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Managing The Energy Cost of Food[1]

H. J. Whiffen and L. B. Bobroff[2]

INTRODUCTION

Food is important. All living things need energy. Humans, like other animals, get their energy from the food they eat. Energy is necessary to make the food that gives us energy. Fossil fuel energy inputs are used in every step of domestic crop production and food preparation, from seed to supper:

- to plant, irrigate, fertilize and protect the growing crop from pests,
- to harvest and transport raw foods to a processing facility,
- to store (warehouse), clean, cook, mix, process, preserve and package the food,
- to transport the retail product to the grocery store shelf,
- to keep foods fresh when on display in a brightly lit store, perhaps chilled or frozen, awaiting purchase,
- to prepare and serve the food for consumption at home or in a restaurant,
- to dispose of or utilize food waste in a safe, environmentally sound manner.

Getting food to the table, i. e., the food system, accounts for approximately 17% of the 81,300 trillion **Btu** of energy consumed annually in the United States (Table 1). Approximately 18% of this energy is consumed for on-farm food production; 82% is spent on food processing, transportation, marketing and preparation.

Much of the energy used in the U. S. food system comes from fossil fuels like coal, petroleum and natural gas. These are non-renewable energy resources that were formed millions of years ago through long-term geologic processes. The current human population of Earth is consuming fossil fuels 100,000 times faster than they can be produced.

The combustion of these fossil fuels produces environmental pollutants and greenhouse gases. Greenhouse gases influence the temperature of Earth's atmosphere; increased quantities of greenhouse gases might increase these temperatures and affect the stability of our environment. (For more information, see EES-72, Global Climate Change Primer.) Some of the environmental pollutants produced by burning fossil fuels are sulfur dioxide, carbon monoxide and nitrogen dioxide. In addition

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2. H. J. Whiffen, Agricultural Energy Specialist, Energy Extension Service, Agricultural Engineering Department; L. B. Bobroff, Associate Professor, Home Economics Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville Fl 32611.

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to the other environmental concerns related to the production of these pollutants, they can negatively affect the human body's ability to breathe and utilize oxygen. The atmospheric concentrations of these pollutants are already above safe health standards in some places in the United States.

Table 1. Energy consumed in the U.S. food system.

Activity	Percent[1]	Energy Used (Btu)[2]
On-farm Production	3.0%	2,400 trillon
Processing	5.4%	4,400 trillon
Transportation	0.5%	410 trillon
Wholesale/retail	2.6%	2,100 trillon
Preparation at home or restaurant	5%	4,000 trillon
Total	16.5%	13,500 trillon

1. Source: Dowling, 1991.
2. Based on 1991 U.S. energy consumption data from the Energy Information Administration, 1992.

Table 2. Recommended energy intake for people of average height, weight and activity.

Population	Age (years)	Energy Needs (kilocalories)
Children	1 - 3	900 - 1800
Children	4 - 6	1300 - 2300
Children	7- 10	1650 - 3300
Females	11 - 14	1500 - 3000
Females	15 - 18	1500 - 3000
Females	19 - 24	1800 - 2600
Females	25 - 50	1800 - 2600
Females	51+	1500 - 2300
Males	11 - 14	2000 - 3700
Males	15 - 18	2100 - 3900
Males	19 - 24	2100 - 3900
Males	25 - 50	2500 - 3300
Males	51+	1900 - 2700

Source: Food and Nutrition Board, 1989.

This publication provides information on how to shop for and prepare meals that are nutritionally well balanced and energy efficient. A well-planned diet can contribute to long term health and a healthier global environment.

ENERGY FROM THE FOOD WE EAT

Plants store the energy they receive from sunshine in leaves, stem, branches, roots and fruit, through a process called **photosynthesis**. The energy in plants and the animals that consume these plants, is stored as chemical energy, mainly as carbohydrates, fats, oils and proteins. This food energy is measured in **kilocalories**. Fats and oils have, on average, 9 kilocalories per gram (16,400 Btu per lb); starches and proteins have about 4 kilocalories per gram (7,270 Btu per lb). According to the 1989 Recommended Dietary Allowances, an average 25-50 year old female should eat 1,800-2,600 kilocalories of fuel a day. An average male in the same age category requires 32% more kilocalories a day (Table 2). A person's actual energy needs depend upon his/her daily activities, weight and age.

ENERGY USED TO PROCESS THE FOOD WE EAT

Nearly two-thirds of the foods we consume have been processed in some way. Food is processed to make it edible and/or to preserve it for safe use in the future. More than 64% of the energy used to process foods comes from fossil fuels (Table 3).

Sometimes food processing increases the nutrient value of foods. Most legumes contain a number of toxins and substances that inhibit digestive enzymes. Destruction of these toxins and inhibitors by food processors increases the nutritional value of the proteins in legumes.

On the other hand, food processing often decreases the nutrient value of foods. Cooked spinach prepared from a frozen package stored for six months has 50% less **vitamin C** and 67% less **thiamin** than cooked spinach prepared from fresh spinach leaves. **Riboflavin** losses in cooked, frozen peas are twice as high as those cooked fresh. During canning, tomato juice can lose up to 17% of the **niacin** and

40% of the **carotene** found originally in the fresh tomatoes (Table 4).

Table 3. Energy resources used in the U.S. food industry.

Energy sources		%
Electricity from[1] fossil fuels	Coal	6.3%
	Natural Gas	1.2%
	Petroleum	0.3%
	Total	7.8%
Electricity from other energy resources[2]		3.2%
Natural Gas[2]		45%
Petroleum[2]		11%
Other (e.g., coal, bagasse)[2]		33%
1. Based on 1992 U.S. energy consumption data from the Energy Information Administration, 1992.		
2. Source: 1990 projections from Singh, 1986.		

Table 4. Nutrient losses from tomato juice during canning.

Nutrients	Percentage lost
Vitamin C	10 - 65%
Thiamin	0 - 27%
Riboflavin	0 - 14%
Niacin	0 - 17%
Carotene	25 - 40%
Source: Bender, 1978.	

Producing corn on the farm or in a garden uses only about 15% of the total energy used to produce, process, market and cook a 16-oz can of sweet corn. The same quantity of frozen corn requires 26% more energy if stored either at the store or in the home freezer for six months (Table 5). It takes more energy to make the can than the package paper for the frozen corn, but frozen foods take more process and distribution energy than canned goods.

When seasonally available, fresh foods are typically the energy efficient and nutritional choice. They frequently have higher nutritional values because they are not precooked, and less fossil fuel energy is invested in them since they are not processed or packaged.

Table 5. Energy inputs for canning and freezing sweet corn.

Energy inputs	16 - oz can of corn (Btu)	16 ounces of frozen corn (Btu)
Home preparation	1,800	1,800
Shopping	1,200	1,200
Distribution: wholesale & retail	1,400	2,900
Transport	630	720
Packaging	4,000	2,700
Processing	1,000	3,800
Production	1,800	1,800
Total	11,830	14,920
Adapted from Pimentel, 1984.		

ENERGY USED TO TRANSPORT THE FOOD WE EAT

Buying locally-produced food saves energy. On the average, 1.5 Btu of energy are used to move one pound one mile. Using this average figure, 4,050 Btu of energy are used to move one head of lettuce, at one pound per head, the 2,700 miles from Los Angeles, California, to Miami, Florida; 980 Btu of energy are used to transport the same produce the 650 miles from Pensacola to Miami, Florida. That is an energy savings of 76%.

Buying food produced locally can improve the nutrient value of the produce eatten in two ways. To facilitate shipping, some commodities such as tomatoes are picked when they are still green. Tomatoes picked before they are mature have 30% less vitamin C when eaten than those harvested when they are ripe. Tomatoes purchased from a local grower can be picked when they are ripe because they don't need to be shipped.

Second, foods generally are at their nutritional peak at the time of harvest. Produce that sits at room temperature after picking loses nutrients. The sooner the lettuce and cucumbers get from the producer's field to the consumer's refrigerator, the higher the nutrient value retention. Transportation takes time; locally grown produce is often fresher.

Table 6. Direct energy inputs into the U.S. food system by consumers.

Activity	Percentage
Consumer shopping	1.9%
Food preparation and cooking	4.8%
Garbage and sewage disposal	0.3%
Total	7.0%
Adapted from Green, 1978.	

Food commodities produced near to where you live are typically the energy efficient and nutritional choice; less energy is invested in transportation and nutrient retention is higher. Therefore, such foods represent an energy efficient choice when seasonably available.

ENERGY USED TO PREPARE THE FOODS WE EAT

Shopping

The consumer has personal control over approximately seven percent of the total quantity of fossil fuels used in the U. S. food system (Table 6). That's an average energy expenditure of 23 million Btu per person per year invested in grocery shopping and cooking. Use of private cars for grocery shopping consumes 12 billion gallons of gasoline and emits 131 million tons of carbon dioxide, 734,000 tons of sulfur dioxide and 22.5 million tons of carbon monoxide every year.

Consumers can reduce the energy investment in the U.S. food system by reducing the amount of unnecessary packaging they purchase in stores or restaurants and selecting products packaged in recycled materials. For example, more energy is used to make the plastic pouch for two crackers than is used to make the crackers. Approximately 7,000 Btu of energy are required to make an aluminum soda can from "raw" materials; approximately 2,500 Btu of energy are required to make the same can from recycled aluminum (Table 7). (For more information, see EES-77: Waste Prevention Saves Energy; and EES-73: Enviroshopping Energy Considerations.)

Table 7. Energy used to make packaging.

Type	From "raw" materials (Btu/pound)	From recycled materials (Btu/pound)
Aluminum[1]	200,000	71,000
Glass[2]	7,700 (15% cullet)	6,500 (100% cullet)
Plastic (HDPE)[2]	36,500	2,300
Packaging Paper[2]	24,000	22,000
1. World Resources Institute. 1992. The 1992 Information Please Enviromental Almanac. Houghton Mifflin Company, New York, N.Y. 10003		
2. Office of Technology Assessment. 1989. Facing America's Trash: What Next for Municipal Solid Waste. OTA-0-424.		

Preparing Food

Vitamin C, thiamin and riboflavin are water-soluble vitamins: they leach out of produce as it is washed. The longer the soak and the hotter the water, the faster the nutrient loss and the greater the energy investment in pumping and heating water. Wash produce thoroughly but quickly in cold water to save nutrients and energy.

Some of the nutrients in fruits and vegetables are concentrated in the outer leaves or layers. For example, the outer green leaves on a head of cabbage have 90 mg of vitamin C per 100 grams of cabbage while the white leaves inside have 45 mg of vitamin C per 100 grams. The peel on a pear has twice as much vitamin C as the fruit's flesh and is an excellent source of dietary fiber as are the edible outer layers of many horticultural products. Don't throw away the outer layers of produce. Reducing the quantity of waste generated during food preparation can save nutrients and energy and decrease the home's weekly contribution to the landfill.

Cooking

Cooking is the most energy intensive step in food preparation, and overcooking is the greatest nutrient thief. Overcooking food can cause vitamin losses of up to 100%. Vegetables are most nutritious and also the most palatable if they are cooked to the just-crisp point.

In general, gas stoves with electric ignition are more energy efficient and, therefore, less expensive to operate, than electric stoves. A typical electric stove puts 20 Btu of heat energy into the food for every 100 Btu of **primary** energy consumed at the power plant (20% efficient); gas stoves are 33% efficient.

Electric induction ranges use an alternating positive and negative charge to heat magnetic pots and pans. Most of the heat energy is absorbed by these pots and pans instead of the range itself; induction ranges are more energy efficient than regular electric ranges but not as energy efficient as microwave ovens.

Microwaves transfer energy directly to water and fat molecules in foods. These molecules absorb the energy and produce heat. Most of the heat energy ends up in the food instead of the microwave oven or the cooking dish. When cooking small amounts of food, microwave ovens can reduce cooking energy use by one-half.

Microwave ovens save nutrients, too, because the shorter cooking time is less destructive of nutrients. Cooking cabbage on a conventional range can result in the loss of 75% of the vitamin C; cooking rapidly in a pressure cooker, 50%; microwave cooking, only 10%.

Disposal

In the United States 5-10% of the edible food purchased in a grocery store is thrown away. This disposal wastes the energy used to grow, process, package and transport the food and the energy used to dispose of the garbage. Approximately 1,500 trillion Btu of energy are wasted in this manner every year in the United States.

Recycling is an energy efficient waste disposal option. Compost your organic wastes and use the compost to supply your landscape plants and garden vegetables with the nutrients and soil organic matter they need. Participate in a recycling program for your aluminum, steel, glass, plastic and paper packaging materials. (For more information, see CIR-958: *Backyard Composting of Yard Waste*; AE-27: *Converting Yard and Kitchen Waste into Compost*; EES-73: *Enviroshopping Energy Considerations*.)

Energy Efficient Food Tips

- Think "environment" when making purchasing decisions.
- Choose fresh foods grown locally whenever possible.
- Minimize the number of times you drive to the store by making a list of what you need during the week.
- Match the burner and the pan size to the quantity of food to be cooked.
- The flame on a gas stove should be blue; a yellow flame indicates that there is not enough air for energy efficient combustion.
- Consider purchasing a gas oven with an electric ignition the next time you go shopping for a new stove.
- Use the self-cleaning feature on an oven right after baking or broiling to use the heat already built-up in the oven.
- Avoid ceramic top electric resistance ranges; they are generally less energy efficient than ranges with the resistance elements exposed.
- Pre-heat an oven for only 5-8 minutes.
- Open the oven door while cooking as few times as possible. The air temperature drops 25-50°F every time the door is opened.
- Defrost foods in the refrigerator before you begin to prepare them. Frozen foods need more energy to cook than completely thawed foods. A defrosted roast requires 33% less cooking time than one that is still frozen.
- Use as little liquid as possible when cooking to conserve both energy and nutrients.
- Save the juices that cook out of foods and use them to make soups. Food juices frequently

contain a great deal of the nutrients that were originally in the food when it was fresh.

- Cut foods into small pieces to decrease cooking time.

- Maximize surface area to heat source, minimize depth and cook for as short a time as possible to conserve food nutrients. The greatest losses of vitamin C and thiamin take place when food is kept hot.

- When shopping for kitchen appliances, look for and compare the energy efficient ratings on the EnergyGuide stickers. Energy efficient appliances save money, on a long term basis, because the electric bill for operating the appliance is less.

GLOSSARY

Btu: British thermal unit; approximately the energy in one burning wooden match.

Cullet: Recycled glass.

Kilocalories: A unit used to measure the energy in food; 1 kcal. = 4 Btu; there are approximately 40 kcal. in one tablespoon of sugar.

Milligram: 0.001 grams; 0.0000022 lbs.

Niacin: Vitamin B_3; water soluble; part of a coenzyme vital to obtaining energy from glucose; prevents pellagra.

Photosynthesis: A chemical reaction occurring in green plants that makes carbohydrates from carbon dioxide and water, using the sun's energy to power the reaction.

Primary energy: energy available from conversion of the original fuel, such as petroleum or natural gas, rather than from a secondary form, such as electricity.

Riboflavin: Vitamin B_2; water soluble; helps transfer energy from one compound to another.

Thiamin: Vitamin B_1; water soluble; prevents beriberi; helps release energy from food.

Vitamin C: Ascorbic acid; required for the production and maintenance of collagen, a protein substance that forms the base for all connective tissues.

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