Thermal treatment, jelly processing and sensory evaluation of cactus pear fruit juice

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ABSTRACT

Fruit juice plays an important role in human health. In an attempt to increase the use, other than fresh consumption, cactus pear fruit juice was thermally processed (including jelly manufacture) and sensorially analyzed. Fruit from seven cactus pear cultivars used for human consumption, and an animal feed cultivar, was peeled and juice was extracted. Three thermal treatments applied included freezing (-18°C), refrigeration (4°C), and pasteurization (60°C). Ten semi-naïve panelists compared the taste, using their own descriptors and a ten point scale. Twenty four descriptors were generated. The panel was successful in distinguishing between the cultivars used for human consumption and the animal feed cultivar. Pasteurization had a detrimental effect on the flavor of the juice. Descriptive sensory analysis on cactus pear fruit jellies, from seven cactus pear cultivars, compared the following textural attributes: cloudiness, smoothness, pectin content, runniness and cutting edge. Physical analysis of texture was also determined to support the sensory data. There was only a significant difference between the seven cultivars for the sensory descriptor of cloudiness. Both physical tests differed significantly between jellies from the seven cultivars.

***Keywords*:** cactus pear fruit, juice, jelly, sensory analysis, free choice profiling.

INTRODUCTION

The cactus pear (*Opuntia ficus-indica*) is a tropical fruit that contains mostly water. The fruit has a melon-like aroma and a sweet, but rather bland flavor (Piga, 2000). Bissell (1989) described the flavor as warm, sweet and mellow. Regarding the nutritional- and technological characteristics of the fruit, it has a soluble solids content of more than 16%, which makes it a very useful component for processing the fruit into concentrated juices and dehydrated products, where sucrose content or low water activity preserves the product (Saenz, 2000). Other components are proteins, fat, fiber and ash. It is a good source of vitamin C and minerals such as potassium, calcium and phosphorus

(Saenz, 2002). Pectin, as part of dietary fiber, is partially responsible for the viscosity of the pulp and is thus needed for the production of jams, marmalades and juices. Gel formation can be affected by numerous variables including the type of fruit, amount of pectin, sugar- and acid concentration (Frey, 2009).

The nutritional, medicinal and human health properties are factors that could contribute to an increase in cactus pear consumption (Hegwood, 1990). Cactus pear fruit is an important food source in satisfying the nutritional needs (calcium, magnesium, phosphorus and potassium) of populations of various first world, as well as developing countries, especially those in South America, the Mediterranean, South Africa and Israel (Sawaya & Khan, 1982). This fruit may be used in a wide range of products, such as juices and nectars, marmalades, gels and jams, dehydrated sheets, sweeteners, alcohol and wines, canned fruit and frozen fruit (Saenz, 2000). Because juices, in general, are good sources of nutritious components, it could play an important role in human health. Juices have been called liquid fruit (Saenz and Sepulveda, 2001).

In South Africa, *Opuntia* species are grown mainly as a fodder crop (Wessels, 1988). However, as knowledge of the nutritional value of the fruit increased, interest in the expansion of its processing possibilities, to increase shelf-life, was also raised. Since cactus pear fruit is mainly consumed fresh in South Africa, studies by researchers in other countries (Piga, 2000; Saenz, 2000) influences attempts to better use of this plant in South Africa.

The aim of this study was to use sensory analysis to describe the sensory attributes of cactus pear fruit juice, before and after three different thermal treatments, as well as after the juice has been processed into jelly. This was done in an attempt to find more applications for this under-utilized food source in South Africa.

MATERIALS AND METHODS

Fruit collection

Fruit from two cactus pear species, *Opuntia ficus-indica* and *Opuntia robusta* was collected from an experimental orchard outside Bloemfontein (GPS coordinates: 29°10’53’’ S 25°58’38’’ E) (Figure 1). The fruit was picked at 50 % color-break stage.

For heat processing of the juice, eight cactus pear cultivars, with different fruit colors, were chosen and included one *Opuntia robusta* cultivar (Robusta, purple) and seven *Opuntia ficus-indica* cultivars (Berg x Mexican, pink; Fusicaulis, green/white; Meyers, red; Algerian, red; Santa Rosa, orange; Skinners Court, green/white; Morado, white).

For jelly processing of the juice, fruit from six cultivars of *Opuntia ficus-indica* that are generally consumed by humans (Direkteur, Ficus-Indice, Muscatel, Skinners Court, Turpin and Vryheid) and one cultivar from *Opuntia robusta,* an animal-feed cultivar, Monterey, were collected. These cultivars were selected under the basis of cluster analysis (UPGMA) of genetic similarities (Mashope, 2007), to support undergoing research on pectin- and mucilage contents of different South African cultivars.

Figure 1. The experimental spineless cactus pear (*Opuntia ficus-indica* and *Opuntia robusta*) orchard.

Juice extraction, thermal treatment, Free Choice Profiling, sensory- and statistical analysis

The fruit was peeled and the juice was extracted using an electric juice extractor. The juice were divided into three parts for the three treatments: refrigeration (4 °C), freezing (-18 °C for 24 hours) and pasteurization (60 °C for 10 minutes). Fresh juice was extracted from fresh fruit just before the sensory evaluation sessions. Juice extraction and subsequent thermal treatments were done in triplicate for each cultivar.

A group of ten semi-naive panelists were selected to participate in the Free Choice Profiling (FCP) study, based on their taste and smell acuity, interest, ability to discriminate between the four basic tastes and availability for the entire study. No vocabulary development was carried out and each panelist used his/her own descriptive words for the taste attributes. An unstructured line scale, with appropriate anchors, ranging from zero denoting not, to ten denoting extreme was constructed and used to evaluate the different samples. All samples were served and evaluated according to the sensory principles and methods described in the ASTM Manual on Descriptive Analysis Testing for Sensory Evaluation (ASTM Manual Series: MNL 13, 1992).

Recorded data for the sensory analysis were entered into a Microsoft Excel 2003 worksheet and analyzed by Generalized Procrustes Analysis (GPA) (Gower, 1975), using XLstats (2007). GPA was used to provide information on the inter-relationships between samples and assessors (Arnold and Williams, 1986). The main objectives were to obtain an insight into the basic cognitive factors that the consumers used to distinguish between products, as well as the relationships between products in these factors. A consensus configuration was then calculated as the average of individual configurations and simplified to a reduced dimensional plot by Principal Components Analysis (PCA). The interpretation of descriptive sensory evaluation was simplified with the assistance of the PCA (Jack, 1994).

Juice extraction, jelly processing

The fruit was washed and both ends were cut-off. The fruit was cut into squares and cooked slowly in water. The juice was then extracted through a cloth. To 250 ml of juice, 200 g of sugar and 6 g dried apple pectin was added and processed (at 101 °C) into jelly using a standardized method (Homemaking Division, 1986). The pH must vary between 2.8 and 3.4 to process the perfect jelly. In this study, a pH of 3 was used to standardize the method. Lemon juice was added to adjust the pH. Jelly from all seven cultivars was made in triplicate. Three controls were made: Control 1 with water and added pectin, control 2 with orange juice and control 3 with orange juice and added apple pectin (Figure 2).

Figure 2. Cactus pear fruit jelly (orange juice control jellies and Line-Spread test on the left).

Descriptive sensory analysis, physical analysis of processed jelly

Descriptive sensory analysis was done, in triplicate, by seven trained panelists, who compared the texture of the jellies and three control jellies (water, orange juice and, orange juice + pectin), by using a consensus lexicon and ten point scale (Heymann, 1995).

Objective physical analyses were used to evaluate the texture of the jellies. The Line-Spread test (Kim, 2007) and a Brookfield viscometer (Frey, 2009) were used to measure and detect flow properties of the jellies and to compare the relative viscosities of the jellies processed from different cultivars.

Statistical analysis of descriptive sensory- and physical analysis of jelly processing

A Fischer's Least Significant Difference Test at $p < 0.001$ was performed to determine which cultivars differed significantly from one another for the sensory attributes and the physical analysis (NCSS, 2007).

RESULTS AND DISCUSSION

Sensory analysis of thermal-treated juice

FCP generated 24 idiosyncratic descriptors to describe the taste attribute, among the ten panelists (Table 1). Included were the four basic tastes, as well as various vegetable- and fruit tastes.

Table 1. List of idiosyncratic descriptors developed by ten semi-naïve panelists to describe the taste attribute of eight cactus pear cultivars, as well as their respective treatments.

Descriptor	
Apple	Kiwi
Bitter	Cucumber
Green leaves	Neutral
Beans	Pear
Beetroot	Pungent
Grapes	Raw Potato
Frank	Sweet
Berry	Sour
Grassy	Salty
Melon	Tropical
Stoney	Prickly pear
Banana	Fruity

According to the Procrustes Analysis of Variance (PANOVA) (Table 2) (which summarize the efficiency of each GPA transformation in terms of the total variability) for all eight cultivars, scaling, rotation and translation transformations were all significant ($p<0.0001$). These three transformations, performed by the GPA, corrected the differences between the individual assessors' judgments (Arnold and Williams, 1986). The translation step corrected the level effect, the rotation step corrected the terms used and the isotropic scaling step corrected the range effect.

Table 2 Procrustes Analysis of Variance (PANOVA) table for all eight cultivars.

Source	DF	Sum of squares	Mean squares	F	Pr > F
Scaling	9	272.380	30.264	69.418	< 0.0001
Rotation	2484	1949.163	0.785	1.800	< 0.0001
Translation	216	8834.025	40.898	93.808	< 0.0001

The GPA-PCA biplot (according to the Eigen-values which indicates the percentage by which variation is explained in a plot) for the eight cultivars, and their respective treatments, showed that dimension 1 explained 87,63% of the variation, i.e. the panel was capable to distinguish the animal feed cultivar, Robusta and its treatments from the other seven cultivars and their treatments. Dimension 2 explained only 4,14% of the variation, indicating the panel could connect only the animal feed Robusta and its treatments to descriptors such as bitter, green leaves, beans, beetroot, astringent, stony, pungent, raw potato and salty (Figure 3).

The GPA-PCA biplot (Figure 4) divided the 7 cultivars and their treatments into two groups, showing a tendency that pasteurization had a detrimental effect on taste, as it was negatively associated with attributes such as astringent, stony, sour and bitter. According to the Eigen-values, only 55,60% of the variation could be explained by dimensions 1 and 2.

It was reported that both the color and taste is affected by heat processing and that lengthy heat treatments cause and unattractive, hay-like taste (Saenz, 2001). Furthermore, Saenz and Sepulveda (2001) concluded that the purple juice is more stable regarding thermal treatments than green cactus pear juice. With the FCP sensory evaluation, the color of the juice was masked by the red light and could not be detected by the panel. This was done to prevent consumer prejudice. Therefore, taste was the only attribute tested.

Other important deductions could be drawn from this study: pasteurization changed the prickly pear and melon taste of fresh and frozen juice from Santa Rosa to bitter and astringent. Freezing and pasteurization turned the melon and prickly pear taste of the juice from Algerian to bitter and astringent. The frozen juice of Meyers had a more

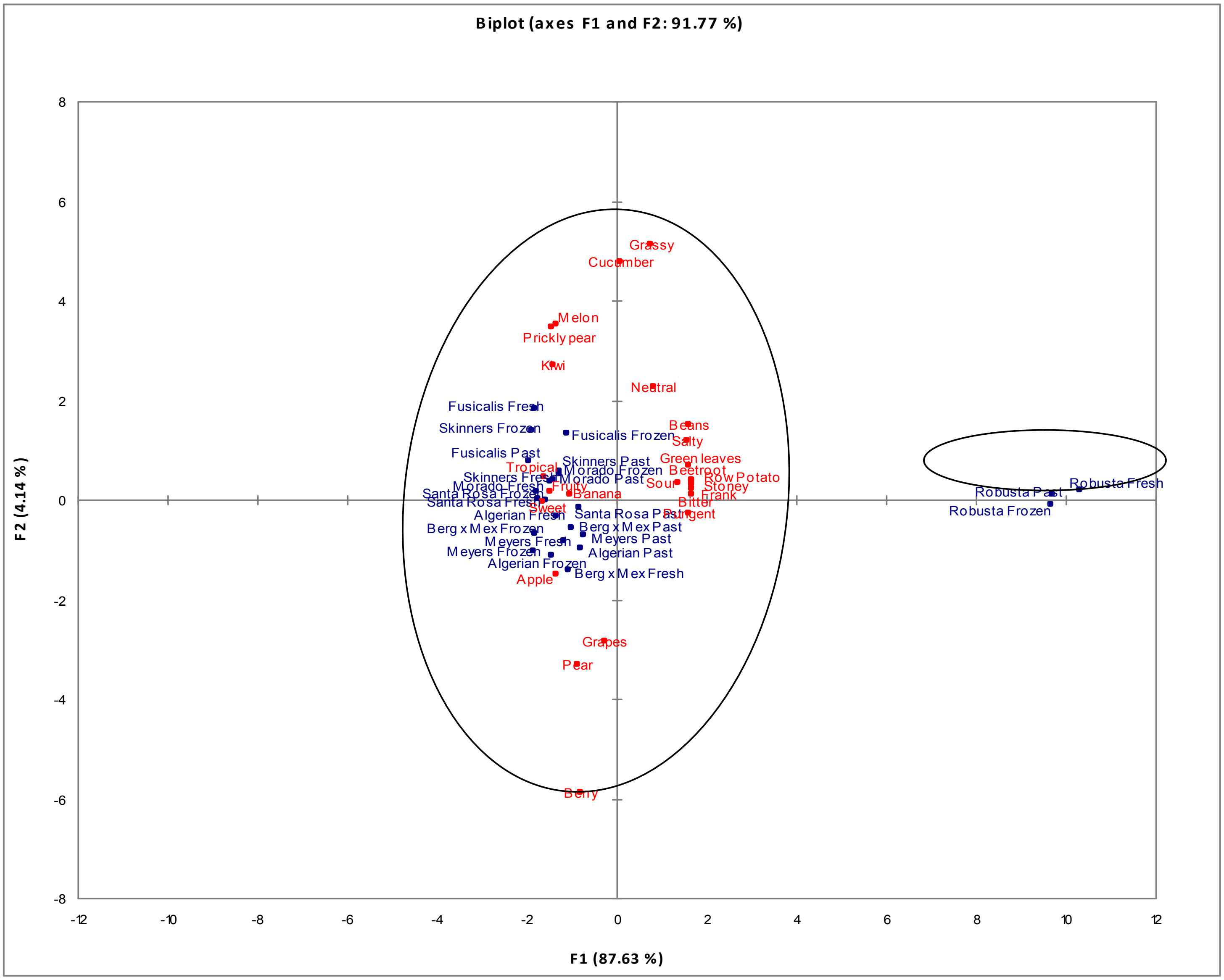

Figure 3. Generalized Procustes analysis biplot (F1 + F2) of free choice profiling for descriptors of the taste attribute of all eight cactus pear cultivars and their three treatments.

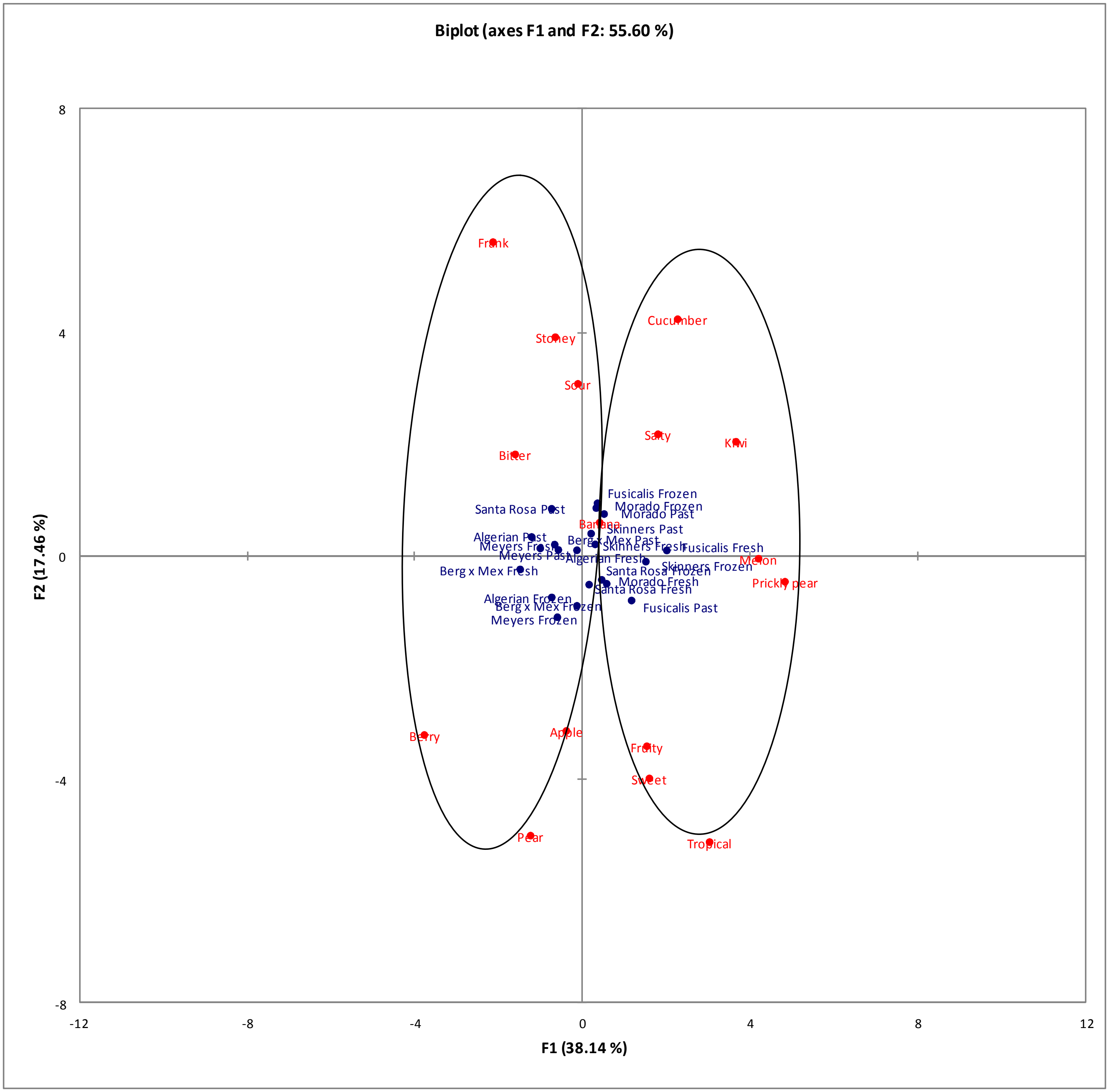

Figure 4. Generalized Procustes analysis biplot (F1 + F2) of free choice profiling for descriptors of the taste attribute of the seven cactus pear cultivars and their three treatments.

acceptable taste than the fresh and pasteurized juices. It was reported by Bunch (1996) that a frozen puree was most stable and versatile.

An interesting observation was that no green or white cultivar obtained any negative descriptors after heat treatments. Green cactus pear juice was also preferred, in terms of aroma and taste, above orange and purple juice (Sepulveda and Saenz, 1999).

Sensory analysis of jellies

An attempt was performed to compare cultivars regarding pectin content by jelly manufacture. Initial pectin tests supported the addition of apple pectin to the cactus pear juice used in jelly processing.

Five sensory descriptors for texture were generated by the trained sensory panel, namely cloudiness, smoothness, pectin content, runniness and cutting edge and a consensus lexicon was constructed (Table 3). Scores for the jellies were generally low compared to two of the control samples (orange juice, and orange juice + pectin). There was no significant difference between the seven cultivars for the descriptors of smoothness, cutting edge, pectin content and runniness (results not shown). For the descriptor of cloudiness, Monterey differed from Direkteur and Skinners Court, Muscatel, Turpin and Vryheid, and *O. ficus-indica* (Figure 5). Saenz (2001) reported that green cactus pear pulp contains little pectin, while purple cactus pear pulp contains no pectin. It was also concluded that the pectin content in cactus pear fruit pulp was insufficient for the production of jelly.

Table 3. Descriptors and definitions created by seven trained panelists for the sensory evaluation of jellies prepared from fruits and peel of seven cactus pear cultivars.

Descriptor	Definition
Cloudiness	Presence or absence of visual particles
Smoothness	Presence or absence of lumps
Pectin content/Gumminess/Syrupy	Presence or absence of mouthfeel characterised by pectin content
Runniness/Gel	Presence or absence of formation of gel
Cutting edge	To be able to be cut with a knife, leaving a clean edge

An interesting observation was that the animal feed cultivar, Monterey, which in a raw state has a beetroot-like taste, was found to have an extremely pleasant flavor, when processed into a jelly.

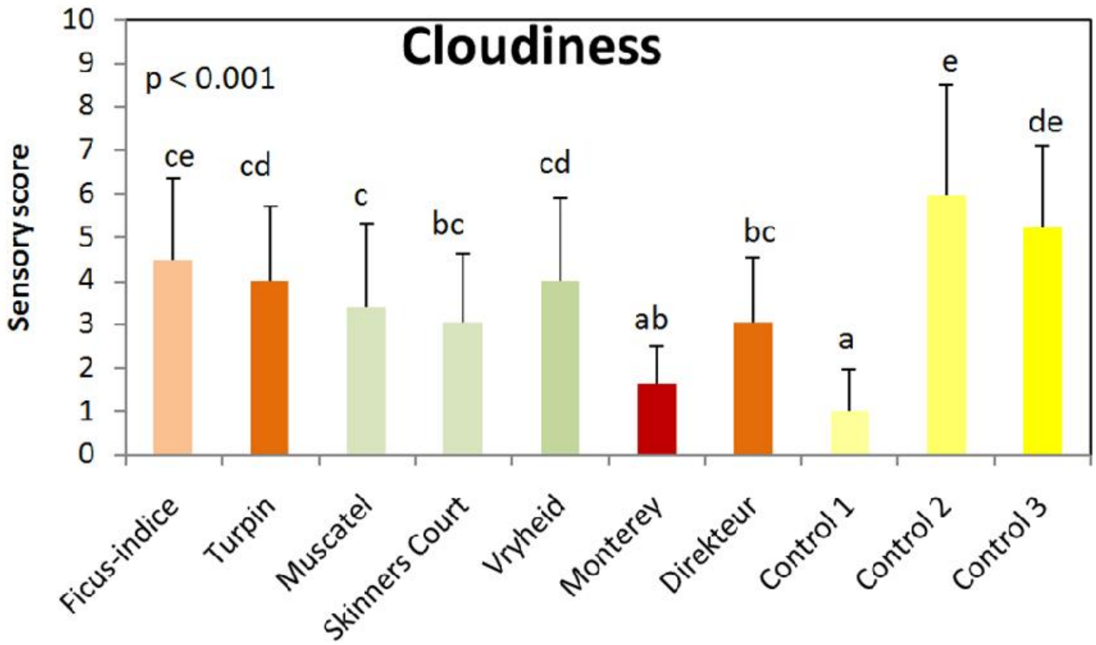

Figure 5. Bar graph for sensory descriptor of cloudiness for fruit jellies made from fruit and peel juice from seven cactus pear cultivars (colors of the bars are representative of the colors of the cactus pear fruit)

Physical analysis of jellies

With regard to the physical texture analysis, there was a significant difference between the seven cultivars. *Opuntia ficus-indica* had the highest viscosity and Line-Spread value, while Direkteur and Skinners Court had the lowest viscosity and Line-Spread value (Figures 6 and 7).

The three control jellies could not be analyzed by the physical tests, since no flow action was observed at the Line-Spread test and furthermore, the spindle of the viscometer could not rotate in any of the three control jellies.

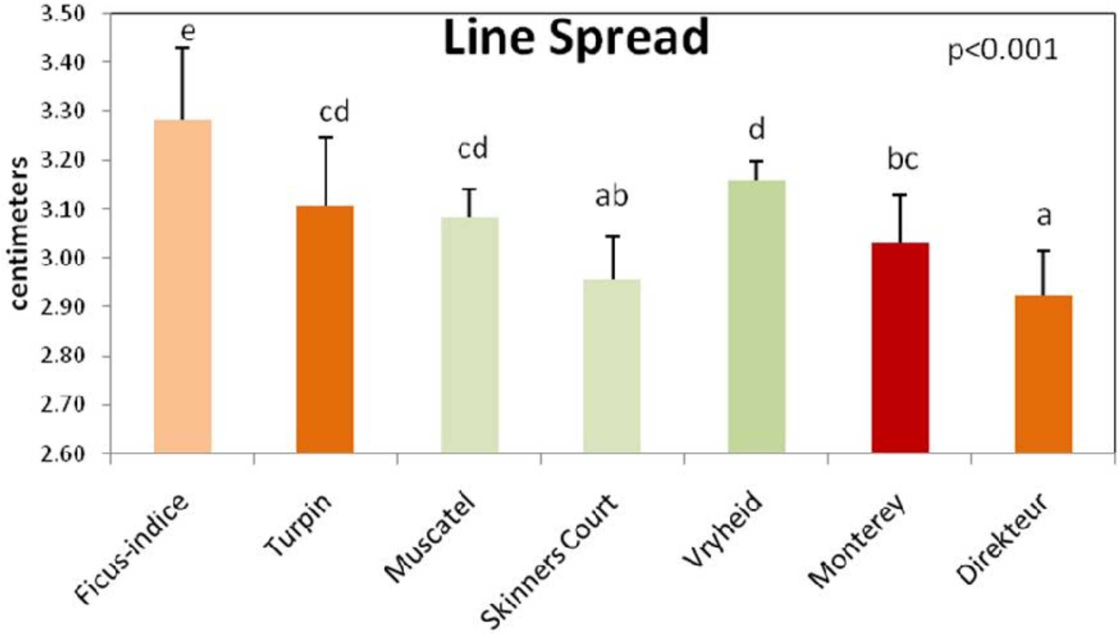

Figure 6. Bar graph for line spread test for fruit jellies made from fruit and peel juice from seven cactus pear cultivars (colors of the bars are representative of the colors of the cactus pear fruit).

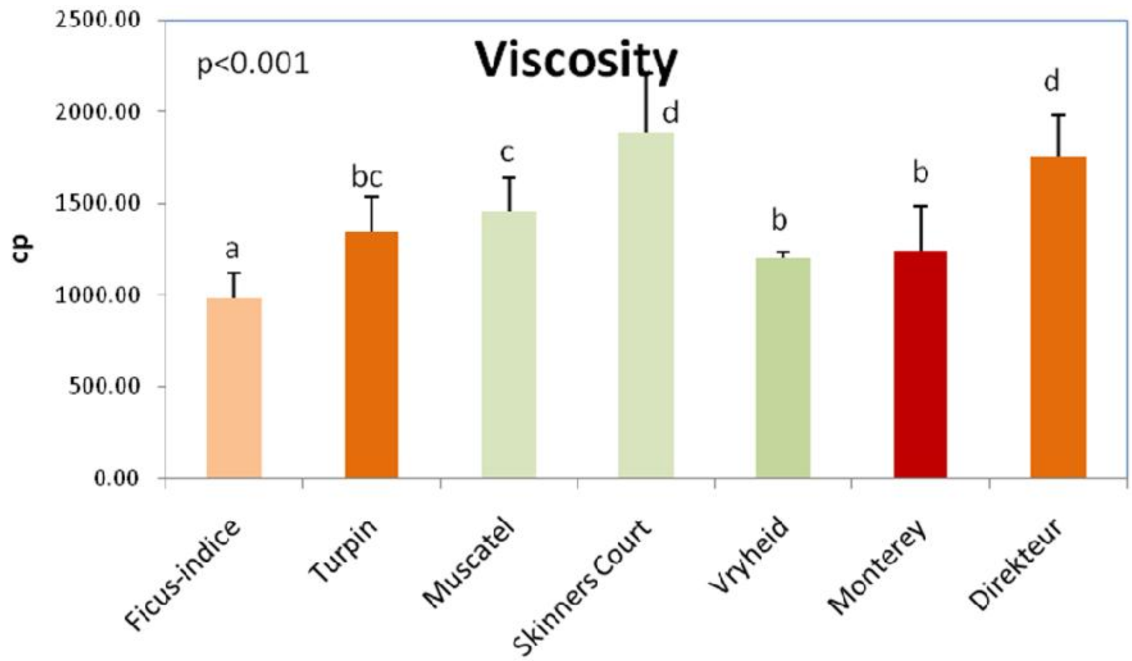

Figure 7. Bar graph for viscometer values for fruit jellies made from fruit and peel juice from seven cactus pear cultivars (colors of the bars are representative of the colors of the cactus pear fruit).

CONCLUSIONS

The Free Choice Profile panel could only significantly distinguish Robusta and its thermal treatments from the other seven cultivars and their respective thermal treatments. The differences caused by the thermal treatments were too small for a consumer-based panel to be detected.

The trained sensory panel did not rate the seven cactus pear cultivars high in regard to the jelly-forming capabilities of their fruit juice jellies. According to the physical analysis of texture, Direkteur and Skinners Court had the lowest viscosity and Line-Spread values; however, these were substantially lower than would be required for a fruit jelly. Future research should focus on the use of the cladodes as possible source of pectin.

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