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Sensory and physicochemical analyses of roasted marama beans [*Tylosema esculentum* (Burchell) A. Schreiber] with specific focus on compounds that may contribute to bitterness

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ABSTRACT

The role of phenolics and saponins in contributing to bitterness in marama beans, an underutilized legume, especially when roasted, was investigated. Marama beans were roasted at 150 °C for 20, 25 or 30 min, then dehulled to separate cotyledons, and pastes were prepared from these. Water extracts were prepared from full fat and defatted flours from roasted and unroasted marama cotyledons. A sensory panel evaluated the sensory attributes of marama pastes and water extracts. Marama water extracts were analysed for total phenolic content, phenolic composition and saponin content. Roasting of marama beans for more than 20 min resulted in negative properties, such as bitterness. The major extractable phenolic acids present in marama water extracts were gallic and protocatechuic acids which increased as a function of roasting time. Saponin content of the water extracts was in the range of 55–63 mg/l. The identified phenolic acids, saponins and other as yet unidentified compounds may contribute to the perceived bitterness.

1. Introduction

There is a worldwide search for food sources to alleviate malnutrition in developing countries, due to a shortage of protein-rich foods. Utilisation of legume sources is one opportunity (Tresina & Mohan, 2013). Consumer acceptance of such food sources is highly dependent on their sensory properties. The marama bean [*Tylosema esculentum* (Burchell) A. Schreiber] is an underutilised legume which grows wild in southern Africa and forms part of the diet of some of the indigenous population (Jackson et al., 2010). Marama bean seeds are not eaten raw as they are tasteless with an unpleasant slimy texture, but after roasting they have a nutty flavour, resembling roasted peanuts (Mmonatau, 2005). The nutty flavour has been suggested to be caused by the formation and release of flavour compounds due to the Maillard reaction, as a result of heating (Kayitesi, Duodu, Minnaar, & De Kock, 2010).

A further reason for heat-treating marama beans is to inactivate anti-nutritional factors. Maruatona, Duodu, and Minnaar (2010) reported that roasting of marama beans at 150 °C for 20 min is required to inactivate trypsin inhibitors. This time/temperature combination is therefore regarded as a minimum requirement for marama beans for intended consumption. Depending on the extent of heating, bitter compounds may develop and contribute to perceived bitterness in marama bean. Mmonatau (2005) reported an undesirable bitter taste in roasted marama bean when heated at 150 °C for 30 min. Furthermore, Kayitesi et al. (2010) reported a slight bitter taste in porridges prepared from composite flours of sorghum and defatted roasted and unroasted marama flours. The perceived bitter taste can limit the utilisation and consumption of this pulse. No specific research has been published on the compounds that could be responsible for bitter taste in marama bean. Troszynska (2004) reviewed phenolic compounds and reported that phenolic acids, flavonoids and tannins are substances responsible for bitterness in plant foods. In addition, other chemical compounds, such as saponins, are believed to impart a high level of bitterness in many edible legumes, including lupins, lentils, chickpeas, soybean, various beans and peas (Rochfort & Panozzo, 2007). The present study aimed at determining the effect of roasting time on the perceived bitterness of marama bean in relation to contents of compounds that could potentially contribute to bitterness.

2. Materials and methods

2.1. Preparation of marama paste and water extracts

Marama beans were collected in the Masokaphala area, Central district of Botswana. Marama beans were heated at 150 °C in a

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forced convection continuous tumble roaster (Roastech, Bloemfontein, South Africa). Speed sets of 290, 240 and 180 rpm were selected, resulting in heating times of 20, 25 and 30 min, respectively. A DF cracker (WMC Metal Sheet Works, Tzaneen, South Africa) was used to dehull the roasted marama beans and the cotyledons were retained. In order to prepare homogeneous samples for descriptive sensory analysis, three marama pastes, namely paste^{20}, paste^{25} and paste^{30} (referring to pastes from the cotyledons of marama beans roasted for 20, 25 and 30 min respectively), were prepared by pulverizing 300 g batches of roasted cotyledons for 15 min, using a CT35 vertical cutter mixer (570 W) with a 3.5 L bowl capacity.

Full fat and defatted marama flours were prepared from cotyledons of roasted and unroasted beans, following the method described by Maruatona et al. (2010). Defatted marama flour was prepared by grinding cotyledons into a coarse flour, using a laboratory Waring blender (Lasec, Johannesburg, South Africa) and oil was extracted twice, each time using hexane (flour-to-hexane ratio of 1:3 w/v) for 2 h. The dry residue obtained after removal of the hexane was milled, using an IKA® A11 basic laboratory mill (IKA Werke, Germany) to pass through a 1000 μm mesh. A total of eight samples of marama flour were prepared, namely, full fat and defatted raw marama flour, full fat and defatted roasted marama (for 20 min) flour, full fat and defatted roasted marama (for 25 min) flour, full fat and defatted roasted marama (for 30 min) flour. All the flours were vacuum-packed and stored at 4 °C until used to prepare marama water extracts.

Water extracts from the eight marama flour samples for descriptive sensory evaluation were prepared by mixing 10 g of marama flour in 150 ml of deionised water and bringing it to the boil for 10 min. The water was decanted and filtered, using a tea strainer and evaluated within 90 min of preparation. For chemical analysis, the extracts were centrifuged at 7500*g* for 10 min (25 °C), using a Rotanta 460 R centrifuge (Labotech, Johannesburg, South Africa) prior to the assays.

2.2. Descriptive sensory evaluation

A ten person (five male, five female) trained sensory panel at the University of Pretoria was used to evaluate the sensory profiles of marama products (pastes and water extracts). The ten panellists were selected and screened for sensitivity for the basic tastes: sweet, salt, sour, umami and specifically bitter (using the one solution propylthiouracil test of Tepper, Christensen, and Cao (2001), and also the ability to differentiate and describe commercial peanut butters. The descriptive sensory panel was trained for 14 h, during hourly sessions twice a week for a period of seven weeks. The training sessions included familiarising the panellists with the marama products (paste and water extract), assessment procedures and sensory evaluation software (Compusense Five version 5.2, Compusense Guelph, ON, Canada). Descriptive terms and scale anchors were developed, defined and agreed upon for evaluation. Before the actual evaluation, the panellists' performance was checked at least twice and the Compusense FCM® tool was used to facilitate the training.

The sensory evaluation of the marama products was conducted in a sensory evaluation laboratory with individual booths. Panellists evaluated all samples in triplicate during three days with one session per day. Each panellist received three samples (20 g each) of marama bean paste in plastic cups with lids and a set of eight water extracts (10 ml each) in size 8 glass polytop containers with lids. All samples were coded with 3-digit random numbers and served at ambient temperature (25 °C) on a white tray, with 3 plastic teaspoons for tasting pastes, a serviette and two plastic disposable cups. One cup contained pieces of carrot for mouth neutralising, and the other cup was filled with filtered tap water for rinsing the mouth before and between tasting the samples. To avoid fatigue and bitter taste build up in the mouth, samples were tasted with a 2 min break in between. Red light in the tasting booths was used to mask the colour of the paste for the panelists, in order to concentrate on aroma and flavour properties. The panel used twelve descriptive terms, grouped under aroma, flavour and aftertaste attributes (Table 1). Aroma was evaluated immediately after removing the cover, using short sniffs. Then a half spoon (5 g) of the paste was chewed in the mouth to test for flavour and texture properties. After swallowing, the panellists analysed the aftertaste properties. Nine-point structured line scales were used to measure the intensity of each attribute for a given sample. Product references to illustrate attribute intensities were provided. The minimum scale value was 1, denoting not intense, and the maximum point was 9, denoting very intense. Panellists tasted and expectorated the entire water extract sample and then only rated the intensity of the bitter taste. Evaluation sequence was based on a randomized complete block design. Approval of the sensory evaluation protocol was granted by the Ethics Committee of the Faculty of Natural and Agricultural Sciences, University of Pretoria (EC080825-035).

2.3. Colour measurements of marama bean pastes

The colour of the pastes was measured, using a Chroma Meter CR-400 (Konica Minolta Sensing, Osaka, Japan). The instrument

Table 1
Descriptive sensory attributes used by a trained panel to evaluate marama bean paste.

Attributes	Definitions	References to explain and anchor sensory attributes
Aroma		
Nutty aroma	The intensity of aroma resembling nuts	Smooth peanut butter (Black Cat) = 7
Roasted aroma	Intensity of aroma resembling roasted nuts	Raw marama bean = 1 Peanut butter (Black Cat) = 7
Burnt aroma	The intensity of aroma similar to burnt food (e.g. burnt peanut)	Overroasted marama beans (150 °C for 35 min) ground to flour = 8
Flavour		
Nutty flavour	Intensity of flavour resembling nuts	Peanut butter (Black Cat) = 8
Bitter taste	Basic bitter taste associated with caffeine or quinine	10% Nescafe Ricoffy in water = 8
Burnt flavour	The intensity of flavour similar to burnt food	Overroasted marama beans (150 °C for 35 min) ground to flour = 8
Roasted flavour	Intensity of flavour resembling roasted nuts	Peanut butter (Black Cat) = 6
Oily(fatty) flavour	Intensity of flavour associated with oils (e.g. sunflower)	
Rancid flavour	Intensity of flavour associated with oxidised fats and oils (e.g. rancid butter)	Oxidised stored peanut butter = 8
After taste		
Bitter aftertaste	Basic bitter aftertaste associated with caffeine or quinine	10% Nescafe Ricoffy in water = 8
Burnt aftertaste	The intensity of aftertaste similar to burnt food	Overroasted marama beans (150 °C for 35 min) = 8
Roasted aftertaste	The intensity of aftertaste similar to roasted nuts	Peanut butter (Black Cat) = 6

1 = not intense; 9 = very intense.