**Figure S1. (a-g)** Raman spectra for camellia-rice blended oil samples with varying adulteration concentrations. The adulteration concentrations are marked in the plots accordingly.
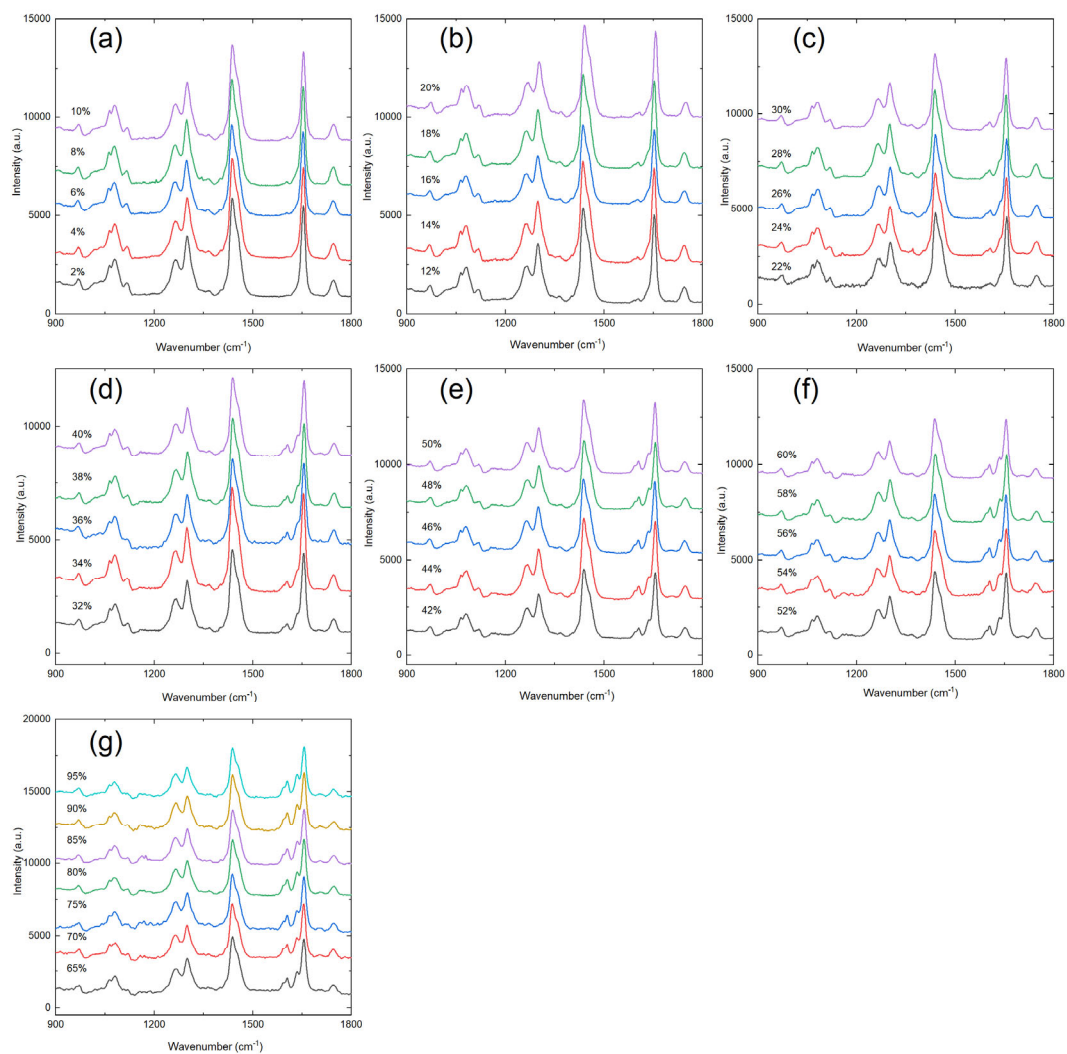
**Figure S2.** Raman spectra for camellia-corn-rice blended oil samples with varying total adulteration concentrations. The adulteration concentrations are marked in the plots accordingly.
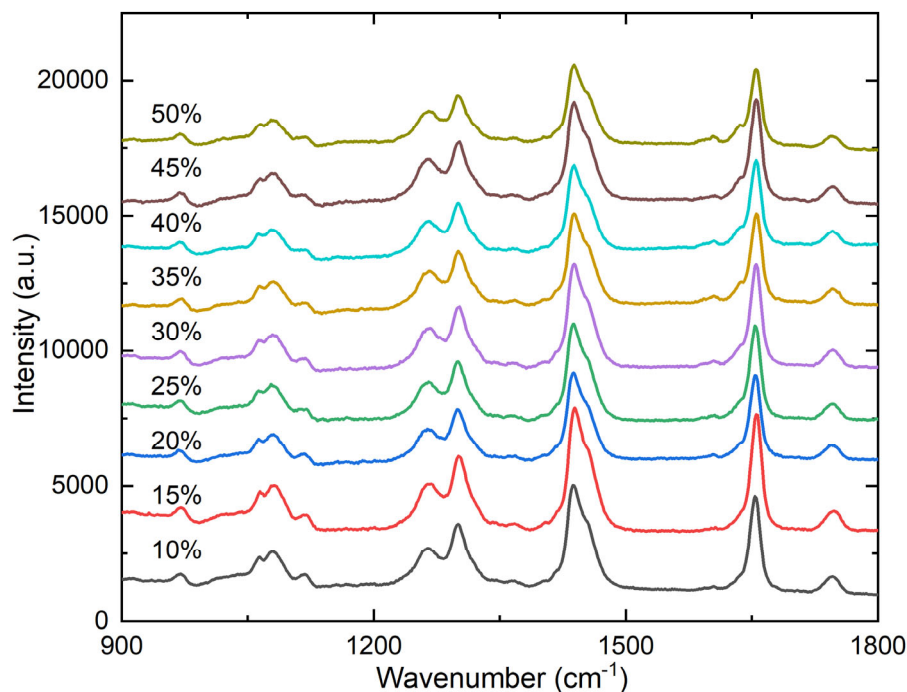


**Figure S3.** Prediction of adulteration concentration for camellia-rice blended oil samples using CARS coupled regression models: regression results for (**a**) BPNN, (**b**) PLSR, and (**c**) RF; residual distribution for (**d**) BPNN, (**e**) PLSR, and (**f**) RF. In panels (d-f), the dash-dotted horizontal line are for eye-guidance purposes.
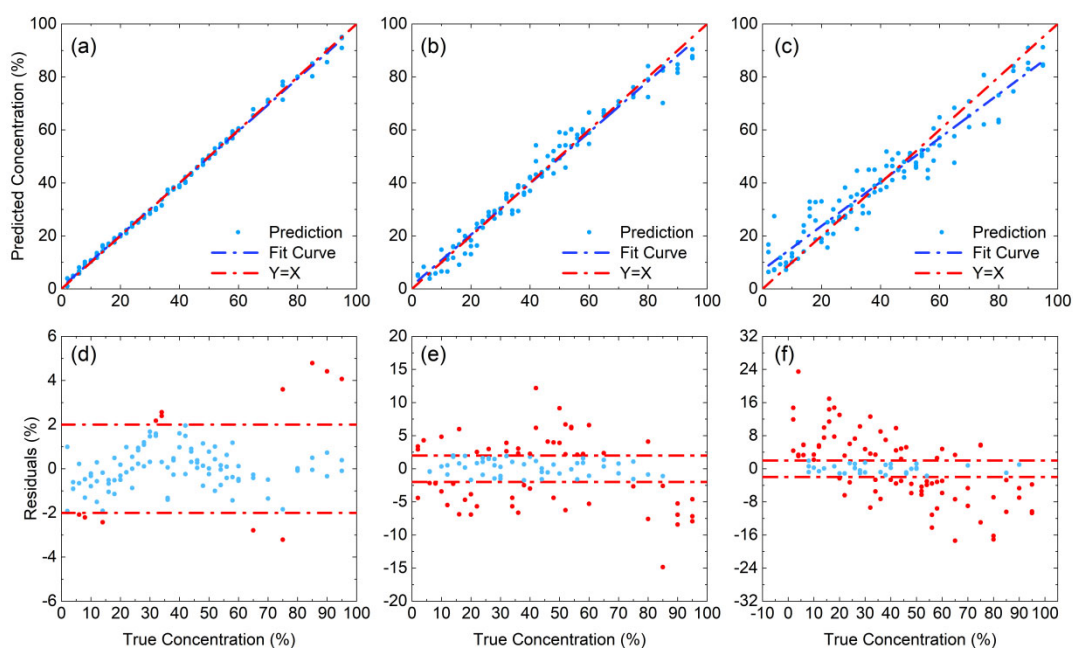
**Figure S4.** Prediction for camellia-corn-rice blended oil samples using CARS-ICA-BPNN model: regression results for (**a**) camellia oil, (**b**) corn oil, and (**c**) rice bran oil; residual distributions for (**d**) camellia oil, (**e**) corn oil, and (**f**) rice bran oil. In panels (d-f), the dash-dotted horizontal lines are for eye-guidance purposes.
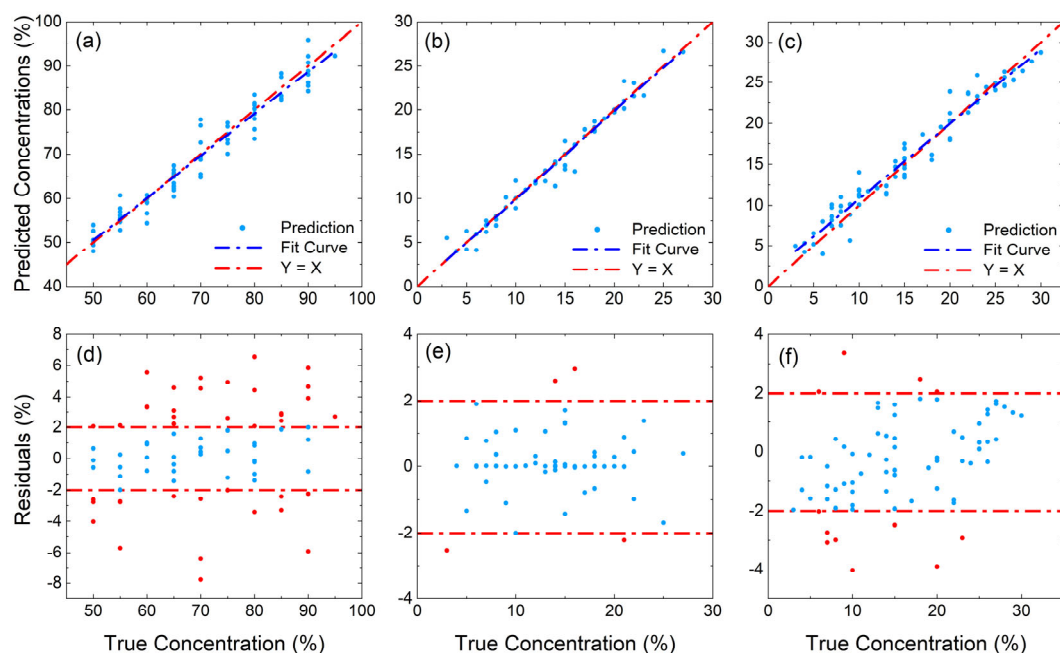


**Figure S5.** Prediction for camellia-corn-rice blended oil samples using CARS-ICA-RF model: regression results for (**a**) camellia oil, (**b**) corn oil, and (**c**) rice bran oil; residual distributions for (**d**) camellia oil, (**e**) corn oil, and (**f**) rice bran oil. In panels (d-f), the dash-dotted horizontal lines are for eye-guidance purposes.
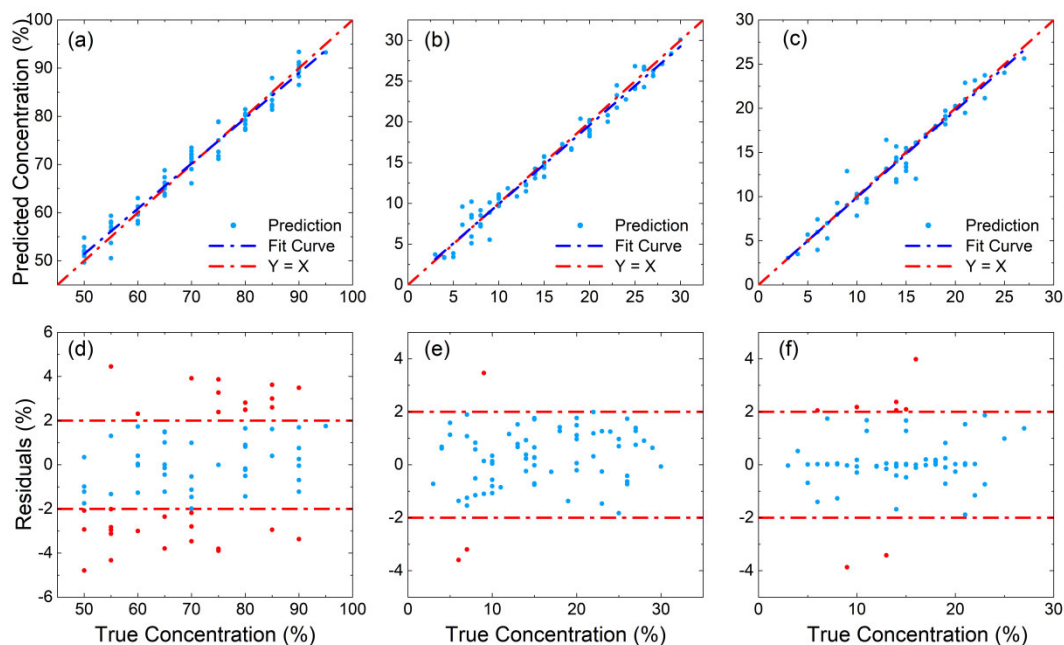
**Figure S6.** Feature extraction results for camellia- rice blended oil samples using different methods: (**a**) ICA, (**b**) CARS.
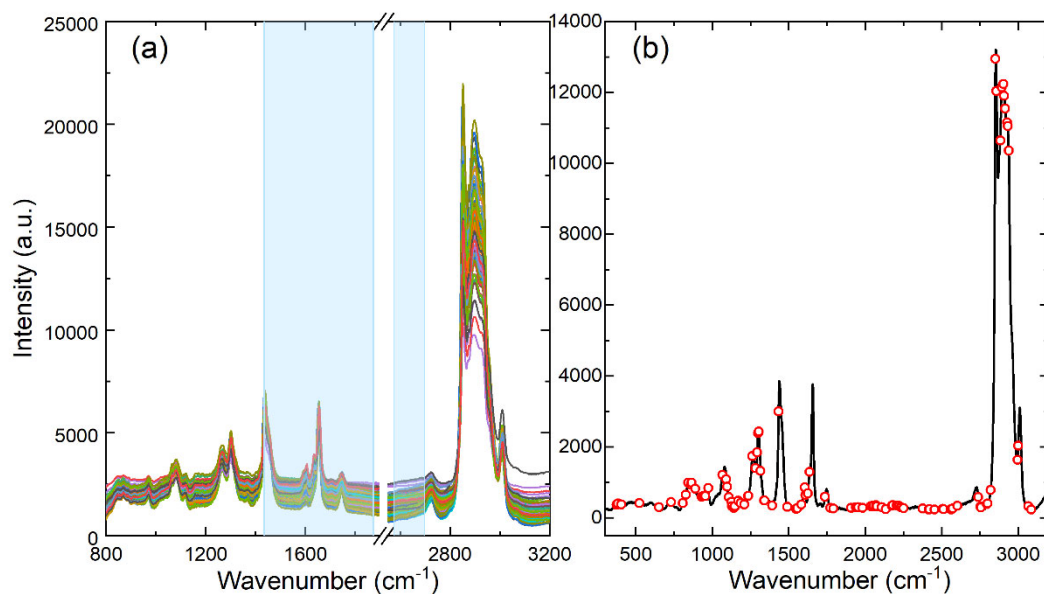


**Table S1.** Cumulative Variance by different number of principal components.

| Principal Component Number | Eigenvalue | Percentage of Variance(%) | Cumulative(%) |
|---|---|---|---|
| 1 | 1924.24643 | 99.44426 | 99.44426 |
| 2 | 7.29821 | 0.37717 | 99.82143 |
| 3 | 2.68536 | 0.13878 | 99.96021 |
| 4 | 0.31605 | 0.01633 | 99.97654 |
| 5 | 0.24336 | 0.01258 | 99.98912 |

**Table S2.** Evaluation metrics of regression models for camellia-rice blended oil samples.

| Regression algorithm | Feature extraction method | Evaluation | | | | | |
|---|---|---|---|---|---|---|---|
| | | R²C | R²P | R² | RMSEC | RMSEP | RMSE |
| BPNN | | 0.9939 | 0.99368 | 0.99379 | 1.9358 | 2.1099 | 2.02285 |
| PLSR | ICA | 0.9975 | 0.94094 | 0.96922 | 1.2161 | 6.3923 | 3.8042 |
| RF | | 0.9702 | 0.9244 | 0.9473 | 5.2633 | 5.8919 | 5.5776 |
| BPNN | | 0.9951 | 0.975 | 0.98505 | 1.7151 | 4.1622 | 2.93865 |
| PLSR | CARS | 0.98734 | 0.94638 | 0.96686 | 2.8168 | 6.454 | 4.6354 |
| RF | | 0.9313 | 0.9529 | 0.9421 | 7.2404 | 5.4685 | 6.35445 |

**Table S3.** Evaluation metrics of regression models for predicting camellia oil concentration in camellia-corn-rice blended oil samples.

| Regression algorithm | Feature extraction method | Evaluation | | | | | |
|---|---|---|---|---|---|---|---|
| | | $R^2C$ | $R^2P$ | $R^2$ | RMSEC | RMSEP | RMSE |
| BPNN | ICA | 0.6700 | 0.5245 | 0.5972 | 7.3177 | 9.129 | 8.2234 |
| | CARS | 0.9504 | 0.8877 | 0.9191 | 2.8888 | 4.3545 | 3.6217 |
| | ICA-CARS | 0.1864 | 0.1299 | 0.1582 | 11.4836 | 12.6277 | 12.0557 |
| | CARS-ICA | 0.9444 | 0.9447 | 0.9445 | 2.9238 | 3.1859 | 3.05485 |
| PLSR | ICA | 0.9321 | 0.6212 | 0.7766 | 3.4618 | 7.4757 | 5.4688 |
| | CARS | 0.9717 | 0.8699 | 0.9208 | 2.0964 | 4.8441 | 3.4703 |
| | ICA-CARS | 0.2354 | 0.1726 | 0.2040 | 10.8406 | 12.5429 | 11.6918 |
| | CARS-ICA | 0.9721 | 0.9634 | 0.9678 | 2.3187 | 2.3428 | 2.3307 |
| RF | ICA | 0.8604 | 0.8652 | 0.8628 | 6.2449 | 7.5394 | 6.8922 |
| | CARS | 0.944 | 0.886 | 0.915 | 4.5964 | 5.9175 | 5.2560 |
| | ICA-CARS | 0.8282 | 0.7781 | 0.80315 | 7.2328 | 7.0781 | 7.1555 |
| | CARS-ICA | 0.9717 | 0.96139 | 0.966525 | 2.1448 | 2.5342 | 2.3395 |

**Table S4.** Evaluation metrics of regression models for predicting corn oil concentration in camellia-corn-rice blended oil samples.

| Regression algorithm | Feature extraction method | Evaluation | | | | | |
|---|---|---|---|---|---|---|---|
| | | $R^2C$ | $R^2P$ | $R^2$ | RMSEC | RMSEP | RMSE |
| BPNN | ICA | 0.46037 | 0.34497 | 0.40267 | 7.0131 | 6.0245 | 6.5188 |
| | CARS | 0.7421 | 0.6343 | 0.6882 | 4.5936 | 5.4622 | 5.0279 |
| | ICA-CARS | 0.0338 | 0.0776 | 0.0557 | 9.2851 | 7.9023 | 8.5937 |
| | CARS-ICA | 0.98446 | 0.95455 | 0.969505 | 0.63449 | 1.3635 | 0.998995 |
| PLSR | ICA | 0.9963 | 0.5135 | 0.7549 | 0.17241 | 6.5117 | 3.342055 |
| | CARS | 0.86833 | 0.82815 | 0.84824 | 3.4063 | 3.5549 | 3.4806 |
| | ICA-CARS | 0.1511 | 0.045677 | 0.0984 | 8.1351 | 9.5439 | 8.8395 |
| | CARS-ICA | 0.99309 | 0.98476 | 0.988925 | 0.61429 | 0.90761 | 0.76095 |
| RF | ICA | 0.7798 | 0.753 | 0.7664 | 5.0542 | 5.7265 | 5.39035 |
| | CARS | 0.94396 | 0.88597 | 0.914965 | 4.5964 | 5.9175 | 5.25695 |
| | ICA-CARS | 0.7507 | 0.8172 | 0.78395 | 7.352 | 6.9679 | 7.15995 |
| | CARS-ICA | 0.98147 | 0.964853 | 0.9732 | 0.98853 | 1.6583 | 1.323415 |

**Table S5.** Evaluation metrics of regression models for predicting rice bran oil concentration in camellia-corn-rice blended oil samples.

| Regression algorithm | Feature extraction method | Evaluation | | | | | |
|---|---|---|---|---|---|---|---|
| | | R²C | R²P | R² | RMSEC | RMSEP | RMSE |
| BPNN | ICA | 0.34456 | 0.35333 | 0.348945 | 6.0367 | 4.0201 | 5.0284 |
| | CARS | 0.4561 | 0.4571 | 0.4566 | 5.2662 | 4.1439 | 4.70505 |
| | ICA-CARS | 0.3712 | 0.065 | 0.2181 | 5.3183 | 6.9147 | 6.1165 |
| | CARS-ICA | 0.96044 | 0.92145 | 0.940945 | 1.3665 | 2.3334 | 1.84995 |
| PLSR | ICA | 0.8821 | 0.40875 | 0.645425 | 2.388 | 4.6205 | 3.50425 |
| | CARS | 0.83773 | 0.45112 | 0.644425 | 2.5742 | 5.4684 | 4.0213 |
| | ICA-CARS | 0.29063 | 0.14988 | 0.220255 | 4.7907 | 8.0655 | 6.4281 |
| | CARS-ICA | 0.97058 | 0.98126 | 0.97592 | 0.77216 | 0.79957 | 0.785865 |
| RF | ICA | 0.8125 | 0.8403 | 0.8264 | 3.6186 | 2.7407 | 3.17965 |
| | CARS | 0.8671 | 0.826 | 0.84655 | 3.5392 | 2.2051 | 2.87215 |
| | ICA-CARS | 0.7404 | 0.7798 | 0.7601 | 4.3123 | 2.8997 | 3.606 |
| | CARS-ICA | 0.9615 | 0.9479 | 0.9547 | 1.0258 | 1.48 | 1.2529 |

**Table S6.** Time cost (duration) and complexity (number of spectral variables) for predicting rice bran oil concentration in camellia-rice blended oil samples. The algorithms are run by a regular laptop with the following configuration: Intel(R) Core(TM) i5-10210U, 8GB RAM and 256GB SSD.

| Regression algorithm | Feature extraction method | Number of spectral variables | Feature extraction duration (s) | Modeling duration (s) | Total duration (s) |
|---|---|---|---|---|---|
| BPNN | / | 1934 | | 141.627475 | 141.627475 |
| | ICA | 380 | 80.210116 | 13.255057 | 93.465173 |
| | CARS | 102 | 60.309124 | 5.922844 | 66.231968 |
| PLSR | / | 1934 | | 4.67658 | 4.67658 |
| | ICA | 380 | 80.210116 | 2.667561 | 82.877677 |
| | CARS | 102 | 60.309124 | 1.507114 | 61.816238 |
| RF | / | 1934 | | 598.245278 | 598.245278 |
| | ICA | 380 | 80.210116 | 441.150655 | 521.360771 |
| | CARS | 102 | 60.309124 | 381.049474 | 441.358598 |

**Table S7.** Time cost (duration) and complexity (number of spectral variables) for predicting camellia oil concentration in camellia-corn-rice blended oil samples. The algorithms are run by a regular laptop with the following configuration: Intel(R) Core(TM) i5-10210U, 8GB RAM and 256GB SSD.

| Regression algorithm | Feature extraction method | Number of spectral variables | Feature extraction duration (s) | Modeling duration (s) | Total duration (s) |
|---|---|---|---|---|---|
| BPNN | / | 1934 | | 98.13487 | 98.13487 |
| | ICA | 284 | 99.585532 | 15.606808 | 115.19234 |
| | CARS | 44 | 40.331264 | 8.50749 | 48.838754 |
| | ICA+CARS | 11 | 115.977688 | 10.848021 | 126.825709 |
| | CARS+ICA | 18 | 53.861053 | 16.934077 | 70.79513 |
| PLSR | / | 1934 | | 8.156823 | 8.156823 |
| | ICA | 284 | 99.585532 | 2.764287 | 102.349819 |
| | CARS | 44 | 40.331264 | 3.102079 | 43.433343 |
| | ICA+CARS | 11 | 115.977688 | 2.51694 | 118.494628 |
| | CARS+ICA | 18 | 53.861053 | 3.327756 | 57.188809 |
| RF | / | 1934 | | 398.56732 | 398.56732 |
| | ICA | 284 | 99.585532 | 167.979836 | 267.565368 |
| | CARS | 44 | 40.331264 | 265.034759 | 305.366023 |
| | ICA+CARS | 11 | 115.977688 | 174.9192 | 290.896888 |
| | CARS+ICA | 18 | 53.861053 | 139.677742 | 193.538795 |

**Table S8.** List of abbreviations.

| | |
|---|---|
| Savitzky-Golay | S-G |
| Multiplicative Scatter Correction | MSC |
| Independent Component Analysis | ICA |
| Competitive Adaptive Reweighing Sampling | CARS |
| Principal Component Analysis | PCA |
| Levenberg Marquardt | LM |
| Partial Least Squares Regression | PLSR |
| Backpropagation Neural Network | BPNN |
| Random Forest | RF |
| Linear Discriminant Analysis | LDA |
| Coefficient of Determination | $R^2$ |
| Root Mean Square Error | RMSE |