Marileena Koskela & Markus Vinnari (editors)

FUTURE OF THE CONSUMER SOCIETY

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CARBON FOOTPRINT OF FOOD MAINTENANCE IN FINNISH HOUSEHOLDS

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ABSTRACT – This paper identifies the primary consumer actions having an effect on carbon footprint, their relative importance and their sensitivity to consumer choice concerning food maintenance. Food maintenance (transportation, preservation and preparation of food) of a Finnish household produces annually 170 kilograms of CO_2-equivalent per individual as an average which corresponds approximately 2% of the greenhouse gas emissions of private consumption. Of transportation, preservation and preparation, we find the preservation as the most important source of greenhouse gas emissions.

INTRODUCTION AND BACKGROUND

Food comprises 20–30% of carbon foot print of consumer actions[1]. This paper identifies the primary consumer actions having an effect on carbon footprint, their relative importance and their sensitivity to consumer choice concerning food maintenance. The functional unit of study is a person belonging to a household, which in Finland includes an average of 2.1 people[2].

Let us define main factors having an effect on the carbon footprint of food after leaving the grocery. These are food transport, preservation, preparation, dishwashing and waste management. In this paper we take interest on food maintenance of a consumer from the point of view transport, preservation and preparation.

Methods and need for travel are influenced by life situation, which age has correlation with. The most intensive phase is when children are in primary school and retirement is not current. We can also note that the interval of grocery shopping trips has steadily decreased, while the proportion done by private car has increased[3].

The selection of food articles has increased, resulting in a wider variety of possibilities for preserving and preparing them. At the same time the use of convenience food has increased in Finland, having a reverse effect.[2] In Finland, milk, milk products and corn, baking, fruit and berry products are by mass the most used foodstuffs. In this sense it can be argued that the Finnish diet has become more wholesome than in the past, although the use of soft drinks has increased. In fact, they are now by mass the fourth biggest group of foodstuff[2].

Identifying the dynamic nature of household food maintenance, we discuss here only the current situation in the light of national averages. In addition, the sensitivity of these averages to individual choice is studied. The focus is in identifying the relative proportions of carbon footprint of primary consumer actions considering household food maintenance. To this end, the absolute annual values for carbon footprint of transportation, preservation and preparation are estimated using current average data. As the absolute average values are found out, it becomes a point of interest to study the effect of individual choice on these values. Thus this paper proceeds with sensitivity analysis to show the range of carbon footprint of food maintenance. Last, the food maintenance patterns are studied to show how the results can be used to compare different methods of households' food maintenance.

MATERIAL AND METHODS

Households' transportation of food was studied using The National Travel Survey[3], which discusses private Finnish transportation in 2004–2005. The survey was conducted by interviewing approximately 13 000 Finns by telephone during the years 2004–2005. It includes 5449 interviews on transportation to

grocery shop (from small size shops to big stores). The data collected includes both households, which travel directly from home to grocery shop, and households which obtain their groceries while travelling between other destinations, e.g. work and home.

The results of the survey are statistically generalizable on all Finnish people above 6 years of age. Data is classified according to residential area and mode of transportation. Residential areas are classified as follows: downtown area, block-intensive area (outside city centre), one-family house intensive area and rural area. Modes of transportation include pedestrianised, bicycling, passenger car (one passenger), passenger car (more than one passenger), bus, metro/tram and train. We should note however, that the instances of travel done by bus, metro, tram or train have proportionally little presence in the data (less than 3 percent of all trips) and therefore include considerable uncertainties.

According to the survey, an average travel distance to do grocery shopping is 4.9 kilometres. These trips are conducted at an average of 0.41 per citizen daily. Most of the trips are done by passenger cars with one or more than one passengers (46 and 17 percent, respectively). Groceries are obtained by foot in 27 percent of cases. These percentages vary when considering different residential areas. The CO_2-equivalents produced in the transportation to and from grocery shop are studied as follows. The average distance of transportation is known for different residential areas3. The emissions by passenger cars, buses and trains can be calculated using emission factors produced by Technical Research Centre of Finland[4] per kilometre of transport in the city or road. For trams and metros the emission factors per kilometre have been received from Helsinki City Transport. Helsinki[5] is the only city in Finland which currently has trams or metros. In average, four-fifths of the kilometres of travel are done by metro and one fifth by tram[6].

The energy need of food preservation can be studied in two different ways, either on micro or macro level. On micro level, we may try and suggest, what sort of refrigeration devices are needed to store typical foodstuffs, and how much space do typical foodstuffs require in a refrigeration device. Then a typical energy use per year can be solved for the foodstuffs stored by an individual, if the energy consumption of refrigeration devices is known. The energy consumption is allocated by volume to the foodstuffs stored in the refrigeration device, and as we know the type of energy, e.g. electricity used, we may solve the greenhouse gas (GHG)-emissions by using appropriate factors.

The above discussion presents the carbon footprint of preservation of food on micro level. On macro level however, the aim is to study total energy used by household for food preservation. As it is more than usual in Finland that the energy is in form of electricity, here we study only the household electricity used by refrigeration devices in total. Total household electricity for this purpose can be further divided by population of Finland to acquire electricity used for refrigeration devices per person, in average. The carbon footprint is calculated in the same manner as for micro level.

On macro level, there are data available on the annual total of electricity use of Finnish households on refrigeration devices. Then the electricity use for the annual foodstuffs preservation per person can be solved by dividing total electricity use by the population of Finland. For reliability the preservation is studied only on macro level.

Besides refrigeration devices, the energy use for food stored in room temperature can be studied. There are no statistics available for household energy consumption of food stored in room temperature; therefore it is studied only on micro level. The residential heating appliances are an important factor in forming the final greenhouse gas emissions. Here it is assumed that the room is heated with electricity, which is one of the most environment intensive forms of heating. On the other hand, electricity is needed to preserve food, or to redirect heat energy, in refrigerators, freezers and in possible combinations of the two. In Finland, the foodstuffs stored in room temperature need a heated room to sustain their temperature. The greenhouse gas emissions depend not only on the technology but also on the source of energy used. While considering the emissions caused by preservation in room temperature, it is presupposed that about 50 percent of the volume of a typical closet is usable for preservation.

The electricity use of refrigerator; low top freezer and refrigerator; tall bottom freezer and refrigerator; and chest freezer are obtained from Work Efficiency Institute.[7] In Finland, other forms of energy

are rarely used in refrigeration devices. Respectively, the energy used in residential heating is obtained from a communication published by Technical Research Centre of Finland[8].

Preparation of food needs electricity via household appliances '(e.g. stove, microwave or electric oven) production of heat energy. Other possible sources of heat include gas or firewood. More recent technologies are also available, such as convection oven. Preparation of food is a more multifaceted object of study compared to food preservation, originating from the more numerous techniques of preparation and preparation equipment in a household. Evaluating the carbon footprint beginning from the micro level requires studying the energy use of different preparation methods. After identifying the source of energy used, the typical food preparation methods should be chosen in order to form an average emission value for an average dish.

Discussing food preparation from macro level, the analysis is based on national averages, as in food preservation. In this paper the total Finnish use of household electricity when using stove or other food preparation equipment is used as a reference[9].

In order to calculate the carbon footprint of individual foodstuffs 'preparation on micro level, the energy use of different preparation equipment is needed. In this research the energy required for boiling water on a stove and keeping it boiling are evaluated, as well as for warming up a pan and keeping it in the desired warmth. In addition the electricity use of an oven is studied, both while warming up to 200 degrees of Celsius and keeping that desired warmth. Convection oven is not included in the calculation. The specific heat capacities of different foodstuffs are not included in calculations. Variation of recipes and quantities of food need variable amount of energy for a serving, which were considered in micro level calculations.

RESULTS

Considering food transport, preparation and preservation, the total carbon footprint for food maintenance in a Finnish household is 170 CO_2-equivalents, from which 50% is coming from food preservation, 27% from food transportation and 23% from food preparation. The food preservation was identified as having the largest carbon footprint of the three areas studied. This is due to excessive use of freezers, which produce largest emissions per litre stored, as well as annually.

We find that the average annual carbon footprint of *food preservation* is approximately 87 kilograms per capita. We can note that the electricity used by refrigeration devices for one person in a household equals in average the electricity use of one low top freezer and refrigerator. It can be said then, that it is likely that 25 percent of the volume of refrigeration devices is in efficient use as presupposed earlier, while studying preservation on micro level.

Furthermore, we can note that foodstuffs stored in room temperature have low GHG-emissions compared to those stored in refrigeration devices.

On macro level the annual electricity use in a household for stove and other *food preparation* is formed as previously for food preservation. It should be noted that the micro level average contains considerable uncertainty owing to two presuppositions presented. However, both annual values were 39 kg GHG-emissions per person. The annual average using micro level data is given here as an item of interest only because the macro level data verifies its magnitude.

We find that the average annual carbon footprint of *transportation* to grocery shop in Finland is approximately 47 kilograms per capita. When travelling in a car with more than one passenger, it is simply assumed that the car holds two people. This is reasonable, as the average size of a Finnish household is 2.1 people[2]. Of course, the emissions per person are smaller if more than two people travel by passenger car. The distances to grocery shop are considerable in rural areas, compared to other residential areas. The largest GHG-emissions in food maintenance transportation are produced in the rural areas as well. There are fewer alternatives in rural areas for passenger car transportation, at least in practice. However, it is possible to compensate high GHG-emissions of food maintenance transportation by other, more responsible food-related consumer actions.

In the following, three food maintenance patterns are studied for a Finnish average family of four. In the first food maintenance pattern, food maintenance is integrated into work travel and is done daily. In the second pattern food maintenance is done separately once a week by private car. Third food maintenance pattern includes three trips to a grocery per week by private car.

Let us first study the first food maintenance pattern (Maintenance pattern number 1), where food maintenance is integrated to work travel. It is possible to argue that travelling to work is done even if no food maintenance is done while doing so. Therefore the carbon footprint of food transport, if it is done while commuting, is zero. The food preservation time is about 2 –3 days, so the need for freezer capacity is reduced. Therefore a family of four is assumed to have a tall bottom freezer and refrigerator. Food preparation is more dependent on individual preferences than anything else, so the average is used here.

The second food maintenance pattern (Maintenance pattern number 2) uses a car for food transport once a week. It is known that in average one trip to a grocery by car produces 1.1 kg of CO_2-equivalents. The food preservation is needed for 5 –7 days, which means that more products are stored in a freezer. The family of four is therefore assumed to have a tall bottom freezer and refrigerator, and a chest freezer. For food preparation, again, the national average is used. Maintenance pattern number 3 includes three trips per week to grocery shop and therefore the food preservation time is 2 –3 days, as in Maintenance pattern number 1.

The difference between the Maintenance patterns number 1 and 2 is one-third because of transport and two-thirds because of preservation. The reason why transport has a substantial effect is more obvious, as the maintenance pattern number 1 uses no separate transportation for groceries. The preservation is more elaborate subject. The difference between carbon footprints of preservation in the two maintenance patterns is because of a chest freezer, which usually has a larger volume and yet approximately as large a need for electricity per litre as a regular freezer. A presupposition is made that maintenance pattern number 2 uses a chest freezer with a gross volume of 400 litres. This is possible, but it is also quite possible that there is no need for a freezer this large, in which case the difference between the maintenance patterns is smaller.

It can also be noted that the maintenance pattern number 3 produces less GHG-emissions than the maintenance pattern number 2. This is due to greater difference in carbon footprint of refrigerator devices compared to the carbon footprint of transportation by car.

For food preparation, the minimum and maximum values were based on hypothetical examples of cooking porridge (prepared for four people at a time) and cooking potatoes (prepared for one person at a time). The resulting minimum carbon footprint by eating only porridge should be regarded as the absolute minimum value for the food preparation. The maximum value of eating only potatoes could still be increased by increasing the number of food articles prepared.

DISCUSSION AND CONCLUSIONS

Sensitivity analysis can assist in showing how much consumer action considering food maintenance can affect the carbon footprint. This analysis was carried out using the carbon footprint of different possibilities for food transport, preparation and preservation. For food transport, the minimum carbon footprint is formed when going to a grocery by foot or by bike, in fact in this case the carbon footprint is zero. The maximum for food transport is formed when travelling alone to a grocery with a car, for which the carbon footprint is about 89 kg per year (average value for single passenger).

Minimum for food preservation is evaluated by the carbon footprint of a low top freezer and refrigerator and the maximum is evaluated by the carbon footprint of a tall bottom freezer, refrigerator and a chest freezer. Both for minimum and maximum the result is divided for two people. That is, two people are using the common refrigerator equipment, both in minimum and maximum case.

The total for food maintenance can be more than six times higher when minimum values are compared with maximum values. In food preservation the difference is the smallest, with four-fold difference between the minimum and maximum value. In food transport the difference is the largest, and food preparation has a ten-fold difference when the minimum and maximum values are compared.

Household should transport about 12 servings of food at a time if the average carbon footprint of transport should equal the carbon footprint of preparation of said servings. A litre preserved in a freezer annually equals approximately 17 average food preparations when comparing the carbon footprints. If preserved in refrigerator, the respective figure would be 9 times of food preparation, and in room temperature 1/3 times of food preparation. Food prepared in a microwave oven has the smallest carbon footprint.

As an average, preservation of food has about two times as large carbon footprint compared to preparation or transportation of food. Food transport has a slightly higher average than food preparation.

The largest carbon footprints considering food transport are generated in rural areas, where the distances are longer. On the other hand, food transport is more and more done by private cars in other areas as well.

Sensitivity analysis shows that the average carbon footprint of food maintenance can be affected by consumer choice, giving an annual range of 45–340 kg per person. Anyhow, it should be noted that the sensitivity analysis did not include food choices, only choices concerning food maintenance. In addition the values used have considerable uncertainties. However, the order of magnitude of the absolute values presented for minimum and maximum values, and the proportions of different elements of food maintenance are reliable. The average values are well-founded on previous research.

To further introduce the use of carbon footprints of food maintenance, two maintenance patterns were studied. The analysis was revealing, showing that a very simple case of change of transportation habits in obtaining food can have a notable effect on how much freezer space is needed. Consequently, obtaining food more rarely is followed by increased need of refrigeration equipment, which in turn can have a larger effect on the carbon footprint than the more frequent grocery shopping. The consideration of maintenance patterns revealed that all the elements of food maintenance discussed here should be included in the analysis, if one is to reduce the total carbon footprint of food maintenance. Considering these findings, the discussion should not be limited on transportation distances.

From a point of view of a consumer, results achieved advocate shorter transportation distances, lesser need for freezer appliances and non-energy intensive food preparation methods. This could mean dispensing with the chest freezer and increasing the use of microwave oven in food preparation.

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