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Wheat gluten feed in diets for intensive bull beef production *

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Summary — The use of wheat gluten feed in concentrate diets for beef bulls has been investigated in 3 experiments. Sugar-beet pulp was replaced by 15% wheat gluten feed in the first experiment and by 15, 30 or 45% in the second. Higher levels of wheat gluten feed initially reduced growth rate as a consequence of a lower feed intake. Afterwards, the animals fed these diets ate more and underwent a partial compensatory gain. For the entire period, growth rate was not significantly different. There was a small improvement of dry matter conversion when sugarbeet pulp was replaced by wheat gluten feed. Carcass data were not affected by the inclusion of wheat gluten feed in the diet. Regarding initial and overall growth rate and feed intake, the best results were obtained when 15% wheat gluten feed was incorporated in the diet. In a third experiment the voluntary intake of concentrate containing 15% wheat gluten feed was lower than for concentrate with no wheat gluten feed, when both were offered free choice. The dry matter digestibility of the diets, determined with sheep, was slightly but not significantly improved when wheat gluten feed was incorporated.

wheat gluten feed / beef production / liveweight gain / carcass quality

Résumé — Le *gluten feed* de blé dans des rations pour la production intensive de viande bovine avec des taurillons. *L'utilisation de* gluten feed *de blé dans des rations concentrées pour des taurillons à l'engrais a été étudiée dans 3 essais. La pulpe de betteraves sucrières était remplacée par 15% de* gluten feed *de blé dans un premier essai, et par 15, 30 ou 45% dans un deuxième essai. Le* gluten feed *de blé à des niveaux élevés a réduit la vitesse de croissance initiale à cause d'une ingestion plus faible. Ensuite, les animaux ont eu une ingestion plus élevée et ont réalisé une croissance compensatrice partielle. Pour la période totale, la croissance n'a pas été significativement différente entre les rations. La substitution de la pulpe de betteraves sucrières par le* gluten feed *de blé a amélioré légèrement l'indice de consommation. Les caractéristiques de la carcasse n'ont pas été modifiées. Si l'on se base sur la croissance et l'ingestion, les meilleurs résultats ont été obtenus avec 15% de* gluten feed *de blé dans la ration. Dans un troisième essai, la quantité de concentré volontairement ingérée contenant 15% de* gluten feed *de blé a été plus faible par comparaison à un concentré contenant du* gluten

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feed *de blé, quand les 2 étaient librement disponibles. La digestibilité de la matière sèche des rations, déterminée sur des moutons, n'est que légèrement, mais pas significativement, améliorée par l'incorporation de* gluten feed *de blé.*

gluten feed *de blé / production de viande bovine / croissance / qualité de carcasse*

INTRODUCTION

Primary food crop production yields a considerable amount of products that are not suitable for human consumption. It can be estimated that about 50% of the food crop dry matter is not edible (de Boer, 1985). In the case of starch production from maize grain, the amount of by-products may exceed 30% (Boucqué and Fiems, 1988) without taking the maize stover into account.

Although maize grain is mostly imported, it is still a major raw material for starch production in the EC. The lack of home-grown maize grain and the wheat surplusses in the EC led to the use of wheat grain for starch production, with wheat gluten feed (WGF) as a by-product.

In comparison with dried sugarbeet pulp (SBP), which is often used in concentrates, WGF has a slightly higher net energy content for fattening (7.63 *vs* 7.51 MJ/kg DM). Its crude protein content averages 165 g, while intestinal digestible protein and degradable protein balance amount to 89 and 15 g per kg dry matter (DM) in comparison with 96, 106 and –70 g for SBP (Fiems *et al,* 1994).

This report presents the effect of WGF, produced by means of biotechnological techniques, in a concentrate diet on the performances of finishing bulls.

MATERIALS AND METHODS

Two experiments were conducted, both with Belgian White-blue bulls with normal conformation. Animals were purchased in the market as store cattle. They were randomly divided into equal groups after an adaptation period, based on live weight, pre-experimental gain and body conformation, and confined in straw-bedded loose houses. Weighings occurred on 3 consecutive days at the start and the end of the experiment and at 4-week intervals during the experiment.

In *Experiment 1,* 15% SBP in the concentrate was replaced by WGF. In *Experiment 2,* SBP was gradually replaced by 15, 30 and 45% WGF. To keep the concentrates isonitrogenous, soybean meal was partly replaced by tapioca. Incorporation of calcium phosphate was reduced with increasing amounts of WGF, while limestone was increased. Other ingredients were incorporated at the same level. Each concentrate contained 24 ppm salinomycin.

The concentrates were abruptly introduced at the start of the experiments and fed to satiation. Intake of concentrate was measured on a pen-basis. Straw was freely available to prevent rumen fermentation disorders, but intake was not recorded.

Concentrates were chemically analysed. Digestibility was determined with 5 mature wethers in *Experiment 1* and 4 in *Experiment 2* to calculate net energy for fattening according to van Es (1978).

Besides concentrate intake and growth rate, the carcass characteristics of the bulls were also investigated. Animals were fasted for 20 h prior to slaughtering. Carcasses were weighed immediately after slaughtering and after a 24-h chilling period. Dressing percentage was expressed as cold carcass weight over fasted live weight. Carcass composition of each animal was assessed by an 8th-rib-cut dissection (Verbeke and Van de Voorde, 1978).

Palatability of WGF was assessed in *Experiment 3* with 2 groups of 4 and 3 bulls, weighing 660 ± 29 kg. They were group-fed and could choose between the concentrates which were fed in *Experiment 1,* containing 0 or 15% WGF in substitution for SBP. The animals were accustomed to a concentrate diet, but the 2 experimental concentrates were abruptly introduced. The concentrates were put in different mangers.

Eating straw was available in the rack. Concentrate intake was measured over 14 d. Refusals were weighed every day.

Treatment effects were calculated by analysis of variance in *Experiment 1* and *2* and by Student's test in *Experiment 3*; in *Experiment 2* means were ranked for significance using Duncan's multiple range test (Snedecor and Cochran, 1980). Statistical analysis of intake was based on weekly pen intake data.

RESULTS AND DISCUSSION

The substitution of SBP for WGF resulted in a considerable decrease of crude fibre in the concentrate and an increase of N-free extract (table I). Organic matter and ether extract were slightly increased when the amount of WGF was raised.

In *Experiment 1*, the digestibility of ether extract tended to be higher when WGF was included ($P = 0.06$). Other digestion coefficients were not different. In *Experiment 2*, the ether extract digestibility increased and the crude fibre digestibility decreased as the incorporation level of WGF increased.

WGF contains less crude fibre and more N-free extract than SBP (Fiems *et al*, 1994). This can explain the change in chemical composition of the diets. Furthermore, the digestibility of some components of the concentrates may also differ as a result of diverging digestion coefficients between SBP and WGF, such as protein, fat and

Table I. Chemical composition and digestibility of the concentrates.

WGF (g/kg)	*Dry matter*	*Organic matter*	*Crude protein*	*Ether extract*	*Crude fibre*	*N-free extract*	*Ash*
Experiment 1							
Chemical composition (g/kg DM)							
0	885	911	145	15	137	614	89
150	886	913	143	21	118	631	87
Digestibility (%)							
0	81.3	86.3	73.1	63.8	79.7	91.4	
150	82.4	86.9	74.6	68.6	78.4	91.8	
se	2.0	1.9	3.9	4.3	4.0	1.6	
Experiment 2							
Chemical composition (g/kg DM)							
0	884	910	152	14	139	605	90
150	887	911	145	20	118	629	88
300	887	917	145	18	100	654	83
450	884	920	146	24	80	670	80
Digestibility (%)							
0	80.1	84.8	72.9	64.8^{a}	77.6^{a}	89.9	
150	82.7	87.0	76.0	71.4^{ab}	79.4^{a}	91.4	
300	82.8	86.5	78.1	79.1^{bc}	74.3^{ab}	90.8	
450	82.8	85.9	78.1	82.7^{c}	67.5^{b}	79.9	
se	2.4	2.4	3.7	4.6	5.6	1.8	

Values without superscripts or with the same superscripts are not significantly different ($P > 0.05$).

crude fibre. However, the changes cannot be solely ascribed to the substitution of SBP for WGF, as there was also a replacement of soybean meal by tapioca.

The net energy for fattening of the concentrates amounted to 7.82 and 7.94 MJ per kg DM in *Experiment 1* and 7.51, 7.96, 8.07 and 8.08 MJ per kg DM in *Experiment 2*.

Liveweight gain and concentrate intake in *Experiment 1* are given in table II. Daily liveweight gain was not significantly different and averaged 1.42 and 1.43 kg when a concentrate containing 0 or 15% WGF was fed. However, daily DM intake from concentrate was slightly lower when 15% WGF was incorporated into the concentrate. The difference was significant from d 113 onwards and for the entire period ($P < 0.05$). DM and net energy intakes from the concentrates per kg gain were significantly affected ($P < 0.05$).

Increasing the amount of WGF in the concentrate up to 45% in *Experiment 2* (table III) exerted a negative effect on growth rate during the first 28 and 112 d ($P < 0.05$). From d 85 onwards, the bulls receiving the concentrate with 30% WGF even underwent a slight compensatory gain. A similar result was observed from d 141 for the animals that received 45% WGF in the concentrate. It is assumed that this is a true compensatory gain, as daily concentrate intake was similar. As a consequence, average daily gain during the entire period was not significantly affected by the level of WGP in the diet.

The rate of gain was good in both experiments and averaged 1.43 and 1.39 kg per day. It was higher than in an experiment of Istasse *et al* (1989), where isonitrogenous diets, based on maize silage and including 15% WGF or 15% maize gluten feed,

Table II. Effect of wheat gluten feed on average liveweight gain and feed intake in *Experiment 1*.

	WGF (g/kg)		
	0	*150*	*Pooled se*
Number of bulls	36	35	
Initial weight (kg)	352.6	353.3	18.3
Final weight (kg)	678.1	679.8	35.6
Experiment days	229.0	228.4	23.6
Daily gain (kg)			
Start – 112 d	1.48	1.50	0.20
113 d – end	1.37	1.36	0.19
Entire period	1.42	1.43	0.16
Daily DM intake [c] *(g/kg $W^{0.75}$)*			
Start – 112 d	85.2	83.6	6.5
113 d – end	80.7[a]	78.8[b]	5.0
Entire period	82.8[a]	81.1[b]	6.1
Intake per kg gain			
Concentrate (kg DM)	6.30	6.15	1.24
Net energy [c] (MJ)	49.28	48.84	9.90

Values with intake superscripts differ significantly ($P < 0.05$); [c] straw not included.

Table III. Effect of wheat gluten feed on average liveweight gain and feed intake in *Experiment 2*.

	WGF (g/kg)				*Pooled se*
	0	*150*	*300*	*450*	
Number of bulls	12	11	12	10	
Initial weight (kg)	351.6	354.2	351.8	351.3	22.9
Final weight (kg)	673.3	691.2	676.4	665.9	40.0
Experimental days	233.7	232.2	233.1	234.6	23.4
Daily gain (kg)					
1 – 28 d	1.19^{a}	1.18^{a}	0.83^{b}	0.68^{b}	0.32
29 – 56 d	1.61^{a}	1.61^{a}	1.56^{a}	1.36^{a}	0.32
57 – 84 d	1.62^{a}	1.77^{a}	1.56^{a}	1.56^{a}	0.38
85 – 112 d	1.35^{a}	1.52^{ab}	1.62^{b}	1.37^{a}	0.29
113 – 140 d	1.32^{a}	1.35^{ab}	1.60^{b}	1.38^{ab}	0.31
141 – 168 d	1.66^{a}	1.59^{a}	1.52^{a}	1.71^{a}	0.31
169 – 196 d	1.25^{a}	1.34^{ab}	1.30^{a}	1.57^{b}	0.30
197 – end	0.97^{a}	1.15^{a}	1.37^{a}	0.98^{a}	0.45
1 – 112 d	1.44^{a}	1.52^{a}	1.39^{ab}	1.24^{b}	0.18
123 – end	1.32	1.39	1.39	1.43^{a}	0.20
Whole period	1.38	1.45	1.39	1.34	0.15

Values with different superscripts differ significantly ($P < 0.05$).

yielded a daily gain of 1.33 and 1.27 kg, respectively, in double-muscled White-blue bulls with an average liveweight range of 276 to 554 kg.

An increasing incorporation of WGF resulted in a considerable depression of concentrate DM intake per kg $W^{0.75}$ at the beginning of the experiment. The reduction amounted to 0.7, 4.5 and 9.6% of the WGF-free diet (table IV).

A significant relationship ($P = 0.05$) was found between daily concentrate DM intake per kg $W^{0.75}$ (Y(g)) during the first 112 d of the trial and the level of WGF (X(%)): $Y = 82.8 - 0.004X^2$; $R^2 = 0.996$. Afterwards, intake from diets with WGF was similar to or slightly higher than in the control diet, meaning that the animals adapted to the taste of WGF. For the entire period, intake of the diet with the highest WGF level was not significantly lower ($P > 0.05$).

Intake per kg gain tended to be unfavourable for higher WGF levels during the first 112 d, but showed an opposite effect afterwards.

Feeding diets containing WGF did not significantly affect carcass characteristics (table V). Dressing percentage ranged between 64.0 and 64.5% and was similar in both experiments. Carcass fat content averaged 20%.

In *Experiment 3*, daily free choice concentrate intake averaged 9.55 ± 1.10 and 1.60 ± 0.69 kg when 0 or 15% WGF was incorporated per kg concentrate ($P < 0.001$).

The intake obtained during the initial 112 d in *Experiment 2* is in agreement with the lower intake observed in *Experiment 3*, where a concentrate with 15% WGF was reluctantly consumed. Therefore, it is supposed that WGF is less palatable than SBP.

The reduced concentrate intake obtained with higher levels of WGF in the diet may be related to the property of the gluten, which forms a pasty mass in the mouth and is unpalatable for animals (Todorov, 1988).

However, a palatability test may not be a good reflection of the intake, when the feeds are fed separately. Forbes *et al* (1967) concluded that the effect of the palatability must not be exaggerated: ewes receiving 3

Table IV. Effect of wheat gluten feed on average feed intake in *Experiment 2*.

	WGF (g/kg)				*Pooled se*
	0	*150*	*300*	*450*	
Daily DM intake [c] *(g/kg $W^{0.75}$)*					
Start – 112 d	82.7^{a}	82.1^{a}	79.0^{ab}	74.8^{b}	7.6
113 d – end	76.6^{ab}	76.3^{a}	79.5^{b}	78.2^{ab}	6.8
Entire period	79.4^{a}	79.0^{a}	79.1^{a}	76.0^{a}	7.4
Intake per kg gain					
Concentrate (kg DM)					
Start – 112 d	5.43^{a}	5.18^{a}	5.37^{a}	5.61^{a}	0.97
113 d – end	7.00^{a}	6.74^{ab}	6.84^{a}	6.43^{b}	0.88
Entire period	6.21^{a}	5.95^{a}	6.13^{a}	6.07^{a}	1.07
Net energy [c] (MJ)					
Start – 112 d	40.9^{a}	41.3^{a}	43.3^{ab}	45.4^{b}	7.7
113 d – end	52.4^{a}	53.6^{a}	54.7^{a}	51.8^{a}	6.9
Entire period	46.6^{a}	47.4^{a}	49.2^{a}	49.0^{a}	8.3

Values with different superscripts differ significantly ($P < 0.05$); [c] straw intake not included.

Table V. Effect of wheat gluten feed on carcass characteristics [a].

	WGF (g/kg)							
	Experiment 1		*Pooled se*	*Experiment 2*				*Pooled se*
	0	*150*		*0*	*150*	*300*	*450*	
Fasting weight loss (%)	2.7	2.5	0.7	2.4	1.8	2.5	2.2	0.7
Dressing (%)	64.4	64.4	1.7	64.5	64.4	64.0	64.2	1.5
EUROP classification								
Conformation [b]	11.9	12.0	1.5	12.6	12.5	12.5	12.6	1.2
Fatness [c]	8.2	7.9	1.5	7.7	7.5	7.5	7.8	1.4
Carcass composition (%)								
Meat	66.0	66.2	3.1	66.9	66.0	66.3	66.2	3.3
Fat	20.6	20.3	3.2	19.3	20.2	19.8	20.3	3.6
Bone	13.4	13.5	1.0	13.8	13.8	13.9	13.5	0.8

[a] Means do not differ ($P > 0.05$); [b] E = 15; U = 12; R = 9; O = 6; P = 3; [c] class 1 = 3 (very lean); class 5 = 15 (very fat).

silages of different quality ate very little of a poor-quality silage when the silages were offered together, while intake of the poor-quality silage was slightly different from the intake of the other silages when fed separately.

Except for the concentrate with 45% WGF during the first 112 d, feed conversion was always slightly improved by the inclusion of WGF. According to De Laporte and Demeersman (1988) WGF may possess antibacterial properties. However, there was no improvement of energy efficiency.

It can be concluded that WGF obtained by biotechnological processing of wheat is a high-energy feed. Based on initial and overall daily gain, concentrate intake and feed efficiency, the best results were obtained when 15% WGF was included in the diet. Initial concentrate intake and growth rate were negatively affected at higher incorporation levels of WGF. Incorporation levels of WGF have no effect on carcass quality.

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