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Carbon foot print analysis: A tool for sustainable food process development

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Abstract
Reducing greenhouse gas emissions and primary energy use are the important steps for sustainable production of processed foods and development of food process industries. Maintenance of GHG emissions and energy consumption are increasing the competitiveness of food industries at global level. Evolution of CO_2 emissions illustrates the necessity for each state to plan more sustainable energy future.

Keywords: Greenhouse gas, carbon foot print, food industries, CO_2

1. Introduction

Nowadays demand for high quality, safe, nutritious processed foods is increasing due to urbanization and affluence of the people. Besides that, awareness on water scarcity, carbon neutral and environmental factors are increasing. Since the food industries are becoming globalised, it is necessary for analyses of environmental, social and economical factors. This creates colossal burden on food industries to develop a sustainable processing methods for food processing to reduce the water consumption and carbon emission. This process must address both economic and social sustainability to food industries along with the environmental sustainability. For ensuring the sustainability of food industries, an integrated approach for monitoring environmental performance, regulatory compliance and consumer communication must be made. This integrated approach will change the global food processing system. Past studies of LCA and carbon foot print analysis on foods is presented in the table 1.

Carbon foot print analysis is a process of measuring the amount greenhouse gases (GHG) released during processing and indicated as equivalent carbon dioxide (eCO_2). Each greenhouse gas (GHG) persists for a different length of time and has a different global warming potential (GWP). The carbon footprint of food processing is an estimate of all the emissions caused during processing of food products i.e. raw material to finished products. Food processing system emits CO, CO2, N_2O, HFC's, PFC's, SO_2, SF_6 etc. carbon footprints helps the manufactures to identify the steps to save energy and consumers to choose environmental friendly products. Carbon foot prints are analyzed for 1.To manages the footprint and reduce emissions over time, and 2. To fulfill requests of third parties like business or retail customers, and investors for marketing and Corporate Social Responsibility (CSR).

2. Scope of the carbon foot print

Carbon foot prints are values of carbon emission as pollutant into the atmosphere during each operation of food processing. Carbon emission is calculated by taking average of emission in the operations. World Resources Institute and World Business Council for Sustainable Development developed the protocol for emission of GHG that is the most used standard for measuring carbon emissions (Wiedmann and Barrett, 2011) [20]. Globally, there are available several databases for emission factors, among which the IPCC (Melanta, 2010) [11]. IPCC also developed a methodology for quantifying GHG emitted by system and that is used for the amplification of GHG inventories on national level. Commonly the IPCC database is used by all activity sectors at national level, organizational level and individuals (Lundie *et al.* 2009) [7]. Wiedmann *et al.* (2007) [21] described two methods to calculate the carbon footprint using LCA: process analysis (PA) and Environmental Input-Output Analysis (EIO).

The process analysis is a bottom-up approach to analyze a product from creation to the end of its life, taking into account direct and some secondary emissions, but having the disadvantage of double counting. EIO involves a top-down approach and is applied on sectoral level, expanding boundaries and eliminating the problem of double counting. So before calculating the carbon emission, the scope and boundary of the process must be described.

Table 1: Carbon foot print analysis and LCA on foods

S. No	Title	Reference
1	Life cycle boundaries and greenhouse gas emissions from beef cattle	Dudley (2012) [5]
2	Greenhouse gas emissions from Swedish production of meat, milk and eggs 1990 and 2005.	Cederberg (2009) [3]
3	Comparing environmental impacts for livestock products: A review of life cycle assessments.	de Vries and de Boer (2010) [4]
4	The price of protein: Review of land use and carbon footprints from life cycle assessments of animal food products and their substitutes.	Nijdam *et al*. (2012) [13]
5	Carbon footprint of livestock production – variations and uncertainties.	Röös and Nylinder (2013) [18]
6	Life cycle assessment in the food supply chain: a case study	McCarthy *et al*. (2015) [9]
7	Life cycle inventory and carbon and water foodprint of fruits and vegetables: application to a Swiss retailer.	Stoessel *et al*. (2012) [19]
8	Life cycle assessment of cassava flour production: A case study in Southwest Nigeria.	Olaniran *et al*. (2017) [15]
9	Life cycle assessment of pasta production in Italy.	Bevilacqua *et al*. (2007) [2]
10	Environmental impacts of organic and conventional agricultural products–Are the differences captured by life cycle assessment?	Meier *et al*. (2015) [10]
11	Analysing the carbon footprint of food	Röös (2013) [17]
12	Life cycle assessment in the cereal and derived products sector.	Renzulli *et al*. (2015) [16]
13	Life cycle assessment in the agri-food sector. Life Cycle Assessment in the Agri-food Sector	Notarnicola *et al*. (2015) [14]
14	Life cycle and economic assessment of Western Canadian pulse systems: the inclusion of pulses in crop rotations.	MacWilliam *et al*. (2014) [8]
15	Carbon footprint and energy use of food waste management options for fresh fruit and vegetables from supermarkets.	Eriksson and Spångberg (2017) [6]
16	Life cycle environmental impacts of carbonated soft drinks.	Amienyo *et al*. (2013) [1]

Scope 1: Direct Emissions

Direct emission is releasing of greenhouse gases (GHG) such as carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) as well as ambient air pollutions from the stationary combustion Sources such as boilers, burners, turbines, heaters, furnaces, ovens, dryers internal Combustion Engines, electricity Generator. Further emissions from all the other units, physical building boundary and mobile combustion sources such as road transport, air transport, water transports which are providing transportation services within the physical boundary which releases the GHG due to combustion should be accounted. Some of the organizations emit the GHG directly like methane, So_2, N_2O nitrous oxide etc.

Scope 2: Indirect Emissions

Indirect emission is releasing of GHG from the use of energy from electricity for heating and cooling, steaming and electricity purchased for operating mobile combustion sources. During cooling, Hydrofluorocarbons (HFC) and perfluorocarbons (PFC), which are commonly used in refrigeration and air conditioning sectors, are GHGs with global warming potentials (GWP) much higher than that of carbon dioxide.

Scope 3: Other Indirect Emissions

Each product or service that is purchased by an organization is responsible for emissions. So the way the organization uses products and services affects its carbon footprint. For example, a company that manufactures a product is indirectly responsible for the carbon that is emitted in the preparation and transport of the raw materials. Downstream emissions from the use and disposal of products can also be indirectly attributed to the organization.

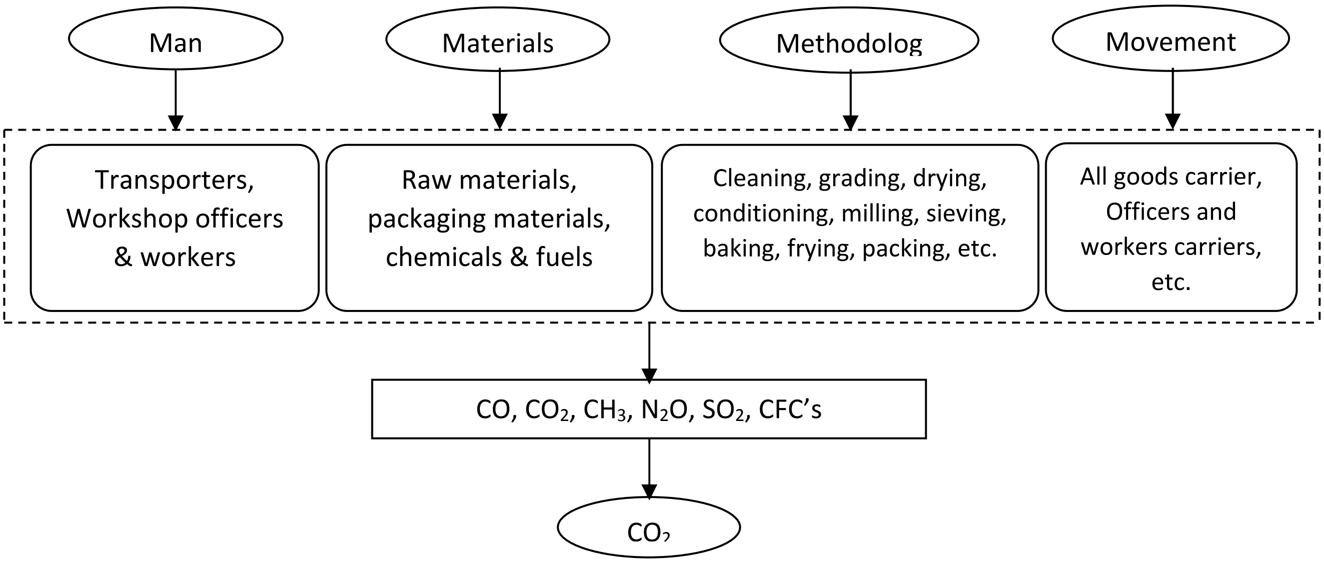

Fig 1: Methodology of the carbon foot print analysis

Table 2: Model Data collection table

Steps	Operation name	Man	Materials	Methodology	Movement
1	Reception				
2	Storage				
3	Cleaner				
4	Scourer				
5	Magnetic separator				
6	Washer –stoner				
7	Tempering				
8	Blending				
9	Entoleter				
10	First break roller				
11	Sevier				
12	Reducing roller				
13	Wheat flour				

3. Methodology

Measurement of carbon emission can be done by defining the scope and boundary of the process as shown in the figure 1. PAS 2050, GHG Protocol and ISO 14067 are the three commonly used methods established through ISO 14040 and ISO 14044 for analyzing carbon footprint of the product and standards applicable to the product (Muthu, 2015) [12]. These methods are established based on these methods are developed on existing life cycle assessment LCA methods and which consists the goal and scope definition, data collection strategies, and reporting.

According to process steps, a data sheet is prepared for collecting data (Table 2). The process steps within the boundary of the work are verified by on site verification. Data can be collected for calculating carbon foot print analysis can be obtained from primary and secondary data. Primary data can be collected by personal observation in the field, interview and questionnaire. Secondary can be collected in the form of published and unpublished data from publications of government, organization, trade journal, public records, websites and shed. All collected data are verified, entered in to the spread sheet. Before analysis, data are checked for its suitability, reliability, and adequacy. Emission of CO_2 is calculated using the formula. Some of the Equivalent factor (kg CO_2) per unit is given in the Table 3.

$$\text{Amount of } CO_2 \text{ by material} = \sum \text{Materials used, kg} \times CO_2 \text{emission factor}$$

$$\text{Amount of } CO_2 \text{ by methology} = \sum \text{Energy consumed, kWh} \times CO_2 \text{emission factor}$$

$$\text{Amount of } CO_2 \text{ by movmetn} = \sum \text{Distance travelled, km} \times CO_2 \text{emission factor}$$

4. Conclusion

In this paper, the importance, scope and boundary, methodology and use of carbon footprint analysis in food industries is presented. This study demonstrated that how to approach the carbon footprint analysis in food processing sector. Analysis of carbon foot print is very important in food industries to increase the market potential, augment the reputation of products, enhance the engaging with suppliers, and other stakeholders. Furthermore it is an important process to study the environmental assessment comprehensively.

Table 3: Equivalent factor (kg CO_2) per unit

Electricity	Unit	Emission factor (kg CO_2 eq per unit)
Energy		
CNG	kWh	0.18
Crude oil	kWh	0.27
Diesel	kWh	0.30
Diesel	liter	2.79
Kerosene	kWh	0.27
LPG	liter	1.69
Biogas	kg	1.61
Biomass	kg	0.11
Steam	kg	0.61
Building		
Glasswool	kg	1.35
Insulation	kg	1.86
Mineral wool	kg	1.20
Wool	kg	0.15
Cement	kg	0.89
Concrete	m3	263.00
Reinforced concrete	kg	0.36
Cast iron	kg	1.51
Reinforced steel	kg	1.49
Stainless steel	kg	6.15
Aluminium	kg	8.14
Copper	kg	2.77
Glass	kg	0.85
Paper	kg	2.42
HDPE	kg	1.10
Water	m^3	0.03
RF bulk large	t.km	0.01

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