REDUCTION OF CARBON FOOT PRINT IN LONG DISTANCE MILK TRANSPORTATION BY CONCENTRATION TECHNIQUES LIKE REVERSE OSMOSIS AND EVAPORATION

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Introduction

Today, one aspect in which all countries in the world, whether developed or developing, have unarguably agreed upon is "How to reduce global warming by controlling greenhouse gas (GHG) emissions?

The total quantity of GHG emissions caused by an organization, event or product is known as **'Carbon Footprint'** and is expressed in terms of the amount of carbon dioxide or its equivalent of other GHGs, emitted.

The Food and Agricultural organization (FAO) report of 20th April 2010 assesses dairy GHG emissions at ~ 4% of global anthropogenic GHG emissions. This figure includes emissions associated with production, processing and transportation of milk products as well as those related to meat production from dairy animals. Considering just global milk production, processing and transportation and excluding meat production, the sector contributes 2.7 % of global anthropogenic GHG emissions.

In this context, we shall discuss about GHG emissions related to milk processing, especially concentration techniques and its influence in long distance transportation of milk in India.

Need for Pasteurized Chilled Milk Transportation in India

India is the largest milk producer in the world with an estimated milk production of 108.5 MT per annum in 2008-09, accounting for 16 % of global milk production. Even though, India is self sufficient in milk production, the availability of milk varies from place to place and hence within the country there are states with surplus and deficit in milk. This coupled with rapid urbanization and increased health awareness have resulted in higher demand for the fluid milk in metro cities like Delhi, Mumbai, Kolkata and Chennai. The demand in metro cities are met by milk transported from the interior parts of the states as well from Gujarat, Andhra Pradesh, Maharashtra, where milk is in surplus.

Case study of GHG emission in concentrated milk and unconcentrated milk transportation

Milk for Delhi market is regularly transported from places like Gujarat and Andhra Pradesh involving distance that ranges from 1000 - 2000 km. In most cases, the milk is transported in the form of pasteurized milk without concentrating. The long distance transportation makes it important to find ways to reduce transportation costs and GHG emissions.

Milk can be concentrated through multi-effect TVR/MVR based falling film evaporator or modern membrane technology (i.e. Reverse Osmosis - RO). Even though, theoretically whole milk can be concentrated to 48 % TS in an evaporation plant for producing milk powder, the limit for transportation at 2°C is ~ 30 % TS. This is

Table 1 : Processes involved in the transportation of market milk, with and without concentration.

Process	Un-concentrated Milk	Milk concentrated by	
		Evaporation	Reverse Osmosis
Pre-transportation	Pasteurization and chilling – 4°C	Pasteurization and chilling – 4°C	Pasteurization and chilling – 4°C
	-	Concentration by evaporation (28% and 4°C)	Concentration by Reverse Osmosis (28% and 4°C)
	Deep Chilling - 2°C	Deep chilling of concentrate – 2°C	Deep chilling of concentrate – 2°C
Transportation	Transportation	Transportation	Transportation
Post-Transportation	-	Dilution with DM/R.O water	Dilution with DM/R.O water
	Re-pasteurization, Standardization and packing	Re-pasteurization, Standardization and packing	Re-pasteurization, Standardization and packing

due to higher viscosity of chilled concentrate and to avoid fat separation during transportation.

Whole milk can be concentrated with RO to a level of 25 - 30% TS and it equals to 2-2.4 times volume concentration factor (VCF) for an initial solid content of 12.5 %. RO is a pressure driven membrane separation technique in which membranes are used to separate different components in a fluid, based on their molecular size. RO membranes have pore size less than 0.001 μ and operating pressure range of 400-1000 psi is used to force the water out.

RO avoids the phase change unlike evaporation technique, preserves the functional properties of proteins and the product does not develop cooked flavor. The processing temperature of whole milk is typically less than 6°C and at which fat molecules are not ruptured and hence no rancid flavor in the concentrated milk.

It is to be noted that the extra activity involved in the concentrated milk transportation are concentration and diluting with RO/DM water. Other activities are common for all the three options.

Impact of CO_2 emission for processing and transportation of 2,00,000 LPD pasteurized chilled milk (80% full cream milk with 15.4% TS and balance 20% toned milk with 12% TS) vs equivalent milk solids in the concentrated form (96,500 LPD of 28% TS) is worked out (Refer Annexure-I) and the conclusions are as given below:

1) CO_2 emission was higher in the case of pasteurized milk transportation, followed by concentrated milk by evaporation and then by R.O. The CO_2 emission values are 1: 0.9:0.69, in that sequence.

2) Membrane filtration technology is the right choice; the question is whether or not it is tested and proven in India. The Dairy industry has started realizing the hazards of CO_2 emission and GEA process engineering India (Pvt) Ltd, hopes to have successful trial run by this year end for whole milk concentration and transportation.

Annexure-I

Calculation for CO_2 Emission

Assumptions

1. Milk transported per day : 2,00,000 LPD
2. Composition of Milk : 80 % full cream milk with 15.4 % TS and 20 % toned milk with 12 % TS
3. Concentrated milk transported per day : 96,500 LPD of 28 % TS
4. One way transportation distance = 1000 km.
5. Milk is concentrated either by 5–effect TVR based evaporation plant or in R.O plant at feed rate of 10,000 LPH.

The process–wise emission of CO_2 for all the three options of milk transportation are given in Table 2.

References

- http://en.wikipedia.org/wiki/Carbon_footprint
- http://www.fao.org/news/story/en/item/41348/icode/
- World Dairy situation 2008, IDF Bulletin 432.
- Emission facts: Average carbon dioxide Emissions resulting from gasoline and diesel fuel. http://www.epa.gov/otaq/climate/420f05001.htm

Table 2 : The process–wise emission of CO_2 for all the three options of milk transportation.

Sr. No.	Utilities Name	CO_2 emission	Remarks
1	Power generation using 50 % coal and 50 % natural gas	777 gm - CO_2 Eq / KW - hr	CO_2 emission of coal and gas based plants are 955 and 599 gm - CO_2 Eq / KW-hr respectively.
2	Steam generation through Furnace Oil (FO)	205 gm - CO_2 Eq/Kg	Steam produced is 13 Kg/Kg of FO
3	Cooling load per ton of Refrigeration	1166 gm - CO_2 Eq / TR	Power consumed is 1.5 KW/TR
4	Tanker using diesel as fuel	658 gm CO_2 Eq / Litre	Average fuel consumption is 4 km/lit.

Note: The CO_2 emission through activities like transportation of raw milk, raw milk chilling, milk pasteurization, standardization, re-pasteurization and re-standardization, packed milk storage and transportation are excluded from the calculation.

Table 3 : GHG Emission for unconcentrated and concentrated milks for transportation

Sr. No	Process	Elements	Emission (CO_2- gm-Eq / Unit)	Pasteurised Milk (Without Concentration)		Milk Concentrated through			
						R.O		Evaporation	
				Consn. Fig.	CO_2-Emission (Kg)	Consn. Fig.	CO_2-Emission (Kg)	Consn. Fig.	CO_2-Emission (Kg)
1	Pre-transportation	Power - KW-hr	777	-	-	1517	1179	570	443
		Steam- Kg	205	-	-	336	69	19000	3902
		Chilled Water - TR	1166	-	-	291	339	-	-
2	Transportation	Diesel - Lit.	2664	5000	13320	2406	6411	2406	6411
3	Post -transportation	Chilled Water - TR	1166	-	-	892	1039	892	1039
		Power - KW-hr, R.O. Water	777	-	-	187	145	187	145
4	Total CO_2-Emission				13320		9181		11,940
5	CO_2- Emission Ratio(*)				1		0.69		0.9

(*) Note: The ratio is calculated with reference to maximum value.