Introduction

The juice authenticity is essential to the socially high quality of the finished juice/wine product and to the compliance with labeling. However, partial replacement of high-cost ingredients with lower grade or cheaper substitutes can be very attractive and lucrative for a fruit supplier. Raw fruit materials with different composition of a sample and provide structural information based on chemical characteristics need to be analyzed and evaluated to differentiate the source. These factors have underlined the need of rapid, reliable, easy-to-use and cost-effective techniques for the juice/wine industry and regulatory agencies to effectively check the authenticity of the incoming fruit material. Traditional chromatography methods are costly, time consuming, and dependent on non-universal market compounds as reference (1) and certain diagnostic markers (2).

The infrared (IR) spectra (4000–700 cm−1) reflect the total biochemical compositions and are often used in quality control and authenticity assessments of various food products. Conventional infrared spectroscopy is widely used in chemical analysis for the quantification and qualitative determination of compounds. Despite that, only a few studies have focused on authentication of fruit products with IR (3, 4, 5), all done with intact product. In recent years, several authors and regulatory agencies a rapid, high-throughput and low cost analysis of juice authenticity and quality. In this study we developed a robust method to evaluate intact fruit juices as well as their sugar-rich and phenol-rich fractions for juice authentication and quality. The results demonstrated feasibility of using FTIR to pickup subtle compositional differences among juices.

Materials and Methods

Juice samples. Twelve different juices were obtained from local grocery stores to test the feasibility of using FTIR to recognize subtle compositional differences among different juices. Afterwards, cranberry, blueberry and Concord grape juices each manufactured by three companies and four different batches from each company (a total of 36 samples), were obtained to test the potential ability of using FTIR to differentiate juices caused by origin/manufacturer and processing conditions. Four additional juices were used to validate the developed method. Two different pH values juices were made by mixing 1 volume of supernatant juice with 2 volume of acidified (pH 1.75) or basic solvents (pH 11).

Sample preparation. Juice samples were centrifuged at 3,000 rpm for 10 min to remove non-soluble particles. After that, 0.5 mL of each juice sample was added to 2 mL of methanol and sonicated for 2 min. Each juice fraction was applied 3 times for repeated measurement. FTIR spectra were collected over 4,000–700 cm−1.

Detection of phenolic compounds is an important issue in food safety and quality control. Mid-infrared spectroscopy provides rapid chemical profiling of multiple phenolic compounds and could become an effective tool for authentication when coupled to chemometrics. This study developed a simple protocol for classifying different juices and fruits using the technique of mid-infrared spectroscopy, and sought for improvements of modeling power by analyzing the taxonomic compounds of the phenol-rich fraction. Samples from 52 juices together with their extracted sugar-rich and phenol-rich fractions were obtained to construct multivariate models (PCA and HCA) for pattern recognition analysis and classification. Spectra of the sugar-rich fraction, comprising primarily of sugars and water, were collected. Spectra of the phenol-rich fraction, comprising of phenol and other minor compounds, were collected. PCA was done with the whole juice and phenol-rich fraction models. HCA was done with the whole juice and phenol-rich fraction models. Z-score pre-treatment was used to normalize the data before the analysis. The constructed statistic models demonstrated the potential to provide the juice/wine industry with a rapid and reliable tool for authenticating incoming materials and monitoring the finished product quality.

Discussions and Conclusions

The phenol-rich fraction spectra was greatly affected by pH (Figure 2). As pH dropped below 2, the spectra became stable. Therefore we decided to use acidified solvents for phenol-rich fraction. The whole juice spectra was nearly identical to those in the sugar-rich fraction, which contained primarily sugars and the non-polar hydrocarbons such as ketones, aldehydes and alcohols. Therefore we hypothesized that we may find improved prediction power using the phenol-rich fraction as compared to the whole juice.

The ultimate goal of our research is to provide the juice/wine industry and regulatory agencies a rapid, easy-to-use and cost-effective technique for the juice authenticity and quality. In this study we developed a robust method to evaluate intact fruit juices as well as their sugar-rich and phenol-rich fractions for differentiation of juices and identification of potential adulterants.

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References


Figure 1. Flow chart of juice fractionation and IR spectral data acquisition.