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Biofuels: Consequences for Feed Formulation

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Introduction

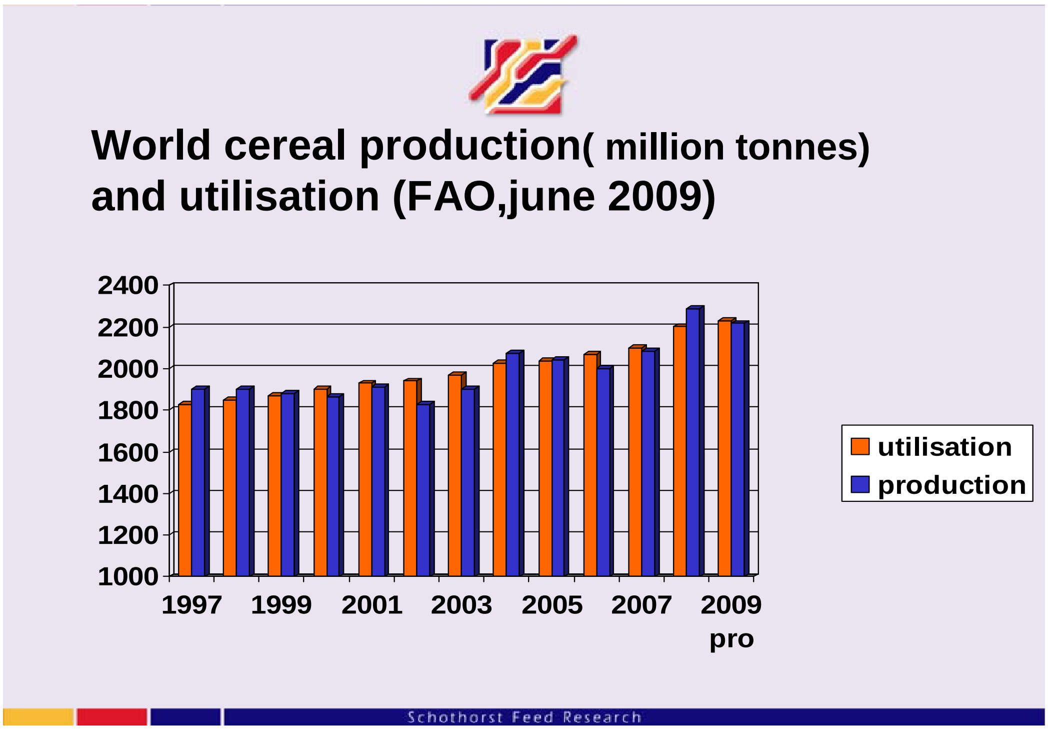
The increasing global demand for energy and the consequences of the use of fossil energy on global heating and production of greenhouse gasses, have generated an accelerating interest in energy production from sustainable energy sources. One of the possible alternative energy sources is energy produced from biomass. The last decade many initiatives to generate energy from biomass have emerged. Currently, production of bioethanol from starch or sugar rich crops and the production of biodiesel from different fat sources, mainly oilseeds, are the most important methods to convert biomass into energy. It is expected that as time develops other production methods, using other substrates and technologies will appear.
The production of bioethanol from wheat creates as much co-product as ethanol. The feed industry has a long time experience in validation of co-products from different industries, especially the food industry. Well known examples are brewer grains, wheat middlings, beet pulp, molasses, etc. The use of biomass for energy results also in large amounts of co-products. The use of the co-products as feedstuff for animals not only reduces the costs of these production but also solves pollution and odor problems for these producers. At the same time the fact that the production of co-products is not their core business , producers not always take into account the optimal conditions for the co-product as feedstuff for animals, resulting in a large variation in nutritional value for livestock animals is large.

For the feed industry relevant aspects of the biofuel production will be:

- The effect on feedstuff availability and the types of co-products that will become available.
- The effect on feedstuff prices and the changes in relative value between feedstuffs.
- Feed and food safety related to the use of the co-products.
- Environmental effects
- Ethical considerations regarding the use of food as energy source.
- Variation in nutritional value of the co-products
- Effects on the quality of animal products.

Global developments

It is forecasted that the USA will produce in 2015 approx . 57 million ton ethanol, requiring 43% of a maize crop. Currently approx 30% of the corn crop is used for bioethanol production. The biodiesel production will be approx. 2,8 million ton, requiring 29% of the soybean production. In Europe the production is relative more focused on the production of biodiesel. It is projected that in 2013 the bioethanol production will be 7 million ton, whereas the current production of biodiesel is 5,5 million ton. To meet the objective to incorporate 10% energy from biomass in fuel for cars, the production will have to increase to approx. 35 million ton in 2020. These developments require an expansion of cereal and oil seed production. In figure 1 the world cereal production and utilization is depicted over the last 12 years. Despite the fact that in 2009 the second largest in history it is forecasted, it is predicted that the utilization will be larger than the production. Over the last 4 years the utilization for food and feed has been increased by approx 5% whereas the utilization for other purposes, mainly biofuel, has increased with 24% (FAO,2009).



The demand on the world market for protein rich feedstuffs will develop gradually and will be fulfilled by a higher production of SBM, RSM and DDGS. In Europe, the amount of DDGS and RSM will increase at the cost of SBM.(table 1)

Table 1. Changes in protein rich feedstuffs in Europe

x mln ton	2004/05	2010
Total oil meal and expellers	45.2	48.8
Soy bean meal	33.1	25.0
Rapeseed meal	7.5	13.3
Sunflower	4.1	3.0
DDGS	**0.5**	**7.2**

The higher availability of RSM and DDGS is due to the increase production of biodiesel and ethanol resp. In Europe the DDGS will mainly originate from wheat. Besides the change in protein sources glycerol, a byproduct from the biodiesel production, will become available as a new energy source.

Economic consequences

The increased demand for biomass for biofuel production will have a considerable impact on the price formation for raw materials. The prices paid for cereals by the biofuel producers will depends on the oil price. Calculations of the University of Missouri, (Vernon,2007) show that the break even point for bioethanol producers in the USA, at a oil price of $ 60 and $ 70 per barrel is at a price of $ 4.30 to 4.60 and $ 5.40 and $ 5.70 /bushel maize or $ 175 and $ 220/tonne resp. Therefore the bottom price for the value of cereals will be set by the oil price.
Since the co-products of the biofuel production are relative rich in protein. The price for energy in the feed will relative become higher than the value for protein. The creates a situation in which the protein content of the animal feeds might increase with potentially a higher risk for more severe gastro-intestinal disorders and increased emissions of N and ammonia.

Feed and Food safety

During the production process of ethanol roughly 33% of the cereal will be converted into ethanol, 30% is converted during the fermentation into CO2 and the remaining is DDGS available as feedstuff for animals. It means that various contaminants in cereals, like mycotoxins and residues of crop protection agents, are concentrated in the DDGS.
Another potential risk for the safety of feed are formed by production aids. During the production of bioethanol, some producers add antibiotics to the system to control the fermentation process. Currently it is not know whether residues of these antibiotics are recovered in the DDGS. This may exert a limitation in the use of DDGS in livestock.
During the production of biodiesel, methanol and hydroxides are used as production aids. The feed grade glycerol contains typically 80 glycerol. Besides water it contains high level of either K or Na salts. The feed manufacturers should take these high levels into account in the feed formulations. In most feeds it will limit the incorporation level. Although the level of methanol in glycerol is normally not at toxic levels for the animals, it remains a point of attention.
Probably the most limiting factor for the use of maize DDGS in Europe is that most imported DDGS originates from GMO maize. Therefore, it is expected that due EU-legislation maize DDGS used by the European feed industry will be of European origin.

Quality of animal products

The quality of animal products can either directly or indirectly be affected by the use of co-products of biofuel production. Regarding the use of esp. maize DDGS several authors have mentioned negative effects on fat quality due to a high level of unsaturated fatty acids in the body fat. The European feed producers are used to limit the amount of energy from unsaturated fats in the diets. Under certain conditions this may limit the incorporation level of maize DDGS. The same applies for the use of RSM. The high mineral contents of both glycerol and DDGS will especially in poultry create an additional risk for wet litter and egg shell dirtiness.
Glycerol has potentially a positive effect on water binding capacity of meat. French research (Mourot,e.a.,1993) has shown that incorporation of 9% glycerol in the diets of fattening pigs has a positive effect on water binding capacity of pork and the cooking losses of hams were reduced.

Nutritional value of the co-products

The nutritional value of co-products from the biofuel industry, especially of the bio-ethanol production varies considerably. The nutritional quality depends on the type of cereal used in the fermentation, the pre-fermentation processing of the cereal, the post fermentation processing, f.i. the drying temperature and the amount of solubles added. Furthermore within an animal species the relative value of these feedstuffs compared to other feedstuffs, is determined by the age and physiological status of the target animal.

In an experiment by Pahm e.a. (2008) the effect of amount of maize distillers solubles added to distiller grains on lysine availability. The results are presented in table 3. The pure CDS had the lowest protein content and the DDG were 20 and 40% of CDS were added, were equally reduced. The same accounts for the lysine content. Not only is the protein level lower in distiller solubles but also the lysine content of the protein. Furthermore the amount of reactive lysine, which is correlated with the intestinal lysine digestibility, is reduced both in absolute amount as percentage of lysine, indicating a lower digestibility. Therefore the amount of solubles added has a large impact on the nutritional value.

Table 3. The effect of amount of distiller soluble (CDS) added to DDG on protein, lysine and reactive lysine.

	DDG	DDG 20	DDG40	CDS
protein	35.9	33.3	28.1	14.6
Lysine	1.11	1.01	0.84	0.42
Lys/cp	3.06	3.33	3.01	2.88
reactive Lys	0.89	0.79	0.71	0.21
react Lys/Lys	80.9	79.2	83.3	51.9

The same group observed that drying temp exerted a large effect on the amount of reactive lysine. The higher the drying temp, the lower the reactive lysine content and thus the intestinal digestible lysine. The reduction in reactive lysine occurred at lower temp for the solubles then for the DDG. Most likely the amount of reducing sugars in the solubles cause the formation of unavailable Maillard products during heating.

Regarding to the energy content of the maize DDGS a large number of maize DDGS were examined. In terms of net energy a high correlation between NET Energy and the fat content was observed. The higher the fat content, the higher the NE-value (R2=0.86). The fat content is both a measure of the amount of maize kernels added/removed and the amount of solubles added.

The large variation in amino acid availability is clearly shown by Stein (2007). In an experiment with 33 different maize DDGS samples he observed a variation in SID of lys ranging from 44 to 78%, meth from 74-89%, Thr from 62 to 83% and for Tryp from 54 to 80%. The variation in amino acid digestibility is the largest for Lys.

In Europe, it is expected that the co-products of the biofuel industry will replace SBM. Therefore the amino acid profiles of these proteins are compared with SBM (table 4). In comparison with rapeseed meal (RSM) and DDGS from both wheat and maize, SBM contains relatively little Met and Thr. Therefore if these co-products are used in feed formulations the amount of pure lys will relatively increase whereas the use of pure Met and Thr and to a lesser extent Tryp will become less attractive.

Table 4. Amino acid profiles of SBM,RSM, wheat and maize DDGS

	SBM	RSM	DDGS maize	DDGS wheat
Lys	**100**	**100**	**100**	**100**
Met	**23**	**36**	**70**	**96**
Thr	**63**	**80**	**126**	**177**
Tryp	**21**	**23**	**26**	**61**

The value of wheat and maize DDGS in animal feeds differ. Depending on the price situation and the relative costs of protein and energy the value for different feeds may vary. However based on cost price calculations by Doppenberg (2009) wheat DDGS has the highest value in dairy ratios and in poultry feeds in which the amount of RSM is limited. Wheat DDGS has the lowest value in diets for gestating sows. Table 5 depicts the value of wheat and maize DDGS in different feeds in the period from 2006 to 2009.

Table 5. The values of wheat and maize DDGS (Euro/100kg) in feed for dairy, slaughter pigs and gestating sows (shadow prices in least cost formulations)

		2006	2007	2008	2009
Dairy	wheat	13.55	17.90	26.76	20.27
	maize	12.55	17.00	24.83	15.09
Slaughter	wheat	10.40	13.10	19.47	12.30
Pigs	maize	10.90	15.00	20.00	11.62
Gestating	wheat	8.90	9.60	15.87	10.03
sows	maize	12.10	14.50	22.87	13.66

In general the value of maize DDGS is higher for diets with a low lys/energy ratio, like diets for slaughter pigs and gestating sows, whereas wheat DDGS has a higher value in protein rich feeds. Due to the relatively high protein prices in 2009 wheat DDGS had a higher value than maize DDGS in fattening pig diets.

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Inclusion levels in the diets

In theory the inclusion levels of feedstuffs in feed formulations are not limited if the nutritional values of feedstuffs are known. However, other compounds, like ANF's, compounds affecting animal health or the quality of the animal products may restrict the incorporation levels of feedstuffs. The use of co-products of the biofuel production also is affected limited. First of all the large variation in quality requires large safety margins and therefore limited use of especially DDGS is advised. RSM products are limited by their contents of antinutritional factors like glucosinolates and saponins. Doppenberg en Van der Aar (2007) showed that α-glucosinolate levels in the diet for fattening pigs of 2,0 μmol/g feed reduced feed intake and daily growth. Higher amounts resulted in depressed feed efficiency. Therefore the use of rapeseed meal is limited by the amount of glucosinolates. The use of DDGS is restricted by the amount of soluble NSP 's which may result in excessive fermentation in the hindgut and increases the risk for diarrhea. In some Western European countries the high content of P and low digestibility of lysine may limit their use because of high N and P excretion. The use of maize DDGS may also be limited in diets for fattening pigs, due to the relatively high levels of unsaturated fatty acids that may result in too soft fat. Therefore the total amount of unsaturated fatty acids in the diets is restricted.

Conclusions

Although co-products of the biofuel industry are normal feedstuffs, the variation in quality requires special attention of nutritionists. Especially the digestibility of Lys in DDGS is of concern. The origin, production process, and the cereal the DDGS is produced of should be known in order to be able to made a good estimation of the nutritional quality. The co-products of biofuel production are relative poor in lysine and rich in Met and Thr. Special attention should be paid to the maximum NSP contents in diets formulation. The future availability of maize DDGS for the European feed industry will depend on the EU-regulations on the acceptance of DDGS originating from GMO maize.

The following changes in the feed composition are expected:

- Relatively more pure lysine will be used in diets
- In dairy rations the use of wet wheat DDGS will increase at the expense of SBM, RSM and molasses
- In pig diets the incorporation levels of RSM will increase and to a lesser extent those of DDGS at the expense of SBM.
- In poultry diets in which the use of RSM is restricted due to the contents of saponins, Wheat DDGS may become interesting especially for brown layers at the expense of SBM