Environmental impact of processed tomato in France and in Turkey

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ABSTRACT

The FLONUDEP project carried out an environmental LCA « from cradle to grave » of processed tomatoes made in France and Turkey. We compared the environmental impact of tomato sauce made in France with French tomato paste, with that made with Turkish tomato paste. Data have been collected through surveys among a sample of farms (France=4; Turkey=4), processing plants (France= 2; Turkey=4), logistic organization (France=2), 1 supermarket and consumers (n=800), Findings show that French tomato sauce is slightly less impacting than the Turkish one for GHG emissions and human toxicity, whereas results are similar for eutrophication. Critical points are mainly packaging, energy used and steam production at plant level, fertilization and phytosanitary treatments at agricultural level, and finally, consumer behavior (shopping by car) and packaging recycling.

Keywords: Environmental impact, LCA, Tomato sauce, France, Turkey

1. Introduction

Studies on the environmental impact of agricultural products are now frequent; those on processed industrial products are rare. However, these are very useful as a European regulation regarding the display of the environmental impact of food products is currently under course. Industrials and supermarket chains (Casino, Auchan, and Leclerc) have already anticipated the regulation and present now a display of GHG emissions or water consumption related to the product's manufacturing. Environmental LCAs are fragmentary and often concern only one of the sectors of the food chain. However, several studies have been carried out on processed tomato products, with different system boundaries. Andersson's (Andersson et al., 1998) measured the environmental impacts associated with ketchup's life cycle, from "cradle to grave" and showed that the "hot spots" in the whole system were represented by packaging and food processing. Other two very recent studies (Del Borghi et al., 2014; Manfredi and Vignali, 2014) carried out an LCA on processed tomato from "cradle to the factory gate" (including packaging disposal) and from "cradle to the retailer" respectively , and highlighted the importance of packaging. Findings of the first study show that the impact of the agricultural stage is also considerable, whereas in the second, processing and transport to the retail center are also in cause.

The FLONUDEP project carried out an environmental LCA on the entire food chain, "from cradle to grave", for processed tomatoes in France and Turkey. The latter exports very few industrial products to France but has a huge potential. Turkey is in fact the 4th processed tomatoes producer in the world and holds 6% of the global market.

The purpose of the study is to conduct an environmental LCA of two processed tomato's value chains with the aim of identifying the environmental "hot spots" for each of them. The selected products are concentrated tomato paste and tomato sauce made in France and concentrated tomato paste made in Turkey and exported to France to be used in making sauce.

2. Methods

2.1. System boundaries

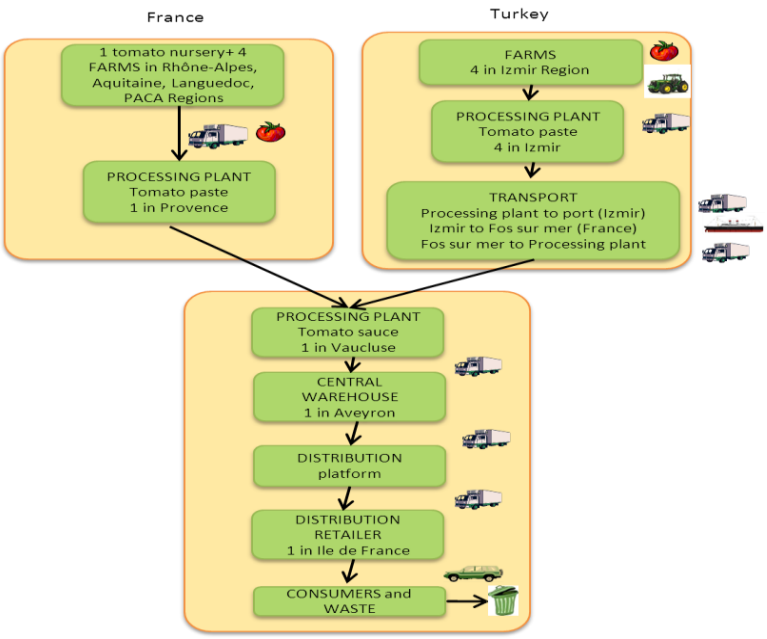
An LCA approach, from "cradle to grave" has been applied to both chains, that of French and that of Turkish tomato paste exported to France. For France, the system boundaries include: two tomato nurseries, four farms, a first (tomato paste) and a second (tomato sauce) processing plant, the warehouse, the distribution platform, the supermarket, the final waste, as well as transports between these. In Turkey, the study considered four farms, four first processing plants, as well as transport from the field to the plant and from the plant to France. Then the second processing plant in France, the warehouse, the distribution platform, the supermarket and final waste, as

well as all transports between these. At agricultural level, allocation methods have not been necessary, as data was collected exclusively for tomatoes. Instead, at plant level, a mass allocation was applied in France and an economic one in Turkey; finally, at logistic and consumer level a mass allocation was applied. Logistics includes storage in the warehouse, the distribution platform, and the supermarket, as well as all the materials used for transport (further packaging), and type, consumption and fill rate of trucks used for transportation. The end of life of intermediate packaging (such as plastic bins and metal drums used to carry tomato paste to the second processing plant) and that of organic waste of fresh tomatoes, have not been taken into account, as the first are often recycled and waste from tomatoes are usually fed to animals. Finally, according to the consumer survey that was carried out during the study, consumers drive to supermarkets and recycle the tin can containing tomato sauce.

Comparison between the two systems taken into consideration in this study is possible, as much of the life cycle is in common (from the second processing plant onwards) (Figure 1). Furthermore, at plant level, whether in France or Turkey, the same flows necessary for tomato processing (energy, water and packaging-excluding its end of life-and storage) were considered in the inventory analysis. However, at agricultural level some differences exist: in France, the tomato nursery and the transport from the nursery to the farm have been studied, whereas this has not been possible for Turkey, as some producers grow the plants themselves.

Three impact categories were selected for the environmental measurements: GHG emissions, eutrophication and human toxicity. The first two are in fact among the criteria taken in consideration by the ADEME (French Environment and Energy Management Agency) regarding the regulation on the display of the environmental impact of consumer products, whereas human toxicity was chosen for its relevance. The environmental LCA was carried out using the SIMAPRO software and the CML 2 baseline V2.05 world method and Ecoinvent database.

Figure 1. System boundaries in France and Turkey



2.2. Functional unit

At agricultural level, in France and in Turkey, the Functional Unit (FU) is 1 Kg of tomatoes. At industrial level, the FU is 1 packed product at the plant's gate (1 metal drum or 1 plastic pouch for concentrated tomato paste, 1 can for sauce); for logistics and consumption the FU is 1 Kg of packed processed tomatoes. In spite of these FU differences between agricultural and post-agricultural levels, the system has been studied as a whole by converting all results in 1 Kg of packed processed tomatoes. The functional unit is therefore 1 kg of packed pro-

cessed tomatoes using different reference flows for the different stages. We considered two cases: tomato sauce made with French tomato paste and the other with Turkish tomato paste exported to France.

2.3. Quality of data

Most of the data are issued from surveys conducted or from direct observations. To complete missing information, a literature revue and interviews with experts were conducted. In order to be representative, the 4 farms surveyed in Turkey have been chosen in the Egee region which produces 24% of Turkish tomatoes. We do not have the exact number of farms in this area but the choice is justified by the fact that the chosen farms supply the industrial plants under study, which buy 31% of Turkish industrial tomatoes. In France, industrial tomato production systems are very homogeneous, therefore the 4 farms chosen are considered as representative. The first processing plant buys 38.5% of the total industrial tomato production (SONITO, 2009) and the second processing plant is the first French firm of ready-made meals. The logistic taken in consideration is that of the two firms surveyed. Finally, at consumer level, the LCA is carried out with data from a survey among a sample of 800 people (men and women, 20 to 65 years old). It would have been desirable to carry out a sensitivity analysis; this had in fact been initially planned, but finally had to be postponed.

3. Results

The comparison between the two supply chains shows that environmental impacts associated with a can of 1 kg of tomato sauce as purchased by the consumer and then recycled is slightly lower for the strictly French chain, with regards to GHG emissions and human toxicity. The Turkish supply chain and the French one are identical for eutrophication (tables 1 and 2).

Table 1. Contribution analysis of the environmental impacts of 1 kg of processed tomatoes (sauce) produced in France from French tomato paste, by impact category

	Farm	Transport	Plant Tomato paste	Logistics	Plant Tomato sauce	Logistics to Supermarket	Supermarket	Consumers	TOTAL
GHG kg CO2 eq	0.0511	0.0063	0.0668	0.0032	2.2472	0.1219	0.0221	0.1800	**2.6987**
Human toxicity kg 1,4-DB eq	0.0307	0.0016	0.9727	0.0029	0.8478	0.0217	0.0358	0.4500	**2.3633**
Eutrophication kg P eq	0.0004	0.00001	0.0001	0.000001	0.0028	0.0001	0.0000	0.0002	**0.0037**

Table 2. Contribution analysis of the environmental impacts of 1kg of processed tomatoes (sauce) produced in France from Turkish tomato paste, by impact category

	Farm	Transport	Plant Tomato paste	Logistics	Plant Tomato sauce	Logistics to Supermarket	Supermarket	Consumers	TOTAL
GHG kg CO2 eq	0.0823	0.0259	0.3756	0.0086	2.2472	0.1219	0.0221	0.1800	**3.0635**
Human toxicity kg 1,4-DB eq	0.0247	0.0283	1.2374	0.0031	0.8478	0.0217	0.0358	0.4500	**2.6488**
Eutrophication kg P eq	0.0005	0.00003	0.0001	0.000011	0.0028	0.0001	0.0000	0.0002	**0.0037**

Regardless of the supply chain, the highly critical points are clearly the companies, particularly the 2nd stage processing plants. Indeed, it is at this stage that most of the emissions (¾) are generated, especially for GHG and eutrophication with the tin can and the energy used to produce steam (mostly natural gas) being the main causes. Regarding human toxicity risks, the 1st stage processing factory is also a critical point because of the metal drums used. Interestingly, the agricultural stage, whether in France or Turkey, has very limited responsibility with regards to all impact categories, with the exception of eutrophication (around 12% of the impacts).

At agricultural level, the impacts are quite similar between the two countries: GHG emissions are 1.6 times higher in Turkey, human toxicity is slightly higher in France, whereas eutrophication levels are practically the same. On the contrary, Turkey features much higher environmental impacts if we consider transport from the

field to the first processing plant (an average of 70 km by tractor and 110 km by truck) for all 3 impact categories, as well as higher impacts for GHG emissions generated by the first processing plant alone. Regarding transport, findings highlight that rather than distance, it is the mean of transport that influences environmental impacts: for example, pollution (per kg of tomato sauce) due to transport between the field and the first processing plant (by tractor and truck) in Turkey is much higher (for example, 3 times for GHG emissions) than that between the Turkish processing plant and France (an average of 120 km by truck and 1225 km by ship). In France the shorter distance between the production sites and the processing plants (an average of 76 km) coupled with a rationalization of transportation of fresh tomatoes, makes GHG emissions 4 times lower than in Turkey.

Both in France and in Turkey, among technical operations, fertilization has the highest impact, compared with soil preparation, planting, protection, harvest and post-harvest work. This is true for 2 out of three impacts categories: global warming (F=62.7%, T=61%) and eutrophication (F=95%, T=93%). In France, an average of 106 kg of nitrogen, 134 kg of phosphorus and 223 kg of potassium are used per hectare, with great differences among the four farms. In Turkey, these are respectively, 133 kg, 90 kg and 184 kg. Yields are much higher in France than in Turkey, being 102.5 tons per hectare for the first and 72.5 tons per hectare for the latter. The second activity that impacts the most is soil preparation and harvest (36% of human toxicity and 30% of GHG in France). However, regarding human toxicity, phytosanitary treatments also play an important role in France.

In France, differences can be observed between the agricultural practices in the South-East and in the South-West. Due to different soil and climate conditions, use of fertilizers is higher in the South-East, whereas the opposite is true for pesticides. Therefore, eutrophication levels are 1.4 times higher for tomato production in the South-East. However, GHG emissions and human toxicity levels are similar.

The consumer stage also has a significant impact on the whole supply chain: 6% of GHG emissions, 19% of human toxicity and 5% of eutrophication. This is mainly due to the can recycling. Shopping also holds a part of the responsibility, as the majority of consumers drive to supermarkets. This generates a significant amount of impacts, especially with regards to global warming.

The main objective of an LCA is to compare the environmental impact of a product with that of another, in order to decide between the two. Therefore, we decided to compare the environmental impacts of two methods of tomato sauce preparation: the first one from fresh tomatoes and the second one from processed tomatoes. The consumer effectively choses between products that have the same function. At home it takes 2 Kg of fresh tomatoes, 30 minutes of cooking on an electric stove to obtain 1 Kg of sauce (according to our survey, the electric stove is the most common cooking method). The results show that at consumer level, both types of sauce have a similar impact on global warming. Differently, eutrophication is 1.5 times higher for home-made sauce while human toxicity is 10 times higher for sauce made with processed tomatoes. In the first case, the use of water is in cause, whereas for the second one it is rather the impact associated with the can.

4. Discussion

Very few studies take in account the whole system, including production, processing and distribution. The FLONUDEP project can be considered as the first of its kind in France. Results regarding Turkey are similar to others carried out in the same country (Karakaya and Özilgen, 2011).

Comparison with recent literature shows a certain consistency with results from the FLONUDEP project. In his study (Brodt et al., 2013), Brodt highlights the importance of transport rather than distance by making a comparison between a local supply chain of processed tomatoes and a national one. In this study, the choice of environmental impacts is also important because it can significantly change the results. Furthermore, an Italian study (Marletto and Silling, 2010) indicates that the impact of transport by car between the supermarket and home is a critical point which generates a significant amount of impacts. Another recent study in Turkey (Karakaya and Özilgen, 2011) highlights the responsibility of transport by tractor between fields and processing plants in generating impacts, as well as very different impacts depending on the energy source used in the plants. However, the supply chain stages which appear as the most impacting ones are not the same in this latter study as in the FLONUDEP study. This would require further research.

At farm level, if we refer to other LCAs for the same product (fresh field tomatoes) and with the same system boundaries, general results are similar: if eutrophication is higher in the production systems in Turkey (Karakaya and Özilgen, 2011), GHG emissions and acidification are higher in Spain (Martinez-Blanco et al., 2011). The French farms hold an intermediate position for all impact categories.

Table 3. Comparison of environmental impacts at the agricultural stage for industrial tomatoes (for 1kg of fresh tomato)

Category of impact	Unit	France	Turkey	Spain
GHG	kg CO2 eq	0.03424099	0.07951771	0.150
Acidification	kg SO2 eq	0.00058862	0.00049713	0.000888
Eutrophication	kg PO4 eq	0.00030962	0.00037501	0.000234

Source: Our study Flonudep, 2013; Karakaya and Özilgen, 2011; Martinez-Blanco et al., 2011

5. Conclusion

The advantage of such a study taking into consideration all the components of a system is to put into perspective the importance associated with some factors. Often agriculture is regarded as the most impacting sector. However results show that the main critical points are at plant level and more specifically packaging. It is therefore necessary to rethink packaging solutions and take into account their environmental impact associated with manufacturing and recycling. At plant level, two critical points clearly appear: the kind of energy used (there is a big difference between France which essentially uses nuclear energy and Turkey which uses fuel oil and gas) and the production of steam (with gas). A debate on production processes and "clean" energy is needed. . Furthermore, we should rationalize logistics according to environmental criteria rather than economic criteria. This would imply, for example, using local grouping platforms, closer to the production sites. We should also rethink transport for food products, as findings show that transport by truck in highly polluting. At agricultural level, as well as in all the other case studies taken in consideration, fertilization is the most polluting activity, followed by soil preparation and harvest for GHG. Phytosanitary treatment has also a significant role in terms of human toxicity. If ferti-irrigation is a partial solution, it would be useful to consider organic production or choose more energy efficient and less polluting agricultural equipment. Finally, it would be necessary to promote more "environmentally friendly" purchasing and consumption behavior among consumers. However, isn't the modern supply and consumption system responsible? This is particularly true regarding consumption of ready-made, processed food, and supermarkets placed far out of the city centre.

The FLONUDEP research has been carried out on a limited sample of farms and processing plants in France and Turkey. Therefore, caution must be taken in interpreting results. However, the project highlights the critical points in the supply chain, and shows that according to environmental criteria, local products are not necessarily "better" than imported ones.

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