Commentaries

Food (miles) for Thought

Energy Balance for Locally-grown versus Imported Apple Fruit

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Abstract

This commentary compares the primary energy requirement for apples (cultivar 'Braeburn'), which were either imported or locally-grown in Meckenheim, Germany. Imported apples of the same cultivar were grown in a Southern hemisphere winter in Nelson, Southland, New Zealand, and were picked at the end of March with subsequent 28 d transport by sea for sale in April in Germany. Locally-grown apples (cultivar 'Braeburn') were picked in mid-October and required a primary energy of nearly 6 MJ/kg of fruit including 0.8 MJoule/kg for five months CA storage at 1°C during a Northern hemisphere winter until mid-March. This compared favourably with 7.5 MJoule/kg for overseas shipment from New Zealand, i.e. a ca. 27% greater energy requirement for these imported fruits. Overall, the primary energy requirement of regional produce, stored several months on-site, partially compensated for the larger energy required to import fresh fruit from overseas. This result is in marked contrast to reported overestimates of a reported up to 8-fold energy requirement for domestic versus imported apple juice concentrate [7]. Our own findings of less primary energy required for domestic apple fruit is discussed with respect to providing local employment, fruit orchards preserving the countryside, quality assurance systems for local fruit such as QS and EUREP-GAP, networking and other factors favouring regional production.

Keywords: Apples; energy; food chain; food miles; fruits; Life Cycle Assessment (LCA); primary energy requirement; transport

Introduction

European consumers have the choice to get either locally-grown or imported fresh fruit from overseas. Many European countries such as Germany, England and those countries of Scandinavia are net fruit importers and import fresh fruit from overseas during the Northern hemisphere winter. With 60,000–65,000 t, Germany imports most of its apples from the Southern hemisphere, from New Zealand. The objective of this joint commentary from Klein-Altendorf Research Station of Bonn University and the Consumers Protection Agency of North Rhine-Westphalia in Düsseldorf is to compare the energy required to import these fruits with that required for storage of locally-grown apples of the same variety or cultivar 'Braeburn'. It was of particular interest, whether several months of local storage in Germany compensates for the energy required for shipment from overseas.

1 Apple Cultivation and Local Storage Over Winter in Germany

The primary energy requirement was calculated for cultivar. 'Braeburn' apples grown on dwarfing M9 rootstock in Meckenheim, Germany's third largest fruit growing region. After harvest in mid-October, the fruit are stored in 300 kg boxes for five months on the farm until mid-March (**Table 1**). In these controlled atmosphere (CA) stores, oxygen is largely depleted to 1% O_2 and carbon dioxide enriched to 1% CO_2, as well as the temperature held at 1°C to maintain high quality of the cultivar 'Braeburn' apple fruit during a Northern hemisphere winter. After storage, cultivar 'Braeburn' apples were transported over 20 km by smaller farmer's vehicles to the wholesale market in Roisdorf. Fruit sold is taken by large 40 t retailer's trucks over an averaged 150 km to retail outlets (**Fig. 1**) in the Rhine-Ruhr area with a population of ca. 8 million.

Table 1: Apple cultivar 'Braeburn' cultivation in Germany versus New Zealand

Parameter	Apple	Apple
Variety	Braeburn	Braeburn
Rootstock	M 9	MM 106
Growing region	Meckenheim/Bonn	Nelson/New Zealand
Harvest	mid-October	End of March
Yield	40 t/ha	90 t/ha
Storage	5 months til March	Fresh fruit (no storage)
Marketing	April: Rhine-Ruhr	April: Rhine-Ruhr

2 Apple Cultivation in New Zealand and Overseas-Shipment

This was compared to cultivar 'Braeburn' apples grown on a vigorous MM106 rootstock in the apple growing region near Nelson on the north coast of the southern island of New Zealand. Apples of cultivar 'Braeburn', freshly harvested in March, were cooled and shipped on reefer ships

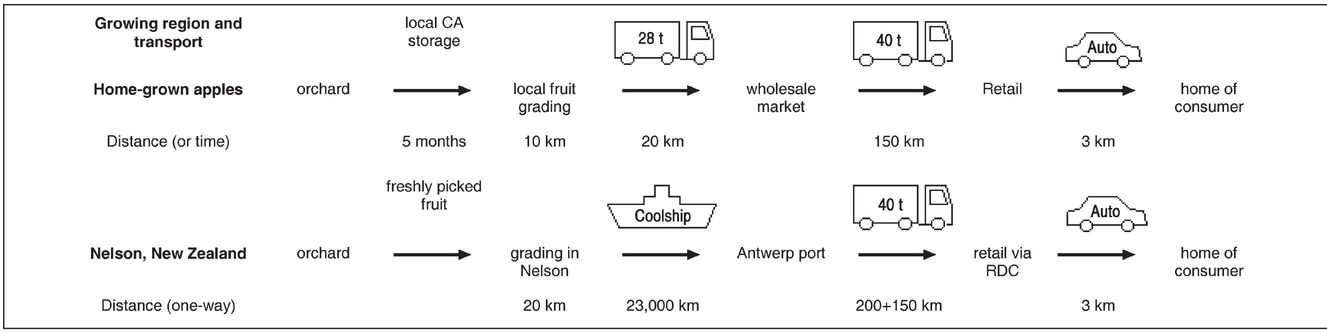

Fig. 1: Transport channels of the food supply chain employed in the present study to compare primary energy requirements of locally-grown apples stored for 5 months versus freshly harvested apples imported from New Zealand in March/April

directly from Nelson over ca. 23,000 km to Antwerp within 28 days. Retailer's 40 t trucks transport the fruit boxes from Antwerp over an average of 200 km to regional distribution centres (RDCs). Retail 40 t trucks collect the apples in open top trays from the distribution centres [4], e.g. of the EDEKA supermarket chain in Meckenheim, for marketing in retail outlets in the Rhine-Ruhr area (see Fig. 1).

3 Calculation of Primary Energy Requirement from Crop Cultivation to End Users (System Boundaries)

For comparative purposes, the primary energy requirement was calculated employing the same system boundaries from crop cultivation to end user. April was chosen as a time when apples of the same cultivar, but different origin, are available (see Fig. 1). The primary energy requirement for apple cultivation - the first system boundary – of 2.8 MJ/kg apple fruit by Pimentel (1979) [6], including fuel, pesticides and fertiliser, was adopted for Europe and modified, i.e. reduced by 25% for the 2.5fold larger yields in New Zealand (see Table 1). In both countries, apples are cooled down quickly after harvest, requiring 86 kJ/kg in energy. The two transport forms include 0.3 MJ/t/km for cooling the fruit on the truck and 11 kJ/kg/day for cooling on board the reefers (Frischknecht et al. 1994) [2]. An average German consumer in built-up areas drives 3 km each way for his shopping to acquire 20 kg of apples for a family, which requires 190 kJ/kg/km or 1.15 MJ/kg apples (Kjer et al. 1994) [3] to the other system boundary at the end user, assuming only apples are being shopped.

4 Data Interpretation

The largest portion of the primary energy requirement for fruit imports was, as expected, the 2.8 MJ/kg for the shipment from overseas, which exceeded the 0.81 MJ/kg for five months CA storage in Germany (**Table 2**). The energy requirement for providing imported, freshly harvested cultivar 'Braeburn' apple fruit from New Zealand of ca. 7.5 MJ/kg exceeded the nearly 6 MJ/kg for locally-grown, stored apples of the same variety by ca. 27%. Considering the smaller energy input for NZ apples due to their 2.5 greater yields, apples, which were grown locally in Germany, would have to be stored for 18 months, i.e. beyond next year's harvest, to fully compensate for the energy required for fruit imports. The ca. 27% larger energy requirement for fruit import from New Zealand seems to be in an apparent discrepancy to the reported up to 8-fold larger energy requirement for juice from locally-grown apples versus that made from imported apple juice concentrate (Schlich et al. 2003, Schlich and Fleissner 2004) [7,8]. Their calculation is based on different system boundaries and on a comparison of small, inefficient, remote local juicing works in comparison with juice made from imported concentrate out of large scale factories (Demmeler and Burdick 2004, Jungbluth and Demmeler 2004) [1,5].

5 Conclusions

Such comparative calculations of primary energy requirement rely on the settings of the system boundaries. Corrected values for juice from locally-grown apples versus imported juice re-

Table 2: Food miles – primary energy requirement per kg of locally-grown versus apples imported from New Zealand in April

Home-grown, local fruit	Energy per unit [per kg, t, km or day]	Primary energy requirement [MJ/kg apples]	Import from New Zealand	Energy per unit [per kg, t, km or day]	Primary energy requirement [MJ/kg apples]
Apple cultivation	2.8 MJ/kg[1]	2.800	Apple cultivation	2.8 MJ/kg[1]	2.100
20 km transport to Meco	3.47 MJ/t/km[2]	0.069	40 km transport to Nelson	3.47 MJ/t/km[2]	0.139
Initial cooling	86.3 kJ/kg[3]	0.086	Initial cooling	86.3 kJ/kg[3]	0.086
150 days CA storage at 1°C in Meckenheim	5.4 kJ/kg/day	0.810	23,000 km reefer Nelson-Antwerp[3]	0.11 kJ/kg/km[3]	2.534
			28 days cooling on board[3]	10.8 kJ/kg/day[3]	0.302
Packaging	650 kJ/kg	0.650	Packaging	650 kJ/kg	0.65
40 km in < 28 t truck to wholesale market Roisdorf	2.32 MJ/t/km[2]	0.093	200 km in < 40 t truck to regional distribution centre	1,38 MJ/t/km[2]	0.276
150 km < 40 t truck to retail	1.38 MJ/t/km[2]	0.207	150 km < 40 t truck to retail	1.38 MJ/t/km[2]	0.207
Cooling on truck 95 km	0.3 MJ/t/km	0.028	Cooling on truck 175 km	0.3 MJ/t/km	0.055
Consumer shopping 6 km[4]	3.83 MJ/km[4]	1.150	Consumer shopping 6 km[4]	3.83 MJ/km[4]	1.150
	Local fruit	5.893		Imported fruit	7.499

[1] Pimentel (1979); [2] Frischknecht et al. (1994); [3] Hochhaus et al. (1994); [4] Kjer et al. (1994)

sulted in energy balances similar to those presented here (Demmeler and Burdick 2004) [1]. However, primary energy calculations are only one approach and may not represent all environmental issues of fruit imports, e.g. CO_2 efflux and maintaining fruit orchards as an essential part of an intact countryside, social factors such as local employment and product traceability, fruit quality assurance systems such as QS and EUREP-GAP and fruit availability. On the other hand, fruit imports from the southern hemisphere are part of a free market and free trade. New Zealand imports German goods, which in return secure employment in Germany. These fruit imports offer fresh produce, and apple varieties or other fruit species such as kiwi, citrus and avocado which cannot be grown in Germany.

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The Ecology of Scale: Assessment of Regional Energy Turnover and Comparison with Global Food

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Goal, Scope and Background. Obviously, people assume that the regional production and distribution of food requires less energy turnover, compared with global transports of food. Politicians claim the term 'regionality', maintaining that regionality is a medicine against wasting so much energy for the global food distribution. Additionally the energy turnover is causing pollution. But remarkably, there is a lack of empirical data to support this idea. At the same time, nobody really requires regional origin for non-food items, e.g. for bicycles, dishwashers, furniture or cars etc. The public mainstream asks for regional origin merely for food. Hence, the first scientific issue worked out in this paper is how the energy turnover of comparable food items can be measured, regarding the lifecycle of food in total. That means to investigate the partial systems of crop or breed, of food production, of packaging including transport and distribution up to the point of sale. Secondly, it has to be checked, if the assumed coincidence of low energy turnover and regional origin can be verified.
The specific energy turnover, calculated in the unit [kWh per kg] or [kWh per l] of food, is investigated by comparing regional with global process chains for different food items. Two examples of food – fruit juices and lamb meat – are researched, by personal investigation worldwide. Firstly, fruit juices of high grade quality from Brazil, from European origin and from local German farmers are compared, in terms of energy. Secondly, a comparison of lamb meat from New Zealand and lamb meat from local German farmers is conducted. Lamb meat has been investigated, because it is shipped around the world as frozen natural food, not concentrated like juices. In addition, the business size of the food producers is researched for both examples.

Methods. As a part of LCA the energy turnover of each process step from the very beginning up to the point of sale is investigated. These primary results are the basic empirical data, in order to allocate the energy turnover at the food items as functional units. The results of regional, European-continental and of global process chains are compared. In addition, the issue is investigated, whether the specific energy turnover depends upon the business size.

Results and Discussion. Surprisingly, the data in both cases demonstrate a strong degressive relation of the specific energy turnover and the business size. Here it is not important, if the business is regional or not. Merely the efficiency and logistics of the production and the operations determine the specific energy turnover. These findings seem closely connected with the business size, because small companies are not able to invest in energy recovering and saving technology. The regional juices business is worsened by the huge number of small-sized transports of the crop and the nearly bottle-wise distribution. Regarding lamb meat we once more find the disadvantages of comparably small farms again. In addition, the German farmers need daily shepherds, fences by night, stables and usually additional feed during the wintertime. All these efforts are not necessary in New Zealand, where the climatic conditions and the open countryside with low population allow rather easy and low energy breeding of lamb.

Conclusion. The coincidence of economic and ecological facts is obvious. As a matter of fact, in economics there is a strong degressive relation between the production costs and the number of produced items. This relation is very well known as 'Economy of Scale.' Our findings lead to similar conclusions, in terms of ecology. That means, the production ecology depends on the number of produced items. Additionally, our results demonstrate a minimum business size, so that we can claim an 'Ecology of Scale' as well.
However, on the other hand, the reported data and the conclusions are valid for the investigated food items – fruit juices and lamb meat – only. Nevertheless, one conclusion is already evident: The most popular claims for regional food production and distribution instead of global process chains are not generally valid. Small farmers basically need much more energy to produce and distribute their products, compared with bigger units. Both food items demonstrate clearly, that the ecological quality is mainly influenced by the operational efficiency and not by the marketing distance itself.

Recommendation and Outlook. Much more detailed data of all the investigated operational units, processing fruit juices and lamb meat, have been published (Fleissner 2001). As a further example, we investigate wine from different countries as a further example. Different from fruit juices, which can be shipped as a concentrate, and different from lamb meat, which is shipped as frozen food, wine of high grade quality is always bottled close to the place of origin. That means, that not only the food, but also the heavy weight packaging is transported around the world. So, we are very curious about the results, which we expect for 2004.

Keywords: Business size; chains; comparable process; ecology of scale; fruit juices; lamb meat; marketing distance; operational efficiency; regional and global food items; specific energy turnover