Nutritive value of wheat distiller's dried grains with solubles (WDDGS) in nutrition of growing-finishing pigs*

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Nutritive value of WDDGS (wheat distiller's dried grains with solubles) in pig nutrition was evaluated. The indicators of the evaluation included production results, digestibility of feed components, and meatiness of carcasses and certain measurements of physicochemical evaluation of meat. The experiment covered three groups of fatteners from which group I received standard cereal mixture with soybean - and rapeseed - oil meal, group II – the mixture, in which 66% of soybean meal was replaced by 9% addition of WDDGS and group III where the whole content of soybean and rapeseed meal was replaced by the addition of WDDGS in the quantity of 21%. The mixtures were balanced in respect of protein, energy and basic amino acids. Replacement of 2/3 of soy meal by the addition of 9% of wheat DDGS in the mixtures for fatteners did not have any significant effect on daily body gains of animals (903 g vs. 922 g), feed conversion (2.87 kg/kg vs. 2.81 kg/kg), meatiness (57.54% vs. 58.02%) and carcass fatness (13.53 mm vs.13.33 mm), digestibility of solid nutrients and nitrogen balance. Only complete replacement of soy and rape meals by wheat DDGS in the quantity of 21% in the mixtures caused deterioration of fattening results.

KEY WORDS: WDDGS / nutritive value / growing-finishing pigs

Dried distiller's grains with solubles (DDGS) as a waste product in the production of bioethanol from cereal grains, mainly corn (USA) and to a lesser extent, wheat (Canada

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and Europe) is still relatively not very widespread in the Polish feed market. It has been used as feed for many years in the USA, where its annual production in 2008 amounted to more than 18 million tons [19]. It is mainly applied in ruminant feeds, just like in Europe. Research on pigs with the use of DDGS and, particularly, with wheat DDGS (WDDGS) is rather scarce. In Poland, there are few such studies. First of all, there is no complete information about the origin of the domestic WDDGS and the comprehensive assessment of its chemical composition. The literature data indicate that WDDGS contains, similarly as corn DDGS, several times more protein, far more crude fat and ash and phosphorus in particular [6, 9, 18] as compared to the grain of its origin. However, according to many authors [3, 7, 9] the product contains also much more fiber and its fractions – NDF and ADF, compared to wheat, which in the opinion of Nyachotti et al. [9] may limit its use in feeding of pigs, especially of young animals.

In our studies [17] on assessment of chemical composition of one of Polish wheat DDGS, it has been shown that the discussed product, compared with the grain of wheat, contains much more protein (33.8% vs. 11.9%), crude fat (4.88% vs. 2.0%), some minerals as iron (249 mg/kg vs. 43 mg/kg) and copper (15.5 mg/kg vs. 2.7 mg/kg) and, first of all, crude fiber (14.22 % vs. 2.9%) and its fractions: NDF (30.35% vs. 12.23%) and ADF (15.07% vs. 3.17%).

The aim of the present study was to evaluate the suitability of WDDGS in feed rations for pigs. WDDGS was produced in the Wielkopolskie Zakłady Farmaceutyczne BIO-WIN (Pharmaceutical Works) in 2008. Criteria of WDDGS evaluation included live and *post mortem* fattening indices of animal assessment and the digestibility of nutrients in fed mixtures and nitrogen balance.

Material and methods

The experiment was performed on three groups of pigs (hybrids coming from crossbreeding of sows Polish Large White x Polish Landrace with Duroc boars in the quantity of 45 animals (15 barrows in each group). They were individually fed the full-ration compounds from body weight about 30 kg to ca. 110 kg. The mixtures contained similar quantities of protein, energy and certain essential amino acids: lysine, methionine with cystine and threonine (Tab. 1). They were administrated throughout the fattening period, in a dry form, increasing the rations at intervals of 2-3 weeks. The mixture for group I (control) contained soybean meal and rapeseed meal, in the mixture for group II, 2/3 of soybean meal were replaced by WDDGS and in the mixture for group III, the whole soybean and rapeseed meals were replaced by WDDGS. All animals had the constant access to drinking water owing to nipple drinkers, installed in each pen.

The composition and the nutritional value of the mixtures (Tab. 1) used in the experiment, were calculated on the basis of fixed composition and formulation, contained in the tables of chemical composition and nutritive value of feeds [8]. Missing data in the tables relating to the chemical composition of WDDGS derived from own chemical analyses [17]. In case of metabolic energy, its value was adopted on such level which was present in wheat bran [8]. Content of essential nutrients in fed mixtures and excreted faeces and of nitrogen in urine was determined by AOAC [1], using Foss-Tecator apparatus.

Table 1 – Tabela 1

Chemical composition (%) and nutritive value of experimental mixtures
Skład chemiczny (%) i wartość pokarmowa mieszanek doświadczalnych

Components Składniki	Group – Grupa		
	I	II	III
Barley Jęczmień	32.75	32.65	32.55
Wheat Pszenica	20	20	20
Corn grain Ziarno kukurydzy	20	20	20
Wheat bran Otręby pszenne	9	6	3
Rapeseed meal Poekstrakcyjna śruta rzepakowa	6	6	0
Soybean meal Poekstrakcyjna śruta sojowa	9	3	0
Mineral and vitamin premix Premiks mineralno-witaminowy	3	3	3
WDDGS	0	9	21
Lysine Lizyna	0.25	0.35	0.45
Methionine Metionina	–	–	0.1
Threonine Treonina	–	–	0.05
Chemical composition and energy value Skład chemiczny i wartość energetyczna			
Dry matter (%) Sucha masa (%)	85.1	85.7	86.4
Metabolizable energy (MJ/kg) Energia metaboliczna (MJ/kg)	12.3	12.3	12.3
Crude protein (%) Białko surowe (%)	15.3	15.2	15.1
Lysine (%) Lizyna (%)	0.84	0.85	0.84
Methionine (%) Metionina (%)	0.55	0.53	0.54
Threonine (%) Treonina (%)	0.53	0.52	0.53
Crude fibre (%) Włókno surowe (%)	5.1	5.7	6.1
Protein: energy (g/MJ) Białko: energia (g/MJ)	12.4	12.4	12.3

During fattening period, animal health and feed intake was constantly monitored. In the middle of fattening period, after weighing all animals (the mean body weight ca. 65 kg), the digestibility of nutrients and nitrogen balance were determined. The discussed study was performed by conventional balance method with 8 porkers from each group. On the day before the end of fattening, there was sampled venous blood from the front vein in order to determine certain blood serum biochemical indices: TP – total protein, ALB – albumins, CRSC – creatinine, ALT – alanine aminotransferase, AST – aspartate aminotransferase, GLU – glucose, CHOL – cholesterol, TRIG – triglycerides, VLDL – lipoproteins of a very low density. Biochemical parameters in blood serum of pigs were determined by spectrometry, using VITROS analyzer in a system EKTAchem DT–60–II with module, DT, DTE, DTSC, using sets of slides of Johnson & Johnson Clinical Diagnostics.

After completion of the experiment, all animals were subject to evaluation of their slaughter value. To this aim, immediately after slaughter, some slaughter value indicators such as hot carcass weight, degree of carcass fatness and meatiness, were determined. The mentioned determinations were carried out according to EUROP system, using ultrasonic apparatus CGM 100; the measurements were performed on the level of last thoracic vertebra, at the distance of 7 cm from the dorsal line. After 24-hour chilling of carcasses, the samples were collected for testing of meat from *musculus longissimus dorsi*; chemical composition, including dry matter [12], total ash [13] and total protein content (by the Kjeldahl method) [14] and crude fat content (by Soxhlet method) [15], was determined. The meat samples were also subject to physico-chemical evaluation. The discussed assessment included pH level, colour and water holding capacity (WHC). The pH level was determined after 45 min and after 24 h from slaughter, using pH-meter of Hanna Instruments with microelectrode 301, according to ISO 2917:2001/AP1:2002 [16]. The colour of meat was characterized on basis of following parameters: L* – brightness, a* – intensity of red colour, b* – intensity of yellow colour in CIELAB system [4]. The parameters of L*, a* and b* were determined by the reflection method, using Plus XE MiniScan Hunterlab by a direct twice-repeated measurement of transverse muscle cross-section area. Water holding capacity was determined by the method of Grau and Hamm acc. to Oeckel et al. [10].

The results were statistically developed by the method of variance analysis ANOVA in a single-factor system, using programme Statgraphics 6.0 Plus.

Results and discussion

Table 2 shows the results of digestibility of nutrients, contained in the mixtures, employed in the experiment and certain results of nitrogen balance. The highest digestibility of organic matter and crude protein was observed in animals of group I (control) and then, of group II (2/3 soybean meal in the mixture was replaced by 9% addition of WDDGS). The complete replacement of soybean and rapeseed meals by the addition of 21% of WDDGS (group III) decreased the digestibility coefficients for the above mentioned components in statistically significant degree ($P<0.01$). Also, the digestibility of crude fibre and nitrogen-free extractives was the lowest in group III. In the literature concerning the digestibility of nutrients in pigs, receiving wheat DDGS, we find different results, although most of them indicate that the product reduces the digestibility. It was demonstrated, *inter alia*, in

Table 2 – Tabela 2

The results of nutrients digestibility (%) and nitrogen balance
Wyniki strawności składników pokarmowych (%) i bilans azotu

Ingredient Składnik	Group – Grupa			SEM	P
	I	II	III		
Organic matter Substancja organiczna	87.4^{A}	86.0^{A}	82.8^{B}	0.0050	0.0000
Crude protein Białko surowe	79.7^{a}	80.4^{a}	76.4^{b}	0.0110	0.0416
Ether extract Tłuszcz surowy	70.8	82.3	73.5	0.0554	0.3292
Crude fibre Włókno surowe	42.5^{a}	37.4^{ab}	33.3^{c}	0.0204	0.0160
N-free extractives Bezazotowe wyciągowe	91.5^{A}	90.0^{B}	87.2^{C}	0.0024	0.0000
N balance – Bilans azotu					
N-retention (g/day) Retencja azotu (g/dzień)	32.5	32.5	32.0	0.5886	0.7836
N-retention/N-intake (%) Retencja N/N pobrany (%)	51.2	51.3	50.9	0.9285	0.9369
N-retention/N-digested (%) Retencja N/N strawiony (%)	64.3	63.9	66.6	1.2425	0.2655

a, b, c – mean values within a row with different superscripts are different (P<0.05) – średnie oznaczone w wierszu różnymi literami różnią się przy P<0,05
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the studies of Nyachoti et al. [9] and Widyaratne and Zijlstra [22] in which 40% of wheat meal in the diets for pigs was replaced by an equal amount of WDDGS. There was found, indeed, a substantial reduction in the digestibility coefficients of dry matter, crude protein, amino acids and energy. This poorer digestibility of WDDGS was recorded in the measurements performed the end of small intestine as well as to the end of digestive tract of pigs. The lower digestibility of protein and amino acids, especially of lysine in case of WDDGS compared to the grains of wheat has been also confirmed in the studies of Lan et al. [6], conducted on the fatteners, with the application of synthetic diets. The authors such as Thacker [20] and Pedersen and Lindberg [11] argue that the higher is the level of WDDGS in the diets for growing pigs, the more deteriorated is the digestibility of nutrients. In turn, Emiola et al. [5] found no significant differences in the digestibility coefficients for dry matter, organic matter and crude protein, irrespectively of the level of WDDGS (15 or 30%) in corn-soy diets for pigs with body weight of ca. 55 kg.

Contrary to the digestibility, there were no significant differences found in nitrogen retention and the extent of its utilization (Tab. 2). The mentioned results were similar in all groups and it should be also added that they were high (N retention was equal to ca. 30

Table 3 – Tabela 3

Production results and indices of carcass quality
Wyniki produkcyjne i wskaźniki jakości tuszy

Specification	Group			SEM	P
	I	II	III		
Initial body weight (kg) Początkowa masa ciała (kg)	33.9	33.8	33.9	0.6486	0.9925
Final body weight (kg) Końcowa masa ciała (kg)	112.5^{a}	110.9^{ab}	108.1^{b}	1.0414	0.0201
Total gain (kg) Przyrost ogółem (kg)	78.6^{a}	77.1^{ab}	74.2^{b}	1.0904	0.0270
Daily weight gain (kg) Przyrost dobowy (kg)	0.922^{A}	0.903^{A}	0.848^{B}	0.0114	0.0002
Daily feed intake (kg) Dzienne spożycie paszy (kg)	2.58	2.59	2.59	0.0082	0.7766
Feed efficiency (kg/kg) Zużycie paszy (kg/kg)	2.81^{A}	2.87^{A}	3.06^{B}	0.0395	0.0002
Hot carcass weight (kg) Masa tuszy ciepłej (kg)	87.37^{A}	85.15^{A}	79.99^{B}	1.1522	0.0002
Meatiness (%) Mięsność (%)	58.02	57.54	56.66	0.5552	0.2551
Backfat thickness (mm) Grubość słoniny (mm)	13.33	13.53	13.14	0.7199	0.9315
Thickness of *longissimus dorsi* muscle (mm) Grubość *m.l.d.* (mm)	60.13	58.86	55.85	1.4126	0.1113

a, b – mean values within a row with different superscripts are different ($P<0.05$) – średnie oznaczone w wierszu różnymi literami różnią się przy $P<0,05$
A, B – mean values within a row with different superscripts are different ($P<0.01$) – średnie oznaczone w wierszu różnymi literami różnią się przy $P<0,01$

g/day), what may be an evidence of a high genetic potential of pigs in respect of protein depositing and on the other hand, a good balance of energy and particular nutrients in the diet, especially of protein and amino acids.

Table 3 contains some live and slaughter fattening results. The highest daily gains and feed conversion were obtained in the control group (I) and in the group, receiving 9% addition of WDDGS (II). Between these groups, there were no significant differences in the analyzed fattening indicators. Thus, the replacement of 2/3 of the soybean meal by 9% of WDDGS in the compound s for the pigs had no effect on daily gains of animals (903 g vs. 922 g) and feed conversion (2.87 kg/kg vs. 2.81 kg/kg). Only the total replacement of soybean and rape seed meals by WDDGS in the quantity of 21% in the mixtures for group III resulted in deterioration of the discussed fattening parameters. It should be mentioned,

however, that even in this case, daily body gains and feed conversion were quite good (848 g and 3.06 kg/kg, respectively). There were no significant differences found between the groups in respect of slaughter value indices (meatiness and fatness, and thickness of *musculus longissimus dorsi*). Hot carcass weight was the exception; this parameter was the highest in fatteners of group I (0% of WDDGS) and II (9% of WDDGS); in group III (21% of WDDGS), it was significantly lower ($P<0.05$). It could result from the fact that the fatteners in group III received the mixtures with a higher content of crude fibre compared to the pigs of group II and group I (Tab. 1). It was due to a high content of the discussed component in WDDGS (14.22%); the participation of WDDGS in the diet for group III was the highest one. Such conclusion is justified (via a certain analogy) by many studies, i.a. of Thacker [20, 21] where the relationship between WDDGS level in the diets for fatteners (and by this, fibre content) and the slaughter value was recorded.

In the studies of growing pigs (50-85 kg), conducted by Widyaratne and Zijlstra [22], it was found that the replacement of a part of wheat and soybean meal in the corn-soy mixtures for pigs by the addition of 25% of WDDGS, caused a significant decrease of their body gains but without differentiation in the degree of feed conversion. In similar studies of fatteners, being only lighter (20-51 kg) and receiving 0, 5, 10, 15, 20 or 25% of WDDGS in wheat – soybean diets, Thacker [20, 21] observed a linear reduction of feed intake and decrease in daily gains while feed conversion was unchanged. In the successive stage of the discussed studies, performed on heavy fatteners (52-113 kg) receiving 0, 3, 6, 9, 12 or 15% of WDDGS in the diets, the author did not find any significant differences in the production results of the pigs. Nevertheless, he recorded the deterioration in dressing percen-

Table 4 – Tabela 4

Some physical-chemical parameters of meat
Parametry fizyczno-chemiczne mięsa

Parameters Parametry	Group – Grupa			SEM	P
	I	II	III		
Total protein (%) Białko ogólne (%)	22.89	22.41	22.76	0.2029	0.1403
Ether extract (%) Tłuszcz surowy (%)	1.82	2.07	1.71	0.2122	0.4845
Ash (%) Popiół (%)	1.16	1.14	1.13	0.0109	0.3259
pH_{45}	6.35	6.30	6.38	0.0468	0.4457
pH_{24}	5.55	5.48	5.46	0.0339	0.1332
Water holding capacity (cm^2) Wodochłonność (cm^2)	7.34	7.12	7.32	0.3133	0.8598
Meat colour – Barwa mięsa					
a *	6.24	6.60	6.68	0.2802	0.2790
b *	14.07	14.52	14.48	0.2679	0.4374
L*	56.54	57.39	57.52	0.7333	0.6609

Table 5 – Tabela 5

Some biochemical indices of blood
Parametry biochemiczne krwi

Parameters Parametry	Group – Grupa			SEM	P
	I	II	III		
TP (g/dl)	6.71	6.44	6.43	0.1440	0.3005
ALB (g/dl)	3.83	3.91	3.88	0.1017	0.8315
ALT (U/l)	57.00[a]	62.12[ab]	69.13[b]	3.4793	0.0682
AST (U/l)	55.88	47.13	46.25	4.5495	0.2762
CRSC (mg/dl)	1.79[b]	1.63[ab]	1.61[a]	0.0563	0.0711
GLU (mg/dl)	69.50	67.60	72.50	3.4657	0.6116
CHOL (mg/dl)	87.25	83.00	85.25	2.9170	0.5955
TRIG (mg/dl)	22.33	19.17	23.75	2.1955	0.3070
VLDL (mg/dl)	4.50	3.83	4.75	0.4410	0.3058

a,b – mean values within a row with different superscripts are different (P<0.05) – średnie oznaczone w wierszu różnymi literami różnią się przy P<0,05

tage and meatiness. In his opinion, the optimal results of fattening in feed nutrition provide for maximum 5-10% addition of WDDGS to feeds of grower type and 15% addition to the mixtures of finisher type in a final period of fattening. In the latter case, WDDGS supplement may completely replace the soybean meal. The author stresses, however the absolute need to supplement the limiting amino acids in the diets. WDDGS was also used in feeding of piglets directly after weaning, in the attempts to replace soybean meal in the compounds [2]. Increasing level of WDDGS (5, 10, 15 and 20%) resulted in highly significant (0.001) reduction in daily gains and feed conversion. The authors suggested maximum level of WDDGS for piglets as equal to 10%.

Table 4 shows the results of the qualitative assessment of meat samples, collected from *musculus longissimus dorsi*. Regardless of the employed diet, both the chemical composition of meat from fatteners (dry matter, protein and fat content) and its certain physical--chemical qualities traits did not differ significantly. These data cannot be referred to literature, because, as it has been reported by Stein and Shurson [19], there is little information so-far available about the effects of diets, containing WDDGS on certain qualities of pig carcasses. We may only suppose that since WDDGS contains more fat, including polyunsaturated fatty acids (PUFA) as compared to wheat, it is similarly as in case of corn DDGS: greater differences might arise in evaluation of the quality of fat itself. It is supported by the results of certain studies where the application of corn DDGS for fatteners showed that both intramuscular fat and backfat were less stable [20, 21].

In the studies, any significant differences for most of the blood chemical indices were not found (Tab. 5). The exception included alanine transaminase and creatinine. The activity of the former was increasing together with the rise of WDDGS participation in the mixture while creatinine level declined. It should be, however, mentioned that all the tested biochemical parameters were found within the limits of the reference standards for fatteners.

The present study shows that WDDGS, as administrated in full-ration diets for fatteners (30-110 kg) in the quantity of ca. 10% may effectively replace two thirds of participation of soybean meal, without deteriorating live and post mortem results of fattening. The complete replacement of soybean and rapeseed meals by the addition of ca. 20% of WDDGS in the diets for fatteners could deteriorate digestibility of nutrients and by this, the performance results.

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Wartość żywieniowa suszonego wywaru z pszenicy (WDDGS) w tuczu świń

Streszczenie

Oceniano przydatność paszową WDDGS w tuczu świń. Wskaźnikami oceny były wyniki produkcyjne, strawność składników pokarmowych, mięsność tusz i niektóre pomiary oceny fizyko-chemicznej mięsa. Doświadczenie obejmowało trzy grupy tuczników, z których grupa I otrzymywała standardową mieszankę zbożową z poekstrakcyjną śrutą sojową i rzepakową, grupa II – mieszankę, w której 66% poekstrakcyjnej śruty sojowej zastąpiono dodatkiem 9% WDDGS i grupa III – mieszankę, w której

całość śruty sojowej i rzepakowej zastąpiono dodatkiem WDDGS w wysokości 21%. Mieszanki były zbilansowane w białko, energię i podstawowe aminokwasy. Zastąpienie w mieszankach dla tuczników 2/3 części poekstrakcyjnej śruty sojowej dodatkiem 9% WDDGS nie miało istotnego wpływu na dzienne przyrosty zwierząt (903 g vs. 922 g), wykorzystanie paszy (2,87 kg/kg vs. 2,81 kg/kg), mięsność (57,54% vs. 58,02%) i otłuszczenie tuszy (13,53 mm vs. 13,33 mm) oraz strawność podstawowych składników pokarmowych i bilans azotu. Dopiero całkowite zastąpienie w mieszankach poekstrakcyjnej śruty sojowej oraz rzepakowej dodatkiem suszonego wywaru w ilości 21% spowodowało pogorszenie wyników tuczu.

SŁOWA KLUCZOWE: WDDGS / wartość żywieniowa / początkowy i końcowy okres tuczu