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Carbon footprints of Indian food items

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ABSTRACT

Carbon emission occurs during various stages of life cycle of food products. Greenhouse gases (GHG) emission from 24 Indian food items showed that animal food products (meat and milk) and rice cultivation mostly contributed to methane (CH_4) emission, while food products from crops contributed to emission of nitrous oxide (N_2O). Emission of CO_2 occurred during farm operations, production of farm inputs, transport, processing and preparation of food. The GHG emission during the life cycle of cooked rice was 2.8 times the GHG emission during the life cycle of chapatti, a product of wheat flour. Mutton emitted 11.9 times as much GHG as milk, 12.1 times fish, 12.9 times rice and 36.5 times chapatti. As Indians mostly consume fresh foods produced locally, 87% emission came from food production followed by preparation (10%), processing (2%) and transportation (1%). For a balanced diet (vegetarian) an adult Indian man consumed 1165 g food and emitted 723.7 g CO_2 eq. GHG d^{-1}. A non-vegetarian meal with mutton emitted GHG 1.8 times of a vegetarian meal, 1.5 times of a non-vegetarian meal with chicken and an ovo-vegetarian meal and 1.4 times a lacto-vegetarian meal. Change in food habit thus could offer a possibility for GHG mitigation.

1. Introduction

The food consumption in relation to environmental impact has received political and social attention in recent years. The growth in food consumption causes increasing pressure on the environment. Research into the environmental effects of food consumption usually focuses on energy use and the production of waste and rarely has been evaluated for greenhouse gases (GHG) emission. From the food consumption, carbon dioxide (CO_2) is the most important GHG followed by methane (CH_4) and nitrous oxide (N_2O) (Kramer et al., 1999). Fuel combustion activities are the main sources of CO_2 emission, whereas animal husbandry and rice cultivation are the main sources of CH_4 emission, and the emission of N_2O is mainly from turnover of nitrogen in soil, application of N fertilizer and industry.

Carbon footprint is the total set of GHGs emission caused by a product. It is often expressed in terms of carbon dioxide equivalent of all GHGs emitted. A product's carbon footprint can be measured by undertaking a GHG emissions assessment. Once the size of a carbon footprint is known, a strategy can be devised to reduce it by technological developments, better process and product management and alternate consumption strategies. Emission of GHG occurs in various stages of the life cycle i.e., production, transport, processing and preparation of food products. Food chains around the world are responsible for a large share of total emission of GHGs. Steinfeld et al. (2006) reported that 18% of global GHGs emission could be attributed to animal products alone. For the European Union, about 29% of GHG emissions are related to food consumption (EIPRO, 2006). Agriculture contributes about 13.5% of global emission (IPCC, 2007). In India, this sector contributes 18% of the total GHG emission (INCCA, 2010). The emissions from agriculture are primarily due to methane emission from enteric fermentation in ruminants (63%) and rice fields (21%), nitrous oxide from application of N through manure and fertilizer to agricultural soil (13%) and manure management and burning of crop residue (2.7%).

The Inter-Governmental Panel on Climate Change (IPCC) in its Fourth Assessment Report (AR4) pointed out that lifestyle changes and behaviour patterns can contribute to climate change mitigation across all sectors. In this context it is argued that reducing animal protein consumption can bring down GHG emission. Worldwide animal protein is being consumed at an increasing rate. Earlier this trend was limited to the developed world. But with rapid increase in purchasing power in recent decades in developing countries, animal protein consumption has gone up substantially. This trend will not only cause a major setback to global food security but also add to mounting emission of GHG.

The objectives of this article were to calculate carbon footprint of Indian food consumption, analyze the differences in GHG emission from vegetarian and non-vegetarian foods and estimate GHG emission at current and projected levels of food consumption in India. This will enable individuals to calculate carbon emission from the food they consume and develop safer options. Furthermore, the article indicates how these insights may be

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Table 1
Ingredients for one serving-portion of various food items commonly consumed in Indian households.

Food item	No./quantity	Ingredient (fresh weight, g)				Water for preparation (g)	Product fresh weight (g)	Product dry weight (g)
		Main	Oil	Vegetable	Spice/sugar			
Chapatti[a]	4	100				40	140	90
Bread[a]	2	60				20	80	54
Paratha[a]	2	100	5	50	5	60	220	144
Burger[a]	1	75	15	50	5	25	170	131
Rice (ordinary)	1 plate	100				45	145	88
Rice (basmati)	1 plate	100				40	140	88
Dosa[a]	1	50	5		5	50	110	53
Idli[a]	1	25				25	50	22
Pulse	1 cup	30	5		5	100	140	37
Sambar[a]	1 cup	30	5	15	5	100	155	51
Potato	1 cup	120	5		5	25	155	26
Cauliflower	1 cup	100	5		5		110	17
Brinjal	1 cup	100	5		5		110	13
Poultry meat	1 plate	100	10		10		120	39
Mutton	1 plate	100	20		10		130	39
Fish	2 pieces	100	10		5		115	33
Egg	1	50					50	25
Omlette	1	50	3		3		56	25
Milk	1 glass	250			5		255	33
Curd[a]	1 cup	100					100	10
Lassi[a]	1 cup	50			15	50	115	7
Butter[a]	1 spoon	10					10	8
Apple	1	100					100	15
Banana	1	100					100	10

Source: updated from Khanna et al. (1997).
[a] Main ingredients of these food items are wheat, rice, pulse and milk, respectively.

translated into GHG mitigation options with regard to food consumption.

2. Materials and methods

2.1. Common food items in India and their ingredients

India, being diverse in climate and culture, has wide diversity in consumption of food. For example, rice is preferred as a staple food in the eastern and southern regions whereas wheat is the staple food in the northern region. However, because of more urbanization and increasing income, food habits are changing and today's cosmopolitan Indians consume diverse food items. For this research the GHG emission in the various stages of the life cycle of 24 most common Indian food products was included. Table 1 shows the ingredients used to prepare these products. Requirement of primary and secondary ingredients for one serving-portion of various food items was calculated based on Khanna et al. (1997).

2.2. Emission of GHG during the life cycle of various food items

Basically four stages of life cycle of food products i.e., production, processing, transportation and preparation were considered in this study. The means of purchasing and storing by individual households were not considered. Similarly losses occurring during storage and handling during production were not accounted for. Food products from animal determined the CH_4 emission, while food products from crop determined the emission of CH_4 (from rice cultivation) and N_2O (from all crops). Emission of CO_2 occurred during farm operations, production of farm inputs, transport, processing and preparation of food.

2.2.1. Emission of GHG during production of the food

Data used to calculate CH_4 and N_2O emission factors of the main ingredients of the food products are given in Table 2. Methane emission for rice production (M_rice, kg kg^{-1}) was calculated using the following equation.

$$\text{M\_rice} = \frac{\text{E\_rice}}{\text{P\_rice}}$$

where E_rice is CH_4 emission (3.64 Mt) from 44.25 Mha of Indian rice fields (NATCOM, 2004) and P_rice is production of rice (93.4 Mt) (MoA, 2006a).

Emission of GHGs (except methane from rice) from crop production was calculated from the data generated through a series of field experiments conducted at Indian Agricultural Research Institute, New Delhi to quantify the GHG emission related to production of various crops (Pathak et al., 2002, 2003, 2005; Majumdar et al., 2002; Bhatia et al., 2004; Jain et al., unpublished).

Table 2
Emission of greenhouse gases due to production of various food products from crop and animal.

Crop/animal product	GHG emission (g kg^{-1})			
	CH_4	N_2O	CO_2	GWP (CO_2 eq.)
Wheat	0.0	0.3	45.0	119.5
Rice	43.0	0.2	75.0	1221.3
Rice, basmati	53.7	0.3	82.5	1515.4
Pulse	0.0	0.8	83.3	306.8
Potato	0.0	0.1	10.0	24.9
Cauliflower	0.0	0.1	13.3	28.2
Brinjal	0.0	0.1	12.5	31.1
Oilseed	0.0	1.3	50.0	422.5
Poultry meat	0.0	2.7	50.0	846.5
Mutton[a]	482.5	0.0	0.0	12,062.7
Egg	0.0	2.0	1.0	588.4
Milk[a]	29.2	0.0	0.0	729.2
Banana	0.0	0.2	10.0	71.6
Apple	0.0	1.0	41.7	331.4
Spice	0.0	2.5	100.0	845.0
Fish	25.0	0.3	18.8	718.3

Source: calculated from Bhatia et al. (2004), NATCOM (2004), Chhabra et al. (2009), Pathak et al. (2009b) and Jain et al. (unpublished).
[a] Emission of nitrous oxide and carbon dioxide for milk and mutton production was not considered as buffalo, cattle and goat in India are mostly fed with by-products of crops.