Marileena Koskela & Markus Vinnari (editors)

FUTURE OF THE CONSUMER SOCIETY

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IMPACT OF CONSUMERS' DIET CHOICES ON GREEN-HOUSE GAS EMISSIONS

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ABSTRACT – This study explores the impacts on agricultural and total GHG emissions of Finnish consumption if the share of animal based food products was reduced and if the share of ecologically produced food was to increase in Finland. GHG emissions associated with production of basic food items were quantified (per capita per annum) for current food consumption, for national standard diet recommendations, for a diet with no milk and beef and for a vegan diet including an oat-based milk substitute.

The major source of GHG in primary food production is the cultivated soil. For the present average food consumption the emissions from the soil comprise 62%, the share of the emissions due to enteric fermentation is 24%, whereas energy consumption and fertilizer manufacture both contribute about 8%. Because of the extensive production mode, regarding GHG emissions the environmental performance, of organic production is poor.

A strict vegan diet would result in nearly 50% reduction in GHG emissions from agriculture, but the reduction of the total emissions due to consumption would be about 8%. Reducing the volume of GHG emissions through food consumption would require large-scale changes among the entire population and is, therefore, unrealistic. Instead of stressing the impact of individual citizens' diet choices more attention should be paid to public catering and to development of business and policy instruments. Rather than focusing only on GHG emissions, attention should be paid to the overall sustainability of food supply.

INTRODUCTION

There is growing concern about the environmental impacts of food production, and attempts to slow down climate change are not compatible with continuously increasing use of non-renewable fossil energy in food production and for transport. The environmental consequences of food production have increasingly concerned greenhouse gas (GHG) emissions, and discussion has focused particularly on dairy cattle whose enteric fermentation produces considerably more methane than is produced from pork and poultry production[1].

It has been argued on environmental grounds that a vegetarian diet would pay dividends[2, 3, 4, 5]. Increasing the share of locally grown vegetarian products was shown to reduce GHG emissions when compared with the diets more reliant on imported vegetables and animal products[6, 7], but the impact of dietary choice has also been questioned[8].

The contribution of food production chain to total GHG emissions in Finland is about 24%[9]. Milk products represent about 30% of the average Finnish diet and beef comprises 26% of the meat consumed. About 40% of the consumed beef is a side product of milk production. Dairy products together with beef, provide 33% of the total energy intake in the current average Finnish diet[10].

There is a strong belief that consumers can make a positive contribution to reducing the environmental load through food purchases by substituting animal-based products, especially dairy cattle products, for vegetarian products[11]. These changes in purchasing are encouraged through various tools designed for consumers[12, 13, 14]. Public discussion is lively, and the interest in personal carbon emissions suggests that among environmentally aware consumers there is a willingness to change individual food consumption habits. However, although the consumption of vegetable products has been slowly increasing during recent decades, compared with the national standard dietary recommendations, current average food consumption in Finland is still biased towards animal products[10]. Currently only about 1–5% of

Finns are vegetarians, some of whom eat fish, eggs and/or milk products. The number of orthodox vegans is not known[15]. More often the reasons for veganism concern personal health, animal welfare or simply food price rather than environmental considerations[16].

The benefits of organic production over conventional production appear to be widely accepted in public discussion.[17, 18, 19] One of the central arguments is absence of chemical fertilizers in organic production, the manufacture of which consumes large amounts of fossil fuel with consequent greenhouse gas emissions.[20] As a response to the growing concern about the environment, large scale organic production has been offered as an overall solution to the environmental problems of agriculture worldwide created by the present global food markets[21, 20, 22]. However, global organic food markets are likely to end up with some of the same problems as conventional production, i.e. large scale industrial mode of production with monocultures and competition based on price and efficiency[23]. International trade means long transports, increased energy consumption and GHG emissions[7, 24, 25]. It also means placeless food with the producers and consumers distanced from each other[26]. It has been claimed, that big organic does not anymore represent real alternative, but it has become part of the mainstream global food trade where production is controlled by large agrifood corporations[26].

Various surveys have shown that Finnish consumers prefer domestic products to imported ones and often also organic to conventional food, if such products are reasonably priced.[19] Through the demand-supply mechanism consumers are, therefore, identified as important actors in deciding about the fate of domestic, and specifically of organic, food production. It was reported however that consumers more often express their ideals about food choices rather than make actual choices[27].

This article compares national GHG emissions in primary food production, i.e. in agriculture alone, for four diet scenarios: present day "business as usual" average food consumption, nutritionally balanced diet based on national health impact based dietary recommendations, diet with no milk products and with no ruminant meet, and vegan diet. Also, the GHG emissions associated with conventional and organic production are compared. The aim is to assess, how such diet and/or production system choices, if generalized to apply the whole nation, would contribute to goals of reducing GHG emissions in agriculture, and in the food chain as a whole. With such scenario assessment we wish to stimulate critical discussion on the environmental impacts of food consumption patterns, with the possibilities for consumer choices to "save the world".

MATERIAL AND METHODS

The study deals with the GHG emissions from agricultural production, inclusive fertilizer use and energy consumption, of the food necessary to satisfy Finnish consumption requirements. Domestic production meets the need of about 85% of the basic foodstuffs currently consumed in Finland[10]. In this study it was assumed that meat, milk, eggs, fish, grains, potato, sugar, oil seeds, vegetables, fruit, berries and feed for animal husbandry were domestically produced. This is an approximation, as imports balance the exports of some of these commodities. Fully imported food items not possible to produce in the Boreal agriculture of Finland, i.e. mainly citrus fruit and rice, were not considered in the calculations. Exclusion of these items is justified by assuming that the studied diet scenarios would share equal amounts of consumption of these. Wild berries and even fish in the Finnish case are not agricultural products, and these items were ignored in the calculations.

The field area needed to produce food plants and fodder for livestock to meet consumption demand was calculated on the basis of the following data: food consumption[10], feed requirements of production animals[28], long term average yield per hectare of various food and feed crops, output per animal of various animal products and factors converting yields to food.[29] The number of different production animals to satisfy annual demand for animal products was calculated on the basis of these data.

The greenhouse gases considered here comprise methane (CH_4) from enteric fermentation of the production animals, CH_4 from dung, carbon dioxide (CO_2) and nitrogen oxidule (N_2O) from agricultural soil as well as the CO_2 associated with fertilizer use and agricultural energy consumption. The CH_4 emissions from production animals were quantified using the animal specific emission factors[30], and the emissions of N_2O and CH_4 from dung were calculated on the basis of published data[31]. For the GHG emissions from soil, the average Finnish annual value of 2819 kg CO_2 equivalents ha^{-1} [30] was used. The emissions from fertilizer manufacture were calculated using the value 2.28 kg CO_2 equivalents kg^{-1} total fertilizer and assuming application of fertilizers according to the terms of environmental subsidy. The energy consumption, electricity and fuel oil, of the various agricultural products was obtained from the farm model data basis[32] the associated GHG emissions were calculated using the emission factor 2.68 g CO_2 l^{-1} for oil, and 250 g CO_2 kWh^{-1} for electricity[7]. The GHG emissions into the atmosphere were expressed as CO_2 equivalents, and the conversion factor of 21 for CH_4 and 310 for N_2O were used[33]. The details of the calculations and the exact figures for the calculation parameters were published in a separate report[34].

A special feature in Finnish food system is a relative large proportion of meat from game, especially elk (*Alces alces*), and from reindeer (*Rangifer tarandus*). Reindeer meat and game meat together represent only about 2.5% of consumed food, but this amount is associated with large populations of the animals. In estimating the GHG emissions associated with these (semi)wild animals the whole supporting population[29] was accounted for, and only metabolic methane production from these sources was included. No GHG emission factors are available for reindeer and game animals, and the CH_4 emissions were approximated by using the factors for ewes for reindeer and deer, and those for beef cattle for elk.

The national diet scenarios, for which the greenhouse gas emissions (GHG) in agriculture were approximated, were:

- BAU: the present day "business as usual" average Finnish diet.
- NUH: a nutritionally balanced diet based on national health impact based dietary recommendations, and including an increased share of food of plant origin, reduced share of food of animal origin, and only 60% of the present day milk consumption[35].
- REX: a "ruminants excluded" diet with no milk products and with no ruminant meet, pork and poultry replacing beef and mutton.
- VEG: vegan diet with no milk and meat products and introducing an oat-based milk substitute at a level equal to the current day milk consumption; according to the ingredient declaration of the commercial product, the milk substitute contains 10% oat, which means about 100 grams extra oat *per capita* per day.

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29 200.000 reindeer, 84.000 elk and 5000 white-tailed deer (pers.com. Aslak Ermala, Finnish Game and Fisheries Research Institute, October 2008)

*Table 1. The dietary options used in the GHG calculations and expressed on the basis of daily per capita consumption: BAU - current average food consumption; NUH - nutritionally balanced diet based on dietary recommendations; REX- diet with no milk products and with no beef or mutton; VEG - vegan diet; * not accounted for in the GHG calculations.*

	BAU		NUH		REX		VEG	
	g	kJ	g	kJ	g	kJ	g	kJ
Wheat	132	1887	148	2118	160	2290	160	2290
Rye	45	584	70	918	70	918	70	918
Barey	3	35	15	213	20	284	20	284
Oat	12	180	25	374	80	1196	140	2093
Rice*	14	217	11	171	11	171	14	211
Potato	191	595	250	777	250	777	250	777
Sugar	85	1414	81	1346	70	1163	60	995
Vegetable oils	15	542	20	744	27	1004	49	1822
Pea	3	45	5	68	5	68	17	232
Vegetables, excl. tomatoes	116	126	230	251	232	253	233	254
Fruit, excl.citrus	93	206	152	339	152	339	125	278
Garden berries	19	40	85	348	85	348	85	348
Wild berries*	19	40	152	623	152	623	152	622
Citrus fruit*	13	35	13	36	13	36	0	0
Tomato	31	26	35	30	35	30	35	30
Eggs	26	164	30	193	35	225	0	0
Milk	1082	3257	680	1503	0	0	0	0
Beef	51	396	32	250	0	0	0	0
Pork	94	848	35	316	75	677	0	0
Poultry	43	262	45	273	82	497	0	0
Mutton	1	11	1	9	0	0	0	0
Reindeer, game	8	34	8	33	8	33	0	0
Offals*	4	22	4	23	4	23	0	0
Fish	37	187	39	199	39	199	0	0
kJ, total		11153		11153		11153		11153

In each scenario, the GHG emissions were quantified for each basic food item on an annual *per capita* basis. In compiling the dietary options the total energy intake was kept constant, and the options were nutritionally balanced in terms of reasonable daily intakes of carbohydrates, fats and proteins (see Table 1).

For comparison of conventional and organic production options, the GHG emissions were first calculated on the basis of conventional production. Then, the impact of organic production on the emissions was estimated for the present day food consumption using three simplifying approximations: 1) the share of fertilizer manufacture was ignored, 2) for the same amount of production the extensive production mode needed 30% more cultivated area[36, 32] and 3) the feed requirements of the animals were the same as in conventional production, consequently also the output per animal was the same.

RESULTS

The results from quantifying the GHG emissions for the basic food items in the four dietary options suggest that diet choice makes a great difference. Comparing the present day average food consumption (BAU) with the purely vegan diet (VEG), the GHG emissions of the primary phase of food production would be approximately halved. The other options would also result in apparently significant reductions in GHG emissions (see Table 2).

Table 2. The per capita annual consumption of food expressed in kilograms for the four dietary options, and the associated GHG emissions due to primary production assuming conventional production, kg CO_2 equivalents. ”Soil” comprises food and fodder production, ”livestock” comprises the GHG emissions from the manure and metabolism. BAU - current average food consumption; NUH - nutritionally balanced diet based on dietary recommendations; REX- diet with no milk products and with no beef or mutton; VEG - vegan diet.

	BAU	Greenhouse gas emissions, kg $CO_{2eq.}$ /year					NUH	Greenhouse gas emissions, kg $CO_{2eq.}$ /year				
	Consumption kg/capita /year	Soil	Fertiler	Energy	Livestock	total	Consumption kg/capita /year	Soil	Fertilizers	Energy	Livestock	total
Wheat	48	80	8	4		92	54	90	8	5		103
Rye	16	27	2	2		30	26	42	4	2		48
Barley	1	2	0.1	0.1		2	5	9	1	1		10
Oat	4	11	1	1		13	9	24	2	1		27
Potato	70	10	1	1		12	91	14	2	1		16
Sugar	31	149	21	2		172	30	142	19	2		163
Vegetable oils	5	63	6	2		70	7	86	9	2		96
Pea	1	2	0.1	n.d.a.		2	2	3	0.1	n.d.a.		3
Vegetables, excl. tomatoes	42	5	0.4	3		8	84	9	1	6		17
Fruit, excl.citrus	34	34	4	7		45	56	56	6	11		74
Garden berries	7	11	0.3	2		13	31	49	1	8		57
Tomato	11	0.3	0.1	34		34	13	0.3	0.1	38		39
Crop production total		394	44	56		494		523	53	77		653
Eggs	9	36	3	2	1	42	11	42	4	3	1	49
Milk	395	355	43	28	268	695	248	223	27	18	165	433
Beef*	18	71	8	8	64	152	12	49	6	6	45	106
Pork	34	139	12	20	32	203	13	52	4	7	8	72
Poultry	16	46	4	10	5	64	16	48	4	11	5	67
Mutton	0.4	4	1	n.d.a.	1	6	0.4	4	1	n.d.a.	1	5
Reindeer and game	3				35	35	3				35	35
Animal production total		650	71	69	408	1198		417	46	44	261	768
All		1044	115	125	408	1692		940	99	121	261	1421

Table 2. continues

	REX	Greenhouse gas emissions, kg $CO_{2eq.}$ /year					VEG	Greenhouse gas emissions, kg $CO_{2eq.}$ /year				
	Consumption kg/capita /year	Soil	Fertilizers	Energy	Livestock	total	Consumption kg/capita /year	Soil	Fertilizers	Energy	Livestock	total
Wheat	58	98	9	5		112	58	98	9	5		112
Rye	26	42	4	2		48	26	42	4	2		48
Barley	7	12	1	1		14	7	12	1	1		14
Oat	29	76	6	4		86	51	133	11	6		150
Potato	91	14	2	1		16	91	14	2	1		16
Sugar	26	123	17	2		141	22	105	14	1		121
Vegetable oils	10	116	12	3		130	18	210	21	5		236

Pea	2	3	0,1	n.d.a.		3	6	9	0,4	n.d.a.	9
Vegetables, excl. tomatoes	85	10	1	6		17	85	10	1	6	17
Fruit, excl.citrus	56	56	6	9		72	46	46	5	12	63
Garden berries	31	49	1	9		59	31	49	1	5	55
Tomato	13	0,3	0,1	38		39	13	0,3	0,1	38	39
Crop production total		597	59	81		736		727	70	83	879
Eggs	13	49	4	3	2	56					
Milk	0	0	0		0	0					
Beef*	0	0	0		0	0					
Pork	27	131	11	16	26	184					
Poultry	30	87	7	19	9	122					
Mutton	0	0	0		0	0					
Reindeer and game	3				35	35					
Animal production total		267	23	38	72	398					
All		864	81	119	72	1134		727	70	83	879

n.d.a. = no data available

However, the impact is not as marked as it looks at first sight. The GHG emissions were quantified for the primary production. The total annual GHG emissions for Finnish consumption are about 11000 kg CO_2 *per capita*, of which the share from food is 24% or about 2600 kg[9]. The figure includes also the emissions associated with imported items that are produced abroad for Finnish consumption. The about 1700 kg CO_2 equivalents from agriculture comprise 73% of the GHG emissions associated with food. The impact of the dietary choice on total personal GHG emissions is, therefore, much more moderate and depending on the diet option, ranges from about 2.6 to 7.5% reduction in the emissions due to Finnish consumption. The impact on the total GHG emissions of the Finnish economy is even less, 2.2 –6.6% (see Table 3). This is because the emissions associated with the Finnish export industry comprise about 42% of the total GHG emissions of the Finnish economy[9], and these are not included in the GHG emissions associated with Finnish consumption.

The relative contributions of cultivated soils, fertilizer manufacture, agricultural energy consumption and animals to the GHG emissions from primary production, food production, total GHG emissions of Finnish consumption and total emissions of the Finnish economy are shown in Table 4. Depending on the dietary option, the soil comprises 62 to 82% of the emissions from primary production, the fertilizers 7 –8%, agricultural energy consumption 8 –11% and livestock metabolism and dung about 6 –24%. However, the relative shares of the agricultural GHG emissions are effectively diluted when compared with the total emissions or even with the emissions associated with food consumption.

Table 3. The GHG emissions for the four dietary options, reduction of emissions compared with present day average food consumption (kg CO2 equiv. per capita per annum), the percentage impact of the four dietary options reducing the GHG emissions of primary food production, of food production and total GHG emissions. BAU - current average food consumption; NUH - nutritionally balanced diet based on dietary recommendations; REX- diet with no milk products and with no beef or mutton; VEG - vegan diet.

	BAU	NUH	REX	VEG
GHG emissions of primary production, kg CO2 equiv.	1692	1421	1134	879
Reduction of the GHG emissions, kg CO2 equiv.		270	558	812
Reduction compared to GHG emissions of agriculture, %		16	33	48
Reduction compared to GHG emissions of food consumption, %		10.8	22.9	34.2
Reduction compared to total GHG emissions of consumption, %		2.6	5.2	7.5
Reduction compared to total GHG emissions of Finnish economy, %		2.2	4.5	6.6

Table 4. The relative contribution of the soil, fertilizers, energy consumption and livestock on GHG emissions from agriculture, food consumption, total consumption and the Finnish economy for the four dietary options. BAU - current average food consumption; NUH - nutritionally balanced diet based on dietary recommendations; REX- diet with no milk products and with no beef or mutton; VEG - vegan diet.

Share from the GHG of agriculture, %				
	BAU	NUH	REX	VEG
Soil	61.7	66.2	76.1	82.6
Fertilizers	6.8	6.9	7.2	7.9
Energy consumption	7.4	8.5	10.5	9.5
Livestock	24.1	18.4	6,3	0
Share from the GHG of food consumption, %				
Soil	40.6	37.5	35.4	30.6
Fertilizers	4.5	3.9	3.3	2.9
Energy consumption	4.9	4.8	4.9	3.5
Livestock	15.9	10.4	2.9	0
Share from total GHG emissions of consumption, %				
Soil	9.7	8.9	8.4	7.3
Fertilizers	1.1	0.9	8.4	0.7
Energy consumption	1.2	1.2	1.2	0.8
Livestock	3.8	2.5	0.7	0
Share from total GHG emissions of Finnish economy, %				
Soil	8.3	7.6	7.3	6.6
Fertilizers	0.9	0.8	0.7	0.6
Energy consumption	1	1	1	0.8
Livestock	3.2	2.1	0.6	0

The impact of organic production on the GHG emissions is exemplified using current average food consumption (BAU). The results show that compared with conventional production, the GHG emissions for organic production are nearly 20% higher (see Table 5).

Table 5. GHG emissions for current average food consumption (BAU) assuming the food was organically produced, kg CO2 equivalents per capita per annum; n.d.a. = no data available on energy consumption

	Consumption, kg/cap/y	Soil	Energy	Animals	total
Wheat	48	115	5.6		120
Rye	16	38	1.45		39
Barley	1	2	0.1		2
Oat	4	16	0.58		17
Potato	70	15	0.83		16
Sugar *	31	213	2.31		215
Vegetable oils*	5	89	1.65		91
Pea*	1	2	n.d.a.		2
Vegetables, excl. tomatoes*	42	7	3.55		10
Fruit, excl.citrus*	34	49	7.81		57
Garden berries*	7	16	1.95		18
Tomato*	11	0,4	37.01		37
Crop production total		563	63		626
Eggs	9	51	3	1	55
Milk	395	507	33	268	809
Beef	18	101	9	64	175
Pork	34	198	31	32	262
Poultry*	16	65	12	5	82
Mutton	0.4	6	n.d.a.	1	8
Animal production total		929	89	372	1391
All		1492	152	372	2017

*estimation is based on the average 10% and 23% more energy consumption in plant cultivation resp. animal husbandry

Reliability of the results: The conversion factors for N_2O and CH_4 are internationally accepted values33, and the calculations for farm land requirements are based on the long-term national averages of yield and production levels, which are the best available data. The primary energy consumption and the CH_4, CO_2 and N_2O emissions associated with fertilizer manufacture and transports were deduced from the data of a single study[37] assuming consumption of 3.6 MJ primary energy per kWh and emissions equivalent to 250 g CO_2 per kwh[7]. The obtained emission factor 2.28 kg CO_2 equivalents kg^{-1} total fertilizer (inclusive phosphorus and potassium) is very close to the value of 1.98 kg CO_2 equivalents kg^{-1} N-fertilizer based on the LCA data from Yara (Frank, pers.com 2009). Thus, the results regarding CO_2 equivalents associated with fertilizer manufacture appear also reliable and express the relative differences between the dietary options fairly accurately. Data on agricultural energy consumption are somewhat less accurate. Since no data were available for several of especially the organic production lines (see Tables 2 and 5), the missing data were approximated assuming that the energy consumption in organic plant cultivation is 10% and in organic animal production 23% higher compared to conventional production; the percentages represent the average difference between organic and conventional production.

The annual GHG emissions of 1692 kg CO_2 equivalents per capita presented here for current food consumption are very close to the 1658 kg CO_2 equivalents calculated using the IPCC (Intergovernmental Panel on Climate Change, www.ipcc.ch) approach including only the GHG emissions from soils and livestock30. Adding the GHG emissions associated with fertilizer manufacture and energy consumption into the IPCC figure would result in somewhat higher emissions than obtained here. The difference is explained by the fact that, in reality the production from animal husbandry in Finland is somewhat in excess of the domestic demand[29], and this is accounted for in the IPCC calculations, which are based on actual animal numbers, whereas the present calculations are based on the amount of food consumed.

The emissions associated with reindeer and game ruminants are very rough estimates. For lack of specific emission factors, the factors were chosen on the basis of animal size. The main purpose of including reindeer and game in the study was to draw attention to and stimulate research on this issue.

DISCUSSION

Primary production is responsible for approximately 60 –90% of GHG emissions in the food chain[7]; this is in agreement with the 73% obtained in the present study. The major source of GHG emissions during primary food production is the cultivated soil. Fertilizer manufacture represents under 10 percent, and contribution from agricultural energy consumption is of the same order of magnitude (Table 4). Therefore, regarding GHG emissions, the environmental performance of extensive organic production is poor compared with conventional production as it involves increased cultivated acreage and consequently also higher consumption of fuel energy in comparison with conventional cultivation. Similar results have been reported elsewhere[7, 38], although improving knowledge on soil carbon storage and nitrous oxide emissions could change current thinking[39]. However, there are environmental impacts other than GHG emissions, and the positive impact of organic farming on biodiversity was demonstrated in several studies[40, 41, 42]. Assessments of farming practices, including prohibition of biocide use, crop rotation, mulching and use of cover crops indicate environmental benefits from organic farming[43, 44], and organic production has been emphasized as one contributing factor in promoting sustainable agriculture within the EU[17]. Global food security is a growing challenge as the world population increases and the area of farmland *per capita* continuously shrinks. At the same time, as a consequence of improving living standards, use of animal products is increasing[45], which increases both environmental and health costs of food production. The actual capacity of organic agriculture should be seriously considered at local and national scales before advocating large-scale shifts towards more extensive organic production.

The importance of diversity of cultivated species has been lately stressed, and instead of focusing production on the three major cereals, rice, wheat and maize, there is a need to revive the local food plant species and cultivars and landrace animals in order to secure both the species and genetic diversity necessary for food production and adequate nutrition as well as to provide material for breeding new genotypes to secure adaptation to changing environments[46]. The available farmland *per capita* in Finland is about 0.43 hectares, which is enough for food self-sufficiency, inclusive of the production of animal feed based on domestic cultivars, and to secure independence from import of basic food and feed items. With increased vegetarian food consumption, national food self-sufficiency in Finland could be based on organic production[47].

Dietary choice appears to have an impact on GHG emissions. Choosing the vegan diet over the current average diet, GHG emissions from primary food production would be nearly halved. However, because food represents only about 24% of the total GHG emissions[9] and agriculture comprises about 70% of the GHG of food production, such a radical change in food consumption would mean a reduction of about 7% in the total *per capita* GHG emissions attributable to consumption. Moreover, the environmental benefits of vegan diets are not clear-cut. It has been shown that increasing the share of vegetarian products in the diet decreases nutrient surpluses and greenhouse gas and acid emissions. On the other hand, vegan diets are not optimal in terms of effect on the diversity of wild species[47]. This is because areas covered with vegetation throughout the year are especially important for maintenance of diversity of wild species in agro-environments. Grasslands, green fallows, cultivated and natural pastures secure habitat heterogeneity and provide abundant ecological niches for farmland birds, overwintering invertebrates and for game species, some of which have recently become rare or extinct[48, 49, 50]. These areas have been created by and are maintained to a large extent by dairy cattle and other grazing animals.

As regards climate change, it is the total absolute volume of GHG emitted into the atmosphere that is crucial, not the percentage reduction in personal GHG emissions. To have some impact on the total volume of GHG emissions would require large-scale changes in the average Finnish food consumption habits, and even then the impact on total emissions would only amount to a few percent. Such changes are hardly realistic because consumer attitudes towards food and consumer behaviour are not consistent;

citizens express various demands and wishes that change over time and depend on general overall trends and personal circumstance, including purchasing power. The direct impact of the changes on individual food consumption habits on the environment is, therefore, restricted and can only be gauged over a very long time span, if at all.

Sustainable food supply includes socio-cultural and ethical aspects as well as economic feasibility; it is not merely a matter of ecological sustainability and ecological sustainability is not merely a matter of GHG emissions. The basic requirement is for adequate production of food, and every nation should have the right to basic food security. Initiatives for sustainable catering have emerged in Italy, UK, Denmark and in Sweden, among other countries, featuring the use of local and organic food[51, 52]. The Finnish committee for sustainable production and consumption proposed that the use of organic and local food by catering organizations is to be increased annually by 10 –15%. However, to date, realization of the recommendation has not been followed and, at present, customers are rarely informed about the origin and production ethics of the food provided by public catering[11].

In general, the prerequisite for sustainable consumption is to introduce services to substitute for material consumption. Although food itself cannot be substituted, a lot can be done at the household level to improve sustainability of food provisioning[53]. Responsibility for sustainable food consumption cannot solely be pushed onto the consumers, and recommendations alone are not sufficient. There is a need to develop effective policy measures and instruments with the primary aim of improving overall sustainability of food provisioning[54].

Compared with individual citizens, institutional consumers and public catering represent a more homogeneous consumer group with somewhat better prerequisites for consistent behaviour. If public catering were committed to the principles of sustainable food provisioning, it could provide a more effective channel for improving sustainability in the food sector. This is done already to some extent through the sheer volume of public food purchases, but most importantly through food and sustainability education for citizens. Public catering already plays an important role in guiding nutritional behaviour among Finns, and it has contributed to increased use of vegetarian products and improved public health[35]. Similarly to nutritional education, public catering could provide a clear signal to the population regarding the kind of food that meets the sustainability criteria.

CONCLUSIONS

- The major source of GHG from food production is cultivated soil.
- Contribution from fertilizer manufacture and agricultural energy consumption is small compared to the GHG emissions from soil.
- Regarding GHG, the environmental performance of organic production is poor compared with conventional production.
- The impact of giving up animal husbandry on total GHG emissions could result, at maximum, in about 7% reduction in total emissions for all consumption.
- To have any impact on the actual volume of GHG emissions through changed food consumption would require large-scale changes among the whole population and a shared view of the extent of the necessary changes.
- Instead of stressing the impact of individual citizens 'food choices, more attention should be paid to designing effective policy instruments and to institutional consumers.
- Public catering has the potential to exert a positive influence through volume of food purchases and setting an example by implementing food and sustainability education for its own activities.
- Consumer information is important from the viewpoint of food and sustainability education, leading eventually to adopting more sustainable life styles in the coming generations.
- Environmental considerations for food production and consumption should not be restricted to GHG emissions. Rather than focusing on low carbon diets and carbon bonuses or on organic versus conventional comparisons, attention should be paid to overall sustainability of food supply.

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