Crude Oil and Vinegar: The Energy Consumption Behind Your Salad

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Introduction

This study examines the total energy consumed in the process of producing and transporting produce from "farm to table." Estimates indicate that in 2002, the U.S. food system alone accounted for 17 percent of all hydrocarbon fuel use in the country and 14.4 percent of all energy consumed.[1,2] In 2007, the U.S. food system accounted for a total 15.7 percent of national energy consumption.[3] The aim of this study is to illuminate where and when energy is consumed within this system. From this information, we can draw meaningful conclusions about what aspects of this system are wasteful, efficient, and what can be changed and what cannot. Since the majority of food in the U.S. is produced in the industrial agricultural system, I will compare this system with the energy expenditures in the local organic sector.

It is estimated that the U.S. food system "consumes ten times more energy than it produces in food energy."[4] This study examines the validity of this claim using Head (Iceberg) lettuce and fresh, red ripe tomatoes as example cases. Lettuce and tomatoes are among the top five most consumed vegetables nationally, and together comprise the basic American salad.[5] These foods are likely inextricably tied to the food system's addiction to crude oil, because they are so widely consumed.

Agrochemicals 30.8 kcal + **Farm Machinery** 74 kcal + **Irrigation** 4.3 kcal + **Transportation** 137 kcal =

= 246.1 kcal per serving to produce

Agrochemicals 15.3 kcal + **Farm Machinery** 37.4 kcal + **Irrigation** 2.2 kcal + **Transportation** 82 kcal =

= 136.9 kcal per serving to produce

Methods

To calculate the energy consumed to produce the basic components of salad, each major energy input was analyzed separately. Identifying each energy input provides both an accurate estimate of total energy consumed, as well as facilitates the identification of wasteful and efficient practices within the food system.

For each major energy input, the amount of energy consumed was calculated per standard serving of vegetables, as specified by the Nutrition Labeling and Education Act.[6]

Metabolic Energy: NLEA Serving of Head (Iceberg) Lettuce

Weight	89 g
Energy	12 kcal

Metabolic Energy: NLEA Serving of Fresh, Red Ripe Tomatoes

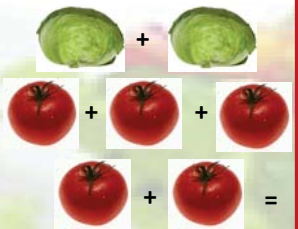
Weight	148 g
Energy	27 kcal

Irrigation

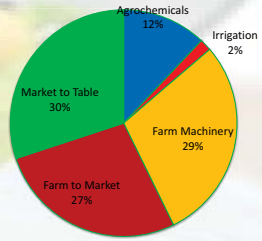
The majority of crops are irrigated using electric or diesel fuel-powered pumps. The method used and need for irrigation varies widely, especially in a geographically diverse state such as the U.S. Therefore I will use a rough estimate of energy consumed per irrigated acre. Energy consumption per acre ranges from about 300000 kcal to 500000 kcal per acre, so we will consider 400000 kcal to be consumed per acre of irrigated crops.[12]

$$\frac{400000\,\text{kcal}}{1\,\text{acre}} \text{x} \frac{1\,\text{acre}}{30600\,\text{lb}} = \frac{13.1\,\text{kcal}}{1\,\text{lb}} = \frac{4.3\,\text{kcal}}{\text{serving of tomatoes}}$$

$$\frac{400000\,\text{kcal}}{1\,\text{acre}} \text{x} \frac{1\,\text{acre}}{36500\,\text{lb}} = \frac{11\,\text{kcal}}{1\,\text{lb}} = \frac{2.2\,\text{kcal}}{\text{serving of lettuce}}$$



383 kcal = the energy consumed to produce just a salad containing these foods (39 kcal)



Energy Expended to Produce a Salad

Agrochemicals

The production, packaging, and transportation of fertilizers and pesticides are indirect sinks of energy in the food system, while the application of agrochemicals is a direct result of farming practices. Fertilizers and pesticides range in the amount of energy required to produce them, as well as how much is applied to each crop.[7,8,9]

Average Amount of Agricultural Chemicals Applied

	Tomatoes	**Lettuce**
Pesticides	lb/acre	lb/acre
Herbicides	0.5	1.9
Insecticides	3.9	0.4
Fungicides	22	1.1
Fertilizers		
Nitrogen	216	258
Phosphate	132	227
Potash	286	47

Energy Input via Agrochemicals per Serving

	Tomatoes	**Lettuce**
Pesticides	kcal	kcal
Herbicides	0.159	0.338
Insecticides	1.293	0.076
Fungicides	4.763	0.134
Fertilizers		
Nitrogen	17.955	11.985
Phosphate	2.457	2.359
Potash	4.196	0.383
Total	30.823	15.275

Farm Machinery

The energy required to operate farm machinery throughout the growing season is about 6,948,000 kcal per acre, which is primarily consumed by diesel and gasoline combustion engines.[10,11]

$$\frac{6948000\,\text{kcal}}{1\,\text{acre}} \text{x} \frac{1\,\text{acre}}{30600\,\text{lb}} = \frac{227\,\text{kcal}}{1\,\text{lb}} = \frac{74\,\text{kcal}}{\text{serving of tomatoes}}$$

$$\frac{6948000\,\text{kcal}}{1\,\text{acre}} \text{x} \frac{1\,\text{acre}}{36500\,\text{lb}} = \frac{190.4\,\text{kcal}}{1\,\text{lb}} = \frac{37.4\,\text{kcal}}{\text{serving of lettuce}}$$

Transportation

Farm to Market*:* Average distance to market = 1300 to 1800 miles[13]
The overwhelming majority of lettuce crops are transported via diesel-powered trucks capable of transporting 38000 lb of produce in one load.[14]

$$\text{Avg. }1500\,\text{miles x} \frac{1\,\text{gallon}}{6.1\,\text{miles}} = \frac{213\,\text{gallons of diesel}}{1\,\text{load}} = \frac{7519542\,\text{kcal}}{38000\,\text{lb}} = \frac{198\,\text{kcal}}{1\,\text{lb}}$$

$$= \frac{65\,\text{kcal}}{\text{serving of tomatoes}} \qquad = \frac{39\,\text{kcal}}{\text{serving of lettuce}}$$

Market to Plate: The average round trip to supermarket is about 5 miles total, while the average auto fuel economy is 21.5 miles per gallon.[15]

$$\text{Avg. }5\,\text{miles x} \frac{1\,\text{gallon}}{21.5\,\text{miles}} = \frac{.23\,\text{gallons}}{\text{trip}} = \frac{6691\,\text{kcal}}{\text{trip}}$$

Approximately 13.7 kg of food are transported from the grocery store on each trip.[16]

$$\frac{6691\,\text{kcal}}{\text{Avg. }13.7\,\text{kg}} \text{x} \frac{\text{serving of lettuce}}{89\,\text{g}} = \frac{43\,\text{kcal}}{\text{serving of lettuce}}$$

$$\frac{6691\,\text{kcal}}{\text{Avg. }13.7\,\text{kg}} \text{x} \frac{\text{serving of tomatoes}}{148\,\text{g}} = \frac{72\,\text{kcal}}{\text{serving of tomatoes}}$$

Discussion and Policy Recommendations

The food production system of tomatoes and lettuce by conventional methods consumes a significant amount of energy. The food system consumes approximately 9 times as much energy as it produces in metabolic energy from tomatoes, and approximately 11 times as much energy as it produces in metabolic energy from head lettuce. The energy consumed to produce just a serving of tomatoes and a serving of lettuce to make a salad is equivalent to the metabolic energy contained in two whole heads of lettuce and five large tomatoes.[17] Most of this consumption takes place during the transportation of produce and the use of mechanized equipment on farms.

Greater sourcing of produce from local and organic sources can possibly mitigate these consumption patterns. However, since lettuce and tomatoes grow seasonally, producing these foods off-season in heated greenhouses locally consumes even more energy than that expended via transportation.[18] Head lettuce is especially low in nutrition content, and as such, perhaps is not worth the costs of production and emissions during the off-season.[19] Local is not necessarily always more fuel-efficient, but seasonal and local is.

One interesting finding is that more energy is consumed by weight during a 5-mile round trip to the grocery store than is consumed in the average 1500 mile trip from farms to markets. Americans on average travel to the grocery store 3 times a week.[20] Fewer trips to the store, and buying more foods in a single trip would significantly decrease consumption levels on the part of consumers.

Conclusion

This case study of energy consumption in the conventional U.S. food system reveals considerable opportunities to curb energy consumption, and therefore greenhouse gas and particulate emissions. The American people's addiction to lettuce and tomatoes is deeply related to the country's addiction to crude oil. Energy sourcing from alternative fuels as well as efficiency measures such as decreasing the distance between the farmer and consumer are good ways to mitigate this issue. This study illuminates the fact that though industrialization facilitates the production of a large amount of food for a large population, future policy decisions and consumer choices should consider the quality of foods produced and possible wasteful practices behind their production.

References

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