LIFE Project Number

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LIFE PROJECT NAME or Acronym

LIFE-F4F (Food for Feed)

Annex Data

Action:	B4 Evaluating the Produced Feed for Pigs and Poultry Husbandry
Partner:	AUA
Deliverable B4.3.:	D4.3 Economic evaluation of the produced feed, regarding pigs and poultry husbandry

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1. ACTION B.4.: Evaluating the Produced Feed for Pigs and Poultry Husbandry

2. Introduction

Methodology for economic evaluation of a feed

Advances in the agri-food sector are necessary in order to promote global food security and nutrition, environmental sustainability and to benefit global food production by reducing production costs. According to the 2019 World Population Prospects of the United Nations, the world's population is estimated at 7.7 billion and is projected to increase to 9.7 billion in the middle of this century. At the same time, global consumer demand for food is expected to rise due to population growth and increased per capital incomes, with developing countries expected to experience a market increase in consumption of meat-based products.

It is very likely that food production needed to correspond with consumer demand will be limited due to finite natural resources. Agricultural land which is available for food production may not expand and is even possible to be less available for that purpose. Concurrently, one-third of the total food produced is lost or wasted globally, an amount of food equal to 1.3 billion tons. Food losses that arise at the final sectors of the food supply chain namely retail and final consumption are referred to as 'food waste'. Food waste accounts for a substantial quantity of wasted resources most notably the nutrients present.

Although the main effort to reduce food waste should be on prevention, its re-entrance in the food supply chain is a prerequisite for putting into effect the principles of the circular economy, the later considers waste as resources. Food waste could be a substitute for part of cereal grains and plant protein sources used in animal nutrition, which would alleviate food competition between humans and animals. Food waste disposal has big consequences for the environment and therefore, a 'waste management hierarchy' has been adopted defining the most and the least preferable disposal options. The best way to face the food waste disposal problem is the prevention of wasting food, and secondly, the re-use and redistribution of food. Moreover, recycling of food waste in animal nutrition is, also, a good option even less preferable. Currently, under the EU legislation being in force, a small proportion of the generated food waste can be utilized in animal nutrition. According to the European Former Foodstuff Processors Association (EFFPA), food waste appropriate for use as animal feed represents only 5 million tons of food waste, which is a small proportion compared to the total food waste generated. Any feed, available to be used in animal nutrition, should be first of all acceptable and appropriate from dietary, nutritional, and hygiene point of view, and of low cost. Thus, an acceptable feed should then be evaluated from an economic point of view. From the FOOD4FEED Life Project, a dry product has been produced from the food lefts of Hotel which can be used as feedstuff for fur, pets and monogastric (pigs, poultry) animals. Its chemical composition, despite its expected variability, shows that it is a valuable product due to its relatively high crude protein (~ 22-24 %) and fat (~ 21-23 %) content, which mainly determines the dietary value of a feedstuff, and consequently its market price.

In animal nutrition, there is a practical methodology for economic evaluation of any available in the market feedstuff. There is the PETERSON method for feedstuffs evaluation, based on two widely used feedstuffs accepted as prototypes: the corn grain and the soybean meal. According to this method, any feedstuff under economic evaluation is compared with the mixture of the two prototype feedstuffs mentioned above. Thus, if X=corn and Y=soybean

X+Y= 1 K g of the feedstuff under evaluation

based on energy, crude protein, the essential amino-acids lysine and methionine, Calcium and available Phosphorus content. In practice, that means that 1 Kg of an under economic evaluation feedstuff (in our case 1 Kg of dry food waste) is comparable (equivalent) with X+Y Kg corn and soybean meal mixture (where X+Y # 1) from nutritional point of view for the animal species aimed to be fed. Thus, the value of 1 Kg dry food waste is X.a +Y.b where X=Kg of corn, a= the market price of 1 Kg of corn, Y=Kg of soybean meal, and b=the market price of 1 Kg of soybean meal. For example, if the energy content of the dry food waste is 11 MJ ME/ Kg with 220 g Crude Protein/Kg, then the equations for energy and protein are the following ones: 14X + 9Y = 11 (for energy) and 85X + 430Y = 220 (for protein). The solution of this equations' system gives that: 1 Kg of dry food waste is equivalent with 0.851 Kg of corn + 0.344 Kg of soybean meal. Then, if the market prices for corn and soybean meal are 250 and 400 euros/ ton respectively, the max market price for the dry food waste will be: 0.851x250 + 0.344x400 = 350 euros/ton.

Thus, due to price changes of the prototype feedstuffs in the market, the relative max purchase price for each feedstuff under evaluation is also changeable.

This principle is implemented today with linear programming in computers to formulate the right (appropriate) diet for each animal species with the min cost. In this case the inclusion percentage of each feedstuff is determined from the proposed solution (from zero to X %).

The simplest approach is to make a control diet (A), and a similar one (B) in which the feedstuff under evaluation has been included in a certain percentage (e.g. 12%), acceptable from nutritional point of view. In this case, if the cost of the diet A is 350 euros/ ton, and that of B 310 euros/ton (the cost of all ingredients except the 12 % of the feedstuff under evaluation), then the max price of the feedstuff under evaluation will be:

(350 - 310: 0.12 = 333 euros/ton

The Dry Food Waste Lefts (DFWL) price (in euros/Kg) estimation based on the experimental results

In order to evaluate the dry food waste lefts (DFWL) of the F4F project, the following experiments were designed and carried out:

A. Broilers from 0 to 42 days of age, fed a control (C) diet based on corn and soybean meal, and the Treatment (DFWL) one, based, also, on corn and soybean meal and 15 % DFWL. The results showed a 5 % lower feed efficiency (Kg of feed / Kg body weight gain) for the DFWL group compared with that of the C group.

B. Broilers from 0 to 42 days of age, fed a control (C) diet, based on corn and soybean meal, the Treatment A (DFWL-NM) diet based, also, on corn and soybean meal and 10 % DFWL without meat (NM) in it, and the Treatment B and C diets, based, also, on corn and soybean meal and 10 % DFWL sterilized and no sterilized respectively. The results showed a 12 % lower feed efficiency for Treatment A, and 5 % for Treatment B and C groups compared with that of group C, without any difference between groups B and C.

C. Fattening pigs from 50 to 100 Kg body weight, fed a control (C) diet based on corn, soybean meal and wheat middlings, and the Treatment (DFWL) one, based, also, on corn, soybean meal and wheat middlings, and 10 % DFWL. The results showed a 3 % lower feed efficiency for the DFWL group compared with that of the C group.

D. Fattening pigs from 50 to 110 Kg body weight, fed a control (C) diet based on corn, soybean meal and wheat middlings, and the Treatment one based, also, on corn, soybean meal and wheat middlings and 8 % DFWL without meat (NM) in it. The results showed a 2.6 % lower feed efficiency for the DFWL-NM group compared with that of C group.

The DFWL products decided to be tested, as animal feed for broilers and pigs, were the DFWL (sterilized and no sterilized) and the DFWL-NM. Both products, DFWL and DFWL-NM, have a variability in their chemical compositional which is expected since the food waste lefts are not, in any case, the same. This is not a real problem for the feed industry since such a variability exists in a any raw material, and due to that each feed, before its use, is analyzed.

One of the feed quality criteria is the protein solubility, which is, mainly, affected by heat treatment. The DFWL should be sterilized for safety (hygiene) reasons due to possible contamination with harmful microbes. The in vitro tested solubility of this material (DFWL product) did not show any significant difference between sterilized and no sterilized product. However, since the in vitro results are not always highly correlated with those in vivo, it was decided to include both of them, as treatments, in the experimental diets of broilers.

According to the existing legislation (EU relevant Directives), the DFWL, with meat in it, is forbidden to be used in diets of productive livestock (ruminants, poultry, pigs, rabbits). For this reason, it was decided, as alternative, to exclude all the meat lefts and to test the DFWL-NM after sterilization in broilers and pig diets. The DFWL is a product of lower energy and protein content, but still a valuable product to be used as raw material in animal feeding.

The following Tables 1 and 2 present the estimated actual prices of the fed experimental diets to broilers and pigs respectively, of all the experiments, and the calculated potential max market price of the different DFWL products of the F4F project. For the calculations, the following parameters were taken into account:

- The current market prices of all the raw materials used in the diets, which were the same for all the other ingredients apart from the corn and the soybean meal. Those prices were: 210 euros / ton corn and 380 euros / ton soybean meal in 2019, and 250 and 480 euros / ton respectively for the year 2020. Thus, two scenarios were made for the calculations:
  - **SC-I (2019)** with the low prices of corn and soybean meal, and
  - **SC-II (2020)** with the higher prices

- The feed efficiency (Kg of feed/ Kg of body weight gain) of each dietary treatment was, also, taken into account, in order to get comparable values, since the feed efficiency is very important for the economic evaluation in animal nutrition.

Table 1.

	Experiment I		**Experiment II**		
	C	Treat	C	Treat A	Tr - B
DFWL (%)	-	15	-	-	10
DFWL –NM (%)	-	-	-	10	-
Diets' cost (€/Kg)					
SC-I (2019)	371		368		
SC-II (2020)	431		428		
DFWL (€/Kg)					
- SC-I (2019)		485			466
- SC-II (2020)		546			520
DFWL-NM (€/Kg)					
- SC-I (2019)				145	
- SC-II (2020)				190	

Table 2. The real cost of the diets (in euros/ton) used in each pigs' experiment, and the potential max market price of the different DFWL products used in those experiments for the F4F project

	Experiment I		**Experiment II**	
	C	Treat	C	Treat
DFWL (%) **DFWL–NM** (%)	- -	10 -	- -	- 8
Diets' cost (€/Kg)				
SC-I (2019) SC-II (2020)	287 331		396 439	
DFWL (€/Kg) - SC-I (2019) - SC-II (2020)		 428 481		
DFWL-NM (€/Kg) - SC-I (2019) - SC-II (2020)				195 260

3. Discussion

The results of Tables 1 and 2, presenting the economic evaluation of the DFWL products, shows that the max market price of this product fluctuates, with this fluctuation depending on:

a. Animal species (broilers, pigs) diets in which is used. This is because different animal species, at different production stages (growth, lactation, reproduction etc.), have different energy and protein requirements. The higher the animal's requirements in energy and protein (broilers > pigs in our experiments), the higher the market price of the DFWL product, due to its high energy (because of its high content in fats and oils) and protein content.

b. DFWL's inclusion percentage in animal's diet. The higher the inclusion percentage, the higher its market price. This is, also, related to its (DFWL) high energy and protein content.

c. Prototype animal feeds (corn, soybean meal) prices. The higher the market prices of these two prototype feedstuffs, the higher the under evaluation feed (DFWL) market price.

d. Chemical composition of the produced DFWL. From what it has been seen so far, when the DFWL has meat lefts in it, the crude protein (CP) is high (>20 %), while when meat lefts are excluded, its CP content is much lower (< 20 %), and thus its price is getting lower.

Apart from that, the DFWL has a better (higher) essential amino acids' profile compared with that of DFWL-NM (with no meat in it) which gives to it a higher dietary value, and consequently a higher market price. The energy content of these two products (DFWL and DFWL-NM) is, also, different, depending mainly on their fats and oils content. Thus, the calculated energy content for broilers was 15 and 12 MJ ME poultry/ Kg, and for pigs 13 and 10 MJ ME swine/Kg, respectively.

Further to the above economic evaluation of those products (DFWL and DFWL-NM), based strictly on dietary criteria, two extra points should be considered:

a. Due to their high ether extracts (fats and oils) content, they are prone to oxidation and develop rancidity. To preserve them for longer, and to prevent rancidity, a fortification with Vitamin E and Se (selenium) is needed. The storage conditions (temperature, humidity, duration) of those products should also be taken into account.

b. The experimental results showed that there is no negative effect of the sterilization process on their dietary value. That means that for safety (hygiene) reasons the product should be sterilized before its use as animal feed.

In conclusion, the DFWL products of the F4F project are quite valuable and can be used as raw material in animal feeding (according to EU directives) due to their relatively high energy and protein content, apart from the environmental benefits from their use. This is supported by the experimental results with broilers and fattening pigs (growth rate and carcass

quality parameters), and from the relatively high potential market price (at least quite comparable with that of soybean meal) they can get.