**Microbiome and Volatile Metabolic Profile of Acetic Acid Fermentation using Multiple Starters for Traditional Grain Vinegar**

Haram Kong, Sun Hee Kim, Woo Soo Jeong, So–Young Kim, Soo–Hwan Yeo\*

*Fermented and Processed Food Science Division, Department of Agrofood Resources, NIAS, RDA, Wanju, 55365, Republic of Korea*

**Supplementary files:**

**Table 1.** Fermentation efficiency according to concentration of ethanol and initial pH

**Table 2.** Fermentation efficiency under multiple starters according to initial pH and fermentation period

**Table 3.** Volatile compounds according to fermentation period using *Acetobacter ascendens* GV-8 (A) and *A. ascendens* GV-12 (B) (Unit: Area%)

**Table 4.** The volatile compound according to fermentation period using *Acetobacter ascendens* GV–8 (A) and *Acetobacter pasteurianus* GV–22 (D) (Unit: Area%)

**Table 5.** The volatile compound according to fermentation period using *A. ascendens* GV–8 (A), *A. ascendens* GV–12 (B), *A. pasteurianus* GV–17 (C), and *A. pasteurianus* GV–22 (D) (Unit: Area%)

**Table 6.** Alpha diversity analysis under multiple starters and fermentation temperature

**Table 1.** Fermentation efficiency according to concentration of ethanol and initial pH.

|  |  |  |
| --- | --- | --- |
| **Fermented condition** | **Strains** | **Efficiency (%) according to the fermentation period (days)** |
| **3** | **6** | **9** | **12** | **15** |
| Concentration of EtOH | 5% | GV–5 | 14.72±2.611,a | 35.12±7.36a | 50.61±5.68ab | 60.12±3.99a | 67.02±2.00a |
| GV–8 | 13.96±1.38a | 32.67±4.30a | 53.53±5.06ab | 59.66±0.31a | 62.12±2.15ab |
| GV–12 | 14.42±1.54a | 29.45±3.53a | 43.40±2.61b | 62.58±1.84a | 67.79±0.15a |
| GV–16 | 15.95±2.45a | 30.21±10.59a | 46.78±5.98ab | 59.36±6.60a | 65.34±3.38a |
| GV–17 | 14.26±3.53a | 29.14±8.90a | 44.63±9.51ab | 54.14±8.13a | 66.26±2.30a |
| GV–22 | 15.03±1.23a | 32.67±2.30a | 54.91±3.22a | 61.35±1.69a | 63.34±0.31ab |
| 8% | GV–5 | 1.34±1.06cd | 7.38±2.11c | 18.12±4.60d | 27.32±2.59c | 40.55±3.36ef |
| GV–8 | 0.96±0.77d | 6.90±2.30c | 17.16±3.45d | 26.36±2.69c | 37.96±4.79f |
| GV–12 | 4.51±0.68bc | 15.34±2.30bc | 27.51±5.66cd | 42.27±5.28b | 57.32±3.93bc |
| GV–16 | 4.51±0.29bc | 14.95±1.73bc | 25.79±3.74cd | 32.59±1.34c | 46.01±2.97de |
| GV–17 | 5.66±1.63b | 19.27±5.85b | 32.11±10.16c | 40.84±8.25b | 54.26±10.36c |
| GV–22 | 1.63±0.96cd | 6.33±0.39c | 19.65±2.01d | 32.50±1.92c | 51.19±4.60cd |
| Initial pH | pH 3.0 | GV–5 | 0.51±0.17e | 3.73±0.47h | 30.42±6.6f | 32.41±6.60g | 30.11±7.06g |
| GV–8 | 1.12±0.38e | 65.39±1.87cd | 78.12±3.09c | 74.59±4.31d | 66.77±1.72de |
| GV–12 | 0.46±0.46e | 51.38±9.83de | 65.80±10.9d | 62.27±5.70e | 57.06±4.94ef |
| GV–16 | 0.01±0.01e | 38.9±8.92ef | 55.78±6.02e | 58.84±1.04ef | 56.08±8.92ef |
| GV–17 | 0.87±0.78e | 30.47±10.60fg | 53.93±10.30e | 53.63±2.26f | 51.94±13.51f |
| GV–22 | 0.31±0.40e | 21.58±2.80g | 38.14±0.76f | 36.61±2.80g | 30.47±11.20g |
| pH 4.0 | GV–5 | 24.08±0.41c | 103.53±0.85a | 107.67±0.15b | 106.75±3.45b | 103.68±0.85a |
| GV–8 | 45.65±2.62a | 105.32±21.78a | 123.11±2.61a | 115.59±5.83a | 88.91±4.45b |
| GV–12 | 33.44±1.38b | 109.66±3.99a | 117.79±6.75ab | 115.03±7.67a | 110.43±8.13a |
| GV–16 | 16.87±1.53d | 70.25±10.28c | 86.20±2.61c | 85.89±2.15c | 82.67±1.69bc |
| GV–17 | 15.95±1.53d | 69.33±2.77c | 86.96±4.30c | 84.97±1.84c | 73.31±3.84cd |
| GV–22 | 17.79±3.07d | 87.12±2.15b | 113.04±1.38ab | 108.90±3.38ab | 107.52±5.37a |

1 Values are presented as means ± standard deviation. Different letters in the same row show significant differences (*P* < 0.05) in Duncan’s multiple range test.

**Table 2.** Fermentation efficiency under multiple starters according to initial pH and fermentation period.

|  |  |  |
| --- | --- | --- |
| **Initial pH** | **Strains1** | **Efficiency (%) according to the fermentation period (days)** |
| **3** | **6** | **9** | **12** | **15** | **18** | **21** | **24** | **27** |
| pH 3.0 | AB | 0.64±0.212,de | 3.14±1.18de | 10.58±0.49d | 31.11±2.45b | 40.33±0.70b | 45.37±0.94cde | 56.56±2.34b | 54.72±0.77b | 58.77±0.39c |
| AC | 0.97±0.90cde | 4.22±0.19bc | 17.31±0.66a | 40.79±5.86a | 47.74±4.15a | 57.02±2.65a | 64.64±2.98a | 57.95±1.36a | 63.91±2.23b |
| AD | 0.35±0.19e | 1.28±0.21g | 10.52±0.65d | 27.74±2.15bcd | 35.61±0.43cd | 42.55±4.25e | 50.60±1.99d | 42.06±2.48e | 54.97±0.85d |
| BC | 0.22±0.10e | 2.18±0.65f | 8.21±0.37ef | 23.89±0.37de | 32.49±1.02e | 47.37±2.62bc | 55.54±2.25bc | 51.55±0.55c | 61.81±0.70bc |
| BD | 0.97±0.99cde | 3.10±0.28e | 7.10±0.21gh | 25.18±2.82cde | 34.03±2.03de | 43.13±2.61de | 51.80±2.60cd | 47.62±1.01d | 55.06±0.11d |
| CD | 0.66±0.34de | 2.04±0.38fg | 8.74±0.28e | 27.73±1.53bcd | 40.03±0.43b | 50.84±1.92b | 63.27±1.31a | 58.29±0.21a | 59.82±0.65c |
| ABCD | 0.78±0.53ccde | 2.11±0.49fg | 8.52±0.28e | 28.44±2.03bc | 36.43±0.49c | 48.54±1.11bc | 63.60±3.78a | 58.01±0.64a | 61.14±1.61bc |
| pH 4.0 | AB | 1.30±0.28bcd | 2.96±0.28e | 6.53±0.49h | 12.92±0.10f | 15.87±0.38h | 22.08±0.95g | 30.35±1.69g | 31.93±1.23f | 42.48±0.46f |
| AC | 2.13±0.65ab | 3.05±0.28e | 6.78±0.36h | 13.56±0.53f | 14.91±0.21h | 21.31±1.59g | 25.46±1.84h | 29.29±1.54g | 38.34±4.14g |
| AD | 2.66±0.21a | 5.48±0.28a | 14.33±0.38b | 26.81±0.28cd | 31.98±0.46e | 46.98±2.62bcd | 59.05±2.92b | 58.28±0.92a | 72.55±3.53a |
| BC | 1.58±0.00bc | 3.61±0.37cde | 7.72±0.39fg | 16.52±1.21f | 18.73±0.64g | 30.23±1.87f | 37.73±3.07f | 42.48±0.92e | 58.13±3.53cd |
| BD | 2.16±0.32ab | 3.95±0.28bcd | 11.26±0.28c | 22.63±0.37e | 25.22±0.49f | 32.35±1.50f | 40.49±3.22ef | 47.09±0.46d | 61.20±2.15bc |
| CD | 0.69±0.32cde | 1.37±0.28fg | 6.65±0.10h | 14.64±0.57f | 15.50±0.65h | 22.64±2.17g | 26.69±2.46gh | 28.83±2.92g | 38.19±0.15g |
| ABCD | 1.33±0.42bcd | 4.47±0.28b | 10.31±0.19d | 21.68±0.93e | 25.62±0.49f | 33.85±1.82f | 42.64±1.54e | 47.70±2.15d | 61.04±0.92bc |

1 Symbols: A, *Acetobacter ascendens* GV–8; B, *A. ascendens* GV–12; C, *A. pasteurianus* GV–17; D, *A. pasteurianus* GV–22.

2 Values are presented as means ± standard deviation. Different letters in the same row show significant differences (*P* < 0.05) in Duncan’s multiple range test.

**Table 3.** Volatile compounds according to fermentation period using *Acetobacter ascendens* GV-8 (A) and *A. ascendens* GV-12 (B) (Unit: Area%)

|  |  |  |  |
| --- | --- | --- | --- |
| **Temp.1** | **20℃** |  | **30℃** |
| **Period (days)****Compounds** | **0** | **12** | **18** | **27** |  | **0** | **12** | **18** | **27** |
| Acetic acid, ethyl ester | 71.89±2.452,j | 81.85±2.02hi | 79.15±0.79i | 81.27±2.41hi |  | 67.29±2.16k | 78.93±1.68i | 84.51±1.32gh | 16.18±2.45m |
| Ethanol | 14.61±0.53de | 10.9±0.86fgh | 10.32±0.42h | 6.75±0.31i |  | 17.27±0.74bc | 9.47±0.50h | 6.49±0.47i | ND3 |
| 2–Methyl–1–propanol | 0.02±0.00de | 0.04±0.01cde | 0.03±0.02cde | 0.06±0.02cd |  | 0.01±0.00e | 0.04±0.00cde | 0.03±0.01cde | 0.04±0.01cde |
| 2–Octanone | 0.02±0.00e | 0.06±0.01bc | 0.05±0.02cd | 0.08±0.01b |  | ND | 0.02±0.01e | 0.03±0.01cde | 0.04±0.00cde |
| 2–Methyl–1–butanol | 0.02±0.00h | 0.03±0.00gh | 0.02±0.00h | 0.05±0.02cdefg |  | ND | 0.04±0.01efgh | 0.04±0.01efgh | 0.08±0.02b |
| Octanal | 0.07±0.01de | 0.08±0.02de | 0.09±0.01cde | 0.07±0.01de |  | 0.07±0.01de | 0.11±0.03cde | 0.15±0.03bcd | 0.06±0.01de |
| 2–Hexadecanol | 0.07±0.00cd | 0.17±0.03bc | 0.18±0.05b | 0.17±0.04bc |  | 0.16±0.05bcd | 0.13±0.05bcd | 0.16±0.04bcd | 0.15±0.05bcd |
| 6–Methyl–5–hepten–2–one | 0.05±0.00cdef | 0.02±0.00ef | 0.02±0.01def | 0.01±0.00f |  | 0.08±0.01c | 0.05±0.01cdef | 0.07±0.02cde | 0.08±0.02c |
| Acetic acid, 2–ethylhexyl ester | 0.07±0.00bcde | 0.09±0.01bcde | 0.12±0.04b | 0.12±0.03b |  | ND | 0.05±0.02cde | 0.06±0.02cde | 0.07±0.03bcde |
| Nonanal | 0.17±0.00hijk | 0.17±0.03hijk | 0.23±0.04fghij | 0.18±0.02hijk |  | 0.16±0.01hijk | 0.19±0.02hijk | 0.26±0.04fgh | 0.15±0.03jk |
| Acetic acid | 1.08±0.02lm | 3.78±0.02ef | 1.28±0.22klm | 2.47±0.10ghi |  | 0.69±0.02m | 2.11±0.06ghijk | 2.98±0.10fg | 6.30±0.09c |
| 2–Ethylhexanol | 1.48±0.02bcde | 1.35±0.03bcde | 1.65±0.22bc | 1.70±0.02b |  | 0.60±0.01f | 1.54±0.07bcde | 1.18±0.02cde | 1.39±0.11bcde |
| Decanal | 0.38±0.02efghij | 0.20±0.02k | 0.22±0.03ijk | 0.27±0.08hijk |  | 0.40±0.02efghi | 0.47±0.05defg | 0.68±0.12b | 0.41±0.03efgh |
| 2–Amino–5–methylbenzoic acid | 0.55±0.04bcd | 0.64±0.06bcd | 0.69±0.04bcd | 0.83±0.07b |  | 0.60±0.02bcd | 0.45±0.07d | 0.56±0.05bcd | 0.49±0.02d |
| 2–Hydroxy–Benzoic acid, methyl ester | 1.38±0.02lm | 3.85±0.08d | 5.70±0.02b | 5.18±0.30c |  | 2.37±0.09i | 2.70±0.21hi | 3.30±0.09fg | 3.05±0.09g |
| 2,4–Di–tert–butylphenol | 2.34±0.05hi | 3.32±0.18bc | 3.43±0.34b | 3.25±0.12bcd |  | 1.44±0.05k | 2.29±0.31ij | 2.69±0.10efghi | 1.67±0.03k |

1 Fermentation temperature.

2 Values are presented as means ± standard deviation. Different letters in the same row show significant differences (*P* < 0.05) in Duncan’s multiple range test.

3 Not detected.

**Table 4.** Volatile compounds according to fermentation period using *Acetobacter ascendens* GV-8 (A) and *Acetobacter pasteurianus* GV-22 (D) (Unit: Area%).

|  |  |  |  |
| --- | --- | --- | --- |
| **Temp.1** | **20℃** |  | **30℃** |
| **Period (days)****Compounds** | **0** | **12** | **18** | **27** |  | **0** | **12** | **18** | **27** |
| Acetic acid, ethyl ester | 123.43±1.262,a | 108.39±1.57c | 118.44±1.39b | 87.30±0.66g |  | 70.28±1.11jk | 96.86±3.01e | 91.62±1.10f | 1.42±0.12n |
| Ethanol | 217.16±2.60a | 14.30±0.26de | 12.99±0.19ef | 6.77±0.32i |  | 16.39±0.12cd | 10.63±0.29gh | 6.35±0.19i | ND3 |
| 2–Methyl–1–propanol | 0.23±0.05a | 0.05±0.01cde | 0.05±0.01cde | 0.12±0.05b |  | ND | 0.06±0.01cd | 0.11±0.06b | 0.07±0.01c |
| 2–Octanone | 0.11±0.01a | 0.02±0.01e | 0.04±0.02cde | 0.02±0.00e |  | ND | 0.04±0.02cde | 0.02±0.01e | 0.03±0.01de |
| 2–Methyl–1–butanol | 0.29±0.05a | 0.06±0.01bcdef | 0.07±0.02bcd | 0.08±0.02bc |  | ND | 0.04±0.01defgh | 0.04±0.01efgh | 0.04±0.00efgh |
| Octanal | 1.30±0.18a | 0.08±0.01cde | 0.12±0.04cde | 0.06±0.01e |  | 0.04±0.01e | 0.09±0.01cde | 0.06±0.00de | 0.09±0.01cde |
| 2–Hexadecanol | 0.63±0.07a | 0.06±0.02d | 0.08±0.01cd | 0.18±0.08b |  | 0.14±0.06bcd | 0.15±0.05bcd | 0.15±0.04bcd | 0.19±0.10b |
| 6–Methyl–5–hepten–2–one | 0.16±0.07a | 0.04±0.01cdef | 0.09±0.01bc | 0.04±0.03cdef |  | 0.05±0.02cdef | 0.05±0.01cdef | 0.08±0.00cd | 0.13±0.07ab |
| Acetic acid, 2–ethylhexyl ester | 0.78±0.06a | 0.04±0.00de | 0.05±0.02cde | 0.07±0.03bcde |  | 0.03±0.02e | 0.05±0.01cde | 0.04±0.01de | 0.05±0.01cde |
| Nonanal | 3.20±0.06a | 0.31±0.05ef | 0.25±0.05fghi | 0.18±0.09hijk |  | 0.13±0.06k | 0.17±0.01hijk | 0.28±0.03fg | 0.47±0.06bc |
| Acetic acid | 16.29±1.38a | 2.44±0.23ghij | 2.40±0.44ghij | 2.80±0.12g |  | 0.81±0.15m | 2.50±0.03gh | 4.37±0.10de | 10.78±0.77b |
| 2–Ethylhexanol | 15.70±0.95a | 1.39±0.39bcde | 1.37±0.26bcde | 1.32±0.05bcde |  | 1.13±0.12de | 1.10±0.07e | 1.30±0.07bcde | 1.56±0.11bcde |
| Decanal | 6.15±0.03a | 0.55±0.18bcde | 0.48±0.09defg | 0.21±0.07jk |  | 0.28±0.08hijk | 0.50±0.15def | 0.32±0.06ghijk | 0.33±0.08fghijk |
| 2–Amino–5–methylbenzoic acid | 4.89±0.54a | 0.42±0.14d | 0.61±0.29bcd | 0.79±0.04bc |  | 0.57±0.03bcd | 0.42±0.06d | 0.44±0.04d | 0.47±0.05d |
| 2–Hydroxy–Benzoic acid, methyl ester | 13.07±0.29a | 1.23±0.09m | 1.45±0.18klm | 1.76±0.04jk |  | 3.01±0.05gh | 3.47±0.11ef | 3.56±0.02def | 3.76±0.19de |
| 2,4–Di–tert–butylphenol | 18.93±0.68a | 1.83±0.07jk | 2.49±0.19ghi | 2.52±0.37fghi |  | 2.76±0.07defghi | 2.48±0.28ghi | 2.60±0.06efghi | 3.05±0.39bcde |

1 Fermentation temperature.

2 Values are presented as means ± standard deviation. Different letters in the same row show significant differences (*P* < 0.05) in Duncan’s multiple range test.

3 Not detected.

**Table 5.** Volatile compounds according to fermentation period using *A. ascendens* GV-8 (A), *A. ascendens* GV-12 (B), *A. pasteurianus* GV-17 (C), and *A. pasteurianus* GV-22 (D) (Unit: Area%).

|  |  |  |  |
| --- | --- | --- | --- |
| **Temp.1** | **20℃** |  | **30℃** |
| **Period (days)****Compounds** | **0** | **12** | **18** | **27** |  | **0** | **12** | **18** | **27** |
| Acetic acid, ethyl ester | 103.52±1.762,d | 98.73±1.55e | 107.63±3.51c | 92.50±1.50f |  | 56.50±3.90l | 86.70±1.97g | 98.89±1.02e | 99.15±0.78e |
| Ethanol | 18.6±0.46b | 11.17±0.55fgh | 11.68±0.28fgh | 6.14±0.11i |  | 18.93±0.82b | 17.23±1.77bc | 16.06±3.31cd | 12.63±2.79efg |
| 2–Methyl–1–propanol | 0.03±0.01cde | 0.06±0.03cd | 0.03±0.00cde | 0.06±0.01cd |  | ND3 | 0.02±0.02de | 0.03±0.03cde | 0.03±0.02cde |
| 2–Octanone | 0.02±0.00e | 0.02±0.01e | 0.01±0.01e | 0.03±0.02cde |  | ND | ND | 0.03±0.03cde | 0.03±0.03cde |
| 2–Methyl–1–butanol | 0.01±0.00h | 0.03±0.01fgh | 0.04±0.01efgh | 0.05±0.02cdefg |  | ND | ND | 0.04±0.03defgh | 0.07±0.01bcde |
| Octanal | 0.11±0.06cde | 0.05±0.01e | 0.04±0.00e | 0.06±0.01de |  | 0.07±0.02de | 0.17±0.10bc | 0.21±0.06b | 0.13±0.00bcde |
| 2–Hexadecanol | 0.15±0.05bcd | 0.15±0.03bcd | 0.10±0.00bcd | 0.16±0.09bc |  | 0.08±0.02cd | 0.06±0.03d | 0.11±0.07bcd | 0.12±0.05bcd |
| 6–Methyl–5–hepten–2–one | 0.07±0.07cde | 0.07±0.00cdef | 0.03±0.01cdef | 0.06±0.01cdef |  | 0.06±0.00cdef | 0.14±0.04a | 0.08±0.03c | 0.15±0.00a |
| Acetic acid, 2–ethylhexyl ester | 0.12±0.06b | 0.08±0.02bcde | 0.08±0.01bcde | 0.05±0.01de |  | 0.06±0.01cde | 0.10±0.02bcd | 0.10±0.07bc | 0.07±0.01bcde |
| Nonanal | 0.16±0.01ijk | 0.12±0.04k | 0.20±0.07ghijk | 0.25±0.03fghi |  | 0.19±0.02hijk | 0.39±0.08cd | 0.51±0.07b | 0.38±0.09de |
| Acetic acid | 1.56±0.12ijklm | 1.53±0.10jklm | 1.87±0.10hijkl | 4.70±1.65d |  | 1.10±0.14lm | 1.46±0.13klm | 1.55±0.12ijklm | 2.18±0.14ghijk |
| 2–Ethylhexanol | 1.39±0.03bcde | 1.69±0.25b | 1.62±0.05bcd | 1.39±0.26bcde |  | 1.41±0.07bcde | 1.74±0.19b | 1.44±0.22bcde | 1.64±0.24bc |
| Decanal | 0.32±0.08ghijk | 0.22±0.05jk | 0.27±0.10hijk | 0.39±0.03efghi |  | 0.29±0.08hijk | 0.59±0.09bcd | 0.67±0.22bc | 0.51±0.07cde |
| 2–Amino–5–methylbenzoic acid | 0.61±0.05bcd | 0.62±0.06bcd | 0.51±0.07cd | 0.70±0.25bcd |  | 0.41±0.07d | 0.46±0.11d | 0.49±0.08d | 0.44±0.12d |
| 2–Hydroxy–Benzoic acid, methyl ester | 2.54±0.35i | 2.53±0.25i | 1.49±0.03klm | 2.36±0.54i |  | 1.44±0.12klm | 1.75±0.20jkl | 1.93±0.07j | 1.70±0.28jkl |
| 2,4–Di–tert–butylphenol | 3.21±0.24bcd | 2.83±0.12cdefgh | 3.02±0.15bcdef | 1.77±0.18k |  | 2.54±0.12fghi | 3.26±0.28bcd | 2.91±0.59cdefg | 1.83±0.12jk |

1 Fermentation temperature.

2 Values are presented as means ± standard deviation. Different letters in the same row show significant differences (*P* < 0.05) in Duncan’s multiple range test.

3 Not detected.

**Table 6.** Alpha diversity analysis under multiple starters and fermentation temperature.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Strain1** | **Temp.** | **Period (day)** | **Valid reads and OTUs** |  | **Species richness** |  | **Species evenness** |  | **Phylogenetic diversity** | **Good's coverage (%)** |
| **Target reads** | **OTUs** |  | **ACE** | **CHAO** | **Jackknife** |  | **NPShannon** | **Shannon** | **Simpson** |  |
| AB | 20℃ | 12 | 33,527 | 7 |  | 13 | 10 | 11 |  | 0 | 0 | 1 |  | 19 | 100 |
| 27 | 30,341 | 9 |  | 14 | 12 | 14 |  | 0 | 0 | 1 |  | 44 | 100 |
| 30℃ | 12 | 36,745 | 9 |  | 10 | 10 | 12 |  | 0 | 0 | 1 |  | 22 | 100 |
| 27 | 33,253 | 5 |  | 11 | 7 | 8 |  | 0 | 0 | 1 |  | 10 | 100 |
| AD | 20℃ | 12 | 31,131 | 5 |  | 7 | 6 | 7 |  | 0 | 0 | 1 |  | 9 | 100 |
| 27 | 28,716 | 12 |  | 18 | 15 | 18 |  | 0 | 0 | 1 |  | 28 | 100 |
| 30℃ | 12 | 26,815 | 8 |  | 9 | 9 | 11 |  | 0 | 0 | 1 |  | 20 | 100 |
| 27 | 29,326 | 9 |  | 37 | 20 | 20 |  | 0 | 0 | 1 |  | 40 | 100 |
| ABCD | 20℃ | 12 | 33,601 | 7 |  | 9 | 8 | 10 |  | 0 | 0 | 1 |  | 21 | 100 |
| 27 | 30,470 | 5 |  | 11 | 7 | 8 |  | 0 | 0 | 1 |  | 14 | 100 |
| 30℃ | 12 | 34,377 | 4 |  | 4 | 4 | 5 |  | 0 | 0 | 1 |  | 11 | 100 |
| 27 | 26,846 | 5 |  | 11 | 7 | 8 |  | 0 | 0 | 1 |  | 19 | 100 |

1 Symbols: A, *Acetobacter ascendens* GV–8; B, *A. ascendens* GV–12; C, *A. pasteurianus* GV–17; D, *A. pasteurianus* GV–22.