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Determination of Carbon Footprint of Selected Major Cereals

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ABSTRACT

A significant portion of the global population relies on cereals, a family of grasses, as their primary source of food that provide essential nutrients and energy. However, 30% of greenhouse gas emissions worldwide are now attributable to the global food system as a whole. When food is grown, transformed, packaged, transported, sold, and consumed, greenhouse gas emissions are created. Methane, nitrous oxide, and carbon dioxide are the three primary greenhouse gases. Hence, this study aims to investigate the carbon footprint associated with the production and consumption of cereals in Coimbatore, a bustling city in Tamil Nadu, India. To determine the carbon footprint, all stages of cereal production including cultivation, water consumption, land use and transportation were considered. Primary data is collected through surveys and secondary data from scientific literature, government reports, and databases. The carbon footprint of the foods was determined per year. The study result highlights that rice (1252.01 kgco$_2$e/yr)have a high carbon footprint when compared to other cereals followed by Italian millet (860.48kgco$_2$e/yr) which have high negative impact on environment whereas tender maize (100.35kgco$_2$e/yr) emits less carbon compared to others and has low impact on environment. By providing a comprehensive analysis of the carbon footprint of cereals in Coimbatore, this study helps to create awareness on the importance of sustainable agricultural practices. Legislators, cultivators, and other partners in the cereal supply chain may use the insightful information it provides to adopt focused actions aimed at reducing emissions and enhancing environmental sustainability.

Keywords : Carbon footprint, Cereals, Cultivation, Water consumption, Land use and Transportation

INTRODUCTION

A significant amount of dietary energy and nutrients are obtained from cereals and cereal products, which are staple foods in the majority of human diets in both developed and developing nations (McKevith, 2004; Kushiet *al.*, 2009; McIntosh, 2001). They make up over 75% of carbohydrates, mostly starches, and 6-15% protein. Globally, they account for more than 50% of the energy supply (WHO, 2003). The fact that cereal production, which totals around 2600 million tons annually, is the primary factor affecting global food security further supports the significance of cereals and cereal products (FAO, 2018).

Xuet *al.*, (2021) opines that grains constitute an essential part of the world's food systems and a vital source of nourishment for millions of people. However, there are environmental costs associated with the production and use of grains, chiefly in the form of carbon footprint and greenhouse gas (GHG) emissions. It's essential to comprehend and deal with cereals' carbon footprint in order to create sustainable farming methods and slow down global warming.

The Food and Agriculture Organization (FAO, 2018) estimates that 14% of the world's greenhouse gas emissions are related to agriculture, particularly the production of cereals. This covers emissions from changing land use, fertilization, crop cultivation, processing, shipping, and packing, among other phases of the grain production cycle. Significant volumes of methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2) are released during these operations. These gases are powerful contributors to climate change (Patiet *al.*, 2017; Mohapatra *et al.*, 2017).

It is essential to take into account every step of the manufacturing process, from seed to plate, in order to fully assess the carbon footprint of cereals. Changes in land use, especially the conversion of grasslands and forests to croplands, release a significant amount of CO_2 into the atmosphere. Commonly employed in cereal farming, synthetic fertilizers increase emissions of N_2O, a gas with a far greater warming potential than CO_2. Furthermore, the carbon footprint is increased by energy-intensive procedures related to transportation, automation, and irrigation (Yongchanget *al.*, 2018).

Balafoutiset *al.*, (2017) highlighted that lowering the carbon footprint of cereals necessitates a multifaceted strategy that includes advancements in technology, sustainable agricultural methods, and alterations in consumer behaviour. Important tactics for reducing emissions include promoting precision agricultural practices, minimizing fertilizer usage, implementing renewable energy sources, and enhancing supply chain effectiveness. Positive change may also be sparked by educating customers on the carbon footprint of cereals and promoting sustainable consumption practices. Therefore, the purpose of this study is to look into the carbon footprint related to the production and consumption of grains in Coimbatore, Tamil Nadu, India's busy metropolis.

MATERIALS AND METHODS

Selection of samples

According to Pingali., (2017),for a substantial proportion of the world's population, grains are important sources of nutritional value and dietary energy. These are adaptable crops that work well in a variety of climates and environments, making them appropriate for a wide range of geographical locations and cultural contexts. Furthermore, cereals are frequently inexpensive, the mainstay of daily meals, and a major weapon in the fight against hunger and malnutrition, particularly in poor nations. Totally 12 cereals that are often found in Coimbatore, such as Rice (*Oryza Sativa*), Wheat (Triticum Aestivum), Maize (*Zea Mays*), Italian millet (*Setaria Italica*), Sorghum (*Sorghum Bicolor*), Pearl millet (*Pennisetum Glaucum*), Barley (*Hordeum Vulgare*), Proso millet (*Panicum Miliaceum*), Finger millet (*Eleusine Coracana*), and Little millet (*Panicum Sumatrense*)have been chosen as the dietary category for the carbon footprint calculation.

Carbon footprint

The total quantity of greenhouse gas produced over a product's life cycle is known as its "carbon footprint." The Carbon Footprint has gained popularity and acceptance in scientific and industrial domains; however, since it is an output indicator pertaining to a single environmental effect, it must be complemented by the use of an all-encompassing input indicator to analyze biotic and abiotic material flows in a more comprehensive manner (Schmidt, 2008).

The data regarding the places where cereals are received for sales were collected. By using that data, distance from that place to Coimbatore was estimated and also data about the mode of transport, irrigation methods, such as fertiliser used, watering methods, harvesting methods, mode of vehicles used during the process and total yield of foodwere collected as secondary data.

Primary data is collected through surveys and secondary data from scientific literature, government reports, and databases. The carbon footprint of cereals and grains was determined for a year. The total emission factor of irrigation and transport for cereals and grains were applied in the carbon footprint formula.

The carbon footprint of the food ingredients were calculated per year by using the formula,

$$\boxed{\text{Carbon footprint} = \text{Consumption of items / day (kcal/day)} \times 365 \times \text{Emission factor (kgco}_2\text{ekcal)}}$$

(Formula - 1)

Whereas here,

Consumption of items / day (kcal/day) - The energy in kcal of selected food items consumed by the subjects, the energy was calculated for each food items using IFCT nutritive value book (2017).

365 - Number of days in a year

Emission factor - Adjusted daily emission factor for a particular harvested area

RESULTS AND DISCUSSION

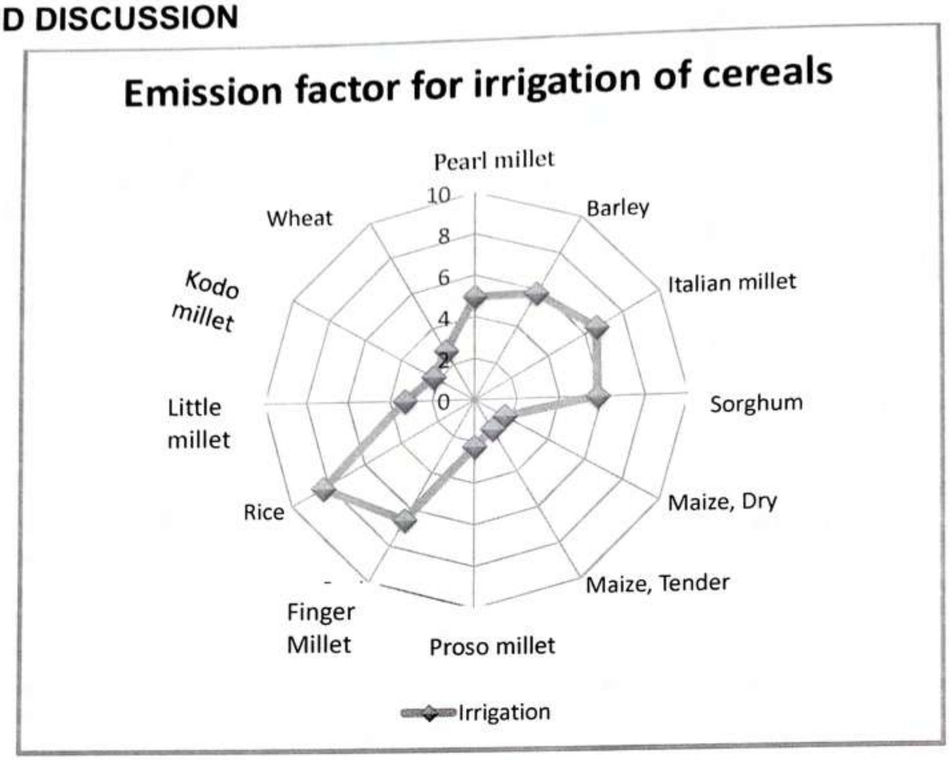

FIGURE I : Emission factor for irrigating the cereals

Figure I presents emission factor for irrigating the cereals and highlighted that the emission factor for irrigation of maize was lower and emits less carbon when compared to others and emission factor for irrigation of rice was higher and emits more carbon during irrigation when compared to others.

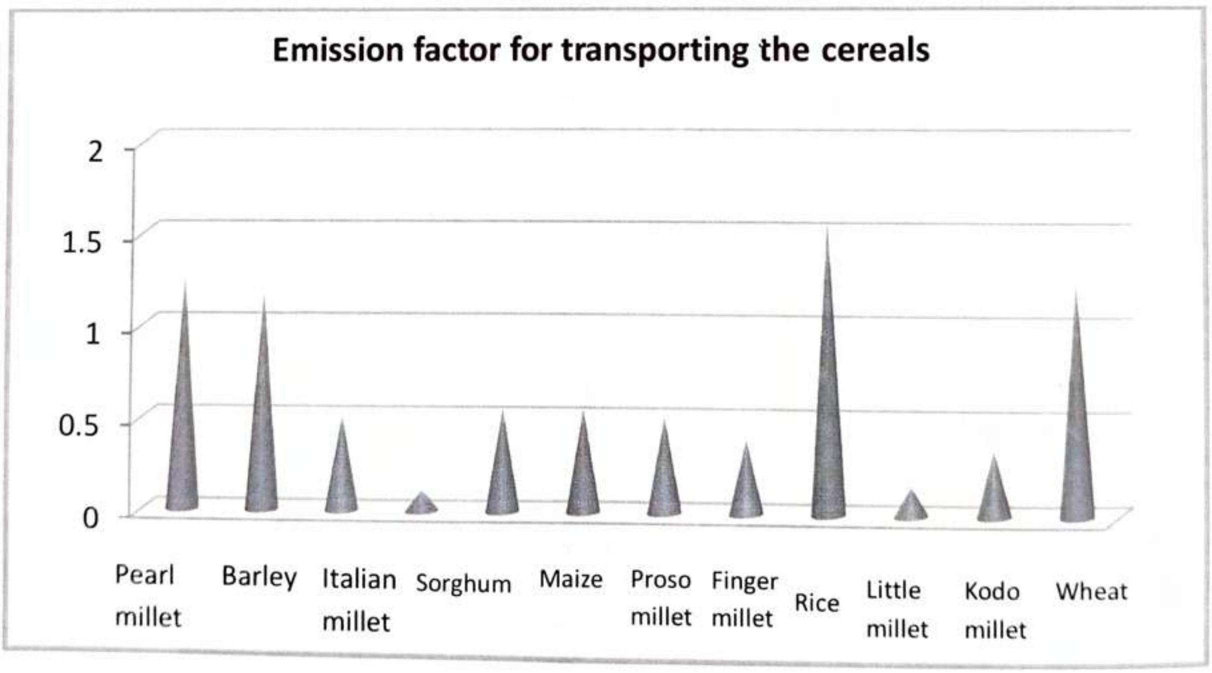

FIGURE II : Emission factor for transporting the cereals

Figure II provides Emission factor for transporting the cereals. It shows that the emission factor of jowar was lower and the emission factor of rice was higher followed by wheat than others.

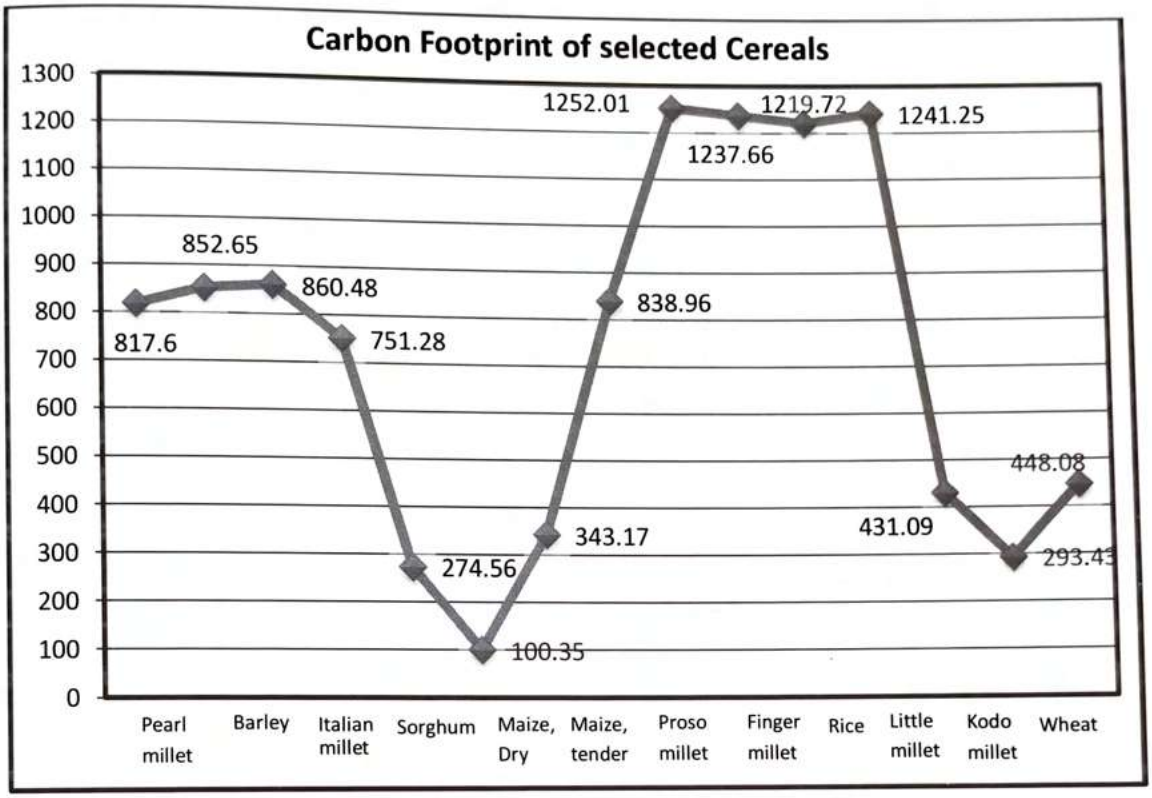

FIGURE III : Carbon Footprint of selected Cereals

The data elucidated in figure III reveals that the carbon footprint of parboiled milled rice was higher compared to all the other cereals followed by raw milled rice and which was clear that these cereals have high negative impact on environment and should be consumed in lesser quantity. And also shows that tender maize have lesser carbon footprint and less impact on environment which can be recommended in higher quantity.

DISCUSSION

The findings indicate that each package of 4 kilogramme of polished rice has a 7.7 $kg^{-6}CO_2eq$ carbon impact. Production of raw materials has a significant impact, particularly regarding methane emissions from paddy fields (Yoshikawa., 2010).

Agricultural activities are responsible for more than 10% of the anthropogenic emissions of CH_4, with rice fields making up the majority of these releases (Scheehle and Kruger, 2006). In continuous flooding settings, the carbon emission in rice varies between 21.96 and 60.96 Tg C yr^{-1} due to variations in urea doses, as reported by Pathak*et al.* (2012).

Blengini and Busto (2009) estimated rice has a 2.90 kg CO_2-e kg^{-1} yield carbon footprint from sowing to the farm to gate. The Intergovernmental Panel on Climate Change (IPCC, 2007) estimates that Egypt's rice fields produce between 20 and 100 Tg annually on average to global emissions. This amounts to around 5–20% of total CH_4 emissions originating from human activities. Measurements were taken in paddy fields in the US, Spain, Italy, China, India, Australia, Japan, and Thailand (IPCC, 1997).The primary contributors to this carbon footprint are the methane produced by flooded rice (67%) and the deforestation brought on by the continuous use of 149 000 hectares of hillside slash-and-burn land for rice farming (29%) (Bockel*et al.*, 2010).

As to a research conducted by Cheng *et al.* (2011), the average carbon intensity in China changed between 1993 and 2007 for cultivated lands, ranging from 0.64 tCE ha/yr to 0.92 tCE ha/yr, and between 1993 and 2007 for total production, which was 0.11 tCE t/yr.

In addition to other pollutants including carbon monoxide (CO), particulate matter (PM), and dangerous polycyclic aromatic hydrocarbons (PAHs), burning rice residue is another source of emissions that generates carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (Lemieux *et al.*, 2004).

CONCLUSION

The carbon footprint of cereals, encompassing the entire production chain from cultivation to consumption, is a significant environmental concern in the context of sustainable agriculture and climate change mitigation. This article has provided insights into the factors contributing to the carbon footprint of cereals.Efforts to reduce the carbon footprint of cereals require a multi-pronged approach. Sustainable farming practices play a crucial role in emissions reduction. Precision agriculture techniques, such as optimized nutrient management and water conservation, can minimize the use of synthetic fertilizers and irrigation-related emissions. Conservation tillage and soil carbon sequestration practices can further contribute to mitigating emissions. Innovation in post-harvest processes, such as adopting renewable energy sources for processing and transport, utilizing sustainable packaging materials, and shortening supply chains, can also help reduce emissions. These steps not only lower the carbon footprint but also promote overall resource efficiency and resilience in the cereal industry.

Consumer choices and behaviour have a significant impact on the carbon footprint of cereals. By making informed decisions, such as opting for sustainably produced cereals, reducing food waste and supporting local and seasonal produce, consumers can contribute to emissions reduction. Policy interventions and industry initiatives are crucial for driving systemic change. Government regulations can incentivize sustainable farming practices; promote renewable energy adoption, and support research and development for low-carbon technologies. Industry collaborations, certification schemes, and labelling initiatives can further encourage sustainable practices across the cereal supply chain.

While progress has been made in understanding and addressing the carbon footprint of cereals, further research is needed to refine measurement methodologies, evaluate regional variations, and assess the effectiveness of mitigation strategies. Additionally, ongoing monitoring and assessment of the carbon footprint of cereals will be essential to track progress and inform future sustainability efforts. In conclusion, mitigating the carbon footprint of cereals is essential for achieving sustainable agriculture and combating climate change. By implementing sustainable farming practices, adopting innovative technologies, promoting responsible consumption, and enacting supportive policies, it is possible to reduce emissions and create a more resilient and environmentally friendly cereal industry. Collectively, these efforts will contribute to a more sustainable and climate-resilient future.

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