LCA Food 2018: *(1-D) Ways towards SDGs*

Feed eco-design: how to make a good decision? Part 1- Uncertainty analysis of feed formulation

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Abstract

The purpose of this study was to consider the uncertainty of environmental impacts of main feedstuffs produced in France due to different processes and areas of production, and its effect on eco-feed formulation. For energy consumption and climate change, and for many feedstuffs, the use of national average data of environmental impacts is sufficient for the eco-design exercise of feed manufacturers. Despite this, it is necessary to complete the ECOALIM dataset with more detailed data for maize and wheat.

Keywords: *environmental impacts, LCA, feed, formulation, databases, uncertainties*

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1. Introduction

Are the environmental data concerning feed ingredients adapted to eco-design for feed manufacturers? The question is of interest because eco-labeling brings to the production of several national databases on environmental impacts of products which are now available for economic stakeholders. ECOALIM dataset, included in AGRIBALYSE® database, is one of them and contains the environmental impacts of 150 different feedstuffs (Wilfart et al., 2016) with average national data for France. Feed manufacturers can use them in formulation in order to produce eco-feeds with less environmental impacts. Garcia-Launay et al. (2016) proposed a methodology to do so with a multi-objective function in order to simultaneously optimize the environmental improvement of several environmental impacts (climate change, phosphorus consumption, energy consumption and land occupation) for a minimal overcost. The eco-feeds lead to decrease incorporation of several feedstuffs in formula by replacing them with other feedstuffs of lower impacts. Therefore the value of the environmental impacts of each feedstuff has a huge importance, especially considering the fact that there is a huge diversity of production processes and pedoclimatic conditions in France. In this context, the objective of this study was to consider the uncertainty of environmental impacts of main feedstuffs produced in France due to different processes and areas of production, and its incidence on eco-feed formulation.

2. Material and methods

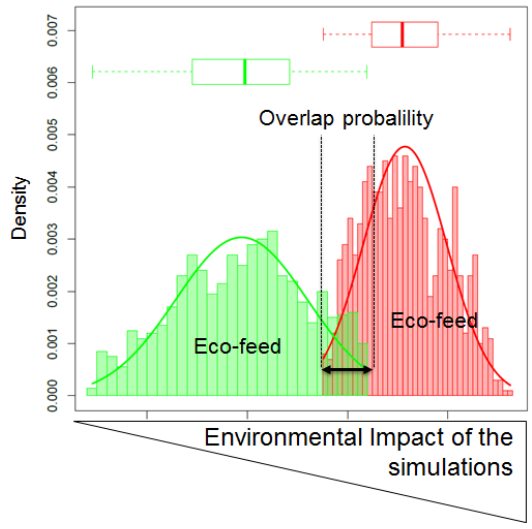
First, standard feeds and eco-feeds were formulated for fattening pigs (growing and finishing feeds) in 4 contrasted economic contexts concerning the price of feedstuffs (2011, 2012, 2013 and 2014) and two different contexts of feedstuff availability (current context with the actual availability of feedstuffs LIM and a prospective context with an increased availability LIM+). The standard feeds used a least-cost formulation and the eco-feed used ECOALIM dataset in a multi-objective

formulation which minimizes the cost and four environmental impacts: energy consumption (EC), phosphorus consumption (PC), climate change (CC) and land occupation (LO). The methodology also considers two other impacts: acidification (AC) and eutrophication (EU) with the constraint to not increase them over 5% relatively to leas-cost formulation. Then, an uncertainty analysis was conducted following the approach of Payraudeau et al. (2007) considering distributions of frequencies of environmental impacts for each of the main crops used in feeds (wheat, maize, barley, rapeseed, sunflower …) and their transformed coproducts (bran, middling, meal…). In these ranges, we created random samples in R according to a normal distribution, bounded on the minimum and maximum values. Two steps were used in the methodological approach (figure 1).

Step 1: The average environmental impact values of the feedstuffs were used to formulate both standard and eco-feeds. Then the environmental impacts of standard and eco-feeds were calculated with the values obtained from 1000 random values, in order to estimate the impacts' overlap between the two types of feeds.

Step 2: The random samples (N=500) were used to generate the eco-feeds in order to estimate the incidence of the impacts of feedstuffs on their use in eco-feed.

Distribution of environmental impact for standard and eco-feeds among simulations of step 1 with overlap probability



Step 2: Distribution of the difference of impacts between standard and eco-feeds for each simulation of step 2

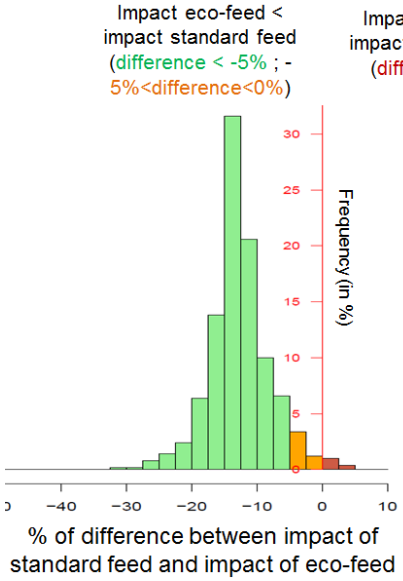


Figure 1: Types of result looked at for step 1 and step 2 of the methodological approach

3. Results and discussion

The results of step 1 (table 1) show that the respective distributions of environmental impacts for standard feeds and eco-feeds among simulations have an overlap rate quite low for the impacts energy consumption and climate change included in the multi-objective function (mainly < 20%) except for phosphorous consumption for finishing feed in LIM context and land occupation which is an impact hard to reduce simultaneously to the others. Indeed, the feedstuffs with lower impacts have often a lower yield. For the impacts which were not minimized by the function (acidification and eutrophication), the overlap rate was more important showing no significant difference between standard feed and eco-feeds.

By using the variability of the environmental impacts of the feedstuffs to perform the multi-objective formulation (step 2), we noticed that we could obtained eco-feed in most of the simulations with difference of impacts compared to standard feeds higher than 5% (Table 2). The probability is mainly higher than 90%, except for several cases where it is higher than 83%: this is the case for the impacts phosphorous consumption and land occupation of some feeds. For the

impacts acidification and eutrophication, the impacts could be higher with eco-feed than with standard feed, as in step 1.

Table 1: Overlap probabilities (in %) with the mean obtained among simulations of step 1 (*and the standard deviation)* for the environmental impacts of growing and finishing feeds and for the two contexts of feedstuffs availability (LIM and LIM+)

		4 impacts of the multi-objective function					
		PC	EC	CC	LO	AC	EU
Growing feed	LIM	29 *(25)*	**0** *(0)*	**0** *(0)*	65* *(28)*	92* *(6)*	77* *(11)*
	LIM+	**0** *(0)*	**0** *(0)*	**0** *(0)*	47 *(38)*	78* *(19)*	55* *(15)*
Finishing feed	LIM	83* *(18)*	**14** *(17)*	**18** *(22)*	59* *(36)*	90* *(3)*	76* *(15)*
	LIM+	**20** *(27)*	**0** *(0)*	**6** *(12)*	53* *(46)*	87* *(15)*	77* *(10)*

Legend : **bold :** Overlap probability < 20 % ; * : Overlap probability > 50 %

Table 2: Percentages of simulations with difference >5% between the environmental impact of standard feed and eco-feed (on the left of "/") and <0% (on the right of "/) concerning the growing and finishing feeds and for the two contexts of feedstuffs availability (LIM and LIM+)

		4 impacts of the multi-objective function					
		PC	EC	CC	LO	AC	EU
Growing feed	LIM	**97** / 1	**100** / 0	**100** / 0	89 / 4	67 / 24	72 / 18
	LIM+	**100** / 0	**100** / 0	**100** / 0	**95** / 1	77 / 21	87 / 8
Finishing feed	LIM	86 / 4	**99** / 0	**100** / 0	**96** / 1	76 / 20	84 / 12
	LIM+	**94** / 1	**96** / 0	**94** / 0	83 / 5	70 / 27	77 / 15

Variability of impacts of feedstuffs changed the incorporation rates and the feedstuffs selected among simulations of step 2 (figure 2). The modifications were quite stable for some feedstuffs like rapeseed, wheat middlings, pea and faba beans which incorporations are mainly increased in formula of eco-feed compared to standard feed. For others feedstuffs like sugar beet pulp its increase is not systematic, just for finishing feed and in lower proportion (<5%). On the contrary some other feedstuffs are mainly reduced in the formula of eco-feed: this is the case for sunflower meal from Ukraine, triticale and maize coproduct. For wheat and maize the incorporation rates can be either increased of decreased, depending on the simulation, and to a large extent (+/- 60%).
Such uncertainty analysis is necessary to improve the quality of the decision we are making by using environmental data in eco-design processes. Our analysis has assets and limits. One of the assets is that we look at the impact reduction at the diet level as suggested by Leinonen et al. (2013): it allows us to consider all the substitutions. Another asset is that we considered different economic contexts: it was estimated relevant by Pomar et al. (2007) because costs of the feedstuffs change widely the formulation. As a limit, we decided to apply a normal distribution to the range of impacts values for feedstuffs. It is an assumption which impacts the results as indicated by Leinonen et al. (2013). As the results suggested for some feedstuffs, national average could be insufficient and more detailed production processes are required. Nguyen et al. (2012) proposed an approach with different maize from different parts of France. This approach is not approved by the sectors of grain and oilseed crop because it sets the regions against each other on the basis of their production potential: they prefer a distinction based on the production processes which could be applied everywhere.

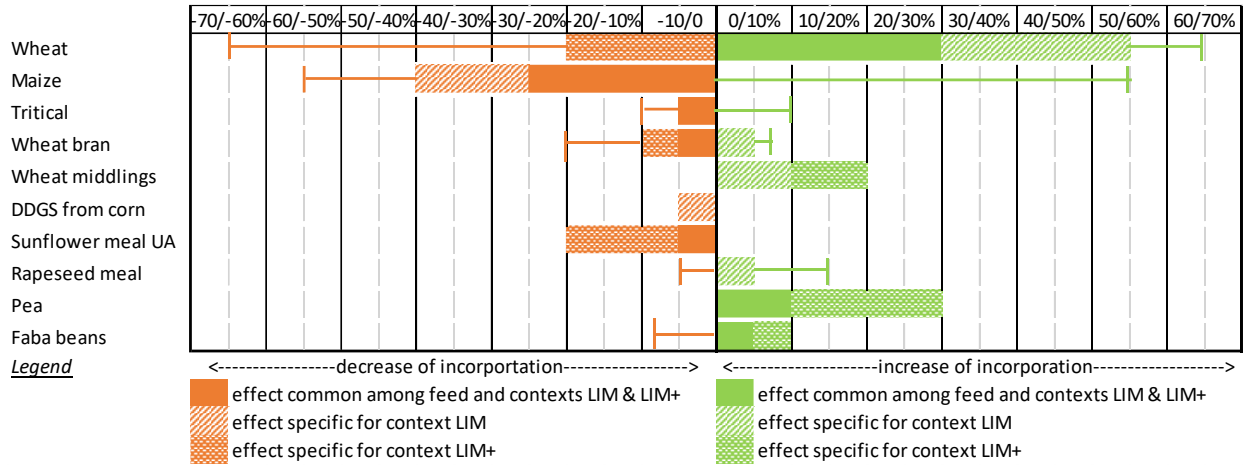


Figure 2: Box plots of the difference of incorporation rates of feedstuff between standard and eco-feed among the simulations of step 2

4. Conclusions

In most cases and for many feedstuffs, the use of national average data concerning the environmental impacts is sufficient for the eco-design exercise of feed manufacturers. Despite this, it is necessary to complete the ECOALIM dataset with more detailed data for maize and wheat.

Thanks to the uncertainty analysis, we identified robust feedstuffs to use in order to reduce the environmental impacts of feeds (protein crops like pea and wheat coproducts). The results are also quite stable for others feedstuffs which should be limited in feed (Ukrainian sunflower meal…).

For others feedstuffs like wheat and maize that have high incorporation levels in feed, different production processes should be available in the database to replace the average national impacts. Otherwise the substitution observed between feedstuffs when shifting from least-cost formulation to multi-objective formulation is not always relevant, depending on the location of feedstuffs production.

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