# Supplementary Materials

# Effectiveness of different sample treatments for the elemental characterization of bees and beehive products

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**Table S1.** Element concentrations (mg kg$^{-1}$) in working bee samples applying four digestion methods prior to analysis by ICP-MS and ICP-OES.

| Element | N[a] | Measured concentration[b] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Method A | | Method B | | Method B1 | | Method B2 | |
| | | M | SD | M | SD | M | SD | M | SD |
| **Al** | 18 | **17.7[c]** | **4.0** | **17.4[d]** | **3.5** | **50.4[c,d]** | **5.2** | 37 | 12 |
| As | 13 | 0.0182 | 0.0096 | 0.025 | 0.015 | <2 | - | <2 | - |
| **B** | 18 | **13.7[c]** | **3.9** | **12.3[d]** | **4.0** | **52.8[c,d]** | **2.1** | 31.3 | 5.2 |
| Ba | 18 | 2.45 | 0.48 | **1.36[c,d]** | **0.63** | **3.9[c]** | **1.1** | **3.71[d]** | **0.38** |
| Be | 13 | 0.00397 | 0.00066 | 0.0029 | 0.0013 | <0.02 | - | <0.02 | - |
| Bi | 13 | 0.0048 | 0.0025 | 0.00301 | 0.00084 | <0.4 | - | <0.1 | - |
| Ca | 18 | **818[c]** | **190** | 737 | 130 | 578 | 33 | **395[c]** | **40** |
| Cd | 12 | 0.0070 | 0.0027 | 0.0055 | 0.0011 | <0.06 | - | <0.02 | - |
| Ce | 12 | 0.094 | 0.023 | 0.078 | 0.032 | <0.1 | - | <0.4 | - |
| Co | 14 | 0.046 | 0.015 | 0.036 | 0.010 | <0.09 | - | <0.1 | - |
| Cr | 18 | **0.047[c]** | **0.009** | **0.043[d]** | **0.010** | **0.121[c,d]** | **0.008** | <0.1 | - |
| Cs | 12 | 0.0271 | 0.0060 | 0.022 | 0.010 | - | - | - | - |
| Cu | 18 | 7.83 | 0.94 | 6.98 | 0.74 | 7.5 | 1.2 | 8.13 | 0.69 |
| Fe | 18 | 49.5 | 5.9 | 49.4 | 13.0 | 58.4 | 9.7 | 50.4 | 7.2 |
| Ga | 12 | **0.070[c]** | **0.013** | **0.042[c]** | **0.024** | <1 | - | <0.4 | - |
| K | 18 | **5109[c]** | **435** | 4801 | 719 | 4186 | 347 | **3287[c]** | **302** |
| La | 13 | 0.048 | 0.012 | 0.039 | 0.015 | <0.07 | - | <0.05 | - |
| Li | 12 | 0.0179 | 0.0035 | 0.0185 | 0.0084 | <0.1 | - | <0.1 | - |
| Mg | 18 | **411[c]** | **50** | 388 | 87 | 400 | 27 | **298[c]** | **6** |
| Mn | 18 | 13.5 | 6.1 | 8.6 | 1.9 | 10.5 | 4.3 | 16.0 | 3.1 |
| Mo | 18 | **0.176[c]** | **0.015** | 0.152 | 0.039 | 0.112 | 0.011 | **0.109[c]** | **0.011** |
| Na | 18 | 274 | 26 | 264 | 24 | 280 | 15 | 267 | 14 |
| Nb | 12 | 0.0087 | 0.0025 | 0.0063 | 0.0026 | <0.1 | - | <0.3 | - |
| Ni | 12 | 0.057 | 0.020 | 0.064 | 0.021 | <0.4 | - | <0.6 | - |
| P | 18 | 1980 | 726 | **1484[c]** | **186** | **3322[c]** | **294** | 2890 | 76 |
| Pb | 15 | 0.141 | 0.043 | 0.105 | 0.035 | <0.2 | - | <0.2 | - |
| Rb | 15 | 13.0 | 1.4 | 12.2 | 3.5 | 0.69 | 0.25 | <2 | - |
| S[e] | 10 | **462[c]** | **40** | 713 | 105 | 1805 | 168 | **2334[c]** | **164** |
| Sb | 12 | 0.0215 | 0.0035 | 0.028 | 0.030 | <0.7 | - | <0.5 | - |
| Se | 7 | <0.02 | 0.0065 | 0.0082 | 0.0046 | <4 | - | <4 | - |
| Si | 18 | 62 | 11 | 83 | 27 | 78 | 16 | 70 | 45 |
| Sn | 13 | 0.085 | 0.035 | 0.135 | 0.052 | <0.1 | - | <0.1 | - |
| Sr | 18 | 3.3 | 1.4 | 2.4 | 1.1 | 2.47 | 0.39 | 2.33 | 0.04 |
| Te | 7 | 0.00058 | 0.00056 | 0.00078 | 0.00077 | <1 | - | <0.6 | - |
| Ti | 18 | 0.88 | 0.22 | 1.09 | 0.74 | 2.39 | 0.39 | 2.45 | 0.58 |
| Tl | 12 | 0.068 | 0.032 | 0.072 | 0.045 | <4 | - | <3 | - |
| U | 12 | 0.00366 | 0.00069 | 0.0034 | 0.0014 | <3 | - | <3 | - |
| V | 16 | 0.053 | 0.014 | 0.047 | 0.015 | 0.146 | 0.028 | <1 | - |
| W | 12 | 0.037 | 0.018 | 0.037 | 0.020 | <1 | - | <1 | - |
| Zn | 18 | 33.6 | 22.0 | 27.9 | 3.5 | 35 | 13 | 38.5 | 7.3 |
| Zr | 13 | 0.052 | 0.015 | 0.049 | 0.014 | <0.3 | - | <0.1 | - |

[a] N, number of valid data. [b] M, mean; SD, standard deviation. Digests obtained by methods A or B were analyzed with ICP-MS, and digests obtained by methods B1 or B2 were analysed with ICP-OES. [c,d] Results marked in bold were considered statistically significant for p-values <0.05. Same superscript letters within rows are significantly different. [e] S was determined with ICP-OES.

**Table S2.** Element concentrations (mg kg$^{-1}$) in working beeswax samples applying four digestion methods prior to analysis by ICP-MS and ICP-OES.

| Element | N[a] | Measured concentration[b] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Method A | | Method B | | Method B1 | | Method B2 | |
| | | M | SD | M | SD | M | SD | M | SD |
| Al | 16 | 0.75 | 0.34 | 1.8 | 1.5 | 1.65 | 0.56 | 0.76 | 0.46 |
| As | 11 | 0.0041 | 0.0036 | 0.0047 | 0.0035 | <2 | - | <2 | - |
| B | 3 | 0.22 | 0.31 | 0.28 | 0.34 | <13 | - | <8 | - |
| Ba | 10 | <0.4 | | <0.2 | | 1.12 | 0.39 | 1.22 | 0.97 |
| Be | 10 | 0.00053 | 0.00046 | 0.00036 | 0.00016 | <0.02 | - | <0.02 | - |
| Bi | 10 | <0.4 | | <0.1 | | <0.4 | - | <0.1 | - |
| Ca | 13 | 155 | 36 | 196 | 56 | 161 | 26 | <80 | - |
| Cd | 11 | 0.0031 | 0.0019 | 0.00215 | 0.00047 | <0.06 | - | <0.02 | - |
| Ce | 11 | 0.0085 | 0.0014 | 0.0099 | 0.0017 | <0.1 | - | <0.4 | - |
| Co | 10 | 0.0025 | 0.0018 | 0.0043 | 0.0032 | <0.09 | - | <0.1 | - |
| Cr | 17 | 0.41 | 0.51 | 0.62 | 0.26 | 0.37 | 0.19 | 1.26 | 0.77 |
| Cs | 11 | 0.00073 | 0.00044 | 0.00082 | 0.00069 | - | - | - | - |
| Cu | 11 | 0.204 | 0.046 | 0.159 | 0.060 | <0.4 | - | <0.3 | - |
| Fe | 17 | 3.7 | 3.0 | 8.8 | 4.4 | 4.2 | 1.8 | 5.1 | 3.8 |
| Ga | 7 | 0.0145 | 0.0156 | 0.0043 | 0.0086 | <1 | - | <0.4 | - |
| K | 10 | 15.1 | 6.6 | 21 | 24 | <140 | - | <100 | - |
| La | 11 | 0.0042 | 0.0006 | 0.0050 | 0.0021 | <0.07 | - | <0.05 | - |
| Li | 11 | 0.0036 | 0.0016 | 0.0051 | 0.0039 | <0.1 | - | <0.1 | - |
| Mg | 16 | 3.8 | 1.5 | 4.9 | 2.1 | 4.24 | 0.35 | <2 | - |
| Mn | 17 | 0.277 | 0.090 | 0.31 | 0.14 | 0.277 | 0.025 | 0.21 | 0.15 |
| Mo | 11 | 0.0034 | 0.0028 | 0.0037 | 0.0013 | <0.09 | - | <0.1 | - |
| Na | 11 | 10.2 | 5.7 | 12.5 | 4.4 | <10 | - | <12 | - |
| Nb | 9 | 0.00029 | 0.00036 | 0.00016 | 0.00020 | <0.1 | - | <0.3 | - |
| Ni | 11 | 0.028 | 0.028 | 0.087 | 0.048 | <0.4 | - | <0.6 | - |
| P | 13 | 10.6 | 6.8 | 10.9 | 7.4 | <20 | - | <20 | - |
| Pb | 13 | 0.214 | 0.039 | 0.208 | 0.027 | <0.2 | - | <0.2 | - |
| Rb | 13 | 0.028 | 0.021 | 0.0195 | 0.0087 | 0.73 | 0.38 | <2 | - |
| S[e] | 5 | <20 | | <20 | | 90 | 45 | 35 | 21 |
| Sb | 11 | 0.0050 | 0.0025 | 0.00339 | 0.00048 | <0.7 | - | <0.5 | - |
| Se | 1 | <0.02 | | <0.007 | | <4 | - | <4 | - |
| Si | 2 | <9 | | <8 | | <15 | - | <15 | - |
| Sn | 14 | 0.021 | 0.014 | 0.0198 | 0.0060 | 0.28 | 0.20 | 0.11 | 0.11 |
| Sr | 14 | 0.40 | 0.14 | 0.36 | 0.18 | 0.171 | 0.011 | <0.3 | - |
| Te | 5 | 0.0009 | 0.0011 | <0.003 | | <1 | - | <0.6 | - |
| Ti | 16 | **0.030**[c] | **0.016** | 0.075 | 0.047 | **0.22**[c] | **0.13** | 0.112 | 0.058 |
| Tl | 11 | 0.00052 | 0.00022 | 0.00078 | 0.00029 | <4 | - | <3 | - |
| U | 11 | 0.00134 | 0.00039 | 0.00144 | 0.00021 | <3 | - | <3 | - |
| V | 4 | 0.0013 | 0.0020 | 0.0015 | 0.0025 | <0.1 | - | <0.1 | - |
| W | 1 | <0.0003 | | <0.0002 | | <1 | - | <1 | - |
| Zn | 14 | 3.2 | 1.4 | 3.8 | 1.1 | 4.34 | 0.78 | <3 | - |
| Zr | 11 | 0.0040 | 0.0032 | 0.0063 | 0.0040 | <0.3 | - | <0.1 | - |

[a] N, number of valid data. [b] M, mean; SD, standard deviation. Digests obtained by methods A or B were analyzed with ICP-MS, and digests obtained by methods B1 or B2 were analysed with ICP-OES. [c,d] Results marked in bold were considered statistically significant for p-values <0.05. Same superscript letters within rows are significantly different. [e] S was determined with ICP-OES.

**Table S3.** Element concentrations (mg kg$^{-1}$) in working honey samples applying four digestion methods prior to analysis by ICP-MS and ICP-OES.

| Element | N[a] | Measured concentration[b] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Method A | | Method B | | Method B1 | | Method B2 | |
| | | M | SD | M | SD | M | SD | M | SD |
| Al | 14 | **0.48[c]** | **0.13** | 0.61 | 0.14 | 0.701 | 0.070 | **2.90[c]** | **0.27** |
| As | 8 | 0.0037 | 0.0018 | 0.0057 | 0.0038 | <2 | - | <2 | - |
| B | 14 | 4.67 | 0.56 | 5.0 | 1.0 | 16.8 | 3.1 | 15.4 | 0.3 |
| Ba | 12 | 0.63 | 0.34 | **0.45** | **0.39[c]** | 1.28 | 0.22 | **1.66[c]** | **0.11** |
| Be | 0 | <0.00002 | | <0.00002 | | <0.02 | - | <0.02 | - |
| Bi | 3 | <0.00004 | | <0.00006 | | <0.4 | - | <0.1 | - |
| Ca | 8 | 85 | 17 | 84 | 17 | <140 | - | <80 | - |
| Cd | 3 | 0.00031 | 0.00050 | 0.00012 | 0.00010 | <0.06 | - | <0.02 | - |
| Ce | 8 | 0.00124 | 0.00015 | 0.00136 | 0.00024 | <0.1 | - | <0.4 | - |
| Co | 8 | 0.00142 | 0.00039 | 0.00192 | 0.00035 | <0.09 | - | <0.1 | - |
| Cr | 8 | 0.14 | 0.16 | 0.22 | 0.33 | <0.1 | - | <0.1 | - |
| Cs | 8 | 0.0188 | 0.0033 | 0.0187 | 0.0031 | - | - | - | - |
| Cu | 9 | 0.157 | 0.008 | 0.144 | 0.033 | <0.4 | - | <0.3 | - |
| Fe | 14 | 1.45 | 0.87 | 1.44 | 0.91 | 0.863 | 0.084 | 1.46 | 0.36 |
| Ga | 8 | 0.025 | 0.012 | 0.0220 | 0.0075 | <1 | - | <0.4 | - |
| K | 14 | 752 | 99 | 741 | 80 | 462 | 51 | 497 | 13 |
| La | 8 | **0.000615[c]** | **0.000028** | **0.000532[c]** | **0.000036** | <0.07 | - | <0.05 | - |
| Li | 8 | 0.0020 | 0.0015 | 0.0041 | 0.0016 | <0.1 | - | <0.1 | - |
| Mg | 14 | 21.8 | 2.2 | **23.5[c]** | **4.1** | **12.6[c]** | **0.5** | 14.9 | 0.8 |
| Mn | 14 | 0.248 | 0.030 | 0.243 | 0.019 | 0.20 | 0.012 | 0.231 | 0.002 |
| Mo | 8 | **0.00416[c]** | **0.00086** | **0.00258[c]** | **0.00011** | <0.09 | - | <0.1 | - |
| Na | 14 | 28.0 | 1.6 | 30.5 | 7.9 | 32.5 | 1.4 | 35.9 | 1.9 |
| Nb | 6 | 0.00051 | 0.00044 | 0.000029 | 0.000050 | <0.1 | - | <0.3 | - |
| Ni | 0 | <0.002 | | <0.003 | | <0.4 | - | <0.6 | - |
| P | 14 | 58 | 19 | 51 | 12 | 52 | 5.0 | 58.5 | 1.9 |
| Pb | 0 | <0.001 | | <0.001 | 0.037 | <0.2 | - | <0.2 | - |
| Rb | 9 | 4.87 | 0.64 | 5.02 | 0.82 | <0.6 | - | <2 | - |
| S[e] | 5 | <20 | | 23.9 | 0.4 | <52 | - | 48.6 | 1.3 |
| Sb | 7 | 0.0037 | 0.0030 | 0.0035 | 0.0032 | <0.7 | - | <0.5 | - |
| Se | 0 | <0.02 | | <0.007 | | <4 | - | <4 | - |
| Si | 8 | 57.0 | 6.6 | 44.8 | 6.8 | <15 | - | <15 | - |
| Sn | 10 | 0.00362 | 0.00056 | 0.00301 | 0.00091 | <0.1 | - | <0.1 | - |
| Sr | 14 | 0.93 | 0.33 | 0.76 | 0.28 | 0.580 | 0.056 | 0.633 | 0.033 |
| Te | 4 | 0.00052 | 0.00039 | <0.0003 | | <1 | - | <0.6 | - |
| Ti | 10 | **0.0110[c]** | **0.0008** | **0.0138[c]** | **0.0008** | <0.05 | - | <0.1 | - |
| Tl | 8 | 0.0101 | 0.0017 | 0.0113 | 0.0030 | <4 | - | <3 | - |
| U | 7 | 0.000048 | 0.000014 | 0.000048 | 0.000057 | <3 | - | <3 | - |
| V | 6 | 0.0037 | 0.0038 | 0.0012 | 0.0010 | <0.1 | - | <0.1 | - |
| W | 5 | 0.00086 | 0.00074 | 0.00038 | 0.00024 | <1 | - | <1 | - |
| Zn | 8 | 0.98 | 0.24 | 0.97 | 0.18 | <3 | - | <3 | - |
| Zr | 8 | 0.00273 | 0.00059 | 0.00178 | 0.00029 | <0.3 | - | <0.1 | - |

[a] N, number of valid data. [b] M, mean; SD, standard deviation. Digests obtained by methods A or B were analyzed with ICP-MS, and digests obtained by methods B1 or B2 were analysed with ICP-OES. [c,d] Results marked in bold were considered statistically significant for p-values <0.05. Same superscript letters within rows are significantly different. [e] S was determined with ICP-OES.

**Table S4.** Element concentrations (mg kg⁻¹) in working bee pollen samples applying four digestion methods prior to analysis by ICP-MS and ICP-OES.

| Element | N[a] | Measured concentration[b] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Method A** | | **Method B** | | **Method B1** | | **Method B2** | |
| | | M | SD | M | SD | M | SD | M | SD |
| Al | 18 | **3.3[c,d]** | **1.5** | 18.2 | 2.1 | **24.0[c]** | **3.4** | **47[d]** | **12** |
| As | 12 | 0.0140 | 0.0070 | 0.0258 | 0.0087 | <2 | - | <2 | - |
| B | 18 | **9.2[c]** | **3.0** | **9.6[d]** | **2.7** | **30.5[c]** | **3.1** | **42.4[d]** | **9.2** |
| Ba | 18 | **2.05[c]** | **0.57** | 2.09 | 0.35 | 3.68 | 0.31 | **4.23[c]** | **0.59** |
| Be | 12 | **0.00059[c]** | **0.00030** | **0.00114[c]** | **0.00029** | <0.02 | - | <0.02 | - |
| Bi | 9 | 0.00045 | 0.00065 | 0.00055 | 0.00084 | <0.4 | - | <0.1 | - |
| Ca | 18 | 726 | 202 | 863 | 256 | 715 | 66 | 778 | 49 |
| Cd | 18 | 0.048 | 0.014 | 0.061 | 0.015 | 0.073 | 0.011 | 0.075 | 0.013 |
| Ce | 12 | **0.0106[c]** | **0.0037** | **0.0395[c]** | **0.0057** | <0.1 | - | <0.4 | - |
| Co | 18 | 0.151 | 0.020 | 0.161 | 0.015 | 0.191 | 0.031 | 0.193 | 0.026 |
| Cr | 18 | **0.0173[c,d]** | **0.0063** | 0.040 | 0.032 | **0.112[c]** | **0.037** | **0.113[d]** | **0.024** |
| Cs | 12 | 0.041 | 0.027 | 0.038 | 0.010 | - | - | - | - |
| Cu | 18 | **5.7[c]** | **1.4** | 7.3 | 1.8 | 7.44 | 0.24 | **7.96[c]** | **0.21** |
| Fe | 18 | **29.6[c]** | **4.4** | 37.3 | 2.2 | 36.8 | 4.6 | **41.5[c]** | **7.1** |
| Ga | 12 | 0.050 | 0.031 | 0.051 | 0.026 | <1 | - | <0.4 | - |
| K | 18 | 4755 | 973 | 5199 | 678 | 4470 | 281 | 4641 | 97 |
| La | 13 | **0.0048[c]** | **0.0016** | **0.0186[c]** | **0.0029** | 0.079 | 0.085 | <0.05 | - |
| Li | 12 | **0.0164[c]** | **0.0031** | **0.0302[c]** | **0.0083** | <0.1 | - | <0.1 | - |
| Mg | 18 | 392 | 109 | 469 | 33 | 447 | 12 | 478 | 21 |
| Mn | 18 | 32 | 11 | 27.5 | 9.1 | 35.8 | 5.2 | 33.0 | 4.6 |
| Mo | 13 | 0.0200 | 0.0071 | 0.0197 | 0.0083 | <0.09 | - | <0.1 | - |
| Na | 18 | **28.4[c]** | **8.7** | 40.8 | 11.0 | 62.2 | 2.3 | **69.3[c]** | **0.1** |
| Nb | 12 | 0.00116 | 0.00062 | 0.00114 | 0.00042 | <0.1 | - | <0.3 | - |
| Ni | 18 | 1.43 | 0.44 | 1.69 | 0.36 | 1.66 | 0.11 | 1.64 | 0.19 |
| P | 18 | 1751 | 625 | 1554 | 41 | 3688 | 320 | 3917 | 75 |
| Pb | 12 | 0.028 | 0.035 | 0.026 | 0.012 | <0.2 | - | <0.2 | - |
| Rb | 10 | 7.2 | 3.8 | 5.4 | 1.0 | <0.6 | - | <2 | - |
| S[e] | 10 | 735 | 67 | **714[c]** | **82** | 1718 | 132 | **2544[c]** | **139** |
| Sb | 12 | 0.0039 | 0.0033 | 0.0044 | 0.0030 | <0.7 | - | <0.5 | - |
| Se | 9 | 0.0230 | 0.0147 | 0.0145 | 0.0070 | <4 | - | <4 | - |
| Si | 15 | 44 | 21 | 51 | 25 | **<15[c]** | **-** | **139[c]** | **36** |
| Sn | 12 | 0.0039 | 0.0019 | 0.0091 | 0.0053 | <0.1 | - | 0.15 | 0.11 |
| Sr | 18 | 1.83 | 0.50 | 2.35 | 0.79 | 1.70 | 0.43 | 1.96 | 0.27 |
| Te | 9 | 0.00093 | 0.00082 | 0.00105 | 0.00056 | <1 | - | <0.6 | - |
| Ti | 18 | **0.202[c]** | **0.030** | 0.46 | 0.15 | 0.74 | 0.11 | **2.82[c]** | **0.40** |
| Tl | 12 | 0.0027 | 0.0020 | 0.0034 | 0.0019 | <4 | - | <3 | - |
| U | 12 | **0.00051[c]** | **0.00012** | **0.00125[c]** | **0.00027** | <3 | - | <3 | - |
| V | 12 | **0.0094[c]** | **0.0052** | **0.0332[c]** | **0.0082** | <0.1 | - | <0.1 | - |
| W | 3 | 0.00049 | 0.00059 | 0.00037 | 0.00059 | <1 | - | <1 | - |
| Zn | 18 | 35 | 11 | 28.1 | 2.0 | 38.2 | 5.5 | 38.3 | 0.8 |
| Zr | 13 | 0.0099 | 0.0060 | 0.0111 | 0.0032 | <0.3 | - | <0.1 | - |

[a] N, number of valid data. [b] M, mean; SD, standard deviation. Digests obtained by methods A or B were analyzed with ICP-MS, and digests obtained by methods B1 or B2 were analysed with ICP-OES. [c,d] Results marked in bold were considered statistically significant for p-values <0.05. Same superscript letters within rows are significantly different. [e] S was determined with ICP-OES.

**Table S5.** Element concentrations (mg kg$^{-1}$) in working propolis samples applying four digestion methods prior to analysis by ICP-MS and ICP-OES.

| Element | N[a] | Measured concentration[b] | | | | | | | |
|---------|------|----------|----|----------|----|-----------|----|-----------|----|
| | | Method A | | Method B | | Method B1 | | Method B2 | |
| | | M | SD | M | SD | M | SD | M | SD |
| Al | 19 | **152**[c,d] | **29** | 260 | 44 | **925**[c] | **86** | **1161**[d] | **52** |
| As | 13 | 0.69 | 0.19 | 0.62 | 0.15 | <2 | - | <2 | - |
| B | 19 | 9.4 | 1.9 | **8.34**[c] | **0.78** | 28.4 | 4.2 | **40.1**[c] | **1.6** |
| Ba | 19 | **1.12**[c] | **0.28** | 2.01 | 0.56 | 26.7 | 2.5 | **30.0**[c] | **2.0** |
| Be | 19 | **0.0439**[c] | **0.0068** | 0.053 | 0.013 | 0.0652 | 0.0070 | **0.082**[c] | **0.012** |
| Bi | 13 | 0.0149 | 0.0054 | 0.0192 | 0.0036 | <0.4 | - | <0.1 | - |
| Ca | 19 | **1684**[c] | **433** | **1523**[d] | **477** | 2105 | 202 | **2602**[c,d] | **122** |
| Cd | 19 | **0.066**[c] | **0.014** | 0.070 | 0.028 | 0.180 | 0.039 | **0.234**[c] | **0.020** |
| Ce | 19 | **1.18**[c] | **0.19** | **1.15**[d] | **0.19** | **0.303**[c,d] | **0.045** | 0.384 | 0.017 |
| Co | 19 | **0.89**[c] | **0.14** | 1.08 | 0.35 | 1.07 | 0.11 | **1.79**[c] | **0.37** |
| Cr | 19 | **1.78**[c] | **0.76** | 2.07 | 0.62 | 4.3 | 2.0 | **4.30**[c] | **0.51** |
| Cs | 13 | 0.283 | 0.047 | 0.290 | 0.039 | - | - | - | - |
| Cu | 19 | 10.6 | 2.7 | 11.8 | 7.0 | 11.1 | 1.7 | 18 | 10 |
| Fe | 19 | 1315 | 392 | 1624 | 545 | 1728 | 355 | 2158 | 496 |
| Ga | 13 | 6.6 | 1.5 | 10.7 | 6.9 | <1 | - | <0.4 | - |
| K | 19 | 1682 | 285 | 1620 | 192 | 1566 | 113 | 1927 | 84 |
| La | 19 | 0.60 | 0.11 | 0.581 | 0.094 | 0.623 | 0.061 | 0.786 | 0.070 |
| Li | 19 | **0.264**[c,d] | **0.056** | 0.482 | 0.073 | **0.610**[c] | **0.070** | **0.91**[d] | **0.15** |
| Mg | 19 | **313**[c] | **43** | 377 | 50 | 371 | 17 | **442**[c] | **13** |
| Mn | 19 | **22.4**[c] | **4.9** | 23.4 | 5.2 | 32.4 | 2.8 | **50.2**[c] | **9.7** |
| Mo | 19 | 0.43 | 0.12 | 0.34 | 0.15 | 0.280 | 0.080 | 0.365 | 0.089 |
| Na | 19 | 273 | 49 | 311 | 99 | 290 | 17 | 419 | 12 |
| Nb | 14 | 0.075 | 0.016 | 0.087 | 0.016 | <0.1 | - | <0.3 | - |
| Ni | 19 | 1.40 | 0.33 | 2.07 | 0.53 | 1.98 | 0.55 | 2.05 | 0.22 |
| P | 19 | 491 | 152 | 370 | 76 | 503 | 62 | 548 | 9 |
| Pb | 19 | 15.3 | 7.8 | 15.7 | 5.4 | 20.5 | 6.9 | 26.2 | 4.5 |
| Rb | 13 | 7.9 | 1.7 | 7.13 | 0.86 | <0.6 | - | <2 | - |
| S[e] | 10 | 271 | 20 | 257 | 35 | 789 | 100 | 870 | 24 |
| Sb | 14 | 0.214 | 0.041 | 0.196 | 0.060 | <0.7 | - | <0.5 | - |
| Se | 13 | **0.069**[c] | **0.023** | **0.115**[c] | **0.035** | <4 | - | <4 | - |
| Si | 19 | **120**[c] | **40** | 680 | 321 | 1539 | 537 | **4999**[c] | **545** |
| Sn | 19 | **0.50**[c,d] | **0.11** | 1.12 | 0.35 | **1.50**[c] | **0.41** | **1.49**[d] | **0.12** |
| Sr | 19 | 18.7 | 6.8 | 19.3 | 9.2 | 19.5 | 4.3 | 24.6 | 0.4 |
| Te | 13 | 0.0016 | 0.0014 | 0.0014 | 0.0010 | <1 | - | <0.6 | - |
| Ti | 19 | **7.3**[c,d] | **1.9** | 17.6 | 3.2 | **49**[c] | **16** | **203**[d] | **15** |
| Tl | 13 | 0.027 | 0.011 | 0.0326 | 0.0073 | <4 | - | <3 | - |
| U | 13 | 0.041 | 0.018 | 0.048 | 0.011 | <3 | - | <3 | - |
| V | 19 | **0.69**[c,d] | **0.13** | 1.12 | 0.11 | **2.08**[c] | **0.62** | **2.84**[d] | **0.43** |
| W | 13 | 0.046 | 0.020 | 0.0263 | 0.0051 | <1 | - | <1 | - |
| Zn | 19 | 309 | 80 | **258**[c] | **94** | 393 | 121 | **487**[c] | **65** |
| Zr | 19 | **0.57**[c,d] | **0.13** | 1.15 | 0.25 | **1.95**[c] | **0.14** | **3.47**[d] | **0.40** |

[a] N, number of valid data. [b] M, mean; SD, standard deviation. Digests obtained by methods A or B were analyzed with ICP-MS, and digests obtained by methods B1 or B2 were analysed with ICP-OES. [c,d] Results marked in bold were considered statistically significant for p-values <0.05. Same superscript letters within rows are significantly different. [e] S was determined with ICP-OES.

**Table S6.** Element concentrations (mg kg$^{-1}$) in working royal jelly samples applying four digestion methods prior to analysis by ICP-MS and ICP-OES.

| Element | N[a] | Measured concentration[b] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Method A | | Method B | | Method B1 | | Method B2 | |
| | | M | SD | M | SD | M | SD | M | SD |
| Al | 12 | 0.337 | 0.051 | 0.59 | 0.21 | 0.62 | 0.30 | 0.86 | 0.38 |
| As | 7 | 0.0073 | 0.0051 | <0.001 | | <2 | - | <2 | - |
| B | 9 | 0.607 | 0.043 | 0.78 | 0.17 | <13 | - | <8 | - |
| Ba | 9 | 0.45 | 0.23 | <0.2 | | 0.749 | 0.082 | 1.16 | 0.11 |
| Be | 8 | 0.000065 | 0.000033 | 0.000081 | 0.000017 | <0.02 | - | <0.02 | - |
| Bi | 6 | 0.00016 | 0.00030 | 0.00039 | 0.00043 | <0.4 | - | 0.28 | 0.24 |
| Ca | 14 | 309 | 25 | 293 | 30 | 213 | 68 | 176 | 12 |
| Cd | 6 | 0.00066 | 0.00045 | 0.00030 | 0.00028 | <0.06 | - | <0.02 | - |
| Ce | 9 | 0.0023 | 0.0014 | 0.00304 | 0.00071 | <0.1 | - | <0.4 | - |
| Co | 7 | 0.0025 | 0.0017 | 0.0025 | 0.0016 | <0.09 | - | <0.1 | - |
| Cr | 12 | **0.0120[c]** | **0.0062** | **0.103[c]** | **0.006** | <0.1 | - | <0.1 | - |
| Cs | 8 | 0.015 | 0.012 | 0.0244 | 0.0035 | - | - | - | - |
| Cu | 12 | 5.4 | 1.0 | 5.7 | 1.4 | 5.92 | 0.40 | 6.39 | 0.10 |
| Fe | 12 | 9.1 | 2.2 | 10.9 | 4.2 | 12.5 | 1.2 | 13.3 | 0.2 |
| Ga | 5 | 0.0105 | 0.0044 | <0.00001 | | <1 | - | <0.4 | - |
| K | 14 | 3620 | 600 | 3310 | 580 | 2900 | 200 | 3110 | 72 |
| La | 8 | 0.00113 | 0.00080 | 0.00142 | 0.00049 | <0.07 | - | <0.05 | - |
| Li | 8 | 0.0042 | 0.0021 | 0.00339 | 0.00072 | <0.1 | - | <0.1 | - |
| Mg | 14 | 324 | 33 | 361 | 23 | 323 | 25 | 338 | 9 |
| Mn | 14 | 0.80 | 0.15 | 0.693 | 0.061 | 0.862 | 0.072 | 0.913 | 0.011 |
| Mo | 8 | 0.0499 | 0.0057 | 0.0614 | 0.0098 | <0.09 | - | <0.1 | - |
| Na | 14 | **116[c]** | **23** | 132 | 31 | 173 | 13 | **183[c]** | **4** |
| Nb | 7 | 0.00015 | 0.00015 | 0.00010 | 0.00017 | 0.098 | 0.084 | <0.3 | - |
| Ni | 5 | 0.016 | 0.024 | 0.0297 | 0.0045 | <0.4 | - | <0.6 | - |
| P | 14 | **2180[c]** | **200** | 2240 | 303 | 2800 | 240 | **3010[c]** | **21** |
| Pb | 6 | 0.0052 | 0.0048 | 0.0099 | 0.0030 | <0.2 | - | <0.2 | - |
| Rb | 8 | 17.5 | 3.0 | 16.8 | 3.3 | <0.6 | - | <2 | - |
| S[d] | 10 | 474 | 40 | 462 | 34 | 1400 | 160 | 2050 | 57 |
| Sb | 7 | 0.00093 | 0.00056 | 0.00062 | 0.00019 | <0.7 | - | <0.5 | - |
| Se | 8 | 0.0410 | 0.0079 | 0.0363 | 0.0038 | <4 | - | <4 | - |
| Si | 8 | **45.3[c]** | **3.5** | **76.6[c]** | **7.8** | <15 | - | <15 | - |
| Sn | 8 | 0.00221 | 0.00039 | 0.00198 | 0.00084 | <0.1 | - | <0.1 | - |
| Sr | 8 | 0.232 | 0.047 | 0.265 | 0.082 | <0.1 | - | <0.3 | - |
| Te | 5 | 0.00048 | 0.00039 | 0.00058 | 0.00059 | <1 | - | <0.6 | - |
| Ti | 11 | 0.077 | 0.012 | 0.102 | 0.015 | <0.05 | - | 0.108 | 0.025 |
| Tl | 8 | 0.00209 | 0.00056 | 0.00214 | 0.00073 | <4 | - | <3 | - |
| U | 8 | 0.000199 | 0.000052 | 0.000272 | 0.000031 | <3 | - | <3 | - |
| V | 5 | 0.0039 | 0.0026 | 0.0013 | 0.0017 | <0.1 | - | <0.1 | - |
| W | 2 | 0.00044 | 0.00053 | <0.0002 | | <1 | - | <1 | - |
| Zn | 14 | 25.4 | 1.0 | 25.5 | 1.9 | 27.6 | 3.3 | 28.9 | 0.6 |
| Zr | 8 | 0.0033 | 0.0029 | 0.0032 | 0.0011 | <0.3 | - | <0.1 | - |

[a] N, number of valid data. [b] M, mean; SD, standard deviation. Digests obtained by methods A or B were analyzed with ICP-MS, and digests obtained by methods B1 or B2 were analysed with ICP-OES. [c] Results marked in bold were considered statistically significant for p-values <0.05. Same superscript letters within rows are significantly different. [d] S was determined with ICP-OES.

**Table S7.** Wavelengths ($\lambda$ and $\lambda*$, nm), linearity range (LLOQ–ULOQ; mg kg$^{-1}$), and limits of determination (LODs; mg kg$^{-1}$) for each element and sample digestion treatment (methods A, B, B1, and B2) by ICP-OES.

| Element | $\lambda$ | $\lambda*$ | LOD$_A$ | LOD$_B$ | LOD$_{B1}$ | LOD$_{B2}$ | N | LLOQ–ULOQ |
|---|---|---|---|---|---|---|---|---|
| Al | 237.312 | 396.152 | 1 | 1 | 0.6 | 0.7 | 4 | 2 – 50 |
| As | 188.98 | 193.696 | 2 | 2 | 2 | 2 | 3 | 5 – 50 |
| B | 208.889 | 249.772 | 5 | 2 | 13 | 8 | 5 | 27.5 – 550 |
| Ba | 233.527 | 455.403 | 0.1 | 0.1 | 0.2 | 0.3 | 3 | 5 – 50 |
| Be | 234.861 | 313.042 | 0.01 | 0.01 | 0.02 | 0.02 | 5 | 1 – 50 |
| Bi | 190.171 | 223.061 | 0.1 | 0.1 | 0.4 | 0.1 | 4 | 2 – 50 |
| C | 193.027 | 247.856 | 194 | 465 | 300 | 500 | 4 | 1000 – 20000 |
| Ca | 315.887 | 317.939 | 30 | 30 | 140 | 80 | 5 | 500 – 10000 |
| Cd | 214.439 | 226.502 | 0.07 | 0.07 | 0.06 | 0.02 | 4 | 2 – 50 |
| Ce | 407.347 | 418.659 | 0.3 | 0.6 | 0.1 | 0.4 | 5 | 3 – 50 |
| Co | 228.615 | 238.892 | 0.1 | 0.1 | 0.09 | 0.1 | 4 | 5 – 50 |
| Cr | 267.716 | 284.984 | 0.2 | 0.3 | 0.1 | 0.1 | 4 | 2 – 50 |
| Cs | 459.311 | 697.327 | - | - | - | - | 4 | 2 – 50 |
| Cu | 324.754 | 327.395 | 0.05 | 0.05 | 0.4 | 0.3 | 4 | 2 – 50 |
| Fe | 238.204 | 259.94 | 0.1 | 0.5 | 0.3 | 0.2 | 3 | 20 – 100 |
| Ga | 294.363 | 417.204 | 0.7 | 0.6 | 1 | 0.4 | 4 | 2 – 50 |
| K | 766.491 | 769.897 | 50 | 40 | 140 | 100 | 5 | 250 – 5000 |
| La | 333.749 | 379.477 | 0.07 | 0.07 | 0.07 | 0.05 | 5 | 1 – 50 |
| Li | 460.289 | 670.783 | 0.1 | 0.1 | 0.1 | 0.1 | 3 | 2 – 10 |
| Mg | 279.078 | 280.270 | 2 | 1 | 3 | 2 | 5 | 250 – 5000 |
| Mn | 257.61 | 260.568 | 0.02 | 0.02 | 0.05 | 0.06 | 4 | 2 – 50 |
| Mo | 202.032 | 204.598 | 0.05 | 0.07 | 0.09 | 0.1 | 5 | 1 – 50 |
| Na | 589.592 | 568.821 | 5 | 5 | 10 | 12 | 5 | 250 – 5000 |
| Nb | 295.088 | - | 0.1 | 0.4 | 0.1 | 0.3 | 4 | 2 – 50 |
| Ni | 222.295 | 231.604 | 0.2 | 0.3 | 0.4 | 0.6 | 4 | 2 – 50 |
| P | 185.878 | 213.618 | 20 | 20 | 20 | 20 | 5 | 100 – 5000 |
| Pb | 182.143 | 220.353 | 0.1 | 0.2 | 0.2 | 0.2 | 4 | 2 – 50 |
| Rb | 420.179 | 780.026 | 0.8 | 0.2 | 0.6 | 2.0 | 3 | 5 – 50 |
| S | 180.669 | 181.972 | 20 | 20 | 50 | 20 | 6 | 200 – 10000 |
| Sb | 206.834 | 217.582 | 0.4 | 0.1 | 0.7 | 0.5 | 4 | 2 – 50 |
| Se | 196.026 | 206.279 | 6 | 6 | 4 | 4 | 3 | 10 – 50 |
| Si | 251.611 | 288.158 | 10 | 10 | 15 | 15 | 4 | 250 – 5000 |
| Sn | 189.927 | 242.95 | 0.1 | 0.1 | 0.1 | 0.1 | 4 | 2 – 50 |
| Sr | 407.771 | 460.733 | 0.1 | 0.1 | 0.1 | 0.3 | 5 | 27.5 – 55 |
| Te | 214.282 | 238.579 | 0.3 | 0.6 | 1 | 0.6 | 4 | 2 – 50 |
| Ti | 334.941 | 336.122 | 0.2 | 0.2 | 0.05 | 0.1 | 5 | 2 – 1010 |
| Tl | 351.923 | 377.572 | 3 | 3 | 4 | 3 | 3 | 25 – 100 |
| U | 263.553 | 385.464 | 1 | 1 | 3 | 3 | 3 | 5 – 50 |
| V | 268.796 | 292.401 | 0.3 | 0.3 | 0.1 | 0.1 | 5 | 1 – 50 |
| W | 209.475 | 239.708 | 3 | 1 | 1 | 1 | 3 | 5 – 50 |
| Zn | 206.2 | 213.857 | 0.5 | 1 | 3 | 3 | 6 | 20 – 5000 |
| Zr | 339.198 | - | 0.3 | 0.3 | 0.3 | 0.1 | 4 | 2 – 50 |

**Table S8.** Element concentrations of the certified material (NIST 1515; n=6; mg kg⁻¹) obtained by ICP-MS (methods A, B, and B1) and ICP-OES (method B2).

| Element | NIST 1515[a] | Measured concentration[b] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Method A | Z-score[c] | Method B | Z-score[c] | Method B1 | Z-score[c] | Method B2 | Z-score[c] |
| Al | 284.5 ± 5.8 | 248 ± 31 | -2.8 | 257 ± 10 | -6.5 | 274 ± 12 | -2.1 | 254 ± 15 | -5.0 |
| As | – | 0.118 ± 0.026 | – | 0.149 ± 0.051 | – | <2 | – | <2 | – |
| B | 27.6 ± 2.8 | 17.7 ± 0.6 | -31.1 | 17.0 ± 0.6 | -43 | 30.0 ± 1.2 | 2.4 | 24.5 ± 1.4 | -4.3 |
| Ba | 48.8 ± 2.3 | 44.1 ± 0.7 | -13.7 | 42.5 ± 0.4 | -35.5 | 49.0 ± 5.2 | 0.1 | 43.4 ± 2.6 | -4.2 |
| Be | – | 0.00872 ± 0.00020 | – | 0.0104 ± 0.0002 | – | 0.0126 ± 0.0012 | – | <0.02 | – |
| Bi | – | 0.00278 ± 0.00060 | – | 0.00286 ± 0.00028 | – | 0.00359 ± 0.00013 | – | <0.1 | – |
| Ca | 15250 ± 100 | 15300 ± 65 | 0.2 | 14800 ± 97 | -2.1 | 16400 ± 3000 | 0.8 | 12700 ± 670 | -7.5 |
| Cd | 0.0132 ± 0.0015 | 0.0126 ± 0.0017 | -0.7 | 0.0129 ± 0.0002 | -4.3 | 0.0120 ± 0.0005 | -5.4 | <0.02 | – |
| Ce | 3 | 2.46 ± 0.01 | -132 | 2.80 ± 0.01 | -50.0 | 2.81 ± 0.27 | -1.4 | 2.74 ± 0.70 | -0.9 |
| Co | 0.09 | 0.0978 ± 0.0014 | 46.2 | 0.101 ± 0.002 | 31.6 | 0.107 ± 0.008 | 4.1 | <0.1 | – |
| Cr | 0.3 | 0.080 ± 0.018 | -24.6 | 0.305 ± 0.056 | 0.2 | 0.327 ± 0.056 | 1.2 | 0.327 ± 0.008 | 6.5 |
| Cs[d] | – | 0.00391 ± 0.00030 | – | 0.00525 ± 0.00013 | – | 0.00600 ± 0.00041 | – | – | – |
| Cu | 5.69 ± 0.13 | 4.59 ± 0.13 | -21.4 | 5.44 ± 0.16 | -3.8 | 5.58 ± 0.26 | -1.0 | 5.43 ± 0.25 | -2.1 |
| Fe | 82.7 ± 2.6 | 79.5 ± 9.3 | -0.7 | 88.1 ± 2.0 | 4.9 | 89.2 ± 6.2 | 2.1 | 65.9 ± 3.1 | -10.7 |
| Ga | – | 0.0735 ± 0.0023 | – | 0.115 ± 0.008 | – | 0.304 ± 0.021 | – | <0.4 | – |
| K | 16080 ± 210 | 14000 ± 184 | -22.5 | 15300 ± 393 | -4.2 | 16000 ± 1200 | -0.2 | 13600 ± 55 | -91.8 |
| La | 20 | 16.4 ± 0.3 | -24.8 | 17.8 ± 0.3 | -15.0 | 18.1 ± 1.5 | -1.7 | 18.0 ± 2.6 | -1.5 |
| Li | – | 0.0226 ± 0.0015 | – | 0.0856 ± 0.0003 | – | 0.0886 ± 0.0050 | – | 0.100 ± 0.001 | – |
| Mg | 2710 ± 120 | 2560 ± 12 | -31 | 2590 ± 22 | -10.7 | 2740 ± 150 | 0.4 | 2490 ± 69 | -6.5 |
| Mn | 54.1 ± 1.1 | 59.3 ± 4.7 | 2.2 | 55.5 ± 2.5 | 1.1 | 55.8 ± 3.3 | 1.1 | 47.1 ± 2.1 | -6.7 |
| Mo | 0.095 ± 0.011 | 0.0793 ± 0.0029 | -10.8 | 0.0820 ± 0.0046 | -5.6 | 0.092 ± 0.013 | -0.6 | <0.1 | – |
| Na | 24.4 ± 2.1 | 27.9 ± 0.2 | 38.3 | 28.4 ± 1.1 | 7.7 | 27.1 ± 3.4 | 1.6 | 27.1 ± 0.9 | 6.0 |
| Nb | – | 0.00220 ± 0.00018 | – | 0.0116 ± 0.0002 | – | 0.0285 ± 0.0016 | – | <0.3 | – |
| Ni | 0.936 ± 0.094 | 0.982 ± 0.022 | 4.2 | 0.938 ± 0.012 | 0.4 | 1.04 ± 0.12 | 2.2 | 0.811 ± 0.031 | -8.0 |
| P | 1593 ± 68 | 1640 ± 11 | -3.3 | 1570 ± 25 | -0.7 | 1580 ± 36 | -1.5 | 1620 ± 84 | 0.5 |
| Pb | 0.470 ± 0.024 | 0.372 ± 0.024 | -8.2 | 0.475 ± 0.040 | 0.2 | 0.444 ± 0.027 | -1.9 | 0.59 ± 0.10 | 2.3 |
| Rb | 10.2 ± 1.6 | 9.37 ± 0.42 | -4.4 | 9.34 ± 0.46 | -4.2 | 9.33 ± 0.43 | -4.5 | 6.54 ± 0.39 | -18.8 |
| S[e] | 1800 | 1862 ± 56 | 2.9 | 1870 ± 52 | 3.1 | 1930 ± 51 | 6.2 | 2000 ± 250 | 1.6 |
| Sb | 0.013 | 0.0120 ± 0.0028 | -0.9 | 0.0128 ± 0.0011 | -0.4 | 0.0119 ± 0.0029 | -0.9 | <0.5 | – |
| Se | – | 0.055 ± 0.010 | – | 0.051 ± 0.023 | – | <4 | – | <4 | – |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Si** | – | 432 ± 22 | – | 573 ± 22 | – | 550 ± 30 | – | 647 ± 65 | – |
| **Sn** | – | 0.0359 ± 0.0015 | – | 0.0451 ± 0.0017 | – | 0.0497 ± 0.0002 | – | 0.27 ± 0.24 | – |
| **Sr** | 25.1 ± 1.1 | 25.4 ± 1.2 | 0.6 | 23.7 ± 0.2 | -11.6 | 22.9 ± 3.5 | -1.2 | 21.2 ± 0.6 | -13.8 |
| **Te** | – | 0.0033 ± 0.0010 | – | 0.0034 ± 0.0034 | – | 0.0094 ± 0.0020 | – | <0.6 | – |
| **Ti** | – | 0.62 ± 0.13 | – | 3.9 ± 1.4 | – | 11.5 ± 1.6 | – | 12.5 ± 0.8 | – |
| **Tl** | – | 0.00885 ± 0.00076 | – | 0.00803 ± 0.00023 | – | 0.0097 ± 0.0021 | – | <3 | – |
| **U** | 0.006 | 0.00325 ± 0.00020 | -28.0 | 0.00415 ± 0.00016 | -22.6 | 0.00548 ± 0.00056 | -2.2 | <3 | – |
| **V** | 0.254 ± 0.027 | 0.239 ± 0.015 | -2.0 | 0.274 ± 0.032 | 1.3 | 0.250 ± 0.014 | -0.6 | 0.235 ± 0.039 | -1.0 |
| **W** | 0.007 | 0.0085 ± 0.0037 | 0.8 | 0.00479 ± 0.00013 | -34.1 | 0.0074 ± 0.0013 | 0.8 | <1 | – |
| **Zn** | 12.45 ± 0.43 | 11.2 ± 0.9 | -3.1 | 11.8 ± 0.4 | -3.8 | 12.4 ± 0.2 | -0.6 | 11.1 ± 0.7 | -4.9 |
| **Zr** | – | 0.0323 ± 0.0004 | – | 0.0586 ± 0.0021 | – | 0.0689 ± 0.0033 | – | 0.29 ± 0.21 | – |

[a] Information mass fraction values for elements in SRM 1515. [b] ±Uncertainty = (k × Xf × CVr)/100 × √n; Xf = mean of observed values, CVr = repeatability as coefficient of variation percent intra-run (n = 6), and k = 2 (p = 95%). [c] Z-score = (Xf − Xc)/(SDr/√n) where Xc is the certified value and SDr the standard deviation for the repeatability precision. [d] Cs could not be analyzed because axial view ICP-OES is strongly affected by ionisation interference when elements with low ionisation potentials coexist in the sample. [e] S concentration is determined with ICP-OES.

**Table S9.** Trueness bias percentage (Tbias%) and repeatability (CVr%) of the certified material (NIST 1515; n=6; mg kg$^{-1}$) obtained by ICP-MS (methods A, B, and B1) and ICP-OES (method B2).

| Element | Method A | | Method B | | Method B1 | | Method B2 | |
|---|---|---|---|---|---|---|---|---|
| | Tbias% | CVr% | Tbias% | CVr% | Tbias% | CVr% | Tbias% | CVr% |
| Al | -12.8 | 12.7 | -9.7 | 4.0 | -3.7 | 4.5 | -10.7 | 5.8 |
| B | -35.9 | 4.4 | -38.3 | 3.5 | 8.7 | 8.0 | -11.1 | 7.1 |
| Ba | -9.6 | 1.9 | -12.9 | 1.0 | 0.4 | 13.0 | -11.1 | 7.3 |
| Ca | 0.3 | 3.0 | -2.9 | 3.4 | 7.6 | 22.2 | -16.6 | 6.5 |
| Cd | -4.6 | 16.2 | -2.6 | 1.6 | -8.9 | 4.4 | nd[a] | nd[a] |
| Ce | -18.0 | 0.4 | -6.8 | 0.4 | -6.4 | 11.6 | -8.7 | 25.5 |
| Co | 8.7 | 1.4 | 12.2 | 1.8 | 12.6 | 11.2 | nd[a] | nd[a] |
| Cr | -73.4 | 27.6 | 1.6 | 22.6 | 9.0 | 17.0 | 9.1 | 3.2 |
| Cu | -19.4 | 2.8 | -4.3 | 2.9 | -1.9 | 4.6 | -4.6 | 5.6 |
| Fe | -3.9 | 14.3 | 6.5 | 3.0 | 7.9 | 8.5 | -20.3 | 5.8 |
| K | -12.9 | 1.6 | -5.1 | 3.2 | -0.7 | 9.2 | -15.7 | 0.5 |
| La | -17.8 | 2.1 | -10.9 | 2.0 | -9.7 | 15.5 | -9.9 | 17.6 |
| Mg | -5.6 | 0.5 | -4.3 | 1.0 | 1.0 | 6.7 | -8.2 | 3.4 |
| Mn | 9.6 | 9.8 | 2.7 | 5.5 | 3.2 | 7.2 | -12.9 | 5.4 |
| Mo | -16.5 | 4.5 | -13.7 | 6.9 | -3.6 | 14.5 | nd[a] | nd[a] |
| Na | 14.3 | 0.8 | 16.6 | 4.5 | 11.0 | 15.3 | 11.0 | 4.1 |
| Ni | 4.9 | 2.7 | 0.2 | 1.5 | 11.3 | 11.2 | -13.4 | 4.7 |
| P | 3.1 | 0.9 | -1.6 | 2.6 | -1.0 | 3.5 | 1.4 | 6.4 |
| Pb | -20.9 | 7.9 | 1.1 | 10.4 | -5.5 | 7.4 | 24.8 | 20.8 |
| Rb | -8.1 | 4.9 | -8.4 | 5.4 | -8.5 | 5.0 | -35.9 | 7.3 |
| S[b] | 3.4 | 2.8 | 3.9 | 3.0 | 7.2 | 2.6 | 11.4 | 15.3 |
| Sb | -7.7 | 23.6 | -1.4 | 9.0 | -8.5 | 24.6 | nd[a] | nd[a] |
| Sr | 1.3 | 5.6 | -5.5 | 1.2 | -8.6 | 18.6 | -15.7 | 3.3 |
| U | -45.8 | 7.4 | -30.9 | 4.8 | -8.6 | 10.3 | nd[a] | nd[a] |
| V | -5.9 | 7.6 | 7.8 | 14.1 | -1.6 | 7.1 | -7.5 | 20.4 |
| W | 22.0 | 52.5 | -31.6 | 3.3 | 5.9 | 18.1 | nd[a] | nd[a] |
| Zn | -10.0 | 8.8 | -5.2 | 3.6 | -0.7 | 3.2 | -10.5 | 5.9 |

[a] nd, not determined because the element concentration was lower than LOD. [b] S concentration is determined with ICP-OES.

**Table S10.** Concentrations (mg Kg$^{-1}$) of each element in some commercially beehive products obtained by method B.

| Element | Honey 1 | | Honey 2 | | Honey 3 | | Honey 4 | | Honey 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | M | SD | M | SD |
| Al | 0.61 | 0.12 | 0.318 | 0.063 | 7.74 | 0.49 | 5.60 | 0.22 | 0.597 | 0.071 |
| As | <LOD | - | <LOD | - | <LOD | | <LOD | | <LOD | - |
| B | 6.23 | 0.30 | 0.671 | 0.027 | 3.28 | 0.12 | 3.63 | 0.28 | 7.22 | 0.35 |
| Ba | <LOD | - | <LOD | - | 1.722 | 0.025 | 0.503 | 0.045 | <LOD | - |
| Be | <LOD | - | <LOD | - | 0.00116 | 0.00023 | 0.00139 | 0.00023 | <LOD | - |
| Bi | <LOD | - | <LOD | - | 0.000261 | 0.000053 | <LOD | - | <LOD | - |
| Ca | 83.0 | 8.2 | 32.5 | 8.1 | 147 | 10 | 129 | 17 | 55 | 14 |
| Cd | 0.000177 | 0.000028 | 0.00067 | 0.00023 | 0.00159 | 0.00047 | <LOD | - | <LOD | - |
| Ce | 0.00104 | 0.00023 | <LOD | - | 0.0131 | 0.0010 | 0.0184 | 0.0004 | 0.000968 | 0.000059 |
| Co | 0.00597 | 0.00057 | 0.00144 | 0.00037 | 0.0105 | 0.0005 | 0.0105 | 0.0010 | 0.00151 | 0.00036 |
| Cr | 0.0129 | 0.0016 | 0.0377 | 0.0099 | 0.0204 | 0.0029 | 0.0153 | 0.0040 | <LOD | - |
| Cs | 0.00412 | 0.00020 | 0.00049 | 0.00010 | 0.696 | 0.012 | 0.502 | 0.032 | 0.00250 | 0.00039 |
| Cu | 0.301 | 0.038 | 0.076 | 0.017 | 0.764 | 0.034 | 1.02 | 0.10 | 0.150 | 0.020 |
| Fe | 3.10 | 0.19 | 2.20 | 0.56 | 3.98 | 0.94 | 4.59 | 0.57 | 0.742 | 0.081 |
| Ga | 0.00248 | 0.00038 | <LOD | - | 0.0378 | 0.0043 | 0.0124 | 0.0029 | <LOD | - |
| K | 1330 | 20 | 96.7 | 6.0 | 4700 | 204 | 3791 | 223 | 750 | 28 |
| La | 0.00050 | 0.00010 | 0.000172 | 0.000038 | 0.00800 | 0.00054 | 0.00991 | 0.00023 | 0.00070 | 0.00016 |
| Li | 0.00938 | 0.00089 | 0.00918 | 0.00051 | 0.00334 | 0.00028 | 0.0107 | 0.0004 | 0.00442 | 0.00020 |
| Mg | 47.5 | 3.1 | 21.1 | 0.9 | 91.1 | 3.1 | 107 | 3 | 18.9 | 0.9 |
| Mn | 1.07 | 0.05 | 0.314 | 0.024 | 2.13 | 0.23 | 2.09 | 0.17 | 0.120 | 0.022 |
| Mo | 0.00444 | 0.00093 | 0.00054 | 0.00018 | 0.0080 | 0.0011 | 0.0056 | 0.0010 | 0.00166 | 0.00032 |
| Na | 51.5 | 1.7 | 109 | 6 | 32.7 | 2.8 | 51.7 | 0.9 | 16.8 | 2.1 |
| Nb | 0.0000203 | 0.0000028 | <LOD | - | 0.00093 | 0.00025 | 0.00100 | 0.00029 | 0.000053 | 0.000010 |
| Ni | 0.0357 | 0.0059 | 0.0217 | 0.0036 | 0.0391 | 0.0021 | 0.0586 | 0.0092 | 0.0090 | 0.0021 |
| P | 54.9 | 7.8 | 10.6 | 0.8 | 65.5 | 2.4 | 136 | 9 | 32.4 | 1.7 |
| Pb | 0.0286 | 0.0059 | 0.00199 | 0.00055 | 0.0296 | 0.0075 | 0.0347 | 0.0049 | 0.0234 | 0.0081 |
| Rb | 1.76 | 0.11 | 0.0983 | 0.0076 | 59 | 12 | 49.2 | 8.9 | 1.54 | 0.18 |
| Sb | <LOD | - | 0.00201 | 0.00071 | <LOD | - | <LOD | - | 0.00208 | 0.00083 |
| Se | <LOD | - | <LOD | - | <LOD | - | <LOD | - | <LOD | - |
| Si | 43.0 | 8.9 | 32.4 | 3.9 | 27.3 | 0.9 | 48.5 | 4.5 | 51.9 | 2.2 |
| Sn | 0.0055 | 0.0019 | 0.00108 | 0.00016 | 0.0137 | 0.0019 | 0.00494 | 0.00043 | 0.0028 | 0.0008 |
| Sr | 0.494 | 0.004 | 0.102 | 0.020 | 1.15 | 0.10 | 1.14 | 0.22 | 0.175 | 0.032 |
| Te | <LOD | - | <LOD | - | 0.0056 | 0.0015 | 0.0053 | 0.0013 | 0.0023 | 0.0006 |
| Ti | 0.0633 | 0.0028 | 0.0408 | 0.0072 | 0.160 | 0.012 | 0.183 | 0.025 | 0.056 | 0.012 |
| Tl | 0.000176 | 0.000011 | 0.000205 | 0.000054 | 0.0378 | 0.0016 | 0.298 | 0.024 | 0.000387 | 0.000049 |
| U | 0.000105 | 0.000013 | 0.000182 | 0.000043 | 0.00117 | 0.00020 | 0.00143 | 0.00010 | 0.000093 | 0.000032 |
| V | <LOD | - | <LOD | - | 0.0170 | 0.0033 | 0.0207 | 0.0062 | 0.0071 | 0.0024 |
| W | <LOD | - | <LOD | - | <LOD | - | <LOD | - | <LOD | - |
| Zn | 1.62 | 0.07 | <LOD | - | 0.82 | 0.16 | 2.14 | 0.26 | <LOD | - |
| Zr | 0.00128 | 0.00028 | <LOD | - | 0.0141 | 0.0011 | 0.0190 | 0.0040 | 0.00058 | 0.00014 |

**Table S11.** Concentrations (mg Kg$^{-1}$) of each element in some commercially beehive products obtained by method B.

| Element | Honeydew 1 | | Honeydew 2 | | Beeswax | | Pollen | | Royal jelly | |
|---|---|---|---|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD | M | SD | M | SD |
| Al | 1.39 | 0.13 | 4.43 | 0.19 | 0.38 | 0.15 | 6.76 | 0.36 | 0.624 | 0.032 |
| As | <LOD | - | <LOD | | 0.0385 | 0.0061 | 0.013 | 0.022 | <LOD | - |
| B | 4.09 | 0.26 | 7.17 | 0.26 | <LOD | - | 4.96 | 0.45 | 1.45 | 0.16 |
| Ba | 0.060 | 0.015 | 0.9 | 0.1 | <LOD | - | 1.29 | 0.10 | <LOD | - |
| Be | <LOD | - | 0.00244 | 0.00023 | <LOD | - | 0.00051 | 0.00018 | <LOD | - |
| Bi | 0.000400 | 0.000072 | 0.000301 | 0.000082 | <LOD | - | <LOD | - | <LOD | - |
| Ca | 20.2 | 4.5 | 115 | 9 | 86 | 19 | 441 | 97 | 159 | 41 |
| Cd | 0.00120 | 0.00024 | 0.00069 | 0.00018 | <LOD | - | 0.085 | 0.014 | <LOD | - |
| Ce | 0.00279 | 0.00067 | 0.0404 | 0.0020 | 0.00100 | 0.00023 | 0.0086 | 0.0016 | 0.00054 | 0.00013 |
| Co | 0.0167 | 0.0010 | 0.0261 | 0.0016 | <LOD | - | 0.177 | 0.020 | 0.00195 | 0.00030 |
| Cr | 0.0282 | 0.0048 | 0.0682 | 0.0091 | 0.0308 | 0.0018 | 0.24 | 0.13 | 0.0370 | 0.0040 |
| Cs | 0.00339 | 0.00016 | 0.521 | 0.026 | 0.00039 | 0.00020 | 0.0114 | 0.0022 | 0.00079 | 0.00017 |
| Cu | 1.95 | 0.08 | 3.51 | 0.19 | <LOD | - | 6.16 | 0.36 | 4.75 | 0.16 |
| Fe | 2.91 | 0.21 | 5.20 | 0.38 | 0.324 | 0.040 | 33 | 4 | 10.7 | 0.7 |
| Ga | 0.00169 | 0.00043 | 0.0179 | 0.0010 | <LOD | - | 0.0328 | 0.0079 | <LOD | - |
| K | 6540 | 270 | 2550 | 131 | <LOD | - | 4237 | 312 | 2750 | 120 |
| La | 0.00142 | 0.00026 | 0.0165 | 0.0011 | <LOD | - | 0.0043 | 0.0011 | 0.000383 | 0.000077 |
| Li | 0.00933 | 0.00037 | 0.00512 | 0.00037 | <LOD | - | 0.0169 | 0.0011 | 0.00378 | 0.00050 |
| Mg | 105 | 5 | 126 | 6 | 2.8 | 2.2 | 381 | 25 | 262 | 9 |
| Mn | 1.17 | 0.04 | 2.69 | 0.14 | 0.039 | 0.016 | 19 | 0 | 0.701 | 0.054 |
| Mo | 0.0844 | 0.0044 | 0.00363 | 0.00082 | <LOD | - | 0.044 | 0.013 | 0.0502 | 0.0018 |
| Na | 10.0 | 1.2 | 44.3 | 1.0 | 148 | 9 | 24.2 | 4.5 | 103 | 5 |
| Nb | 0.000151 | 0.000036 | 0.00119 | 0.00008 | <LOD | - | <LOD | - | 0.000032 | 0.000029 |
| Ni | 1.04 | 0.06 | 0.0342 | 0.0043 | <LOD | - | 1.71 | 0.01 | <LOD | |
| P | 225 | 11 | 180 | 9 | <LOD | - | 1636 | 294 | 1020 | 26 |
| Pb | 0.0208 | 0.0040 | 0.0211 | 0.0026 | 0.0124 | 0.0066 | 0.0203 | 0.0048 | 0.0067 | 0.0014 |
| Rb | 3.54 | 0.12 | 23.1 | 2.3 | 0.0179 | 0.0032 | 3.8 | 1.8 | 2.17 | 0.07 |
| Sb | 0.0080 | 0.0025 | 0.000894 | 0.000082 | 0.0046 | 0.0024 | <LOD | - | 0.00037 | 0.00029 |
| Se | <LOD | | <LOD | - | <LOD | - | <LOD | - | 0.025 | 0.013 |
| Si | 71.2 | 7.9 | 64.2 | 1.0 | 214 | 39 | 50.9 | 9.5 | 50.3 | 4.5 |
| Sn | 0.0103 | 0.0018 | 0.00490 | 0.00041 | 0.0059 | 0.0011 | 0.00572 | 0.00020 | 0.338 | 0.022 |
| Sr | 0.0713 | 0.0043 | 2.71 | 0.29 | <LOD | - | 0.840 | 0.036 | 0.0373 | 0.0051 |
| Te | <LOD | | <LOD | | <LOD | - | 0.0025 | 0.0020 | 0.00101 | 0.00008 |
| Ti | 0.0910 | 0.0009 | 0.262 | 0.043 | 0.040 | 0.018 | 0.93 | 0.25 | 0.205 | 0.014 |
| Tl | 0.000325 | 0.000010 | 0.0114 | 0.0008 | <LOD | - | <LOD | - | 0.000809 | 0.000055 |
| U | 0.000249 | 0.000021 | 0.00144 | 0.00012 | 0.000203 | 0.000055 | 0.000306 | 0.000072 | 0.000163 | 0.000034 |
| V | <LOD | | 0.0363 | 0.0059 | 0.168 | 0.023 | 0.71 | 0.33 | 0.0059 | 0.0015 |
| W | <LOD | | <LOD | | <LOD | - | <LOD | - | <LOD | - |
| Zn | 0.41 | 0.11 | 2.56 | 0.13 | 2.40 | 0.22 | 24.1 | 3.3 | 22.5 | 0.7 |
| Zr | 0.00059 | 0.00010 | 0.0293 | 0.0041 | 0.00118 | 0.00027 | 0.00592 | 0.00055 | 0.00017 | 0.00011 |
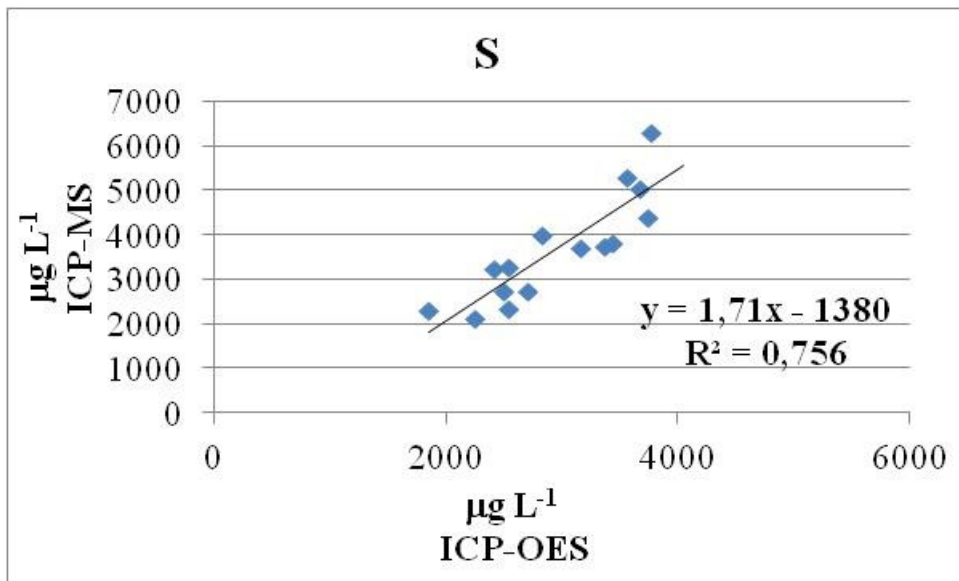
**Figure S1. C**orrelation between the S data obtained in working samples by ICP-MS and ICP-OES.