Local and Imported Fruits in Hawai‘i
From a Nutrient Perspective
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Abstract
This paper seeks to illustrate the nutrients of fruits that are locally produced and those that are imported. The fruits reviewed are those common and readily available in the local grocery stores or farmers’ markets, including the downtown market in Honolulu. The sources of the nutrition values are provided. Locally produced fruits identified appear to be more nutritious than imported fruits. The long shipping journey can potentially result in the loss of nutrients for many of the imported fruits. Nevertheless, more work is needed in determining the nutrient values of many of the locally produced tropical fruits.

Introduction
Beyond organics and the “buy local” movement, nutrition is rapidly capturing the attention of increasingly savvy food consumers in the marketplace. Many of these conscientious consumers are reading the nutrition labels of food products in supermarket aisles before purchase. For many, nutrition is the ultimate goal in the purchase of both organic and local food products. For these individuals, organics appear healthier, as well as supporting environmental sustainability. Local foods are associated with freshness and food less travelled, as well as a lower carbon footprint and the recirculation of monies in the local economy.

Hawai‘i is closer to achieving food self-sufficiency in the category of fresh fruits than in any other food category (Loke and Leung 2013). Pineapples, papayas, and avocados are grown for the export market. Mangoes are grown commonly in residential backyards across the state. And other fruits, from watermelons, cantaloupes, and honeydew melons to bananas, are grown commercially by relatively large farms for the local market.

Less than a decade ago, in 2007, Hawai‘i embarked on an ambitious 30-year public policy plan to address food sustainability by 2050 (Hawai‘i 2050). The plan outlined five goals and set action priorities to be achieved by 2020. One of the strategic actions was to “increase the production and consumption of local foods and...
products, particularly agricultural products.” The state later unveiled a strategic/functional plan to increase food security and food self-sufficiency in accordance with HRS Chapter 226 (DBEDT-OP 2012). While official government support is advantageous, the implementation of public policy goals is often delayed due to political discourse and competing special interests. In the meantime, local producers are facing the prospects of lower commodity prices and mounting industry-specific regulations (food safety, water, pesticides, etc.). Reflecting these sentiments, a recent blog post (Kamiya 2016) spoke of the plight of local farmers, their frustrations with policymakers, and the willingness of consumers to pay more for imported fruits but not locally grown ones.

**Objectives**

Beyond government policies, the authors recognize that for agriculture to grow there must be a partnership between stakeholders in the food supply chain, from producers, wholesalers, and grocery stores to consumers. Despite growing interest, general information on fruit nutrients is deficient. This paper is an attempt to fill that gap in the existing literature and to explore the possibilities of increased fresh fruit consumption in Hawai‘i. The objectives of this effort are as follows: i) select, collect, and tabulate nutrient information on local and imported fresh fruits commonly available in Hawai‘i; ii) analyze and compare discernable differences between the two categories of fresh fruits; iii) discuss possible findings of interest; iv) communicate meaningful results to educate and help guide consumers to make better, informed decisions in the purchase of fresh fruits; and v) recommend follow-up actions, if any.

One would assume that a better-informed consumer would be able to make superior choices about food purchases. Consumers who pay attention to nutrient facts are more likely to eat healthier, be better nourished, and enjoy better health, as compared to those who do not.

**Materials and Method**

The selection criterion in this study is simply what fruits are readily available to the average consumer in Hawai‘i. The authors realize that it is not practical to include a comprehensive list of fruits found on the Islands. Hence, the fruits must be available at either the major grocery chains or farmers’ markets (including Honolulu Chinatown). This paper focuses strictly on the nutrient content of select fruits and excludes other nutrition information such as calories, fat, and total carbohydrate levels. In the spirit of Occam’s razor, only a limited number of nutrient parameters are considered, to offer a simplified but still meaningful comparative analysis.

The nutritional values are obtained from the USDA food composition database (ARS 2016) and other sources when needed. Portions are assumed to be 100 grams or 3.5 ounces of edible fruit. Unless otherwise stated, the data does not differentiate between varieties within a fruit group (e.g., apples). Data are reflective of apples per se, not any specific variety. Additionally, the presence of flavonoids is based on the work of Bhagwat et al. (2014). For flavonoids present in the fruits, we used a scorecard indicated by “+”. Fruits with many different flavonoids have more “+” signs compared to those with fewer. This approach is adopted due to a lack of indisputable evidence as to the amount each flavonoid contributes to the maintenance of good personal health or as to how the different flavonoids interact with each other to provide tangible health benefits.

Figure 2. Locally grown emerging fruits. 2A, mamey sapote; 2B, starfruit; 2C, jackfruit; 2D, soursop

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1See the column by Lee Cataluna (2016) for a critical review of planning for the future and government’s resolve in addressing contemporary problems facing Hawai‘i’s society today.
## Results

Table 1 shows select nutrients of locally sourced fresh fruits (see also Figure 1) that are commonly available to consumers in Hawai‘i. The list of 11 nutrients includes vitamins, minerals, protein, and flavonoids. All the 11 local fruits listed are sold in neighborhood supermarkets, specialty grocery stores, and farmers’ markets. The table shows many local fruits with high nutrient contents. Avocado, for example, is relatively rich in thiamine (vitamin B₁), vitamin E, niacin (vitamin B₃), folate (folic acid), phosphorus (P), potassium (K), and protein. Cantaloupe is filled with vitamin A and niacin, while both longan and lychee are rich in vitamin C and phosphorus. Local mango, harvested when ripe, is loaded with vitamins A and E. Pineapple is rich in vitamin B and calcium. Finally, the papaya is rich in vitamin C, beta-carotene, and calcium. It also has an enzyme called papain that has been shown to help digest meat fibers and is anti-inflammatory (Vannella et al. 2016).

Fruits like watermelon, cantaloupe, papaya, and dragon fruit are also rich in lycopene. This antioxidant is known for its anti-aging properties (Rao and Rao 2007, Evans and Johnson 2010), helping to fight prostate cancer (Wertz 2009) and breast cancer (Eliassen et al. 2012), and preventing heart diseases (Böhm 2012, Kolla et al. 2010). Dragon fruit has been cited as helping to reduce glucose in type 2, diabetic individuals (Hadi et al. 2012). Vitamin C and vitamin E have been reported to prevent atherosclerosis and cell death (Rossig et al. 2001, Salonen et al. 2003). Vitamin C can also protect against oxidative stress (Goldfarb et al. 2005), and there is evidence that it reduces the risk of gastric cancer (Waring et al. 1996).

Fruits are also an important source of potassium. The concentration of potassium in tropical fruits is high.

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### Table 1. Selected Nutrient Information of Local Fresh Fruits Commonly Available in Hawai‘i

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Avocado*</th>
<th>Banana (Apple)*</th>
<th>Cantaloupe</th>
<th>Dragon Fruit†</th>
<th>Honeydew Melon</th>
<th>Longan‡</th>
<th>Lychee§</th>
<th>Mango</th>
<th>Papaya</th>
<th>Pineapple¶</th>
<th>Watermelon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vit. A (IU)</td>
<td>146.00</td>
<td>1.34</td>
<td>3382.00</td>
<td>NA</td>
<td>50.00</td>
<td>NA</td>
<td>1.05</td>
<td>1082.00</td>
<td>950.00</td>
<td>52.00</td>
<td>569.00</td>
</tr>
<tr>
<td>Thiamine* (mg)</td>
<td>0.45</td>
<td>0.03</td>
<td>0.13</td>
<td>0.08</td>
<td>0.14</td>
<td>NA</td>
<td>0.01</td>
<td>0.19</td>
<td>0.09</td>
<td>0.21</td>
<td>0.10</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>1.74</td>
<td>0.67</td>
<td>0.73</td>
<td>0.40</td>
<td>0.42</td>
<td>0.30</td>
<td>0.61</td>
<td>0.67</td>
<td>0.52</td>
<td>0.47</td>
<td>0.18</td>
</tr>
<tr>
<td>Vit. C (mg)</td>
<td>10.00</td>
<td>8.71</td>
<td>36.70</td>
<td>7.00</td>
<td>18.00</td>
<td>84.00</td>
<td>71.58</td>
<td>36.40</td>
<td>60.9</td>
<td>16.9</td>
<td>8.10</td>
</tr>
<tr>
<td>Vit. E (mg)</td>
<td>2.07</td>
<td>0.00</td>
<td>0.05</td>
<td>0.40</td>
<td>0.02</td>
<td>NA</td>
<td>0.00</td>
<td>0.90</td>
<td>0.30</td>
<td>0.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Folate (µg)</td>
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<td>20.10</td>
<td>21.00</td>
<td>44.00</td>
<td>19.00</td>
<td>NA</td>
<td>1400.00</td>
<td>43.00</td>
<td>37.00</td>
<td>18.00</td>
<td>3.00</td>
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<td>Ca (mg)</td>
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<td>5.36</td>
<td>9.00</td>
<td>6.00</td>
<td>6.00</td>
<td>1.00</td>
<td>5.26</td>
<td>11.00</td>
<td>20.00</td>
<td>13.00</td>
<td>7.00</td>
</tr>
<tr>
<td>P (mg)</td>
<td>52.00</td>
<td>22.11</td>
<td>15.00</td>
<td>29.00</td>
<td>11.00</td>
<td>21.00</td>
<td>31.05</td>
<td>14.00</td>
<td>10.00</td>
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<td>11.00</td>
</tr>
<tr>
<td>K (mg)</td>
<td>485.00</td>
<td>359.80</td>
<td>267.00</td>
<td>350.00</td>
<td>228.00</td>
<td>266.00</td>
<td>171.05</td>
<td>168.00</td>
<td>182.00</td>
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<td>112.00</td>
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<tr>
<td>Protein (g)</td>
<td>2.00</td>
<td>1.34</td>
<td>0.84</td>
<td>1.40</td>
<td>0.54</td>
<td>1.30</td>
<td>1.05</td>
<td>0.82</td>
<td>0.47</td>
<td>0.55</td>
<td>0.61</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>++++</td>
<td>+++++++</td>
<td>+++</td>
<td>+++</td>
<td>+++++</td>
<td>+++++</td>
<td>++++</td>
<td>+++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
</tr>
</tbody>
</table>

*Avocado – all commercial varieties; pineapple – fresh, traditional varieties.
+Thiamine = Vitamin B₁
Sources: ARS, USDA Nutrient Database; †CTAHR-CRC, Hawai‘i Foods website (data is converted to reflect 100g)
‡Calorie Slism – Food Calorie Calculator and Nutrition Information
§SELF Nutrition Data – Food Facts, Information and Calorie Calculator
Table 2. Selected Nutrient Information of Imported Fresh Fruits Commonly Available in Hawai'i

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Apple*</th>
<th>Avocado</th>
<th>Banana</th>
<th>Blue-berry</th>
<th>Grape*</th>
<th>Nectarine</th>
<th>Orange</th>
<th>Pear</th>
<th>Peach*</th>
<th>Plum</th>
<th>Strawberry</th>
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</thead>
<tbody>
<tr>
<td>Vit. A (IU)</td>
<td>54.00</td>
<td>147.00</td>
<td>64.00</td>
<td>54.00</td>
<td>100.00</td>
<td>332.00</td>
<td>247.00</td>
<td>25.00</td>
<td>326.00</td>
<td>345.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Thiamine* (mg)</td>
<td>0.49</td>
<td>0.51</td>
<td>0.04</td>
<td>0.13</td>
<td>0.26</td>
<td>0.09</td>
<td>0.20</td>
<td>0.07</td>
<td>0.08</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>0.09</td>
<td>1.91</td>
<td>0.67</td>
<td>0.42</td>
<td>0.30</td>
<td>1.13</td>
<td>0.43</td>
<td>0.16</td>
<td>0.81</td>
<td>0.42</td>
<td>0.39</td>
</tr>
<tr>
<td>Vit. C (mg)</td>
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<td>8.80</td>
<td>8.70</td>
<td>9.70</td>
<td>4.00</td>
<td>5.40</td>
<td>59.10</td>
<td>4.30</td>
<td>6.60</td>
<td>9.50</td>
<td>58.80</td>
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<tr>
<td>Vit. E (mg)</td>
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<td>0.10</td>
<td>0.57</td>
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<td>0.12</td>
<td>0.73</td>
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<tr>
<td>Folate DFE~ (µg)</td>
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<td>89.00</td>
<td>20.00</td>
<td>6.00</td>
<td>4.00</td>
<td>5.00</td>
<td>34.00</td>
<td>7.00</td>
<td>4.00</td>
<td>5.00</td>
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<tr>
<td>Ca (mg)</td>
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<td>13.00</td>
<td>5.00</td>
<td>6.00</td>
<td>14.00</td>
<td>6.00</td>
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<td>9.00</td>
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<td>6.00</td>
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<tr>
<td>P (mg)</td>
<td>11.00</td>
<td>54.00</td>
<td>22.00</td>
<td>12.00</td>
<td>10.00</td>
<td>26.00</td>
<td>23.00</td>
<td>12.00</td>
<td>20.00</td>
<td>16.00</td>
<td>24.00</td>
</tr>
<tr>
<td>K (mg)</td>
<td>107.00</td>
<td>507.00</td>
<td>358.00</td>
<td>77.00</td>
<td>191.00</td>
<td>201.00</td>
<td>166.00</td>
<td>116.00</td>
<td>190.00</td>
<td>157.00</td>
<td>153.00</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>0.26</td>
<td>1.96</td>
<td>1.09</td>
<td>0.74</td>
<td>0.63</td>
<td>1.06</td>
<td>0.91</td>
<td>0.36</td>
<td>0.91</td>
<td>0.70</td>
<td>0.67</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>++++</td>
<td>+</td>
<td>++++</td>
<td>++++</td>
<td>++</td>
<td>++</td>
<td>++++</td>
<td>+++</td>
<td>++++</td>
<td>++++</td>
<td>+++</td>
</tr>
</tbody>
</table>

*Apple – with skin; grapes – American type; peaches – yellow, fresh. +Thiamine = Vitamin B₁. ~Diet Supplement Fact Source: ARS, USDA Nutrient Database

Table 3. Nutrient Information of Emerging Local Fresh Fruits

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Cherimoya</th>
<th>Jackfruit</th>
<th>Rambutan¹</th>
<th>Starfruit</th>
<th>Soursop</th>
<th>Mamey Sapote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vit. A (mg)</td>
<td>5.00</td>
<td>110.00</td>
<td>NA</td>
<td>61.00</td>
<td>2.00</td>
<td>143.00</td>
</tr>
<tr>
<td>Thiamine* (mg)</td>
<td>0.49</td>
<td>0.49</td>
<td>0.02</td>
<td>0.05</td>
<td>0.18</td>
<td>0.85</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>0.64</td>
<td>0.92</td>
<td>0.78</td>
<td>0.37</td>
<td>0.90</td>
<td>1.43</td>
</tr>
<tr>
<td>Vit. C (mg)</td>
<td>12.60</td>
<td>13.70</td>
<td>39.50</td>
<td>34.40</td>
<td>20.60</td>
<td>23.00</td>
</tr>
<tr>
<td>Vit. E (mg)</td>
<td>0.27</td>
<td>0.34</td>
<td>NA</td>
<td>0.15</td>
<td>0.08</td>
<td>2.11</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>23.00</td>
<td>24.00</td>
<td>NA</td>
<td>12.00</td>
<td>14.00</td>
<td>NA</td>
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<tr>
<td>Ca (mg)</td>
<td>10.00</td>
<td>24.00</td>
<td>7.90</td>
<td>3.00</td>
<td>14.00</td>
<td>18.00</td>
</tr>
<tr>
<td>P (mg)</td>
<td>26.00</td>
<td>21.00</td>
<td>16.50</td>
<td>12.00</td>
<td>27.00</td>
<td>26.00</td>
</tr>
<tr>
<td>K (mg)</td>
<td>287.00</td>
<td>448.00</td>
<td>179.70</td>
<td>133.00</td>
<td>278.00</td>
<td>454.00</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>1.57</td>
<td>1.72</td>
<td>NA</td>
<td>1.04</td>
<td>1.00</td>
<td>1.45</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>NA</td>
<td>++</td>
<td>NA</td>
<td>NA</td>
<td>++</td>
<td>NA</td>
</tr>
</tbody>
</table>

*Rambutan – canned, syrup packed. +Thiamine = Vitamin B₁ Source: ARS, USDA Nutrient Database ¹HealWithFood
Some good sources include banana, avocado, and dragon fruit. Potassium is necessary for regulation of desirable heart rhythm and blood pressure (Haddy et al. 2006).

Likewise, Table 2 shows selected nutrients of imported fresh fruits that are commonly available to consumers in Hawai‘i. The same list of 11 nutrients is included, and all the imported fruits listed are also readily available in neighborhood supermarkets, specialty grocery stores, farmers’ markets, and stores in downtown Honolulu. Again, the table shows some imported fresh fruits with high nutrient content. Similar to the local variety, the imported avocado is relatively rich in thiamine (vitamin B₁), niacin (vitamin B₃), vitamin E, folate (folic acid), phosphorus, potassium, and protein. The orange, a leading volume import, is rich in vitamin C, folate, and calcium. The nectarine is filled with vitamin A, niacin, vitamin E, phosphorus, and protein. The Cavendish banana is endowed with vitamin B and potassium, while the plum is filled with vitamin A.

In Table 3, we present a listing of six emerging local fresh fruits (see also Figure 2) with their select nutrient contents. As a group, they display a fairly high level of nutrients. Most impressive is mamey sapote, which is relatively rich in vitamin A, thiamine, niacin, vitamin E, potassium, phosphorus, and calcium. The jackfruit is also impressive, with high levels of folate, calcium, protein, vitamin A, thiamin, niacin, and vitamin E. The cherimoya contains high doses of thiamine, folate, potassium, phosphorus, and protein. The rambutan and starfruit are rich in vitamin C, and the soursop is equally rich in phosphorus. The mamey sapote, which is also known as the “chiku/chico” in Honolulu’s Chinatown markets, is rich in niacin, potassium, and vitamin E. The nutritional benefits of these “rare” fruits in the US markets have been touted in several papers published in magazines such as Healthy Living, Stethnews, and NutriLiving.

The nutrient data of these fruits can further be visualized by using bubble charts, as in Figures 3, 4, and 5, where the correlations of vitamin A, vitamin C, and niacin of different fruit categories (local, imported, and
Figure 4. Vitamin C, Niacin, and Vitamin A Nutrient Values of Imported Fresh Fruits

Figure 5. Vitamin C, Niacin, and Vitamin A Nutrient Values of Emerging Local Fresh Fruits
Figure 6. Potassium, Calcium, and Folate Nutrient Values of Local Fresh Fruits

Figure 7. Potassium, Calcium, and Folate Nutrient Values of Imported Fresh Fruits
emerging local) are presented. In Figure 3, the location of the bubble is determined by the intersection of vitamin C (x-axis), niacin (y-axis), and the amount of vitamin A influenced the size of the bubble. Such interpretation of the “3-D” presentation of the data apply to Figures 3–8.

Several local-origin fruits are shown to have higher concentrations of these nutrients. Local fruits such as cantaloupe, mango, and papaya are high in both vitamins A and C. Longan and lychee are high in vitamin C but have no vitamin A values available in the literature. The absence of vitamin A for lychee was also reported in the “Hawai’i Foods” website. Imported fruits, orange and strawberry have similar vitamin C and niacin values to papaya, but their vitamin A values are significantly lower. Values of vitamin A, vitamin C, and niacin for emerging local fruits are illustrated in Figure 3. At the top of the list and deserving mention are starfruit and mamey sapote. Overall, the niacin values across the three fruit categories are evenly distributed.

Similar visual comparisons for potassium, calcium, and folate acid are presented in Figures 6, 7, and 8. Potassium and calcium values determined the position of the “bubble.” The folate values for each fruit determined the size of the “bubble”; the higher the amount, the larger the bubble. Potassium is important for cardiac health, calcium is necessary for maintaining bone and dental health, and folate is an important nutrient for cell regeneration. Avocado and banana, both of local and import origin, tops the list here. They are followed by dragon fruit, cantaloupe, honeydew melon, papaya, and mango, all locally grown and seasonal. Imported fruits such as orange and strawberry follow. Folate (a water-soluble, vitamin B) is an important nutrient for cell regeneration, heart health, reproductive processes, and prevention of anemia, etc. (NIH 2017).

**Storage time, temperature, and light effects on fruits**

Time, temperature, and light exposure have the greatest effect on deterioration of vitamins and some flavonoids in fruits (Klimczak et al. 2007, Zee et al. 1991). McDougall and Dobson (2011) showed that polyphenols and antioxidants decreased by more than 50% with time and temperature (over one week and 64°F /18°C). Similarly, Watada and Tran (1987) reported storage time affected vitamin C, B₁ and B₂. In some cases, the deterioration of antioxidants occurred by day 10 after harvest (Sarkar et al. 2014). A simple review of nutrient deterioration in fresh fruits and vegetables was presented by Barrett (2007). Furthermore, Barrett et al. (2010) also provided a good review on the relationship of fruit nutrient values
with ripeness, color, flavors, textures, and the challenges of handling and shipping requirements over time. Fruits shipped over long distance are picked earlier, prior to its peak ripeness, optimum flavor and nutritive value.

The ocean shipment of food from the U.S. West Coast to Hawai‘i takes about 5 days. Upon arrival at the docks, more time is spent on unloading, storage at the warehouses, transportation from wholesalers to retailers, repackaging, and final sale to consumers. Additionally, one has to account for the time spent for imported fruits to be transported from growing orchards to the West Coast docks. The transport time from foreign ports is also considerable. In some cases, the imported fruits come from Chile, Australia, etc. via the ports on the West Coast, thus increasing the time duration in the fruit supply chain. The more time spent in transit, the faster deterioration in fresh food (and its nutrients) accelerates. It is no coincidence that waste of fresh fruits by edible weight (47.5%) in Hawai‘i is the highest degree of waste among the major food groups (Loke and Leung 2015).

Summary
This simple illustration of the vitamins and minerals in fruits available to consumers in Hawai‘i demonstrates that locally grown fruits are seemingly more nutritious. Since they are grown locally and harvested closer to ripening, they generally have more nutrients and better flavor. Additionally, without delays in transportation, they are subject to less deterioration in nutrient content and leave a much smaller carbon footprint in terms of food miles. Increased support for the purchase of local fresh fruits also ensures the economic sustainability of small farms, preserves rural landscapes, and maintains the lifestyle of rural communities across the state. The conucopia offering of readily available local fruits, ranging from papaya, mango, and avocado to dragon fruit, cantaloupe, and maney sapote, is a true tropical delight. The opportunities to showcase these fruits’ respective contributions to health exist, but more research work on enhancing the nutritional database for locally available fruits is compelling.

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