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Modifying the sensory profile of green honeybush (*Cyclopia maculata*) herbal tea through steam treatment

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ABSTRACT

Green honeybush (*Cyclopia* spp.), superior to the traditional "fermented" product in bioactive phenolic content, is not well accepted by consumers due to its predominant vegetal aroma. Steam treatment of fresh, shredded plant material (0, 30, 60, 90 and 120 s) and dried, shredded plant material (0, 1, 2, 3 and 4 min) of *Cyclopia maculata* was investigated to improve the aroma of the infusion, but without compromising green colour and phenolic content of the product. Steam treatment increased and decreased fruity and vegetal aroma attribute intensities, respectively. The dried plant material was less susceptible than the fresh plant material to the impact of steam. The fresh and dried plant material should be steam-treated for at least 60 s and 2 min, respectively. Steam treatment had little impact on leaf colour, although the total chlorophyll content was decreased. The individual polyphenol content of the plant material also remained largely unaffected, with reductions in the content of some compounds only when the fresh plant material was steam-treated for 30 s (mangiferin, isomangiferin, 3-β-D-glucopyranosyliriflophenone and hesperidin) and dried plant material steam-treated for 4 min (eriodictyol-*O*-glucopyranoside). Except for hesperidin, longer steam treatment of the fresh plant material did not affect its individual phenolic content.

1. Introduction

Processing of traditional honeybush (*Cyclopia* spp.) requires a high-temperature oxidation step, also termed "fermentation", to develop the characteristic floral, fruity, woody, plant-like and sweet aromas associated with this herbal tea (Erasmus, Theron, Muller, Van der Rijst, & Joubert, 2017). However, fermentation also has a detrimental effect on the phenolic content, antioxidant activity and phyto-estrogenic activity of *Cyclopia* (Joubert, Gelderblom, Louw, & De Beer, 2008). Major bioactive phenolic constituents, such as the xanthone, mangiferin, and the benzophenone, 3-β-D-glucopyranosyliriflophenone, are susceptible to degradation, as fermentation reduces their content in *C. genistoides* hot water extracts by 48% and 62%, respectively (Beelders, De Beer, & Joubert, 2015). Green, "unfermented" honeybush is therefore considered a "healthier" version of this herbal tea. Despite this, only a fraction of

Abbreviations: ANOVA, analysis of variance; DMSO, dimethyl sulfoxide; DSA, descriptive sensory analysis; HPLC-DAD, high-performance liquid chromatography with diode array detection; LSD, least significant difference; PCA, principal component analysis; PVDF, polyvinylidene fluoride; TC, total chlorophyll; TSS, total soluble solids.

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the annual harvest is processed as green honeybush (Joubert, Joubert, Bester, De Beer, & De Lange, 2011). Consumer acceptance of green honeybush is poor, largely due to a preference for the sweet, floral aroma of the traditional product. The overpowering vegetal aroma of green honeybush is thus often masked by addition of artificial fruity flavours or natural ingredients such as mint. Volatile compounds typically associated with "green" or "herbaceous" aroma descriptors have been identified in green honeybush (*C. genistoides*) (Le Roux, Cronje, Joubert, & Burger, 2008). 6-Methyl-5-hepten-2-one, a major compound of the volatile fraction, is described as "oily, green herbaceous" (Leffingwell & Alford, 2005). The description of the aroma-active volatiles is, however, dependent on their concentration in solution or whether present in a mixture. For example, geraniol, present in the volatile fraction of both green and fermented honeybush (Le Roux et al., 2008) and described as "floral, woody" (Jumtree, Komura, Bamba, & Fukusaki, 2011), enhances the green note of Japanese green tea (Hattori, Takagaki, & Fujimori, 2005).

"Green honeybush" implies a product with a green colour, creating an expectation by the consumer in terms of colour. Current South African export regulations for colour are not specific, except to specify that green honeybush should have the "distinctive" colour of the product. No definition is provided, nor do quality guidelines relating to colour, either in terms of visual colour or objective colour parameters exist. Greater insight into the effect of processing on colour retention is required before objective specifications can become a reality.

In previous research, steam treatment of fresh, shredded *C. subternata* plant material led to a significant loss of green colour compared to fresh, whole leaves (Joubert, Manley, Maicu, & De Beer, 2010). However, steam treatment of whole leaves is not practical as the shoots are shredded for herbal tea production. Exclusion of the steaming step after the plant material was shredded, led to reduced colour retention, soluble solids content and polyphenol content of the final herbal tea product, indicating that steam treatment may be beneficial to limit these changes. Changes in sensory attributes of the steam-treated plant material were not investigated. For the present study *C. maculata* was chosen, not only because it differs in phenolic composition from *C. subternata* (De Beer et al., 2012; Schulze, De Beer, De Villiers, Manley, & Joubert, 2014), but its leaf shape is also different, affecting heat transfer. *Cyclopia maculata* has thin needle-like leaves, limiting the cut surface, while *C. subternata* has flat, linear leaves (Joubert et al., 2011). These differences may affect their respective susceptibilities to chemical changes introduced by steam treatment.

The aim of the present study was to improve the aroma of green *C. maculata* herbal tea through steam treatment of the plant material, whilst minimising changes to green colour and phenolic content. Two steam treatment strategies were investigated, *i.e.* application of steam to fresh, shredded plant material prior to drying or to the dried herbal tea product. The duration of the steam treatment was varied and changes in the sensory profile of the herbal tea infusions, as well as the colour and phenolic content of the plant material were determined.

2. Materials and methods

2.1. Plant material

Five batches of *C. maculata* shoots, comprising leaves and stems (5–6 kg/batch), were harvested manually according to industry practice for each experiment. For the first experiment, plants were harvested in autumn (April) at Koksrivier farm (Overberg, Western Cape Province, South Africa). For the second experiment, plants were harvested in winter (June) at Nietvoorbij farm (Stellenbosch, Western Cape Province, South Africa). Extra thick (>5 mm) stems were removed before processing.

2.2. Chemicals

High-performance liquid chromatography (HPLC)-grade acetonitrile was purchased from Sigma-Aldrich (St Louis, USA). Other chemicals and solvents were analytical grade, sourced from Sigma-Aldrich or Merck Millipore (Darmstadt, Germany). Authentic phenolic reference standards (purity >950 g/kg) were sourced from Sigma-Aldrich (mangiferin, hesperidin and 3-β-D-glucopyranosyliriflophenone) and Phytolab (Vestenbergsreuth, Germany: vicenin-2 and eriocitrin). Stock solutions of the phenolic standards were prepared in DMSO at *ca.* 1 g/L and aliquots kept frozen (−20 °C) until analysis.

2.3. Experimental layout

Experiments were conducted on fresh, shredded and dried, shredded *C. maculata* plant material to evaluate the effects of steam treatment. Experiment 1 entailed steam treatment of the fresh, shredded plant material as outlined in Fig. 1a. For each batch, the fresh shoots were shredded to 2–3 mm lengths using a mechanised fodder cutter and thoroughly mixed to improve homogeneity. Each batch was sub-divided without delay into treatment samples (T1 to T5) by spreading the shredded plant material thinly across 10 drying trays (20 × 30 cm; 0.595 mm mesh stainless steel sieve; *ca.* 300 g per tray). For each batch, two trays were randomly allocated per treatment. The two trays representing the control sample (t = 0 s) were placed in a laboratory cross-flow drying tunnel and dried at 40 °C for 6 h to a moisture content <100 g/kg (*ca.* 84 g/kg; a_w = 0.477). Steaming of the remaining trays was performed in a pre-heated steam cabinet at ± 96 °C. The steam pressure, generated with a THE 400 NM Electropac electrode boiler (John Thompson Boilers, Cape Town), was maintained at 2.76 N/m^2 at the inlet of the cabinet. At each predefined time point (t = 30, 60, 90, and 120 s) two trays were removed and placed without delay in the drying tunnel. The dried plant material of two trays, allocated per treatment, was pooled and sieved (30 s at 90 rpm) to obtain the "tea bag" fraction (<1.68 mm and >0.42 mm), using a SMC Mini-sifter (JM Quality Services, Cape Town, South Africa). Sieved samples were sealed in glass jars and stored in the dark at 0 °C until analysis.

For experiment 2, outlined in Fig. 1b, five batches of plant material were also individually shredded and mixed as before. Each batch was divided into five sub-batches, SB1 to SB5 (*ca.* 600 g fresh material each) where a sub-batch represented a treatment (e.g. SB1 used for T1, *etc.*). Each sub-batch was spread across two drying trays (39.5 × 56.5 cm; 0.595 mm mesh Polymon sieve; Polymon supplied by Swiss Silk Bolting Cloth Mfg. Co. Ltd., Switzerland), and dried for 6 h at 40 °C. The pooled dried material was then sieved to obtain the tea bag fraction as described for experiment 1. For steam treatment, the tea bag fraction of each sub-batch was spread on 2 drying trays (20 × 30 cm; 0.595 mm mesh stainless steel sieve; 70 g dry tea material/tray). The control (t = 0) was not steam-treated. The other trays were placed in the steam cabinet and exposed to steam (1, 2, 3 or 4 min) as described for experiment 1. The treated samples were dried again for 30 min at 40 °C and stored as for experiment 1. Each procedure was repeated separately for each independent batch of plant material.

2.4. Analysis of plant material

The sieved, intact plant material was used for colour measurements and preparation of infusions for sensory analysis. An aliquot