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Life cycle assessment of Swedish single malt whisky

Ola Eriksson*, Daniel Jonsson, Karl Hillman

University of Gävle, Faculty of Engineering and Sustainable Development, Department of Building, Energy and Environmental Engineering, Kungsbäcksvägen 47, S-801 76 Gävle, Sweden

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ABSTRACT

Agricultural production and further processing to food and drink have large impacts on the environment. However, there are still few examples of LCA studies on beverages such as whisky. This paper presents a life cycle assessment of Swedish single malt whisky and different environmental improvements of the production chain are discussed. The functional unit is one bottle (70 cl) of whisky and results are obtained for global warming potential (GWP), Acidification Potential (AP), Eutrophication potential (EP) and primary energy (PE). The contribution to GWP is dominated by CO_2 emissions from transport of stillage. When avoided emissions from use of biogas are included, the net result is 2.1 tonnes CO_2-eq. Acidification is mainly due to emissions of SO_2 from bottle production, transport and barley cultivation which ends up to 14.6 kg SO_2-eq. Eutrophication results are totally dominated by barley cultivation, in total 8.6 kg PO_4^{3-}. The total use of primary energy is 53.5 MJ/FU with a 50/50 distribution in renewable and non-renewable. Non-renewables emanate from fossil fuels used for transports and in glass production, whereas renewables are mostly used for heating in the distillery. Improvement analysis of transports included; (1) decreasing need of transport, (2) change of fuel and (3) change of transport mode. Decreasing transport of stillage is an efficient measure to reduce GWP and use of non-renewable energy. Substituting diesel with biodiesel for all road transports is an even more efficient measure for these categories, but increases other environmental impact. For all impact categories except use of renewable energy a scenario combining all improvements is the most efficient measure to reduce environmental impact. The results can be used by the manufacturer, but an improved and expanded LCA on product level can be used for a more specific eco-labelling of the different whisky editions.

1. Introduction

It is well established that agricultural production and further processing to food and drink have large impacts on the environment (Tukker et al., 2006). There is an increasing amount of literature applying life cycle assessment (LCA) methodology to identify opportunities for improvement of established product chains in the agricultural sector (PRé, 2014) and since many years there are international conferences dedicated to LCA of foods (LCA Food, 2014, 2014).

Consumption of whisky per capita varies between countries, with France on top with about 2 L per person and year, while India is the country with the largest total consumption (Ferdman, 2014). Still, there are very few examples of LCA studies on whisky production. For example, it is not included in the World Food LCA Database, implemented in Ecoinvent v3. Actually, most beverage-related LCAs are for the packaging, but a few exceptions exist. Amienyo (2012) apply LCA to investigate a number of beverages relevant for the UK market, including Scotch whisky. There is also another LCA of Scotch whisky, which is not presented in any scientific publication (Scotch Whisky Association, 2006). Finally, Garnett (2007) discusses the greenhouse gas emissions from alcohol consumption in the UK. Despite these contributions, we acknowledge that there is actually a gap to fill when it comes to whisky LCA in the scientific literature.

The present case study emanates from discussions on branding and marketing if whisky with Mackmyra Svensk Whisky, a new producer of whisky established in Sweden in 1999 (von Schultz, 2012). Branding issues are essential for whisky, and it is expected to be difficult to introduce new brands on the market. However, environmental concern holds the potential to niche products and constitute an added value for whisky produced by a less famous, but still well reputed, producer like Mackmyra. A life cycle assessment of whisky from Mackmyra Svensk Whisky may act as a starting point for ecolabelling of the different whisky types

* Corresponding author. Tel.: +46 26 64 81 45.

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produced, and may also later on be expanded to ISO 14001 certification (environmental management system) of the company. When it comes to eco-labelling, as an example, four out of 1719 whisky products (0.23 percent) available on the Swedish market holds are labelled as organic (Systembolaget, 2014). The market for organic wine sets a remarkable example, with a percentage of 7.1 (Systembolaget, 2014). According to ProWein (2013), the number of organic vineyards increased from 88,000 to 256,000 ha between 2004 and 2011. ISO certification has become more common since the turn of the millennium, and large companies like Pernod Ricard has almost of all its sites ISO certified (ISO, 2000; Pernod Ricard, 2014).

As there are few LCA of whisky documented in scientific literature the aim of the paper is to present a life cycle assessment of Swedish single malt whisky and discuss different means of improvement.

2. Material and methods

The Life Cycle Assessment has been performed in accordance with ISO 14040 (ISO, 2006). Data used are primarily from the actual processes involved, but to some extent generic LCA data have been used, e.g. for use of fuels in energy supply and transports. Direct measurements have been performed to determine total surface area of packaging (Ericsson and Jonsson, 2013). The performance of the LCA has been cross-checked with the ILCD Handbook (Joint Research Centre, 2010) but has not been subject to critical review.

2.1. Goal and scope definition

2.1.1. Aim and goal

The objective with this LCA is threefold, namely to:

1. Calculate the potential environmental impact of a bottle of whisky made in Sweden
2. Identify which parts of the production chain are the major contributors to environmental impact
3. Investigate the consequences of different improvements of the whisky production

2.1.2. Functional unit

There are mainly three types of products stemming from the whisky production, i.e. products that can be purchased from the whisky production company:

1. Whisky in a cask of 30 L (which is later tapped on bottles of 50 cl)
2. Whisky in a bottle of 70 cl (sold at liquor stores)
3. By-products such as (1) wood chips from worn out casks intended to add flavour in barbecue and (2) stillage to be used as substrate for biogas production

The vast majority of the whisky produced is tapped in bottles of 70 cl with alcoholic strength 41–46 % (for some editions up to 52%). Therefore the functional unit is one bottle of single malt whisky with a volume of 70 cl produced by Mackmyra Svensk Whisky AB (Mackmyra Svensk Whisky AB, 2014) referring to number 2 in the above list. How energy use and emissions are allocated with respect to the other products is described in the allocation section. Whisky is not just one single product as it comes with different flavours, some whisky is subject to malt smoking and there are different storing time frames for different types of whisky. This LCA is made for an average of available types/editions from the same manufacturer/distillery. Differences between different whisky editions have not been studied.

2.1.3. System boundaries

The geographical boundaries are set for production of whisky in Sweden at a distillery placed in the city of Gävle. Most processes take place in Sweden as well as raw materials acquisition, except casks which mainly are imported from Spain and the USA, bottles which are manufactured in Great Britain and corks produced at several places outside Sweden. Concerning temporal boundaries most data are invented for 2012. For some processes, e.g. water supply, other time periods may have been used for calculation of averages, this is further described in the inventory part.

The studied system (cf. Fig 1) covers production of raw materials (barley cultivation, water supply and yeast production), malting, distillery operation, long term maturation (five years), filling and distribution until the product is delivered at liquor stores in Sweden. The environmental impact of all transportation is included in the study, although several shipments have been estimated with respect to environmental standards and size of the truck/ship. In addition cask, bottle, cork and cardboard packaging are initially included. All above processes constitutes the foreground system. The background system comprises by-product management (a by-product of whisky production is stillage, from which biogas is produced substituting fossil vehicle fuels) and energy supply (LCI data on generation of electricity and heat as well as fuels used in transports). Information on boundaries to natural systems (barley cultivation) as well as datasets are described in the life cycle inventory.

2.1.4. Allocation

Besides specific allocations on sub-process level, which are addressed below in the description of the product system, the distillery produces different products for which allocation has been made. The first allocation is between the main product (whisky) and by-products such as barbecue chips and stillage. As described below barbecue chips are made out of worn out casks. Cask production is not included, but transport of casks has been allocated to the whisky production. Casks can be used several times until they are discarded. As the whisky production is relatively young (the distillery was inaugurated in 2011), there is no reliable data on how many cycles each cask is used. We have made a conservative assumption that casks are just used once, i.e. the casks become waste after being used. Waste management for worn-out casks are not included due to lack of data but some casks are made into

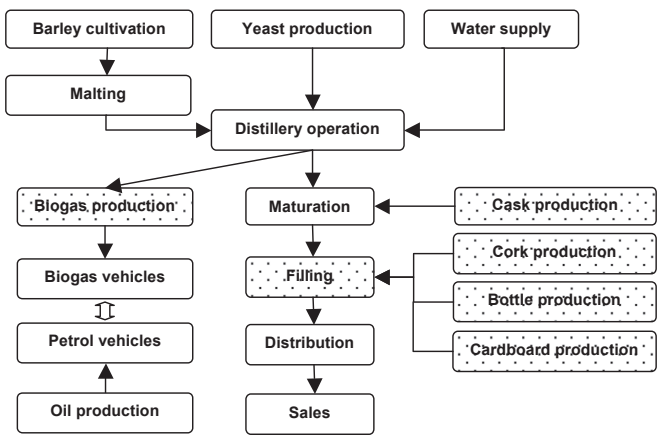

Fig. 1. Processes in the studied product system. Arrows represent material flows. Boxes with dotted background are not (entirely or partly) followed from cradle to grave.

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