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The effect of mechanical dehuskers on the quality of macadamia kernels when dehusking macadamia fruit at differing harvest moisture contents

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ABSTRACT

Dehusking to remove the fibrous husk of the macadamia fruit following abscission is an essential first step in postharvest handling of macadamia nuts. Commercial dehusking uses machines, causing trauma for nuts. Mechanical dehusking of macadamia fruit at "field" (mean harvest) moisture content causes shoulder damage but the effect on kernel quality of dehusking fruit that has dried while on the ground between harvest rounds to "low harvest" moisture content is not known. We dehusked macadamia fruit by hand and with two mechanical dehuskers at field moisture content (23%) and at low harvest moisture content (10–12%) after ambient drying for three weeks. After-roast-darkening (dark, reject kernels), shoulder damage and weight of pieces increased while whole kernel was reduced when dehusking at low harvest moisture content compared with dehusking at field moisture content. There were only minor differences between mechanical dehuskers for kernel damage and no difference between dehuskers for dark roasted kernel. Kernel quality of macadamia is more affected by slow, ambient drying than the type of dehusker used. Improving harvest management by reducing time between harvest rounds is more important to macadamia kernel quality than the type of dehusker used.

1. Introduction

Macadamia integrifolia Maiden and Betche, *M. tetraphylla* L.A.S. Johnson (Proteaceae) and their hybrids are cultivated for their edible kernels in Australia, Hawaii, South Africa and other countries such as Brazil, Kenya, Malawi and China (Wallace and Walton, 2011; Trueman, 2013). Both species are indigenous to subtropical coastal rainforests of the east coast of Australia (Gross et al., 1995). The fibrous husk of freshly harvested macadamia fruit constitutes 40–45% of the fruit weight (Cavaletto, 1983).

Macadamia harvest management is critical for maintaining kernel quality. Macadamia fruit is usually harvested from the ground after natural abscission although Ethephon® can be used to enhance abscission when that is advantageous for harvest management (Richardson and Dawson, 1993; Trueman et al., 2002). The first step in postharvest processing is dehusking, the removal of the fibrous husk to release nuts (Mason and McConachie, 1994; Trueman et al., 2000; Walton and Wallace, 2005a). The mean harvest ("field") moisture content of macadamia nuts can range from 25% down to 16% (wet basis) (Hansen and Gough, 1977; Wall and Gentry, 2007; Walton and Wallace, 2008). As these are means of nuts both freshly abscised and those which have been on the ground for up to five weeks, some nuts would be of much lower moisture content than 17%, e.g., 10–12% ("low harvest" moisture content). Dehusking is performed commercially by mechanical dehuskers, preferably within one day of harvesting (O'Hare et al., 2004). Many machines have been developed for dehusking, but despite the stresses applied to the fruit during this essential operation there has been limited research on the effect of mechanical dehuskers on macadamia kernel quality.

Physical damage to kernels may result from postharvest handling of macadamias, such as shoulder damage, breakage into pieces, bruising, production of dust and excessive browning at roasting (Walton and Wallace, 2008, 2010). Mechanical dehuskers squeeze the fruit to remove the fibrous husk, e.g., a new dehusker was evaluated by Luan and Liang (1983) for dehusking efficiency and number of cracked nuts. Mechanical dehuskers cause 'shoulder damage' to the kernel when dehusking fruit at field moisture content (Walton and Wallace, 2005a) however, the effect on kernel quality of dehusking at low harvest moisture content (e.g. 10–12%) is not known, nor the effect on quality of dehusking

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different cultivars. Other studies have found that macadamia nuts at low and intermediate moisture contents (3%, 7% and 10%) are more susceptible to damage from postharvest handling such as shoulder damage, bruising and surface mottling (Walton and Wallace, 2008, 2010). Cellular damage in macadamia is associated with after-roast-darkening of kernels, a postharvest disorder whereby apparently normal kernels become excessively dark after roasting (Albertson et al., 2005, 2006). There is limited information available on the effects of different dehuskers on kernel quality parameters other than shoulder damage, such as percentage of whole kernel recovered and breakage into pieces. Importantly, the effects of mechanical dehusking on roasting quality including after-roast-darkening have not been reported.

The aims of this study were to compare the effect of different mechanical dehuskers on kernel damage when dehusking at low harvest moisture content and at field moisture content. We compared two mechanical dehuskers and used hand dehusking as a control. Because moisture content of nuts during postharvest handling has a critical impact on damage, we compared dehusking of macadamias (1) at low harvest moisture content (10%) after partial drying on the ground using two cultivars, HAES 344 and HAES 741; and (2) both immediately after harvest at field moisture content (23%) and at low harvest moisture content after partial drying on the ground using cultivar HAES 344 only. These cultivars are used because they are two of the most widely planted macadamias. Cultivar HAES 344 only was used for the second trial to reduce variables and simplify analysis. Partial drying on the ground simulates commercial practice when harvest is delayed and fruit may remain on the ground for extended periods. Our hypotheses are (1) that kernels from fruit mechanically dehusked at low harvest moisture content are more likely to be damaged than those dehusked at normal field moisture content and (2) that mechanical dehuskers cause damage to kernels, predisposing them to after-roast-darkening.

2. Material and methods

2.1. Effects of mechanical dehuskers on raw kernel quality

2.1.1. Experiment 1: Effects of mechanical dehuskers when dehusking at low harvest moisture content

We compared the effect of two mechanical dehuskers and a hand dehusked control on the quality of raw macadamia kernel using fruit at low harvest moisture content (~10%). Hand dehusking does not put pressure on or squeeze the fruits and so it can be used as a control to test the effects of mechanical dehuskers. Fruit of cultivars HAES 344 and HAES 741 was sampled from the ground at Warawee Plantation, Wolvi, South Eastern Queensland, Australia (26°9.63′S, 152°48.65′E). There were three treatments: (1) Hand dehusking, (control), using aviation snips to gently remove the husk; (2) Mechanical dehusking with a scroll-type mechanical dehusker, widely used in the macadamia industry, which employs rollers with metal spiral scrolls working fruit against spring loaded fingers and (3) Mechanical dehusking with an "Admac" dehusker, which squeezes fruit between an auger fitted with strips of rubber and an outer longitudinally- barred metal cage. All moisture contents are calculated on a wet basis.

A bulk sample was obtained from 10 trees and this sample was sub-sampled for 10 replicates of 50 fruit for each dehusker treatment. Fruit was dried partially at ambient outdoor temperature (~18–21 °C max.) before dehusking by spreading the fruit in a single layer on a concrete slab. The slab received mild sunlight in the afternoon but was protected from rain by a roof. This was intended to simulate slow drying of fruit on the orchard floor post-abscission when harvest is delayed, to eliminate the confounding effect of rainfall and to produce nuts at low harvest moisture content. When nuts had dried to ~10% moisture content (approximately three weeks of drying) they were dehusked by the above three methods, then nuts dried to 3% moisture content for cracking as described in Walton and Wallace (2009). Kernels were assessed for whole kernel weight (whole kernel weight as % of sound kernel weight), shoulder damage (whole kernels with shoulder damage as % of whole kernel number), weight of pieces (as % weight of sound kernel), dustiness (dusty whole kernels as % of whole kernel number) and oiliness (oily whole kernels as % of whole kernel number). 'Sound kernel' refers to kernels free from mould, insect damage, discolouration and immaturity. 'Shoulder damage' refers to torn areas of kernel in the apical (micropylar) hemisphere of the kernel that was formerly in contact with the white enamel region of the shell. A kernel was considered to have shoulder damage if an area of tissue greater than 3 mm diameter was removed. Kernels with greater than one eighth missing were excluded from the whole kernel count. Pieces were smaller than halves, but with a diameter greater than 5 mm. Pieces <5 mm diameter were not recorded because of the small weights involved. Dustiness refers to a visible dusty coating on the surface of the kernel that was confirmed by touch. Oiliness refers to a darker, 'oily' appearance of the nut than is normal. This was confirmed by rubbing the apparently oily surface gently on white paper; if the kernel left a mark on the paper the kernel was deemed oily.

2.1.2. Experiment 2: Dehusking fruit at both field and low harvest moisture contents

We compared the effect of two mechanical dehuskers and a hand dehusked control on the kernel quality of both raw and roasted macadamia when dehusking at field and low harvest moisture contents. The three dehusker treatments for both moisture contents of this experiment were the same as for experiment 1: hand dehusking (control), a scroll type dehusker and an "Admac" dehusker.

Fruit of cultivar HAES 344 was sampled from the ground at Sahara Farms at Glasshouse Mountains, South Eastern Queensland (26°53.44′S, 152°56.16′E). There were 10 replicates of 50 fruit per dehusker treatment per moisture content. Fruit for the dehusker treatments at field moisture content was dehusked immediately following harvest when the nut-in-shell moisture content was 23%. Fruit for the dehusker treatments at low harvest moisture content was dried for three weeks on the ground under a roof at ambient outdoor temperatures (~18–21 °C max.) to ~12% (11.8%) nut moisture content to simulate slow drying of fruit on the orchard floor post-abscission, then dehusked. Following dehusking, nuts were dried to 3% moisture content before cracking. Kernel quality was assessed as described for experiment 1.

2.1.3. Statistical analysis, raw kernel

Parametric data for whole kernel, shoulder damage, weight of pieces, dustiness and oiliness were initially analysed by SPSS statistics (IBM, Chicago) using a factorial ANOVA with dehusker, cultivar and dehusker*cultivar as factors for Experiment 1, or dehusker, moisture content, and dehusker* moisture content as factors for Experiment 2. Due to significant interactions between factors in these experiments, all data were subsequently analysed using a series of one way ANOVAs with each cultivar and dehusker combination as treatments for experiment 1, and each moisture content and dehusker combination as treatments for experiment 2. Where significant differences were detected, means were compared using Duncan's multiple range test.

2.2. Effects of mechanical dehuskers on roasted kernel quality

2.2.1. Roasting methods

An evaluation of the effect of mechanical dehusking at high and intermediate moisture contents on roasted kernel quality was