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Canopy position and cold storage duration affects mealiness incidence and consumer preference for the appearance and eating quality of 'Forelle' pears

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ABSTRACT

The position of fruit within the pear tree canopy may affect fruit quality characteristics. The objective of this study was to determine whether outer and inner canopy 'Forelle' pears differ in quality attributes and how these differences relate to consumer preference when stored for 9, 12 and 16 weeks at −0.5 °C in air and ripened for 7 days at 20 °C. Fruit firmness, size, colour, total soluble solids concentration (TSS), titratable acidity (TA), internal ethylene concentration, dry matter concentration (DMC) as well as the incidence of mealiness were determined after each cold storage period and subsequent ripening. The flavour and texture of the pear samples were assessed by a trained panel and consumer groups scored pears for eating quality and appearance. In 2011, inner canopy pears that were cold stored for 12 and 16 weeks and ripened were preferred for eating quality. Mealiness was generally low in inner canopy pears and significantly lower than in outer canopy pears. Mealiness was low for both canopy positions after 16 weeks cold storage plus ripening. While the preference for inner canopy pears after 12 weeks storage may relate to the lower incidence of mealiness, reasons for the preference after 16 weeks cold storage are uncertain. In 2012, the incidence of mealiness in outer canopy pears was double that of inner canopy pears, which may explain the general consumer preference for inner canopy pears. The canopy position effect was less in 2012 when fruit were picked at more optimal firmness (±6.4 kg) compared to harvesting at pre-optimum firmness (±7.9 kg) in 2011. Mealiness levels decreased from 9 and 12 weeks cold storage to 16 weeks cold storage in 2012. This study therefore supports the mandatory 12 weeks cold storage period at −0.5 °C for 'Forelle' pears to ensure optimum eating quality. In light of the above, inner canopy 'Forelle' pears should not be viewed as inferior to outer canopy pears. The consistent differences in mealiness incidence between inner and outer canopy 'Forelle' pears opens up a new avenue for investigating mealiness development.

1. Introduction

Forelle (*Pyrus communis* L.), a late season red blush pear, is South Africa's second most planted pear cultivar and occupies 26% of the area under production (HORTGRO, 2014). 'Forelle' pears are prone to mealiness (De Vries and Hurndall, 1993), a dry, soft textural disorder that is associated with a floury sensation in the mouth, with loss of juiciness (Barreiro et al., 1998). Mealiness peaks after 6 to 12 weeks, but decreases beyond 12 weeks of cold storage (Martin, 2002; Carmichael, 2011; Crouch, 2011). Consequently, South African 'Forelle' pears undergo mandatory 12 weeks cold storage at −0.5 °C for fruit to ripen to an acceptable eating quality and to minimize the incidence of mealiness. Export reports also indicated a high incidence of astringency in 'Forelle' pears that were cold stored for less than 12 weeks (Crouch and Bergman, 2010).

Differences in eating quality between pears of the same cultivar (Predieri et al., 2005) may relate to the effect of canopy position on internal fruit quality attributes. Irradiance levels and fruit peel temperatures in the tree canopy are highly variable (Fouché et al.,

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2010). Hamadziripi et al. (2014) found that outer canopy apple fruit have higher total soluble solids (TSS), lower titratable acidity (TA), higher antioxidant capacities and a sweeter taste compared to inner canopy apples. Since anthocyanin synthesis in European pears is light-dependent, the position of fruit in the tree canopy also influences the extent of red colouration (Steyn et al., 2005). At present, outer and inner canopy 'Forelle' pears are marketed separately. Red blushed outer canopy 'Forelle' pears receive higher prices on the export market compared to inner canopy pears that lack blush colouring and are marketed under the 'Vermont Beauty' label.

In light of the above, the objective of this study carried out over two seasons (2011/2012) was to determine the effect of canopy position (inner canopy vs. outer canopy) and cold storage duration (9, 12 and 16 weeks) on the physicochemical and sensory (flavour and texture) attributes of 'Forelle' pears and the effect thereof on consumer preference for the eating quality and appearance of the pears. Particular attention was paid to the incidence of mealiness considering its importance in 'Forelle'.

2. Materials and method

2.1. Plant material

A total of 420 inner canopy fruit as well as 420 outer canopy 'Forelle' pears were harvested on 24 February 2011 and again on 2 March 2012 from an orchard at Glen Fruin farm in Elgin (latitude: 34°10′S, longitude: 19°03′E). The orchard was planted in 1970 at a spacing of 4.28 m × 2.65 m in an N–E row orientation and trained to a central leader training system. The outer canopy pears were harvested from the top and outer parts of the canopy while the inner canopy pears were harvested from the shaded inner parts of the canopy. The average flesh firmness of pears at harvest, based on a random sample of 20 fruit per canopy position, was 7.9 kg and 7.8 kg in 2011, and 6.3 kg and 6.4 kg in 2012 for inner and outer canopy pears, respectively.

2.2. Experimental design

In 2011, the experimental design was a completely randomised factorial with ten random replicates (separate boxes) of 14 fruit each for each of the six treatment combinations (inner and outer canopy pears stored in air at −0.5 °C for 9, 12 and 16 weeks). In 2012, the experimental design was a completely randomised split plot with storage period as main plot factor and canopy position as subplot factor. There were ten random replicates (separate boxes) for each of three storage periods (9, 12 and 16 weeks), each containing 14 inner and 14 outer canopy pears.

Fruit were placed on pear pulp trays and then packed into cartons lined with a polyethylene bag (37.5 μm), which was folded over to cover the fruit completely. After cold storage, 'Forelle' pears were ripened at room temperature (20 °C) for seven days before commencement of physicochemical analysis, sensory descriptive analysis and consumer preference assessment. Of the fourteen pears per treatment replicate, five were used for physicochemical analyses, four pears for descriptive sensory analysis and five pears to assess consumer preference.

2.3. Physicochemical analyses

Due to time constraints and to compare measurements with previous research, fruit of two replicates were combined to obtain 5 replications of 10 pears each for ethylene assessment. Each composite sample was placed into 5 L air tight plastic jars and left at room temperature for 30 min. After 30 min, gas samples were taken using gas tight 10 mL syringes, which were then injected into a gas chromatograph (Model N6980, Agilent technologies, Wilmington, U.S.A.) with a PorapakQ and Molsieve packed column and flame ionization and thermal conductivity detectors. The total fruit mass and volume of free space in the jar were used to calculate the ethylene production rates.

Fruit firmness (kg) was determined as the maximum force required to push an 8 mm diameter probe with a convex tip into the flesh after peeling two equatorial sites, approximately halfway between the calyx and the stem, of each pear using a motorized penetrometer (Fruit Texture Analyzer, Güss Manufacturing, Strand, South Africa). Longitudinal wedges (±1/6th of fruit) were cut from each of the pears to assess the incidence of mealiness. The wedges were tasted for mealiness as well as squeezed to assess free juice. Fruit with a dry, soft and floury texture were classified as mealy. The same evaluator assessed mealiness for the duration of the study. Percentage dry matter concentration (DMC) was calculated as dry weight as a percentage of fresh weight after drying a pear sample at 45 °C until all the moisture had evaporated. A composite flesh sample of five pears from each replicate was placed in a juice extractor and the juice was used to determine the TSS concentration (°Brix) with a calibrated hand-held refractometer (PR32; Model N1, Atago, Tokyo, Japan). TA was determined using an automated titrator (Tritino 719S and Sample Changer 674, Metrohm Ltd., Herisau, Switzerland) to titrate 10 g of juice from each composite pear sample with 0.1 N NaOH to a pH of 8.2. TA is expressed as percentage malic acid.

2.4. Descriptive sensory analysis (DSA)

DSA for all three cold storage periods was carried out in the sensory laboratory of the Food Science Department, Stellenbosch University by the same panel of eight experienced panellists who were familiar with the sensory attributes of fresh pears. The panel received extensive training using the consensus method to develop and define descriptors (Lawless and Heymann, 2010). The definitions used for the sensory attributes were similar to those used by Daillant-Spinnler et al. (1996). After each cold storage period, two training sessions were held; approximately 40 min per session. During each training session the panel members were exposed to 5 inner canopy and 5 outer canopy 'Forelle' pear samples. Product-specific scaling was used to rate attribute intensities. The 100 mm unstructured line scale, where the left side of the scale corresponds to the lowest intensity and the right hand side corresponds to the highest intensity, was used to rate each attribute (Lawless and Heymann, 2010).

Panellists were seated individually at sensory booths that were light and temperature controlled (21 °C) and fitted with the data capturing software programme Compusense five (Compusense®, Guelph, Canada). For the DSA, each judge received 20 samples (10 inner and 10 outer canopy) in a completely randomised order, evaluated over two sessions. Each judge received a slice from the same pear; hence the sample size was an eighth of a pear. Each pear sample was coded with a three-digit random code and presented on petri dishes. The judges were asked to peel the pears. Distilled water and unsalted fat free biscuits were provided as a palette cleanser between the samples.

2.5. Consumer preference

Consumer preference analyses were conducted after each cold storage period on approximately one-hundred and twenty recruited South African pear consumers living in the Stellenbosch area. Consumers were presented with a questionnaire that captured socio-demographical information and the frequency of their pear consumption. For the second section of the questionnaire, consumers had to indicate their degree of liking for the overall eating quality of the pears using a nine-point hedonic scale (Lawless and