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Appendix A
Table of raw data for samples by GC-MS-HS

| sample | variables | | | | | | | | | | | | | | | | | |
|--------|-----------|-------|-------|-------|-------|------|-------|-------|-------|------|------|-------|-------|-------|--------|-------|-------|------|
| | A | B | C | D | E | F | G | H | K | L | P | Q | U | V | Y | Z | | |
| aA1 | 0.00 | 3.16 | 0.00 | 0.00 | 0.00 | 0.00 | 8.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.23 | 0.00 | 5.00 | 0.00 | | |
| aA1 | 0.00 | 3.16 | 0.00 | 0.00 | 0.00 | 0.00 | 8.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.91 | 3.23 | 100.00 | 5.00 | 0.00 | |
| aA1 | 0.00 | 7.26 | 0.00 | 0.00 | 0.00 | 0.00 | 9.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.70 | 0.00 | |
| aA2 | 0.00 | 3.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| aA2 | 0.00 | 3.32 | 0.00 | 0.00 | 0.00 | 0.00 | 9.32 | 0.00 | 158 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.95 | 0.00 | |
| aA2 | 0.00 | 6.15 | 0.00 | 0.00 | 0.00 | 0.00 | 9.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.05 | 0.00 | |
| aA3 | 0.00 | 14.82 | 0.00 | 0.00 | 0.00 | 0.00 | 2102 | 4.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.16 | 0.00 | |
| aA3 | 0.00 | 9.53 | 0.00 | 0.00 | 0.00 | 0.00 | 15.18 | 2.62 | 2.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.22 | 0.00 | |
| aA3 | 0.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2115 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.82 | 0.00 | |
| aB1 | 0.00 | 19.38 | 15.69 | 6.39 | 4.88 | 0.00 | 0.00 | 4.27 | 9.68 | 0.00 | 0.00 | 0.00 | 0.00 | 15.69 | 100.00 | 4124 | 0.00 | |
| aB1 | 0.00 | 16.50 | 4.20 | 0.00 | 0.00 | 0.00 | 5.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.53 | 75.21 | 3186 | 8.08 | |
| aB1 | 0.00 | 12.07 | 0.00 | 0.00 | 0.00 | 0.00 | 4.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.78 | 43.52 | 23.91 | 0.00 | |
| aB2 | 0.00 | 16.63 | 2.04 | 0.00 | 0.00 | 0.00 | 4.23 | 0.00 | 0.00 | 0.00 | 0.00 | 185 | 0.00 | 14.44 | 53.27 | 22.17 | 0.00 | |
| aB2 | 0.00 | 14.48 | 5.93 | 4.65 | 0.00 | 3.70 | 0.00 | 4.37 | 7.15 | 0.00 | 0.00 | 0.00 | 0.00 | 15.76 | 100.00 | 47.13 | 0.00 | |
| aB2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 47.13 | 0.00 | |
| aB2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 45.31 | 0.00 | |
| aB3 | 4.74 | 13.32 | 6.76 | 4.59 | 3.34 | 4.78 | 120 | 0.00 | 4.17 | 0.00 | 0.00 | 0.00 | 0.00 | 13.65 | 100.00 | 45.31 | 0.00 | |
| aB3 | 0.00 | 13.32 | 0.00 | 0.00 | 0.00 | 0.00 | 120 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.65 | 0.00 | 0.00 | 0.00 | |
| aB3 | 0.00 | 13.32 | 0.00 | 0.00 | 0.00 | 0.00 | 120 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.65 | 0.00 | 0.00 | 0.00 | |
| aC1 | 0.00 | 7.62 | 0.00 | 0.00 | 0.00 | 0.00 | 6.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.56 | 3.67 | 97.75 | 0.00 | 0.00 | |
| aC1 | 4.22 | 3.31 | 5.47 | 3.42 | 0.00 | 0.00 | 0.00 | 0.00 | 5.93 | 0.00 | 0.00 | 0.00 | 0.00 | 6.11 | 100.00 | 6.97 | 0.00 | |
| aC1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| aC2 | 0.00 | 4.13 | 0.00 | 0.00 | 0.00 | 0.00 | 9.61 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.11 | 3.16 | 100.00 | 0.00 | 0.00 | |
| aC2 | 1158 | 3.57 | 15.13 | 6.93 | 3.61 | 0.00 | 0.00 | 0.00 | 5.34 | 0.00 | 0.00 | 0.00 | 0.00 | 3.29 | 100.00 | 8.20 | 0.00 | |
| aC2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.20 | 0.00 | |
| aC3 | 2171 | 2.65 | 24.55 | 4.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.92 | 76.28 | 10.00 | 0.00 | |
| aC3 | 0.00 | 3.10 | 0.00 | 0.00 | 0.00 | 0.00 | 145 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.05 | 2.88 | 72.43 | 10.00 | 0.00 |
| aC3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| bA1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 19.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 89.00 | 10.00 | 0.00 | 0.00 |
| bA1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 88.00 | 10.00 | 0.00 | 0.00 |
| bA1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 |
| bA2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 19.00 | 4.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.00 | 0.00 | 0.00 |
| bA2 | 0.00 | 199 | 0.00 | 0.00 | 0.00 | 0.00 | 19.00 | 0.00 | 4.74 | 0.00 | 0.00 | 0.00 | 0.00 | 7.71 | 100.00 | 13.03 | 0.00 | 0.00 |
| bA2 | 0.00 | 3.09 | 0.00 | 0.00 | 0.00 | 0.00 | 19.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.71 | 100.00 | 15.43 | 0.00 | 0.00 |
| bA3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| bA3 | 0.00 | 10.44 | 0.00 | 3.38 | 0.00 | 3.58 | 23.91 | 7.22 | 8.77 | 0.00 | 0.00 | 0.00 | 0.00 | 2.37 | 100.00 | 27.17 | 0.00 | 0.00 |
| bA3 | 0.00 | 10.44 | 0.00 | 5.34 | 0.00 | 0.00 | 23.91 | 8.78 | 10.21 | 0.00 | 0.00 | 0.00 | 0.00 | 2.37 | 100.00 | 22.15 | 0.00 | 0.00 |
| bB1 | 0.00 | 13.22 | 0.00 | 0.00 | 0.00 | 0.00 | 7.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.54 | 89.37 | 47.12 | 0.00 | 0.00 |
| bB1 | 0.00 | 20.81 | 5.91 | 8.51 | 5.49 | 0.00 | 7.28 | 7.09 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.48 | 100.00 | 47.42 | 0.00 | 0.00 |
| bB1 | 0.00 | 29.62 | 0.00 | 0.00 | 0.00 | 0.00 | 7.28 | 0.00 | 0.00 | 4.73 | 0.00 | 0.00 | 0.00 | 22.67 | 100.00 | 57.80 | 0.00 | 0.00 |
| bB2 | 0.00 | 13.51 | 0.00 | 0.00 | 0.00 | 0.00 | 9.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.00 | 99.45 | 23.41 | 0.00 | 0.00 |
| bB2 | 0.00 | 1150 | 3.97 | 4.31 | 2.94 | 3.43 | 2.00 | 5.37 | 7.41 | 0.00 | 0.00 | 0.00 | 0.00 | 13.03 | 100.00 | 36.11 | 0.00 | 0.00 |
| bB2 | 0.00 | 29.88 | 0.00 | 16.34 | 13.02 | 0.00 | 173 | 0.00 | 10.42 | 0.00 | 0.00 | 0.00 | 0.00 | 17.75 | 100.00 | 37.96 | 0.00 | 0.00 |
| bB3 | 0.00 | 9.95 | 0.00 | 3.48 | 0.00 | 0.00 | 6.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.19 | 100.00 | 45.28 | 0.00 | 0.00 |
| bB3 | 0.00 | 5.11 | 2.33 | 0.00 | 0.00 | 0.00 | 8.49 | 0.00 | 5.00 | 0.00 | 0.00 | 0.00 | 22.23 | 12.54 | 91.18 | 45.28 | 0.00 | 0.00 |
| bB3 | 0.00 | 10.90 | 15.56 | 9.68 | 7.05 | 6.90 | 8.49 | 0.00 | 10.65 | 0.00 | 0.00 | 0.00 | 0.00 | 12.54 | 100.00 | 46.08 | 0.00 | 0.00 |
| bC1 | 0.00 | 0.00 | 4.69 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.21 | 0.00 | 3.11 | 0.00 | 0.00 | 0.00 | 100.00 | 130 | 0.00 | 0.00 |
| bC1 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 7.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.08 | 100.00 | 6.75 | 0.00 | 0.00 |
| bC1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| bC2 | 4.89 | 4.79 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.47 | 100.00 | 0.80 | 0.00 | 0.00 |
| bC2 | 0.00 | 4.24 | 0.00 | 0.00 | 0.00 | 0.00 | 9.34 | 5.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.93 | 100.00 | 0.80 | 0.00 | 0.00 |
| bC2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| bC3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.67 | 3.00 | 91.69 | 0.00 | 0.00 |
| bC3 | 0.00 | 173 | 10.25 | 3.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.77 | 100.00 | 9.93 | 0.00 | 0.00 |
| bC3 | 0.00 | 6.95 | 14.76 | 8.98 | 0.00 | 0.00 | 7.03 | 0.00 | 8.08 | 0.00 | 0.00 | 0.00 | 0.00 | 6.57 | 100.00 | 5.56 | 0.00 | 0.00 |
| cA1 | 0.00 | 1.78 | 1.96 | 1.23 | 3.72 | 0.00 | 1172 | 0.00 | 0.00 | 0.00 | 6.42 | 22.64 | 3.00 | 93.62 | 0.00 | 0.00 | 0.00 | 0.00 |
| cA1 | 0.00 | 5.47 | 0.00 | 0.00 | 0.00 | 0.00 | 14.50 | 124 | 2.82 | 0.00 | 0.00 | 0.00 | 0.00 | 3.06 | 93.62 | 6.64 | 0.00 | 0.00 |
| cA1 | 0.00 | 5.04 | 0.00 | 0.00 | 0.00 | 0.00 | 14.50 | 0.00 | 0.00 | 0.00 | 2.56 | 0.00 | 0.00 | 3.39 | 100.00 | 7.15 | 0.00 | 0.00 |
| cA2 | 0.00 | 8.61 | 0.00 | 0.00 | 0.00 | 0.00 | 17.7 | 181 | 3.28 | 0.00 | 0.00 | 0.00 | 0.00 | 3.41 | 100.00 | 7.55 | 0.00 | 0.00 |
| cA2 | 0.00 | 8.73 | 0.00 | 0.00 | 0.00 | 0.00 | 17.7 | 184 | 3.21 | 0.00 | 0.00 | 0.00 | 0.00 | 3.09 | 100.00 | 8.09 | 0.00 | 0.00 |
| cA2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| cA3 | 0.00 | 11.05 | 0.00 | 2.20 | 0.00 | 2.81 | 14.07 | 5.74 | 8.72 | 0.00 | 0.00 | 0.00 | 0.00 | 7.45 | 100.00 | 15.43 | 0.00 | 0.00 |
| cA3 | 0.00 | 11.48 | 0.00 | 0.00 | 0.00 | 2.23 | 20.52 | 4.03 | 7.09 | 0.00 | 0.00 | 0.00 | 0.00 | 7.45 | 91.84 | 0.00 | 0.00 | 0.00 |
| cA3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.45 | 91.84 | 0.00 | 0.00 | 0.00 |
| cB1 | 0.00 | 19.84 | 9.33 | 12.40 | 0.00 | 0.00 | 4.50 | 13.31 | 19.68 | 0.00 | 0.00 | 0.00 | 0.00 | 18.27 | 100.00 | 49.76 | 0.00 | 0.00 |
| cB1 | 0.00 | 19.11 | 0.00 | 0.00 | 0.00 | 0.00 | 8.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.50 | 97.47 | 47.36 | 0.00 | 0.00 |
| cB1 | 0.00 | 29.16 | 0.00 | 7.64 | 0.00 | 6.90 | 2.43 | 7.77 | 15.89 | 0.00 | 0.00 | 0.00 | 0.00 | 18.48 | 100.00 | 42.60 | 0.00 | 0.00 |
| cB2 | 0.00 | 29.66 | 7.75 | 10.90 | 0.00 | 0.00 | 0.00 | 8.72 | 17.30 | 0.00 | 0.00 | 0.00 | 0.00 | 17.39 | 100.00 | 46.98 | 0.00 | 0.00 |
| cB2 | 0.00 | 11.03 | 0.00 | 0.00 | 0.00 | 0.00 | 3.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 96.57 | 20.22 | 0.00 | 0.00 |
| cB2 | 0.00 | 14.11 | 0.00 | 6.31 | 0.00 | 0.00 | 8.06 | 6.03 | 12.53 | 0.00 | 0.00 | 0.00 | 0.00 | 13.23 | 100.00 | 37.01 | 0.00 | |

Appendix B

Symbol used for each volatile compounds

| Variables | Volatile compounds |
|-----------|--------------------|
| A | Heptanal |
| B | Nonanal |
| C | Octanal |
| D | E-2-decenal |
| E | 2-undecenal |
| F | 2-pentylfuran |
| G | Hexanal |
| H | 2,4-decadienal |
| K | E-2-heptenal |
| I | 1-pentanol |
| P | 2-heptanal |
| Q | Butanal, 3-methyl |
| U | Octane |
| X | Pentane |
| Y | Heptane |
| Z | Butane |

Appendix C

Scores plot for 0 % lard and 15 % lard

| | PC-1 | PC-2 | PC-3 |
|-----|----------|----------|----------|
| aA1 | 25.59734 | 35.46469 | 5.601321 |
| aA1 | 23.59734 | 38.11149 | 7.666986 |
| aA1 | 26.44842 | 30.48746 | 5.30778 |
| aA2 | 27.17982 | 35.46469 | 5.601321 |
| aA2 | 26.11143 | 32.37979 | -6.55911 |
| aA2 | 26.54726 | 31.94707 | 5.642529 |
| aA3 | 30.50578 | 26.81212 | 6.653435 |
| aA3 | 29.27584 | 27.59417 | 5.337365 |
| aA3 | 27.1697 | 32.27229 | 4.561091 |
| aB1 | 14.7431 | 8.038725 | 11.21321 |
| aB1 | 16.52489 | 8.346877 | 13.23864 |
| aB1 | 14.6738 | 8.411014 | 16.63274 |
| aB2 | 47.29673 | 8.46065 | 9.92287 |
| aB2 | 45.60699 | 9.700069 | 11.6063 |
| aB2 | 47.17982 | 5.464694 | 5.601321 |
| aB3 | 64.47923 | 8.08367 | 11.96778 |
| aB3 | 67.17982 | 5.464694 | 5.601321 |
| aB3 | 67.17982 | 5.464694 | 5.601321 |
| aC1 | -30.4132 | -11.7529 | -18.775 |
| aC1 | -41.4555 | -1.88117 | -12.2207 |
| aC1 | -67.1798 | 5.464694 | -5.60132 |
| aC2 | 24.5352 | -38.1158 | 5.168603 |
| aC2 | 61.65419 | 44.28025 | -8.74763 |
| aC2 | -67.1798 | 5.464694 | -5.60132 |
| aC3 | -51.381 | 78.1658 | -4.57602 |
| aC3 | -54.7743 | -0.53488 | -6.09359 |
| aC3 | -67.1798 | 5.464694 | -5.60132 |

| | PC-1 | PC-2 | PC-3 |
|-----|----------|----------|----------|
| bA1 | 56.66505 | 4.397368 | 3.228132 |
| bA1 | 56.22382 | 3.482517 | 10.79624 |
| bA1 | 57.17982 | 5.464694 | 5.601321 |
| bA2 | 37.12228 | 25.41083 | 15.75927 |
| bA2 | 30.56996 | 21.39774 | 13.57495 |
| bA2 | 30.46425 | 21.53261 | 13.67577 |
| bA3 | 36.79742 | 14.67182 | 10.9577 |
| bA3 | 38.08333 | 11.67071 | 10.15995 |
| bA3 | 35.64114 | 10.96982 | 14.95837 |
| bB1 | 20.94332 | 4.122425 | 19.63227 |
| bB1 | 47.93319 | 13.8989 | 10.10625 |
| bB1 | 51.99727 | 22.26362 | 8.606457 |
| bB2 | 41.8072 | 6.123018 | 7.879699 |
| bB2 | 40.56987 | 10.69027 | 12.51431 |
| bB2 | 56.04556 | 16.97173 | 12.81565 |
| bB3 | 48.3132 | 5.528522 | 12.36561 |
| bBB | 47.50913 | 2.95777 | 9.33993 |
| bB3 | 44.72299 | 6.823721 | 10.80466 |
| bC1 | 34.91104 | -11.5666 | -15.5822 |
| bC1 | 49.13669 | -7.32045 | -27.5153 |
| bC1 | -67.1798 | 5.464694 | -5.60132 |
| bC2 | 46.14335 | 11.38221 | -11.595 |
| bC2 | 49.76233 | 9.407163 | 24.60545 |
| bC2 | -67.1798 | 5.464694 | -5.60132 |
| bC3 | -56.8068 | -0.12458 | -5.77175 |
| bC3 | 47.27895 | 13.41009 | -10.6975 |
| bC3 | 53.40203 | 16.83881 | 26.58041 |

Appendix D

x- loading value for 0 % lard and 15 % lard

| Variables | PC-1 | PC-2 | PC-3 |
|-----------|----------|-----------|----------|
| A | 0.019131 | 0.110388 | -0.03289 |
| B | 0.150071 | 0.23575 | 0.154421 |
| C | 0.046794 | 0.155256 | -0.03518 |
| D | 0.035498 | 0.063953 | 0.023776 |
| E | 0.015799 | 0.027193 | 0.023665 |
| F | 0.010895 | 0.007602 | 0.005242 |
| G | 0.056569 | -0.11729 | 0.97027 |
| H | 0.013703 | -0.01283 | -0.03761 |
| K | 0.042284 | 0.032176 | 0.029896 |
| L | 0.00425 | 0.002921 | -0.01373 |
| P | -0.00011 | -4.00E-05 | 0.003981 |
| Q | -0.01266 | -0.06834 | 0.111844 |
| U | 0.125145 | 0.296699 | 0.039526 |
| X | 0.897818 | -0.42159 | -0.1071 |
| Y | 0.382233 | 0.782612 | 0.039784 |
| Z | 0.001047 | -0.00052 | 0.016888 |

Appendix E

Scores plot for 0 % lard and 30 % lard

| | PC-1 | PC-2 | PC-3 |
|-----|----------|----------|----------|
| aA1 | 25.59734 | 35.46469 | 5.601321 |
| aA1 | 23.59734 | 38.11149 | 7.666986 |
| aA1 | 26.44842 | 30.48746 | 5.30778 |
| aA2 | 27.17982 | 35.46469 | 5.601321 |
| aA2 | 26.11143 | 32.37979 | -6.55911 |
| aA2 | 26.54726 | 31.94707 | 5.642529 |
| aA3 | 30.50578 | 26.81212 | 6.653435 |
| aA3 | 29.27584 | 27.59417 | 5.337365 |
| aA3 | 27.1697 | 32.27229 | 4.561091 |
| aB1 | 14.7431 | 8.038725 | 11.21321 |
| aB1 | 16.52489 | 8.346877 | 13.23864 |
| aB1 | 14.6738 | 8.411014 | 16.63274 |
| aB2 | 47.29673 | 8.46065 | 9.92287 |
| aB2 | 45.60699 | 9.700069 | 11.6063 |
| aB2 | 47.17982 | 5.464694 | 5.601321 |
| aB3 | 64.47923 | 8.08367 | 11.96778 |
| aB3 | 67.17982 | 5.464694 | 5.601321 |
| aB3 | 67.17982 | 5.464694 | 5.601321 |
| aC1 | -30.4132 | -11.7529 | -18.775 |
| aC1 | -41.4555 | -1.88117 | -12.2207 |
| aC1 | -67.1798 | 5.464694 | -5.60132 |
| aC2 | 24.5352 | -38.1158 | 5.168603 |
| aC2 | 61.65419 | 44.28025 | -8.74763 |
| aC2 | -67.1798 | 5.464694 | -5.60132 |
| aC3 | -51.381 | 78.1658 | -4.57602 |
| aC3 | -54.7743 | -0.53488 | -6.09359 |
| aC3 | 17.17982 | 5.464694 | -5.60132 |

| | PC-1 | PC-2 | PC-3 |
|-----|----------|----------|----------|
| cA1 | 16.2517 | 31.56558 | 2.30389 |
| cA1 | 15.1189 | 28.92548 | 6.523902 |
| cA1 | -70.1074 | -14.0886 | 12.84967 |
| cA2 | 28.08849 | 24.8503 | 6.190594 |
| cA2 | 28.19343 | 23.84249 | 7.796701 |
| cA2 | 28.98377 | 26.68578 | 10.0334 |
| cA3 | 32.68305 | 18.30684 | 24.51387 |
| cA3 | 31.89302 | 17.96297 | 20.06738 |
| cA3 | 37.35209 | 18.81144 | 28.31728 |
| cB1 | 50.85921 | -7.9288 | 19.31305 |
| cB1 | 44.59227 | 2.79994 | 19.40334 |
| cB1 | 45.94096 | -2.97353 | 22.86793 |
| cB2 | 45.55016 | -20.5973 | 26.1654 |
| cB2 | 41.57624 | -23.8457 | 25.23219 |
| cB2 | 41.11749 | -24.5048 | 22.92817 |
| cB3 | 41.07526 | -12.1562 | 11.6588 |
| cB3 | 46.37685 | -6.68578 | 6.445455 |
| cB3 | 38.98377 | -6.68578 | 10.0334 |
| cC1 | 39.82369 | -8.4445 | 10.93007 |
| cC1 | -18.4867 | 3.696771 | 24.72209 |
| cC1 | -55.1503 | -38.2668 | 1.907576 |
| cC2 | 37.79158 | -3.98845 | -13.1527 |
| cC2 | -43.2937 | 9.452102 | 5.90177 |
| cC2 | 34.21036 | 3.181734 | -17.302 |
| cC3 | 40.0054 | -11.3173 | -15.2304 |
| cC3 | 45.76239 | -21.9269 | -7.22571 |
| cC3 | -49.6364 | 4.03299 | 6.097345 |

Appendix F

x- loading value for 0 % lard and 30 % lard

| Variables | PC-1 | PC-2 | PC-3 |
|-----------|----------|----------|----------|
| A | 0.019392 | -0.10276 | 0.010249 |
| B | 0.128673 | -0.19129 | 0.246046 |
| C | 0.046673 | -0.14884 | 0.035042 |
| D | 0.0366 | -0.05721 | 0.055216 |
| E | 0.011754 | -0.01851 | -0.00756 |
| F | 0.00878 | -0.00461 | 0.008382 |
| G | 0.030278 | 0.344352 | 0.909498 |
| H | 0.028308 | -0.00913 | 0.057318 |
| K | 0.058218 | -0.04569 | 0.078168 |
| L | 0.001299 | -0.00062 | -0.00355 |
| P | 0.004165 | 0.009082 | 0.006562 |
| Q | -0.0221 | 0.074764 | 0.081257 |
| U | 0.102906 | -0.28357 | 0.098352 |
| X | 0.923411 | 0.34221 | -0.1636 |
| Y | 0.332089 | 0.77502 | 0.222697 |
| Z | 0.001021 | 0.000951 | 0.011273 |

Appendix G

Raw data for value for IV, PV and color (a*)

| | IV | PV | Color (a*) |
|-----|--------------|--------------|--------------|
| aA1 | 58.00 ± 0.59 | 2.26 ± 0.04 | -1.97 ± 0.01 |
| aA2 | 57.74 ± 0.20 | 15.35 ± 0.35 | -1.62 ± 0.03 |
| aA3 | 56.35 ± 0.00 | 32.28 ± 0.41 | -1.58 ± 0.02 |
| aB1 | 55.32 ± 1.10 | 13.60 ± 0.00 | -1.72 ± 0.00 |
| aB2 | 53.09 ± 0.06 | 14.30 ± 0.20 | -1.31 ± 0.01 |
| aB3 | 54.19 ± 0.07 | 16.43 ± 0.43 | -1.29 ± 0.01 |
| aC1 | 56.64 ± 0.13 | 8.26 ± 0.58 | -1.76 ± 0.01 |
| aC2 | 54.95 ± 0.05 | 6.40 ± 0.10 | -1.33 ± 0.00 |
| aC2 | 53.95 ± 0.05 | 5.73 ± 0.15 | -1.23 ± 0.02 |
| bA1 | 55.40 ± 0.40 | 10.17 ± 0.22 | -1.79 ± 0.01 |
| bA2 | 55.17 ± 0.05 | 17.76 ± 0.00 | -1.54 ± 0.01 |
| bA3 | 54.40 ± 0.23 | 29.20 ± 0.60 | -1.26 ± 0.00 |
| bB1 | 56.81 ± 0.82 | 20.00 ± 0.00 | -1.83 ± 0.05 |
| bB2 | 54.77 ± 0.43 | 19.23 ± 0.33 | -1.81 ± 0.01 |
| bB3 | 54.09 ± 0.05 | 17.10 ± 0.06 | -1.44 ± 0.03 |
| bC1 | 55.57 ± 0.87 | 8.46 ± 0.77 | -1.56 ± 0.01 |
| bC2 | 53.25 ± 0.25 | 8.01 ± 0.00 | -1.33 ± 0.01 |
| bC3 | 51.89 ± 0.30 | 7.12 ± 0.12 | -1.18 ± 0.01 |
| cA1 | 54.04 ± 0.09 | 14.59 ± 0.21 | -1.90 ± 0.07 |
| cA2 | 53.99 ± 0.11 | 25.95 ± 0.05 | -1.60 ± 0.03 |
| cA3 | 53.27 ± 0.23 | 46.67 ± 0.11 | -1.36 ± 0.02 |
| cB1 | 59.14 ± 0.37 | 20.70 ± 0.00 | -1.60 ± 0.04 |
| cB2 | 56.21 ± 0.41 | 17.30 ± 0.20 | -1.55 ± 0.00 |
| cB3 | 53.65 ± 0.35 | 15.38 ± 0.38 | -1.17 ± 0.01 |
| cC1 | 59.14 ± 0.15 | 9.15 ± 0.15 | -2.38 ± 0.01 |
| cC2 | 56.67 ± 0.53 | 7.27 ± 0.24 | -1.31 ± 0.00 |
| cC3 | 53.62 ± 0.74 | 5.61 ± 0.10 | -1.07 ± 0.00 |

*values given are the mean of two duplicates

*a = 0 % lard in 100 % RBD palm oil, b = 15 % lard in 85 % RBD palm oil, c = 30 % lard on 70 % RBD palm oil, A = 120 °C, B = 180 °C, C = 240 °C, 1 = 1 hour heating time, 2 = 2 hours heating time, 3 = 3 hours heating time

Appendix H

Table Scores plot for sample a, b and c

| | PC-1 | PC-2 | PC-3 |
|-----|---------|--------|--------|
| aA1 | 13.338 | -3.296 | 0.074 |
| aA1 | 13.466 | -4.473 | -0.068 |
| aA2 | 0.601 | -2.637 | -0.192 |
| aA2 | -0.116 | -2.262 | -0.112 |
| aA3 | -17.181 | -0.782 | -0.015 |
| aA3 | -16.361 | -0.746 | -0.043 |
| aB1 | 1.953 | -1.457 | 0.029 |
| aB1 | 1.872 | 0.501 | 0.232 |
| aB2 | 1.298 | 2.322 | 0.01 |
| aB2 | 0.903 | 2.174 | 0.015 |
| aB3 | -0.556 | 1.153 | -0.129 |
| aB3 | -1.41 | 0.99 | -0.155 |
| aC1 | 6.697 | -0.979 | 0.123 |
| aC1 | 7.867 | -1.189 | 0.089 |
| aC2 | 8.968 | 0.772 | -0.141 |
| aC2 | 9.172 | 0.671 | -0.152 |
| aC3 | 9.551 | 1.696 | -0.177 |
| aC3 | 9.846 | 1.814 | -0.135 |
| bA1 | 5.599 | -1.302 | 0.09 |
| bA1 | 5.137 | 0.537 | 0.191 |
| bA2 | -2.314 | 1.054 | 0.125 |
| bA2 | -2.31 | 0.956 | 0.104 |
| bA3 | -13.143 | 0.591 | -0.2 |
| bA3 | -14.323 | 0.085 | 0.251 |
| bB1 | 10.18 | 1.158 | 0.188 |
| bB1 | -10.113 | -2.796 | 0.088 |
| bB2 | 3.408 | -0.093 | 0.269 |
| bB2 | 4.103 | 0.737 | 0.335 |
| bB3 | 1.714 | 1.08 | 0.016 |
| bB3 | -1.598 | 1.179 | -0.014 |
| bC1 | 7.816 | -0.184 | -0.018 |
| bC1 | 6.219 | 1.164 | 0.134 |
| bC2 | 7.412 | 2.091 | 0.008 |
| bC2 | 7.382 | 2.389 | 0.049 |
| bC3 | 8.533 | 1.046 | 0.058 |
| bC3 | 8.117 | 3.451 | -0.013 |
| cA1 | 1.064 | 1.146 | 0.481 |
| cA1 | 0.637 | 1.308 | 0.599 |
| cA2 | 10.55 | 0.95 | 0.175 |
| cA2 | -10.448 | 0.74 | 0.113 |
| cA3 | -3.354 | 0.96 | -0.036 |
| cA3 | -2.115 | 0.515 | -0.113 |
| cB1 | -3.332 | -4.364 | -0.335 |
| cB1 | -3.362 | -3.623 | -0.309 |
| cB2 | -1.952 | -1.42 | -0.132 |
| cB2 | -1.585 | -0.588 | -0.047 |
| cB3 | -0.35 | 1.989 | -0.153 |
| cB3 | 0.438 | 1.326 | -0.233 |
| cC1 | 6.34 | -3.524 | 0.462 |
| cC1 | 6.652 | -3.811 | 0.442 |
| cC2 | 8.489 | -0.48 | -0.291 |
| cC2 | 8.063 | -1.552 | -0.401 |
| cC3 | 9.703 | 2.143 | -0.262 |
| cC3 | 9.948 | 1.058 | -0.374 |

Appendix I

Table loading plot for IV, PV and color intensity

| | IV | PV | Color |
|------|----------|----------|----------|
| PC-1 | 0.040992 | -0.99916 | -0.00137 |
| PC-2 | -0.99382 | -0.04091 | 0.103151 |
| PC-3 | -0.10312 | -0.00287 | -0.99466 |

Appendix J

Papers Presented at Postgraduate Colloquium 2015

Effect of Heating on Lard Adulteration in RBD Palm Oil Using Gas Chromatography and ChemometricsA.H Sulaiman^{1*}, M.S Hassan^{2*}, A.A Rahim^{1*},

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Abstract

Adulteration has gained much concern in the oil and fats industry due to health and religious issues. This study assess the effect of heating on the profiling of lard (15 % and 30 % lard) spiked in RBD palm oil at 120 °C, 180 °C and 240 °C for 1, 2 and 3 hours. The volatile compounds released were identified using GC-MS headspace method. Multivariate data from GC-MS-Headspace were mean centre prior to Principal Components Analysis (PCA) using Unscrambler. The result obtained from the score plot for 30 % lard and 15 % lard in the RBD palm oil showed the same pattern for heating temperature 120 °C and 180 °C. At 240 °C both sample and control are scattered in the score plot. Meanwhile, most volatiles compounds detected did not significantly correlate with samples.

Keywords: Adulteration, Heating effect, Lard profiling, GC-MS Headspace, PCA