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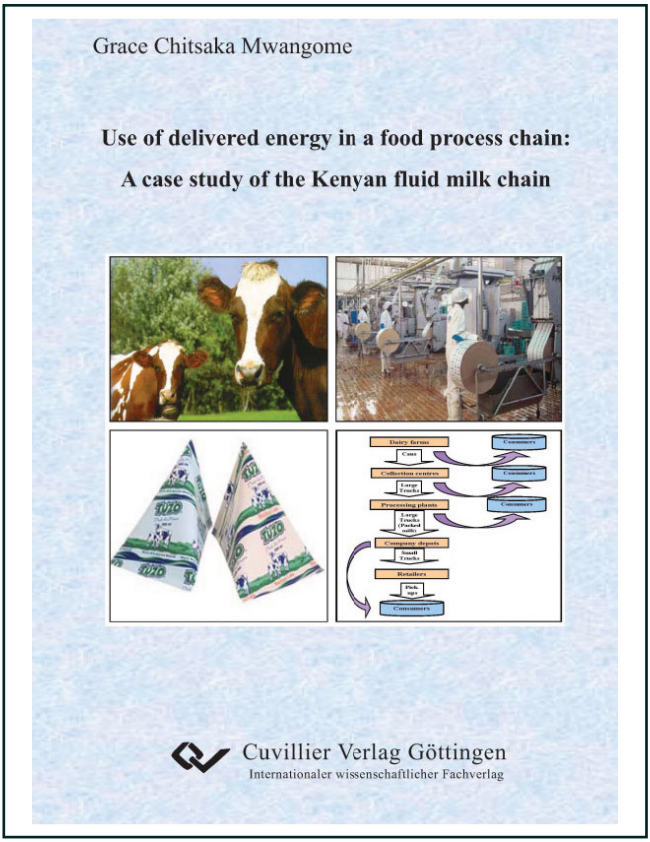
Use of delivered energy in a food process chain: A case study of the Kenyan fluid milk chain



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1 General Introduction

1.1 An Overview of the Kenyan dairy industry

Kenya is a country named after the second highest mountain in Africa, standing at 5,199 metres above sea level. Kenya covers an area of about 582,650 square Kilometres and is located in the East African region 1 00N and 38 00E; it borders Ethiopia and Sudan to the north, Somalia to the east, Tanzania to the southwest and Uganda to the west. It also borders the Indian Ocean to the southeast. The country has seven (7) administrative provinces and one (1) area. The population is estimated at 35 million people with a 2.6% (2006) population growth rate. Kenya also hosts an estimated 250,000 refugees from neighbouring countries.

Agriculture plays an important role in the country's economy as it composes 16.3% of the gross domestic product (GDP) and involves 74.6% of the population. The livestock sector contributes 7% of the GDP (IFC, 2006). Of the total land area, 46% is under cultivation and 80.5% under pasture. Kenya's economy comprises more imports than exports; she is a net but modest importer of meat and milk (FAOSTAT, 2005). Kenya is among the leading dairy producing countries in Africa and is reported as being largely self-sufficient in milk production, except during dry spells (KDB, 2007; Reynolds *et al*., 2003). Currently, 3.5 billion litres of milk are produced per annum by a dairy herd of 3.3 million cows; although this is sufficient for domestic consumption, a lot more is needed for export (IFC, 2006). Dairy production is an important source of livelihood for about 625,000 small-holder farmers who contribute 56% of Kenya's milk and over 70% of all marketed milk. It is estimated that more than 2 million people are employed in the sub-sector in one way or another (EPZ, 2005 and Omore *et al.,* 2004). Therefore, any factors affecting this sub-sector affect many small-scale business people and farmers. Similarly, any growth in this sub-sector will lead to growth in the whole economy (IFC, 2006).

Before 1954, commercial dairy production was the sole preserve of the white farmers living in the "white highlands" of the Rift Valley and around the Nairobi area. The period after independence in 1964 was marked by a large drop in cattle population and in large-scale farms, and a significant increase of small-holder contribution in dairying activities. This was because of the large transformation in the land acquisition, division and redistribution, shifting from the large-scale "white settlers" farms to much smaller portions. Co-operatives and other agencies emerged to assist small-scale farmers to market their produce both in the rural (informal) and urban (formal) markets. Between 1969 and 1992, the Kenyan dairy

industry was controlled by the government, which gave the policy guidelines, set prices and determined the players in the industry, as well as setting the market rules. This resulted in a protected monopolistic market by one major government-owned milk processor, the Kenya Co-operative Creameries (KCC). All dairy farmers had to supply their milk to the KCC which had branches and milk collection centres countrywide. In 1992, the government of Kenya decided to implement specific policy actions that liberalised the dairy market and encouraged commercialisation and privatisation of dairy support services.

Most dairy farming activities are found in the Central and Rift Valley provinces and the Coastal Lowlands, with a higher concentration of small-holder dairy farms in peri-urban areas. There is also a limited number of large-scale dairy farms owned both by private firms and private institutions (Chilonda, 2005). The total milk produced comes mainly from cows, goats and camels, each accounting for 71%, 28% and 1% respectively (FAOSTAT, 2006). Milk production is by rain-fed agriculture, mainly carried out by up to 635 000 small-scale dairy farmers and about 2 000 medium- to large-scale farmers. Most small-scale farmers use manual and animal labour for transporting on-farm requirements. Sunlight is mainly used for most drying operations and biomass energy for heating operations. Electricity is mainly afforded by medium- to large-scale farmers. In 2003, the Kenya Electricity Generation Company (KENGEN) produced a total of 4.343 billion kilowatts hour [kWh], out of which 4.238 kWh was consumed. The main source of electricity is hydroelectric power generation. Other electricity sources include: geothermal, thermal, diesel, gas and wind energy. Kenya utilises no nuclear resources for electricity generation (KENGEN, 2006). Farmers employ a variety of milk production systems, including large-scale open grazing, small-holder open grazing, and small-scale zero grazing employed mainly by small-holder dairy farmers. These include stall-fed cut-and-carry systems and supplementation with purchased concentrated feed in areas of high population density where extensive farming systems are not possible (Reynolds *et al.*, 2003).

Most of the dairy producers have no on-farm cooling facilities and must transport their milk to cooling/ bulking stations owned by large dairy processors or dairy co-operative groups. In the rural areas, farmers resort to a wide range of transport means, including hired vehicles, *matatus* (14-passenger vehicles), bicycles, pulling carts, and even on donkey backs. In many cases, the milk is delivered on foot over long distances of up to 10 km or more to a collection point, cooling plant, co-operative society, processing factory or directly to consumers.

Cooling and short-term storage takes place before the milk is collected and transported by large milk tankers to the milk processing plants. Milk cans made of aluminium and plastics are mainly used on bicycles, animal carts and pick-up vehicles, depending on volume and distance to the delivery point. Unlike in some developed countries, Germany for example, where farmers are contracted to supply their milk to the nearest milk processor, in Kenya the farmers choose the processor or bulking facility they prefer. Sometimes these preferences involve a lot of transport efforts as farmers ignore the closest collection facility to send their milk to a much farther station of choice. This pattern, therefore, has large implications on the transport effort involved in the milk chain. Most milk processors are compelled to source raw milk from more distant places as the immediate milk shed area is increasingly being dominated by the itinerant trader; a trend that further increases milk transport distances.

Energy is a major input in all parts of the food processing industry as most processes involved in food production and processing consume energy. Recent increases in energy costs and concerns about global warming have encouraged food processors to try and optimise their use of energy. Energy use--especially the burning of fossil fuel--contributes significantly to the production of green house gases (GHGs) and ultimately climate change. It is also clear that with increasing energy prices and depleting natural petroleum reserves, the issue of energy use has, in the recent past, taken a centre stage in many round-table discussions among food producers and processors. This is not only for ecological reasons but also for economic reasons, as it is getting increasingly difficult to maintain reasonable profit margins without considering the high cost of the energy input. The Kenyan milk chain is quite unique compared to other countries' milk chains; it is of interest to study the total energy balance of the whole chain so as to establish any relationship between the size of the enterprises and energy turnover, since the industry is dominated by small-holder enterprises. However, there is a lack of empirical data on energy use in the Kenyan dairy chain. This has created the necessity to apply the Life Cycle Assessment (LCA) technique to collect data on total energy turnover for the complete dairy chain for the time period of one year. With regard to time, a distinction can be made between a time frame between LCAs that is very short (less than a year), short (years), long (decades), or very long (centuries) (Thomassen *et. al.,* 2008). Therefore, the present study may be termed as a very short LCA because it was carried out for a period of one year.

LCA has been greatly applied to study milk production, mostly in developed economies (Hospido *et al.,* 2003; Casey & Holden, 2005, Halberg *et al.*, 2005, Vergé *et al.,* 2007); nevertheless, concerning LCA in developing economies, little work has been reported, and a global and reliable inventory of the same is still lacking. Moreover, there is no reported study of LCA application to establish energy turnover for a developing economy like Kenya. Given its already described unique features, the empirical data available from very developed milk chains reflect little of the Kenyan situation. Therefore, there is need for Kenyan scientists to apply this modern LCA technique to establish energy requirements for this rapidly growing industry. Therein lays the possibility of identifying inefficiencies and most of the burdensome stages that can help to lower production costs in terms of energy use, as well as the environmental burden of milk processing.

Energy balances are part and parcel of LCA studies. However, a full LCA would include inventorying all emissions rather than just energy and greenhouse gas emissions, including the impacts of pollutants released to the air, water and land during production, processing, storage, transport, use and disposal of a food product. Using the energy component of LCA as a standardised method of all the energy efforts of the whole process have been identified and allocated to the food items as functional units (Schlich and Fleissner, 2003). The scope of this LCA study is limited to energy consumption, since energy consumption may lead to reduction in the direct cost of the products, in addition to being directly linked to the environmental performance of a product (Tokyo, 2000). The turnovers of energy in all steps of the process were first evaluated then allocated to the functional units. From this database, the primary energy and environmental impacts were then calculated (Schlich and Fleissner, 2003).

The present study aims at investigating whether operation efficiency and logistics of the dairy industry in Kenya, as influenced by the size of the business enterprises, are more important than transport distances by regarding all specific energy efforts of the whole process chain. Policy makers and food manufacturers can use the information generated by this research to formulate policies that will lead to unit process improvement and lowering of production costs of the fluid milk chain in Kenya.