



Plant Based Proteins for Environmental Sustainability

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Abstract

Livestock production contributes 10 percent of India's greenhouse gas (GHG) emissions. Meat consumption has become one of the most contributing factors in climate change in two ways- first, through cows' emission of methane, a potent greenhouse gas, and second, by destroying forests as they are converted to grazing land, hence shift from animal proteins to green proteins are at forefront. Ayurved Research Foundation (ARF) a public charitable trust, conducting research in the areas of food safety, agriculture, hydroponics, AMR, animal health and nutrition, medicinal plants, soil and water health, waste to wealth management. Its 5 F (Food, Fuel, Feed, Fertilizer & Fodder) initiatives are oriented towards carbon footprint management and environmental sustainability.

Keywords: *Plant proteins, GHGs, Climate Changes, Meat Consumption, carbon footprint.*

Introduction

Worldwide observed and anticipated climatic changes for the twenty-first century and global warming are significant global changes that have been encountered during the past 65 years. Besides, the irregular weather patterns, retreating of global ice sheets and corresponding elevated sea level rise are among the most renowned international and domestic effects of climate change. With the onset of the industrial revolution, the problem of earth climate has amplified manifold. However, anthropogenic activities like excessive agricultural operations, which further involves high use of fuel based mechanization, burning of agricultural residues, burning fossil fuels, deforestation, national and domestic transportation sectors, etc., are currently regarded as most accountable for climate change which consequently, lead to climatic catastrophes, damaging local and global infrastructure, human health, and total productivity. Numerous agro-environmental and climatic factors that have a dominant influence on agriculture productivity are significantly impacted in response to precipitation extremes including floods, forest fires, and droughts [Abbass, K. *et al.*, 2022].

Ayurved Research Foundation (ARF) a public charitable trust, undertakes various initiatives

for the sustainable integration of livestock and agriculture for the benefit of farmers and society at large. Its 5 F (Food, Fuel, Feed, Fertilizer & Fodder) initiatives are oriented towards carbon footprint management and environmental sustainability. Biogas produced is being used as fuel for generating electricity for hydroponics machine which supports soil less crop production and water conservation. Organization also carries out awareness programme among farmers to stop stubble burning during the season. ARF is continuously working on one health for environment, people & animal through innovative technologies & methods.

Discussion

Livestock production contributes 10 percent of India's greenhouse gas (GHG) emissions. With growing meat consumption in fast-growing urban areas, Indian diets may fast become a global climate concern [Rao, N.D. *et al.*, 2018]. Worldwide, the consumption of food contributes a substantial part of the total energy used and the total greenhouse gases (GHG) emitted. However, the inefficiencies in livestock production reported by a number of authors also lead to large contributions of CO₂. Environmental impacts not directly related to climate change, such as water use and eutrophication or deforestation and

desertification can also be contributory factors from livestock production [Gonzalez, A.D. *et al.*, 2011]. Meat consumption has become one of the most contributing factor in climate change in two ways- first, through cows' emission of methane, a potent greenhouse gas, and second, by destroying forests as they are converted to grazing land [www.scientificamerican.com].

India has an abundance of protein rich foods such as pulses, soybean, legumes, seeds, nuts, and wheat which are excellent alternatives to meat proteins. As we race into new decade, it is no secret that plant based diets are on the rise and as the trend continues to grow, so too are the companies growing with vegetarian and vegan options within the food and beverage industry (*The Dawn of a Plant- Based Age - Plant Based Foods Industry Association*). Consumers are becoming very receptive to plant based meat substitutes. Amid the Covid-19 pandemic, the popularity of these products has surged as they are being perceived as immunity boosting food products. Now vegetarians can relish the taste of animal meat without consuming animal products.

At a time when we are facing the existential threats posed by climate change and are challenged with feeding our growing world population, optimism shines bright via the dynamic plant based foods industry. The power and influence of this industry has the potential to revolutionize the food system while presenting solutions that help us mitigate our collective impact on the climate

and provide better food security and nutrition for the world's population.

The plant-based foods industry in the U.S. has achieved unparalleled growth in recent years; generating over 7.4 billion USD in retail sales in 2021. The incredible innovation, surging consumer demand, and growing multi-stakeholder support show no sign of slowing, thus leading us to say that the growth will continue to be both accelerated and sustained.

The market for plant based foods in India is growing strongly, driven by an increase in access and products. The current plant based milk and meat markets are estimated to be \$20 million and \$30-40 million, respectively.

In most cases, meat production is proportionately more carbon expensive than the equivalent crop production for food energy. Total livestock supply chain contributes approximately 15% or 7.1 gigatonnes of carbon dioxide equivalent (CO₂-eq) per annum of anthropogenic GHGs [Graham, T. *et al.*, 2017]. Trends in the demand for meat matter for many reasons like meat can be an important source of nutrients for people on low incomes with restricted diets, but there is also evidence that high meat consumption may increase the risk for some types of chronic disease.

Among the food supply chain, meat and dairy (animal protein) production generates a significant amount of GHG emissions. Livestock alone represents at least 14% of the total world emissions.

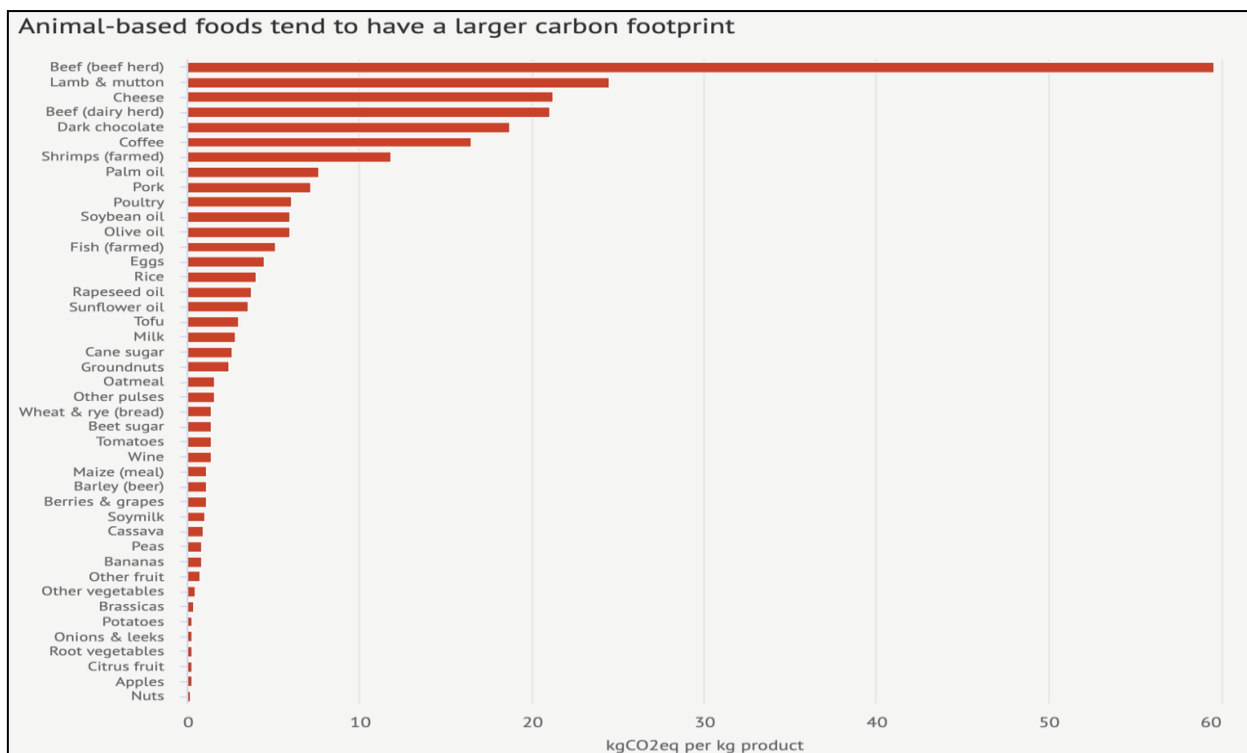


Figure1: Average greenhouse gas emissios produced per kilogram of meat and different food products (interactive.carbonbrief.org)

More than half of the emissions from food stems from livestock because a number production steps are carbon intensive. For example, to produce beef, everything that happens at the farm (methane emissions from cows, farm machinery) represents on its own 66% of the emissions. Land use change (initial deforestation to create a pasture, and subsequent soil contamination) represents 27% and animal feeding (growing crops to feed livestock) represents 3%. Meat produces more emissions per unit of energy compared with plant-based foods because energy is lost at each trophic level. The most important anthropogenic GHGs are carbon dioxide (CO₂), methane, and nitrous oxide (N₂O). Meat production results in the emissions of all three and is the single most important source of methane. This estimate suggests that meat production really matters in calculations of future global warming [Gaillac, R. *et al.*, 2021; Godfray, *et al.*, 2018]. The chart (Fig 1) compares the average greenhouse gas

emissions produced per kilogram of different food products and illustrates that producing beef is more than twice as carbon intensive as producing lamb meat [interactive.carbonbrief.org].

The increase in the consumption of animal products is likely to put further pressure on the world's freshwater resources also. The water footprint of any animal product is larger than the water footprint of crop products with equivalent nutritional value. The average water footprint per calorie for beef is 20 times larger than for cereals and starchy roots. For every kilogram of livestock meat grown, water of 20.7 tones is required for beef, 5.9 tones for pork and 4.5 tones for poultry for every kilogram of feed crops. The global average water footprint (**Table 1**) per ton of crop increases from sugar crops (roughly 200 m³/ton) and vegetables (300 m³/ ton) to pulses (4,000 m³/ ton) and nuts (9,000 m³/ ton).

Table 1: Water Footprint of Some Selected Food Products from Vegetable and Animal Origin [Mekonnen, M.M. *et al.*, 2012]

Food item	Water footprint per ton (m ³ /ton)				Nutritional content			Water footprint per unit of nutritional value		
	Green	Blue	Grey	Total	Calorie (kcal/kg)	Protein (g/kg)	Fat (g/kg)	Calorie (liter/kcal)	Protein (liter/g protein)	Fat (liter/g fat)
Sugar crops	130	52	15	197	285	0.0	0.0	0.69	0.0	0.0
Vegetables	194	43	85	322	240	12	2.1	1.34	26	154
Starchy roots	327	16	43	387	827	13	1.7	0.47	31	226
Fruits	726	147	89	962	460	5.3	2.8	2.09	180	348
Cereals	1,232	228	184	1,644	3,208	80	15	0.51	21	112
Oil crops	2,023	220	121	2,364	2,908	146	209	0.81	16	11
Pulses	3,180	141	734	4,055	3,412	215	23	1.19	19	180
Nuts	7,016	1367	680	9,063	2,500	65	193	3.63	139	47
Milk	863	86	72	1,020	560	33	31	1.82	31	33
Eggs	2,592	244	429	3,265	1,425	111	100	2.29	29	33
Chicken meat	3,545	313	467	4,325	1,440	127	100	3.00	34	43
Butter	4,695	465	393	5,553	7,692	0.0	872	0.72	0.0	6.4
Pig meat	4,907	459	622	5,988	2,786	105	259	2.15	57	23
Sheep/goat meat	8,253	457	53	8,763	2,059	139	163	4.25	63	54
Beef	14,414	550	451	15,415	1,513	138	101	10.19	112	153

When we look at the water requirements for protein, we find that the water footprint per gram of protein for milk, eggs and chicken meat is about 1.5 times larger than for pulses. For beef, the water footprint per gram of protein is 6 times larger than for pulses [Takefuji, Y, 2021; Mekonnen, M.M. *et al.*, 2012]. It is projected that between 2010 and 2050, the world demand for food will double alongside the growing population and, consequently, the demand for animal-based foods will increase by nearly 70%, particularly from ruminant meat (from cattle, sheep and goats) hence, transitioning towards more sustainable diets and exploring alternative protein sources have been at the forefront [Lonnie, M. *et al.*, 2020].

Plant protein is simply a meaningful food source of protein which is from plants [www.birdseye.co.uk]. Protein is the basic ingredient of food and is an abundant intracellular organic biomolecule with different polypeptide chains, also called macromolecules. Conjugated protein is formed by combining simple proteins with a non-protein or chemical substance. These types of proteins are lipoproteins, glycoprotein, nucleoproteins, phosphoproteins, hemoproteins, flavoproteins, metalloproteins, phytochromes,

cytochromes, opsins, and chromoproteins [sciencequery.com]. Natural proteins are obtained by isolation procedures depending on the physicochemical properties of proteins. Isolation and purification of single protein from cells containing mixtures of unrelated proteins is achievable due to the physical and chemical attributes of proteins. The following characteristics are unique to each protein: Amino acid composition, sequence, subunit structures, size, shape, net charge, isoelectric point, solubility, heat stability and hydrophobicity [Nehete, J.Y. *et al.*, 2013]. Foods of plant origin (Green Protein) are significant sources of anti-oxidative vitamins, minerals, unsaturated fats, complex carbohydrates, non-essential amino acids, and are unique or principal sources of vitamin C, folate, fibre and various non-nutrients, which are associated with prevention of chronic diseases as well as healthy lifestyle. As the name referred, plant-based proteins are found in the plant food sources, such as whole grain, legumes, and nuts, etc. [Krajcovicova-Kudlackova, M. *et al.*, 2007; Qin, P. *et al.*, 2022]. India is a leading producer of crops rich in protein and well positioned to supply both the national and international plant based foods sector. The country ranks as one of the top five producers for each of a core set of

plant proteins: chickpeas, lentils, millet, peas, rice, soybeans, and wheat. Analyzing pulses collectively, India is the largest producer by a significant margin, accounting for 24 percent of global production, followed next by Canada with 8 percent. India also stands alone in millet production, accounting for 41 percent of global production, with the next two top producers- Niger and China- producing less than half combined. Production over the last decade has grown for all key plant proteins, though the gains range widely.

Compared to animal derived foods, plant based foods have a substantially lower environmental footprint. Compared to ground beef burger, burger generates 89 percent fewer greenhouse gas emissions and 92 percent fewer aquatic pollutants while utilizing 87 percent less water and 96 less land per a comprehensive life cycle assessment. While life cycle assessments are not available for all plant based foods yet, the vast majority, relative to their animal derived counterparts, will have low environmental footprints based on the footprint of core ingredients. Pulses are protein rich and their production has low greenhouse gas footprint. What further sets them apart strategically is that they also fix atmospheric nitrogen and release high quality organic matter into the soil, reducing reliance on chemical fertilizers while rebuilding soils. Millets are hardy crops which require significantly less water to cultivate than rice, and thus can be rain-fed even in drier zones with less nutritive soils. They are easy to digest, highly nutritious, nonglutinous, and high in fiber. Furthermore, the diversity of millets in India - sorghum, pearl millet, maize, barley, finger millet and small millets such barnyard millet, foxtail millet, kodo millet, proso millet - reflect a ripe opportunity for product innovation and diversity [The Dawn of a Plant- Based Age - Plant Based Foods Industry Association].

Animal-based protein sources are generally considered complete protein sources for supporting indispensable amino acid requirements for human growth and

development. Plant proteins, however, may have insufficient levels of one or more indispensable amino acids. Protein Digestibility Corrected Amino Acid Score (PDCAAS) was developed in 1989 by a Joint FAO/WHO Expert Consultation on Protein Quality Evaluation to compare the indispensable amino acid content of a test protein (mg/g protein) to a theoretical reference protein thought to meet indispensable amino acid requirements (mg/g protein) for a given age group, creating a ratio known as the amino acid or chemical score. PDCAAS of most plant proteins may be less than 1.00, the individualized protein scoring system is only one way to evaluate the potential contributions of a protein to the diet. In the case of plant versus animal proteins, simply consuming more of the plant protein can help to provide higher indispensable amino acid intakes. Factors contributing to the rise in popularity of plant proteins include: potential health benefits in diseases like cardiovascular, diabetes, cancer, renoprotective effect, etc. [Hertzler, S.R. *et al.*, 2020]. Overall it can be concluded that mixtures of plant proteins can serve as a complete and well-balanced source of amino acids that effectively meet human physiological requirements [Young, V.R. *et al.*, 1994].

Conclusion

With growing meat consumption in fast-growing urban areas, animal based diets may fast become a global climate concern because livestock alone contribute to 14% of total emission of greenhouse gases. Among the food supply chain, meat and dairy (animal protein) production generates a significant amount of GHG emissions. More than half of the emissions from food stems from livestock because a number production steps are carbon intensive. The water footprint of any animal product is larger than the water footprint of crop products with equivalent nutritional value. Foods of plant origin are significant sources of anti-oxidative vitamins, minerals, unsaturated fats, complex carbohydrates, non-essential amino acids, and are unique or principal sources of vitamin C,

folate, fibre and various non-nutrients, which are associated with prevention of chronic diseases as well as healthy lifestyle. Plant protein is simply a meaningful food source of protein and are known to possess potential health benefits in various diseases like cardiovascular, diabetes, cancer, renoprotective effect, etc. Mixtures of plant proteins can serve as a complete and well-balanced source of amino acids that effectively meet human physiological requirements. In the case of plant versus animal proteins, simply consuming more of the plant protein can help to provide higher indispensable amino acid intakes. Compared to animal derived foods, plant based foods have a substantially lower environmental footprint. Overall it can be concluded that mixtures of plant proteins can serve as a complete and well-balanced source of amino acids that effectively meet human physiological requirements.

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