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Comment on Effect of Drying of Jujubes (*Ziziphus jujuba* Mill.) on the Contents of Sugars, Organic Acids, α-Tocopherol, β-Carotene, and Phenolic Compounds

Red dates (*Ziziphus jujuba*) are a very versatile fruit in that they serve a multitude of purposes. Found throughout Europe and southern Asia, jujubes have been utilized in nutrition, medicine, and aroma therapy.[1−3] The seeds have significant uses in the medicinal field for their sedative, antihypoxia, and antihyperlipidemia activities.[4,5] With regard to nutritional value, jujubes have a large amount of vitamins, minerals, and phenols that make them well-known as an antioxidant.[1,2] The sugars present also contribute greatly to the demand for and subsequent production of jujubes.[2,3] The concern is that these compounds reduce in quantity immediately after the fruit is harvested, resulting in spoilage after approximately 2 days.[1]

Drying is a common method utilized to preserve the fruits until they reach the consumer. The primary goal of drying is to preserve the fresh qualities or compounds present when harvested. Because there are multiple methods of drying jujubes, the original authors attempted to delineate the most effective means of preserving multiple primary and secondary metabolites via sun-, microwave-, freeze-, and oven-drying methods while utilizing fresh fruits as the control.[1] All compounds were measured by high-performance liquid chromatography. Among the results, glucose concentrations were highest utilizing the sun-drying technique. Oven-drying increased the concentration of β-carotene compared to the fresh fruit. In metabolites pivotal for antioxidant activity, microwave-drying conserved the highest amount of individual phenols, but freeze-drying conserved the highest amount of total phenolic content (TPC). The final conclusion was that freeze-drying would produce high-value jujube products but cost would limit availability, and therefore microwave-drying would be the most efficient means of jujube preservation.[1]

Whereas the original paper[1] evaluated each method on the basis of individual metabolites, comparison based on all metabolites together as a whole was not made. Here, we analyzed their data utilizing principal component analysis (PCA). Because PCA can reduce the dimensionality of variables into a lower dimension, it can analyze interrelationships of a multivariate data set more efficiently.[6−9] We applied PCA to extract a more definitive depiction of the optimal method to dry jujubes.

In our PCA, we included all variables reported in the original paper; these include the concentrations of 18 individual metabolites and total phenolic compounds and antioxidant capacity. The number of variables of the data was 20. When the metabolite concentration was under the detection limit, we used 0.01 as the value. The inclusion of the arbitrary number may lower the precision of our analysis, but makes it more comprehensive by including eight more variables otherwise not considered. PCA of the data was conducted with Minitab (v. 15) using the correlation matrix to standardize the variables.[10] We found that the 20 variables were successfully reduced to four dimensions that cumulatively illustrated all of the data (Figure 1A). This reduction indicates that there were significant correlative behaviors of the metabolites due to the similar physicochemical

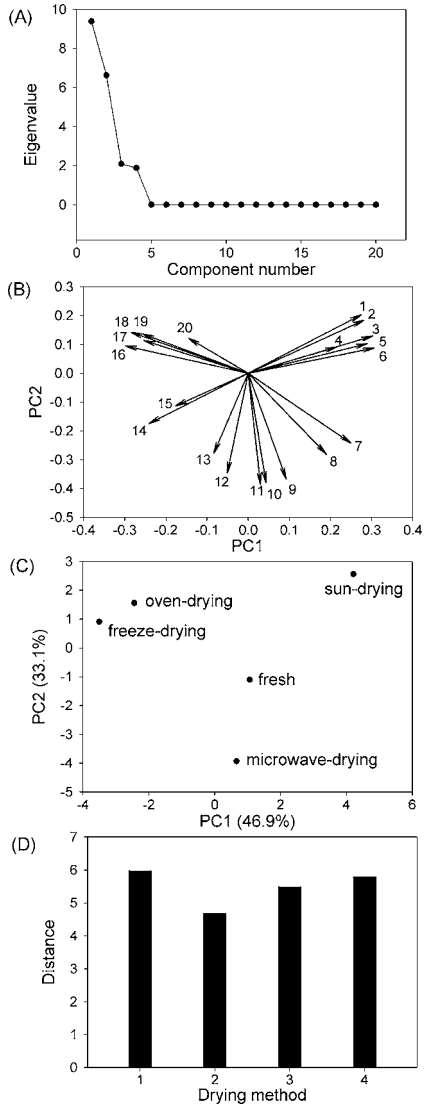

Figure 1. (A) Scree plot of the PCA. The first four components retain 100% information of the original data. (B) PCA loadings plot of the 20 variables (1, *p*-hydroxybenzoic acid; 2, *p*-coumaric acid; 3, vanillic acid; 4, fructose; 5, glucose; 6, ferulic acid; 7, cinnamic acid; 8, rutin; 9, protocatechuic acid; 10, epicatechin; 11, catechin; 12, sucrose; 13, ABTS; 14, TPC; 15, malic acid; 16, β-carotene; 17, gallic acid; 18, α-tocopherol; 19, succinic acid; 20, citric acid). (C) Two-dimensional score plot of the four methods and the fresh fruit produced from PCA with the correlation matrix. (D) Distance of each method (1, freeze-drying; 2, microwave-drying; 3: oven-drying; 4, sun-drying) from the fresh fruit coordinate in the score plot.

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properties (Figure 1B). To assess the similarity of fruits produced by each method to the fresh fruit, the distance (D) between each drying method relative to fresh fruit in the score plot space (Figure 1C) was calculated using eq 1

$$D = \sqrt{\sum_{n=1}^{4} (x_n^{M} - x_n^{F})^2} \quad (1)$$

where x_n^{M} and $x_n^{F}$are coordinates of a drying method and the fresh fruit on the principal component n in the score plot. The distance of each method to fresh fruit is shown in Figure 1D. This figure clearly shows that microwave-drying is the closest to fresh fruits.

In conclusion, by utilizing PCA we quantitatively identified that jujubes processed by microwave-drying are the most similar to the fresh fruit on the basis of a collective comparison. This conclusion is consistent with that of the original paper. We expect the algorithm introduced in this paper may be applied to the evaluation of other food-processing methods.[11,12]

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Notes

The authors declare no competing financial interest.

REFERENCES

(1) Gao, Q.; Wu, C.; Wang, M.; Xu, B.; Du, L. Effect of drying of jujubes (*Ziziphus jujuba* Mill.) on the contents of sugars, organic acids, α-tocopherol, β-carotene, and phenolic compounds. *J. Agric. Food Chem.* **2012**, *60*, 9642−9648.

(2) Outlaw, W., Jr.; Zhang, S.; Riddle, K.; Womble, A.; Anderson, L.; Outlaw, W.; Outlaw, N.; Outlaw, E.; Thistle, A. The jujube (*Ziziphus jujuba* Mill.), a multipurpose plant. *Econ. Bot.* **2002**, *56*, 198−200.

(3) Meiselman, H.; Halpern, B.; Dateo, G. Reduction of sweetness judgements by extracts from the leaves of *Ziziphus jujuba*. *Physiol. Behav.* **1976**, *17*, 313−317.

(4) Cheng, G.; Bai, Y.; Zhao, Y.; Tao, J.; Liu, Y.; Tu, G.; Ma, L.; Liao, N.; Xu, X. Flavonoids from *Ziziphus jujuba* Mill var. *spinosa*. *Tetrahedron* **2000**, *56*, 8915−8920.

(5) Zhao, J.; Li, S.; Yang, F.; Li, P.; Wang, Y. Simultaneous determination of saponins and fatty acids in *Ziziphus jujuba* (Suanzaoren) by high performance liquid chromatography-evaporative light scattering detection and pressurized liquid extraction. *J. Chromatogr., A.* **2006**, *1108*, 188−194.

(6) Sun, F.; Levin, G.; Downie, S. A multivariate analysis of *Pseudocymopterus* (Apieaceae). *J. Torrey Bot. Soc.* **2006**, *133*, 499−512.

(7) Izhaki, I.; Tsahar, E.; Paluy, I.; Friendman, J. Within population variation and interrelationships between morphology, nutritional content, and secondary compounds of *Rhamnus alaternus* fruits. *New Phytol.* **2002**, *156*, 217−223.

(8) Wold, S.; Esbensen, K.; Geladi, P. Principal component analysis. *Chemom. Intell. Lab.* **1987**, *2*, 37−52.

(9) Tikunov, Y.; Lommen, A.; Ric de Vos, C.; Verhoeven, H.; Bino, R.; Hall, R.; Bovy, A. A novel approach for nontargeted data analysis for metabolomics. Large-scale profiling of tomato fruit volatiles. *Plant Physiol.* **2005**, *139*, 1125−1137.

(10) Field, A. *Discovering Statistics Using SPSS*, 2nd ed.; SAGE Publications: London, UK, 2005; 643 pp.

(11) White, B. L.; Howard, L. R.; Prior, R. L. Impact of different stages of juice processing on the anthocyanin, flavonol, and procyanidin contents of cranberries. *J. Agric. Food Chem.* **2011**, *59*, 4692−4698.

(12) Xu, B.; Chang, S. K. Isoflavones, flavan-3-ols, phenolic acids, total phenolic profiles, and antioxidant capacities of soy milk as affected by ultrahigh-temperature and traditional processing methods. *J. Agric. Food Chem.* **2009**, *57*, 4706−4717.