Lack of correlation between instrumental firmness values and sensory perception of fruit texture in apples

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INTRODUCTION

Textural characteristics of the apple fruit are one of the most important components of eating quality. To estimate textural preference of consumers for apples for fresh consumption, penetrometric measurements are being used. Such measurements are widely accepted for both research and industrial (at retailers/ supermarkets) purposes. The aim of this study was to evaluate the relationship between instrumental firmness measurements (Effegi-type) and consumer preference for fruit texture, and to describe textural characteristics of the cortex tissue of apple cultivars at the ultra-structural level.

METHODS

Fruit of cultivars (see below) characterized with different texture were picked at full maturity and flesh firmness was determined on peeled flesh of 30 apples using an Effegi FT-327 hand penetrometer (McCormick Fruit Tree Inc., Yakima, WA, USA) with an 11-mm tip.

For probing into consumer preference for texture of the same cultivars, taste testing was organized at an exhibition (Fabulous Food Show, Cleveland, OH) in 2010 November. Untrained consumer panels with over 100 attendees in each session carried out the sensory assessments. There were 3 different sessions with 4 cultivars tested in each session. Cultivars and there order presented to consumers were as follows:

Session 1: 'Candy Crisp', 'Red Delicious', 'Gala', 'GoldRush'. *Session 2:* 'Suncrisp', 'Sundance', 'GoldRush', 'Granny Smith'. *Session 3:* 'Crimson Crisp', 'SweeTango', 'Honeycrisp', 'GoldRush'.

Each session consisted of a visual examination of the cultivars (4 whole fruit per cultivars), tasting of a slice of each 4 cultivar, and filling out a questionnaire. Questionnaires consisted of three parts: 1. questions about the quality of apples (appearance, taste); 2. background questions about their gender, age, social background; and 3. questions about consumers' purchasing behavior. In this paper, we present results of responses for textural characteristics of cultivars and their relationship with instrumentally measured firmness data.

RESULTS

There were considerable differences between instrumental firmness values of the cultivars tested; In Session 1, 'Gala' (7.8 kg·cm^{-2}) and 'GoldRush' (7.9 kg·cm^{-2}) had the greatest firmness, followed by 'Candy Crisp' (7 kg·cm^{-2}) and 'Red Delicious' (6.9 kg·cm^{-2}) (Fig. 1A). In Session 2, 'Suncrisp' (9.1 kg·cm^{-2}) had significantly firmer fruit than 'Granny Smith' (8.1 kg·cm^{-2}), 'Sundance' (8 kg·cm^{-2}) or 'GoldRush' (7.9 kg·cm^{-2}) (Fig. 1B). In Session 3, 'GoldRush' and 'SweeTango' had a firmness of 7.9 kg·cm^{-2} and 7.8 kg·cm^{-2}, respectively. 'Honeycrisp' (7.2 kg·cm^{-2}) and 'Crimson Crisp' (6.5 kg·cm^{-2}) (Fig 1C).

In Session 1, highest rating scores given for texture were found for 'GoldRush' (8.3) and 'Candy Crisp' (8.3), followed by 'Gala' (7.6) and 'Red Delicious' (5.3) (Fig. 1A). In Session 2, 'Granny Smith' (7.2) was given significantly lower scores than 'Suncrisp' (8.1), 'Sundance' (7.7) and 'GoldRush' (7.7) (Fig. 1B). In Session 3, no significant differences were observed in texture rating scores between cultivars (Fig. 1C).

The distribution of rating scores given for texture showed usually increasing number of consumers giving higher rating scores. Exceptions were 'Red Delicious' in Session 1 and 'Granny Smith' in Session 2 (Fig. 2). Preference ratings given by consumers did not closely correlate with instrumental firmness data (R^2 = 0.1214, combined data of the three sessions) (Fig. 3), therefore penetrometric firmness values did not seem to be accurate predictors of textural preference of consumers for apples.

Scanning electron microscopy imaging of broken cortex surfaces (for mimicking a bite into an apple fruit) revealed that in cultivars characterized by crisp texture, such as 'Honeycrisp' or 'Candy Crisp', cells usually broke apart with emptying the entire cell content on the fracture surface when biting into an apple ("Fracture-type") (Figs. 4A, B). In contrast, in non-crisp non-firm cultivars, such as 'Red Delicious', whole cell separation was observed on the fracture surface of the cortex without apparent cell damage, i.e., breaking, and emptying the cell content ("Cell-to-cell debonding type") (Figs. 4C, D). Non-crisp but still firm cultivars, such as 'Granny Smith', were characterized by cell rupture on the fracture face of the cortical tissues ("Rupture type") (Figs. 4E, F). No close relationships between structural characteristics (cell size, cell wall thickness) of apple cortex and instrumental firmness values or sensory texture preference were found (data not presented).

Within a cultivar, decreasing firmness values were measured with increasing fruit size. Ultrastructural characteristics of the cortex tissues were essentially the same for both small and large fruit of a cultivar with the difference of larger intracellular spaces in latter case (Figs. 5A–D).

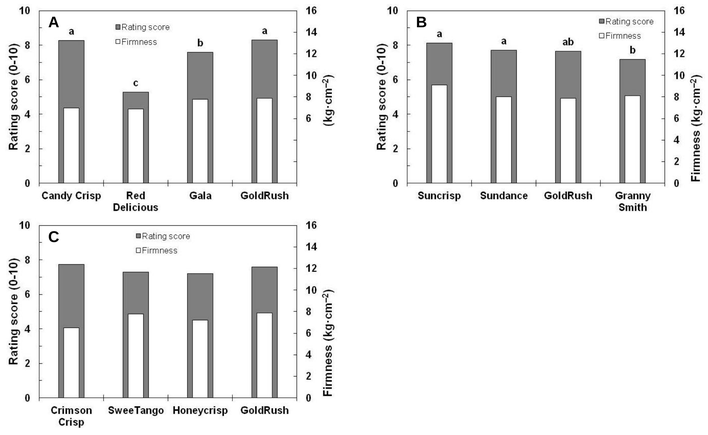

Fig. 1. Firmness and rating scores given for texture in the different tasting sessions; Session 1 (A), Session 2 (B), and Session 3 (C).

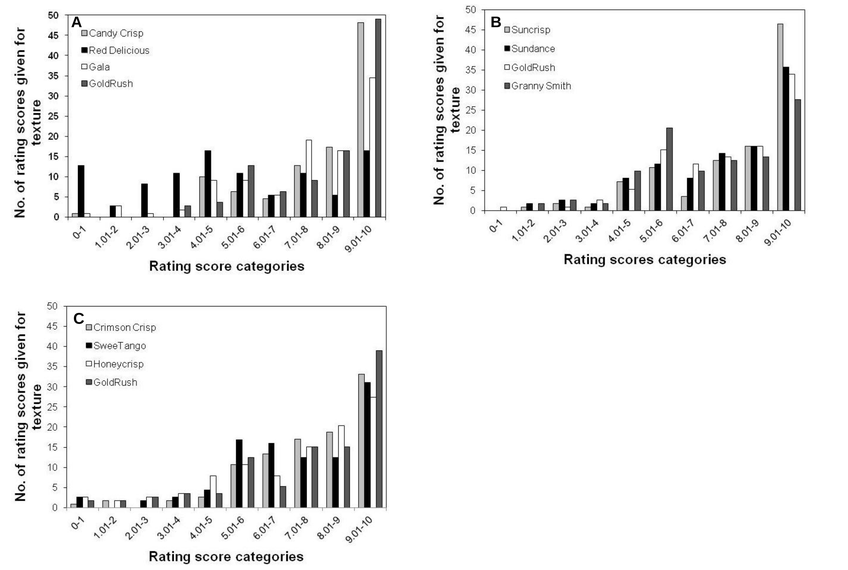

Fig. 2. Rating scores (i.e., sensory perception) in different categories given for texture from 100 consumers; Session 1: 'Candy Crisp', 'Red Delicious', 'Gala' and 'GoldRush' (A), Session 2: 'Suncrisp', 'Sundance', 'GoldRush', and 'Granny Smith' (B); and Session 3: 'Crimson Crisp', 'SweeTango', 'Honeycrisp' and 'GoldRush' (C).

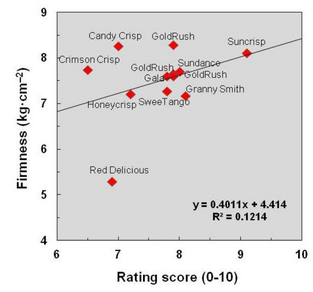

Fig. 3. Relationship between instrumental firmness and sensory perception (i.e., rating scores given by consumers) of texture. Combined data from the three sessions.

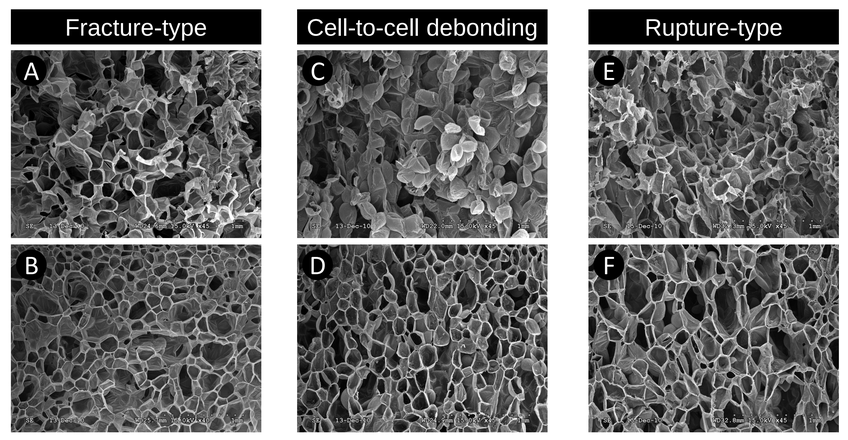

Fig. 4. Scanning electron micrographs of fracture and cut surfaces of 'Honeycrisp' (= "Fracture type" A, B), 'Red Delicious' (= "Cell-to-cell debonding type" C, D) and 'Granny Smith' apples (= "Rupture type" E, F).

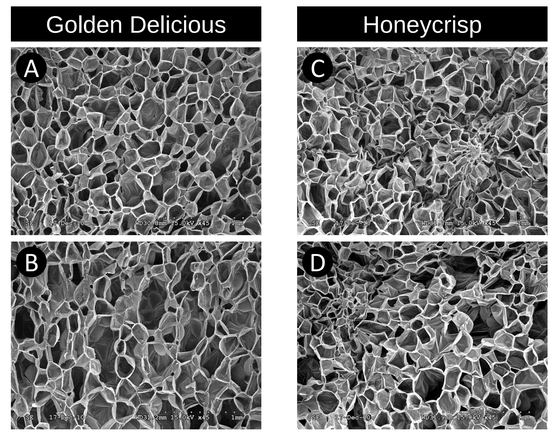

Fig. 5. The effect of fruit size on cortex cell ultrastructure; small (A) and large fruit (B) of 'Golden Delicious' and small (C) and large fruit (D) of 'Honeycrisp' apples.