Co-products from the biofuel industry

Distillers Dried Grains and Solubles (DDGS)

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Summary

DDGS will be available late spring 2009 from the Ensus plant on Teeside. This plant, which is currently being built, will ferment up to 1million tonnes of wheat producing some 350 thousand tonnes of DDGS. Whilst this material could be co-fired, or exported, both economics and politics strongly suggest that feeding is the most appropriate outlet.

The initial reaction by many is that this material would largely be destined for dairy and beef feeds and indeed this is a market for the material. However the cattle market is seasonal, largely based on the West of the country, and for feeder wagons pelleted material is preferred. There is a ready market for wheat DDGS "on the doorstep" for pig feeding.

DDGS from the new bio-ethanol plants should not be confused with traditional distillers from UK whisky production, nor imported U.S. maize distillers, as both of these are of inferior quality.

Home produced wheat DDGS is likely to have an oil of almost 8%, 38% crude protein, and fibre of 6.9%. It has a DE higher than wheat, but because the protein and fibre are high, a lower net energy (similar to soya 48). Digestible amino acids, with the exception of lysine, are similar to rape meal. Wheat DDGS is a good source of digestible phosphorus.

UK wheat DDGS is a key co-product from large scale, modern ethanol plants. The operators of these plants understand the importance of consistent quality to the livestock sector and that drying conditions are crucial to quality. Wheat DDGS contains no anti-nutritive factors. The fibre is quite digestible and U.S. research has indicated reduced problems with ileitis when DDGS is fed.

High inclusion rates of DDGS have been successfully used providing that feeds are formulated on a net energy and digestible amino acid basis, and that the material is carefully dried. It should though be pointed out that most of these trials have been conducted on maize DDGS, in maize based feeds, on slatted systems. UK feeds are higher in fibre, and many pigs consume straw making fibre intakes higher still.

DDGS flows easily in a bulk bin. Unfortunately as the amino acid concentration in the protein is low for every 10% DDGS used in a feed formulation crude protein is increased by 1%. This may place limitations on its use in areas where nitrogen excretion is controlled.

In conclusion wheat DDGS is likely to be a valuable and safe commodity for pig feeding in the UK.

Introduction

There are a number of co-products arising from the bio-fuels industry that have ready application in the feeding of pigs. These include DDGS from ethanol production from cereals, and expeller rapeseed meal and glycerol from biodiesel production. At the time of writing the bio-diesel industry in the UK is relatively small. However bio-ethanol looks like making a significant impact with, for example, 350 thousand tonnes of wheat DDGS being available from the Ensus plant in Teeside from the spring of 2009. This article looks at the use of DDGS in pig feeds.

What is DDGS?

The cereal is ground and steeped and enzymes are added to convert the starch into sugars. Yeast is then added to further convert the sugar into ethanol. The ethanol is distilled off. What remains is the wet distillers grains in the fermentation vessels, and the solubles left after the distillation. These are normally combined and then dried. Wet distillers grains and wet distillers solubles may also be available from some plants. Roughly for every unit of wheat used the process yields 1/3 ethanol, 1/3 DDGS, and a third carbon dioxide.

How does it analyse?

The ethanol is derived from the starch and sugar of the wheat and so these are at low levels in the DDGS, around 3-4%. This means that the other nutrients in wheat become more concentrated in DDGS, typically by a factor of 3.3-3.4. Thus for example if the wheat used is 2.3% oil, 11% protein and 2.3% crude fibre the DDGS is around 7.7% oil, 37% protein and 7.7% crude fibre. This is a useful "rule of thumb" and helps us visualise what is happening in the process. In fact the analysis is slightly better than this as DDGS is drier than the wheat from which it originates.

This simple rule however does not apply to digestible amino acids; they are unfortunately not 3.3-3.4 times higher in DDGS than in wheat. There are two problems both of which arise primarily in drying. Firstly there is thermal destruction of some of the amino acids, and then the digestibility of the remaining amino acids is reduced. Modern bio-ethanol plants understand that drying is critical to the value of DDGS, particularly for pigs and poultry, and drying conditions are far more optimised than is the case in "old" bioethanol or whisky distilleries.

On the plus side the fermentation removes much of the phytic acid so that the phosphorus digestibility in DDGS is much higher than in wheat. At a time of unprecedented phosphate prices this is clearly a potentially valuable bonus.

Finally energy. The digestible energy (DE) of DDGS is high, on a dry matter basis, and is not dissimilar to the wheat from which it is derived. This though is misleading, as DDGS is high in both fibre and in protein, which means that its net energy (NE) for growing pigs is less than that of barley, whilst net energy for sows is higher than barley.

The following table suggests an analysis of UK based wheat DDGS. It is an estimate, as material is yet to be produced.

		Barley	Wheat	**Wheat DDGS**	Wheat feed	Rape extr.	Soya 48
Oil B	%	2.6	2.3	**7.9**	4.5	5.0	2.6
Protein	%	11.0	11.0	**38**	15.4	33.9	48.0
C. Fibre	%	4.8	2.0	**6.9**	8.5	12.0	3.7
N.D.F	%	16.0	8.5	**29.4**	34.0	22.0	7.0
DE	MJ/kg	13.0	14.0	**14.5**	11.2	11.9	15.2
NE grow	MJ/kg	9.7	10.6	**8.5**	7.6	6.5	8.4
NE sow	MJ/kg	9.8	10.8	**9.3**	8.1	7.0	8.9
Dig lys*	%	0.31	0.26	**0.65**	0.45	1.37	2.66
Dig M+C	%	0.34	0.38	**1.19**	0.41	1.10	1.18
Dig Thr	%	0.30	0.27	**0.91**	0.37	1.04	1.66
Dig Try	%	0.11	0.11	**0.32**	0.17	0.31	0.56
Dig Val	%	0.42	0.41	**1.34**	0.53	1.24	2.01
Ca	%	0.06	0.04	**0.12**	0.10	0.80	0.30
P	%	0.36	0.30	**1.1**	0.95	1.10	0.65
Dig P**	%	0.14	0.14	**0.77**	0.28	0.30	0.25

*Digestible amino acids are ileal digestible ** digestible P in meal feeds. Source: PremierAtlas 2008

This distinction between net energy and digestible/metabolisable energy is an important one for the following reason. Most of the trials on DDGS are from North America, and most of the trial feeds are formulated to ME. At higher inclusion rates of DDGS a number of trials show a reduction in pig performance. This isn't though, in most cases, a reflection of the feeding value of the DDGS – it is simply that its energy value is overestimated using the ME system. These trials are often further compromised as feeds are formulated to total and not digestible amino acids. The digestibility of amino acids in DDGS is less than the digestibility of the amino acids in the soya that it typically replaces in these trials, so that the digestible amino acid levels in the trial feeds falls with increasing DDGS inclusion. It isn't just DDGS that falls into this "trials trap". A recent report from the U.S. I read, concluded that performance of finishing pigs fell with the use of wheatfeed. Re-interpreting the data on a NE/digestible amino acid basis (rather than ME and total amino acids) soon showed exactly why the pigs didn't perform – the specification of the feeds effectively fell as wheatfeed level increased.

I have laboured the above point a bit but it is fundamental. If you are considering using DDGS then make sure your nutritionist uses NE and digestible amino acids in formulating your feeds.

What are the potential pitfalls?

If the DDGS is over-dried then the digestible amino acids, available energy levels and palatability all fall. Smell and colour is a good guide, as is taste if you are brave enough!

Whilst DDGS is high in protein the digestible amino levels are low compared to soya and rape. For every 10% DDGS included in feeds crude protein is likely to rise about 1% which has implications for those farms where nitrogen excretion is an issue.

The 3.3-3.4 times concentration “rule of thumb” above also applies to mycotoxins. There has been some concern about mycotoxins in the U.S., leading to some companies being cautious about DDGS and excluding them from sow feeds. However the U.S. is largely based on maize, and a glut of DDGS led to some material sitting in the open for some time before shipping. I can’t help but feel that the sellers of mycotoxin binders have fuelled the mycotoxin issue - but maybe age makes one cynical!

The UK material will, for the foreseeable future, be wheat based, and as HGCA/Harper Adams have shown UK wheat has a very low mycotoxin risk. Add to this that the Ensus plant alone will be handling 1 million tonnes of wheat/annum, in the unlikely event that there are any deliveries high in mycotoxins the huge scale of this plant will mean that levels in finished DDGS will be minimal. This is not to say we should ignore mycotoxins but that we need to keep a potential problem in context. We need to be vigilant if in a particular year growing and harvesting conditions of cereals predispose to mycotoxin formation, but in most years, at least to date, mycotoxins in cereals have not been a major problem in the UK.

There have been problems in the U.S with soft carcase fat when high levels of maize DDGS are fed to finishing pigs. The level of fat in wheat DDGS is lower than that in maize, and the feed specification can be set up to control this, so I do not see this as an issue in the UK.

Not only have the majority of trials been conducted on maize DDGS but almost certainly the pigs have been housed on slats and fed maize/soya based feeds. This may be important in our deliberations as the maize DDGS has been included in low fibre feeds, where pigs are not eating straw. Feed conversion is poorer in deep straw by as much as 0.2 and the pigs are fatter. Why is this? Is it environmental, nutritional or both? We may need to more cautious with DDGS inclusion rates when formulating feeds for straw based finishing until we are clearer to the answers to these questions.

A final point is too many trials look at live weight performance. With higher fibre ingredients such as DDGS this may be misleading, as killing out percentage falls with increasing dietary fibre. In the end it’s the weight of pig meat we sell not the live weight!

What are the potential bonuses?

The first bonus is an obvious one and is that we have another useful raw material for pig feeding. DDGS has a number of attributes one of which is its high fibre. For example wheatfeed is in increasingly short supply, and prices are erratic. DDGS supplies a similar fibre level to wheatfeed but with higher energy, phosphorus and digestible amino acids.

Another point of interest is that veterinary trials in the U.S. have suggested that maize DDGS improves gut health, in particular helping to reduce the incidence of ileitis caused by *lawsonia intracellularis*. The reasons for this are unclear but it may be related to the high level of digestible fibre or yeast cell walls and/or their metabolites.

Digestible carbohydrates that influence hind gut fermentation (sugar beet, inulin from chicory) also reduce skatole, an important element of boar taint, and the high digestible fibre in wheat DDGS may be useful in this regard.

How much can we use?

The maximum inclusion rate of any raw material in a pig feed is controlled by a number of factors including anti-nutritive factors, palatability and concern over scour. There have been a large number of performance trials conducted on maize DDGS but far fewer, as yet, on wheat DDGS. The maize DDGS trials though should be reasonably indicative of how much we can feed although we should bear in mind the higher fibre of the wheat derived material (particularly when used in conjunction with other high fibre raw materials such as wheatfeed and rapeseed or the finished feed is to be used in a straw based system).

In contrast to other proteins (soya, rape, peas) there are no known anti-nutritive factors in DDGS of commercial relevance and accordingly, providing the material isn't burnt, then there are no issues of palatability. The total fibre level is high though, similar to wheatfeed, so bulk may limit intake at higher inclusion rates. Scour doesn't appear to be a concern – indeed DDGS may be helpful in this regard.

	Inclusion rate of DDGS (%)	
	Initial/conservative maximum	Maximum with high quality wheat DDGS in UK feeds?
13-30kg	7.5	10
30-65kg	10	15
65kg+	12.5	25
Dry sow	10	No limit
Lactating sow	10	20

The maximum levels suggested above might surprise. However one of our Canadian clients has used 25% DDGS in finishing feeds, with no soya, without any performance deterioration. Dry sows have been fed 50% maize DDGS over 4 parities without problems (apart from a very high nitrogen excretion!). Perhaps most surprising of all pigs fed 25% maize DDGS from 7kg bodyweight only showed a minor decline in performance.

What will the wheat DDGS replace in pig feed formulations?

There is no one answer to this question as it depends upon prevailing raw material costs, and the raw materials actually available.

We can probably assume that home –produced commodities such as DDGS, extracted rape meal, and wheatfeed will always be priced cost-effectively against cereal and soya meal as they have to be used. The following table gives some examples of what formulations may look like next year as DDGS becomes available. Feeds are formulated to be the same net energy and digestible lysine content.

In a cereal/soya based grower feed DDGS replaces largely soya meal and barley. More lysine is used to balance the amino acid profile, and the phosphate addition is reduced, as DDGS is rich in digestible phosphorus. The protein content of the feed increases by 1% (i.e. 1% for 10% DDGS inclusion).

In a finisher feed, which additionally uses wheatfeed and rape meal, a 20% inclusion of DDGS replaces approximately 8% soya, 8% wheatfeed, 3% wheat and 1% rape. Again more lysine is used to balance the protein, and again the crude protein of the feed increases in line with the 1% crude protein with 10% DDGS inclusion.

	Grow. 13-20kg		Fin. 65-100kg	
DDGS	0	10.0	0	20.0
Wheat	50.0	50.0	50.0	46.3
Barley	19.5	15.0	15.0	15.0
Wheatfeed			15.0	7.4
Soya 48	26.0	21.0	8.5	0.5
Rape extr			7.5	6.6
Soya oil	2.1	2.1	1.3	1.3
Lysine	0.41	0.51	0.42	0.59
Threonine	0.17	0.19	0.14	0.16
Methionine	0.14	0.10	0.03	0
Monocal P	0.32	0.12	0.1	0

Lime	1.0	1.0	1.5	1.6
Salt	0.5	0.5	0.6	0.5
Oil (%)	4.0	4.38	3.75	4.75
Protein (%)	20.6	21.6	16.7	18.8
Fibre (%)	3.26	3.58	4.75	5.0

Phytase levels in feeds varied