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## When product diversification influences life cycle impact assessment: A case study of canned anchovy

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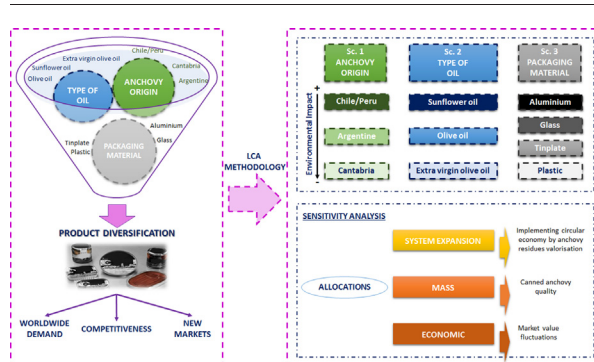
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### HIGHLIGHTS

- Companies aim introducing their diverse products in new green markets.
- Anchovy origin, type of oil and packaging material are the main product variables.
- The life cycle assessment of the canned anchovy are performed from cradle to grave.
- Imported anchovies, sunflower oil and aluminum are the worst environmental option.
- System expansion, mass and economic allocation are compared.

### GRAPHICAL ABSTRACT



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### ABSTRACT

The anchovy canning industry is one of the most important economic resources of the Cantabria region in Spain. However, environmental, economic and social problems over the past years have forced companies to apply marketing strategies, develop product diversification, create new products and introduce them in new “green markets”. Launching Cantabrian canned anchovies into more sustainable markets requires measuring the environmental performance using Product Category Rules (PCRs) and Environmental Product Declarations (EPDs). EPDs and PCRs include the environmental profile of a range of similar products, such as all of the available canned anchovy products. The great variety of anchovy canned products depends on three process variables: the origin of the anchovy (Cantabria, Argentina and Chile or Peru), the type of oil (refined olive oil, extra virgin olive oil and sunflower oil) and the packaging (aluminum, tinplate, glass and plastic).

This work aims to assess the environmental impact from cradle to grave of canned anchovies in oil using the life cycle assessment methodology (LCA). Moreover, the paper evaluates the influence of the above-mentioned three product variables in the LCA results. The results show that out of all of the alternatives, Chilean and Peruvian anchovies have the highest environmental burdens due to the transportation by ship. The production of anchovies in sunflower oil is a less environmentally friendly oil process due to the low yield per hectare of sunflower cultivation. Finally, the use of aluminum as the packaging material has the largest environmental impact out of almost all of the impact categories. Moreover, because the LCA results can be significantly affected by the allocation procedure, a sensitivity analysis comparing system expansion, mass and economic allocation is performed. In this case, the system expansion approach presents the highest environmental impacts followed by the mass allocation.

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## 1. Introduction

The food production system as a whole is recognized as one of the major contributors to environmental impacts since it is a great consumer of both energy and natural resources (Iribarren et al., 2010b). In particular, the quality and prestige of canned anchovies are of particular relevance in the Cantabria region in North Spain. Nevertheless, there are several environmental, economic and social problems in this sector. From an environmental point of view, the manufacturing process generates large amounts of effluents (mainly water and oils), fish residues and packaging wastes. Moreover, in recent years, the stock level of the Cantabrian anchovy (*Engraulis encrasicolus*) has been in a critical situation whereas the costly distribution to new markets has hindered the growth of the sector. The main economic and social problems of the sector were the closing of the anchovy fishery in 2005. The capture decreased from 982,000 kg in 2004 to 12,000 kg in 2005, causing the loss of a significant number of jobs in the canning sector of Cantabria Region. (ICANE 2016). Consequently, the sector needs to develop local strategies to reach global development. The anchovy canning industry has considerable product diversification due to the high worldwide competitiveness and demand, which makes the development of marketing strategies to reach and maintain a leading position in the market necessary. From the entire range of products, the key one is the so-called “octavillo”, which is formed by 30 g of Cantabrian anchovy fillets in 20 g of extra virgin olive oil (total 50 g) contained in an aluminum can. Consumers around the world see this canned food as a gourmet product. However, the sector has developed a wide range of new products combining the main variables of the process as a diversification strategy. That is, the canning plants were forced to import fresh and salted anchovies from other countries due to the depleted stock level in the Cantabria Sea. Anchovies may come from Cantabria (*Engraulis encrasicolus*), Argentina (*Engraulis anchoita*), Chile and/or Peru (*Engraulis ringens*) according to the market demand. Regarding the consumers' preferences, the anchovies may be preserved in sunflower oil, olive oil or extra virgin olive oil, and the primary packaging is available in aluminum cans, tinplate or glass jars; all of them are shipped inside cardboard boxes. Moreover, the size of the packaging varies from 50 g to 1 kg.

These products employ the same materials, namely, anchovies, salt, brine, oil and the packaging; however, the combination of these three

product variables (anchovy origin, type of oil and packaging) generates new canned products with different environmental impacts.

Launching Cantabrian canned anchovy products onto new “green markets” using Environmental Product Declarations (EPDs) and Product Category Rules (PCRs) (Haprowine, 2010) stated by the European policy “Building the Single Market for Green Products” (European Commission, 2013) will contribute to the development, recognition and expansion of this food sector. The PCRs define the rules and requirements for the EPDs of a certain product category. EPDs (ISO, 2006a) communicate quantitative information about a specific product both to manufacturers and distributors and to the final consumer using the Life Cycle Assessment (LCA) methodology (ISO, 2006b, 2006c) (Ibañez-Forés et al., 2013). Similar products from the same company can be included in the same EPD if the differences between the mandatory impact indicators are lower than 10% (Environdec, 2016). LCA is a standardized methodology for analyzing the potential environmental impacts of a product or service throughout its life cycle (Pirlo et al., 2016). Therefore, determining the environmental performance and analyzing the influence of the three variables in the life cycle of each canned anchovy product are required. This is the first step in the development of PCRs for this product category. Fig. 1 shows the procedure for defining the PCRs and EPDs of the canned anchovy category based on product diversification in the canning anchovy sector.

In addition to the product variables, there are other aspects of the LCA methodology, such as allocations, that have large influences on the results, and it is convenient to carry out a sensitivity analysis (Guo and Murphy, 2012).

This work aims to fill in the gap of LCA studies of canned anchovies from cradle to grave, which is the first step in developing the PCRs of this gourmet product. Concerning Peruvian anchovies, several studies have been published about the anchoveta fishery (Fréon et al., 2014a, 2014b; Avadí et al., 2014a) and the anchoveta production and consumption (Avadí et al., 2014b; Avadí and Fréon, 2015).

There have been no previous LCA studies on European anchovies (*Engraulis encrasicolus*). The authors published the two first papers regarding this species. In particular, Laso et al., 2016a evaluated the management of the anchovy residues generated during the canning process, and Laso et al., 2016b assessed the environmental performance of the production of one can of anchovies in olive oil (from gate to grave),

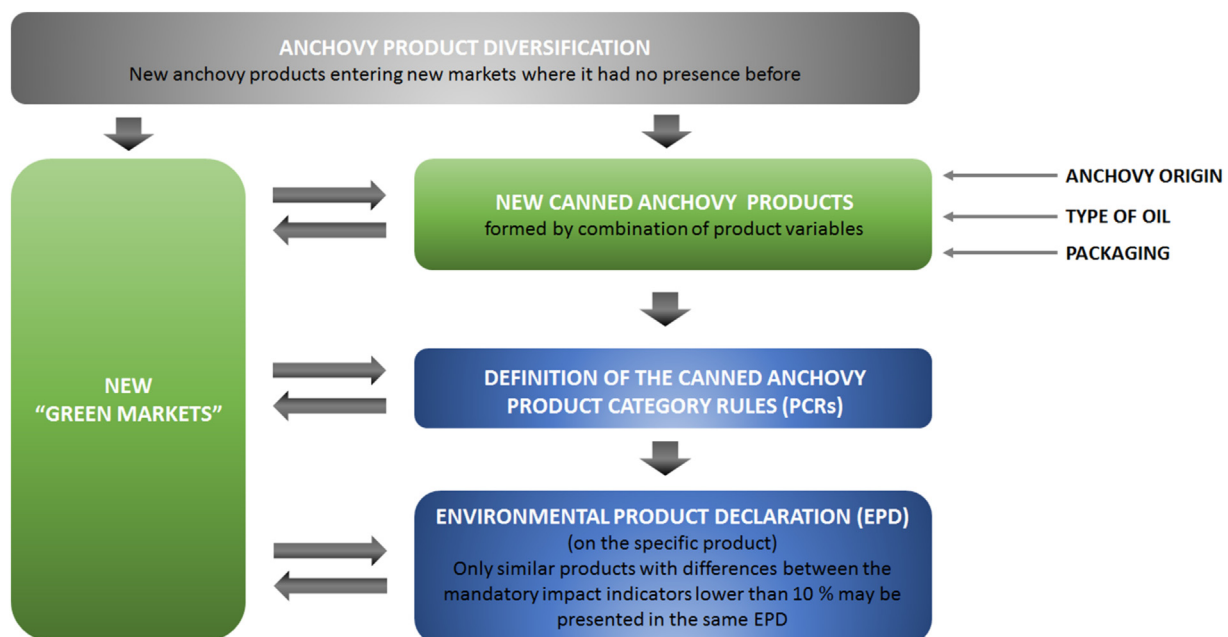


Fig. 1. Procedure for defining the PCRs and EPDs of the canned anchovy category.

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