A Decision Tree for Co-Product Utilization

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▪ Introduction

Co-products from the agro-food industry do play an important role in modern animal and fish nutrition. Total feed consumption by the livestock and aquaculture industry in the 25 EU countries (EU-25) is estimated to be approximately 450 million tonnes per year. Besides 270 million tonnes of home grown cereals and forages, farmers use about 140 and 40 millions tonnes of industrial compound feed and purchased straight feedstuffs, respectively. The last two categories comprise about 60 million tonnes of co-products from the European agro-food industry and 35 million tonnes imported from other parts of the world (FEFAC and CIAA, 2006).

The variety of such co-products is huge, including vegetable products derived from cereals, oil seeds, fruits, tubers and roots, and animal products from the processing of milk, meat and fish. Most of those co-products represent only a small percentage of the total added value to the original raw material. However, some of the products are contributing to a major proportion of the added value, such as soybean meal from the oil crushing industry.

The major reasons for using co-products in animal feed are related to costs, availability and nutrition value. Co-products have proven to be financially attractive, in particular in areas with a seaport and /or a high density of agro-food industry. Both conditions have contributed to the rapid development of the Dutch livestock industry and historically the Dutch feed industry is using high levels of co-products (**Table 1**). Most of the co-products are unfit for human consumption, the nutrition value for animals might be excellent. This can be explained by intrinsic factors related to the co-products and physiological properties of animals such as a different taste perception and digestive system. Pigs and in particular ruminants are capable to convert fibrous components into valuable nutrients finally resulting in high quality animal products, such as milk and meat. As a consequence, many co-products can be fed to those species, even high-moisture co-products. The latter is feasible because of the existence of sophisticated liquid feeding systems, especially designed for the feeding of high-moisture co-products. In the Netherlands, more than 10% of the total dry matter usage in pig feeds is of liquid co-products (**Table 2**). The most important liquid co-products in pig diets are wheat starch, whey and steamed potato peals (Landbouw Economisch Instituut, 2005).

Table 1: Use of co-products in pig feeds in the EU and the Netherlands (source Fefac, 2004)

Feedstuff	EU-15	NL
Cereals	48	18
Co-products ‘oil seed crushing’	25	32
Co-products ‘food industry’ (dry and wet)	14	28
Leguminose seeds	2	2
Fats / oils	2	4
Tapioca	1	11
Other	8	5

Table 2 Feed usage in kton 88% dm equivalents in the Netherlands in 2004 (source: Blonk Milieu Advies, 2005, adapted from figures PDV, OPNV, LEI and CBS).

	Total	Ruminants	Pigs	Poultry
Grass and corn silage	14480	14480		
Other roughage (CCM)			60	
Liquid co-products	1210	440	770	
Compound feed	13750	3344	6048	3766
Total	29440	18263	6878	3766

Nevertheless, the use of co-products in animal feed certainly has its limitations. Many species show physiological constraints which require a more specific nutritional approach and some co-products require appropriate risk management. Fortunately, nowadays almost all agro-food companies treat their co-products for animal nutrition in the same way as their core products for food applications. However, the past showed that co-products sometimes happened to be out of the scope of Hazard Analysis and Critical Control Point (HACCP)-based quality assurance programmes and incidentally even be spoiled with waste, both resulting in unacceptable feed and food safety risks.

Increasing awareness in both the food and feed industry and continuously improving risk management strategies, such as the NuTrace® program (Nutreco, Boxmeer, The Netherlands), have proven to be effective to reduce the number of incidents. These measures and the reform in the European food and feed legislation, including the implementation of the General Food Law, the Hygiene Regulations and other legislation addressing quality, safety, health and environmental protection, make it possible to use co-products from the agro-food industry in a sustainable way.

The aim of this paper is to describe a decision tree for judging the economical value, safety and applicability of new co-products. The risk assessment of both the supplier and the co-product is an essential part of the analyses for decision making. A logical start of the process is to start with introducing the product and the supplier. As an example, co-products of the biofuel industry are illustrated.

▪ Step 1: Introducing the Product and the Supplier

In the first step, information is gathered about the supplier, product composition, production process, available volumes, some major quality aspects and indicative prices for assessing the technical-economical feasibility. Based on an ‘expert opinion’ the most appropriate animal categories for the co-product are defined (sows, piglets or growing pigs) and the nutritional value of the product is estimated (**Table 3**). Finally, the economical feasibility is assessed in a least-cost formulation exercise. If the results demonstrate that the co-product is financially attractive, time is invested in the risk assessment. If not, there will be a ‘no-go’ for the co-product.

To illustrate this procedure an example is given with the assessment of wheat Dried Distiller Grain Solubles (DDGS). These co-products of the bioethanol production can be used in animal feeds and is in the EU (as in the rest of the world) an emerging co-product. However, little information is available about the application of wheat DDGS in pig nutrition. Most published information is about corn DDGS. The nutritionist has to predict the nutritional value based on literature data, other external sources and in some cases also ‘educated guesses’. In the case of wheat DDGS, the information of nutrient digestibility in pigs can be obtained, for example, from the INRA tables (Sauvant et al., 2004) and Widyaratne (2005). These literature sources provide information about the digestible energy value, apparent ileal amino acid digestibilities, and phosphorus digestibility. This is sufficient for assessing the economical value. If it is economically viable, the following phase is entered in which the feed and food safety are analysed.

Table 3: The technical-economical analyses of a co-product.

	Information Needed
Technical	
Product form	moisture level, particle size, free-flowing properties
Sensory aspects	colour, odour, palatability
Preservation	pH, ‘shelf’ life, risk of spoilage (also feed and food safety aspect)
Nutritional	
Energy value	faecal digestible crude protein, ether extract, crude fibre, starch, sugar
Protein quality	non-protein nitrogen, apparent ileal digestible amino acids
Fat quality	eluable fat, fatty acid composition, free fatty acids
Fibre quality	crude fibre, NDF, ADF, ADL or NSP composition
Starch quality	total starch, slow and readily degradable starch
Sugar	total sugars, sugar composition
Minerals	calcium, phosphorus, digestible P, sodium, chlorine, potassium
Vitamins	optional
Other factors	organic acids
ANF	enzyme inhibitors, allergenic agents, saponins, alkaloids, glucosinolates
Economic	
Product	available volumes, price product
Target animal	piglets, growing pigs, gestating and/or lactating sows
Inclusion level	estimated maximum inclusion level per animal category
Price effect	impact of inclusion on feed price or price sensitivity analyses

Step 2: The Risk Assessment and Risk Management

The next phase is to assess the risks of the product and supplier (**Figure 1**). For this procedure we use a so called ‘Quick Scan’. A questionnaire has to be filled, which functions as a checklist for the risk assessment. The quality assurance program of the producer is reviewed and critical control points of the production process, the product and the logistics are defined. In the Netherlands, every supplier to the feed industry or home-mixer requires GMP certification (Productschap Diervoeder, 2006). This program includes also aspects of HACCP. If suppliers do not have this, or a similar, certification, the first logical step of the supplier would be to obtain such a certificate. In addition, we will make our own assessment by visiting the producer/supplier, defining the critical control points and reviewing their quality assurance system.

The most common risk is contamination with undesired substances and microbes. It can be caused in various stages of the production process, such usage of contaminated raw materials, the use of drying processes that may cause contamination with for example dioxins, preservation properties of the final co-product and contamination during transport. It is therefore logical to have a thorough screening of the co-products on these aspects. If we take for example DDGS (**Figure 2**), a Quick Scan of the product delivers that pesticides in wheat, the inactivation of live yeast and the risk of moulding in DDGS are critical control points that must be assured and monitored. The supplier is asked to provide information about the quality control system, the frequency of controls and guaranteed maximum levels.

From a nutritional point of view, it is also important to control the consistency in nutrient levels. If different co-products are mixed in order to obtain the final co-product, for example, the Dried Distiller Grain and the Dried Distiller Solubles in DDGS, the composition may vary dependent of the proportion. Heating and drying may cause early-Maillard reactions that limit the availability of amino acids and furthermore, the fermentation step in the process may result in variability in protein composition. These aspects have to be taken into account in the quality assurance system.

The Quick Scan will result in a ‘go/no-go’ for the supplier and the product. After approval by the responsible quality manager and nutritionist, the purchase department is informed that there is green light for the supplier and the new co-product. Dependent of the market price the product may be purchased. The supplier and product combination are now participating in the routine Quality Assurance System based on GMP and HACCP (see Figure 1: Risk Management). Important items in the risk management are the routine monitoring and evaluation of product safety and quality, and the installation of early warning / rapid alert systems (European Commission, 2006).

Figure 1: Sourcing of feed ingredients: A flowchart for risk assessment and risk management.

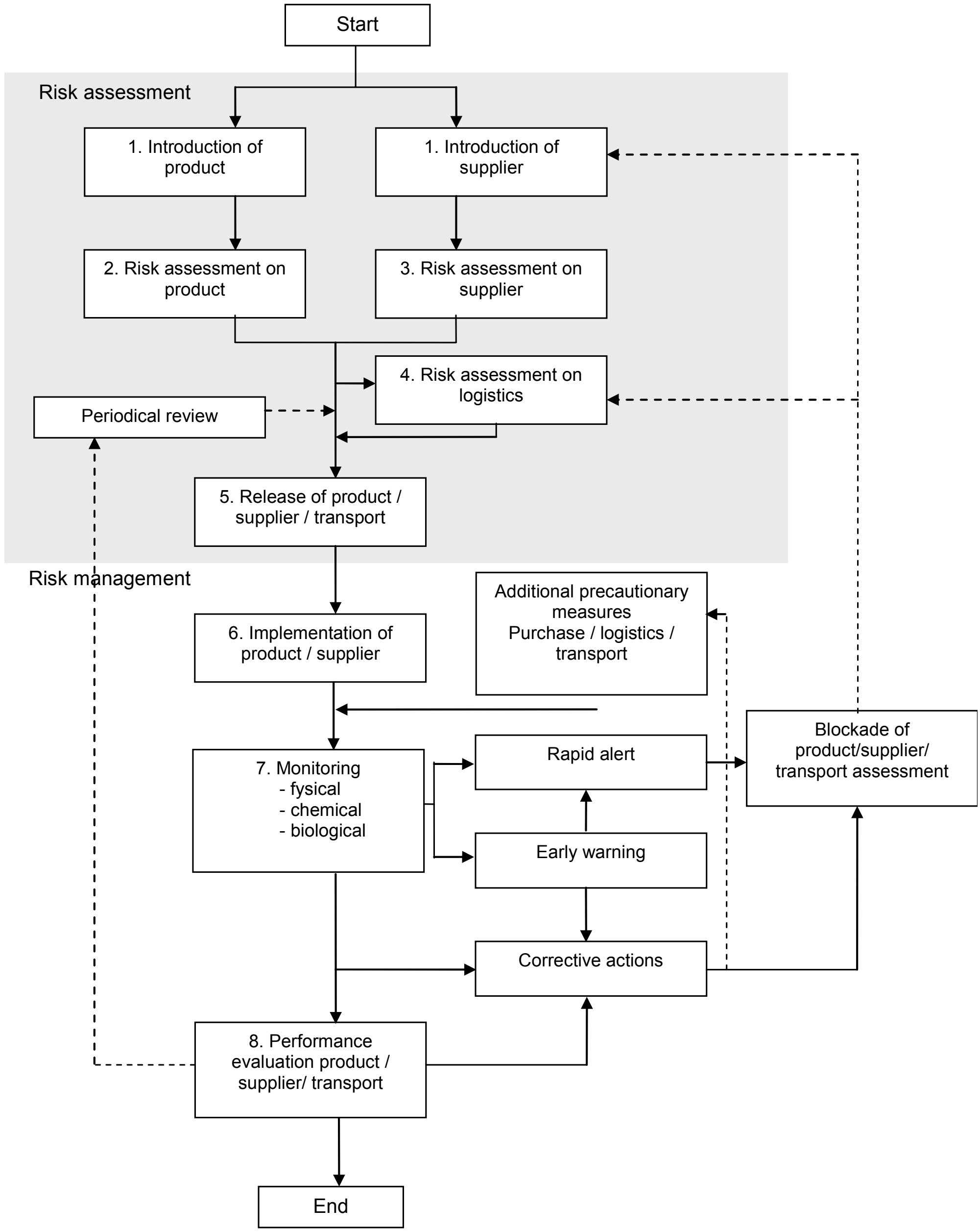
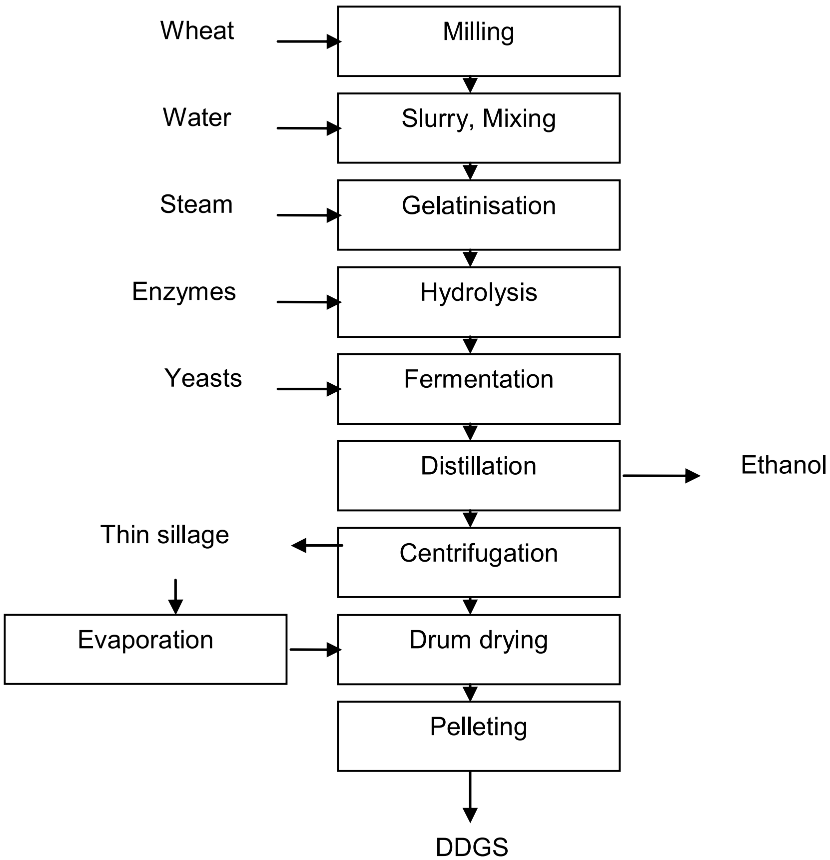


Figure 2: Production process of bioethanol from wheat.



If the product has in volume and price a high potential, it is often considered to carry out additional animal studies in order to obtain more detailed information about the nutritional value, the maximum inclusion level and the impact on carcass and meat quality.

■ Step 3 (optional): Detailed Assessment of Nutritional Value and Applicability

Based on the technical and economical feasibility it is judged whether it is worthwhile to test the co-product in animal studies. A variety of tests can be used to assess the nutritional value and applicability. Some options with biofuel co-products are highlighted.

- Determination of the faecal digestibility of Weende analyses components (crude protein, crude fat, crude fibre and other organic matter) in growing pigs for calculating the digestible and net energy content. For DDGS it would be logical to assess the faecal energy and protein digestibility.

- Determination of the ileal digestibility of crude protein and amino acids. This requires an investment in an animal study with cannulated piglets. In vitro methods for predicting the ileal digestibility in pigs, are with the majority of feedstuffs not reliable. Also with DDGS, to our knowledge, there is not a reliable method available.

- Dose-response studies in the target category (sows, piglets, growing pigs) to assess the effects of inclusion rate on feed intake, daily gain, feed efficiency, carcass quality and health (with often incidence of diarrhoea as the main health parameter). The results are used to define inclusion bounds in feed formulation. In our facilities we have a standard methodology for assessing the feasible inclusion levels of new co-products, using electronic feeder stations for piglets and growing pigs. Besides the total intake, we measure also the number of meals, the meal size, the eating time and the rate of feed intake.

- Additional studies of technological aspects related to transport volumes, storage and free flowing properties, dust-formation, preservation characteristics, effects on pellet quality etc. dependent of the type of product.

- Studies for upgrading the quality and nutritional value of the co-product by specific treatments. In many cases the cost-addition of such treatments is economically not feasible.

Conclusion

The described procedure is derived from internal procedures that are operational in Nutreco's feed producing companies. However, the described steps above are basically also relevant for home mixers that have to judge the utilization of a new co-product. Resources to asses the quality and risk of a new material may be limited, but in principle all steps in the decision tree have to be taken also by the pig farmer that is offered a new co-product as single ingredient. In many cases, the feed company, the supplier of the co-product and other authorities provide the information and advice that is necessary for decision making at farm level.

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