

Non-destructive quality assessment of herbal tea blends using hyperspectral imaging

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ABSTRACT

The consumption of herbal teas is increasing as consumers become more appreciative of the health benefits. Herbal tea blends comprise of two or more plant species blended to improve taste and multiply the health benefits. Quality control (QC) of herbal teas like other nutraceuticals, is important to ensure safety and efficacy. Current QC methods are chromatography-based and require destructive sample preparation using solvents. In this study, hyperspectral imaging is applied as a fast and non-destructive method for the quality control of herbal tea blends. The technique combines conventional spectroscopy and digital imaging to gather chemical information and visualise spatial distribution of chemical constituents within a matrix. Certified raw materials (*Sceletium tortuosum* and *Cyclopia genistoides*) and herbal tea blends were acquired from Parceval Pty (Ltd). Hyperspectral images of the raw material and tea blends were captured on a SisuChema[®] SWIR (short wave infrared) hyperspectral pushbroom imaging system using ChemaDAQ[®] software. The images were analysed using Evince[®] multivariate analysis software 2.4.0. Principal component analysis (PCA) revealed 54.2% chemical variation between *S. tortuosum* and *C. genistoides* raw materials. A partial least squares-discriminant analysis (PLS-DA) model with predictive ability of 95.8% was developed. Based on pixel classification, it was possible to visualise the tea blend constituents as *S. tortuosum* and *C. genistoides* and quantitatively predict *C. genistoides* as the major constituent (> 97%) while *S. tortuosum* was present in lower amounts (< 3%). The predictions confirm that HSI is a potentially favourable visual tool for the quality assessment of herbal tea blends. However, due to low instrument sensitivity quantitative determinations showed some deviation from the company formulation.

1. Introduction

Second only to water, tea is the most widely consumed beverage worldwide. It is a pleasant, popular, economical, socially acceptable beverage savoured by hundreds of millions of people across the globe and its consumption reflects local preferences and traditions (Tea USA, 2015; Trevisanato and Kim, 2000). In the USA on any given day, more than half of the American population drinks tea and it can be found in nearly 80% of all US households. Black and green tea imports in the US totalled 28 million pounds with an estimated wholesale value of about \$12 billion in 2016 (Tea USA, 2015). In Europe, tea consumption totals 229 thousand tonnes in 2015 with the United Kingdom as the main market with consumption amounting to 113 thousand tonnes. The four countries with the highest per capita tea consumption in Europe in 2015 included Ireland (2.2 kg), the UK (1.9 kg), Poland (1 kg) and The Netherlands (0.8 kg) (CBI, 2017). Tea is prepared exclusively from *Camellia sinensis* (L.) Kuntze (Theaceae) leaves by brewing in hot water

and the processing of the leaves determine whether the teas are black, green or white (Trevisanato and Kim, 2000). Herbal teas should more accurately be referred to as tisanes/infusions as opposed to 'teas', as they are prepared from the leaves, bark, roots, berries, seeds and spices of various plant species (Sponagle, 2016). However, they are commonly known and referred to by consumers and researchers alike as herbal teas. The consumption of green, herbal and fruit teas increased in popularity in all European markets as a result of consumer awareness of the health benefits associated with these teas (CBI, 2017). Three herbal teas including rooibos, Yerba mate and honeybush, surged into popularity from obscurity to being on about every tea vendor's product list partly due to the successful marketing and partly due to concerns about the caffeine content of true tea (JaseTea, 2015).

Honeybush is used as a collective name to refer to several species of *Cyclopia*, endemic to the Western and Eastern Cape Provinces of South Africa. *Cyclopia genistoides* (L.) R.Br. (Fabaceae) was the first of the *Cyclopia* species to be used as a tea, it was used as a substitute for tea

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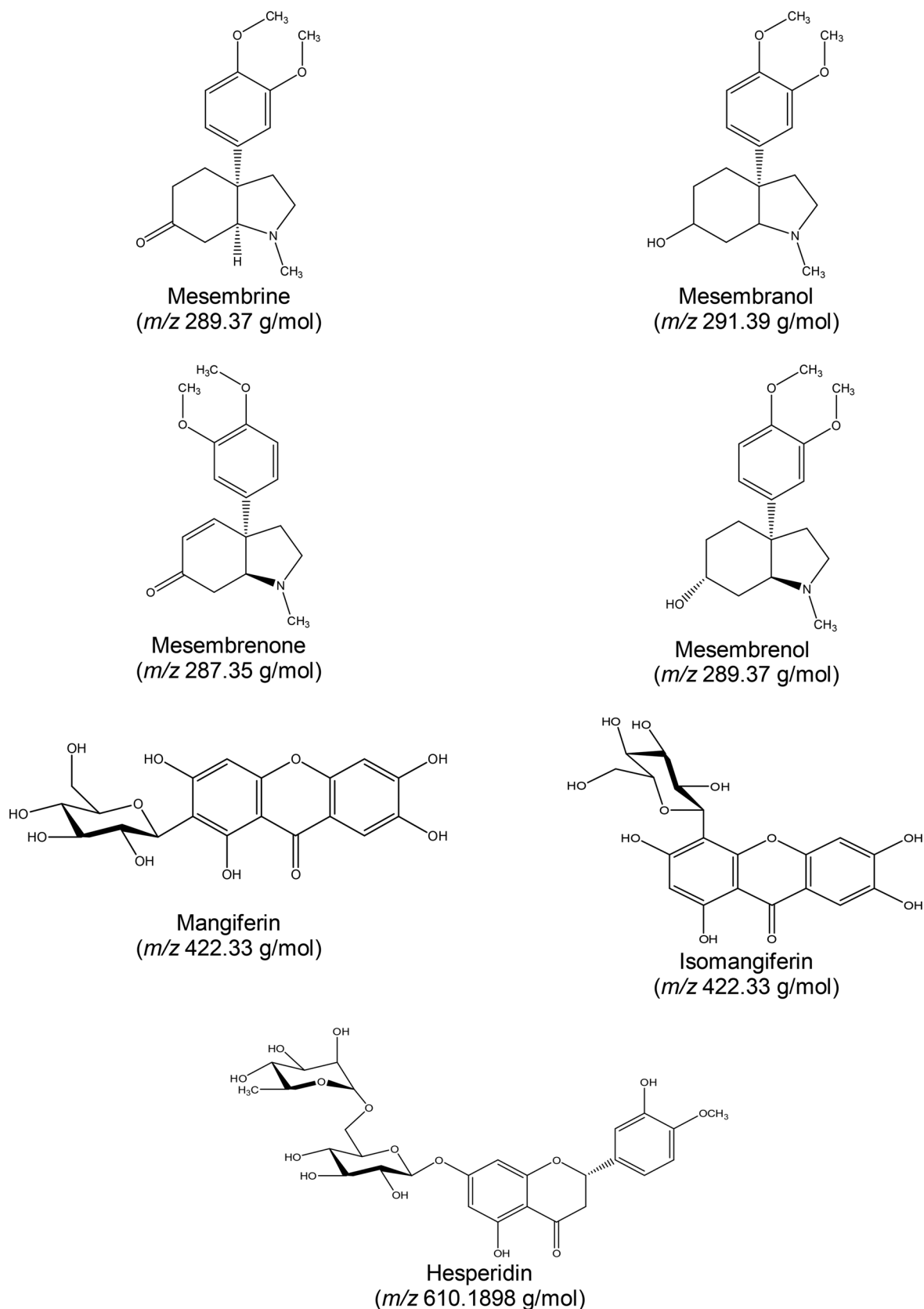


Fig. 1. Chemical structures of marker compounds present in *S. tortuosum* (mesembrine, mesembranol, mesembrenone and mesembrenol) and *C. genistoides* (mangiferin, isomangiferin and hesperidin).

and it is the most common honeybush tea plant. Early reports documented its medicinal properties as a restorative and as an expectorant in chronic catarrh and pulmonary tuberculosis. Honeybush is caffeine-

free with a low tannin content and it contains a wealth of polyphenolic compounds. Research has shown that *C. genistoides* is high in mangiferin, isomangiferin and hesperidin content (Fig. 1) and it has anti-

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