | ttagtcaaacaatacactg |
| S-pr-F | atgaaatgaagtctgtcagtgtattgtttgactaagaataaatttttatcataaac |
| S-pu-R | ttgacttcccataatcactccaacgagcggctgcacggcaaattcctcctattaat |
| purine-F | gtgcagccgctcgttggagtg |
| purine-R | ttattgctcttgcatttgtg |
| S-pu-F | tttcttccgcacatacacaaatgcaagagcaataagaataaatttttatcataaac |
| S-Rb-R | tcgatcgccaggcgcatatattgttcatcgtttcgcatggcaaattcctcctattaat |
| Rb-F | atgcgaaacgatgaacaatatatg |
| Rb-R | tacactccgctagcgcttacaactcacatttatcc |
| M-zl-F | atatatagtggatgtgtcaaaacgcataccattttgagggaaaaagatccttcgc |
| M-pr-R | tgcaaacaattttaaattatgatgacattcagacattcattccttctgcaacctt |
| M-pr-F | atatgaaatgaagtctgtcagtgtattgtttgactaagggaaaaagatccttcgc |
| M-pu-R | ttgacttcccataatcactccaacgagcggctgcactcattccttctgcaacctt |
| M-pu-F | tttcttccgcacatacacaaatgcaagagcaataagggaaaaagatccttcgc |
| M-Rb-R | tcgatcgccaggcgcatatattgttcatcgtttcgcattcattccttctgcaacctt |
| W-zl-F | atatatagtggatgtgtcaaaacgcataccattttgaggttagcggcatcacaga |
| W-pr-R | tgcaaacaattttaaattatgatgacattcagacatcctgtttcacatccttcctttg |
| W-pr-F | atatgaaatgaagtctgtcagtgtattgtttgactaaggttagcggcatcacaga |
| W-pu-R | attgacttcccataatcactccaacgagcggctgcaccctgtttcacatccttcc |
| W-pu-F | tttcttccgcacatacacaaatgcaagagcaataaggttagcggcatcacaga |
| W-Rb-R | atcgccaggcgcatatattgttcatcgtttcgcatcctgtttcacatccttcctttg |

**SUPPLEMENTARY REFERENCES**

1. Yao, Y. *et al.* Catalase involved in oxidative cyclization of the tetracyclic ergoline of fungal ergot alkaloids. *J. Am. Chem. Soc.* **141**, 17517–17521 (2019).

2. Yang, Z. *et al.* Engineering thermophilic *Geobacillus thermoglucosidasius* for riboflavin production. *Microb. Biotechnol.* 1751-7915.13543 (2020).