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Determination of Sugar Content in Apple Juice using FTIR Spectroscopy: A Review

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Abstract

Fruits have many beneficial qualities to one's fitness; they provide an abundance of vitamins, minerals, anti-oxidants and fiber, which are all necessary for the human nourishment. Fruit juices are a suitable approach for people to obtain the benefits of various fruits. Various techniques have been used to measure the sugar quantity in apple juice and other juices. The techniques have been become fast, instantaneous and accurate with time to analyze fruit juice and other soft drinks.

Spectroscopic techniques for sugar determination in apple juice are quick, non-destructive, accurate and effective techniques. Spectroscopic techniques also have been used in quantitative and qualitative analysis of fruit juices. In this paper several techniques of sugar content determination in apple juice are reviewed with the advantages and disadvantages of these techniques.

Keywords: Sugar content, Fruit juice, Refractrometer, FTIR

Introduction

Apple juice has a strong position in the world consumption ranking, being valued not only for its taste and dietary assets but also for its health effects. However, these features relate to a proper juice quality; assessment of the apple juice quality requires determination of the chemical composition, sensory attributes along with the presence of undesired substances such as preliminary fermentation products, patulin or substantial metals. Sugar may not be healthy in high quantities, whether it is natural or not. It was advised that excessive sugar could carry hazardous health effects, as people could develop heart disease, obesity, diabetes, and other complications from surplus consumption.

The main essentials of apple juices contain fructose, glucose, sucrose, as well as organic acids, mineral salts, vitamins, dyes, and phenolic compounds; hence, complex analytical methods are necessary for determination of sugar content in fruit juice.

The most significant criterion for the final product quality of fruit and their by-products in fruit processing industry is their sugar content. Detecting sugar in adulterated apple juice is particularly problematic because of the diversity of commercial sweeteners available that contest the concentration profiles of the major carbohydrates in it. A second noteworthy challenge in the recognition of adulterated apple juice is the natural variation in reliable samples, a result of variances in species, maturity, climate, growing regions, seasons, processing, and storage conditions.

Sugar content determination methods

Different methods are used to measure sugar contents in apple juice.

- Instrumental Methods
- Chemical Methods
- Spectroscopic Methods

Instrumental Methods: Instrumental methods are ancient techniques used to measure sugar by measuring the density of the liquid. Saccharometer and Refractrometer are used to measure the density and reflective index in the denser liquid. They provide the value of sugar in a liquid; in terms of °Brix.

Chemical Methods: Chemical methods are the most common analytical chemistry for separating and analyzing mixtures that can be evaporated without decomposition. Gas chromatography and High Pressure Liquid Chromatography are used to analyze the chemical composition of sugar in terms of glucose, fructose and sucrose.

Spectroscopic Methods: Spectroscopic methods are the optical techniques, which are based on emission, absorption or scattering of electromagnetic radiation. The spectroscopic methods used absorbance of light for sample analysis of fruit juice.

Literature review

Spectroscopic sugar analysis methods are of considerable interest as they are non-destructive, efficient and accurate methods. A variety of methods have been established over time and provided improved results. This section reviews the various techniques of sugar content determination of apple juice and focuses on their merits and demerits.

L. F. Leopold et al in [1], have confirmed the efficiency of FTIR spectroscopy, in combination with multivariate statistics, reliable and economical tool for routine monitoring of multiple ingredients in fruit juices, as quality indicators. The Unscrambler software (CAMO, Norway) was used for multi component analysis by using the PCA and PLS routine analysis. The Results of spectra were found best predictive capacity.

G. M. Mohamed et al in [2], have demonstrated the capability of FTIR spectroscopy as a simple, rapid and accurate method for instantaneously determining pectin, sugar and organic acid contents (citric acid) in certain natural and synthetic fruit products. The results of this work recommend FTIR spectroscopy as a potential analytical rapid, economic and non-destructive tool to detect any adulterants, added in the food industries, of certain food products as juices and jams.

D. Helm et al in [3], have described a computer based technique for classifying and recognizing bacterial samples using Fourier transform infrared spectroscopy (FTIR) patterns. FTIR can be used as an easy and harmless method for the quick identification of clinical isolates. FTIR spectroscopy permits the quick and time-saving determination of some particular microbiological features such as PHFA production, O-antigenic properties.

Chenxu Yu et al in [4], have confirmed that FTIR is a spectroscopy based approach for microbial quantification and differentiation in apple juice. By using principal component analysis and canonical variate analysis (CVA), the first derivatives of the spectra have high key peaks. The result shows the potential of FTIR to become a fast, sensitive, and easy-to-operate substitute to customary plate count and other involved methods to measure microbial concentration in liquid food samples.

N. Vlachos et al in [5], have extended the application of Fourier transform infrared (FTIR) spectroscopy arrangement technique in the field of food research, simplifying mainly the studies on edible oils and fats. The detection limit for oil adulteration was 9% if the adulterant corn oil or sesame seed oil while it was lower (6%) if the adulterant was sunflower oil or soybean oil. This methodology could be convenient to estimate the oxidative state of edible oils in a simple and fast way.

Petr Šnurkovič et al in [6], has described the detection of substances used for the adulteration of fruit juice using near-infrared spectroscopy (NIR). The NIR spectroscopy was enabled the detection of relatively low concentration of admixtures, and could be used also for the differentiation of individual samples from all others. In all cases it was possible to construct discrimination cross so that the NIR spectroscopy was able to detect admixtures of various substances to fruit juices.

LIU Yan-de et al in [7], have estimated the potential of FTIR spectroscopy and the influence of the distance between the light source/detection probe and the fruit for measuring sugar content of Fuji apples, diffuse reflectance spectra was measured in the spectral range. The results showed that the light/detection probe-fruit distances affect the apple reflective spectra and SC Predictions.

Tsuyoshi TEMMA et al in [8], have considered application using the NIR method measure the sugar content of apple quantitatively. NIR spectroscopy was value in utilizing it for samples that were mainly water. The analysis of the near-infrared absorption spectra of the apple and apple juice used the second derivative spectra. The results showed that this should become an influential supporting technology in the realization of precision farming.

Mengqi Ye et al in [9], have discussed the possibility of rapid, immediate analysis of soluble solid content (SSC), total acidity, total ester content and pH in apple wine by FT-NIR spectroscopy together with PLS models. Spectra were pretreated using altered methods in the software OPUS 5.5, with MSC (multiplicative scatter correction), vector normalization (VN), first derivative (FD), second derivative (SD), eliminate the constant offset (ECO), eliminate the constant offset (ECO), Min/Max normalization (MMN), and minus a straight line (MSL), to enhance the spectral difference and minimize baseline variation.

Haisheng Gao et al in [10], have expanded the fruit quality recognition methods which were based optical properties, sonic vibration, machine vision technique, MNR, electronic noses, electrical properties, computed tomography. In the results, the simple, quick, accurate and comprehensive detection methods apply to the research and application were shown.

Dazhou Zhu et al in [11], have discussed that the processing and storing of apple juice often starts quality deterioration regarding nutritional appreciated compounds and unfavorable color variations resulting from browning. Fluorescence and near-infrared spectroscopy were applied to sense such quality loss in apple. Results indicated that the combination of fluorescence EEM and NIR spectra can be used to monitor the quality decline of apple juice.

G. E. A. Swann et al in [12], have demonstrated for calculating levels of adulteration in cleaned sediment core diatom samples by using Fourier Transform Infrared Spectroscopy mass-balance method. When compared to XRF (X-ray Fluorescence), the FTIR method shows the key variations in sample adulteration through the core arrangement, approving its use in cases where other destructive techniques are not suitable. The FTIR approach would significantly decrease the time vanished by analyzing contaminated samples for isotope/other geo-chemical techniques.

F.R. van de Voort et al in [13], have developed to simultaneously determine percentage cis and trans content of the edible fats and oils by FTIR. The FTIR-partial least squares (PLS) approach functioned well over a wide range of trans contents. The result showed the FTIR method used for generalized sample-handling accessory designed specifically for fats and oils.

J. Irudayaran et al in [14], have experimented Fourier Transform Infrared Spectroscopy (FTIR) combined with multivariate analysis (MVA) to determine the level of invert sugar adulteration in honey, with an attenuated total reflection sampling accessory. The results showed that this method was potentially rapid, inexpensive, non-destructive, effective, and suitable for monitoring honey quality, but the method should be improved and validated for another honey variety.

Carlo Camerlingo et al in [15], have investigated Liquid samples of clarified apricot and apple juices at different production stages by visible light micro-Raman spectroscopy to evaluate its potential in the monitoring fruit juice production. The result caused exciting for the special use of optical methods for quantitative determination of the elements rather than the biochemical assays commonly used for this purpose, which require various chemical reagents for all of them and also time consuming.

Ponnadurai Ramasami et al in [16], have computed the quantity of sugar in soft drinks and fruit juices. All the statistical calculations were supported by commercial software, The Unscrambler. The results from the three different methods were in agreement and the greater amount of the sugar forecasted by the density and refractrometric methods compared to infrared spectroscopy might be attributed to only sucrose solutions.

Murad A. Al-Holy et al in [17], have used Fourier Transform infrared (FTIR) to identify and differentiate between 4 bacillus isolates and 4 alicyclobacillus strains inoculated independently into apple juice. Multivariate statistical methods as soft independent modeling of class analogy and principle component analysis (PCA) were used to evaluate the spectral data. The results were served as a helpful tool to rapidly identify alicyclobasillus and Bacillus adulteration in the apple juice industry.

Luis E. Rodriguez et al in [18], have analyzed an aqueous solution for sugar mixtures to develop a calibration model. FTIR spectral data were transformed to the second derivative. Partial least square regression (PLSR) was used to generate calibration models that were cross-validated. The FT-NIR spectroscopy allowed for fast, precise and non-destructive analysis of the sugars in juices and could be applied in the quality control of the beverages or to monitor for the adulteration and contamination.

Lu Hui-shan et al in [19], have developed a nondestructive technique for evaluating soluble solids content (SSC) of citrus fruits using FT-NIR measurements collected through the optical fiber. The relationship between FT-NIR spectra of citrus fruits and laboratory SSC were analyzed via PLSR and PCR method. This method was valuable whenever a large number of samples need to be rapidly analyzed.

P. Stober et al in [20], have explained the use of capillary gas chromatography (CGC) to check the authenticity of various fruit juices by analyzing their oligosaccharide fingerprint profile. A standardized approach was proposed which help to reduce differences of interpretation of results between laboratories, thus reinforcing the industrial and legal applications of this valuable method.

Conclusion and future scope

It has been found from previous work that gas chromatography method is time consuming and liquid sample preparation for Raman spectroscopy is difficult. Techniques used for sugar content measurement till date are time consuming and destructive.

The scope of the present work is to introduce a non-destructive technique for sugar measurement which provides precise measurement. It will require no external calibration. Technique with increased speed, collecting a scan every second and sample preparation is easier.

References

[1] Loredana F. Leopold, Nicolae Leopold, Horst-A. Diehl, Carmen Socaciu, 2011. Quantification of Carbohydrates in Fruit Juices using FTIR Spectroscopy and Multivariate Analysis. Journal of Spectroscopy. 26.93-104.

[2] Gamal F. Mohamed, Mohamed S. Shaheen, Safaa K.H. Khalil, Ahmed M.S. Hussein, Mohie M. Kamil, November 2011. Application of FT-IR Spectroscopy for Rapid and Simultaneous Quality Determination of Some Fruit Products. Science Journal. 9.21-31.

[3] D. Helm, H. Labischinski, Gisela Schallehn, D. Naumann, 1991. Classification and Identification of Bacteria by Fourier Transform Infrared Spectroscopy. Journal of General Microbiology. 137. 69-79.

[4] Chenxu Yu, Joseph Irudayaraj, Chitrita Debroy, Ze'ev Schmilivtich, Amos Mizrach, August 2004.Spectroscopic Differentiation and Quantification of Microorganisms in Apple Juice. Journal of Food Science. 69. 268-272.

[5] N. Vlachos, Y. Skopelitis, M. Psaroudaki, V. Konstantinidou, A. Chatzilazarou, E. Tegou,May 2006.Applications of Fourier Transform Infrared Spectroscopy to Edible Oils. Analytica Chimica Acta. 573-574. 459-465,

[6] Petr Snurkovic, January 2013.Quality Assessment of Fruit Juices by NIR Spectroscopy. Journal of Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis. 61. 803-812.

[7] Liu Yan-de, Ying Yi-bin, September 2004. Measurement of Sugar Content in Fuji Apples by FT-IR Spectroscopy. Journal of Zhejiang University Science. 5. 651-655.

[8] Tsuyoshi Temma, Kenkoh Hanamastu, Fujitoshi Shinoki, January 2002. Measuring the Sugar Content of Apple and Apple Juice by Near Infrared Spectroscopy. Optical Review. 9. 40-44.

[9] Mengqi Ye, Tianli Yue, Yahong Yuan, Zhao Li, August 2014. Application of FT-NIR Spectroscopy to Apple Wine for Rapid Simultaneous Determination of Soluble Solids Content, pH, Total Acidity, and Total Ester Content. Food and Bioprocess Technology. 7. 3055-3062.

[10] Haisheng Gao, Fengmei Zhu, Jinxing Cai, 2010.A Review of Non- destructive Detection for Fruit Quality. Computer and Computing Technologies in Agriculture III, Third IFIP TC 12th International Conference CCTA, Beijing, China. 317. 133-140.

[11] Dazhou Zhu, Baoping Ji, Zhaoshen Qing, Cheng Wang, Manuela Zude, 2011. The Detection of Quality Deterioration of Apple Juice by Near Infrared and Fluorescence Spectroscopy. Computer and Computing Technologies in Agriculture IV, Third IFIP TC 12th International Conference CCTA, Nanchang, China. 346. 84-91.

[12] G. E. A. Swann, S. V. Patwardhan, February 2011. Application of Fourier Transform Infrared Spectroscopy (FTIR) for Assessing Biogenic Silica Sample Purity in geochemical Analysis and

Palaeoenvironmental Research. Climate of the Past. 7. 65-74.

[13] F. R. Van De Voort, A. A. Ismail, and J. Sedman, April 1995. A Rapid, Automated Method for the Determination of Cis and Trans Content of Fats and Oils by Fourier Transform Infrared Spectroscopy.Journal of the American Oil Chemists' Society. 72. 873-880.

[14] J. Irudayaraj, F. Xu, and J. Tewari, 2003.Rapid Determination of Invert Cane Sugar Adulteration in Honey Using FTIR Spectroscopy and Multivariate Analysis. Journal of Food Science. 68. 2040-2045.

[15] Carlo Camerlingo, Flora Zenone, Ines Delfino, Nadia Diano, Damiano Gustavo Mita, Maria Lepore, October 2007.Investigation on Clarified Fruit Juice Composition by Using Visible Light Micro-Raman Spectroscopy. Sensors. 7. 2049-2061.

[16] Ponnadurai Ramasamia, Sabina Jhaumeer-Laullooa, Philipe Rondeaub, Frederic Cadetb, Heena Seepujaka, Ashwini Seeruttun, March 2004.Quantification of Sugars in Soft Drinks and Fruit Juices by Density, Refractometry, Infrared Spectroscopy and Statistical Methods.South African Journal of Chemistry. 57. 24-27.

[17] Murad A. Al-Holy, Mengshi Lin, Omar A. Alhaj, Mahmoud H. Abu-Goush, 2015. Discrimination between Bacillus and AlicyclobacillusIsolates in Apple Juice by Fourier Transform Infrared Spectroscopy and Multivariate Analysis. Journal of Food Science. 00. M1-6.

[18] Luis E. Rodriguez-Saona, Fredrick S. Fry, Michael A. McLaughlin, Elizabeth M. Calvey, November 2001.Rapid analysis of sugars in fruit juices by FT-NIR Spectroscopy. Carbohydrate Research. 336. 63-74.

[19] Lu Hui-shan, Xu Hui-shan, Ying Yi-bin, Fu Xia-ping, Yu Hai-yan, Tian Hai- qing, April 2006.Application Fourier Transform Near Infrared Spectrometer in Rapid Estimation of Soluble Solids Content of Intact Citrus Fruits. Journal of Zhejiang University Section B. 7. 794-799.

[20] P. Stober, T. Lamoureux, G. G. Martin, J. M. Durgnat, C. Hischenhuber, March 1998.Standardization of the Detection of Invert Sugar Addition to Apple Juice by Capillary Gas Chromatography. Journal of Food Control and Research. 207. 332-339.