Which packaging system for apple juice is most eco-friendly and at the same time more efficient? Eco-Efficiency Analysis for Apple-Juice Packaging

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Abstract This Eco-Efficiency Analysis case study compares two different types of apple juice – “from concentrate (FC)” and “not from concentrate (NFC)” (German: Direktsaft) – in different packaging systems. The study was carried out for the members of Verband der deutschen Fruchtsaft-Industrie e.V. (VdF) (Association of the German Fruit Juice Industry), calculated by BASF in co-operation with TÜV Rheinland and reviewed by Öko-Institut e.V., Freiburg. The applied method is the Eco-Efficiency Analysis developed by BASF SE in Ludwigshafen. Therefore, several environmental impact categories, like GWP (Global Warming Potential), resource consumption, land use or water emissions, were assessed together with additionally life cycle costs.

1 Introduction

The following case study compares two different types of apple juice in different packaging systems. The types of apple juice are juice “from concentrate (FC)” and “not from concentrate (NFC)”. The different packaging systems are liquid packaging cardboard, glass bottles (returnable) and PET bottles (one-way). The initiators of the project are the members of the Verband der deutschen Fruchtsaft-Industrie e.V. (VdF) (Association of the German Fruit Juice Industry). The assessment was done by BASF in co-operation with TÜV Rheinland. A critical review was subsequently carried out by Öko-Institut e.V., Freiburg.
Goal of this study is to identify the influencing parameters in the product value chain, followed by the creation of positive incentives for the members of the VdF, to ensure a continuous improvement. The article refers to the report

"Ökoeffizienz-Analyse - Vergleich von Prozessierungsarten und Verpackungsalternativen für Apfelsaft" from Klein et al. 2010 which might be published at a later point [1]).

2 Background of the Study

2.1 Functional Unit and Alternatives

The functional unit (FU) is defined as the production and packaging of 1 litre apple juice in Germany. In practice, the container sizes vary from 0.2 litres for catering up to 1.5 litres for bulk containers. However, the common practice is the 1.0 litre packaging. The study also takes the different packaging alternatives into account which contain apple juice “not from concentrate” (NFC) and “from concentrate” (FC). The studied packaging alternatives are liquid packaging cardboard, glass bottles (returnable) and PET bottles (one-way). These size and packaging alternatives reflect over 80% of the German market - information from VdF [summarized in 1].

A main assumption for the definition of the functional unit is the shelf life of the apple juice. Depending on the packaging alternatives it varies between 6 to 18 month (PET 6-12 month; cardboard 10-12 months; glass 12-18 months). Nevertheless, it seems that this fact doesn't have an influence on the comparability. The base case assumes the consumer losses to be (e.g. due to shelf life exceeded, ...) negligible and independent from the packaging, because of the short storage period at the consumer. Therefore the shelf life of the apple juice is not considered.

2.2 System Boundaries

The study considers the current state of the art for the processing steps and packaging systems. The system boundaries include (see Fig.1):

- Cultivation (including conventional and orchard cultivation which if necessary also includes fertilizer or plant protection agents, diesel use, etc.) and storage of apples. In this study it is assumed that Germany generates half of its apple juice consumption itself. The rest is imported apple juice concentrate, mainly from Poland.

- Pressing of apples to juice after cultivation (including auxiliaries and electricity, etc.) plus storage of NFC. The production of NFC is only done in Germany, due to the fact that a higher volume needs to be transported which has an economic influence.
- The production (including auxiliaries, detergents and electricity, etc.) and storage of the concentrate.
- Deloading and storage (including electricity, etc.).
- Production of primary and secondary packaging (including all raw materials, primary energy, etc.).
- Pasteurisation (including dilution, blowing of PET bottles and washing with detergents of glass bottles) and filling.
- Transportation (sum of all transports are included e.g. from field to processing plant) and
- End-of-life treatment of packaging materials (depending statistical data in Germany).

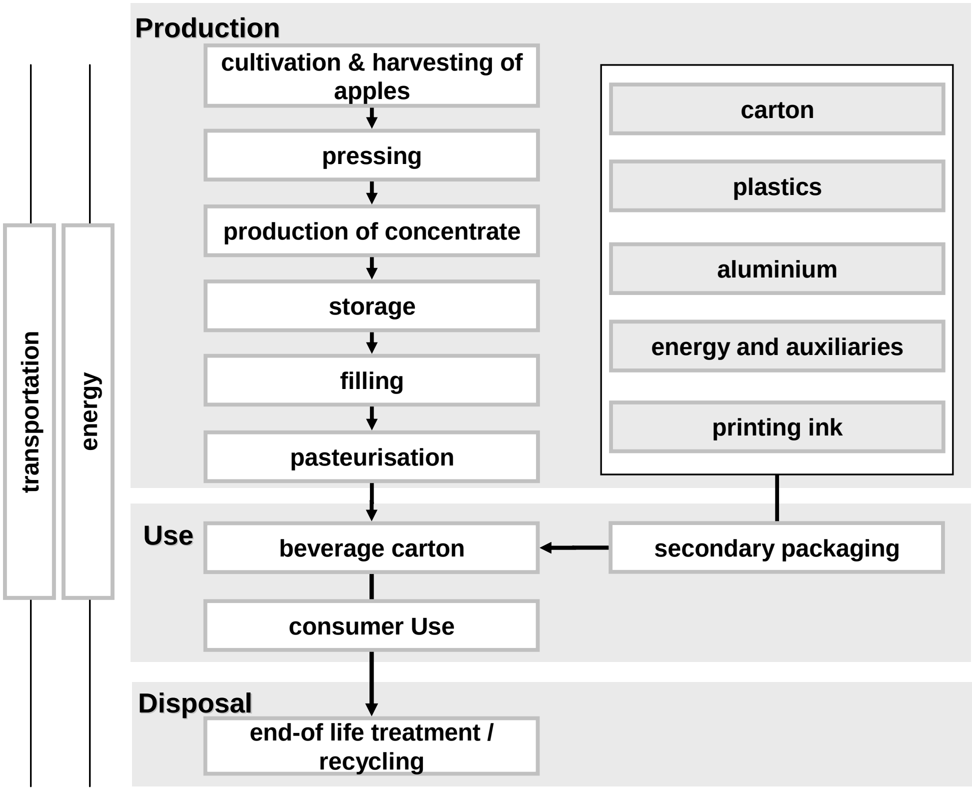

Fig.1: **System boundaries of a beverage carton**

3 Eco-Efficiency Method

The applied method is the Eco-Efficiency Analysis, developed by BASF SE in Ludwigshafen. The environmental assessment follows the ISO standards 14040:2009 and 14044:2006 for life cycle assessment. The BASF Eco-Efficiency methodology goes beyond the standards for the evaluation of the environment by including life cycle costs and weighting factors to derive an environmental fingerprint as well as an overall environmental impact. The environmental part includes different impacts like energy consumption, raw material consumption, global warming potential, acidification potential, ODP, POCP, water emissions, waste, toxicity potential and land use.

The methodology has been validated by the German TÜV Rheinland Group in 2002 and by the US National Sanitation Foundation (NSF) in 2009.

The Wuppertal Institute comments on the method: “Basically, the large number of indicators used in the eco-efficiency analysis of BASF makes relatively reliable statements possible …“. The method was initially developed by BASF and Roland Berger Consulting, Munich. [this section is taken from [1], for further description of the method see Saling et al. (2001) [2]]

4 Results

4.1 Costs

The life cycle costs are shown in Tab.1. These costs include the prices paid by the consumer. It is noticeable that the minimum and maximum price differs by 100%. The prices do not necessarily reflect the processing costs. These are probably lower. The use of consumer prices leads to a relative high weighting of the economic pillar and thus of a high weighting in the Eco-Efficiency portfolio. The prices were used due to the fact that the processing costs were not available.

Tab.1: Considered costs for all Alternatives (translated from [1], SourceVdF)

Alternative	Costs in €/1 litre apple juice
FC in Carton	0,65
FC in PET, one-way	1,00
FC in Glass, returnable	0,85
NFC in Carton	0,80
NFC in PET, one-way (theoretical alternative)	1,15
NFC in Glass, returnable	1,00

4.2 Environmental Evaluation

The environmental assessment is summarized in the ecological fingerprint which is part of the Eco-Efficiency Analysis by BASF.
As a representative for the environmental categories, the Global Warming Potential (GWP) is shown in Fig. 2.

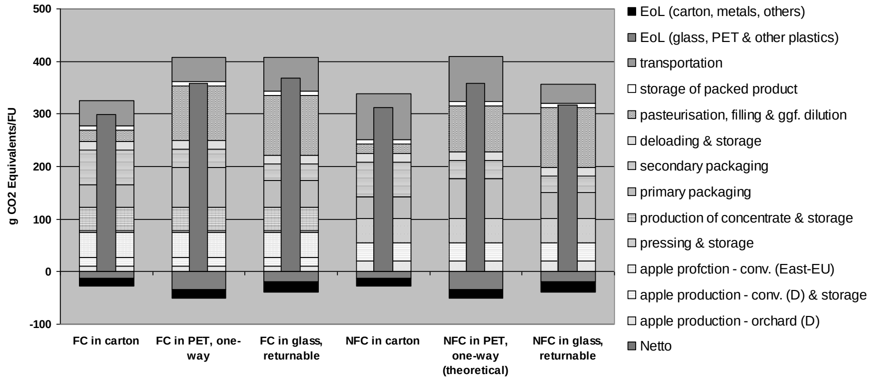

Fig.2: Global Warming Potential per litre of apple juice (translated from [1])

The emission of CO2e (GWP) for apple juice in different packaging solutions varies between 290g-380g CO2e per litre including the life-cycle phases packaging, distribution and end-of-life treatment of the packaging materials. The main contributions to the greenhouse gas emission for the FC-alternatives created by the packaging (negative contribution due to crediting form the disposal with energy resp. materials recovery), pasteurization and filling for the glass and PET options and the transportations. The same applies for the NFC alternatives. The transportation is favourable for the glass-alternative, since significantly shorter transportation routes are used in the basic assumption. The high contribution from the glass and PET alternatives during pasteurisation and filling created for the glass alternative from washing and for the PET alternative from the blowing (started with the pre-form).

In general, the NFC alternatives are comparable to the FC options. Hence, the cardboard and PET options are slightly higher for NFC than for FC juices. This is due to the different transportation distances assumed and the different amounts of juice /concentrates which are transported (concentrate is just 1/6 of the mass of transported good compared to NFC).

Other differences result from cultivation of apples and their origin country due to different amount of fertilizer and pesticides for the conventional cultivation.

4.3 Eco-Efficiency Portfolio

The Eco-Efficiency portfolio summarizes and aggregates the ecological and economic aspects. The x-axes show the normalized costs to 1 and the y-axes shows the normalized environmental impact potentials to 1. The overall results (see Fig. 3) show that the two cardboard boxes have the lowest cost impact, followed by the glass alternatives and then by the PET options. From the environmental point of view, all alternatives show similar results. The study shows that the environmental impacts are evenly distributed throughout the various life cycle stages (see GWP results in Fig.2). Thus, a prioritization of a life cycle phase for optimization cannot be conducted. Rather, there is an opportunity for improvements in different life cycle stages.

In terms of the Eco-Efficiency methodology, the FC in beverage cardboard boxes is more eco-efficient, followed by NFC in the same packaging alternative and by the FC in glass bottles.

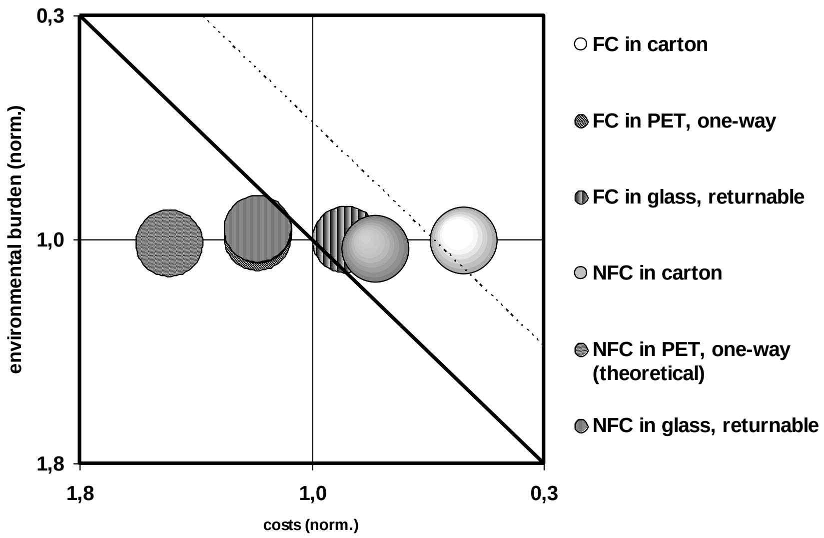

Fig.3: Eco-Efficiency Portfolio (translated from [1])

5 Conclusions

The conducted Eco-Efficiency Analysis supports the members of VdF to achieve a better understanding of their processes and the associated environmental impacts. The study also enables the VdF members to optimize their own supply chain and manufacturing processes systematically and should therefore be considered as a starting point for further improvements. The results show that there are opportunities for improvement in different life cycle phases:

- Apple production, with special reference to the necessary area.
- Packaging & packaging (weight, materials, multiple uses).
- Pasteurization and deposition in particular the cleaning of the bottle and the blowing of PET bottle.
- Logistics (short distances).
- Different potentials due to costs and the environment could be detected and can be used for further improvement of products and processes of VdF.

6 References

[1] Klein, D., Kölsch, D., Achatz, B., Cat-Krause, B. & P. Saling: Ökoeffizienz-Analyse - Vergleich von Prozessierungsarten und Verpackungsalternativen für Apfelsaft. Herstellung, Verpackung und Entsorgung der Verpackung von jeweils 1 L Apfelsaft, Report for VdF by BASF in co-operation with TÜV Rheinland, reviewed by Öko-Institut e.V., Freiburg (publication in progress), 2010.

[2] Saling, P., Kicherer, A., Dittrich-Krämer, B., Wittlinger, R., Zombik, W., Schmidt, I., Schrott, W. & S. Schmidt, *International Journal of Life Cycle Assessment,* Vol. 7, No. 4, 2002, 203-218.