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REVIEW

Sustaining the shelf life of fresh food in cold chain – A burden on the environment

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Abstract Energy consumption in cold chains has been predicted to rise significantly in view of the increasing world population. Of critical attention is the increasing number of road transport refrigeration which is highly gaining enormous ground globally. In view of the fact that 40% of all foods require refrigeration, 15% of world fossil fuel energy is used in food transport refrigeration. This concern necessitates this study to examine cold chain system with the emphasis on the impact of energy consumption in sustaining the shelf life of fresh food. As the world continues to battle with the global warming occasioned by emission of carbon dioxide from fossil fuel, this study identifies alternative means of saving energy in food transportation system through minimizing energy consumption in diesel engine driven vapour compression system. Preserving perishable fresh food (mainly vegetable) under sub-zero weather is another debacle the authors envisaged in the quest to reduce fossil fuel consumption. This process requires heating the mechanical refrigeration unit in a reverse-cycle to raise the temperature at 0 °C which may further result in more energy demand. The conclusion drawn from this study could be useful in re-designing food transport system for optimal energy saving.

Contents

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1. Introduction

Prolonging shelf life of fresh food is vital in sustenance of perishable raw food items. Preserving food is prevalent in the world today as most homes engage in these practices through refrigeration system [35]. Food transport system is another medium of conveying fresh raw food to a possible distant location and it is expected the transportation channels are kept at low temperature conditions (−4 °C to 4 °C) to prolong shelf life and maintain quality of the products. In view of the importance of food transport refrigeration system, United Nation adopted an inter-governmental Agreement on Transportation of Perishable food stuff (ATP) and this agreement provides a specification on insulated body and equipment [31]. Refrigerated vehicles body walls are insulated against heat transfer from ambient temperature into the cooling chamber and ATP developed a blueprint for insulations and equipment to reduce payload on vehicular engine. This agreement classifies transportation equipment (insulation and body wall) as either normally insulated (where the overall heat transfer coefficient U is equal or less than 0.7 W/m^2 K) or heavily Insulated (in which U coefficient equals to or less than 0.4 W/m^2 K). This agreement appeared to have provided the platform for insulating the body wall and despite this regulation, energy consumption in cold chain is still a global challenge and it is reported to account for 30% of total world energy consumption [23]. In the same vein, Meneghetti and Monti [27] have reported that over 40% of all food require refrigeration and about 15% of the same food are being refrigerated due to energy shortfall. In the study conducted by Glouannec et al. [18], it is reported that there are estimated 4 million food transport vehicles in the world and predicted 2.5% increase in the global road freight transport by 2030. This prediction is catastrophic considering the environmental impact of cold chain in view of its energy consumption and emerging implication.

World leaders are currently faced with the challenge of climate change and every resources are being deplored to mitigate its impact on the environment. Sustaining the nature and the climatic environment is a big task to avoid impending and looming danger. Many researchers [2,28] have predicted that the world may naturally go into oblivion if sustainable and pragmatic steps are not taken to reduce fossil fuel consumption which is widely acknowledged to be the major source of carbon emission. Diesel engine driven vapour compression system accounts for huge fuel drain in transport system. A significant CO_2 emission from the refrigerant leakage has equally been source of concern in food transport system. Tassou et al. [31] have studied diesel engine driven vapour compression refrigeration system and concluded that 40% of the greenhouse gas emission results from vehicle's engine and refrigerant leakage. Multi-drop temperature controlled refrigeration system is reported to consume more energy in food chain due to air infiltration as a result of frequent door opening. Table 1 shows CO_2 emission from vehicle engines using an emissions factor for diesel of 2.668 kg CO_2 per litre. For a 38 ton articulated vehicle class, the CO_2 emission of 58 kg CO_2/pallet-km is recorded while 115 kg CO_2/pallet is reported for multi-drop frozen medium rigid vehicle class. Also, CO_2 emission from refrigerant leakage is also a cause of concern to many environmentalists [26,20]. Based on the above, alternative refrigerant may be the best option for refrigerant R404A which has been criticized to be a major contribution to global warming in view of its incessant leakage which could raise the CO_2 emissions from food transport system up to 40% from the vehicle engine (see Table 2). Finnveden et al. [15] have similarly reported 21% of annual refrigerant leakages which is also in the range predicted by Tassou et al. [31]. This study gives the impact of food preservation system on the environment in view of the energy consumption associated with the process. Energy utilisation is a key to social modernization and efforts must be intensified to adopt best international practices to combat climate change which is now a global monster.

2. Energy consumption in cold chain

Preserving quality of fresh food involves a multi-dimensional chain system in which these foods are refrigerated at a lower temperature condition. Different temperature requirements

Table 1 Potential carbon emission from refrigerated vehicles excluding refrigerant leakage (g CO_2/pallet-km) [31].

Category of vehicle	Room condition or ambient	Single drop (chilled)	Multi-drop (chilled)	Single-drop (frozen and varying temperature condition)	Multi-drop (frozen and varying temperature condition)
Medium size	88	106	109	112	115
Large class	85	102	105	108	111
32 ton articulated vehicles	56	69	70	73	75
38 ton articulated vehicles	51	61	63	65	67