A SOCIO-DEMOGRAPHIC ANALYSIS OF THE ENERGY INTENSIVENESS OF FOOD CONSUMED WITH IMPLICATIONS FOR NATIONAL ENERGY CONSERVATION

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ABSTRACT

A SOCIO-DEMOGRAPHIC ANALYSIS OF THE ENERGY INTENSIVENESS OF FOOD CONSUMED WITH IMPLICATIONS FOR NATIONAL ENERGY CONSERVATION

By

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The purpose of this study was to examine the relationship between food consumption choices and their associated energy costs to isolate implications for national energy conservation.

In order to identify the energy intensiveness of individual diets it was necessary to develop a methodology for determining the energy cost per pound and per serving of individual food items. Data on the fossil fuel expended from agricultural processes to the point of consumer purchase at the supermarket was obtained from a variety of sources for the agricultural, transport, processing and retailing sectors and combined to form estimates of the energy cost of different foods.

The food consumption data used came from a larger interdisciplinary field study entitled, "Functioning of the Family Ecosystem in a World of Changing Energy

Availability," funded by the Michigan Agricultural Experiment Station. A subsample of 85 individuals was selected from this field study. Each individual's food consumption choices and the amount consumed for a twenty-four hour span of time was recorded by the individual on a food recall sheet. The estimates of energy cost per serving were then used to calculate the total energy cost of food consumed by each individual over the twenty-four hour time span.

It was hypothesized that the energy intensiveness of individual diets would vary with family income, occupation of the head, education and working status of the wife and urban or rural residence. Individuals were grouped according to appropriate levels of these variables. A one way analysis of variance was used to test for differences in group means.

Without exception, the data did not support any hypothesized differences between groups. The finding of no difference between groups in all hypothesized situations suggests that there is no one group toward which to direct national energy conservation efforts via shifts in food consumption. Rather, all consumers must be informed of the impact of their food choices on energy consumption and given information with which to make rational decisions in the marketplace.

Cheryl Lynn Holmes

The impact of the energy costs of different foods varies greatly with the standard of comparison employed. To analyze energy cost of food consumption choices of individuals in the study the energy cost of food per pound and per serving were employed. Also determined and included is an analysis of the energy cost of food per gram of protein and kilocalories fossil energy expended to food energy received. With each type of analysis food energy implications for national energy conservation change. For the average consumer the energy cost per pound or per serving is the most useful information. For the food professional the other methodologies may be more applicable.

This study did not calculate food shopping, home storage and food preparation energy costs. Therefore, there is room for much further study of the energy cost of food.

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CHAPTER I

INTRODUCTION

The American consumer's food consumption patterns have changed from relatively low energy intensive to high energy intensive food choices. From 1950 to 1971 the per capita consumption of beef increased 36.9%; poultry increased 65.6%; fats and oils increased 12%; canned fruits did not change. Frozen fruits increased 57.9%; canned vegetables 17.8%; frozen vegetables 65%; frozen potato products 67.1%. Eggs decreased 23.8%; fresh potatoes increased 11%; whole wheat flour decreased 22.7%; fresh vegetables 15.5%; fresh fruits decreased 34%; and fluid milk decreased 18.1%. Most of the foods with large increases in per capita consumption require more processing before being eaten than the foods with decreased consumption. (For a more complete breakdown see Appendixes A and B.)

Individual food consumption choices in the United States are many and complicated. If consumer wants and their individual efforts to satisfy these wants are to become energy economizing, i.e. "getting goods to satisfy wants with the most frugal use of resources," consumers must gain a better understanding of the implicit costs of their want and need fulfillment (Fitzsimmons, 1972). The average American consumes 3,300 calories daily; this amount, however, represents 12,000 calories of input (Borgstrom, 1974). At a rate of conversion of approximately 1:3, the fixed supply of energy resources will be inadequate to meet consumer needs as currently expressed. Environmental constraints are creating the need for the population to adapt its high energy cost food choices toward those of lower energy cost.

Statement of the Problem

The purpose of this study is to examine the relationship between food consumption choices and their associated energy costs to isolate implications for national conservation efforts. To determine the associated energy costs of food consumed it is necessary to develop a methodology for determining fossil fuel expended from agricultural processes to the point of consumer purchase from the supermarket. This study will not pursue the fossil fuel energy cost of food storage in the home and meal preparation, nor will it differentiate energy cost intensity between meals consumed in the home and those eaten outside the home.

This study examines the relationship of sociodemographic characteristics to food consumption choices and their associated energy costs. Cain discusses the issue of the energy cost of present consumer food choices. He states:

> We are at a point of no return in the food industry. To provide our people with their present needs and desires the food industry is forced to compete with ever growing energy demands of the rest of society against a limited supply of fossil fuels. Since most of us want to continue eating, the food industry has been given, and probably will be given, priority in getting its food needs satisfied (1973, p. 9).

Udall also emphasizes the need for decreased energy intensive food choices. He states:

> With the increase in high energy intensive food consumption and the possibility of an inadequate supply of fixed resources available to meet consumer needs, it appears valid that the only reasonable course for the United States is to admit it is in trouble in terms of energy consumption and begin a transition to a lifestyle and an economy which emphasizes thrift (1971, p. 76).

The socio-demographic variables to be studied as they relate to food consumption patterns include income level, educational status, employment status of the wife, occupational position and prestige, presence and age of children, race, and urban or rural residence. Research is not presently available concerning energy intensiveness of food consumption as related to these variables. Information is available, however, concerning the relationship of some socio-demographic variables to actual food consumption choices made. Therefore, the review of literature will be based on the relationship of food consumption practices to the various socio-demographic variables.

This study of the relationship between socio-demographic characteristics and energy cost of food consumed is important for society as a whole, the family unit, and for the individual consumer. Energy waste is described by Udall as this generation's great scandal which has brought us to the edge of a crisis that will soon force us either to husband our resources or witness a serious disruption of our whole societal system (1971). The knowledge of the implicit costs of high energy food consumption of various lifestyles can assist the individual in making rational choices in the marketplace, which will then affect society as a whole, the family unit, and the individual consumer.

Food Consumption

The consumption of food may be regarded as a system of behavior involving the selection, acquisition, preparation, and evaluation of food and meals by a family. It is influenced by, and in turn affects, other activities of the family and other people. Although the need for food is largely the result of individual bio-physiological processes, the individual and the family are involved in the processes by which decisions are made as to the foods to be obtained (Coughenour, 1972). It should be possible to identify food consumption goals, specify activities which have the function of attaining the goals and strengthening the family system as a whole. Coughenour states:

> Maintenance of a pattern of food consumption can be viewed as related to the ability of the family system to solve different functional problems involved in the acquisition and allocation of necessary inputs and their processing into desired outputs, i.e. food for consumption (1972, p. 652).

To isolate implications for national energy conservation it is necessary to determine which socio-demographic variables, if any, are associated with consumption of the highest energy intensive foods. Margaret Mead noted:

> Food habits may simply be a carry over from a situation of relative scarcity to one of plenty and to the development of food vending methods which continually expose people to an extreme amount and variety of foods (1964, pp. 24-25).

Learning is very important to developing the complex of particular sets and attitudes that determine what foods are selected and when and how they are eaten. Peryam states:

> One does not change food habits in general, one achieves a change of behavior toward a particular item or group of items, in a particular direction, in a particular situation (1963, p. 717).

Niehof also noted:

> Perception of the individuals of the advantages to be gained from change is the key to the adoption of changes (1969, p. 11).

Attempts to change attitudes about a given food must be directed to goals which are important to the individual or group. When these goals are known, an individual can be convinced that what he eats may affect his achievement of these goals (Dean, 1968).

Family food consumption studies have traditionally used the homemaker as the sole source of information. However, the homemaker has no way of knowing exactly what each family member consumes away from home. Therefore, more reliable data might be collected if each member of the family contributes information about his away from home food consumption patterns. For this reason the analysis of food consumed in this study will consist of food recall sheets recorded individually by the husband, wife, and one child over 12 years of age where present in the sampled families.

Fossil Energy Cost of Food

The development of the methodology for determining the fossil fuel energy cost of food through agricultural production, processing, transportation, wholesaling, retailing, and in-store costs is critical in that the author knows of no comparable method of calculating the energy intensiveness of specific individual diets. Data have been computed on the energy costs of a few selected food items for a particular state as in the paper, "Energy Requirements for Wheat Production and Use in California" (Avlani, 1975). Also, data have been compiled on specific segments of agriculture, processing, transportation, and retailing. The Lifestyle Index is one of the most complete guides currently available, but the food sector's energy costs are computed on a per capita basis for America and represent average annual levels of consumption for each item consumer (Fritsch, 1974). Often these are based on a calculation of a household of four family members. It does not give the cost per pound nor gram of each food item so that one can calculate actual personal consumption. Rather, one must estimate based on an average computation without knowledge of how much actual weight of food consumed this number represents.

The merit of developing a methodology is the compilation of the available fragments of energy cost data by stage of development and forming, as precisely as present data permit, a framework for determining the energy cost of food per gram equivalent consumed. This framework allows one to make judgments concerning the energy cost of food choices made in terms of the energy cost per pound of product, the energy cost per gram protein, and the ratio of kilocalories of energy expended to produce the product to the kilocalories of energy received from the product. One can then compare foods to one another, in food category groups and in general, to examine energy costs of foods of similar and nonsimilar nutritive value. Given this information, the individual can examine energy implications of food preferences to consider the impacts of dietary choices on energy conservation. Paolucci expands the idea of the individual's role in energy conservation in this statement:

> Each person is a part of a living, breathing, loving, caring (family) system, but one that's inextricably tied to the natural environment and (those) finite resources. . . . The family is the place where all our strategies must begin (1976, p. 14).

With knowledge of the energy cost of food it is possible to apply the cost of each food item to a random sample of individuals to discover if socio-demographic variables are related to energy intensiveness of food consumed. These results can be utilized to isolate implications for national energy conservation.

In this study a methodology for determining fossil fuel costs of food per pound consumed was developed. An attempt is then made to discover if socio-demographic variables are related to the energy intensiveness of food consumed, which will then isolate implications for national energy conservation. Specifically, the study examines whether or not level of income, education, employment of wife, occupational status, race, and rural or urban residence are related to the energy intensiveness of food consumed.

Assumptions

1. Respondents will be able to record accurately the food item and amount consumed for a 24-hour span of time.

2. Individuals purchased all their food in stores in a form ready for cooking or consumption and did not grow their food at home nor eat in restaurants.

3. One can combine the computations of the various individuals and governmental reports for different sectors of food production and achieve a reasonable degree of accuracy in developing a methodology for determining energy cost of food.

4. One can classify individuals according to food consumption choices for a 24-hour span of time and make inferences concerning the energy intensiveness of their dietary intake.

5. Transportation energy costs can be estimated according to fossil fuels needed to transport major food category groups.

6. Transportation energy costs for dairy products can be estimated according to the number of pounds of raw milk needed per product when weight is adjusted for multiusage of raw milk.

7. Dairy product energy cost can be estimated according to total pounds of raw milk needed per product, when weight is adjusted for multiusage among products.

8. In-store energy costs are one-half of utility costs.

Objectives

1. To develop a methodology for determining energy cost of food consumed in the U.S. per pound of food consumed.

2. To determine if socio-demographic characteristics are related to the energy intensiveness of food consumed by individuals in the U.S.

3. To isolate implications for national energy conservation efforts.

Hypotheses

Hypothesis I: The energy cost of food consumed will not differ between individuals in families of low, median, and high incomes.

Hypothesis II: The energy costs of food consumed will not differ between individuals in families where the wife's educational attainment is greater than high school completion and those where the wife's educational attainment is high school completion or less.

Hypothesis III: The energy costs of food consumed will not differ between individuals in families where the wives are employed outside the home and those in which they are not.

Hypothesis IV: The energy cost of food consumed will not differ between individuals in families where husbands have white collar occupations and blue collar occupations.

Hypothesis V: The energy costs of food consumed will not differ between individuals in families where wife's race is white and where wife's race is other than white.

Hypothesis VI: The energy cost of food consumed will not differ between individuals in families of urban residence and families of rural residence.

CHAPTER II

REVIEW OF THE LITERATURE

The discussion in this chapter will center on the following points:

1. The development, change, and reason for the study of food habits.
2. The relationship between level of income and food consumption patterns.
3. The relationship between occupational status and food consumption patterns.
4. The relationship between educational status and food consumption patterns.
5. The relationship between employed and non-employed wives, and food consumption patterns.
6. The relationship between race and food consumption patterns.
7. The relationship between rural and urban residence, and food consumption patterns.
8. The relationship of energy needs and food consumption patterns.

To analyze the relationship between food consumption and various socio-demographic characteristics, it is helpful to consider first how food habits are developed, how they can be changed, and even why a study of food habits is of value. This study can also assist in developing greater perspective in isolating implications for public policy recommendations.

Food Habits

Every person has learned what is proper or improper within a cultural system. This learning has been for the most part unconscious and powerful emotions have been generated to support these attitudes. In the same manner people learn what foods are proper and positive emotional feelings, particularly taste, become associated with these foods (Niehof, 1969).

Similarly, Parrish stated:

> There are important differences among societies and subcultures in the pervasiveness of established food habits. Generally, this strength is correlated with other indices of traditionalism: the more slowly social, economic, religious and other changes have taken place the more fixed and persistent will be the food habits (1972, p. 140).

Food habits, once established in an individual person or in a culture, tend to be resistant to change. Change, then, should occur not randomly or capriciously but only when there is reason and motive to make changes (Peryam, 1963). To understand the changes in food patterns we must understand the environment in which food is purchased and consumed. How, when, where, and the form in which it is prepared, served, and consumed are all influenced by other aspects and events in our lives.

Each new condition introduced by changing political organization, new scientific developments, or changes in environment will call for adjustment in the food habits of the population (Ullensvang, 1969).

In the United States food habits have undergone profound change in recent years. Parrish noted:

> The change has been associated with and causally related to increasing urbanization, greater mobility, and altered style and manner of living, all accompanying the diffusion of affluence (1971, p. 140).

Coughenour views maintenance of a food consumption pattern as related to the ability of the family system to solve different functional problems involved in the acquisition and allocation of necessary inputs and their processing into desired outputs which is food for consumption (1972). The purchase and preparation of food for consumption is one of the important, everyday task goals of families, and in this respect consumption may be regarded as a goal-directed social interaction process. To the extent that this is so, family member behavior is organized on a means-end basis, resulting in varying degrees of goal attainment (Coughenour, 1972).

If there is to be a shortage of food or a shrinkage of purchasing power, a knowledge of the people's food habits is essential to make the necessary adjustments to preserve health and strength. Knowledge of the foodways of a society, i.e., the food habits of the members of that society, is a meeting ground for all those attempts to apply modern science to the subject of human nutrition (Mead, 1964).

Variations and changes in food consumption result from a complex interworking of social and economic factors which have varying effects over time (Burk, 1961). Regionality, urbanization, and income are key factors into which merge a wide range of economic and social characteristics or factors which are difficult to study separately. Their net effects may be mirrored in basic food preferences which do not seem to form patterns. Where consumption patterns differ, the economist expects to find major reasons for the differences. These include differences in food supplies, ethnic background of the population, and the family composition of particular groups (Burk, 1961).

Income and Occupational Status and Food Consumption

Rising incomes mean more discretionary spending and greater willingness to spend. Jalso stated:

> People are not going to eat more food because they have more income, but they will spend more for convenience, variety and quality (1965, p. 267).

Economic necessities may become supported by taste preferences. Niehof noted:

> Taste reactions on record indicate that meat, eggs, vegetables and fruits are generally considered the most desirable kinds of foods in the U.S. and Europe.

> The poorer peoples of tropical countries depend much more heavily on starch foods, whether from grains or roots, which is probably the result of economic circumstances (1969, p. 10).

A USDA study in 1965 found in both northern and southern regions of the U.S. that high income households consumed more milk and milk products, meat and poultry, fish, and vegetables and fruits per person than low income households. Low income households used more grain products, sugar, and sweets (1968).

It is realized also that yearly incomes are subject to wide fluctuations for some groups and may not be the basis for expenditures on food. Some households reported incomes that were less than their yearly expenditures for food. Past studies of household food expenditure suggest that the effect of income on expenditures varies among households of different sizes and in different urbanization and regional categories (Hermann, 1967). It was also determined that expenditures of one and two person households for food vary less with income than do those of households of three or more. Although differences in income elasticity of food expenditures between household size categories have been found in previous studies, these differences did not appear to have any clear-cut pattern (Hermann, 1967). On a per person basis, urban families with their smaller average size had food worth more than farm families in every region but the West. Rural nonfarm families were generally between the urban and farm families in both average household size and money value of home food (USDA, 1965).

Income is related to a number of other economic and social factors such as occupation, education, age, race, location, and general situation. These, too, are related to food consumption patterns (Burk, 1961).

To some extent, occupational differences are related directly to food consumption choices, but they are also one of the major elements affecting variations in present and past income. Occupation is tied in with social status and physiological needs; i.e., workers doing heavy manual labor require more high calorie food than do sedentary workers (Burk, 1961). Occupation reflects family food choices, and since most foods are purchased by the contemporary urban family, income partially determines food choices. Occupation also reflects status, and therefore, perhaps differences in values placed on certain foods (USDA, 1961).

Education and Food Consumption

Education and higher standards of living are creating an increasing awareness of cultural niceties in everyday life, all of which affect what people want to eat and when and where they eat (Jalso, 1965). Education of the mother has been found more highly related than income to dietary components (Eppright, 1970). Families at the lowest educational level served dairy products least frequently. The relative frequency of serving dairy products rose with increases in the educational level of the wife. Patterns for serving beef were highest for the intermediate group, falling off at both extremes (USDA, 1961). With increasing education of the mother, the intakes of calcium, iron, thiamine, riboflavin, and ascorbic acid increased significantly. Thus, in general, better educated mothers appear to stress the vitamin and calorie rich foods (Eppright, 1970).

Employment of Wife and Food Consumption

According to Jalso, working mothers are affecting our economy in many ways, but one of the most important is the impact on food patterns. Food shopping, preparation, and eating patterns have all been affected by the movement of women to the working force. Working wives have less time and inclination to cook but family income is higher because there are two income producers. As a result they spend more money on carry-out items: cold cuts, prepared meat, pie fillings, frozen and ready-to-eat desserts, frozen vegetables, packaged dinners, and entrees. Time-saving convenience foods take on new importance (Jalso, 1965). With this trend the employment of the homemaker can lead to a greater flexibility and use of prepared food (Burk, 1961).

Race and Food Consumption

Hueneman found racial classifications showing some significant differences in nutritional intake. Caucasian boys had higher intakes of protein, calcium, Vitamin A, riboflavin, and ascorbic acid than Negro boys. Oriental boys had higher intakes of protein, Vitamin A, niacin, and ascorbic acid than the Negro boys. Caucasian boys had greater intakes of ascorbic acid than Orientals. Negro boys had mean intakes of ascorbic acid slightly below two-thirds of the RDA allowance. Caucasian girls had higher intakes of protein, calcium, riboflavin, and ascorbic acid than Negro girls. Nutrient intakes of Oriental and Caucasian girls showed no differences. Negro girls had mean intakes of calcium below two-thirds of the RDA and all girls had mean intakes of calcium below two-thirds of the RDA (1967). This is the only study the author was able to find regarding racial differences in nutrient intake. It has also been pointed out that food products that have existed solely on regional or ethnic customs are disappearing or being assimilated throughout the U.S. culture (Jalso, 1965).

Residence and Food Consumption

Around the turn of the century, U.S. families produced at home about 25% of all food they consumed. In many rural areas, this production was 80 to 90% of the total food the family consumed. The overall percentage declined to 20% in 1935, rose to 40% during World War II, and then dropped abruptly. By 1965, the U.S. families produced only 4% of their own food. Food production for home use declined dramatically even among farm families. The percentage of home-produced food declined from the very high level of 80 to 90% in 1900 to 31% in 1965. This decline was brought about by the obvious shift of population from farm to city (Parrish, 1971).

Eating trends of farm families now closely parallel those of other families (USDA, 1965; Jalso, 1965). In 1968 net income of big farmers was $24,000. With this kind of income the big farmer could and did buy what he wanted in town in convenient form. The small farmer had no time to produce his own food. His median income was $7,300, but of this 36% came from work off the farm (Parrish, 1971).

Energy Needs and Food Consumption

Energy is used in mechanized agricultural products for machinery, transport, irrigation, fertilizers, pesticides, and tools. Fossil fuel inputs have, in fact, become so integral and indispensable to modern agriculture that the energy crisis will have a significant impact upon food production in all parts of the world that have adopted or are adopting the Western system of agriculture (Pimental, 1974). It is anticipated that increasing investments of fossil fuel energy will be needed to meet both the changes in diet and the increase in population. This surely will escalate demands for food, feed, and fiber. Agriculture's energy needs to feed the U.S. population are expected to increase 60 to 180% within 25 years and will depend strongly on future trends in feed efficiency of animals and energy efficiency of cropping systems (Heichel, 1975).

In 1970 the U.S. accounted for more than one-third of the total world energy consumption and 35% of the world's petroleum with only one-seventeenth of the world's population (Pimental, 1974). The cultivation of each acre of land currently requires a direct energy input of 2.52×10^{16} kilocalories, or formulated another way, the feeding of each American requires fuel input equivalent of 600 liters of gasoline per year. This constitutes two times as much energy as the amount actually contained in any food intake. Yet, the figure includes neither the energy expended in making the farm equipment nor critical costs of food shortage (Borgstrom, 1974). In the satisfied world the ratio between man and livestock as protein consumers is 6:1; for the poor world it is only 3:1, or half as much (Borgstrom, 1974).

It is useful, then, to assess the process of food production in terms of the energy of creation and to utilize this to distinguish between one method of

production and another (Slesser, 1974). The efficiency with which animals convert feed into meat, milk, and eggs has been debated extensively, particularly in the case of beef production where some have found evidence of declining efficiency. If the apparent increase in efficiency of broiler production, decrease in efficiency of hog production, and decrease in efficiency of cattle production in the next quarter century mirror the trends of the past 22 years, the resulting increase in feed energy to produce a 1972 diet level of caloric gain will require an addition of 149 x 10^{16} barrels of crude oil in grain production for animals in the year 2000. This is 25 percent more than the 119 x 10^{16} barrels per year projected at 1972 levels of feed efficiency (Heichel, 1975).

Hirst estimates the total energy cost of food to be 6,119 trillion British Thermal Units. Of this amount 1,898 trillion British Thermal Units are household food expense. The remainder of 4,221 trillion British Thermal Units is consumed in agriculture, processing, transportation, and trade (1974).

Hannon rank orders the 20 most energy intensive personal consumption activities of consumers in the U.S. Food purchases are the seventh most energy intensive personal consumption activity according to his analysis (1975). Families, however, do not make explicit decisions to consume a given amount of energy to some specified dollar amount. Instead families participate in chosen activities which presumably meet family goals. In the process energy is consumed (Gladhart, 1975). A comprehensive but simplified set of consistent measures drawn from a single external conceptual system is needed to improve the analysis of interrelations and trade offs among environmental consequences, economic costs, material requirements, and resource availability (Gilliland, 1975).

CHAPTER III

METHODOLOGY

This study focuses on the examination of the relationship between patterns of food consumption and their associated energy costs to isolate implications for national energy conservation efforts. To determine the associated energy costs of food consumed it is necessary to develop a methodology for determining fossil fuel energy expended from agricultural processes to the point of consumer purchase from the supermarket. This study is a part of a larger interdisciplinary study entitled "Functioning of the Family Ecosystem in a World of Changing Energy Availability," funded by the Michigan Agricultural Experiment Station, Project No. 3152.

Within this chapter discussion will center on the following points, with detailed discussion of the development of the formula for the determination of the fossil fuel cost of food from agricultural processes through in-store costs in a supermarket:

1. Description of sampled community
2. Sample design and selection
3. Description of subsample
    A. Independent variables
    B. Dependent variable

4. Methodology of fossil fuel formula development

The Sampled Community

The initial sample, selected from the larger interdisciplinary study, was drawn from the greater metropolitan area of Lansing, Michigan. This S.M.S.A. is a well-defined community, containing a unique diversity of functions. The area contains light and heavy industry, a major university, and is the seat of the state government. It can be defined as a centrally located area of commercial enterprise and activity, surrounded by a productive agricultural sector.

Lansing, Michigan, was considered to contain a heterogeneous population from which it would be possible to draw a multistage probability sample, consisting of urban, suburban, and rural families. The interdisciplinary team, with this type of sample, was offered the opportunity to study the impact of the energy crisis on a relatively contained geographical area with diversity in its socio-economic characteristics.

Selection of the Sample

A multistage area probability sample design was carried out for the sample selection of the urban area. A random selection of ten census tracts was made with each tract having a probability proportionate to the number of households therein. The selected tracts were determined to be a reasonable approximation of the urban area of the Lansing S.M.S.A. A total of 613 households were randomly selected from the addresses available in the 1973 Polk City Directory for Lansing and suburbs for the 34 blocks contained within the 10 selected census tracts.

In the rural area of the Lansing S.M.S.A., the sampling was done from counties, to townships, and finally to selected sections in each township. Households to be interviewed were randomly selected from the list of rural addresses. For both urban and rural sample, procedures were established to assure attainment of at least 150 urban and 50 rural families. The final sample contained 216 families, 160 urban and 56 rural. To assess the representativeness of this sample, a comparison was made between the census data of 1970 for the Lansing S.M.S.A. and the sample. It was determined the selected sample was representative of Lansing S.M.S.A. families. A complete discussion of sampling procedures can be found in Zuiches, Morrison, and Gladhart (1975).

Selection of the Subsample

To obtain a randomized subsample of families from the larger randomly selected total sample of families surveyed for the interdisciplinary study, the computer was programmed to organize the 216 families into the following large classifications: blue collar worker, white collar worker, wife works, and wife does not work. Each of the families was then placed into categories of no children, eldest child under 12 years of age, eldest child between the ages of 12 and 18, and eldest child over 18 years of age. This procedure resulted in the division of families from the full sample into 16 subgroups. It was then decided to choose four families per subgroup of all families classified into blue collar, white collar, wife works, and wife does not work and four age categories of eldest child, if any. The four families per subgroup were chosen with the aid of a table of random numbers. This, then, gave 63 families for analysis, as one subgroup resulted in only three families rather than four.

In order to check for racial or occupational differences the remaining nonwhite or Spanish-surname families and farm operators were added to the study. This resulted in an additional 22 families for a total of 85 households. Since the principal concern was to estimate the differences in energy intensiveness of diets between identifiable subgroups of the larger sample, it was felt that the sample drawn would accomplish this while minimizing the possibility of bias in the sampling process. The characteristics of the subsample are presented in Table 1A (urban households) and Table 1B (rural households).

Table 1A.--Distribution of sample by income class--urban residence.

Category	$0-7,999	$8-10,999	$11-14,999	$15-20,999	$21-29,999	$30-49,999	$50,000	Refused
Wife works	3	3	7	7	4	1	0	1
Wife does not work	4	6	8	3	4	3	1	0
Husband blue collar occupation	3	4	4	7	0	0	0	0
Husband white collar occupation	2	5	10	3	7	4	1	1
Wife race: white	2	4	8	6	4	2	1	1
Wife race: other	2	2	2	1	1	0	0	0
Education of wife: 12 years or less	5	4	9	6	4	2	1	0
Education of wife: 12 years or more	2	4	6	4	4	2	0	1

Table 1B.--Distribution of sample by income class--rural residence.

Category	$0-7,999	$8-10,999	$11-14,999	$15-20,999	$21-29,999	$30-49,999	$50,000	Refused
Wife works	2	2	3	1	3	0	1	0
Wife does not work	4	3	5	3	0	2	1	0
Husband blue collar occupation	5	3	6	2	1	0	0	0
Husband white collar occupation	0	0	1	0	1	0	0	1
Wife race: white	5	3	7	4	3	2	2	0
Wife race: other	1	0	0	0	0	0	0	0
Education of wife: 12 years or less	6	4	6	4	2	0	2	0
Education of wife: 12 years or more	6	4	6	4	2	0	2	0

Description of Variables

For the purposes of this study, it was necessary to recode the data from the original pilot study. The following discussion focuses on the ways the original data were transformed in order to be used in the analysis of this study.

Independent Variables

Blue Collar Worker:	Those heads of households having a nonskilled, manual labor occupation.
White Collar Worker:	Those heads of households having a skilled, managerial, or professional occupation.
Rural:	Family lives in a rural township.
Urban:	Family lives within a census tract of the Lansing Metropolitan area.
Wife Works:	Wife is employed outside of the home.
Wife Not Working:	Wife is not employed outside the home.
Education of Wife:	Wife has completed more than 12 years of school or 12 years or less of school.
Race of Wife:	Wives of black, Mexican-American, Spanish, or Oriental were classified as other. Caucasian wives were classified as white. Race determination was based on interviewer's report and family surname.

Dependent Variable

Energy Cost of Twenty-Four Hour Food Intake by Individuals

Each item of food and amount consumed per serving for a 24-hour span of time was recorded by an individual family member on a Food Recall Sheet as part of the original study. Responding family members were the husband, wife, and eldest child 12 years of age or older if present in the home. These data were then classified by the author according to the amount consumed per serving of every food item. The classification used was the Home and Garden Bulletin 72 (USDA, 1971). This was chosen because the foods are recorded in household servings which corresponded most directly with food recall data. The nutritional data file, Data Set 72-4-0, available from the USDA is based on this handbook and was used to determine the nutritive values of food consumed (USDA, 1972).

For composite food dishes constituent ingredients were classified by the author according to amount of ingredient present in the number of servings which the individual indicated had been consumed. Standard recipes used were developed by the author or taken from the Betty Crocker Cookbook (1974). (A list of recipes developed by the author can be found in Appendix C.) A special Fortran computer program, developed by Peter M. Gladhart, Department of Family Ecology, Michigan State University, was employed to associate each food entry with the nutritional values of the food and the respective energy cost estimates developed by the author. These were then cumulated for each individual respondent for all foods eaten during the 24-hour span of time.

When indicated by the individual, the actual form of the food consumed was classified. For foods not recorded according to purchased form such as "fresh," "frozen," or "canned," certain assumptions were made. They are shown in Table 2.

Fossil Fuel Cost of Food

To determine fossil fuel costs of food, four main components were computed separately for each food and then added together. The four main sectors were (a) cultural energy or fossil fuel agricultural costs, (b) transportation costs, (c) processing costs, and (d) in-store costs. The energy costs once the food is purchased, transported to the home, stored, and prepared for consumption were not included in this study. The main interest of this study was the costs of individual foods. Data were not available on the energy costs that families incurred in transport from the store to the home, food storage, and food preparation. Further, one cannot differentiate among individual food energy costs when family food transportation, storage, and preparation energy costs are incurred jointly for differing groups of foods. It is

Table 2.--Assumption of the form of food individuals consumed based on seasonal availability when not stated by individual.

Commodity	Food Form Assumed
Meat	Fresh
Dairy:	
Fluid milk	Fresh
Cheese	Fresh
Ice cream	Frozen
Vegetables:	
Asparagus	Fresh
Beans, snap & lima	Canned
Broccoli	Frozen
Cabbage	Fresh
Carrots	Fresh
Cauliflower	Fresh
Corn	Canned
Onion	Fresh
Peas	Canned
Potato	Fresh
French fries	Frozen
Spinach	Canned
Squash	Fresh
Sweet potato	Fresh
Fruits:	
Apple	Fresh
Apricot	Fresh
Blueberry	Canned
Grapefruit	Fresh
Orange	Fresh
Peaches	Canned
Pineapple	Canned
Plums	Fresh
Rhubarb	Fresh
Strawberries	Fresh

recognized that a household may exercise much discretion, but for this study it was not feasible to pursue costs of food once the item left the supermarket. It is also recognized that the supermarket choice determines to a large extent the type of home storage necessary; i.e., frozen peas as compared to canned peas require different facilities for storage in the home.

Cultural Energy

The majority of the energy economists analyzing agricultural costs employ the term "cultural energy." For purposes of this study the term "cultural energy," defined by Heichel and Frink as the fossil fuel energy required to grow crops and to feed and care for livestock, was employed (Heichel, 1975).

The California Department of Food and Agriculture and the Agricultural Engineering Department of the University of California, Davis, have prepared the most comprehensive study that could be found showing the cultural energy costs of many different crops and of animal husbandry (Cervinka, 1974). This study by Cervinka does not include feed costs of raising animals as the study was intended to account for energy used in California agriculture rather than the total energy costs of specific foods. The cultural energy component of animal feed was not included, then, as this would have resulted in double counting. For animal product adjustments a study by

Heichel and Frink was followed. In this study they calculated feed energy cost by using the per capita consumption of food and the caloric content of plant and animal products (Heichel, 1975).

To calculate the calories of feed required to grow the animal products in the daily diet, the efficiency of producing meat and other animal inputs from feed must be known. From available information on the pounds of live gain or other produce produced per pound of corn equivalent, the caloric content of various animal products, and dressing percentage adjustments, the calculation of estimated energy expended to grow crops for a selection of basic foods was possible.

Heichel and Frink (1975) suggest efficiency factors for the conversion of plant to animal products, taking into account yields for dressing percentages. They are shown in Table 3.

Table 3.--Efficiency factors for conversion of plant to animal products.

Commodity	Efficiency Factor
Beef, veal, lamb	.05
Dairy	.19[a]
Pork	.13
Poultry	.12
Eggs	.13

[a]For dairy, assume it is raw milk.

If the caloric gain of converting cultural energy to feed energy is known, the cultural energy associated with the animal feeds can be estimated. Following Heichel and Frink, the caloric gain of Illinois corn of 4.4 to 1.0 was chosen as representative generally of the United States and animal feed was expressed in corn equivalents.

Then, using representative caloric values for one pound of meat and dairy products, the feed energy required (in corn equivalents) to produce one pound of product could be estimated. These results appear in Table 4. The last column indicates the cultural energy in kilocalories required to produce the food energy shown in the second column.

Table 4.--Animal feed cultural energy component per pound retail weight of meat, poultry, and dairy products.

Commodity	Food Energy Kcal/Pound	Conversion Factor	Food and Feed Energy	Caloric Gain	Cultural Energy Kcal/ Pound
Beef, veal lamb	1,165	.05	23,300	4.4	5,795
Dairy (3.5 parts fat)	295	.19	1,553	4.4	353
Pork	1,397	.13	10,746	4.4	2,442
Poultry	565	.12	4,712	4.4	1,071
Eggs	658	.13	5,062	4.4	1,150

The California study was used only for agricultural energy costs, with adjustments for feed costs by Heichel and Frink (1975) because the author wanted to use United States averages for transportation, processing, and in-store fossil fuel costs. California produces more than 50% of the United States production of 18 fruits, vegetables, and nuts (Cervinka, 1974):

Asparagus	Celery	Almonds
Green beans	Lettuce	Apricots
Broccoli	Melons	Grapes
Carrots	Strawberries	Lemons
Cauliflower	Tomatoes	Peaches
Walnuts	Prunes	Plums

To eliminate the energy cost computations for transportation and processing, Tables 44-83 (Cervinka, 1974, pp. 66-106) in the California study were recalculated to include only agricultural constituents. Then, using Tables 84, 85, and 86 the energy costs of fertilizer, irrigation, and other fossil fuel costs were added to the number obtained from Tables 44-83. These estimates do not include indirect costs of fossil fuel energy required to produce agricultural equipment. The result was an adjusted estimate of kilocalories cultural energy per ton farm product. See Table 5 for the cultural energy of food per pound farm weight in kilocalorie units.

Table 5.--Cultural energy per pound of various food commodities.

Commodity	Kcal/lb.
Livestock	
Beef	6,470.945840
Hogs	2,749.672190
Lamb	6,491.281990
Chicken and	1,696.000000
Eggs	1,931.000000
Dairy	
Fluid milk	556.487208
Fruits	
Apple	58.346090
Apricot	146.906160
Grapefruit	18.871610
Grapes	61.673625
Lemon	26.199000
Orange (tangerine)	27.045110
Peaches	57.883314
Plums	142.118085
Prunes	404.510689
Strawberries	23.951220
Blueberries, blackberries, raspberries, boysenberries, cranberries	
Vegetables	
Asparagus	378.866805
Beans, green & yellow snap	333.069620
Broccoli	213.875280
Beets	48.829780
Brussel sprouts	53.904140
Cabbage	53.904140
Carrots	48.829780
Cauliflower	163.876011
Celery	33.259835
Cucumber	73.024790
Dry beans (lima, mung, navy) and peas	423.172055
Lettuce	53.904140
Melon	73.024790
Onions	45.868885
Pepper, green	23.951220
Potatoes, sweet	32.441520
Potatoes, white	32.441520
Pumpkin	73.024790
Radish	45.868885
Squash	73.024790
Tomato	23.951220
Food Grains	
Rice	130.000970
Wheat	97.642650
Corn	478.720840
Sugar	15.763935
Almonds	601.995680
Walnuts	977.371920

Using the factor 3,986 BTU's per kilocalorie, cultural energy estimates were converted to BTU's per pound farm product. These figures were further adjusted for loss in processing or fresh sale and the feed cost of animal products according to the formula expressed in Figure 1.

Crops:

Cultural Energy Per Lb. Farm Weight/Processing Yield = Cultural Energy Per Lb. Retail Weight

Livestock:

([Husbandry Energy Per Lb./Processing Yield])/Yield in Store + Feed Cultural Energy = Cultural Energy Per Lb. Retail Weight

Dairy:

Husbandry Energy + Feed Energy/Processing Yield = Cultural Energy Per Lb. Retail Weight

Figure 1.--Cultural energy formulas.

Fresh meat is subject to losses in cutting at two stages--first, when it is cut into wholesale cuts at the packing plants and, secondly, when it is cut into retail cuts in the store. The factors used for the processing and store yield are shown in Table 6.

Table 6.--Processing and store yield.

Commodity	Processing	In-Store
Beef	60%	67%
Pork, fresh	70%	70%
Pork, cured	70%	100%
Lamb	50%	67%

Processing Energy

To calculate processing energy, a study was selected which was considered to be the best available source of information on a comprehensive, national level (Development Planning & Research Associates, 1974). The study includes estimates of fuel and electrical usage in processing for the following broad groups of foods: livestock, canned fruits, frozen fruits, frozen citrus concentrate, canned vegetables, canned tomato products, frozen vegetables, frozen potato products, fluid milk, bread and rolls, cakes and sweet rolls, and sugar.

The study made estimates of the total fuel and electricity used in selected industries based on information from the Census of Manufacturers for 1971 and estimates of the volume of commodities in terms of processed products. The fuel and electricity expressed in millions of British Thermal Units was then divided by the product output to obtain a measure of BTU's per pound of product. In the case of meat products and milk, these estimates were representative only rather than being based on total product produced. These estimates were compared with those used by the Economic Research Service and found to be similar (USDA, 1974).

For some products the study produced estimates of the total energy required to process certain product categories. These combined with the estimate of total consumption and production yield of energy cost per pound as indicated in Table 7.

Table 7.--BTU costs for processing one pound of food.

Commodity	Millions of BTU's for Total Processed	Thousands of Pounds Processed	Thousands of BTU's Per Pound
Fruits:			
Canned	16,900,000	6,515,056	2.59
Frozen	2,010,000	665,478	3.02
Citrus, frozen	9,610,000	1,585,046	6.06
Vegetables:			
Canned	15,600,000	5,240,904	2.98
Tomato	17,900,000	2,245,800	7.97
Frozen	6,450,000	2,158,290	2.99
Potato, frozen	2,780,000	2,565,118	1.08
Breads/rolls	37,400,000	15,580,000	2.40
Cakes/sweet rolls/cookies	10,600,000	3,420,000	3.10

For other products it was not possible to isolate the energy devoted to a product group and, therefore, estimates of total energy requirements were made. While less precise than desirable, they were the best available and were used by the Economic Research Service (USDA, 1974). The corresponding foods are found in Table 8.

Table 8.--BTU costs for processing one pound of food.

Commodity	Thousands of BTU's Per Pound
Dairy:	
Fluid milk	.300
Cream	3.500
Cottage cheese	3.500
Whole milk cheese	3.800
Ice cream	3.800
Meat:	
Beef, fresh	1.345
Beef, canned	4.645
Beef, dried	13.345
Pork, lamb, chicken	2.527
Pork, cured	12.527
Sausage, fresh	4.027
Hot dogs, lunchmeat	5.726

Transportation Energy

Computation of transportation in BTU's was accomplished using the Economic Research Service (1974), Fritsch (1974), and the Statistical Abstract of the United States (1972). The Economic Research Service document lists the ton miles of various commodities by mode of transportation for the year 1970 and the amount of diesel and gasoline fuel in millions of gallons used per mode of transportation. The Statistical Abstract gives the amount of food item consumed per capita. This, multiplied by the population of the United States for 1971, results in the total consumption of the specific commodity. Using the above data, the following formula was developed to determine cost per pound per mode of transportation used.

I. $\dfrac{\text{Commodity Ton Mile}}{\text{Agricultural Ton Mile Total}}$ x Fuel Per Mode

x BTU Conversion Factor = BTU Per Commodity Group

II. Per Capita Consumption x U.S. Population =

Total U.S. Consumption

The sum of the energy used in all transportation modes for each commodity was divided by the estimated weight of the commodities consumed. The results appear in Table 9.

Retailing Energy

Fritsch and Castleman estimated both direct fuel consumption and indirect use of energy in buildings and supplies for the U.S. Commercial Sector for 1972. Based on the dollar volume of production they allocated 54.8% to wholesale and retail trade. Sales of groceries and other foods accounted for 20.3% of the total sales of the wholesale and retail sector or 5.1107 million BTU's per

Table 9.--BTU cost per pound commodity transported.

Commodity	Millions BTU's for Transportation[a]	U.S. Consumption (Millions of Pounds)[b]	BTU's Per Pound Commodity
Livestock	63,027,550	39,881	1,580
Food grains	29,287,521	29,075	1,007
Fruits	33,309,027	26,884	1,239
Vegetables	97,220,184	79,363	1,225
Sugar	32,573,930	21,110	1,543
Milk	102,619,147	112,152	915

[a]Computed from Tables 51, 53, 54 USDA, 1974.

[b]Computed from Table 809, Statistical Abstract of the U.S. and Census of the Population for July 1972 (206,211,000).

capita when applied to the wholesale and retail energy use (Fritsch, 1972, pp. 50-51). Multiplying by the July 1971 population of 206,211,000 yields an estimated 1,053,896,703 million BTU's used for wholesaling and retailing of food.

The total energy used in food selling can be allocated among major grocery departments by weighting each department share of total sales by the percentage of department sales allocated to energy costs. The share of department sales attributable to energy is available from the Economic Research Service (USDA, 1974, Table 65, p. 76). The authors note that this estimate is based on the assumption that energy costs are one-half of utility costs.

Major department sales as a percentage of all sales in 1971 are reported in the Journal of Supermarketing (1972). When these sales percentages are weighted by department energy cost factors, the allocations of wholesale and retail energy use given in Table 10 result.

Summary

In summary, then, the principal emphasis of this study is the relationship between patterns of food consumption and their associated energy costs to isolate implications for national energy conservation. To determine the associated energy costs of food consumed it was necessary to develop a methodology for determining fossil

Table 10.--Energy retailing costs.[a]

Commodity	Energy as % Sales	Sales as % Total Store Sales	% Food Retail Energy	Total Energy Millions of BTU's	U.S. Consumption Millions of Pounds	BTU's Per Pound
Meat	.37	22.13	23.14	243,871,697.07	39,525.396600	6,170
Dairy[b]	.38	6.43	6.61	69,662,572.06	59,960.402345	1,223
Frozen foods	1.55	4.91	20.58	216,891,941.47	11,891.000000	18,240
Produce	1.35	10.14	37.42	390,152,559.45	41,571.929600	9,385
Dry grocery	.14	33.42	12.65	133,317,032.92	124,016.687000	1,075

[a]Note that the percentages were based on 53% of the markets for all food. Assuming that energy in all other stores was allocated in the same way, estimates would be true of all food markets. It was also assumed when using these retail data that all consumers went through the retailers' hands.

[b]Estimate for retail was made by assuming that 75% of dairy products were sold in stores.

fuel energy expended from agricultural processes to the point of consumer purchases as available data were existent only in many segments or computed for only a few isolated food items.

To determine fossil fuel costs of food, four main components were computed separately for each food and then added together. The four main sectors were (a) cultural energy or fossil fuel agricultural costs, (b) transportation energy costs, (c) processing energy costs, and (d) in-store energy costs. The methodology is expressed in Figure 2.

$$\begin{aligned}
&\begin{pmatrix}\text{Cultural Energy Per}\\ \text{Pound Farm Weight}\end{pmatrix} / (\text{Processing Yield}) / (\text{In-Store Yield})\\
&+ \begin{pmatrix}\text{Processing Energy Per}\\ \text{Pound Processing Weight}\end{pmatrix} / (\text{In-Store Yield})\\
&+ \begin{pmatrix}\text{Transportation Energy Per}\\ \text{Pound Purchased Retail}\end{pmatrix} + \begin{matrix}\text{Retail Energy Per}\\ \text{Pound Retail Weight}\end{matrix}\\
&= \text{Total Energy Per Pound Retail Weight}
\end{aligned}$$

$$\begin{pmatrix}\text{Total Energy Per}\\ \text{Pound Retail}\end{pmatrix} / \begin{pmatrix}\text{Yield in}\\ \text{Cooking}\end{pmatrix} = \begin{matrix}\text{Energy Per}\\ \text{Pound Consumed}\end{matrix}$$

Figure 2.--Complete energy formula.

To determine cultural energy, processing, and transportation costs of dairy products, whole milk dairy products were adjusted according to weight of pounds whole milk to pound product. This was done in order to minimize double-counting because of the multiple use of milk. The following yields were arbitrarily chosen for products listed in Table 11.

Table 11.--Allocation of milk according to pounds needed per dairy product.

Product	Milk Allocation (Process Yield)
Fluid skim milk	.96
Cream	.30
Cottage cheese	.42
Hard cheese	.11
Butter	.30
Ice cream	.12

Fur further explication of the methodology see Tables 12, 13, 14, and 15. Table 12 lists the BTU cost according to major components for retail weight, the cooking yield of each food item, and the BTU's per pound cooked weight. Table 13 lists the BTU's needed to produce one gram of protein, the BTU's needed to produce one pound edible product, the BTU's per serving size of edible product, and the ratio of energy cost to food energy for foods recognized as protein sources. Table 14 lists the BTU's needed to produce one pound edible product, the BTU's needed to produce one serving of edible product,

Table 12.--BTU cost per pound formula component and total BTU cost per pound commodity.

Commodity	Cultural Energy	Processing Energy	Transport Energy	In-Store Energy	Cooking Yield	BTU/ Lb.
	--------BTU's /Pound Retail Weight-------					Cooked Weight
Dairy:						
Butter	22,083	3,500	3,049	1,223	1.0	29,855
Cheese:						
American	17,954	3,800	7,414	1,223	1.0	30,394
Am. Process	19,371	3,800	7,960	1,223	1.0	32,354
Cottage	5,308	3,500	2,196	1,223	1.0	12,227
Cream	7,361	3,500	3,048	1,223	1.0	14,132
Hard	19,371	3,500	7,960	1,223	1.0	32,054
Swiss	16,730	3,800	6,913	1,223	1.0	28,666
Swiss process	18,250	3,800	7,533	1,223	1.0	30,806
Ice cream	7,361	3,800	3,048	1,223	1.0	15,432
Milk:						
Buttermilk	2,253	300	915	1,223	1.0	4,691
Skim	2,291	300	915	1,223	1.0	4,728
Whole	2,208	300	915	1,223	1.0	4,645
Yogurt	5,308	3,500	2,196	1,223	1.0	12,227
Protein:						
Egg	7,665	-----	2,546	1,223	.89	12,848
Beef, fresh	32,620	2,008	1,580	6,170	.92	46,063
Beef, corned	28,790	4,645	1,580	6,170	.64	71,008
Beef, dried	28,790	13,345	1,580	6,170	.58	49,885
Liver	32,620	2,008	1,580	6,170	.93	45,568
Chicken	6,730	2,527	2,546	6,170	.72	26,048
Pork, fresh	13,802	3,609	1,580	6,170	.56	44,931
Pork, cured	12,569	12,527	1,580	6,170	.69	47,602
Bacon	12,569	12,527	1,580	6,170	.33	99,531
Hot dog	12,569	5,727	1,580	6,170	1.00	27,708
Sausage	12,569	4,027	1,580	6,170	.51	47,736
Lamb	27,794	2,527	1,580	6,170	.72	52,876
Nuts	10,859	-----	7,706	1,075	.92	21,347
Peanuts	2,779	2,500	7,706	1,075	1.00	14,080
Vegetables:						
Asparagus, fresh	1,652	-----	1,225	9,385	.53	23,136
Asparagus, canned	1,790	2,977	1,225	1,075	.60	11,777
Lima beans	1,825	-----	1,225	9,385	.74	16,804
Beans, snap	1,786	-----	1,225	9,385	.88	14,087
Beans, snap, canned	908	2,977	1,225	1,075	.58	10,663
Beans, mung	1,679	-----	1,225	9,385	.94	13,073
Beets, canned	153	2,977	1,225	9,385	.84	16,356
Brussel sprouts	267	-----	1,225	9,385	1.06	10,261
Carrots	200	-----	1,225	9,385	.82	13,182
Carrots, canned	248	2,977	1,225	1,075	.66	8,371
Cabbage	230	-----	1,225	9,385	.93	11,656
Cauliflower	707	-----	1,225	9,385	.66	17,147
Celery	142	-----	1,225	9,385	.93	11,561
Corn, fresh	2,063	-----	1,225	9,385	.54	23,468
Corn, canned	4,942	2,977	1,225	1,075	.68	15,028
Lettuce, butterhead	230	-----	1,225	9,385	.72	15,056
Lettuce, crisphead	230	-----	1,225	9,385	.78	13,897
Lettuce, looseleaf	230	-----	1,225	9,385	.64	16,938
Onion	194	-----	1,225	9,385	.90	12,004
Onion, green	194	-----	1,225	9,385	.96	11,254
Peas, canned	1,257	1,217	1,225	1,075	.64	10,146
Pepper, sweet	103	-----	1,225	9,385	.82	13,065
Potato, baked	134	-----	1,225	9,385	.81	13,264
French fries	134	-----	1,225	9,385	.55	19,535
Potato chips	129	-----	1,225	9,385	1.00	10,739

Table 12.--Continued.

Commodity	Cultural Energy	Processing Energy	Transport Energy	In-Store Energy	Cooking Yield	BTU/ Lb.
	--------BTU's/Pound Retail Weight---------					Cooked Weight
Vegetagles (cont'd):						
Potato, boiled	134	-----	1,225	9,385	.97	11,076
Pumpkin	805	2,977	1,225	9,385	.92	15,643
Radish	196	-----	1,225	9,385	1.00	10,805
Sauerkraut	340	2,977	1,225	1,075	.88	6,383
Spinach	1,708	-----	1,225	9,385	.77	15,998
Spinach, canned	1,214	2,977	1,225	1,075	.68	9,546
Squash	290	-----	1,225	9,385	.88	12,386
Sweet potato	143	-----	1,225	9,385	.78	13,786
Sweet potato, canned	147	2,977	1,225	1,075	.65	8,344
Tomato	112	-----	1,225	9,385	.98	10,841
Tomatoes, canned	148	2,977	1,225	1,075	.66	8,219
Tomato, catsup	235	2,977	1,225	1,075	.75	7,348
Tomato juice, canned	145	2,977	1,225	1,075	1.00	5,422
Snapbeans, frozen	1,321	2,988	1,225	18,420	1.00	24,039
Fruits:						
Apple	241	-----	1,239	9,385	.78	13,930
Apple juice, canned	319	2,594	1,239	1,075	1.00	5,227
Applesauce	641	-----	1,239	9,385	.91	12,378
Apricot	641	-----	1,239	9,385	.93	12,112
Apricot, canned	418	2,594	1,239	1,075	.58	9,183
Apricot, frozen	582	3,020	1,239	18,420	.91	23,319
Blueberry	215	-----	1,239	9,385	.98	16,345
Blackberry	227	-----	1,239	9,385	.92	11,794
Cantelope	315	-----	1,239	9,385	.56	18,504
Cherries, canned	594	2,594	1,239	1,075	.97	1,075
Cranberry sauce, canned	83	2,594	1,239	1,075	.95	5,254
Grapefruit	77	-----	1,239	1,075	.97	2,465
Grapefruit, canned	151	2,594	1,239	1,075	.58	8,783
Grapes	269	-----	1,239	9,395	.91	11,970
Lime juice	104	-----	1,239	9,385	.47	22,825
Lemon	108	-----	1,239	9,395	.96	11,179
Orange	111	-----	1,239	9,385	.75	14,313
Peaches, canned	235	2,594	1,239	1,075	.61	8,431
Plums	594	-----	1,239	9,385	.97	11,565
Plums, canned	376	2,594	1,239	1,075	.51	10,360
Rhubarb	221	-----	1,239	9,385	1.00	10,845
Strawberries	227	-----	1,239	9,385	.94	11,543
Tangerine	114	-----	1,239	9,385	.72	14,914
Watermelon	322	-----	1,225	9,385	.52	21,023
Grains:						
Bread:						
White	245	2,400	1,007	1,075	1.00	4,728
Cracked wheat	245	2,400	1,007	1,075	1.00	4,728
Whole wheat	245	2,400	1,007	1,075	1.00	4,728
Cake	1,550	3,099	1,007	1,075	.84	8,013
Brownie	155	3,099	1,007	1,075	.94	5,677
Cookie	171	3,099	1,007	1,075	.90	5,947
Cornflakes	4,942	2,401	1,007	1,075	1.00	9,425
Wheatflakes	355	2,400	1,007	1,075	1.00	4,838
Graham cracker	215	2,401	1,007	1,075	1.00	4,698
Saltine cracker	387	2,401	1,007	1,075	1.00	4,870
Pastry	161	3,099	1,007	1,075	.98	5,452
Doughnut	159	3,099	1,077	1,075	1.02	5,236
Muffin	176	2,401	1,007	1,075	.86	5,417

Table 13.--BTU's needed to produce one gram protein, BTU's needed to produce one pound edible product, BTU's needed per serving of product, and the ratio of energy cost to food energy for foods recognized as protein sources.

Commodity	BTU's Per Gram Protein	BTU's Per Pound	BTU's Per Serving	Kcal Energy Cost to Food Energy
Dairy:				
Cheese:				
American	311.33	30,394	934	5.23
Am. Process	284.06	32,354	1,988	4.77
Cottage	199.26	12,227	6,575	6.37
Cream	403.31	15,132	2,823	2.22
Hard	281.43	32,054	1,970	4.32
Swiss	220.22	28,666	1,762	4.23
Swiss process	236.66	30,806	1,893	4.77
Ice cream	750.08	12,848	2,252	4.42
Milk:				
Buttermilk	280.30	4,697	2,523	7.06
Skim	255.29	4,728	2,533	4.42
Whole	276.40	4,645	2,488	3.92
Yogurt	939.35	12,227	6,575	11.05
Meat and Meat Substitutes:				
Egg	235.00	12,848	1,410	4.44
Beef, fresh	429.70	46,063	8,594	6.56
Beef, corned	602.18	71,008	13,248	18.05
Beef, dried	328.48	49,885	6,241	13.68
Liver	380.07	45,568	5,701	11.05
Chicken	214.97	26,048	5,374	8.74
Pork, fresh	419.14	44,931	8,383	6.60
Pork, cured	495.45	47,602	8,881	9.13
Bacon	655.39	99,531	3,277	9.18
Hot dog	486.53	27,708	3,406	5.05
Sausage	544.84	47,736	2,724	5.49
Lunchmeat	650.20	57,170	7,153	13.35
Lamb	448.41	52,876	9,865	10.58
Nuts	273.33	21,347	6,560	2.11
Peanuts	120.28	14,080	4,450	1.34
Dried bean	482.34	16,804	6,270	8.32

Table 14.--BTU's needed to produce one pound edible product, BTU's needed to produce one serving product, the ratio of energy cost to food energy for foods not generally recognized as protein sources.

Commodity	BTU's Per Pound	BTU's Per Serving	Kcal Energy Cost to Kcal Food Energy
Vegetables:			
Asparagus, fresh	21,136	3,047	76.78
Asparagus, canned	11,777	6,308	35.32
Beans, snap, fresh	14,087	3,865	32.47
Beans, snap, canned	10,663	5,594	31.32
Beans, mung	13,073	3,587	25.83
Beets, canned	16,356	8,832	26.18
Brussel sprouts	10,261	3,491	16.00
Broccoli	18,906	6,432	40.52
Carrots	13,182	1,447	18.23
Carrots, canned	8,371	514	12.96
Cabbage	11,656	1,791	30.09
Cauliflower	17,147	4,516	45.42
Celery	11,561	2,538	42.63
Corn, fresh	23,468	7,212	25.96
Corn, canned	15,028	8,444	12.52
Lettuce, butterhead	15,076	7,270	61.07
Lettuce, crisphead	13,897	1,731	58.17
Lettuce, looseleaf	16,938	1,859	46.84
Onion	12,004	2,898	18.26
Onion, green	11,254	1,235	15.56
Peas, canned	10,146	5,545	8.47
Pepper, sweet	13,065	2,122	35.65
Potato, baked	13,264	2,882	8.07
Potato, boiled	11,076	3,306	7.94
Potato, french fries	19,535	2,444	3.97
Potato chips	10,739	471	1.03
Pumpkin	15,643	7,828	26.30
Radish	10,805	949	47.81
Sauerkraut	6,383	3,292	39.82
Spinach	15,998	6,321	39.82
Spinach, canned	9,546	3,771	21.12
Squash	12,386	5,709	47.96

Table 14.--Continued.

Commodity	BTU's Per Pound	BTU's Per Serving	Kcal Energy Cost to Kcal Food Energy
Vegetables (cont'd):			
Sweet potato	13,786	3,329	5.41
Sweet potato, canned	8,344	3,993	4.28
Tomato	10,941	4,803	30.26
Tomato, canned	8,219	4,348	21.91
Tomato catsup	7,348	4,403	3.83
Tomato juice, canned	5,422	2,892	16.19
Snapbeans, frozen	24,039	6,010	
Fruits:			
Apple	13,930	4,586	16.51
Apple juice, canned	5,227	2,845	5.98
Applecauce	12,378	3.097	14.19
Apricot	12,112	3,031	13.89
Apricot, canned	9,183	5,220	5.98
Apricot, frozen	23,319	5,829	
Blueberry	14,142	4,346	12.88
Blackberry	11,794	3,728	11.05
Cantaloupe	18,534	16,507	69.33
Cherries, canned	1,075	3,037	7.29
Cranberry sauce, canned	5,254	3,194	1.99
Grapefruit	2,465	1,304	7.30
Grapefruit, canned	8,723	4,863	6.81
Grapes	11,970	4,020	15.58
Lime juice	22,825	12,325	47.78
Lemon	11,179	2,699	34.01
Orange	14,313	5,655	21.92
Peaches, canned	8,431	4,756	5.99
Peaches, frozen	22,966	5,741	
Plums	11,565	1,523	15.35
Plums, canned	10,360	5,821	7.16
Rhubarb	10,845	6,474	4.24
Strawberries	11,543	3,775	17.30
Tangerine	14,914	3,797	23.92
Watermelon	21,023	12,612	54.11

Table 14.--Continued.

Commodity	BTU's Per Pound	BTU's Per Serving	Kcal Energy Cost to Kcal Food Energy
Grains:			
Bread:			
White	4,728	259	.93
Cracked wheat	4,728	261	1.00
Whole wheat	4,728	291	1.13
Cake	8,013	957	.96
Brownie	5,677	249	.74
Cookie	5,947	131	.66
Cornflakes	9,425	517	1.30
Wheatflakes	4,698	319	.76
Graham cracker	4,698	289	.66
Saltine cracker	4,870	118	.59
Pastry	5,452	778	.71
Doughnut	5,236	368	.74
Muffin	5,417	476	1.00
Frozen Fruit Concentrate:			
Grapefruit	26,298	11,948	10.04
Lemonade	25,933	14,116	32.34
Orange juice	26,353	14,403	30.25

and the ratio of energy cost to food energy cost to food energy for foods not recognized as protein sources.

Table 15 is a simulated menu depicting the energy costs of major components at retail weight, processing yields of the food product, store yields of the food product, and the yield after cooking of the product. This, in turn, determines the BTU's per pound of edible product and the BTU's per serving. In processing the data for this study, each food item and number of servings consumed were

Table 15.--Simulated menu.

Food Item	Cultural Energy	Process Energy	Transport Energy	In-Store Energy	Process Yield	Store Yield	Cook Yield	BTU/ Pound	BTU/ Serving
Breakfast:									
Orange juice	631	6,063	1,239	18,420	.17	1.00	1.00	26,353	14,403
Egg	7,665	-----	2,546	1,223	1.00	1.00	.89	12,848	1,410
Toast	245	2,400	1,007	1,075	1.58	1.00	1.00	4,728	259
Butter	22,083	3,500	3,049	1,223	.10	1.00	1.00	29,855	328
Lunch:									
Sandwich:									
Lunchmeat	13,802	17,895	1,580	6,170	.70	.70	.69	57,170	7,153
Bread (2)	245	2,400	1,007	1,075	1.58	1.00	1.00	4,728	518
Butter (2)	22,083	3,500	3,049	1,223	.10	1.00	1.00	29,855	656
Potato chips	129	-----	1,225	9,385	1.00	1.00	1.00	10,739	471
Peaches, canned	235	2,594	1,239	1,075	.98	1.00	.61	8,431	4,756
Milk	2,208	3,500	2,196	1,223	1.00	1.00	1.00	12,227	2,488
Dinner:									
Beef, fresh	32,620	2,008	1,580	6,170	.60	.67	.89	46,063	8,594
Potato, baked	134	-----	1,225	9,385	.96	1.00	.81	13,264	2,882
Snap beans, fresh	1,786	-----	1,225	9,385	.94	1.00	.88	14,087	3,865
Muffin	176	2,401	1,007	1,075	2.20	1.00	.86	5,417	476
Butter	22,083	3,500	3,049	1,223	.10	1.00	1.00	29,855	328
Cantaloupe	315	-----	1,239	9,385	.92	1.00	.56	18,504	16,507
Milk	2,208	3,500	2,196	1,223	1.00	1.00	1.00	12,227	2,488

Total BTU's Per Day for an Individual: 67,582 then translated into the BTU's per meal and summed to give the total BTU cost per daily dietary intake of each individual. Extensive discussion of the implications of the results of the calculations is reserved for Chapter IV.

This methodology for determining fossil fuel cost of food does contain limitations. First of all, the resources used to determine fossil fuel costs in each of the four phases are based on national averages, yet the subsample of which these numbers are applied in this study are all Michigan individuals. Secondly, the industry numbers given are all estimates, so while the numbers containing seven digits to the right of the decimal appear very precise, these are still only estimated numbers. The data, thirdly, are based on "middle of the road" assumptions. For example, the costs of machinery, air-conditioning or heating equipment are contained in the energy cost estimates for the in-store segment of the methodology, but are not included in the numbers representing energy costs for cultural energy, processing, or transportation of food. Yet, an energy cost final number is given for each food which is representative only in part of hidden costs.

Packaging is estimated to be approximately 15% of the energy cost of food (Steinhart, 1975). Yet, this study does not allow for packaging costs in the energy cost per pound of food consumed. Data to differentiate between food packaging forms were not available nor were data given in the Food Recall Sheet as to the type of container used in packaging the food consumed.

It is recognized that these limitations are important factors to consider when analyzing the energy cost data of food consumed. Yet, the estimations of the energy cost per pound of edible product, per serving of edible product, per gram of protein, and energy cost expended to food energy received are much closer approximations than were previously available for one to evaluate dietary choices and the impact of these choices on national energy use and conservation.

CHAPTER IV

FINDINGS, DISCUSSION, AND IMPLICATIONS

Tests of Differences Between Groups

In order to test each hypothesis, the mean energy cost of the diets of wives, husbands, and children in each hypothesized subgroup were analyzed using a one-way analysis of variance to test for differences in group means. Without exception, the tests support all the hypotheses that there were no significant differences between groups as were stated in the hypotheses below.

> Hypothesis I: The energy cost of food consumed will not differ between individuals in families of low, median, and high incomes.
>
> Hypothesis II: The energy costs of food consumed will not differ between individuals in families where the wife's educational attainment is greater than high school completion and those where the wife's educational attainment is high school completion or less.
>
> Hypothesis III: The energy costs of food consumed will not differ between individuals in families where the wives are employed outside the home and those in which they are not.
>
> Hypothesis IV: The energy cost of food consumed will not differ between individuals in families where husbands have white collar occupations and blue collar occupations.

Hypothesis V: The energy costs of food consumed will not differ between individuals in families where wife's race is white and where wife's race is other than white.

Hypothesis VI: The energy cost of food consumed will not differ between individuals in families of urban residence and families of rural residence.

While there were no significant differences between mean energy costs of the household with employed or nonemployed wives, there was a slight trend for wives, husbands, and children of nonworking wives to have a higher mean energy cost food consumption. The mean energy cost of wives was 33,530 BTU's. The mean energy cost of the nonworking wife was 34,210 BTU's while the working wife had a mean intake of 32,720 BTU's. Husband's mean energy cost of food was 37,940 BTU's. Those husbands with nonworking wives had a mean intake of 38,970 BTU's. Husbands of wives who are or were employed have a mean energy cost of food consumption of 36,670 BTU's. Children's mean energy cost food consumption was 35,700 BTU's. Those children in a family of the nonworking wife had a mean energy cost of 31,540 BTU's. The children of working wives had a mean intake of 40,110 BTU's. Table 16 gives greater explication of the data.

The areas of greater difference were associated with the occupational status of the wife's present or former occupation (if any were reported) and with the occupational status of the husband. Both wives and husbands had higher mean energy cost in families where the wife reported no present or former occupation. These results are presented in Tables 17 and 18.

Table 16.--Mean intake of family member according to employment status of wife.

Wife's Employment Status	Family Member	N	Mean BTU Intake	F	Sig.
Working	Wife	37	32,720	.19	.66
Nonworking	Wife	44	34,210		
Working	Husband	35	36,670	.40	.53
Nonworking	Husband	43	38,970		
Working	Child	16	40,110	1.65	.21
Nonworking	Child	17	31,540		

Table 17.--Mean intake of family member according to occupational status of the wife.

Wife's Occupational Status	Family Member	N	Mean BTU Intake	F	Sig.
Blue collar	Wife	26	32,890		
White collar	Wife	35	32,225	2.50	.08
No occupation given	Wife	14	35,570		
Blue collar	Husband	26	35,080		
White collar	Husband	34	37,110	1.50	.22
No occupation given	Husband	13	44,420		
Blue collar	Children	12	41,340		
White collar	Children	10	31,520	.64	.53
No occupation given	Children	8	42,430		

Table 18.--Mean intake of family member according to husband's occupational status.

Husband's Occupational Status	Family Member	N	Mean BTU Intake	F	Sig.
Blue Collar	Husband	35	40,280	2.30	.13
White collar	Husband	32	34,660		
Blue collar	Wife	36	33,338	.23	.62
White collar	Wife	31	35,260		
Blue collar	Children	16	32,680	.91	.34
White collar	Children	13	39,800		

For a complete explication of all data supporting the hypotheses of no difference in food consumption intake, see Appendix D.

Energy Costs of Food

Energy Per Gram of Protein

When analyzing BTU cost per gram of protein according to foods normally considered by nutritionists to be foods high in protein, one can see large variations both within each main food category and across groups. Dairy products range between 20 and 40 BTU's per gram of protein, except for ice cream which utilizes approximately 75 BTU's per gram protein. Meat products have rather extensive fluctuations, depending on the product. Fresh beef and fresh pork carry the same approximate BTU cost per gram protein, except in the case of sirloin steak which is 100 BTU's more costly than fresh pork or other fresh beef. Cured pork products are approximately 100 BTU's per gram protein less costly than corned beef, and both are 100 to 200 BTU's per gram protein more energy costly than a fresh product. Dried beef is less energy costly than either fresh or corned beef. Chicken and eggs are the least energy intensive when analyzing BTU per gram protein costs, with an average of 210 to 260 BTU's per gram protein. Vegetables and fruits are not generally recognized as protein sources, except in the case of dried lentils. Dried lentils are equivalent in BTU per gram protein to cured pork, and therefore more energy costly per pound than fresh meat or dairy products. Detailed results of the energy computations for protein were presented in Chapter III, Table 13. Table 19 lists the protein energy costs of many foods analyzed.

Energy Cost/Food Energy

When one considers the ratio of kilocalories of energy cost to kilocalories of food energy for one pound of product the dairy analysis changes as compared to energy costs per gram of protein. Cottage cheese has a ratio of 6.37, while all other dairy products range from 3.92 to 5.23. Ice cream, most costly when comparing BTU's per gram protein, has an average energy cost of 4.42 in this consideration.

Table 19.--Energy per gram of protein.

Food Item	BTU/Gram Protein
Dairy:	
Cheese:	
American	311.33
American process	284.06
Cottage	199.26
Cream	403.31
Hard	281.43
Swiss	220.22
Swiss process	236.66
Ice cream	750.08
Milk:	
Buttermilk	280.30
Skim	255.29
Whole	276.40
Yogurt	939.35
Meat and Meat Substitutes:	
Egg	235.00
Beef, fresh	429.70
Beef, corned	602.18
Beef, dried	328.48
Liver	380.07
Chicken	214.97
Pork, fresh	419.14
Pork, cured	495.45
Bacon	655.35
Hot dog	486.53
Sausage	544.84
Lunchmeat	650.20
Lamb	448.41
Nuts	273.33
Peanuts	120.28
Dried beans	482.34

Source: Table 13.

Table 20.--Energy cost per calorie of food energy.

Food Item	Kcal/Kcal
Dairy:	
American cheese	5.23
Cottage cheese	6.37
Hard	4.32
Ice cream	4.42
Whole milk	3.92
Yogurt	11.05
Meat and Meat Substitutes:	
Egg	4.44
Beef, fresh	6.56
Beef, corned	18.05
Beef, dried	13.68
Chicken	8.74
Pork, fresh	6.60
Pork, cured	9.13
Lunchmeat	13.35
Nuts	2.11
Peanuts	1.34
Dried lentils	8.32
Vegetables:	
Asparagus, fresh	76.78
Snapbeans, fresh	32.47
Broccoli	40.52
Cauliflower	45.42
Lettuce	61.07
Potato chips	1.03
Spinach	39.82
Fruits:	
Cantaloupe	69.33
Lime juice	34.01
Rhubarb	4.24
Watermelon	54.11

Source: Table 14.

Meat products also have a much different appearance when analyzing kilocalories of energy cost to kilocalories of food energy. Beef products, fresh, dried, and corned, have a cost to output ratio greater than six to one. In fact, corned beef has a ratio of 18.05. Pork products, including cured, are less energy intensive than beef, with ratios ranging from 4.68 to 9.13. The exception in the case of pork is lunchmeat, which has a ratio of 13.35. Chicken is less costly than all cuts of beef except ground beef, but very close in energy expenditure to cured pork. Eggs have the least energy cost ratio of 4.44. Dried lentils are equivalent to cured pork and chicken in energy cost when analyzing ratio of kilocalories of energy to kilocalories food energy received.

Vegetables are very high in certain instances with ratios ranging from 39.82 for fresh spinach to 1.03 for potato chips. Some of the most costly vegetables in terms of energy expended to food energy are spinach, lettuce, broccoli, and cauliflower. Fruits are also energy intensive with similar average energy costs as vegetables. The exceptions in fruits are watermelon with a ratio of 93.53, cantaloupe with a ratio of 69.33, and lime juice with a ratio of 47.78. Other fresh fruits have ratios ranging from 12.88 to 21.92 for rhubarb.

Energy Cost/Pound

When one considers the energy cost of food per pound, changes again occur as to which foods have the greatest energy costs. Fluid milk in the dairy category is much less costly than any other dairy product; hard cheese and processed cheese are eight times more energy intensive than fluid milk. Cottage cheese, cream cheese, American cheese, and ice cream are four times more energy intensive than fluid milk per pound. Yet, all dairy products except hard and processed cheese are less energy intensive than meat products per pound. When compared to fluid milk, meat ranges from 6 to 25 times more energy intensive per pound product. Eggs are equivalent in cost to cottage cheese and ice cream.

Meat products vary in BTU cost per pound. Hamburg and dried beef, due to their cooking yield, are approximately one-third less costly than sirloin steak. Corned beef is the most energy intensive of the beef products. Fresh and cured pork are approximately equivalent to fresh beef per pound, except in the case of bacon, which is twice as energy intensive due to its 33% cooking yield. Chicken and hot dogs per pound are equivalent in energy cost.

Fresh vegetable and fruit energy costs per pound vary greatly, depending on which vegetable or fruit one is analyzing. Cultural energy expended per crop type is dependent upon agricultural procedures necessary to produce one pound of product. For example, fresh asparagus requires 1,650 BTU's per pound, while lettuce needs only 230 BTU's. For fruit, differences are also seen, but not such an extreme as one finds in vegetables. An apple requires 241 BTU's while an apricot requires 641 BTU's and a tangerine requires only 114 BTU's. Energy cost of fresh fruits and vegetables vary in energy cost per pound due not only to the differences in major components, but also in the yield of edible product depending on the fruit or vegetable one is analyzing.

Energy cost per pound varies with fruits and vegetables according to the processed form, due in part to the actual processing of the food and the in-store energy cost differences. No energy cost is attributed to fresh fruits or vegetables for processing, although it is recognized that there is some energy expended, as data were not available. The amount of energy expended for canning and freezing of fruits and vegetables was very close in energy cost, with canning approximately 2,977 BTU's and freezing approximately 3,020 BTU's per pound. The great energy variance is seen between frozen fruits and vegetable items as compared to fresh or canned in the in-store sector. When the item is frozen it is estimated to be two times more energy costly than in-store costs for the same item purchased in its fresh form. It is approximately 18 times more costly to purchase a fruit or vegetable in its frozen form as compared to its canned form. For example, fresh shapbeans' energy cost is 1,075 BTU's; frozen snapbeans' in-store energy cost is 18,420 BTU's. Frozen snapbeans are two times more energy costly per pound than fresh snapbeans and two-thirds more energy costly than canned snapbeans. Frozen apricots per pound are twice as energy intensive as fresh apricots. Canned apricots are one-third less energy intensive than fresh apricots per pound, and therefore, less energy intensive than either fresh or frozen apricots. Detailed results of the energy computations per pound of product were presented in Chapter III, Tables 12 and 13. Table 21 lists the energy cost per pound of the foods analyzed.

Energy Cost/Serving

When one considers BTU's per serving of a product, energy costs again vary from other energy considerations of per pound product, per gram protein, or kilocalories energy cost to food energy. In the dairy product area American cheese is two times less costly per serving than cottage cheese and only one-half the cost of all other cheese except for American processed cheese food, which is six times more energy intensive per serving than American cheese. Ice cream is equivalent to whole

Table 21.--Energy cost per pound of food item.

Food Item	Energy Cost Per Pound
Dairy:	
Cheese:	
American	30,394
American process	32,354
Cottage cheese	12,227
Cream	15,132
Hard	32,054
Swiss	28,666
Swiss process	30,806
Ice cream	15,432
Whole milk	12,227
Protein:	
Egg	12,848
Beef, fresh	46,063
Beef, corned	71,008
Beef, dried	49,885
Chicken	26,048
Pork, fresh	44,931
Pork, cured	47,602
Bacon	99,531
Hot dog	27,708
Vegetables:	
Asparagus, fresh	23,136
Beans, snap	11,777
Beans, snap, canned	10,663
Beans, snap, frozen	24,039
Lettuce	15,056
Fruits:	
Apricot	12,112
Apricot, canned	9,183
Apricot, frozen	23,319

Source: Tables 12 and 13.

fluid milk in cost per serving. It is two-thirds less energy costly than yogurt or cottage cheese. When considering fluid milk on a per serving basis, it is equivalent in cost to a serving of cheese. This change in fluid milk and cheese energy cost is important to note, as the per pound energy cost indicates cheese is eight times more energy intensive than fluid milk. When compared to fluid milk or cheese per serving, meat ranges from four to six times more energy intensive per serving of product. This is again a notable difference from the per pound energy intensiveness of meat products, which were 6 to 25 times more intensive.

Meat and meat substitutes vary in BTU cost per serving. Eggs are slightly less energy intensive per serving than fluid milk or most cheeses, and the hot dog is equivalent in energy cost per serving to fluid milk and cheese. Fresh beef and fresh or cured pork are equivalent in energy intensiveness on a per serving basis. Dried beef is one-fourth less energy costly than fresh beef, pork, or cured pork. Corned beef is the most energy intensive of the meat or meat substitutes on a per serving basis, ranging from two to six times more energy costly. Bacon was noted to be twice as energy intensive on a per pound basis as fresh beef or pork. When considering the per serving energy cost, it is only one-half as energy costly as fresh beef or fresh or

Table 22.--Energy cost per serving of product.

Food Item	Energy Cost/Serving
Dairy:	
Cheese	
American	934
American process	1,988
Cottage cheese	6,575
Ice cream	2,252
Milk, whole	2,488
Yogurt	6,575
Meat and Meat Substitutes:	
Egg	1,410
Beef, fresh	8,594
Beef, corned	13,248
Beef, dried	6,241
Chicken	5,374
Pork, fresh	8,383
Pork, cured	8,881
Bacon	3,277
Hot dog	3,406
Lamb	9,865
Nuts	6,560
Peanuts	4,450
Dried lentils	6,270
Vegetables:	
Asparagus	3,047
Lettuce	7,270
Potato	2,882
Pumpkin	7,828
Fruits:	
Apple	4,586
Apricot	3,031
Grapefruit	1,304
Lime juice	12,325
Lemon	2,699
Orange	5,655
Tangerine	3,797
Frozen Concentrate:	
Grapefruit	11,948
Lemonade	14,116
Orange	14,403

Source: Table 14.

cured pork. Hot dogs and chicken are equivalent in energy cost per pound; when considering energy cost per serving, chicken is one-third more energy intensive. Lamb is the most energy intensive per serving of all the meat and meat substitutes except for corned beef. Dried beef and nuts or dried lentils per serving are equivalent in energy cost. Peanuts are one-third less costly than nuts. Detailed results of the energy computations per serving of product are found in Tables 13 and 14.

Fresh vegetable and fruit energy costs per serving vary greatly, depending on which vegetable or fruit one is analyzing. The energy cost per pound of lettuce and asparagus was noted with interest due to the energy intensiveness of asparagus as eight times greater than lettuce. The energy outlook is much different on a per serving basis with lettuce twice as energy costly per serving as asparagus. Fruit differences were noted in the discussion on energy cost per pound with the apricot three times more energy intensive per pound than an apple and six times more energy intensive per pound than tangerines. The energy outlook again is quite different on a per serving analysis, with the apricot one-fourth less energy costly than the apple and slightly less energy costly than a tangerine.

Frozen fruit concentrates are much more energy intensive per serving than the actual fruit item per serving. Frozen grapefruit concentrate is six times more energy intensive than fresh grapefruit per serving. Lemonade, when compared to a lemon, is five times more energy intensive and when compared to an orange is three times more energy intensive. Orange juice frozen concentrate per serving is three times more energy costly than oranges per serving. When compared to each other, grapefruit frozen concentrate is slightly less energy intensive than lemonade or orange juice, and lemonade and orange juice are equivalent in cost.

Implications

From this discussion of the energy cost of food, one can see that the energy intensiveness varies depending on the analytical approach, i.e., BTU's per gram of protein, BTU's per pound of edible product, BTU's per serving, kilocalories of food energy expended per kilocalorie of food value. Large variance in energy cost between products in a category suggests the amount of complexity involved in the process of determining energy costs, as in the case of BTU costs of vegetables when analyzing kilocalories expended to kilocalories gained. This study ends with the in-store segment but the method of home storage, if any, and method of preparation could drastically change the energy intensiveness of food consumption choices. The shopping patterns of the consumer in the number of miles traveled and gas milage obtained from the automobile, if used, must also be considered as part of the energy cost of food.

This study is limited in the actual number of people analyzed, but the sample was stratified and randomized so as to minimize possible sampling biases. Keeping in mind the limitations previously discussed of the lack of completeness of data in the Food Recall Sheets, the combination from a variety of sources of data to determine energy costs of food, and lack of energy cost of packaging of each food product, it seems a tenable proposition that there are no significant differences in the energy intensiveness of food consumption choices from one group to another. The author is not certain what may have been left out of the food recall data as the people recording did not always include all possible information. If all diets were equally complete, changes in the results might occur. However, it seems unlikely that the groups analyzed would have varied systematically in the completeness of reporting so as to mask real group differences. The analyses strongly support the conclusion that the sample analyzed is homogeneous in the energy intensiveness of individual food consumption. The broad groups do not differ significantly in their food consumption choices. This study does not support the idea that energy conservation policies in the area of food consumption should be directed toward any one group, but rather to the total population of the United States.

One must realize that the energy intensiveness of food varies depending on how one is analyzing the food item. The more energy costly food per pound, such as dairy products, becomes one of the best consumer choices when concerned with the grams of protein received per BTU expenditure. If the consumer is making a choice based on kilocalories expended to produce kilocalories of product, a food item such as watermelon becomes one of the most energy costly food choices. And, if the consumer is simply choosing based on BTU's per pound of product or BTU's per serving of product, the choices again are different than when looking at grams of protein or kilocalories of food energy expended for food value.

Given what is known about the American people's dietary preference for meat and the energy cost per pound of meat products, there is evidence to encourage less costly ways to produce meat. It has been stated by many agriculturalists that it is important to limit energy costs at the husbandry level, but when one looks at the energy cost per pound of product for processing, transportation, and in-store costs, one can see the tremendous complexities of reducing energy costs per pound of livestock. The consumer has to face the choice of spending more energy for protein or he must be prepared for more dietary shifts in food consumption choices.

As world population increases and energy costs continue to rise, the more favorable aspects of choosing the lower cost protein sources such as many of the available dairy products becomes a possible consumer selection which controls to an extent the energy intensiveness of his dietary intake. Animal products are used to upgrade the nutritional quality of plant food sources by their high-quality complete protein structure, B-vitamin content, and iron. Grain proteins are generally low in lysine, while milk and meat products are good sources of tryptophan and lysine. Cereal grains are low in calcium while milk and other dairy products are high in this nutrient (National Dairy Council, 1976). Thus, the consumer does presently have the option of choosing the less energy intensive animal products and still select the protein foods which are important in maintaining a good diet.

Due to the complexity of food from agriculture to the table, assessing energy costs is a difficult task. The average consumer has not had information available with which to make informed decisions to conserve energy in the area of personal food consumption choices. The complexities of food involving fossil fuel energy are almost infinite and impossible to account for in total except for estimated or approximate amounts.

This study has attempted to piece together existing information of fossil fuel consumption from agriculture through in-store sectors and is, at best, a rough estimation of the fossil fuel costs per pound of product, per serving of product, per gram protein, and the ratio of kilocalories food energy expended to kilocalories of food value. The energy cost per serving may be the most useful information for the average consumer who will eat food based on daily servings. With knowledge of the energy cost per serving, the consumer can make decisions in the marketplace which will conserve energy at the individual level. The individual or family level of energy conservation was considered by Paolucci (1976) to be the place where energy conservation must have its basis.

For the food professionals, agriculturalists, energy specialists, and educators the energy cost per pound of product, gram of protein, kilocalories of food energy expended for kilocalories of food value as well as energy cost per serving may be of optimal value. Decisions to conserve food consumption energy may best be made by the specialist on a basis other than energy according to serving of food; for example, a high protein diet may best be planned according to energy cost per gram of protein. Energy costs do vary, as was previously noted, with the focus of the analysis one selects. The important consideration is that food consumption choices can be rational decisions made not just on dietary preference, but with the application of available information so as to promote energy conservation through the marketplace.

APPENDICES

APPENDIX A

PER CAPITA CONSUMPTION OF COMMODITIES

APPENDIX A

Table A1.--Per capita consumption of commodities.

Year	Meat	Fresh Fruits	Canned Fruits	Frozen Fruits	Fresh Veg.	Canned Veg.	Frozen Veg.	Milk
1900	151.1	-----	----	----	----	----	----	-----
1910	146.4	137.9	3.6	----	----	14.5	----	315.0
1920	136.0	145.4	9.4	----	95.0	18.5	----	348.0
1930	129.0	133.6	12.8	0.5	111.9	28.4	----	337.0
1940	142.4	142.1	19.1	1.3	116.9	34.4	0.6	331.0
1950	144.6	107.4	22.0	4.3	114.6	42.1	3.4	349.0
1960	160.0	93.4	22.6	9.1	105.9	43.4	7.0	362.3
1970	186.3	81.2	23.3	9.8	98.5	51.1	9.6	300.3
1971	191.8	79.8	21.9	10.2	99.2	51.2	9.7	295.5

Table A1.--Continued.

Year	Eggs	Chicken Turkey	Sugar	Wheat Flour	Fats Oils	Peanuts	Beef	Rice	Frozen Potatoes
1900	----	----	65.2	214	----	2.5	72.5	---	----
1910	301	15.5	75.4	179	----	3.0	77.6	---	----
1920	299	13.7	85.5	171	----	3.2	67.1	---	----
1930	331	17.2	109.6	158	44.1	3.2	55.3	---	----
1940	319	17.0	95.7	155	46.4	5.0	62.3	5.9	----
1950	389	24.7	100.8	135	45.9	4.5	71.4	5.1	0.1
1960	335	34.2	97.6	118	45.3	4.9	85.1	6.1	2.7
1970	311	49.7	102.5	110	53.3	5.9	113.7	6.7	11.1
1971	314	49.9	102.4	110	52.1	5.9	113.0	7.7	12.1

APPENDIX B

PERCENTAGE CHANGE PER YEAR CONSUMPTION

FROM 1971

APPENDIX B

Table B1.--Percentage change per year consumption from 1971.

Year	Eggs	Chicken Turkey	Sugar	Wheat Flour	Fats Oils	Peanuts	Beef	Rice	Frozen Potatoes
1900	-----	-----	36.4%	94.5% decr.	-----	55.3%	37.0%	-----	-----
1910	2.6%	-----	26.4%	62.7% decr.	-----	49.2%	32.0%	-----	-----
1920	4.8% decr.	-----	16.6%	55.4% decr.	-----	45.8%	41.0%	-----	-----
1930	5.4% decr.	72.6%	7.0% decr.	43.6% decr.	15.4%	45.8%	51.1%	-----	-----
1940	1.5% decr.	65.6%	6.6%	4.5% decr.	11.0%	15.3%	44.9%	23.4%	93. %
1950	23.8% decr.	65.6%	4.7%	22.7% decr.	12.0%	23.8%	36.9%	33.8%	67. %
1960	6.6% decr.	50.6%	2.1%	7.2% decr.	13.1%	17.0%	24.7%	20.8%	27. %
1970	1.0% decr.	31.5%	0	0	2.3% decr.	0	.6% decr.	33.8%	8. %

Table B1.--Continued.

Year	Meat	Fresh Fruits	Canned Fruits	Frozen Fruits	Fresh Veg.	Canned Veg.	Frozen Veg.	Milk
1900	22%	---	-----	-----	-----	-----	-----	-----
1910	24%	72%	84.00%	-----	-----	98.1%	-----	6.5% decr.
1920	30%	82%	58.00%	-----	4.3%	63.9%	-----	17.7% decr.
1930	33%	67%	5.16% decr.	5.1%	12.8% decr.	44.6%	-----	14.0% decr.
1940	26%	78%	13.00%	87.3%	17.8% decr.	32.9%	3.9%	12.0% decr.
1950	25%	34%	0	57.9%	15.5% decr.	17.8%	65.0%	18.1% decr.
1960	17%	17%	0	10.8%	6.7%	15.3%	27.9%	22.6% decr.
1970	3%	1%	0	4.0%	.8%	.2%	1.1%	1.0% decr.

APPENDIX C

INGREDIENTS NEEDED FOR INDIVIDUAL

SERVING SIZES OF COMBINATION FOODS

APPENDIX C

INGREDIENTS NEEDED FOR INDIVIDUAL SERVING SIZES OF COMBINATION FOODS

MEATLOAF

1/4 lb. hamburg
1 T. breadcrumbs
1 T. onion
1/8 egg
1 T. milk

HAMBURG

1/4 lb. hamburg
2 slices of bread = 1 bun
1 T. ketsup
1 T. mustard
1 T. onion

POTATO SALAD

1 medium potato
1 t. radish
1 t. celery
1 t. onion
1/4 hard boiled egg
1 T. salad dressing
1 T. mustard

1/8 head lettuce
1/2 medium tomato
1 t. onion
1 t. radish
1 t. celery
1 T. salad dressing

SANDWICH

2 slices of bread
2 pats of butter (1 t. each)
1 ounce of lunchmeat or cheese
or
1 T. peanut butter

APPENDIX D

DATA SUPPORTING HYPOTHESES OF NO DIFFERENCE IN FOOD CONSUMPTION INTAKE

APPENDIX D

DATA SUPPORTING HYPOTHESES OF NO DIFFERENCE IN FOOD CONSUMPTION INTAKE

Table D1.--Wife's mean energy cost food consumption according to income level.

Income Level	Mean BTU Intake	N	F	Sig.
$ 9,999 or less	35,320	25		
$10,000-$15,999	35,360	27	1.09	.33
$16,000 or more	30,040	28		

Table D2.--Husband's mean energy cost food consumption according to income level.

Income Level	Mean BTU Intake	N	F	Sig.
$ 9,999 or less	39,180	23		
$10,000-$15,999	37,530	25	.06	.93
$16,000 or more	38,150	29		

Table D3.--Children's mean energy cost food consumption according to income level.

Income Level	Mean BTU Intake	N	F	Sig.
$ 9,999 or less	28,460	10		
$10,000-$15,999	37,640	10	1.04	.36
$16,000 or more	30,770	13		

Table D4.--Mean intake of family member according to educational status of the wife.

Educational Status of the Wife	Family Member	Mean BTU Intake	N	F	Sig.
High school or less	Wife	32,100	54	1.44	.23
More than high school	Wife	36,390	27		
High school or less	Husband	38,920	51	.19	.65
More than high school	Husband	37,260	26		
High school or less	Children	35,690	25	.00	.99
More than high school	Children	35,730	8		

Table D5.--Mean intake of family member according to race of wife.

Race of Wife	Family Member	Mean BTU Intake	N	F	Sig.
White	Wife	33,200	53	.02	.88
Other	Wife	33,990	9		
White	Husband	34,740	54	2.50	.11
Other	Husband	44,450	7		
White	Children	33,440	26	.06	.79
Other	Children	30,480	3		

Table D6.--Mean intake of family member based on residence.

Residence	Family Member	Mean BTU Intake	N	F	Sig.
Urban	Wife	33,990	51	.12	.72
Rural	Wife	32,740	30		
Urban	Husband	38,930	48	.48	.48
Rural	Husband	36,360	30		
Urban	Children	36,670	20	.12	.72
Rural	Children	34,200	13		

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