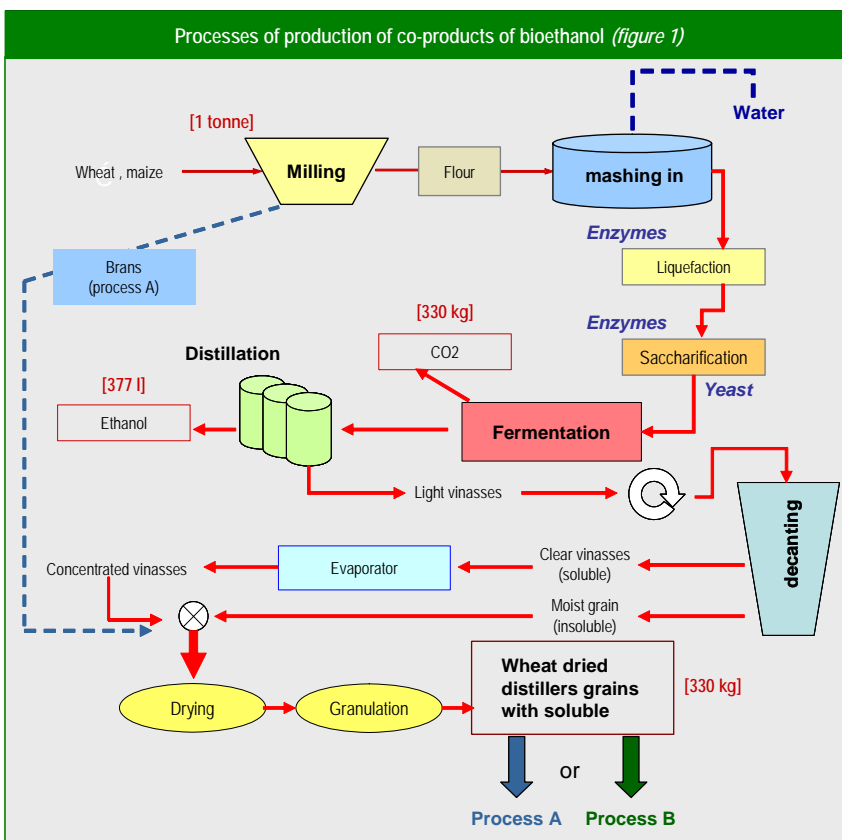


Diversity of bioethanol co-products

New opportunities for animal feeding

The development of bioethanol factories has led to the production of co-products which can be used to feed animals. The analysis of their composition, which varies greatly according to the source, is essential to formulate balanced diets for pigs, poultry and cattle.



wDDGS is the solid residue from the fermentation of the grain used for the production of ethanol.



The colour seems to be an important criterion for assessing the quality of DDGS and its nutritional value.

There is a great deal of variability in composition and nutritional value of European wheat DDGS*, both in terms of energy and protein content. Wheat DDGS is characterised (table 1) mainly by low starch contents (2.5 % - 10.1 % in dry matter, DM) and high protein contents (from 32.7 to 39.2 % DM).

These protein levels, which are comparable with those of oilseed rape meal, allow wDDGS to be a substitute for soyabean meal, the main protein source in animal feeds. The fibre contents are quite high and variable according to the process. The amino acid profile is, for most amino acids, similar to that of wheat. On the other hand it is quite variable and sometimes very degraded for certain essential amino acids such as lysine, arginine and cysteine.

The development in Europe (including France) of new bioethanol factories is accompanied by the production of large volumes of co-products called wheat dried distillers grains with solubles (wDDGS) or wheat gluten feed. Each litre of ethanol produced from wheat or maize thus generates 1 kg of these co-products available for feeding animals (cattle, pigs or poultry). The European production of bioethanol co-products in 2010 is estimated at 2.3 Mt.

Each litre of ethanol produced from wheat or maize generates 1 kg of co-products which are available to feed animals.

In France, the four factories producing bioethanol from cereals should eventually put onto the market 700 000 t of wheat and maize co-products. One distinguishes three main processes, either centred on the complete use of grain (figure 1) either with the bran removed (process A) or not (process B), or the starch type with separation of gluten after the « mashing-in » stage. Other stages also influence the composition of the co-products (ratios of mixtures of soluble and insoluble fractions of the distillation co-product, method and intensity of drying) etc.

A different composition according to the production process

Table 1 : Characteristics of European wDDGS

Composition (% DM)	wDDGS (10 samples)		
	Mean	Min	Max
Dry matter	92.6	89.3	94.4
Protein	36.4	32.7	39.2
Total lysine	1.9	0.8	3.0
Minerals	5.3	4.5	6.9
Ewers Starch	4.5	2.5	10.1
Total sugars	3.9	2.3	7.2
Fat content	4.6	3.4	5.7
Crude Fibre	8.3	6.2	11.4
ADF	11.5	7.5	16.8
Glycerol	4.6	2.0	7.3
Gross energy (kcal/kg DM)	5019	4904	5136
Energy value (kcal/kg DM)			
AMEn cockerels	2474	2151	2708
AMEn broilers	2356	2010	2780
DE pigs	3340	2828	3880
Lysine digestibility (%)			
Dt lysine cockerels	46	0	71
SID lysine pigs	56	9	83

(Source : Cozannet et al., 2009)

The contents of certain essential amino acids such as lysine, arginine and cysteine are sometimes low.

The lowest values are obtained with the darkest wDDGS and the highest with lighter-coloured products. These colour variations are the results of Maillard reactions during the drying process, and seem to be a useful indication of the quality of wDDGS.

The energy value of wDDGS, expressed for poultry as apparent metabolisable energy (AMEn) and for pigs as digestible energy (DE) shows a great deal of variability, with however the same ranking for the two species. Thus the AMEn varies from 2150 to 2710 in adult cockerels and from 2010 to 2780 kcal/kg DM in broilers. In growing pigs, the DE varies from 2830 to 3880 kcal/kg DM. As for the lysine content, the lowest energy values are found in the darkest wDDGS, confirming the important effect of the process of the co-product quality. The protein content of the co-products is represented by the amino-acid fraction digestible by the animal (True digestibility = Dt in poultry and Standardised Ileal Digestibility = SID in pigs) as a fraction of total amino acids. For poultry, the Dt of the amino acids from wDDGS is generally below that of wheat, especially for lysine, the foremost amino acid indispensable for animal growth (46% on average as against 84 and 85% for wheat and maize grain). The Dt of lysine is especially affected in the event of overheating. For pigs, the SID of the lysine can be very high (80%) or very low for the most overheated products (9%). Thus these figures are affected both by the total lysine content and by a fall in its digestibility.

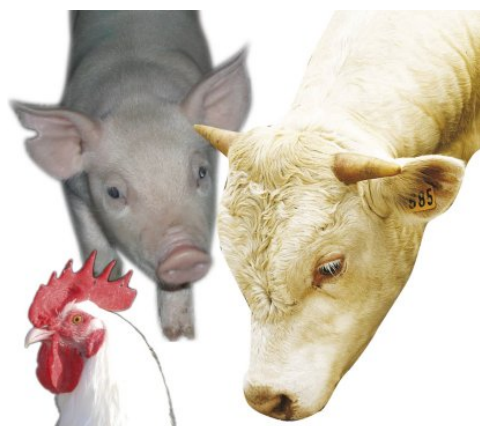
This must be taken into account when formulating feeds. wDDGS can thus be a valuable alternative for feeding animals, provided that it is well characterised. For this purpose, rapid, reliable and inexpensive methods such as the measurement of colour seem very appropriate.

Today in France : one factory = one co-product

* *Programme I3A brings together INRA, ADISSEO, AJINOMOTO Eurolysine and ARVALIS - Institut du végétal, in collaborative work on the characterisation and nutritional evaluation of European bioethanol wDDGS.*

Four large bioethanol factories are already operational in France. Three of them produce wDDGS or corn DDGS (cDDGS) and the fourth a « wheat feed » type of co-product. In spring 2009, ARVALIS-Institut du végétal carried out an evaluation of three of these products in pigs, poultry and ruminants in partnership with Tereos, Nutricia and Adisseo (French cooperatives).

The chemical composition shows big differences between the three co-products (table 2), a reflection of the diversity of their raw materials and production processes. For the energy fraction, the cDDGS grain and the wDDGS show very similar energy recoveries by cockerels and pigs, the wDDGS being converted slightly less efficiently. Furthermore pigs seem to make better use of the wheat feed. In the nitrogen fraction, and in particular for the true digestibility of lysine, the ranking is the same as for energy, with an even clearer difference for wDDGS in pigs. In ruminants, the measurements show a clear improvement in the energy values compared with the values in the INRA-AFZ Tables (reference tables).



The development of new bioethanol factories is accompanied by the production of large quantities of by-products called « wDDGS ».



Table 2 : Characteristics of three French co-products in 2009

Composition (% DM)	wDDGS	cDDGS	WF
Dry matter	92.1	91.2	91.4
Protein (Nx6.25)	35.4	28.2	21.3
Total lysine	0.54	0.76	0.65
Minerals	4.8	4.7	4.9
Ewers Starch	3.1	4.6	21.8
Total sugars	4.9	0.8	7.1
Fat content	6.9	14.2	4.7
Crude Fibre	6.0	7.9	7.1
ADF	9.3	9.1	7.1
Glycerol	5.4	9.2	2.2
Gross energy (kcal/kg DM)	4996	5273	4645
Energy value (kcal/kg DM)			
Cockerels	2900	3525	3110
Pigs	3080	3560	3440
UFV	1.14	1.23	1.14
UFLn	1.10	1.20	1.12
Protein digestibility (%)			
Cockerels	60	70	67
Pigs	50	65	70
PDIA (g/kg)	95	77	38
PDIN (g/kg)	224	155	132
PDIE (g/kg)	149	123	103

This type of wDDGS coming from one plant is less digested by the animals than the two other co-products.

Vocabulary

PDIA : dietary protein undegraded in the rumen, but truly digestible in the small intestine

PDIN = PDIA+PDIMN with PDIMN = microbial protein synthesised in the rumen when degraded dietary N is limiting, which is truly digestible in the small intestine

PDIE = PDIA+PDIME with PDIME = microbial protein synthesised in the rumen when energy available is limiting, which is truly digestible in the small intestine

UFV : Net energy for meat production, avec 1 UFV = 1820 kcal NE mg (net energy for maintenance and gain)

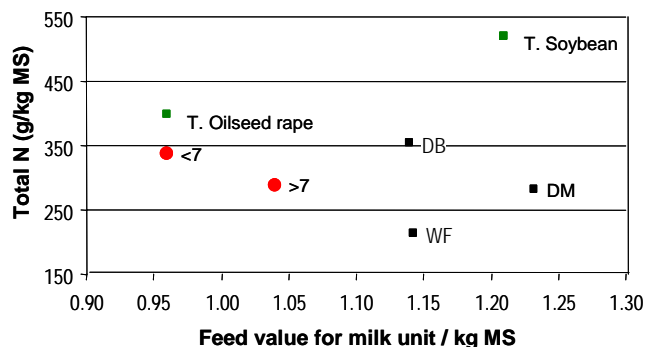
UFL : Net energy for milk production, avec 1 UFL = 1700 kcal NEL (net energy for lactation)



The low digestibility of the lysine should be taken into account when formulating feeds for pigs and poultry in order to satisfy animals needs.

The cDDGS has a higher energy value than that of wDDGS or wheat feed. The PDI contents (protein digestible in the intestine) depend mainly on the initial protein content (N total) ; the ratio PDI/N total varies between 42 and 48% and the PDIN/MAT one from 55 % to 63 %. Figure 2 illustrates the results obtained on the three co-products in comparison with those obtained on soya and rapeseed meals and with values from the INRA-AFZ Tables for wDDGS with < 7 and > 7 % of starch.

Energy and nitrogen value (Feed value for milk unit) of the by-products (Figure 2)



In ruminants, the measurements made show a clear improvement compared with the values given in the INRA-AFZ Tables.

These results thus confirm, for France, that a specific nutritional value should be attributed to each co-product from a given factory. Future work should allow us to provide predictive equations from chemical measurements such as fibre contents and total lysine content and physical criteria such as luminance or near infra-red measurements.

ARVALIS
Institut du végétal

CETIOM
Centre Technique Interprofessionnel
des Oléagineux Métopolitains

Animal feed seminar 2010 - 28th September 2010

The main topic of the next Seminar, co-organized by Arvalis - Institut du végétal and the CETIOM, will be the biofuel and biodiesel coproducts and their uses in animal nutrition. We will focus on the diversity of these coproducts and on the last research results obtained on the nutritional value for different animal utilizations (pig, poultry and cows). We will also look at the technologic and economic impacts of their uses in feed formulation as well as on the future of this production in the EU. *The talks will be in French.*

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