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Calculating Food Miles for a Multiple Ingredient Food Product

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Abstract
This report details the assumptions and calculations used to estimate the food miles for a container of strawberry yogurt.

Keywords
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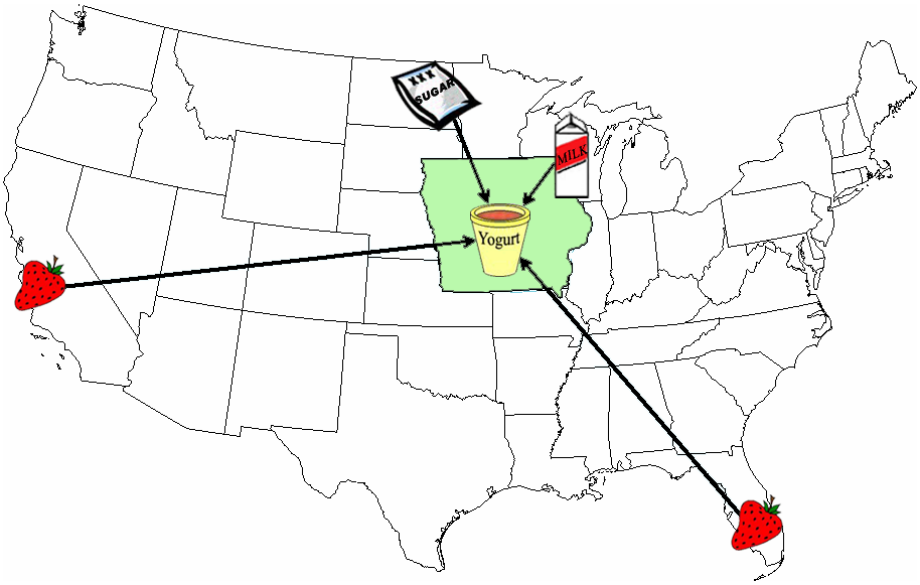

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Calculating food miles for a multiple ingredient food product

Executive Summary
A food mile is the distance food travels from where it is grown or raised to where it is ultimately purchased by the consumer or end user. To determine the average number of food miles a certain food item travels from all sources to reach a certain city or community, it is necessary to calculate a Weighted Average Source Distance (WASD). The WASD from production source to consumption endpoint is a single distance figure that combines information on distances from producers to consumers and the amount of food product transported.

Food miles have become a metaphor to contrast local and global food systems for food systems researchers and local food practitioners alike. Most food miles calculations have been for single ingredient products such as fresh fruit and vegetables. There are, however, few examples of calculated food miles for multiple ingredient food products such as ice cream, pizza, canned vegetable soup, and fruit pie. Since most U.S. consumers buy an array of multiple ingredient food products from both conventional and natural food stores, it is important to explore how food miles can be calculated for such products.

This report details the assumptions and calculations used to estimate the food miles for a container of strawberry yogurt, a multiple ingredient food product containing milk, sugar, and strawberries. Using a set of assumptions and information learned about ingredient sources, we calculated the weighted total source distance (WTSD) for the primary ingredients that make strawberry yogurt (processed in Des Moines, Iowa and shipped to nearby food retailers in Des Moines) to be 2,216 miles. The weighted average source distance – the average distance ingredients travel (based on percent weight in final product) was 277 miles.

The final WTSD of 2,216 miles provides a glimpse at how far-ranging our sourcing of ingredients for multiple ingredient food products can be. It should be noted that the WTSD for strawberry yogurt does not represent the average distance that these ingredients travel to make yogurt that is found in brands and stores across the United States. WTSD values are specific to the source locations and assumptions used to make the calculations. The WTSD for strawberry yogurt likely will be lower in some states and higher in others when compared to our Iowa calculations.

In order for food systems researchers and local food practitioners to use food miles more effectively as a metaphor to contrast local and national/global food systems, food mile values need to be calculated for multiple ingredient food products. This paper provides the details for one such calculation. The values cited here are based on a set of assumptions and are, at best, approximations. Even so, the authors encourage local food practitioners to be as precise as possible in calculating food miles for multiple ingredient food products. The following guidelines are suggested when calculating food miles for multiple ingredient products:

- Check with one or more of the food processors making the product as to the primary sources of the ingredients. It may be necessary – because of a lack of adequate information – to omit from your calculations minor ingredients that make up less than 1 percent of the product by weight.

- Be prepared to investigate and document the sources where other processing steps occurred after the product left the farm. This was the case for sugar (which came from sugar beets) in our example. Another common example is corn syrup used in baked goods or breakfast cereal. Clearly the corn will come from farms, but corn is processed into corn syrup at a location other than the farm and then shipped to the bakery or cereal-making plant.
- Use weighted averages when a primary ingredient comes from multiple sources. It may be simpler to pick one source for an ingredient, but if the ingredient clearly comes from several sources (as indicated on the label or by the food processor), it will be more accurate to include a weighted distance that considers all primary sources.
- For truck-based transport, use road routes rather than "as the crow flies" distances to make your calculations.
- Express your results as how far all the ingredients traveled (WTSD), and how far – on average – did the ingredients travel (WASD).

Background

A food mile is the distance food travels from where it is grown or raised to where it is ultimately purchased by the consumer or end user. It is relatively easy to calculate food miles for a single ingredient, unprocessed food product from the time it leaves the farm until it is purchased. Using fresh produce as an example, lettuce grown in California San Joaquin Valley and transported to supermarkets in Des Moines, Iowa will travel approximately 1,400 miles. Chilean grapes transported by ship from Chile to California and then by truck to Des Moines, Iowa markets travel 7,270 miles[1].

To obtain the average food miles a certain food item travels from all sources to reach a certain city or community, it is necessary to calculate a Weighted Average Source Distance (WASD).[2] The WASD from production source to consumption endpoint is a single distance figure that combines information on distances from producers to consumers and the amount of food product transported.

The formula for the WASD is:

$$WASD = \frac{\Sigma\,(m(k) * d(k))}{\Sigma m(k)}$$

where:

k = different locations of the production origin,
m = amount consumed from each location of consumption origin, and
d = distances from the locations of production origin to the point of consumption.

U.S. Department of Agriculture Agricultural Marketing Service produce arrival data from the Chicago, Illinois terminal market were examined by the Leopold Center for 1981, 1989, and 1998, and a WASD food mile was calculated for arrivals by truck within the continental United States for each year. Produce arriving by truck traveled an average distance of 1,518 miles to reach Chicago in 1998, a 22 percent increase over the 1,245 miles traveled in 1981.[3]

A WASD food mile was calculated for a sampling of produce sales data collected in 2001 by the Practical Farmers of Iowa (a non-profit information and research organization). Iowa farmers sold produce to hotels and conference centers that were featuring locally-grown meals for a number of conferences and workshop events. Another WASD was calculated based on an estimate of where the produce items (which were purchased locally in the Practical Farmers of Iowa data set) would have originated had they come from conventional sources within the continental United States. The average food mile (WASD) for the Iowa locally grown produce

[1] Pirog, Rich and Patrick Schuh, 2002. "The load less traveled: Examining the potential of using food miles in ecolabels." Proceedings from Ecolabels and the Greening of the Food Market Conference, November 2002. p. 69.
[2] Carlsson-Kanyama, Annika. 1997. "Weighted average source points and distances for consumption origin-tools for environmental impact analysis." *Ecological Economics* 23(1997) 15-23.
[3] Pirog, R., T. Van Pelt, K. Enshayan, and E. Cook. 2001. *Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emissions*. Leopold Center for Sustainable Agriculture, Ames, Iowa.

to reach institutional markets was 56 miles, while the conventional food mile total for the produce to reach the same points of sale was 1,494, nearly 27 times further.[4]

There are a number of examples in other states and countries where food miles have been calculated for single ingredient food products**.** Applications have been developed to use food miles to inform consumers about the positive environmental benefits of reducing fuel use and greenhouse gas emissions by reducing transport distance.[5] The Life Cycles Project in Vancouver, Canada allows subscribers to calculate food miles and greenhouse gas (CO_2) emissions for selected food products.[6] In New York, the Farmscape Ecology program helped to develop an in-store computer program to provide customers with a report summarizing the food mile "benefits" from their local food purchases.[7]

Food miles have become a metaphor to contrast local and global food systems for food systems researchers and local food practitioners alike. There are, however, few examples of calculated food miles for multiple ingredient food products such as ice cream, pizza, canned vegetable soup, and fruit pie. Since most U.S. consumers buy an array of multiple ingredient food products from both conventional and natural food stores, it is important to explore how food miles can be calculated for such products. The remainder of this report details the assumptions and calculations used to estimate the food miles for a container of strawberry yogurt, a multiple ingredient food product containing milk, sugar, and strawberries.

Assumptions

As is often the case with multiple ingredient food products, the exact weight and production origin for each ingredient is not available on the product label. One cannot assume that ingredients will be sourced close to where the processing plant is located even though plant location can often be ascertained from the product label. Components for a multiple ingredient food product often are sourced nationally and globally based on ingredient and transport cost. In order to make the necessary food mile calculations for strawberry yogurt, a set of assumptions need to be made:

- The yogurt is sold in eight ounce containers at retail food establishments.
- The primary ingredients needed to make this yogurt include milk (assume 1 percent milk fat), sugar, and strawberries.
- Active yogurt cultures are added at the dairy processing plant.[8]

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[4] Pirog, R. and A. Benjamin. 2003. *Checking the food odometer: Comparing food miles for local versus conventional produce sales to Iowa institutions*. Leopold Center for Sustainable Agriculture, Ames, Iowa.

[5] Pirog, R., T. Van Pelt, K. Enshayan, and E. Cook. 2001. *Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emissions*. Leopold Center for Sustainable Agriculture, Ames, Iowa.

[6] Life Cycle Project web site visited February 2005: www.lifecyclesproject.ca.

[7] Conrad Vispo, 2005. The Green Checkout Report found in *Food Miles: A Farmscape Ecology Program Consumer Education Project.* (www.hawthornevalleyfarm.org/fep/foodmiles.htm)

[8] Conversation with Iowa-based dairy product manufacturer, December, 2004. Exact proportion of ingredients is proprietary information.

- The sugar and strawberries each will represent 3.5 percent of the total weight of the final yogurt product. [9]

- The milk represents 93 percent by weight of the final yogurt product.[10]

- The weight of other ingredients (such as active cultures, natural and artificial flavors) will be less than 1 percent of the product, and will not be factored into the food miles calculations.[11]

- Only the food ingredients will be used to calculate food miles; the origins of the plastic yogurt cup and lid, foil cover, and cardboard case (24 yogurt cups per case) will not be considered.

- The dairy processing facility for this yogurt product will be in Des Moines, Iowa, and the product will be shipped to nearby Des Moines food retail establishments.

- Sugar in the yogurt is processed from sugar beets that are grown in the Red River Valley of Minnesota and North Dakota.

- Milk used in the yogurt is produced primarily on farms in northeast Iowa.

- Strawberries contained in the yogurt come from farms in California and Florida.

- When using USDA Agriculture Statistics Service (NASS) county level data to make estimates of centralized location for product origin, the product is assumed to be equally distributed in each county that is being considered.

Locations

Locations for each ingredient are an assumed centralized location that is characteristic of the typical region from which the ingredients are procured.[12] The county level census data from http://www.nass.usda.gov/census/census02/volume1/index2.htm is used to determine a centralized location of origin. Northeast Iowa is the typical source for milk for these yogurt products. The centralized location was based on a percentage of the total dollars ($) of revenue per county in that region in comparison with the other counties.

Sugar is processed from sugar beets grown primarily in the Red River Valley of Minnesota and North Dakota. The centralized location was based on a percentage of the total dollars ($) of revenue per county in that region compared with other counties in Minnesota and North Dakota.

For sugar beets, the locations for processing plants also were considered in calculating food miles. This information came from:

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[9] Ibid.
[10] Ibid.
[11] Ibid.
[12] Pirog, R. and A. Benjamin. 2003. *Checking the food odometer: Comparing food miles for local versus conventional produce sales to Iowa institutions*. Leopold Center for Sustainable Agriculture, Ames, Iowa.

http://www.crystalsugar.com/coopprofile/532.pdf

Based on the locations of the processing plants relative to the sugar beet farms, it was determined that the added distance from the farm to the processing plant has a minimal impact on the distance from farm to the dairy processing plant. To determine a weighted average distance for the processing plants, we examined annual processing output (annual sugar) from web site data[13] to determine the weighted average location to make our distance calculations (similar to WASD to Des Moines). The path of travel is the same for farm to Des Moines as it is for farm to sugar beet processing plant to dairy processing plant in Des Moines.

The comparison of weights for processed and unprocessed sugar products also was considered. This took into account the fact that the sugar in sugar beets is a percentage of the total weight. Unprocessed sugar beets require more shipping containers than the volume of sugar processed from the sugar beets. The website used to help calculate this ratio is:

http://www.smbsc.com/AboutSMBSC/Sugarbeet.htm

Strawberries are usually sourced from California and Florida. We used a weighted average between California and Florida based on data retrieved from St. Louis and Chicago regional produce markets.[14]

Weighted Total Source Distance
The Weighted Total Source Distance (WTSD) was calculated for the entire processed product. This calculation reflects the total miles the ingredients travel. The shipping distances were calculated using MapQuest (www.mapquest.com). The WTSD calculation is as follows:

$$WTSD = \Sigma (W * D * T * R)_{Ingredient}$$

Where: W = Weight of each ingredient (per container),
D = Shipping distance between ingredient origin and destination,
T = Percent of total amount shipped from each origin per ingredient, and
R = Ratio of shipping weight to processed weight.

Calculations
In this section, we detail the seven steps that lead to our results for strawberry yogurt.

Step 1 – Determine the weight (W) of each product ingredient.
Assuming 93 percent of the product's weight is milk and the total weight of the product is 8 ounces, then:

$$W_{Milk} = (0.93) * (8 \text{ ounces/container})$$
$$W_{Milk} = 7.44 \text{ oz milk/container}$$

[13] The web sites used are: http://www.mdf.coop/agriculture/agriculture.htm and http://www.crystalsugar.com, and http://www.sbreb.org/brochures/SugarCoop/
[14] Pirog, R. and A. Benjamin. 2003. *Checking the food odometer: Comparing food miles for local versus conventional produce sales to Iowa institutions*. Leopold Center for Sustainable Agriculture, Ames, Iowa.

If 3.5 percent of the product's weight is sugar and the total weight of the product is 8 ounces, then:

$$W_{Sugar} = (0.035) * (8 \text{ ounces/container})$$
$$W_{Sugar} = 0.28 \text{ ounce sugar/container}$$

If 3.5 percent of the product's weight is strawberries and the total weight of the product is 8 ounces, then:

$$W_{Strawberries} = (0.035) * (8 \text{ ounces/container})$$
$$W_{Strawberries} = 0.28 \text{ ounce strawberries/container}$$

Step 2 – Determine the source location of each ingredient in order to find the distance (D) to the processing plant.

Since the three yogurt ingredients (sugar, milk, and strawberries) are transported by truck, we used Mapquest (www.mapquest.com) to provide road distances for our calculations. For milk, the primary source is northeast Iowa. We used USDA National Agriculture Statistics Service (NASS) county level data for percent of total dollars of milk sold (Figure 1) to determine a centralized location for milk production. Elkader, Iowa was the chosen centralized location.

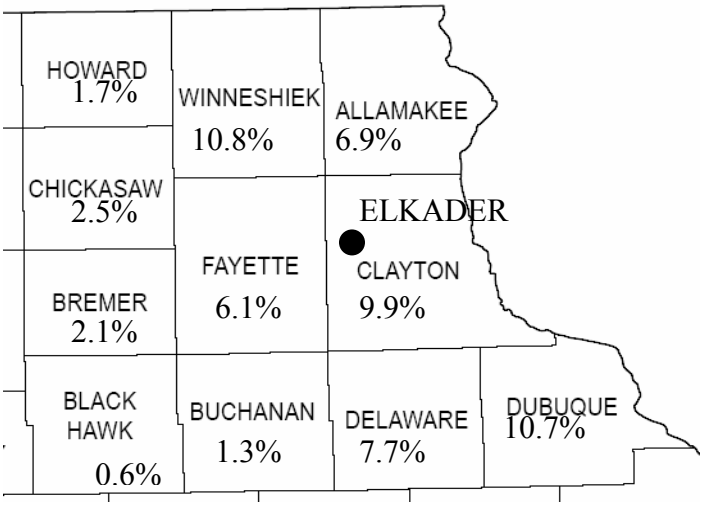


Figure 1. Northeast Iowa county-level dairy production sales **D_{Milk} = 205 miles**

Florida and California have been shown to be two primary sources of strawberries to the upper Midwest based on previous Leopold Center research.[15] We used the source distances from these two states to Des Moines, Iowa.

$$D_{Strawberries\ (CA)} = 1{,}811 \text{ miles}$$
$$D_{Strawberries\ (FL)} = 1{,}394 \text{ miles}$$

For sugar beets, both a centralized location of production and a centralized processing location needed to be determined. The main area of sugar beet production was the Red River Valley area

[15] Ibid.

in Minnesota and North Dakota. The path of travel for sugar beets was assumed to start at the farm where they were produced. Then, the sugar beets are shipped to the processing plant, where they will be processed into sugar and shipped to the dairy processing plant where the sugar is used to make yogurt. The same method used to determine the center of origin for milk production was used for sugar beet production. Crookston, Minnesota was the centralized location.

$$D_{\text{Sugar beet}} = 35 \text{ miles (Distance from farm to sugar processing plant)}$$

To determine the distance from the sugar beet processing plants to the dairy processing plant location, a weighted average source distance (WASD) was calculated. This was completed using the WASD equation:

$$WASD = \frac{\Sigma\,(m(k) * d(k))}{\Sigma m(k)}$$

Where:

k = different locations of the processing plants,
m = annual processed sugar output from each location, and
d = distances from the locations of the sugar plants to the location of the yogurt plant.

WASD = 524

$D_{\text{Sugar}} = 524$ miles

<u>Step 3</u> – Determine the percent of total amount shipped (T) from each ingredient's point of origin.

Single centralized locations were determined for milk, sugar beets, and sugar such that:
$T_{\text{Milk}}, T_{\text{Sugar}}, T_{\text{Sugar beet}} = 100$ percent

For strawberries, we followed previous Leopold Center research[16] and used USDA Agricultural Marketing Service produce arrival data to determine the relative percentages of California and Florida strawberries coming into the upper Midwest market. We found that 81.8 percent of the strawberries come from California while the remaining 18.2 percent come from Florida.

$$T = \Sigma \text{ (Weight to regional markets)}_{\text{Origin}} / \Sigma \text{ (Total regional markets)}$$

$$T_{\text{California}} = [(102 \text{ tons})_{\text{St Louis}} + (243)_{\text{Chicago}}] / (102 + 243 + 17 + 60) = 81.8 \text{ percent}$$

$$T_{\text{Florida}} = [(17 \text{ tons})_{\text{St Louis}} + (60)_{\text{Chicago}}] / (102 + 243 + 17 + 60) = 18.2 \text{ percent}$$

$$T_{\text{Strawberries}} = T_{\text{California}} + T_{\text{Florida}} = 81.8\% + 18.2\% = 100 \text{ percent}$$

[16] Ibid.

Step 4 – Determine the ratio of weight of amount transported to processed weight (R).

For milk and strawberries this ratio is not calculated because it is assumed that the entire volume of the milk and strawberries leaves the farm and arrives at the dairy processing plant. It also assumes that all processing for these ingredients is done at the dairy plant.

We need to use this ratio for the sugar beets to account for the difference in raw sugar beets being shipped to a sugar processing plant versus refined sugar being shipped to the dairy processing plant. If sugar beets contain 17.3 percent sugar[17], then the weight of the transported amount of raw sugar beets required to produce that sugar is:

$$R_{Sugar} = 100 \text{ percent sugar beet} / 17.3 \text{ percent sugar}$$
$$R_{Sugar} = 5.78 \text{ pounds sugar beet} / \text{one pound sugar}$$

Step 5 – Calculate the Weighted Total Source Distance for the processed food product.

$$WTSD_{Dairy\ plant} = \Sigma\ (W * D * T * R)_{Ingredient}$$

$$WTSD = (W * D * T * R)_{Milk} + (W * D * T * R)_{Sugar} + (W * D * T * R)_{Strawberries}$$

$$\begin{aligned} WTSD = {} & (7.44\ {}^{oz}/_{container})\ (205\ mi)\ (100\%)\ (1) && \text{(Milk)} \\ & + (0.28\ {}^{oz}/_{container})\ (35\ mi)\ (100\%)\ (5.78) && \text{(Crude sugar beet)} \\ & + (0.28\ {}^{oz}/_{container})\ (524\ mi)\ (100\%)\ (1) && \text{(Refined sugar)} \\ & + (0.28\ {}^{oz}/_{container})\ (1811\ mi)\ (81.8\%)\ (1) && \text{(California strawberries)} \\ & + (0.28\ {}^{oz}/_{container})\ (1394\ mi)\ (18.2\%)\ (1) && \text{(Florida strawberries)} \end{aligned}$$

$$WTSD_{Dairy\ plant} = 2{,}211 \text{ miles traveled} - \text{ounce per container}$$

Step 6 – Add the average distance from the dairy plant to the retail food store to the WTSD.

One way to calculate this distance is to pick a specific retail food store and using Mapquest (www.mapquest.com) determine the distance from the processing plant to the store. An alternative way to calculate the dairy plant to store distance is to use an average distance to Des Moines-area food retail stores.

The average distance the yogurt travels from the processing plant to Des Moines-area food retail stores (based on information from the predominant grocery chain in Des Moines) can be determined in the following manner:

$$D_{Store} = \sum (\text{Distances}) / (\#\ \text{of Stores})$$
$$D_{Store} = 5.48 \text{ miles}$$

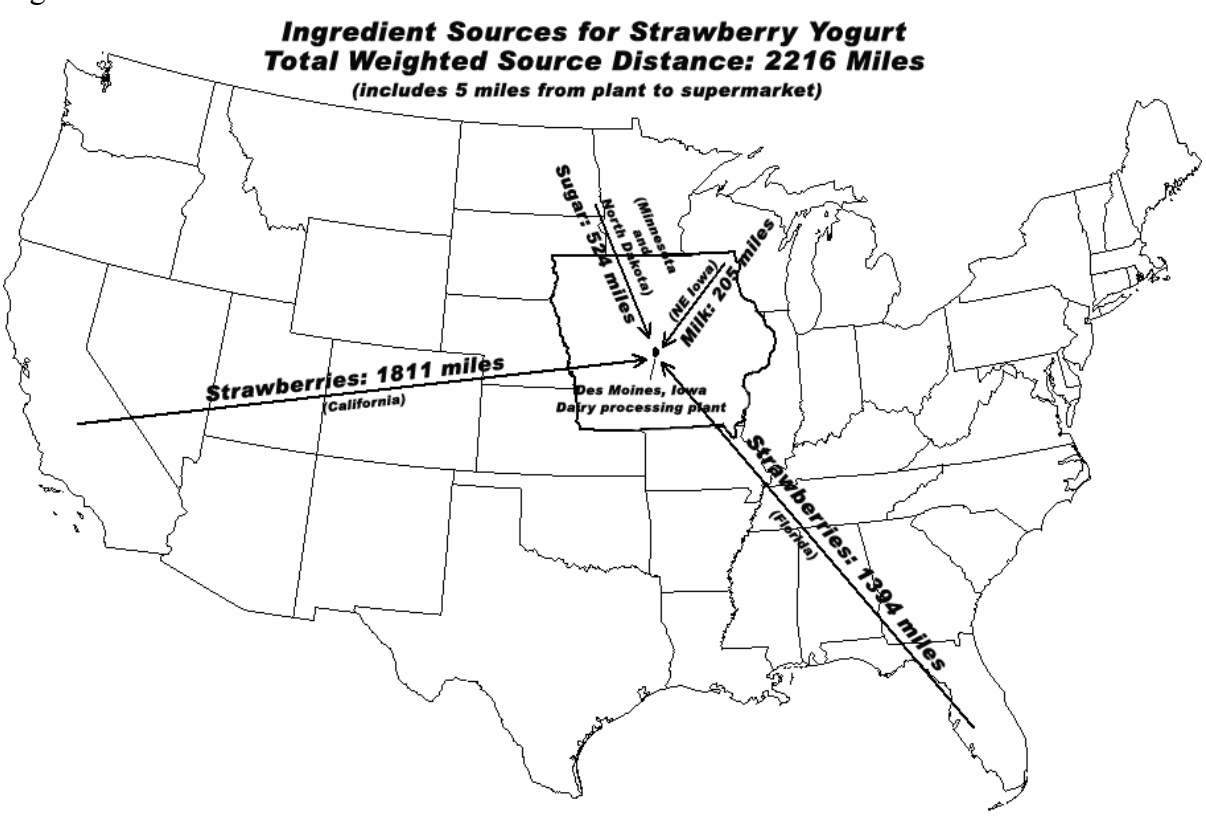
We can add this distance directly to the WTSD:

[17] The sugar beet root is 77.6 percent water, 17.3 percent sugar, 4.4 percent fiber, and 0.7 percent ash. Information found at http://www.smbsc.com/AboutSMBSC/Sugarbeet.htm

$WTSD_{Store}$ = (2211 + 5) miles or 2,216 miles – ounce per container

All of these calculations assume the consumer resides in Des Moines. The source distances for our example are shown on the map in Figure 2.

Figure 2.



<u>Step 7</u> – Calculate the WASD to determine how far – on average – the ingredients traveled

To calculate the distance each ounce of ingredient travels on average (WASD), the total source distance is divided by the number of ounces in a container. This is the weighted average distance the ingredients travel to the processing plant. Since the majority of the product is comprised of milk (93 percent), the WASD will more closely reflect the distance milk travels compared to the other ingredients.

$WASD_{Dairy\ plant}$ = 2211 miles traveled - oz/ 8 oz = 276.4 miles traveled per ingredient

$WASD_{Store}$ = 2216 miles traveled –oz / 8 oz = 277 miles traveled

Conclusions

The weighted total source distance for the ingredients used to make strawberry yogurt and the weighted average distance ingredients in the yogurt travel can be calculated using simple mathematical formulas. Assumptions were made to use only those ingredients that made up 1

percent of more of the total weight of the product, and to use the primary sources for each ingredient considered. The source distances of the yogurt container, lid, seal and shipping box were not considered in the calculations. Both the weighted total source distance and the weighted average source distance should be calculated to give the reader and user of the information a more accurate picture of

- how far all the ingredients traveled (WTSD), and
- how far – on average – did the ingredients travel (WASD).

The final WTSD of 2,216 miles provides a glimpse at how far-ranging our sourcing of ingredients for multiple ingredient food products can be. It should be noted that the WTSD for strawberry yogurt does not represent the average distance that these ingredients travel to make yogurt that is found under various brands in stores across the United States. WTSD values are specific to the source locations and assumptions used to make the calculations. Compared to our Iowa calculations the WTSD in strawberry yogurt likely will be lower or higher in other states.

The typical consumer's retail food purchases include a significant number of multiple ingredient food products, from frozen dinners and pizzas to prepared and ready-to-eat soups, cakes, pies, and cookies. In order for food systems researchers and local food practitioners to use food miles more effectively as a metaphor to contrast local and national/global food systems, food mile values need to be calculated for multiple ingredient food products. This paper provides the details for one such calculation. The values cited here are based on a set of assumptions and are, at best, approximations. Even so, the authors encourage local food practitioners to be as precise as possible in calculating food miles for multiple ingredient food products. The following guidelines are suggested when calculating food miles for multiple ingredient products:

- Check with one or more of the food processors making the product as to the primary sources of the ingredients. It may be necessary – because of a lack of adequate information – to omit from your calculations minor ingredients that make up less than 1 percent of the product by weight.
- Be prepared to investigate and document the sources where other processing steps occurred after the product left the farm. This was the case for sugar (which came from sugar beets) in our example. Another common example is corn syrup used in baked goods or breakfast cereal. Clearly the corn will come from farms, but corn is processed into corn syrup at a location other than the farm and then shipped to the bakery or cereal-making plant.
- Use weighted averages when a primary ingredient comes from multiple sources. It may be simpler to pick one source for an ingredient, but if the ingredient clearly comes from several sources (as indicated on the label or by the food processor), it will be more accurate to include a weighted distance that considers all primary sources.
- For truck-based transport, use road routes rather than "as the crow flies" distances to make your calculations.
- Express your results as how far all the ingredients traveled (WTSD), and how far – on average – did the ingredients travel (WASD).