**FINAL REPORT
on an experiment conducted for
KWS LOCHÓW POLSKA Sp. z o.o.**

**Assessment of suitability for use of hybrid rye
by KWS Lochów Polska sp. z o.o.
for fattening of young beef cattle**

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Experiment II
"Assessment of suitability for use of hybrid rye
by KWS Lochów Polska sp. z o.o. for the fattening of young beef cattle"

The research was aimed at defining the ideal percentage of hybrid rye content in a concentrate mixture and its influence on fattening and slaughter parameters of growing bull calves of the Polish Black-and-White Holstein-Friesian breed.

Material and methods

The experiment was conducted at the Pawłowice Experimental Station of the National Research Institute of Animal Production on 30 Polish Black-and-White Holstein-Friesian bull calves which were randomly assigned to 3 groups consisting of 10 animals each. The fattening process started when the animals reached a body weight of 200 kg (i.e. at the age of approx. 7-8 months). The fattening continued until the animals reached a weight of 600 kg (at the age of approx. 19 months). The animals were fed maize silage, alfalfa silage, beetroot pulp and a concentrate mixture, the quantities of which are specified in Table 3. The mixtures contained 0%, 20% and 40% of Visello hybrid rye, which replaced wheat in the mixture. The mixtures were fed in quantities specified in Table 1.

The animals were fed individually according to DLG standards by weighing the silage out with an accuracy to ± 0.5 kg and the concentrate mixture with an accuracy of ± 0.1 kg. Uneaten feed was weighed once a week. The body weight of the animals was checked once a month. The chemical composition of the feeds was determined by the analysis methods adopted by AOAC (1995) at the Central Laboratory of the National Research Institute of Animal Production which is a Reference Laboratory that meets PN-EN ISO/IEC 17025 standard and bears the accreditation certificate no. 512 issued by the Polish Centre for Accreditation.

After the end of the experiment, the bull calves were slaughtered. The meat content and the class of individual half-carcasses were assessed according to the EUROP scale. In addition, samples of the *M. longissimus dorsi* muscle were collected from the region of the last dorsal and the first lumbar vertebrae. The chemical composition was determined (Budsławski & Drabent, 1972), the pH was measured using a pH meter 45 minutes after slaughter and, next, after cooling at 4°C according to Polish Standard PN-77 A-82058. Quality parameters were determined in meat samples: the meat colour in the L*a*b* system (CIE, 1976), water absorption was determined using Grau and Hamm's method (1953), thermal loss (meat juice loss) was measured during the preparation of the meat for meat texture assessment. The meat texture was assessed using the methodology described by Breene (1975) with the use of a Texture Analyzer TA-XT2 by Stable Miero Systems with a Warner-Bratzler attachment. The following parameters were determined: cutting force, hardness, elasticity, chewability, resilience and cohesion. The following values were determined in meat samples chromatographically: composition of fatty acids after prior fat extraction using the Folch method (1957), cholesterol content according to the method modified by Russo et al. (2005), vitamin E and A levels according to the method described by Ueda and Igarashi (1987) and the TBARS level after the period of storing frozen meat samples for 3 months according to the modified method described by Pikula (1993).

The results obtained were analysed statistically using one-way analysis of variance (ANOVA), while Tukey's test was used to determine the significance of differences with the Statgraphics Plus 4.0 software. The significance of differences

was tested at the significance levels of P≤0.05 and P≤0.01.

Results and discussion

The feeding method is an important factor which determines the quality of beef. During the first period of their lives, calves should receive less milk to stimulate early development of rumens. During this period, the weight gain should be no less than 500-600 grams a day. At the second stage of fattening, the daily gain should be at least 900-100 grams, as only such gain will make it possible to obtain well-muscled cattle from which good-quality culinary meat will be produced. Feeding intensity may influence the fat content in beef carcasses. In the experiment conducted, the 0, 20 and 40% content of Visello hybrid rye, in the concentrate mixture was used for the fattening of cattle for slaughtering according to the scheme specified in Table 1. The bull calves were assigned to 3 feeding groups which consisted of 10 animals each. The composition and the nutritional value of the concentrate feeds included in the feed rations are presented in Tables 2 and 3. The feed rations were characterised by a similar protein content and nutritional value (nBO - protein, MJ - net energy). Thus, it can be concluded that, given the same welfare conditions of all groups, the type of feed could be the experimental factor.

The fattening of the bull calves started when their body weight reached 200 kg and the fattening process lasted 275 days. A significant differentiation (P≤0.05) in the final body weight of the bull calves was found after the end of the fattening process. The animals from the group with the 20% rye content had the highest body weight of 615.2 kg, the bull calves from the control group were ranked next with the weight of 595.7 kg, and the animals from the group with the 40% rye content in the mixture had the lowest weight - 588.4 kg. The average daily body weight gain was high throughout the entire fattening period, ranging from 1,280 g to 1,350 g (Table 5). The body weight gain, which was high for a dairy breed, confirm a correct supply of energy and protein in the feed ration, which corresponded to the demand, during the fattening period. Figure 1 presents the average daily weight gain of the bull calf body weight incrementally in the individual feeding groups in the consecutive months of fattening.

The lowest feed consumption per kg of the body weight gain was found in the group which received 20% of rye, as it amounted to 12.87 kg/kg, while the corresponding values in the control group and in the group with the 40% rye content were: 13.10 and 13.09 kg/kg, respectively. The highest body weight of carcasses was obtained from animals which received 20% of rye as they were on average 10 kg heavier as compared to the weight of carcasses from the other groups, however, no statistically significant differences were found. Carcasses of animals from groups which received hybrid rye (20% and 40%) were characterised by higher dressing efficiency, by 1% as compared to the control group (Table 6). Carcasses of animals from all the feeding groups were characterised by a similar average meat content (02). Opinions on the amount of intramuscular fat in beef are divided. In Central Europe, slightly marbled meat is preferred, while in North and South American countries, highly marbled meat is favoured. This is related to the confirmed fact that marbling fat has an advantageous effect on beef tenderness, juiciness and taste (Bruns et al., 2004). It should be reminded here that the degree of marbling is highly dependent on the total fat content in the carcass.

Intramuscular fat accumulation is usually accompanied by intermuscular, subcutaneous and visceral fat accumulations. Larger amounts of these fats in the

carcass are undesirable. It is known that fat first accumulats in the area of the kidneys and intestines, then subcutaneous fat accumulates and inter- and intramuscular fat builds up only afterwards. Therefore, it is difficult to produce carcasses which contain a lot of intramuscular fat and small amounts of other types of fat at the same time.

It is commonly believed that fat content in meat has a significant influence on sensory experience. In the United States, the 3% fat content level in the *M. longissimus dorsi* muscle was determined as the limit below which the taste of meat decreases abruptly. This level is 2.1% in the United Kingdom and 1.7% in Denmark. In the latest research, it is implied that this level should be no less than 1% and that factors other than marbling also influence sensory desirability of beef (Bruns, 2004). Consumer research also shows that it is easy to adapt to eating beef with a low fat content. Sensory analysis of meat samples showed no significant differentiation with regard to features such as cutting force, hardness, elasticity, cohesion, springiness, chewability and resilience. Meat samples from bull calves from the control group were characterised by a significantly lower pH_{45} value as compared to meat from animals from the experimental groups. After cooling the meat for 24h, no pH differentiation was found as it fell within the range of 6.30-6.40. No differentiation in the meat colour measured in the L*a*b* system.

The use of a higher percentage of hybrid rye in the concentrate mixture had an advantageous influence on the increase in the level of polyunsaturated acids from 12.60 % in the control group to 16.40 and 14.63% in the experimental groups ($P \leq 0.05$). An increase in the PUFA content was accompanied by a significant reduction in the content of the C18:0 acid in the group which received 20% of rye ($P \leq 0.05$). A significant decrease in the SFA content was found in the meat of bull calves which received the concentrate mixture with 20% rye content as compared to the other feeding groups ($P \leq 0.05$). An advantageous tendency for a higher content of PUFAs from the *n-3* family was also observed in the experimental groups (20% and 40% of rye), 1.39% and 1.23% as compared to the control group - 0.97%. In addition, a significantly higher vitamin E level was found in meat obtained from the experimental groups - 3.02 and 3.08 µg/g, as compared to the control group - 2.65 µg/g ($P \leq 0.05$). The vitamin A content in meat was similar in all groups. No significant influence of the use of a feed ration containing 20% and 40% rye in the concentrate mixture was found on the differentiation of the total cholesterol content in meat. No influence of the feed ration on the lipid oxidation level in meat was found as measured by the content of thiobarbituric acid reactive substances (TBARS), which ranged from 0.443 to 0.505 mg/kg.

Conclusions:
1. On the basis of the results obtained, it can be concluded that bull calves of the Polish Black-and-White Holstein-Friesian breed are characterised by high growth potential.
2. Over the first five months of the fattening process, a high weight gain was found in the bull calves, which confirmed very good conversion of nutrients and a good balance of feed rations.
3. During the fattening period (275 days), the highest body weight was obtained by bull calves which received 20% of hybrid rye in their diet, as compared to the control group and the group which obtained 40% rye in their diet.
4. The carcasses obtained from animals from the experimental groups which

received hybrid rye were characterised by higher dressing efficiency, by 1% as compared to the control group.

5. It was found that a significant increase in the vitamin E content occurred in the meat of bull calves which received hybrid rye in the feed ration.
6. An advantageous composition of fatty acids was found in meat from bull calves which received hybrid rye in their diet.
7. A tendency was observed to improve the texture in meat from bull calves fed with a hybrid rye-containing mixture.

Table 1
Design of the nutritional experiment on bull calves

Specification	Group		
	Control Mixture 1	Experimental Mixture 2	Experimental Mixture 3
Proportion of rye in the mixture, %	**0**	**20**	40

Table 2
Composition and nutritional value of concentrate mixtures used in the experiment:

Feed	Proportion in the mixture	[%]	
	Mixture 1 - control	**Mixture** 2 - 20% **of rye**	**Mixture** 3 - 40% **of rye**
Wheat	50.0	30.0	10.0
Hybrid rye	**-**	20.0	40.0
Maize	10.0	10.0	10.0
Wheat bran	10.0	8.0	10.0
Rapeseed meal	22.0	24.0	22.0
Chalk	1.2	1.2	1.2
Phosphate -1 Ca	0.8	0.8	0.8
Molasses	3.0	3.0	3.0
Oil	1.0	1.0	1.0
Premix	2.0	2.0	2.0
TOTAL	100.0	100.0	100.0
Nutritional value [in 1 kg DM]			
DM%	88.21	88.21	88.21
NEL (MJ)	10.84	10.85	10.79
BO%	16.12	16.14	15.35
TS%	3.31	3.17	3.10
WS%	5.06	5.09	5.13
Ca%	1.24	1.26	1.25
P%	0.79	0.77	0.77

Table 3
Composition of doses during individual period of bull calves fattening

Feeds	Proportion in the mixture		[kg]
	Mixture 1 - control	Mixture 2 - 20% of rye	Mixture 3 - 40% of rye
Stage I of fattening body weight 200 - 300 kg			
Maize silage	4	4	4
Alfalfa silage	4	4	4
Ml*	2.65	-	-
M2	-	2.65	-
M3	-	-	2.65
Nutritional value [in 1 kg DM]			
DM g	5206	5206	5205
ME (MJ)	57.39	57.42	57.23
BO g	811	812	813
Stage II of fattening body weight 300 - 400 kg			
Maize silage	6	6	6
Alfalfa silage	6	6	6
Ml	3.5	-	-
M2	-	3.5	-
M3	-	-	3.5
Nutritional value [in 1 kg DM]			
DM g	6786	6786	6795
ME (MJ)	74.3	74.4	74.6
BO g	1181	1177	1179
Stage III of fattening body weight 400 - 500 kg			
Maize silage	8	8	8
Alfalfa silage	8	8	8
Ml	4	-	-
M2	-	4	-
M3	-	-	4
Nutritional value [in 1 kg DM]			
DM g	8604	8604	8608
Emetabol. (MJ)	93.8	93.8	93.9
NEL(MJ)	57.1	57.0	57.2
BO g	1073	1083	1085
Stage IV of fattening body weight 500 - 600 kg			
Maize silage	10	10	10
Alfalfa silage	10	10	10
Ml	4.5	-	-
M2	-	4.5	-
M3	-	-	4.5
SMg	10324	10324	10329
E metabol. (MJ)	112.5	112.5	112.6
NEL(MJ)	68.5	68.4	68.64
BO g	1287	1299	1.302

* composition of Ml, M2 and M3 concentrate mixtures are presented in Table 2

Table 4
Average daily feed intake by bull calves for fattening (DM, kg^{-1}/day)

Feeds	Mixture 1- Control	Groups Mixture 2 - 20% of rye	Mixture 3 - 40% of rye	SEM	P
Daily ration intake, kg					
1st-3rd month of fattening	10.26	10.10	10.19	0.029	0.08
4th-3th month of fattening	15.61	15.46	15.56	0.17	0.95
7th - until the end of fattening	26.27	26.39	26.21	0.32	0.97
average value for the entire fattening period	17.74	17.32	16.79	0.24	0.27

Table 5
Average body weight and average daily gain of bull calves in individual feeding groups

Specification	Feeding group Mixture 1 – control	Mixture 2 - 20% of rye	Mixture 3 - 40% of rye	SEM	P
Number of animals	9	10	9		
Initial body weight, kg	201	202	200		
Final body weight, kg	595.7^{ab}	615.2^{b}	588.4^{a}	5.12	0.11
Number of feeding days	275	275	275		
Average daily gain during the fattening period, g	1354	1.345	1.282	14.53	0.12
Feed consumption per 1 kg of gain, kg	13.10	12.87	13.09	1.12	0.09

Average values in columns which are marked with various letters differ significantly at: a, b p≤0.05; A,B p≤0.01

Table 6. Post-slaughter carcass assessment

Specification	Mixture 1 - control	Feeding group Mixture 2 – 20% of rye	Mixture 3 – 40% of rye	SEM	P
Carcass weight (g)	300.37	309.48	299.64	2.910	0.31
Dressing efficiency (%)	49.99	50.31	50.94	0.192	0.12
Fat content	O2	O2+	O2		

Specification	Control group 0% of rye	Group 20% of rye	Group 40% of rye	SEM
pH$_{45min}$	6.62^{aA}	7.04^{bB}	6.91^{abAB}	0.08

pH$_{24h}$	6.39	6.42	6.30	0.12
Meat colour:				
L*	33.79	32.10	32.13	0.99
a*	23.56	23.40	21.96	0.97
b*	3.47	5.22	4.11	0.30

Table 7
Texture parameters of the *M. longissimus dorsi* muscle

Specification	Control group 0% of rye	Group 20% of rye	Group 40% of rye	SEM
Cutting force, kg	5.85	5.63	5.53	0.30
Hardness	84.25	61.60	76.04	9.57
Elasticity	0.55	0.51	0.53	0.019
Cohesion	0.54	0.49	0.47	0.02
Springiness	82.47	54.34	105.49	6.51
Chewability	25.57	15.17	21.73	3.99
Resilience	0.23	0.19	0.18	0.01

Table 8.
Physicochemical features of the *M. longissimus dorsi* muscle

Specification	Control group 0% of rye	Group 20% of rye	Group 40% of rye	SEM
pH$_{45\ min}$	6.62^{aA}	7.04^{bB}	6.91^{abAB}	0.08
pH$_{24h}$	6.39	6.42	6.30	0.12
Meat colour				
L*	33.79	32.10	32.13	0.99
a*s	23.56	23.40	21.96	0.97
b*	3.47	5.22	4.11	0.30

Average values in columns which are marked with various letters differ significantly at: a, b p≤0.05; A,B p≤0.01

Table 9
Fatty acid composition in samples of the *M. longissimus dorsi* muscle
expressed as percentage of total acids

Fatty acids	Control group 0% of rye	Group 20% of rye	Group 40% of rye	SEM
C 10:0	0.059	0.061	0.068	0.005
C 12:0	0.067	0.072	0.081	0.007
C 14:0	1.85	1.71	1.93	0.15
C14:l	0.51	0.52	0.51	0.06
C 15:0	0.27	0.26	0.29	0.02
C16:0	21.89	21.17	21.83	0.70
C 16:1 n-9	0.27	0.25	0.32	0.02
C 16:1 n-7	3.73	3.92	3.56	0.24
C 17:0	0.82	0.79	0.87	0.08
C 17:l	0.86	0.88	0.91	0.06
C 18:0	13.62[b]	11.83[a]	13.13[ab]	0.41
C 18:1 n-9	40.14	38.47	38.47	1.47
C 18:1 n-7	2.47	2.79	3.03	0.14
C 18:2 n-6	7.69	10.07	9.03	1.25
C 18:3 n-6	0.071	0.084	0.081	0.006
C 18:3 n-3	0.32[a]	0.46[b]	0,42[ab]	0.040
CLA	0.35	0.35	0.35	0.02
C 20:0	0.080	0.084	0.089	0.008
C 21:l	0.20	0.20	0.17	0.015
C 20:2 n-6	0.09	0.12	0.10	0.01
C 20:3 n-6	0.45	0.59	0.52	0.09
C 20:4 n-6	2.56	3.30	2.85	0.40
C 20:5 n-3	0.09	0.15	0.12	0.02
C 22:4 n-6	0.39	0.48	0.44	0.07
C 22:5 n-3	0.45	0.65	0.56	0.09
C 22:6 n-3	0.10	0.11	0.12	0.02
SFA	38.69[b]	36.01[a]	38.37[b]	1.03
MUFA	48.48	47.30	46.75	1.64
PUFA	12.60	16.40	14.63	1.91
PUFA n-3	0.97	1.39	1.23	0.18
PUFA n-6	11.27	14.66	13.04	1.74
PUFA n6/n3	11.99	11.13	10.94	0.76

Average values in columns which are marked with various letters differ significantly at: a, b p≤0.05; A,B p≤0.01

Table 10
The content of vitamins A and E and total cholesterol in samples of the *M. longissimus dorsi* muscle

Specification	Group control of rye	Group 0% 20% of rye	Group 40% of rye	SEM	P
Vitamin A, µg/g	0.052	0.074	0.039	0.02	0.60
Vitamin E, µg/g	2.65[a]	3.02[b]	3.08[b]	0.11	0.02
Total cholesterol, mg/100g	58.62	60.75	60.77	0.83	0.13

*Average values in columns which are marked with various letters differ significantly at: a, b p≤0.05*

Table 11. The TBARS content (thiobarbituric acid reactive substances) in samples of the *M. longissimus dorsi* muscle stored at -19°C for 3 months

Specification	Control group 0% of rye	Group 20% of rye	Group 40% of rye	SEM	P
TBARS, mg/kg	0.496	0.505	0.443	0.03	0.40

Fig 1
Average daily weight gain of bull calves in the individual feeding groups presented incrementally over consecutive months of fattening

daily gain, g
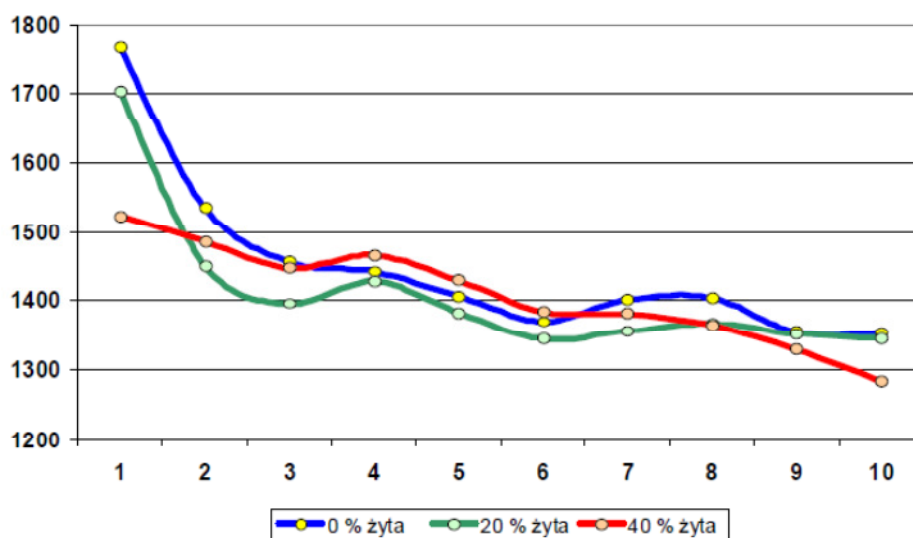
0% of rye
20 % of rye
40 % of rye

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