Energy value of wheat-DDGS in adult cockerels and growth performances of broiler chickens

M. VILARIÑO [1*], J-M. GAÜZERE [2], J-P. MÉTAYER [3] and F. SKIBA [4]

[1] ARVALIS - Institut du végétal, Pouline, 41100 Villerable, France, [2] CENTRALYS, 9-11 Avenue Arago, 78191 Trappes Cedex, France, [3] ARVALIS - Institut du végétal, 91720 Boigneville, France, [4] ARVALIS - Institut du végétal, 21 chemin de Pau, 64121 Montardon, FRANCE.

***Corresponding author: m.vilarino@arvalisinstitutduvegetal.fr**

With ethanol production development in Europe, volumes of wheat dried distillers grains with solubles (w-DDGS) available for animal nutrition are going to increase. Two experiments were carried out in order to study the nutritional value of two w-DDGS batches produced in two different French bioethanol plants. In a first experiment, the energy value (AMEn) of two w-DDGS batches (A and B) was measured in adult cockerels. In a second experiment, we measured the effect of the introduction of 10 and 20% of w-DDGS (B) on the growth performances of broiler chickens. In the first experiment, the AMEn measured were 11.2 and 10.6 MJ/kg DM, respectively for w-DDGS A and B. The results of the second experiment showed that 10 and 20% of w-DDGS in broiler chicken diets reduced the weight gain during the starting period despite similar feed intake. This reduction was probably due to the overestimation of digestible lysine value of w-DDGS during feed formulation. Overall (37 days of the trial) the feed conversion ratio tend to decrease (<2%, p<0.09) with 20% of w-DDGS. In summary, introduction of 20% w-DDGS in poultry feeds is possible if the real digestible lysine content of w-DDGS is taken into account.

Keywords: DDGS; wheat; energy; digestibility; growth performance; poultry; broiler chicken

Introduction

In a very near future, 700 000 metric tons of dried distillers grains with solubles (DDGS) will be commercialized in France among them 80% originating from wheat (w-DDGS) and 20% from corn. According to their chemical composition wheat and corn DDGS will replace partially soya bean meal, wheat and wheat by products in diet formulations. Currently DDGS are mainly used in France in ruminants but the increase of DDGS availability will allow their incorporation in pig and poultry diets. Thus a better knowledge of the nutritional value of w-DDGS is essential. The aim of the present study was to characterize two batches of w-DDGS produced by two French ethanol plants using two different industrial processes and to study their nutritional value for poultry.

Materials and methods

Two w-DDGS batches (A and B) produced by two different industrial processes were used in this study. In the A batch, wheat bran was separated at the beginning of the ethanol production process and then re-introduced just before pelleting w-DDGS. During the second industrial process (B) wheat bran was not separated from the kernel resulting in a lower starch content of this w-DDGS type.

Experiment 1: AMEn value of w-DDGS in adult cockerels

The energy value of both w-DDGS was measured in adult cockerels using a control diet and two experimental diets composed of 47% of the control diet, 50% of each w-DDGS and 3% of a vitamin and mineral premix. Energy values (AMEn) of w-DDGS were calculated by the difference method. Feedstuffs were ground through a 4 mm screen with a hammer mill (3000 rpm, 64 ms^{-1}). Diets were then steam pelleted at 65°C using a 2.5 mm x 35 mm die. Seventy six week old ISABROWN cockerels were fed *ad libitum* in a block design (3 diets × 10 blocks). After an adaptation period of 65 hours of *ad libitum* feeding followed by 24 hours of fasting, faeces were collected daily during the next two days of feeding and during the last 24 hours of fasting. Faeces were freeze dried and analyzed individually. In order to correct AME into AMEn, nitrogen (N) balance was calculated by the difference between nitrogen intake and nitrogen excretion during the balance period.

Experiment 2: Growth performances trial

For this experiment 2430 commercial broiler chickens (Ross PM3) were distributed in 27 pens (90 broilers per pen i.e. 18 chickens/m²). The average body weight and the male/female ratio per pen were identical for each treatment at the beginning of the experiment. Body weight was measured at the beginning of the experiment (Day 0) and at each diet transition (Day 10, 21, 28 and 37). Food intake per pen was measured at the same times. Three iso-protein and iso-energy diets were formulated for each growing period on the basis of 0, 10 or 20% of w-DDGS incorporation. Wheat-DDGS from batch B was used in this experiment. Crude protein (CP), lysine (Lys) and apparent metabolizable energy values were 21.9%, 1.24% and 11.98 MJ/kg for the starter diets, 19.5%, 1.17% and 12.02 MJ/kg for the growing diets, 18.7%, 1.06% and 12.20 MJ/kg for the finishing diets and 18.0%, 1.02% and 12.37 MJ/kg for the withdrawal diets. Coccidiostatic (Monensin 20) was added in each diet and diets were formulated without enzymes. The w-DDGS (batch B) AMEn and Lys digestibility values were set to 10.57 MJ/kg DM (cf. first experiment result) and 65% respectively. Feedstuffs were ground through a 6 mm screen (w-DDGS, wheat, pea, soya bean meal and sunflower meal) or a 8 mm screen (corn) with a hammer mill (3000 rpm, 64 ms^{-1}). Diets were steam pelleted at 65°C using 2.5 x 35 mm die.

Statistical analysis

Results were analyzed by ANOVA with STATVIEW 5.0 (SAS Institute Inc.). For each significant effect, means were compared by Student Newman Keuls multiple comparison test. The level of significance was set at $P<0.05$.

Results and discussion

Chemical composition of w-DDGS (Table 1)

Crude protein was higher in the B batch (32.1% vs. 35.1% MS) whereas starch as a direct consequence of the ethanol production process was higher in the A batch. Wheat-DDGS from the A batch was characterized by a higher sugar proportion (+67%) and a limited quantity of crude fiber (-12%). Among minerals, only Na was different (+68% for B). Compared with a standard wheat (INRA-AFZ Tables, 2004), all the components were subjected to a 2.5 to 3.5-fold increase in w-DDGS except for starch values. However proportions varied according to the component and the w-DDGS batch considered. Crude protein was subjected to a 2.7-2.9-fold increase whereas the increase in amino acids was lower (2.4 to 2.6-fold). Compared with standard wheat, lysine was the most limiting amino acid in w-DDGS with 2.19% and 1.84% Lys/CP for the A and B batches respectively. Cystine was also reduced (0.3-fold) in both w-DDGS batches. Since lysine is considered as the first amino acid to be degraded by high temperatures and represents the most affected amino acid in w-DDGS this suggests the occurrence of Maillard reactions during the w-DDGS industrial production process, probably during the drying step as it has been previously demonstrated in corn-DDGS (Nyachoti *et al*., 2005). This chemical reaction has probably lowered some amino acids analyzed in w-DDGS since they are trapped by sugars. Such amino acid/sugars complexes are not digested by poultry. Another hypothesis is that w-DDGS protein comes not only from wheat but also from yeast resulting in a change in amino acids profile and digestibility between wheat and w-DDGS. Furthermore, wheat protein may have undergone modifications during the industrial process according to the presence of enzymes or variations of pH and temperature.

Table 1: Chemical composition of w-DDGS (% DM)

w-DDGS	A	B	w-DDGS	A	B
Component			***Amino acid***		
Moisture	6.7	4.7	Lysine	0.70	0.64
Crude protein	32.1	35.1	Threonine	0.99	1.06
Crude fat	5.7	6.4	Methionine	0.46	0.51
Starch	11.7	3.0	Cystine	0.62	0.66
Crude fiber	6.1	8.5	Met + Cys	1.08	1.17
WI Cell wall	26.7	26.9	Tryptophane	0.39	0.36
NDF	21.8	24.8	Isoleucine	1.09	1.20
ADF	7.4	9.8	Leucine	2.09	2.33
ADL	2.5	4.0	Valine	1.37	1.52
Sugar	6.5	3.9	Arginine	1.40	1.52
Ash	4.7	5.8	Histidine	0.66	0.72
Ca	0.13	0.15	Phenylalanine	1.38	1.54
P	0.81	0.90	Tyrosine	0.94	1.04
Cl	0.32	0.32	Serine	1.45	1.56
Na	0.35	0.59	Alanine	1.19	1.29
K	1.09	1.09	Aspartic acid	1.63	1.71
			Glutamic acid	8.17	8.95
			Glycine	1.28	1.43
			Proline	2.63	2.97

Apparent metabolizable energy (AMEn) of w-DDGS in adult cockerels

As illustrated in Table 2 AMEn/Gross Energy ratio were relatively low (55.8% and 52.1% for the A and B batch respectively) compared with wheat (78%). However, AMEn/GE values of w-DDGS were higher than rapeseed meal value (34%) or similar to soya bean meal (54%) (INRA-AFZ Tables, 2004). Wheat-DDGS AMEn values were also significantly different between both batches with 11.19 vs. 10.57 MJ/kg DM for the A and B batch respectively. This difference is probably a consequence of the higher starch and sugar values and the lower fiber value of the A batch. The w-DDGS batch A AMEn is close to the one proposed in the INRA-AFZ Tables (10.88 MJ/kg DM) for that kind of DDGS (starch >7%) whereas AMEn value of the B batch is higher than the INRA-AFZ 2004 Tables value (8.64 MJ/kg DM). Although chemical compositions of the w-DDGS used in this study differed from that indicated in the INRA-AFZ Tables (2004), this can not explain entirely the differences between the AMEn measured in this study and the INRA-AFZ Tables (2004) values.

Table 2: Energy value of the diets (50% w-DDGS) and of w-DDGS (difference method) in adult cockerels.

	Diet energy value					***w-DDGS energy value***			
	Control	**A**	**B**	P	SD	**A**	**B**	P	SD
EMA (MJ/kg DM)	14.97 a	12.84 b	12.53 c	<0.001	0.18	11.31 a	10.73 b	0.004	0.38
EMAn (MJ/kg DM)	14.81 a	12.70 b	12.38 c	<0.001	0.19	11.19 a	10.57 b	0.003	0.41
EMAn/GE (%)	79.9 a	66.7 b	64.5 c	<0.001	1.0	55.8 a	52.1 b	<0.001	2.0

Growth performances trial (Table 3)

During the growth trial (0-37 days), chickens fed 20% of w-DDGS showed a significant reduction (-5.4%) of feed intake (FI) compared with chickens fed the control diet. A trend of FI reduction (-1.9%) was also noted in chicken fed the 10% w-DDGS diet, however the difference did not reach statistical significance. This FI reduction resulted in a significant diminution of final body weight (1927, 1873 and 1788 g BW for the control diet, 10% and 20% w-DDGS diets respectively). Food conversion ratio (FCR) was not significantly modified by the introduction of w-DDGS in the diet despite a trend of increase (P=0.09) for chicken fed on the 20% w-DDGS diet (1.85 vs. 1.82 for the control diet). The most important variation in FCR was observed during the starting period. FCR was already increased after 10 days in chickens fed w-DDGS diets (8 and 12% increase for 10% and 20%

w-DDGS respectively). This was due to BWG decrease ($P<0.0001$) observed with w-DDGS diets (20.0 et 19.1 g/d for 10 and 20% w-DDGS compared with 21.1 g/d in the control) since FI was unaffected by the introduction of w-DDGS. The BWG difference observed between 10 and 20%-wDDGS diets suggested a direct relation between w-DDGS levels in the diet and the degradation of the FCR especially during the starting period. In the following growing periods, the differences between control and w-DDGS diets became less pronounced or even no more statistically significant. These results suggest that w-DDGS diets were deficient in digestible amino acids (lysine and sulfur amino acids) especially during the starting period where chicken requirement are the highest. All the diets were formulated with w-DDGS lysine content (0.95 g/kg DM) higher than what was really measured (0.64 g/kg DM). Consequently the real lysine content of the 10 and 20% w-DDGS diets were really reduced by 2.3 and 4.5% respectively compared with the formulated values. Moreover lysine deficiency has been probably amplified on the basis of digestible lysine since the lysine digestibility of this w-DDGS could be lower than the value used during the diet formulation. Therefore chickens have reduced their growth during the starting period and did not make up for the delay during the following period.

Table 3: Growth performances of broiler chickens fed diets containing 0%, 10 or 20% of w-DDGS.

Overall growing period (0-37 days)	**Control diet**	**10% w-DDGS diet**	**10% w-DDGS diet**	P	SD
Feed Intake (g)	3498 a	3433 a	3310 b	<0.001	68
BWG (g/d)	52.1 a	50.6 a	48.3 b	<0.001	0.9
FCR	1.816	1.833	1.851	0.09	0.032
FCR 0-10 d	1.436 b	1.557 a	1.606 a	<0.01	0.084
FCR 10-21 d	1.570	1.547	1.573	NS	0.035
FCR 21-28 d	1.852 b	1.904 a	1.876 ab	<0.05	0.040
FCR 28-37 d	2.212	2.212	2.254	NS	0.083

Conclusion

The present study clearly indicates that the industrial process of ethanol production may significantly affect some parameters of the chemical composition of w-DDGS. In the two w-DDGS batches studied, the low lysine and sulfur amino acids levels remain the most limiting factor since w-DDGS AMEn in adult cockerels were similar to soya bean meal or higher to rapeseed meal. Growth performances of broiler chickens were not affected by the introduction of 10% of w-DDGS in the diet. Food intake and body weight gain decreased when the proportion of w-DDGS reached 20% in diet. However, it can not be excluded that the decrease in growth performances might be related to the lysine deficiency of this diet especially during the starting period which could have penalized the final performances. Consequently, it would be essential to characterize precisely the w-DDGS issued from the different ethanol plants which will produce w-DDGS in the next few years to optimize their use in chicken diets.

References

INRA-AFZ, 2004. Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage. Porcs, volailles, bovins, ovins, caprins, lapins, chevaux, poissons. D. Sauvant, J.M. Pérez, G. Tran (eds), Seconde Edition révisée, INRA, Paris, 301p.

NYACHOTI C.M., HOUSE J.D., SLOMINSKI B.A., SEDDON I.R., 2005. Energy and nutrient digestibilities in wheat DDGS fed to growing pigs. *Journal of the Science of Food and Agriculture* **85**: 2581-2586.