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AN EVALUATION OF SODA-TREATED WHEAT FOR BEEF CATTLE

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by

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AN EVALUATION OF SODA-TREATED WHEAT FOR BEEF CATTLE

Summary

A total of 40 Charolais x Friesian steers were fed ad libitum maize silage supplemented with either caustic soda (NaOH) treated wheat or an untreated rolled wheat ration. Both supplementary rations comprised 2.0 kg of wheat dry matter + 1.2 kg of rapeseed meal dry matter per head per day. The experiment design was randomised complete blocks with four pen replicates of five steers on each of two treatments. The feeding period was from 13 months of age to slaughter.

Rates of live-weight gain were similar for both treatment groups and were 1.38 and 1.41 kg/head/day (SED 0.066) for the NaOH-treated and rolled wheat rations respectively. Similarly there was no difference between treatments in number of days to sale (75.1 v 70.6 days, SED 7.15) or in sale weights (531.9 v 522.3 kg, SED 9.34). Cold carcase weights (285.1 v 279.1 kg, SED 5.30) and dressing proportions, (0.536 v 0.534, SED 0.0040) were also similar for both treatments, as were EC carcase gradings. However, daily intakes of silage dry matter were 9% greater for steers fed NaOH-treated wheat (4.77 v 4.36 kg, SED 0.100), but food conversion efficiency (5.68 v 5.32 kg of DM per kg of live-weight gain, SED 0.312) was similar for both treatment groups. Although the difference in feed conversion efficiency was not large enough to achieve statistical significance at the 5% level of probability, it was sufficient to eliminate any potential improvement in live-weight gain expected from the increased dry matter intake by the NaOH treatment group. It is concluded that the steers fed NaOH-treated wheat utilised the ingested energy less efficiently than those fed rolled wheat.

Introduction

The treatment of grain with NaOH is an alternative to the traditional rolling or milling of grain to render it susceptible to the digestive processes of ruminants. Caustic soda treatment eliminates the need for further processing and is therefore attractive to producers wishing to use home-grown cereals but who do not have rolling or milling facilities. It is claimed that treatment reduces the rate of fermentation of cereal starch in the rumen whilst improving the overall digestibility of the grain. Furthermore the feeding of NaOH-treated grain with low pH forage has the potential to reduce fluctuations in rumen pH and thereby improve digestion and increase total dry matter intake.

The treatment process consists of adding NaOH pearls to the grain, usually in a mixer-wagon, at a rate of 3% by weight for wheat and 5% for barley, and mixing the dry components for 2-3 minutes to evenly distribute the NaOH before adding water at a rate of 100-150 litres per tonne. The components are then mixed for a further period of 10-40 minutes until the grain darkens in colour and heating occurs. The mixing time depends on the quantity of grain to be treated and 10 minutes per tonne is considered ideal. The chemical reaction which occurs during treatment produces considerable heat and a longer mixing-time will help to enhance heat loss and reduce the formation of lumps in the final product. A longer mixing-time will also change the consistency of the NaOH-treated grain, rendering it more friable.

Objective

The objective of the experiment was to investigate the effect on steers of supplementing maize silage diets with either NaOH-treated wheat or untreated rolled wheat during the finishing phase.

Materials and method

Site

The experiment was undertaken at ADAS Rosemaund, near Hereford (OS 566478).

Experiment design

A balanced randomised complete block design with pen replication.

Treatments

All steers received maize silage ad libitum plus either 2.0 kg per head per day of NaOH-treated wheat dry matter or untreated rolled wheat dry matter, plus 1.2 kg per day of rapeseed meal dry matter. Mineral/vitamin supplement was fed (Supramin, Chapman and Frearson, Grimsby) to all steers at the rate of 100 g fresh weight per head per day.

Maize silage

The maize silage was made on 15 October 1991 from 8.5 ha of forage maize (Variety LG 2080). (See Table 1 for nutritive values).

Compound feed

The NaOH-treated wheat and the untreated wheat were purchased from Mole Valley Farmers Ltd. The NaOH treatment involved the addition of 3% by weight of NaOH pearls and 150 litres per tonne of water. The two wheats were mixed with rapeseed meal and minerals/vitamins in the following proportions on a fresh-weight basis:-

NaOH-treated wheat	62.8%	Rolled wheat	60.6%
Rapeseed meal	34.6%	Rapeseed meal	36.8%
Minerals/vitamins	2.6%	Minerals/vitamins	2.6%

Throughout the period of the experiment a mineral/vitamin supplement was fed which is specifically formulated to complement maize silage, since maize silage is deficient in many minerals and vitamins, particularly vitamin E.

Specification of Supramin

Calcium	25.0%
Phosphorous	2.4%
Magnesium	1.1%
Sodium	8.0%
Cobalt (Cobaltous sulphate)	100 mg/kg
Copper (Cupric sulphate)	1000 mg/kg
Iodine (Potassium iodide)	200 mg/kg
Iron (Ferric oxide, ferrous sulphate)	3900 mg/kg
Manganese (Manganous sulphate)	1000 mg/kg
Selenium (Sodium selenite)	15 mg/kg
Zinc (Zinc oxide)	800 mg/kg
Vitamin A	100,000 IU/kg
Vitamin D3	20,000 IU/kg
Vitamin E	125 IU/kg

Stock

Forty Charolais x Friesian bulls were purchased as two-week-old calves in January 1991 and castrated at six months of age.

Management

Steers were blocked on live weights taken on 7 and 9 January 1992, using the mean of two full-bellied weights taken at the same time of day to minimise diurnal variations in gut fill. All subsequent weighings were taken as full-bellied weights and were collected at the same time of day. On 27 and 28 January 1992 all steers were weighed and the mean of these two weights was taken as the 'start weight' for the experiment.

After two months of pre-treatment maize silage feeding, from 30 January steers were fed treatment rations plus ad-libitum maize silage until sale.

The steers were group-fed in part-bedded/part-scraped accommodation in pens of five steers (four pens on each of two treatments) until sale as finished cattle. Forage was fed once daily at 0800, to appetite, and was metered using a forage-box equipped with integrating load cells.

The supplementary treatment ration (compound) was fed at 0800 and 1700, half the daily compound allocation being fed at each feed. The compound was mixed with the silage in the feed trough. Steers were sold for slaughter between 27 February and 21 May 1992.

Assessments

Samples of forage and of compound feeds were taken three times each week. These samples were used for oven dry matter determinations and fresh samples were bulked over periods of one month, the accumulating samples were deep frozen and submitted monthly for chemical analysis to the ADAS Laboratories, Wolverhampton. Until steers were nearing marketable condition live weights were recorded monthly; after this time weighings were more frequent. Steers were selected for slaughter by subjective handling, and were sold when they were adjudged to have attained EC fatness classification 3 or 4L. At the abattoir cold carcase weights and EC carcase gradings were recorded.

Chemical analyses

NCGD was measured by a method based on that of Dowman and Collins (1982). All other analyses were conducted using conventional ADAS techniques (MAFF, 1986).

Data analysis

Steer live-weight data were subjected to analysis of variance, and EC carcase gradings were compared using the Chi-Square test.

Results

Feed analyses

Table 1. Chemical analyses and predicted nutritive values of maize silage at feeding

	Chemical composition									Predicted nutritive values		
	DM % *	pH *	Crude protein %	NH_3 as CP %	Total CP %	NH_3-N as % TOT-N	Ash %	Starch %	NCGD %	D Value	ME (MJ/kg)	DCP (g/kg)
February	31.3	3.6	7.9	0.6	8.5	7	4.3	21.2	71.2	71	11.1	42
March	30.9	3.4	7.5	0.6	8.1	8	4.2	14.1	71.3	70	11.1	38
April	30.9	3.8	7.5	0.6	8.2	8	4.0	21.0	65.2	67	10.5	38
May	33.1	3.8	8.5	0.6	9.1	7	4.1	22.6	69.2	69	10.9	45
MEA	31.55	3.65	7.85	0.60	8.48	7.5	4.15	19.73	69.2	69.3	10.90	40.8
sd (n-1)	1.05	0.19	0.47	0.00	0.45	0.58	0.13	3.82	2.85	1.71	0.28	3.40

Results expressed on a dry matter basis except where marked *.

The maize silage was of excellent quality as indicated by the low ammonia values, high D values and high energy content.

Table 2. Chemical analyses and predicted nutritive values of NaOH-treated wheat + rapeseed meal compound

	Chemical composition							Predicted nutritive value
	DM % *	pH *	Crude protein %	Oil %	Crude fibre %	Ash %	NCGD %	ME (MJ/kg)
February	81.5	8.2	20.0	4.2	8.0	8.4	84.9	12.9
March	81.8	7.0	20.1	3.6	5.5	8.5	86.3	13.0
April	82.6	7.3	21.6	3.6	5.8	8.4	88.7	13.3
May	83.1	9.2	18.3	3.0	4.9	8.8	87.9	13.1
Mean	82.25	7.92	20.00	3.60	6.05	8.53	86.95	13.08
sd (n-1)	0.73	0.99	1.35	0.49	1.35	0.19	1.69	0.17

Results expressed on a dry matter basis except where marked *

Table 3. Chemical analyses and predicted nutritive values of untreated rolled wheat + rapeseed meal compound

	Chemical composition							Predicted nutritive value
	DM % *	pH *	Crude protein %	Oil %	Crude fibre %	Ash %	NCGD %	ME (MJ/kg)
February	85.6	6.0	18.7	4.0	6.8	4.9	88.4	13.4
March	85.8	5.8	23.1	4.0	7.3	6.2	83.8	12.7
April	85.9	6.0	23.0	4.0	6.6	6.3	85.9	13.0
May	86.8	6.1	21.5	3.9	6.3	5.8	85.7	13.0
Mean	86.03	5.97	21.58	3.98	6.75	5.80	85.95	13.03
sd (n-1)	0.53	0.13	2.05	0.05	0.42	0.64	1.89	0.29

Results expressed on a dry matter basis except where marked *

The treated wheat was of lower dry matter content and higher pH than the untreated wheat.

Table 4. Chemical analyses of constituent feeds

	Chemical composition							
	DM % *	pH	Crude protein %	Oil %	Crude fibre %	Ash %	NCGD %	Sodium (g/kg)
NaOH-treated wheat	77.3	11.8	12.1	2.5	3.1	6.8	92.1	21.6
Untreated wheat	86.7	6.7	11.9	3.5	3.7	1.7	91.5	5.5
Rapeseed meal	86.0		38.2	9.3	18.4	7.6	79.1	

Results expressed on a dry matter basis except where marked *.

Animal performance data

Table 5. Mean performance of Charolais x Friesian steers

	NaOH-treated wheat	Rolled wheat	SED
Blocking weight (kg)	404.3	404.3	0.32
Start weight (kg)	428.0	425.6	1.59
Weight at sale (kg)	531.9	522.3	9.34
Daily live-weight gain (kg)	1.38	1.41	0.066
Number of days from start to sale	75.1	70.6	7.15
Cold carcass weight (kg)	285.1	279.1	5.30
Dressing proportion	0.536	0.534	0.0040

Significant differences in animal performance were not observed ($p = 0.05$).

Table 6. Mean daily feed intakes (kg DM per head) and food conversion efficiency (kg DM consumed/kg live-weight gain)

	NaOH-treated wheat	Rolled wheat	SED
Maize silage	4.77	4.36	0.100
Compound	3.31	3.26	0.012
Total intake	8.08	7.62	0.092
Food conversion efficiency	5.68	5.32	0.312

Daily intakes of silage dry matter and total dry matter intakes were significantly greater for steers fed NaOH-treated wheat ($p = 0.05$). Food conversion efficiency was 6% poorer for steers fed NaOH-treated wheat, but this was not significant at the 5% level of statistical probability.

Table 7. EC carcase classifications

	Conformation score		Fat class		
	O+	R	3	4L	4H
NaOH-treated wheat	8	10	2	14	4
Rolled wheat	12	10	6	12	2

Significant differences were not observed in fatness classifications ($0.30 > p > 0.20$), or in conformation scores ($0.60 > p > 0.50$).

Discussion

The maize silage was of excellent quality and was an ideal base ration for the experiment. The two compound feeds, as expected, differed in pH, dry matter and ash content. The addition of NaOH and water reduced the dry matter content of the wheat from 86.7 to 77.3% and increased the ash content from 1.7 to 6.8% compared to the untreated wheat. The NaOH-treated compound was also more alkaline than the untreated compound having a pH of 7.92 compared to a pH of 5.97 for the untreated feed. The ME content of the compounds was similar, but the NaOH-treated compound had a slightly lower crude protein content.

The results confirm that enhanced DM intakes are achievable when NaOH-treated wheat is fed with maize silage. In this experiment silage DM intakes were increased by 9% ($p = 0.05$) compared with those of steers supplemented with rolled wheat. However, this increased intake of dry matter was not translated into improved rates of liveweight gain. This lack of response may be associated with the high dry matter content of the NaOH-treated wheat (77.3% DM), since a lower dry matter content of 70-72% is preferred for improved utilisation of the whole grain (G Newman, personal communication). In addition, although the levels of subcutaneous fat were similar for both treatment groups ($0.3 > p > 0.2$), those steers receiving NaOH-treated wheat showed a tendency to produce fatter carcasses. Since fat is more expensive to produce in terms of ingested energy than is lean tissue, deposition of fat may have taken place at the expense of some live-weight gain for the NaOH treatment group. This is supported by the inferior FCE of these steers. In addition NaOH treatment may have resulted in a larger proportion of wheat grains being voided in the faeces. No faeces samples were taken to monitor this possibility.

Other workers cited by Campling (1991) in his review have also found discrepancies in animal performance when comparing the energy intakes of steers fed alkali-treated grain or rolled grain. Hill and Leaver (1990), working with whole-crop cereals (which also promote an alkaline rumen environment) have also noted a similar effect in dairy cows. Caustic soda treatment should reduce the rate of digestion in the rumen, and therefore allow a greater proportion of the food to be digested in the small intestine thereby increasing the efficiency of the digestive process. However, the partitioning of starch digestion between the rumen and the small intestine may have been modified by the feeding of a high starch maize silage ration.

Conclusions

1. The feeding of NaOH-treated wheat, rather than rolled wheat did not produce differences in animal performance.

2. Daily intakes of silage dry matter were 9% greater for steers fed NaOH-treated wheat than for steers fed rolled wheat.

3. Food conversion efficiency was similar for both treatment groups.

4. Daily financial margins over feed costs were similar for both treatment groups (see Appendix 1).

Recommendations

1. This experiment used steers during the finishing phase, from 13 months of age to slaughter. The conversion of food into live-weight gain, particularly into lean meat, is relatively much more efficient in younger steers. It is recommended that the effects of similar diets on younger steers should be assessed.

2. Future work should be supported by rumen digestion/metabolism studies to fully understand the digestive processes and the interaction of the various ration components.

3. Both grass silage and maize silage should be compared, since the differing starch levels in these forages may affect the efficiency of utilisation of the compound feeds.

4. This work should be repeated using NaOH-treated grain of a higher moisture content. A dry matter content of 70-72% should be the aim for the NaOH-treated grain.

5. In any future experiment a barley-based treatment should also be included to provide a bench-mark for other treatments.

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References

CAMPLING R C (1991). Processing cereal grains for cattle - a review. Livestock Production Science 28: 223-234.

DOWMAN M G and COLLINS F C (1982). The use of enzymes to predict the digestibility of animal feeds. Journal of the Science of Food and Agriculture 33: 689-696.

HILL J and LEAVER J D (1990). Urea treated whole-crop wheat for dairy cattle. Animal Production 50: 578 (abstract).

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD (1986). The analysis of agricultural materials. Reference book 427 third edition, HMSO, London.

APPENDIX I

Financial appraisal

	NaOH-treated wheat ration	Rolled wheat ration
Cost of NaOH-treated wheat (£/tonne)	142.00	-
Cost of untreated wheat (£/tonne)	-	142.00
Cost per tonne of wheat dry matter (£)	183.70	163.78
Cost per tonne of rapeseed meal dry matter (£)	143.02	143.02
Cost per tonne of vitamin/mineral supplement	284.80	284.80
Cost of rolling untreated wheat (£/tonne)	Nil	7.50
Daily cost of silage feeding (£/head)*	0.17	0.15
Daily cost of compound feeding (£/head)	0.57	0.53
Total daily feed cost (£/head)	0.74	0.68
Daily rate of live-weight gain (kg)	1.4	1.4
Value of daily live-weight gain @ £1.10/kg live-weight	1.54	1.54
Daily margin over feed costs (£)	0.80	0.86

* Assumes 1 tonne of maize silage dry matter costs £35 based on harvesting costs and variable costs of production only.

Both rations produced similar high margins over feed costs.

APPENDIX II

Glossary

CP	Crude protein
D value	Digestible organic matter in the dry matter expressed as a percentage
DCP	Digestible crude protein
DM	Dry matter
MAFF	Ministry of Agriculture, Fisheries and Food
ME	Metabolisable energy
NCGD	Cellulase/gamanase digestible organic matter in the dry matter following neutral detergent extraction
NH_3 as CP	Ammonia nitrogen as crude protein equivalent
sd (n-1)	Sample standard deviation using (n-1) degrees of freedom.