Using a refractometer to assess quality of produce from different countries of origin

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Abstract

To meet the demands of consumers, supermarkets must remain stocked year-round with a constant supply of produce. Given that most fruits and vegetables can only be harvested in a specific time period, supermarkets must acquire their produce from several different countries at different periods to ensure a year-round supply of fruits and vegetables. This paper investigates whether the quality of produce varies by country of origin through sampling of mandarins, bananas, and honeydew melons, each grown in two different countries and sold in New Zealand. Quality of the samples was measured by total soluble solids (TSS) and quantified in degrees Brix using a refractometer. Results indicate that at the time of sampling, Australian mandarins and honeydew melon are of better quality than New Zealand varieties, and Ecuadorian bananas better than those from the Philippines. It was also noted that since the produce items sampled were at different stages in the growing season, the results are likely to be different if sampled at another time of the year.

Introduction

The concept of produce quality to consumers has several components. Though consumers' perceptions of quality are altered by cultural and demographic factors (Prussia and Shewfelt, 1993), the most easily measurable and controllable factors of quality are internal and external quality indicators. External factors, such as color, firmness, and size are often the key influence of a consumer's purchase decision. However, internal quality measures such as flavor and nutrition will determine whether consumers choose to repurchase that product (Butz & Hofmann, 2005). If information on internal quality was given to consumers, it would improve their perception of produce, reducing or eliminating the need to use often misleading external cues to decide on a purchase (Shewfelt 1987).

A simple, accessible measurement of internal quality of produce is its total soluble solid (TSS) content. The total soluble solids consist of the sugar, carbohydrate, and micronutrient content of

the product (Chang, 2002). Although a direct relationship between TSS and external quality has been seen in certain fruits (Chutichudet & Chutichudet, 2008), the overwhelming majority of fruits and vegetables show no such relationship (Iglesiaset al., 2012; Jha et al., 2006; Mwithiga et al., 2007). With that in mind, consumers are therefore misled by visual appearance of fruits and vegetables when selecting produce in a market setting, purchasing items of lower internal quality. This measurement has been proven to be a dominating factor influencing consumers' satisfaction with produce, with products of higher TSS content being evaluated as better tasting compared to varieties of lower TSS content (Malundo & Shewfelt, 1995; Obenland et al., 2011). In a study of cherries with similar external characteristics, those with high TSS content were more often bought by consumers (Crisosto et al., 2002). Mineral content analyses of syrup extracts have shown that syrups with higher °Brix also have higher levels of vital mineral nutrients (iron, calcium, magnesium, manganese, copper, and zinc) (Guilherme et al., 2009). Research on different apple cultivars shows that cultivars with the highest TSS content also have the highest levels of antioxidants and polyphenolic compounds, known to help prevent cardiovascular or oncogenic diseases (Rop et al., 2011). Products with higher TSS have also been shown to maintain their peak TSS longer and have a longer shelf life (Jha et al., 2006; Kviklienė et al., 2011). The "internal quality," associated with total soluble solids, therefore, encompasses flavor, nutritional content, and longevity of this quality.

Several factors have been shown to impact TSS content. For one, many studies have shown that the time of harvest has a significant relationship to TSS content (Chutichudet & Chutichudet, 2008; Jha et al., 2006; Mwithiga et al., 2007). The study by Crisosto et al. also found that the skin color and TSS content varied based on their orchard of origin, establishing a significant regional influence on the quality of the product (Crisosto et al., 2002). The nutrition supplied to a crop, in the form of fertilizer, has also been shown to influence TSS content (Ali et al., 2011). Based on these results, if consumers were better informed of both the TSS and region of origin of their produce, they would be able to make a well-informed selection of produce, ensuring that they purchase only the highest quality product (if they so desire). Given that the country of origin of supermarket produce varies by year and quality varies by farm/orchard of origin, it is likely that the quality of produce varies throughout the year as the source of produce changes.

The present study examined country of origin's impact on TSS content using produce from New Zealand. Produce gathered originated from New Zealand, Australia, Ecuador, and the Philippines.

Methods

Produce collection and storage

Produce was collected from various supermarkets on 8 May 2012. Four different items were selected to sample: mandarins, bananas, and honeydew melons. The mandarins and honeydew melons were from New Zealand. The bananas were from the Philippines and Ecuador.

These items were selected based on their current availability. It is important to note that the harvest date within the growing season has a significant effect on the TSS content of produce (Chutichudet & Chutichudet, 2008; Jha et al., 2006). Each item was in its own unique phase in the growing season:

1. The mandarins were in a transitional period in terms of growing season. The Australian mandarins were coming from the end of the growing season, and were part of the last Australian shipment to the supermarket. The New Zealand mandarins were in the early stages of the growing season, and those selected for sampling were among the earliest shipments.
2. Bananas were in similar stages in the growing season in both Ecuador and the Philippines. .
3. The honeydew melons were in a transitional phase from New Zealand grown to Australian. The New Zealand variety was from the last shipment, and the Australian variety from the first.

The produce was kept indoors at approximately 17ºC with minimal sunlight exposure to ensure consistency in day-to-day data collection. Although it is recommended that the refractometer readings be taken at 20 ºC ±0.2 ºC for standardized measurements (Pomeranz, 2002), the readings taken in this study are only being compared to other readings taken in the study. It is therefore acceptable to take measurements at 17 ºC, given that measurements were taken every day at the same temperature.

Data collection and measurement

Data collection occurred once a day over a five-day period, to simulate a typical amount of time that produce would be in a consumer's household before the last of it was consumed. The time of day of measurement was kept as consistent as possible. Measurements were taken with an Atago refractometer, capable of measuring 0-90 ºBrix. Based on time constraints, availability of money, and holding capacity, 5 mandarins and 3 bananas of each variety were sampled each day. For the same reasons, only 1 honeydew melon from each country was sampled.

To sample with the refractometer, juice was extracted from each individual item, and a drop of it was placed on the refractometer prism for measurement. To acquire a proper representative sample of the respective juices of each item, specific methods were used:

1. For the mandarins, 2 slices from opposite ends of the fruit were removed, juiced, and mixed.
2. For the bananas, a slice was taken out of the middle of each banana and ground to a paste which could be sampled with a refractometer.
3. For the honeydew melons, a cross-section was cut out of each and divided into 10 pieces, each of which was juiced and sampled in the refractometer.

Statistical Analysis

For each item of produce, the mean TSS was compared between regions and tested for statistical significance. Standard deviations for each item were also calculated to compare the spread of collected values. To look at the effect of TSS on the longevity of quality, changes in TSS over time were also analyzed for patterns and tested for statistical significance. Given that the honeydew melon was only sampled once, this analysis was only performed on mandarins and bananas.

Results

The mean total soluble solid content (in °Brix) and standard deviation for each item of produce is summed up in Table 1. The difference in average Brix value for each produce item can be explained by the different amounts of nutrients present in each. The higher Brix value seen in bananas is attributed to the presence of fat in bananas, not seen in mandarins or melons. Fat has been shown to contribute more to the Brix reading than carbohydrates or proteins, the other

common nutrients in produce (Chang, 2002). Both Australian mandarins and honeydew melons showed a higher average TSS content than their New Zealand counterparts. Bananas originating from Ecuador had higher TSS than those from the Philippines. No significant patterns can be seen among the standard deviations of the different items.

Given the distribution of data for each produce item, no skew was seen in the data. Therefore, statistical significance was tested with students' t-tests. The results of students' t-tests are displayed in Table 2. Statistical significance was found among mandarins, bananas, and melons at the 99% confidence level.

Regression analyses were performed for mandarins and bananas, comparing TSS vs. time, to investigate if each item had different degrees of change in TSS over time. Figure 1 shows time plots for both items, each with a line of best fit. Although different slopes are seen for each region of origin among each type of produce, none of the regression lines reach a level of statistical significance. No conclusions can be drawn from this analysis.

Discussion

It can be said with certainty that at the time of year in which the produce was purchased, Australian mandarins and honeydew melons were of superior quality to those from New Zealand. It is also certain that Ecuadorian bananas are of higher quality than the Filipino variety. As described here, "quality" is, of course, quantified in terms of TSS, which, as stated above, has been linked to flavor quality, nutritional quality, and storage quality. Spread of TSS data remained similar between produce of each region, indicating that products of higher quality are not necessarily more consistent in quality parameters than lower quality products.

The significant differences seen between regions for each piece of fruit show a clear connection between produce's region of origin and internal quality, in accordance with Crisosto et al.'s findings (Crisosto et al., 2002). There are most likely several factors that can explain this difference. For one, the regional climates are quite different. Varying amounts of rain, sunlight, wind, humidity, and other meteorological factors have a significant impact on crop growth and quality. Seeing as the regions from which the different fruits come from each have a unique climate, it is quite possible that the climate variations in each region impacted the quality of produce. Different regions also have different soils. Some crops may be better suited to soil

from one region over another, which will be reflected in its TSS content and therefore quality. Adding to that, farming practices, such as fertilization, will also have an impact on TSS content (Ali et al., 2011). Depending on regulations and guidelines of each country regarding farming practices, there may be differences between countries' methods of growing crops. Though there may also be variation in quality between farms within a country, supermarket produce tends to be from several different farms at once, so the data collected can draw no conclusions regarding quality from individual farms within a country. Also of importance is the time of year at which this data was collected. The results show quality of produce at a specific time of year, within specific periods of each country's growing season. As stated above, clear connections have been shown between time of harvest and TSS content. Therefore, the differences in TSS in mandarins and honeydew melon may be a result of the fact that the produce was in different stages of the growing season in each country. The results, therefore, are only conclusive for this time of year for those fruits, except for the bananas, which were in the same growing season in both regions. It is therefore fairly certain that the differences in quality seen in bananas would also be seen throughout the year.

No relationship was seen in TSS over time for each fruit to indicate that fruits of higher TSS kept their quality longer. In fact, all fruits sampled showed a slight increase in TSS over time. This is most likely due to the time scale of sampling. Studies that looked at TSS over time during storage periods were on the scale of several weeks, rather than the 5-day scale simulated in this study (Chutichudet & Chutichudet, 2008; Jha et al., 2006; Kviklienė et al., 2011; Obenland et al., 2011). That being said, given a situation in which produce is only kept in a household for a week or less, TSS should show little impact in shelf life.

The scope of the results from this study is rather small. Although the results are conclusive, they represent only a few produce items and a small time scale. Several factors limited the scope. For one, funding was limited. To produce results for more fruits and vegetables over a longer time scale would require lots more produce be bought. Given the small budget of this study, only a small sample could be taken. The results were also limited by the timing of the study. The fruits in this study were selected based solely on the fact that they were the only items that were being sold from different countries of origin at the time of purchase. If the study were extended to a greater time scale, more fruits and vegetables could be sampled as they come and

go from supermarket shelves. Also, for each fruit, the results show only quality measurements for a specific time in the growing season. No overall conclusions can be drawn about fruit quality by country of origin based on these results. For example, although it can be proven that Australian mandarins and honeydew melons are of superior quality at this time of year, the results of this study cannot prove that they are superior year-round, regardless of time of harvest.

Conclusions

With the above limitations in mind, future research could seek to account for the flaws in this study. Long-term sampling would be beneficial in order to draw conclusions about more produce items, as well as how quality changes throughout the growing season. Also, a more regional approach could be taken, in which produce from different farms and orchards within the same country are sampled, in order to take a closer look at how farming practices affect produce quality.

Not only has this study shown regional differences in produce quality, a scale of quality measurement was used that is easy for consumers to interpret. Although TSS content is not always a perfect indicator of specific qualities of a produce item, it is easy enough to interpret and representative enough of general quality that it is a good scale for consumers to use to interpret the quality of the food they purchase. If average TSS contents for produce were reported in supermarkets, consumers would be able to make informed decisions and select the highest quality, most nutritious produce if they so desire.

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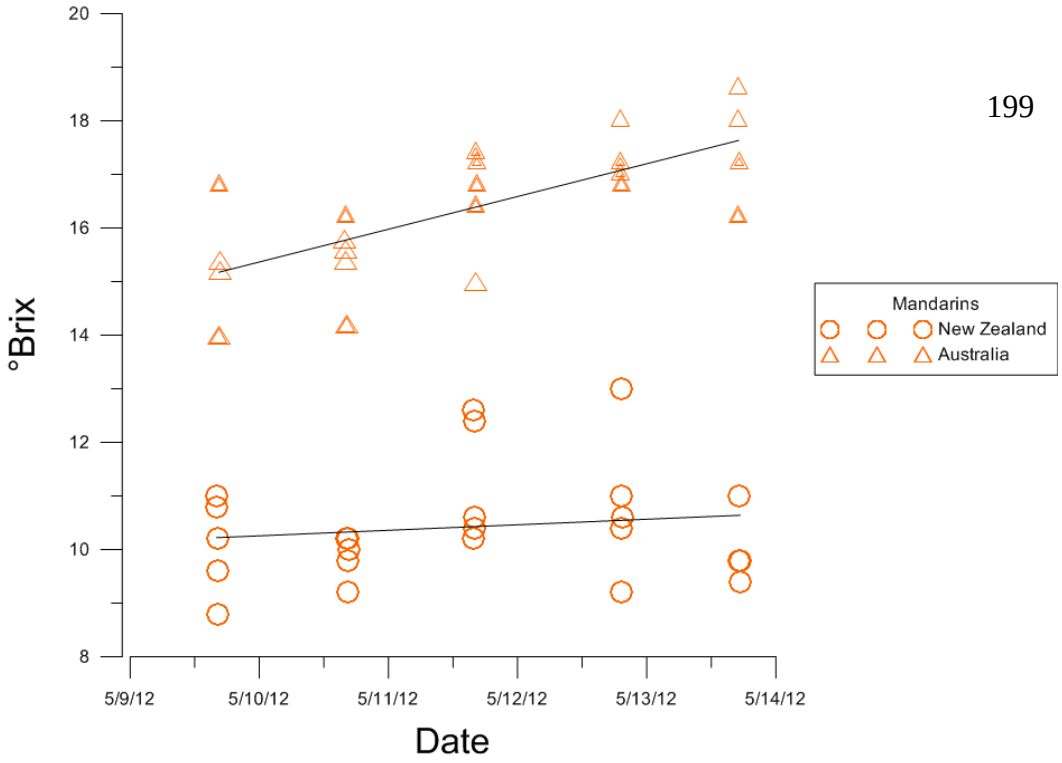
Tables and Figures

	Mean	Standard Deviation
New Zealand Mandarin	10.425	1.051
Australian Mandarin	16.382	1.211
Ecuadorian Banana	23.960	1.029
Filipino Banana	22.720	1.126
New Zealand Melon	7.600	0.499
Australian Melon	9.320	0.567

Table 1: Summary statistics for the sampled produce

	P (two-tail)
Mandarins	3.93736E-21
Bananas	0.003871698
Honeydew Melon	1.06213E-06

Table 2: Results of students' t-tests performed for each produce item. T-tests are two-sample, assuming unequal variances



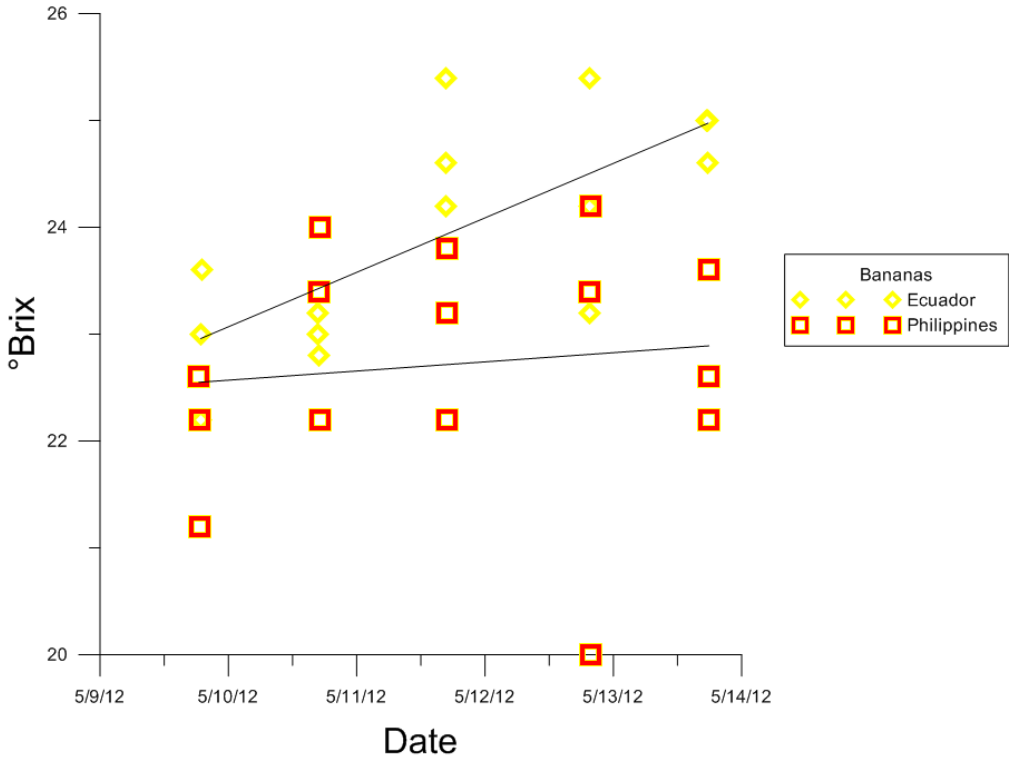


Figure 1: Plots of ºBrix vs. Time for mandarins and bananas. Each plot also contains a line of best fit to clarify change in Brix over time. Although the plots show a clear difference in ºBrix by region for each fruit, the best fit lines and accompanying regression shows no statistical significance