EFFICACY OF DDGS-SUPPLEMENTED DIETS IN THE INTENSIVE FATTENING OF YOUNG BULLS

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Abstract. The study involved 114 young Polish Holstein-Friesian bulls, divided into two groups, experimental and control. Experimental group animals were fed concentrate diets supplemented with corn DDGS. The bulls were slaughtered at approximately 570 kg BW, and carcass quality traits were determined. It was found that DDGS added to complete diets for young bulls fattened to 570 kg BW had a significant effect on higher daily gains and lower feed intake at the first stage of feeding, from 251 kg to 400 kg BW. At the second stage of fattening, from around 401 kg to 570 kg BW, daily gains were similar in the control group and in the experimental group. Carcass dressing percentage was high (above 55%) in both groups, and the majority of carcasses were classified to conformation class O (ca. 90%), and to fat classes 2 and 3 (ca. 98%). The percentage share of retail cuts in the carcass was comparable in both groups, except for the best end of the neck and sirloin, whose proportions were higher in the experimental group. The market value of cuts per 100 kg beef carcass was about 0.5% higher in the control group than in the experimental group. The meat of bulls from both groups was characterized by good quality. As many as 95% of beef samples had pH below 5.80 and could undergo ripening. The meat of bulls fed DDGS-supplemented diets had a lower intramuscular fat content, lower shear force values, higher concentrations of protein and ash, and a higher contribution of the red component.

Keywords: young bulls, fattening, DDGS, slaughter value, meat quality.

ŽLAUGTAIS PAPILDYTO RACIONO ĮTAKA INTENSYVIAM JAUNŲ BULIUKŲ PANĖJIMUI

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Santrauka. Tyrimas atliktas su 114 Holšteino fryzų buliukais, suskirstytais į dvi grupes – eksperimentinę ir kontrolinę. Eksperimentinės grupės galvijai buvo šeriami koncentruotu racionu, papildytu kviečių žlaugtais. Buliai buvo skerdžiami 570 kg kūno masės ir nustatomi jų skerdenos kokybės požymiai. Nustatyta, kad žlaugtais papildyti visaverčiai racionai buliukams, penimiems iki 570 kg kūno masės, turėjo reikšmingos įtakos paros priesvorio didėjimui ir mažesnėms pašarų sąnaudoms pirmoje šėrimo fazėje, nuo 251 kg iki 400 kg kūno masės. Antroje penėjimo fazėje, nuo 401 kg iki 570 kg kūno masės, paros priesvoris kontrolinėje ir eksperimentinėje grupėse išliko panašus. Skerdenos raumeningumo procentas buvo aukštas (daugiau nei 55 proc.) abiejose grupėse. Didžioji dalis skerdenų priskirta O raumeningumo klasei (apie 90 proc.) ir 1 bei 3 riebumo klasėms (apie 98 proc.). Procentinė mažmeninės prekybos skerdenos išpjovų dalis buvo panaši abiejose grupėse, išskyrus geriausią sprandinės dalį ir nugarinę, kurių proporcijos buvo didesnės eksperimentinėje grupėje. Išpjovų rinkos vertė, tenkanti 100 kg jautienos skerdenos, kontrolinėje grupėje buvo 0,5 proc. aukštesnė už eksperimentinės grupės. Abiejų grupių bulių mėsos kokybė buvo gera. Daugiau kaip 95 proc. jautienos mėginių pH buvo mažiau už 5,80 ir galėjo būti naudojama brandinti. Bulių, šertų racionais su žlaugtų priedu, mėsoje buvo mažiau tarpraumeninių riebalų, jos kietumo vertė buvo mažesnė, didesnė baltymų ir pelenų koncentracija, mėsos raudonos spalvos komponentės dalis taip pat buvo didesnė.

Raktažodžiai: buliukai, penėjimas, žlaugtai, skerdenos vertė, mėsos kokybė.

Introduction. Since feed costs make up a large percentage of total cattle production costs, livestock producers continue to search for new, cheaper feed components as a replacement for traditional feedstuffs. Today cattle feed concentrates are often supplemented with dried distillers grains with solubles (DDGS), a co-product of the ethanol production process. Each 100 kg of corn produces 40.2 l of ethanol and 32.3 kg of DDGS (Schingoethe 2006C). DDGS contain unfermented grain residues, including protein, fat and fiber, whose concentrations are three-fold higher than in unprocessed corn grains (Świątkiewicz and Koreleski 2007). Corn DDGS contain 20%–

30% total protein, of which 50%–55% is rumen-undegradable (Klieinschmit 2007), as well as yeast which is a valuable source of protein and vitamins (Tjardes and Wright 2002).

According to Windhorst (2007), in the USA over 80% of DDGS is fed to cattle, of which 45% is included in beef cattle rations. As demonstrated by Schingoethe (2006a and b), up to 40% and 20% of the ration dry matter can be fed as DDGS to beef and dairy cattle, respectively. In 2010, total bio-ethanol production in the European Union was an estimated 6.3 billion liters, which means that approximately 5.06 million tons of DDGS were available for utilization.

The aim of this study was to determine the growth performance and slaughter value of young bulls fed concentrate diets supplemented with corn DDGS.

Material and Methods. The study involved 114 young Polish Holstein-Friesian bulls with initial body weight of around 106 kg, divided into two groups, experimental (24 animals) and control (90 animals). From 106 kg to 220–250 kg BW, the bulls were fed feed concentrate (ad libitum) and meadow hay at 1 – 1.5 kg. Experimental fattening was carried out from 250 kg to approximately 570 kg BW. Over this period, the bulls were fed complete diets formulated according to the changing body weight of animals.

During fattening from 250 kg to 400–420 kg BW, control group bulls were fed a concentrate diet containing 32% corn, 20% wheat mix, 24% barley, 5.3% wheat bran and 16% rapeseed meal. The feed concentrate for experimental group bulls was composed of 30.5% corn, 18% wheat mix, 20% barley and 5.3% wheat bran, and it was supplemented with 23.5% corn DDGS.

At the final stage of fattening, from 400–420 kg to 570 kg BW, the bulls received diets with decreased protein content. The feed concentrate for the control group contained 33% corn, 23% wheat mix, 27% barley, 5.3% wheat bran and 9% rapeseed meal. The diet for the experimental group was composed of 32% corn, 23% wheat mix, 25.7% barley, 5.3% wheat bran and 11.3% DDGS. All concentrate diets were supplemented with 0.5% NaCl, 1.7% limestone and 0.5% premix for beef cattle. The chemical composition of DDGS was as follows: dry matter – 93.30%, crude ash – 5.26%, crude protein – 24.31%, crude fiber – 7.45%, crude fat – 10.45%.

Table 1. **Feeding scheme for intensively fattened young bulls** (determined for daily gains of 1100 - 1300 g)

Body weight (kg)	Feed concentrate (kg)	Hay + straw (kg)	Body weight (kg)	Feed concentrate (kg)	Hay + straw (kg)
200–250	4.3	1.2	400–450	6.7	1.6
250–300	4.9	1.4	450–500	7.4	1.8
300–350	5.5	1.4	500–550	8.1	1.8
350–400	6.1	1.6	550–600	8.9	1.8

The animals were fed according to the above scheme, and the amount of feed concentrate for both groups was determined each day. Straw was supplied at around 1.5 kg per head. Straw intake could be higher as the bulls were kept in pens bedded with straw.

At the end of fattening, the bulls were transported to the meat processing plant where they stayed in the lairage for 20 hours prior to slaughter. The carcasses were chilled for 48 hours at around 2^0C. Chilled right half-carcasses were weighed and divided into retail cuts according to the rules of English market (so-called London method – not published, details available at authors). The following retail cuts were obtained: shoulder, best end of the neck, fore ribs, best ribs, thin flank, brisket, sirloin, rump, thick flank, topside, silverside plus bavette plus gastrocnemius muscle, loin, flank, shank, shin. The external fat layer was not removed.

Meat of quality class I (lean), II (medium-fat), III (stringy) and IV (with traces of blood), fat, tendons and bones were also obtained. The retail cuts from the right half-carcasses were weighed and their percentage share of the total carcass weight was calculated. The price of 100 kg beef carcass divided into retail cuts was determined based on the official wholesale beef-cut prices quoted over the research period.

Samples of *m. longissimus dorsi* were collected from randomly selected loin cuts (between the 11th and 13th thoracic vertebra) to evaluate meat quality; 13 samples were collected in the experimental group (bulls fed a DDGS-supplemented diet) and 32 in the control group. A qualitative analysis was performed 72 hours post mortem. Meat samples were assayed for: the content of dry matter, fat, total protein and ash (Budsławski and Drabent 1972), water-holding capacity by the Grau and Hamm method (1953), pH, and color in the CIE Lab system. The sensory properties (aroma, taste, juiciness, tenderness) of cooked meat were assessed on a five-point scale (1 – lowest score, 5 – highest score), as described by Baryłko-Pikielna (2009). Shear force values were also determined (after heat treatment) using a Warner-Bratzler head (500 N, speed 100 mm/min.) attached to an Instron universal testing machine (model 5542).

The results were verified statistically by a one-way analysis of variance (ANOVA), using STATISTICA ver. 9.0 PL software. The significance of differences between means in groups was estimated by Duncan’s test.

Results and Discussion. In both groups, the highest daily gains (approx. 1400 g) were noted at the first stage of fattening, from 106 kg to 250 kg BW (Table 2). During fattening from 250 kg to 400 kg, daily gains reached 1146 g in the control group and 1374 g in the experimental group fed a concentrate diet supplemented with 23.59% DDGS. The difference between groups was statistically significant. At the second stage of fattening, from around

401 kg to 570 kg BW, daily gains were similar in both groups. Over the entire period of feeding DDGS-supplemented diets (from 251 kg to 570 kg BW), daily gains were significantly higher in the experimental group than in the control group (1277 g vs. 1162 g). In the analyzed period, higher daily gains were accompanied by lower feed intake per kg body weight gain.

Table 2. **Growth performance of young bulls**

Specification	Body weight, kg	Group			
		control		experimental	
		$\bar{x}$	s	$\bar{x}$	s
Daily gains, g	106–250	1400	24	1387	23
	251–400	1146^{a}	28	1374^{b}	28
	401–570	1179	26	1181	30
	251–570	1162^{a}	27	1277^{b}	29
Feed intake per kg body weight gain	251–400	6.12		5.02	
	401–570	7.41		7.80	
	251–570	6.80		6.49	

Values followed by identical superscripts are significantly different: a, b - $P \leq 0.05$

During the fattening of young bulls to around 590 kg BW, Eun et al. (2009) observed significantly higher daily gains (by 110 – 180 g) in animals fed diets with different inclusion levels of DDGS (10% - 17%). In other experiments, DDGS-supplemented diets did not significantly improve daily gains and feed conversion in cattle (Depenbusch et al. 2008, Eun et al. 2009, Vander Pol et al. 2009, Wajda et al. 2006). As demonstrated by Peter et al. (2000), corn DDGS are more effectively utilized by younger animals, which was also noted in the present study. According to Depenbusch et al. (2009), the optimum dietary inclusion level of DDGS is 15% of feed dry matter including straw.

The live weight and carcass weight of control group and experimental group bulls (Table 3) were similar ($P \leq 0.05$), at around 540 kg and 300 kg, respectively. Higher variation in the above parameters was observed in the control group.

The average carcass dressing percentage was also similar ($P \leq 0.05$) in the experimental and control group, at 55.17% and 55.45%, respectively. The noted values were higher than or comparable to those reported by other authors (Heiden 2007, Jasiorowski 1996, Wajda and Wichłacz 1984, Wajda 1988) for young Holstein-Friesian bulls.

Despite the intensive nutritional regime, the majority of carcasses (ca. 90%) were classified to conformation class O, and to fat classes 2 and 3 (all carcasses in the experimental group and ca. 98% of carcasses in the control group) (Table 3). In a study by Schöne et al., the carcasses of young Holstein-Friesian bulls were classified to conformation class O3.

Table 3. **Live body weight and carcass weight of young bulls, carcass grades** (EUROP system) **and carcass dressing percentage**

Specification	Group			
	control		experimental	
	$\bar{x}$	s	$\bar{x}$	s
Live bodyweight, kg	542.40	34.82	539.79	23.33
Carcass weight, kg	300.48	21.84	297.69	17.59
Carcass dressing percentage, %	55.45	2.19	55.17	2.69
Conformation class	Percentage of carcasses		Percentage of carcasses	
O-	6.67		8.33	
O	60.00		54.17	
O+	20.00		29.17	
R-	6.67		8.33	
R	6.67			
Fat class	Percentage of carcasses		Percentage of carcasses	
1	2.22			
2	57.78		62.50	
3	40.00		37.50	

The slaughter value of cattle is determined by the proportion of cuts with the highest market value in the total carcass weight. The weight of half-carcasses and the percentage share of retail cuts are shown in Table 4. Differences between mean values in groups were statistically significant (P≤0.05) only with respect to the percentage share of the best end of the neck and sirloin, which was higher in the experimental group. In another experiment (Wajda et al. 2006), young bulls fed rye DDGS had a higher percentage content of bones, a lower percentage share of fat and similar proportions of retail cuts in the carcass.

Table 4 presents also the market value (wholesale prices) of retail cuts obtained from beef carcasses. The total market value of cuts per 100 kg beef carcass reached PLN 1002.59 in the experimental group and PLN 997.19 in the control group. The price for retail cuts was 0.5% higher in the control group than in the experimental group where the animals were fed DDGS-supplemented diets.

Table 4. **Percentage share of retail cuts in the carcass and the market value of cuts per 100 kg beef carcass** (PLN)

Specification	Control group			Experimental group		
	Percentage share in carcass, %	Price per kg (PLN)	Market value (PLN)	Percentage share in carcass, %	Price per kg (PLN)	Market value (PLN)
Best end of neck	4.10	12.52	51.33	4.43	12.52	55.46
Fore ribs	3.97	12.63	50.14	4.16	12.63	52.54
Best ribs	3.03	15.95	48.33	3.02	15.95	48.17
Thin flank	6.92	7.51	51.97	6.64	7.51	49.87
Brisket	4.40	7.67	33.75	4.53	7.67	34.75
Musculus supraspinatus	0.91	14.80	13.47	0.90	14.80	13.32
Musculus infraspinatus	1.27	14.80	18.80	1.25	14.80	18.50
Musculus subscapularis	1.00	14.64	14.64	1.00	14.64	14.64
Musculus triceps brachii	3.13	14.76	46.20	3.19	14.76	47.08
Musculus biceps brachii	0.70	14.80	10.36	0.69	14.80	10.21
Topside	5.56	17.99	100.02	5.44	17.99	97.87
Silverside + bavette	5.13	18.71	95.98	5.08	18.71	95.05
Thick flank	3.47	15.09	52.36	3.46	15.09	52.21
Rump	3.52	15.37	54.10	3.54	15.37	54.41
Loin	3.23	18.92	61.11	3.31	18.92	62.63
Sirloin	1.34	44.47	59.59	1.43	44.47	63.59
Flank	4.02	15.68	63.03	4.22	15.68	66.17
Musculus gastrocnemius	1.40	13.36	18.70	1.38	13.36	18.44
Shank	2.92	11.54	33.70	2.92	11.54	33.70
Class I meat	0.97	12.92	12.53	1.08	12.92	13.95
Class II meat	11.87	7.65	90.81	10.89	7.65	83.31
Class III meat	1.13	4.75	5.37	1.24	4.75	5.89
Class IV meat	0.68	2.97	2.02	0.58	2.97	1.72
Bones	18.81	0.20	3.76	18.89	0.20	3.78
Fat	5.27	0.90	4.74	5.51	0.90	4.96
Tendons	1.28	0.30	0.38	1.24	0.30	0.37
Total	100.03		997.19	100.02		1002.59

One of the most important quality attributes of beef is intramuscular fat content which has a beneficial influence on the sensory properties of meat (Wajda 1998, Park et al. 2001, Wichłacz et al. 1998). In the present study, the percentage content of intramuscular fat in the meat of control group bulls was slightly higher (P≤0.05) than in the meat of experimental group bulls fed DDGS-supplemented diets (Table 5). According to Wichłacz et al. (1998), the minimum intramuscular fat content of *m. longissiums dorsi* in young bulls, required to achieve a satisfactory sensory quality of beef, is 1%. The sensory properties of meat can be further improved as this level is exceeded. According to other authors (Bach, Dünkel 1993, Wajda, 1998), the optimum amount of intramuscular fat to maintain beef tenderness is 2.5% – 4.5%. Previous research results suggest that such a high intramuscular fat concentration is difficult to achieve in Black-and-White Holstein-Friesian bulls. In this study, the percentage content of dry matter, total protein and ash was similar in the control group and in the experimental group (Table 5). The difference in ash content observed between groups (0.03 percentage point) was statistically significant (P≤0.05), but this was due to the very low variation in ash levels.

One of the main quality characteristics of meat is pH which considerably affects the physicochemical properties (color, water-holding capacity), sensory attributes (tenderness, juiciness) and shelf-life of meat. In the current study, the average pH values of meat from bulls fed DDGS-supplemented diets and control group bulls were similar, at 5.65 and 5.60, respectively (Table 5). A detailed analysis of pH levels revealed that in both groups approximately 95% of meat samples had pH below 5.80 which is considered the maximum acceptable value of pH_u in beef intended for human consumption (Bach, Dünkel 1993, Wajda, 1998). Meat color is another important quality attribute and a factor that substantially influences consumer purchase decisions. An evaluation of meat color in the CIE Lab system showed that the meat of bulls fed DDGS-supplemented diets was characterized by a higher (P≤0.05) value of parameter a^* (redness) in comparison with the meat of control group bulls (Table 5). There were no significant (P≤0.05) differences between the control group and the experimental group in the average values of parameters L^* (lightness) and b^* (yellowness). Meat samples collected in both groups were marked by similar average values of water-holding capacity (Table 5).

An organolpetic evaluation of beef samples revealed that meat from control group bulls tended to be more juicy and tender. There were no statistically significant differences between groups with regard to the aroma, taste, juiciness and tenderness of meat. Shear force values reached 42.60 in the experimental group (DDGS-supplemented feed) and 47.89 in the control group, yet the noted difference was statistically non-significant.

An organoleptic assessment of meat proved its good quality (Table 5). The differences between the control group and the experimental group with respect to the average scores for sensory properties were statistically non-significant (P>0.05). The absence of differences in the tenderness of meat from control group and experimental group bulls was confirmed by shear force measurement (Table 5).

Table 5. **Proximate chemical composition, physicochemical and sensory properties of meat, and shear force values**

Specification	Control group (32 animals)		Experimental group (13 animals)	
	$\overline{x}$	s	$\overline{x}$	s
Dry matter, %	25.40	0.73	25.06	0.57
Fat, %	1.89	0.59	1.51	0.65
Total protein, %	23.26	0.53	23.56	0.59
Ash, %	1.08^a	0.02	1.11^b	0.03
pH_u	5.60	0.08	5.65	0.21
Water-holding capacity, cm^2	5.55	1.25	5.55	0.81
Color evaluation in the CIELab system:				
L^*	36.69	2.06	35.30	2.59
a^*	17.12^a	1.31	18.58^b	2.36
b^*	13.53	1.29	13.92	1.74
Aroma – intensity (points)	3.67	0.63	3.73	0.60
Aroma – desirability (points)	4.95	0.20	5.00	0.00
Taste – intensity (points)	4.17	0.37	4.19	0.38
Taste – desirability (points)	4.94	0.17	4.85	0.32
Juiciness (points)	4.28	0.57	4.04	0.25
Tenderness (points)	3.86	0.61	3.77	0.70
Shear force (N)	47.89	12.68	42.60	14.47

Values followed by identical superscripts are significantly different: a, b - P≤ 0.05

Conclusions

1. DDGS added to complete concentrate diets for young bulls fattened to 570 kg BW had a significant effect on higher daily gains and lower feed intake at the first stage of feeding, from 251 kg to 400 kg BW. At the second stage of fattening, from around 401 kg to 570 kg BW, daily gains were similar in the control group and in the experimental group.

2. Carcass dressing percentage was high (above 55%) in both groups, and the majority of carcasses were classified to conformation class O (ca. 90%), and to fat classes 2 and 3 (ca. 98%). The percentage share of retail cuts in the carcass was comparable in both groups, except for the best end of the neck and sirloin, whose proportions were higher in the experimental group. The market value of cuts per 100 kg beef carcass was about 0,5% higher in the control group than in the experimental group.

3. The meat of bulls from both groups was characterized by good quality. As many as 95% of beef samples had pH below 5.80 and could undergo ripening. The meat of bulls fed DDGS-supplemented diets had a lower intramuscular fat content, lower shear force values, higher concentrations of protein and ash, and a higher contribution of the red component.

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