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Evaluation of puffing quality of Australian desi chickpeas by different physical attributes

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ABSTRACT

Puffing involves roasting grains or legumes in hot sand without oil for a short time resulting in a popped type of healthy snack food. The aim of the present study was to understand the range of puffing ability of Australian desi chickpea genotypes. Calculations for puffing yield, expansion volume and puff size from the literature were applied to our samples. In addition, it was necessary to develop a new formula to measure the ratio of seed expansion without bias from puffing yield to compare the performance of our samples. This was necessary because their puffing yields were generally low relative to more established puffed products such as popcorn. Kyabra was identified as a superior puffing genotype (52% seeds puffed and 0.67–2.09 mL/g expansion volume), whilst Line 4 had the greatest seed expansion (0.62 mL/seed at 25 °C), but with a low puffing yield (7–11%). Storage temperature was investigated and cooler storage was found to generally hinder the puffing yield of chickpea. Australian chickpeas were found to have a range of puffing performance, which suggests that potential exists within the genetic pool to improve both the puffing yield and the expansion volume of seeds for this snack food market.

1. Introduction

Chickpeas (*Cicer arietinum* L.) are the second largest cultivated legume in the world (Varshney et al., 2013) and are available as small-seeded desi (brown-coloured with a wrinkled seed-coat) and bold-seeded kabuli (cream-coloured with a smooth seed-coat). Chickpeas are processed in a variety of ways e.g. puffing, roasting, splitting, frying, canning, and boiling. Puffing of desi chickpeas has been practised for many years in the Indian sub-continent, Asia, Africa and the Middle East. Puffing whole chickpea seeds in sand is a traditional processing method in India, especially in the South. Puffing is a cooking method where whole chickpeas are popped in hot sand without oil, resulting in seeds with lower bulk density and improved flavour.

The literature on puffing is dominated by studies on cereals such as: rice (Mahanta & Bhattacharya, 2010), wheat (Fan, Hsieh, & Huff, 1999), sorghum (Singh & Srivastava, 1993), and corn (Pordesimo, Anantheswaran, Fleischmann, Lin, & Hanna, 1990). In contrast, there are few studies investigating chickpea puffing, despite widespread consumption of this product. The literature on chickpea puffing is scant and mainly examines Indian desi chickpea cultivars, with the latest one published in 2005 (Kaur, Singh, & Sodhi, 2005; Pratape & Kurien, 1986; Singh, Sekhon, Bajwa, & Gopal, 1992), but there are none on Australian desi chickpeas. It has been reported that bold seeded varieties of desi chickpeas with smooth surface are often preferred in India for roasting and puffing (Kaur et al., 2005). This rounder-shaped desi with a smooth seed coat is also called a *gulabi*-type chickpea (Wood & Knights, 2003). The Australian chickpea breeding program does not currently select for *gulabi*-type chickpeas, nor do they evaluate puffing performance (Wood, personal communication).

Various terms are used in the literature to describe the relative proportion of puffed to unpuffed seeds. “Puffing yield” as reported

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in this study, focuses on the relative proportion of puffed seeds by count (Pratape & Kurien, 1986; Singh et al., 1992), whereas "percent hard-shelled grains" puts the emphasis on the unpuffed seeds (Kaur et al., 2005). The two values are directly related as one can be determined from the other by subtracting from 100%. In terms of quality of product, unpuffed seeds are undesirable as they are hard to chew, and can be observed in a finished product due to seed coat retention and their somewhat darker colour. Therefore puffing yield is important from a consumer perspective as the presence of unpuffed seeds decreases the value and acceptability of the final product and high puffing yield is important for processors trying to maximise returns.

The present work evaluates the puffing ability ("puffability") of twelve Australian desi chickpea genotypes from a single trial. The goal was to understand the range in puffability of existing genetic material within the Australian breeding program. In order to evaluate puffability, various methods of puffing performance were measured according to methods in the existing literature. However, it became apparent that the existing calculations for expansion volume were not adequately capturing the actual increase in expansion on puffing due to bias by the puffing yield. Hence, we developed a new expansion volume calculation independent of yield. Chickpea puffability can now be evaluated using two independent traits of puffing; puffing yield and expansion volume. In addition, the effect of two storage temperatures, 7.5 °C and 25 °C, on puffability was also examined.

2. Materials and methods

2.1. Materials

Twelve Australian desi chickpea samples were sourced from the 2012 Coonamble National Variety Trial (NVT), Australia. They included eight breeding lines (Line 1 to Line 8) and four commercial varieties (Jimbour, PBA Boundary, PBA HatTrick, and Kyabra). Composite samples (of three field replicates) were evaluated for each genotype.

2.2. Sample storage

Chickpea samples were stored for one month in airtight PET jars in cycling temperature controlled cabinets (www.labec.com.au); half kept at 7.5 °C and the other half at 25 °C. Chickpeas stored at 7.5 °C temperature were transferred to the 25 °C temperature controlled cabinets 72 h prior to the actual puffing experiments for temperature equalisation. The temperature of 25 °C was chosen as typical of "room temperature", whereas 7.5 °C was chosen as a low contrasting temperature used in similar studies in India (Pratape, V.M. personal communication).

2.3. Physical properties of raw chickpea seeds

Number, weight and seed size of raw chickpeas seeds (approx. 30 g) were recorded by manually counting and weighing 100 seed weights of raw chickpea seeds. Results are expressed as g/100 seeds. Seed volume was measured by placing seeds (approx. 30 g) in a 100 mL graduated measuring cylinder and reading the height of seeds. These methods are prescribed by the International Seed Testing Association (ISTA, http://www.treeseedfa.org/uploaddocuments/IntroductiontoSeedTesting.pdf).

2.4. Puffing process

The puffing method (conducted in batches) was adapted from the method of Pratape and Kurien (1986) to obtain chickpea products with maximum expansion and minimal burning. This method follows the standard processing conditions for puffing chickpeas in India. Briefly, whole chickpea seeds (30 g) were heated to 140 °C in sand (chickpea: sand, 1:5 weight:weight) for 2 min in an open iron *kadai* (purchased from a local store in India) and then tempered (wrapped in a piece of cheesecloth) to equilibrate to room temperature for 100 min. The tempered seeds, held in a perforated strainer, were momentarily dipped in water at room temperature, drained and tipped into hot sand (230 °C) until the seeds started puffing and promptly removed to avoid burning. The distinct "pop" sound with characteristic puffed, roasted aroma at the final stage indicated that the chickpeas had been puffed successfully.

2.5. Puffing quality traits

As there was no clear criteria in the literature for distinguishing between puffed and unpuffed chickpeas, the following criteria were developed in this study to identify each successfully puffed seed within the sample: a puffed seed had a cracked or missing outer husk, with visible golden-yellow coloured cotyledon and an expanded volume. Visually determining expansion is challenging as some chickpea seeds may not expand greatly (see Section 3.2.1, below), although there is a visible crack in the outer husk. Fig. 1 illustrates three examples of puffed chickpeas displaying variability in appearance following puffing.

After puffing, the puffed and unpuffed chickpea seeds were separated and counted. Volumes of puffed and unpuffed chickpeas were determined using 50 and 100 mL graduated measuring cylinder, respectively, and their respective weights and volumes recorded. All measurements were recorded in triplicate and then mean, standard deviations, puffing yield, puff size and expansion volume were calculated. The reduction in weight of chickpea seeds due to puffing was also calculated by subtracting the initial weight of raw seeds from the weight of puffed seeds.

2.5.1. Puffing yield

Puffing yield (%) provides a measure of the proportion of seeds that puff and is calculated as (Singh & Srivastava, 1993):

$$\textit{Puffing yield} = \left(\frac{\textit{Final number of puffed seeds}}{\textit{Number of total seeds}}\right) \times 100$$

2.5.2. Expansion volume

Various measures of expansion volume (Sweley, Rose, & Jackson, 2012) have been reported in the literature for popcorn (Dofing, Thomas-Compton, & Buck, 1990; Pordesimo et al., 1990; Wu & Schwartzberg, 1992) and popped sorghum (Gupta, Srivastava, & Srivastava, 1995).

$$\textit{Expansion volume } 1 = \left(\frac{\textit{Final volume of seeds after puffing (mL)}}{\textit{Initial volume of raw seeds (mL)}}\right) \quad (1)$$

where final volume of seeds after puffing is defined as the volume of all chickpeas (including puffed and unpuffed together) from the original 30 g sample (Wu & Schwartzberg, 1992).

$$\textit{Expansion volume } 2 = \left(\frac{\textit{Total puffed volume (mL)}}{\textit{Weight of puffed seeds (g)}}\right) \quad (2)$$

where total puffed volume is defined as the volume of only puffed chickpeas, separated from the unpuffed seeds, and weight of puffed