Eating Within Region Comparison, Bananas vs. Apples

Bananas

Assumptions:

- Assume bananas grown by Chiquita in Costa Rica (Chiquita is one of the biggest banana distributors in the US and they complete a lot of their farming in Costa Rica)
- Distributed by Chiquita in New Orleans (their US distribution site) and by Meijer in Middlebury, IN (nearest distribution center to South Bend)
- Ignore potential energy requirements for storage of bananas
    - Picked early and exposed to ethylene gas period to being sold
    - These requirements would be more reflective of the timing of picking/selling rather than the geographic differences

Total Bananas

$$\frac{100\ bananas}{40\ lb.\ box} \times \frac{48\ boxes}{pallet} \times \frac{20\ pallets}{truck} = 96,000\ bananas\ per\ truck$$

$$\frac{96{,}000\ bananas}{trailer/truck} \times \frac{500\ trailers}{ship} = 48,000,000\ bananas\ per\ ship$$

Transportation of Bananas (by Ship)

$$\frac{1243\ nautical\ \ miles}{Costa\ Rica\ to\ New\ Orleans} \times \frac{1\ hour}{20\ nautical\ miles} \times \frac{1\ day}{24\ hours} \times \frac{125\ tons\ fuel}{day} = 324\ tons\ fuel$$

Transportation of Bananas (by Truck)

$$\left(\frac{1013\ miles}{New\ Orleans\ \ to\ Midd,\ IN} + \frac{27\ miles}{Midd.\ to\ Mish.}\right) \times \frac{1\ gallon}{6.5\ miles} = 160\ gallons\ per\ truck$$

Energy Equivalent

$$324\ tons \times \frac{748\ gallons}{ton} \times \frac{34\ kWhr}{gallon} = 8,232,285\ kWhr\ per\ ship$$

$$\frac{8{,}232{,}285\ kWhr}{ship} \times \frac{1\ ship}{48{,}000{,}000\ apples} = 0.17\ kWhr\ per\ banana\ on\ ship$$

$$160\ gallons \times \frac{34\ kWhr}{gallon} = 5440\ kWhr\ per\ truck$$

$$\frac{5440\ kWhr}{truck} \times \frac{1\ truck}{96{,}000\ apples} = 0.057\ kWhr\ per\ banana\ on\ truck$$

$$0.17\ kWhr\ on\ ship + 0.057\ kWhr\ on\ truck = 0.23\ kWhr\ per\ banana$$

Apples

Assumptions:

- Assume apples grown in Kent County, MI (county that produces most apples in Michigan)
- Distributed in Meijer Distribution Center in Middlebury, IN (nearest distribution center to South Bend)
- Ignore potential energy requirements for storage of apples, assume picked/sold in season

    - These requirements would be more reflective of the timing of picking/selling rather than the geographic differences

Total Apples In a Truck

$$\frac{48\ apples}{40\ lb.\ box} \times \frac{56\ boxes}{pallet} \times \frac{26\ pallets}{truck} = 69,888\ apples\ per\ truck$$

Transportation of Apples (by Truck)

$$\left(\frac{103\ miles}{Kent, MI\ to\ Midd, IN} + \frac{27\ miles}{Midd.\ to\ Mish.}\right) \times \frac{1\ gallon}{6.5\ miles} = 20\ gallons\ per\ truck$$

Energy Equivalent

$$20\ gallons \times \frac{34\ kWhr}{gallon} = 680\ kWhr\ per\ truck$$

$$\frac{680\ kWhr}{truck} \times \frac{1\ truck}{69,888\ apples} = 0.0097\ kWhr\ per\ apple$$

Eating Within Season, Apples

- Ignore energy consideration of transportation
    - This would be reflective of geographic differences and the following consideration intends to investigate energy used to store apples over time)
- Apples stored in reduced temperature, reduced oxygen cooling rooms
    - Neglect the differences in air composition for heat capacity (heat capacity is dependent on air composition - while the air composition changes, the difference in heat capacity is unlikely to have a significant impact on the energy usage)
    - Not considering the energy required to change the air composition (in order to store apples, oxygen is replaced with nitrogen which slows the ripening process - it is unknown the method for this and thus not accounted for)
- Assume apples are stored for 9 months (after picked in September, through the winter, eaten in July)
- Assume direct relationship between size of fridge and energy consumption (in order to approximate energy consumption of the refrigerator rooms)
- 1,400,000 apple fit in each cooling room (estimation based on number of apples in a box, box on palette, palettes in room)
- Major apple farm/supplier utilizes 30 cooling rooms in this model (Cohen)
- Model initial cooling with only air, some volume/mass will rather be occupied by apple, requiring more energy to cool
    - Apples will require more energy to cool, however it is difficult to approximate the additional energy required to cool the volume occupied by apples compared to the surrounding air, so it is simplified assuming it is all air

Number of Apple

$$\frac{1{,}400{,}000\ apples}{room} \times 30\ rooms = 42{,}000{,}000\ apples$$

Air to Cool

$$40\ ft \times 80\ ft \times 20\ ft \times \left(\frac{1\ m}{3.28\ ft}\right)^3 \times \frac{1.293\ kg}{m3} \times 30\ rooms = 70,299\ kg$$

Initial Cooling

$$70,299\ kg\ air \times (18.9 - 2.2)C \times \frac{0.905\ KJ}{K{*}kg} \times \frac{0.00028\ kWhr}{KJ} = 227.9\ kWhr$$

Storage

$$\frac{4\ kWhr}{day\ (average\ fridge)} \times 3200\ times\ bigger \times 273\ days = 3,504,000\ kWhr$$

Energy Per Apple

$$(227.9\ kWhr + 3,504,000\ kWhr) \div 42,000,000\ apples = 0.083\ kWhr\ per\ apple$$

Industrial Farming Energy Breakdown

Potatoes

Total Emissions: 0.28 kg CO_2/kg potato

Table 1. Breakdown of Emission for the Industrial Farming of Potatoes

Stage	Percentage of Emissions
Agriculture	64
Transport	10
Processing	0
Packaging	6
Storage	20

Kale

Total Emissions: 0.6 kg CO_2/kg potato

Table 2. Breakdown of Emission for the Industrial Farming of Kale

Stage	Percentage of Emissions
Agriculture	24
Transport	18

Processing	3
Packaging	55
Storage	0

Television Comparison
Televisions use 1 kWhr over 10 hours of use.

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