NUTRIENT AVAILABILITY OF WHEAT DISTILLERS DRIED GRAINS WITH SOLUBLES (DDGS) FOR BROILERS

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ХРАНИТЕЛНА СТОЙНОСТ НА ПШЕНИЧЕН ИЗСУШЕН СПИРТОВАРЕН ОСТАТЪК С РАЗТВОРИМИТЕ ВЕЩЕСТВА (ПИСОР) ЗА БРОЙЛЕРИ

РЕЗЮМЕ

Целта на настоящия експеримент беше да се изследва ефектът на шест проби пшеничен изсушен спиртоварен остатък с разтворимите вещества (пИСОР), произведени от един и същ производствен завод (Ensus Limited, UK), върху видимата метаболитна енергия (ВМЕ), видимата коригираната за азотна ретенция енергия (ВМЕа), сухото вещество от целия тракт (СВТ), ретенцията на азота (АР) и коефициентите на смилаемостта на мазнините (СМ), при пилета бройлери.

Използвана беше контролна смеска, базирана на пшеница и соев шрот, съдържаща 13.11 MJ/kg ВМЕ и 219 g/kg суров протеин. Получени бяха още шест смески чрез смесване на 850 g/kg от контролната със 150 g/kg от всяка от шестте различни пИСОР проби. Смеските не съдържаха кокцидиостатици, антимикробни стимулатори на растежа, профилактични антибиотици или други подобни съставки. Всяка смеска беше предоставена на пет бокса с по две мъжки седем-дневни Ross 308 пилета. Смеските бяха давани на пилетата в сухо състояние в продължение на 14 дни. На края на опита бяха взети екскременти за изследване. Във всички смески беше прибавен титаниев диоксид като несмилаем маркер.

Данните бяха статистически анализирани чрез ANOVA. Изчислени бяха и корелационни коефициенти. МЕ и коефициентите на смилаемост на пИСОР пробите бяха определени чрез метода на пропорционалното заместване. Стойностите на ВМЕ и ВМЕа на пробите пИСОР варираха от 10.07 до 13.44 MJ/kg DM и от 9.64 до 13.07 MJ/kg DM, респективно.

Не са установени статистически достоверни разлики (*P*>0.05) в смилаемостта между различните пИСОР проби. Разликите в стойностите на метаболитната енергия бяха свързани с разликите в съдържанието на пепел и нескорбелни полизахариди на пИСОР пробите. Резултатите показват, че има разлики в наличната енергия в различните партиди пИСОР от един и същ производствен завод в една и съща година.

Recent availability of and interest in distillers dried grains with solubles (DDGS) has resulted from the increased production of bio-ethanol. Traditionally fed to ruminants, this abundant and competitively priced co-product of bio-ethanol production can be also used in poultry diet formulations (**Swiatkiewicz & Koreleski,** 2008). **Ivanova et al**. (2013) reported that inclusion of 15% DDGS in broiler diets did not have any negative effect on performance and meat quality. **Noll et al.** (2004)

also reported no negative effects on body weight gain and feed conversion when DDGS was fed to turkeys at up to 20% of the diet. However, most of the research on DDGS exploited North American maize-DDGS and there is a dearth of information about the nutritive value of wheat-DDGS (**Noll & Brannon,** 2006; **Swiatkiewicz & Koreleski,** 2008). It is known that compared to maize, wheat-DDGS has more protein and available phosphorus but also non starch polysaccharides (**Oryschak et al.,** 2010). The nutrient availability has been shown to vary substantially between DDGS samples, especially in the digestibility of lysine (**Thacker and Widyaratne,** 2007; **Bandegan et al.,** 2009). As the price of cereals and protein sources in EC increases, inclusion of EC produced wheat-DDGS could be more routinely used in broiler diets if there was more robust information on its nutrient availability and its variation. Information on its effect on growth performance and bird health needed.

The major objectives of this study were: (1) to examine the differences in the chemical composition of 6 different wheat DDGS sample, (2) to determine the metabolisable energy content and nutrient availability of these samples for broiler chickens using the slope ratio method and (3) to examine the relationship between these factors. Growth performance of birds was also determined.

MATERIAL AND METHODS

The experiment was approved by Harper Adams University Animal Experimental Committee.

Experimental wheat DDGS samples. The six batches of wheat DDGS used in the study were produced by a single manufacturer (ENSUS Bio refinery, Wilton, UK). The batches were manufactured in early 2013 and were used in the experiment after approximately one year of storage. During this period all samples were stored in tote bags at ambient air temperatures in a dry store.

Chemical composition of wheat DDGS samples. Dry matter (DM) was determined by drying of samples in a forced draft oven at 105◦C to a constant weight. Ash was measured in a muffle furnace at 500◦C for 18 h. Crude protein (6.25 X N) in samples was determined by the combustion method (AOAC, 2000) using a Leco (FP-528 N, Leco Corp., St. Joseph, MI). Oil (as ether extract) was extracted with diethyl ether by the ether extraction method (AOAC, 2000) using a Soxtec system (Foss UK Ltd.). The gross energy (GE) value of DDGS samples was determined in a bomb calorimeter (model 6200; Parr Instrument Co., Moline, IL) with benzoic acid used as the standard. The non-starch polysaccharide (NSP) content was determined by the methods of Englyst (1994).

Diet formulation. A wheat-soybean meal basal diet containing 13.11 MJ/kg AME and 219 g/kg crude protein was prepared (Table 1). Another six diets were obtained by mixing 850 g/kg of the control diet with 150 g/kg of each of the six different whet DDGS samples. The diets did not contain any coccidiostat, antimicrobial growth promoters, prophylactic or other similar additives. All diets were fed as mash with 5 g/kg of titanium dioxide included as a marker.

Husbandry and sample collection. Ross 308 male chickens were obtained from a commercial hatchery at 1-d-old and were placed in a single floor pen at 32°C. All birds were given a proprietary chicken starter feed during the 7 d pre-study period. On the first day of the experiment (8 d of age), the chicks were individually weighed and the heaviest and lightest birds discarded, leaving 70 birds which were placed to 35 small floor pens. Each diet was offered *ad libitum* to birds housed in one of 5 pens in a randomised complete block design. The temperature and lighting regime in the room met breeder's recommendations (Aviagen Ltd., Edinburgh, UK). For the last 24 hours of the 14d feeding period the solid floor was replaced by mesh and excreta were collected over night and immediately dried at 60◦C and then milled. The gross energy, dry matter, nitrogen, and fat of each dried excreta sample and the experimental diets were determined as described for the DDGS samples. Titanium in feed and excreta was determined by the method of **Short et al.** (1996).

Dietary metabolizable energy and nutrient availability values were calculated as described by **Lammers et al.** (2008).

The obtained value for the basal feed was then used to enable the calculation of the metabolisable energy and nutrient availability coefficients following the slope ratio method (**Finney,** 1978).

Statistical Analyses. Statistical analyses were performed by GenStat (16th ed.; Lawes Agricultural Trust, VSN International Ltd., Oxford, UK). The data were analysed by ANOVA. Correlation coefficients were also generated to test for a possible relationship between the different variates. In all instances, differences were reported as significant at $P<0.05$ and trends were noted when the P-value was less than 0.10.

RESULTS AND DISCUSSION

The chemical composition of the DDGS samples is presented on Table 2. The amounts of oil and protein were more variable than the contents of ash and GE, and ranged from 42 to 61 g/kg DM, and 274 to 327 g/kg DM, respectively. The mean total NSP content of the wheat DDGS samples was 235.5 g/kg DM, which was comprised of 50.1 g/kg DM of soluble NSP and 185.4 g/kg of insoluble NSP. In general, the results are in agreement with published data on wheat DDGS

Table 1. **Formulation of the control diet / Контролната смеска**

Dietary ingredients	kg/100kg
Wheat	60.26
Soybean meal (48)	26.00
Soybean meal (full fat)	5.00
Vegetable oil	4.50
Monodicalcium phosphate	1.50
Limestone	1.25
NaCl	0.27
Lysine	0.17
Methionine	0.35
Threonine	0.15
NaHCO3	0.15
Vitamin mineral premix[1]	0.40
	100
Calculated analysis (as fed)	
ME MJ/kg	13.11
Crude Protein g/kg	219.4
Crude Fat g/kg	6.48
Ca g/kg	9.0
Available P g/kg	4.7
Lysine g/kg	13.0
Methionine + Cysteine g/kg	9.3

[1]The vitamin and mineral premix contained vitamins and trace elements to meet the breeder's recommendations (Aviagen Ltd., Edinburgh, UK). The premix provided (units/kg complete diet (67% wheat and 33% balancer)): retinol 3600 mg, cholecalciferol 125 mg, á-tocopherol 34 mg, menadione 3 mg, thiamine 2 mg, riboflavin 7 mg, pyridoxine 5 mg, cobalamin 15 mg, nicotinic acid 50 mg, pantotenic acid 15 mg, folic acid 1 mg, biotin 200 mg, iron 80 mg, copper 10 mg, manganese 100 mg, cobalt 0.5 mg, zinc 80 mg, iodine 1 mg, selenium 0.2mg and molybdenum 0.5 mg.

Table 2. **Determined chemical composition of the wheat DDGS samples (DM basis)/ Химичен състав на пробите пшеничен ИСОР (на база СВ).**

DDGS	DM (g/kg)	Ash (g/kg)	Oil (g/kg)	CP (g/kg)	GE (MJ/kg)	NSPs (g/kg)	NSPn (g/kg)
1	896	55	50	318	21.78	45.8	188.6
2	898	65	43	326	20.29	70.2	168.2
3	900	58	42	327	21.42	60.0	174.4
4	892	55	51	322	21.77	52.7	180.5
5	895	53	55	325	21.68	39.1	178.8
6	843	58	61	274	21.16	33.2	221.8

Table 3. **Final body weight (FBW), daily feed intake (FI), daily weight gain (WG), gain to feed ratio (G:F), apparent metabolisable energy (AME), AME corrected for N retention (AMEn), coefficients of dry matter (DMR) and nitrogen (NR) retention and fat (FD) digestibility, of the experimental diets when fed to chickens from 7 to 21d age/Крайно живо тегло (КЖТ), ежедневен прием на храна (ПХ), ежедневен тегловен прираст (ТП), съотношение прираст:прием на храна (П:Х), видима метаболитна енергия (ВМЕ), видима коригирана за азотна ретенция енергия (ВМЕа), коефициенти на сухо вещество (СВТ) и ретенция на азота (АР) и коефициенти на смилаемост на мазнините (СМ), на експерименталните смески, давани на пилета от 7- до 21-дневна възраст**

Diets	FBW (g/b)	FI (g DM/b/d)	WG (g /b/d)	G:F (g:g)	AME (MJ/kg DM)	AMEn (MJ/kg DM)	DMR	NR	FD
1	837^{a}	62.6	47.4^{a}	0.756^{ab}	14.00	13.52	0.700^{ab}	0.602^{ab}	0.759
2	852^{ab}	64.6	48.3^{ab}	0.749^{ab}	13.37	12.88	0.682^{a}	0.566^{a}	0.744
3	854^{ab}	65.4	48.4^{ab}	0.741^{a}	13.60	13.10	0.687^{ab}	0.581^{a}	0.754
4	878^{ab}	66.9	49.6^{ab}	0.741^{a}	13.88	13.38	0.694^{ab}	0.584^{a}	0.785
5	861^{ab}	66.8	48.3^{ab}	0.723^{a}	13.75	13.24	0.693^{ab}	0.588^{ab}	0.767
6	817^{a}	65.6	45.9^{a}	0.700^{a}	13.77	13.26	0.692^{ab}	0.581^{a}	0.770
7	928^{b}	65.8	53.7^{b}	0.816^{b}	14.12	13.63	0.719^{b}	0.638^{b}	0.803
SEM	19.7	1.11	1.33	0.0151	0.168	0.175	0.0075	0.0117	0.0174
P	<0.05	NS	<0.05	0.001	NS	NS	0.05	<0.005	NS

There were 5 observations per treatment. Bird performance was determined from 7 to 21 d age; dietary metabolisable energy and nutrient retention/digestibility data were determined based on last day excreta collection and marker. Results are statistically significant when $P<0.05$; SEM – Standard errors of means; Means within a column with no common superscript differ significantly; NS – not significant

(**Bolarinwa and Adeola,** 2012; **Olukosi and Adebiyi,** 2013).

It should be noted that parameters measured for broiler growth were primarily documented as a control measure to ensure there were no abnormalities caused by feeding different DDGS samples. A study that birds are reared for 5 or 6 weeks would be required in order to obtain more reliable data. The overall final body weight of the birds was 861g at 21d age (Table 3). This is approximately 10% lower than the breeder's performance objectives of 945g at this age (Aviagen Ltd., Edinburgh, UK). However, feeding mash diets instead of pellets may explain the discrepancy with the breeder's recommended weight for this age (**Pirgozliev et al.,** 2015a; 2015b). There were no differences

Table 4. **Apparent metabolisable energy (AME), N corrected AME (AMEn), coefficients of dry matter (DMR) and nitrogen (NR) retention and fat (FD) digestibility, of six wheat DDGS samples when fed to chickens/ Видима метаболитна енергия (ВМЕ), видима коригирана за азотна ретенция енергия (ВМЕа), коефициенти на сухо вещество (СВТ) и ретенция на азота (РА) и смилаемост на мазнините (СМ), на шест проби пшеничен ИСОР, изхранени на пилета**

DDGS sample	AME (MJ/kg DM)	AMEn (MJ/kg DM)	AME : GE	DMR	NR	FD
1	13.44[c]	13.07[b]	0.617	0.605	0.406	0.521
2	10.07[a]	9.64[a]	0.497	0.523	0.237	0.584
3	10.68[ab]	10.13[a]	0.499	0.506	0.260	0.479
4	12.11[bc]	11.56[ab]	0.556	0.533	0.317	0.674
5	11.60[abc]	11.02[ab]	0.535	0.546	0.302	0.564
6	11.32[ab]	10.76[a]	0.535	0.538	0.293	0.582
SEM	0.685	0.727	0.0318	0.0255	0.0459	0.0989
P	<0.05	<0.05	NS	NS	NS	NS

There were 5 observations per treatment. Data were obtained using slope ratio method. Results are statistically significant when $P<0.05$; SEM – Standard errors of means; Means within a column with no common superscript differ significantly; NS – not significant.

($P>0.05$) between the weight of birds fed the basal diet (diet 7) and four of the diets supplemented with DDGS (diets 2, 3, 4, and5). This is also in agreement with the majority of the digestibility data (Table 3), thus supporting the view that 15% is DDGS inclusion rate that is suitable for broiler diets (**Thacker and Widyaratne,** 2007; **Ivanova et al.,** 2013). The results for dietary metabolisable energy and nutrient availability are in line with published literature on wheat DDGS when fed to poultry (**Cozannet et al.,** 2010; **Adebiyi,** 2014; **Whiting et al.,** 2014).

Knowledge on the content of metabolisable energy in wheat DDGS is important for the industry and allows more precise diet formulations. The AME and AMEn value of wheat-DDGS in the current study was determined to vary from 10.07 to 13.44 MJ/kg DM and from 9.64 to 13.07 MJ/kg DM, respectively (Table 4). **Cozannet et al.** (2010) reported the AME and AMEn values of 10 wheat-DDGS to range from 7.7 to 11.5 MJ/kg DM, and from 7.4 to 10.7 MJ/kg DM, respectively. **Adebiyi** (2014) determined AME and AMEn value of wheat-DDGS to be 14 and 13 MJ/kg DM, respectively. It is well known that the chemical properties of DDGS differ significantly among sources (**Fastinger et al.,** 2006). The GE content and the concentration and/or type of dietary fibre are important factors that may define the metabolisable energy content of the feed ingredient. The metabolisable energy values of wheat-DDGS for broilers obtained in the current study was about 2 MJ/kg of DM greater compared with the average AME value of **Cozannet et al.** (2010), but about 1 MJ lower that those reported by **Adebiyi** (2014). Although the GE content of the wheat-DDGS used in the current study was similar to those of **Cozannet et al.** (2010) and **Adebiyi** (2014), 21.35 vs 21.6 and 20.8 MJ/kg DM, respectively, the AME:GE value was 54%, or respectively lower and higher than those reported by **Adebiyi** (2014) and **Cozannet et al.** (2010), or 65 and 47%, respectively. It therefore appears that factors other than the GE content of the wheat-DDGS confer differences in its AME contents among sources.

Results on metabolisable energy and nutrient availability response criteria to wheat DDGS samples are presented on Table 5. There was positive relationship ($P<0.1$) between DDGS metabolisable energy and GE. However, there was a negative ($P<0.1$) relationship between trend DDGS metabolisable energy and ash and trend ($P>0.05$)

Table 5. **Correlation coefficients between metabolisable energy, nutrient retention coefficients and chemical composition of wheat DDGS samples*/ Корелационни коефициенти между метаболитната енергия, коефициентите на хранителна ретенция и химичния състав на пробите пшеничен ИСОР**

	AME	AMEn	AME : GE	GE	DMR	NR	FD	DM	Ash	Oil	CP	NSPs
AMEn	0.998											
AME: GE	0.982	0.990										
GE	0.780	0.743	0.648									
DMR	0.878	0.900	0.935	0.444								
NR	0.990	0.995	0.991	0.710	0.928							
FD	0.054	0.036	0.068	-0.015	-0.097	-0.037						
DM	0.022	0.044	-0.011	0.099	0.014	0.023	-0.210					
Ash	-0.738	-0.695	-0.612	-0.954	-0.462	-0.670	-0.043	0.045				
Oil	0.366	0.328	0.350	0.336	0.306	0.329	0.368	-0.789	-0.544			
CP	-0.068	-0.052	-0.112	0.074	-0.100	-0.082	-0.123	0.988	0.052	-0.765		
NSPs	-0.501	-0.462	-0.456	-0.532	-0.420	-0.477	-0.074	0.686	0.710	-0.938	0.693	
NSPn	0.373	0.353	0.390	0.235	0.343	0.381	0.048	-0.904	-0.339	0.827	-0.943	-0.837

AME, apparent metabolisable energy; AMEn, N corrected AME; AME:GE, gross energy metabolisability coefficient; DMR, dry matter retention coefficient; NR, nitrogen retention coefficient; FD, fat digestibility coefficient; DM, dry matter; NSPs, soluble non-starch polysaccharides; NSPn, non-soluble NSP.

* df = 4, correlation coefficients greater than 0.729, 0.811 and 0.917 are statistically significant at 10% (P<0.1), 5% (P<0.05) and 1% level (P<0.001), respectively.

for a negative relationship with NSPs content of DDGS samples. No relationships (P>0.05) between DDGS nutrient availability data and its chemical composition were detected.

The relatively small differences that ash content explain in metabolisable energy and AME:GE of DDGS would appear not to be due to direct effects on the nutritive value of the wheat DDGS but could be an indication of some crop growth or storage variables. The ash content of different wheat samples can vary due to soil contamination, especially if lodging of the growing crop has occurred prior to harvest. Improper storage may also contribute to a soil contamination.

Soluble viscous NSPs depress the digestibility of protein, starch and fat in broiler diets, and may reduce dietary available energy contents (**Bedford and Classen,** 1992). This is in agreement with the trend of a negative relationship between NSPs in DDGS samples and metabolisable energy and nutrient digestibility coefficients in this study.

The results from this study demonstrated that there were significant differences between the six DDGS batches in AME and AMEn. Differences in metabolisable energy values were generally associated with differences in ash and NSPs contents of DDGS samples. The batch variability of DDGS samples produced by the same manufacturer indicates that there are differences in available energy in different batches from the same production plant in the same year. These differences cannot be explained by the differences in proximate nutrient composition between the samples. Further studies are needed to identify which variables relate to metabolisable energy in wheat DDGS.

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SUMMARY

The aim of the present experiment was to investigate the effect of six samples of wheat distiller dried grains with soluble (DDGS) produced by a single production plant (Ensus Limited, UK), on dietary apparent metabolisable energy (AME), N corrected AME (AMEn), total tract dry matter (DMR), and nitrogen retention (NR), and fat digestibility (FD) coefficients, when fed to broiler chickens. A wheat-soybean meal basal diet containing 13.11 MJ/kg AME and 219 g/kg crude protein was produced. Six more diets were obtained by mixing 850 g/kg of the control diet with 150 g/kg of each of the six different wheat DDGS samples. The diets did not contain any coccidiostats, antimicrobial growth promoters, prophylactic or other similar additives. Each diet was offered to fife pens with two male 7d old Ross 308 broilers. Diets were fed 14 days and at the end of the study excreta were collected. All diets were fed as mash with 5 g/kg of titanium dioxide included as a indigestible marker. Data were statistically analysed by ANOVA. Correlation coefficients were also generated. The ME and digestibility coefficients of the DDGS samples were determined by the slope ratio method. The AME and AMEn value of wheat-DDGS samples varied from 10.07 to 13.44 MJ/kg DM and from 9.64 to 13.07 MJ/kg DM, respectively. There were no differences (P>0.05) in nutrient digestibility variates between DDGS samples. Differences in metabolisable energy values were generally associated with differences in ash and non-starch polysaccharide contents of DDGS samples. The results indicate that there are differences in available energy in different DDGS batches from the same production plant in the same year.

Key words: *Broilers, wheat DDGS, AME, digestibility, batch variability*