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FEEDING VALUE OF SPROUTED WHEAT (*TRITICUM AESTIVUM*) FOR BEEF CATTLE FINISHING DIETS[1]

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ABSTRACT

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The feeding value of sprouted, soft white wheat was compared with that of sound (unsprouted) wheat and barley in the diets of 95 Simmental-Hereford beef cattle. There were no differences ($P > 0.05$) in daily gains, feed intakes or feed/gain ratios of cattle fed on either sound wheat, wheat with 9% sprouted kernels (low-sprout) or wheat with 58% sprouted kernels (high-sprout), when the wheat was included at 25 or 50% of the diet. When sound and sprouted wheats were given to 44-kg sheep, at 75% of the diet, dry matter intake of the sound-wheat diet was 21% less than that of the high-sprout-wheat diet; dry matter digestibility and the digestible energy content of the former diet were slightly greater (74.3 vs 70.7% and 3.2 and 3.0 kcal g^{-1}), but neither difference was significant ($P > 0.05$). It was concluded that sprouting does not affect the feeding value of wheat for finishing beef cattle when offered at 50% of the diet, and reduces it only slightly for sheep when given at 75% of the diet.

INTRODUCTION

The 1978 soft white wheat (*Triticum aestivum*) harvest of Washington and Idaho was delayed by rain and resulted in the pre-harvest germination (sprouting) of about one million tonnes of wheat. Owing to the starch and protein degradation that occurs during sprouting (Ching, 1972), this wheat was unsuitable for baking (Ponte, 1971) and, therefore, was available for livestock

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feeding; wheat grain can be used successfully in cattle finishing diets (Bris and Dyer, 1967). Farlin et al. (1971) observed feedlot performances of steers given diets that contained various amounts of sprouted wheat to be similar to that of steers given sound (unsprouted) wheat. Despite these results, cattle feeders have the opinion that sprouted wheat has a feeding value less than that of sound wheat. Our objectives, therefore, were firstly to re-evaluate sprouted wheat as a cattle feed by comparing feedlot performance of cattle fed on diets containing sprouted wheat with that of cattle fed on diets containing either sound wheat or barley; the digestibility of diets containing either sound or sprouted wheat was also compared in sheep. Secondly, rates of dry matter disappearance in vitro and changes in volatile fatty acid (VFA) concentrations during a 12-h incubation of sound and sprouted wheat in rumen fluid from sheep were compared.

MATERIALS AND METHODS

Wheat types that contained more than 25% sprouted kernels (high-sprout), less than 10% sprouted kernels (low-sprout) and sound wheat were used for our study. The three wheat types were obtained from different sources.

Determination of sprouting

Each wheat type was assessed visually for sprouting by determining the percentage of kernels that displayed one or more of the following conditions: expansion of the pericarp; splitting of the germ face; the presence of sprouts. This assessment was conducted macroscopically.

Since biochemical events precede these visual indications of sprouting (Ching, 1972), the extent of degradation was assayed by using the falling number method described by Mailhot (1980). This method measures the ability of wheat starch to gelatinize, a property that is decreased during

Seven diets consisting of either 0 (77% barley), 25 or 50% of sound (2% sprouted kernels), low-sprout (9% sprouted kernels) or high-sprout (58% sprouted kernels) wheat were compared. Barley was combined with each level of wheat so that grain represented 77% of the diet given. The rest of each diet consisted of 10% chopped alfalfa and brome-grass hay, 10% supplement and 3% cane molasses. The chemical composition of ingredients and supplements used for this experiment is shown in Table I. These diets were given to two or three pens, each containing five or six cattle. Each diet was mixed daily and offered to all cattle ad libitum. The grains were steam rolled. Daily feed intake of each pen of cattle was recorded and body weights were measured every 28 days; access to feed and water was denied each pen for 12 h before the cattle were weighed.

TABLE I

Chemical composition of ingredients and supplements used in feedlot trial

Ingredient	Dry matter[1]	Crude protein	Ash	Ca	P	K
Alfalfa and brome-grass hay[2]	91.1	6.8	6.6	0.56	0.14	1.24
Molasses (IFN 4-04-696)	70.4	5.4	13.8	0.74	0.09	2.79
Finishing supplement[3]	90.4	27.2	15.6	3.52	0.25	0.90
Protein withdrawal supplement[4]	90.0	9.0	12.2	3.40	0.27	0.91
Barley (IFN 4-07-939)	87.4	10.6	2.6	0.09	0.31	0.48
Sound wheat (IFN 4-08-555)	87.0	11.6	1.9	0.09	0.33	0.52
Low-sprout wheat (IFN 4-08-555)	86.3	10.4	1.8	0.07	0.29	0.47
High-sprout wheat (IFN 4-08-555)	86.0	10.1	1.6	0.08	0.31	0.49

[1] Values, except dry matter, expressed on a dry matter basis (%).
[2] Approximately 25% mature, stemmy alfalfa hay and 75% mature, smooth brome-grass hay.
[3] Contained ground barley (IFN 4-07-939), 78.1%; animal fat (IFN 4-00-409), 2.0%; urea (45% N), 7%; trace mineralized salt, 2.00%; $CaCO_3$, 9.00%; KCl, 1.50%; Rumensin-60 (27.3 g Rumensin kg^{-1}), 0.16%; Tylan-40 (18.2 g Tylosin kg^{-1}), 0.11%; Vitamin A, 0.12%.
[4] Same as finishing supplement, but contained 85.1% ground barley and 0% urea.

A finishing supplement (Table I) was given for the first 67 days, and a protein withdrawal supplement for the rest of the trial. The change of supplement reduced the average crude protein content of the diets from 11.8 to 9.9% of dry matter, this being consistent with National Research Council (1976) recommendations for crude protein requirements of finishing beef cattle.

Cattle were removed from the experiment when two-thirds of those in any sex age classification were estimated visually to grade U.S.D.A. choice. This resulted in feeding trials of 111, 176 and 168 days for the yearling heifers, heifer calves and steer calves, respectively. Carcasses were evaluated by using the U.S.D.A. quality and yield grade criteria. Data were statistically analyzed by least squares analysis for unequal sub-class numbers (Harvey, 1960).

Metabolism trial

The purpose of this experiment was to compare the digestibility, in sheep, of a diet that contained sound wheat with a diet that contained the high-sprout wheat.

Twelve 7-month-old Columbia ram lambs, average weight 44 kg, were divided (blocked) by weight into three groups of four lambs. Within each weight group, lambs were randomly assigned to either a 72% sound or a 72% high-sprout wheat diet (two lambs per diet, per block). The rest of each diet consisted of 25% chopped hay and 3% protein-mineral supplement[1]. The chopped hay and wheat (steam rolled) were the same as those used in the feedlot trial, resulting in both the sound-wheat and high-sprout-wheat diets having similar concentrations of dry matter (91.0%), crude protein (11.3%), neutral detergent fibre (26.4%), acid detergent fibre (13.2%) and lignin (2.4%).

Lambs were placed in individual metabolism stalls and allowed to adjust to their respective diets for 11 days. Each lamb had access to fresh water. Voluntary feed intake was established for each lamb and the amount of feed offered was then decreased to 90% of voluntary intake for 8 days. Daily faeces and urine were collected quantitatively after each morning feeding for the last 5 days. Aliquots of feed and faeces were stored at −20°C for later analyses. Proximate analysis (Association of Official Analytical Chemists, 1965), acid detergent fibre and neutral detergent fibre assays (Goering and Van Soest, 1970) and gross energy measurements (bomb calorimetry) were conducted for feeds and faeces. Urinary nitrogen was determined by the Kjeldahl method (Association of Official Analytical Chemists, 1965) and urinary gross energy was measured with a bomb calorimeter. Loss of dietary energy from methanogenesis was calculated (Blaxter and Clapperton, 1965), and was combined with urinary and faecal gross energy values for calculation of metabolizable energy. Data were subjected to analysis of variance for the randomized complete block (Steel and Torrie, 1960).

Laboratory study

The purpose of this experiment was to compare the fermentation of sound wheat with that of high-sprout wheat, both steam rolled, when incubated in rumen fluid for 12 h, in vitro. Since starch and protein degradation occurs with sprouting (Ching, 1972), the effects of sprouting on early rumen fermentation of wheat were investigated by using a 12-h incubation period.

Incubations were conducted in 50-ml test tubes containing 18 ml of fermentation media (Mellenberger et al., 1970) plus 18 ml of rumen fluid

[1] Urea, 14%; NaCl, 7.5%; Ca, 11.5%; P, 4%; K, 9.2%; Co, 0.0003%; Zn, 0.04%; Mn, 0.03%; Mg, 3.8%.

Rumen fluid from two rumen-fistulated sheep was obtained and strained through 6 layers of cheese cloth. Rubber septa, fitted with one-way gas release valves, were used to cap the incubation tubes, and the air space of each tube was flushed with CO_2. Incubations were conducted at 39°C and pH 6.9.

Five triplicate sets of each wheat type (300 mg each) were incubated for either 1, 3, 6, 9 or 12 h. Tubes that contained only fermentation media plus rumen fluid (rumen fluid blanks), and tubes that contained samples of each wheat type plus 36 ml of fermentation media only (substrate blanks) were also incubated.

Fermentation activity was terminated with three drops of $HgCl_2$ (5%). Subsequently, the tubes were centrifuged at 1800 ×g and the supernatants were removed. Aliquots of each supernatant were stored at −20°C for later analysis of VFA concentrations. Dry matter disappearance was corrected for loss of dry matter of the rumen fluid blanks and loss of wheat dry matter of the substrate blanks. Volatile fatty acid concentrations were measured by gas—liquid chromatography.

RESULTS AND DISCUSSION

Composition of the experimental wheats

The extent of sprouting of the experimental wheats is shown in Table II. Visual indications of sprouting appeared in 2, 9 and 58% of the kernels for the sound, low-sprout and high-sprout wheats, respectively. Falling numbers (Table II) represent the seconds required for a metal disc, approximately 20 g in weight, to fall through a paste of gelatinized wheat, under specified conditions (Mailhot, 1980). Because high α-amylase activity reduces the ability of wheat starch to gelatinize, the viscosity of starch from sprouted wheat is relatively low. As the degree of sprout increases, therefore, the falling number decreases and, as shown in Table II, falling numbers of the wheats used in our experiments were in accord with the percentage of sprouted kernels estimated visually.

The three wheat types had similar contents of ash, Ca, P and K (Table I). Crude protein, however, tended to decrease as the degree of sprouting in-

TABLE II

Degree of sprout in experimental wheats

Wheat type	Visual estimation (%)	Falling number[1]
Sound	2	342
Low-sprout	9	118
High-sprout	58	60

[1] Values represent the seconds required for a metal disc, approximately 20 g, to fall through a paste of ground wheat plus water.

creased. Hwang and Bushuk (1973) showed that germination of wheat for 4 days resulted in 8% less protein. Since the wheat types used in our experiments were not obtained from the same source, we are uncertain whether sprouting actually affected the protein content.

Feedlot trial

Results of the feedlot trial are shown in Table III. No significant differences ($P > 0.05$) among diets for average daily gain, feed intake or feed/gain ratio were observed. Similar results were obtained by Farlin et al. (1971) with yearling steers fed on diets that contained 60% wheat, of which 0, 33, 66 and 100% was sprouted. Our results, combined with those of Farlin et al. (1971), indicate that the feeding values of sprouted wheat and sound wheat for finishing cattle are similar.

No significant differences in carcass characteristics (Table III) were observed among the cattle fed on the various diets. Overall, the average values for dressing percentage, quality grade and yield grade were 59.6%, low choice and 2.8, respectively.

TABLE III

Feedlot performance and carcass characteristics of cattle

Diet	Average daily gain (kg)	Average daily feed (kg)	Feed/gain[1]	Dressing percentage	U.S.D.A. yield grade[2]
Barley control	1.32	9.44	7.15	59.3	2.9
25% sound wheat	1.35	9.51	7.03	60.0	2.9
50% sound wheat	1.30	9.16	7.06	59.8	2.7
25% low-sprout wheat	1.28	8.94	6.96	58.4	3.0
50% low-sprout wheat	1.24	9.03	7.27	59.9	2.6
25% high-sprout wheat	1.36	9.51	6.99	60.3	3.0
50% high-sprout wheat	1.29	9.08	7.05	59.3	2.6
Standard deviation	0.245	0.624	0.245	1.61	0.55

[1] Dry matter basis.
[2] Values correspond to the percentage of boneless, closely trimmed retail cuts from the round, loin, rib and chuck. A yield grade of 1.0 would have the greatest percentage and a yield grade of 5 would have the lowest percentage. The average U.S.D.A. quality grade for each diet was choice minus.

Metabolism trial

Results of the metabolism trial are shown in Table IV. Consumption of dry matter by lambs was 21% less ($P = 0.09$) with the sound-wheat diet than

TABLE IV

Intake, digestibility and nutritive value of wheat diets given to sheep[1]

	Wheat		
	Sound	High-sprout	SE[2]
Dry matter intake (g day^{-1})	821	1040	79.1[3]
Apparent digestibility (%)			
Dry matter	74.3	70.7	1.69
Organic matter	76.6	73.0	1.58
Crude protein	66.9	61.0	3.63
Gross energy	73.7	69.6	1.80
Neutral detergent fibre	32.8	25.8	4.32
Acid detergent fibre	26.4	15.4	5.35
Nutritive values[4]			
Nitrogen balance (g day^{-1})	3.4	4.0	0.90
Nitrogen retained (%)	20.8	22.5	4.60
Digestible energy (kcal g^{-1})	3.2	3.0	0.10
Metabolizable energy (kcal g^{-1})	2.7	2.6	0.10

[1] Six sheep per wheat type.
[2] Standard error of the mean.
[3] $P = 0.09$.
[4] Dry matter basis.

with the sprouted-wheat diet. The greater dry matter consumption of the sprouted-wheat diet was associated with somewhat lower average nutrient digestibility of this diet. When apparent digestibility values were adjusted by using dry matter consumption as a covariate, differences between digestibility values of the sound- and sprouted-wheat diets were decreased by an average of 48%. The reason why the sheep fed on the sprouted wheat tended to consume more feed is not clear. Although not significantly different, the digestible energy content of the sprouted-wheat diet, 3.0 kcal g^{-1}, was slightly less than that of the sound-wheat diet, 3.2 kcal g^{-1}. Diets of lower energy density have been shown to result in greater consumption of feed (Baile, 1979). Results of this experiment indicate that diets containing 75% wheat tend to have slightly less nutritive value for sheep if the wheat is sprouted.

Laboratory study

Results of the fermentation in vitro are shown in Table V. The correlation coefficients (*r* values) for all criteria, when regressed against time, ranged from 0.93 to 0.99. Also, no differences in regression coefficients between the two wheats were observed.

After 3 h fermentation, acetate, butyrate and total VFA concentrations

TABLE V

Effect of sound and sprouted wheat on volatile fatty acid concentrations and dry matter disappearence in vitro

	Wheat type	Time (h)				
		1	3	6	9	12
Acetate (mg dl^{-1})	Sound	96	233[3]	344	512	600[3]
	Sprout[1]	124	198	306	498	659
	SE[2]	12	5	18	26	9
Propionate (mg dl^{-1})	Sound	87	145	182	235	258[3]
	Sprout	94	137	174	241	290
	SE	3	2	5	8	5
Butyrate (mg dl^{-1})	Sound	44	115[3]	174	264	298
	Sprout	48	103	158	249	326
	SE	4	1	7	10	8
Total VFA (mg dl^{-1})	Sound	232	505[3]	725	1061	1210[3]
	Sprout	272	452	653	1038	1337
	SE	19	4	33	47	22
DM disappearance (%)	Sound	16.2	28.2	39.2	39.8	47.8
	Sprout	18.0	28.3	38.6	42.4	49.0
	SE	0.6	0.8	0.4	0.8	0.9

[1] High-sprout wheat.
[2] Standard error of the mean.
[3] Sound wheat significantly different from high-sprout wheat ($P < 0.05$).

were significantly greater ($P < 0.05$) for the sound wheat. Extraction of each wheat type in 80% ethanol, as described by McCready et al. (1950), resulted in 5% greater ($P < 0.05$) loss in dry weight from the sound wheat (12.3 ± 0.10%) than from the high-sprout wheat (11.8 ± 0.14%). Ethanol extractable materials would include a combination of free sugars (McCready et al., 1950; Clegg, 1956), lipids (Mecham, 1971) plus proteins (Osborne, 1907) indicating that some nutrients were lost during germination of the sprouted wheat. Thus, greater fermentation could be expected to occur early after consumption of sound wheat than of sprouted wheat. Dapron et al. (1969) demonstrated an increase in lipolytic activity during the germination of wheat; losses in carbohydrate (Lemar and Swanson, 1976) and protein (Hwang and Bushuk, 1973) have also been shown to occur during sprouting.

After 12 h fermentation, however, sprouted wheat gave greater ($P <$ 0.05) concentrations of acetate, propionate and total VFA. Although no significant differences in OM disappearance were observed, 12 h incubation in media only (the substrate blank) resulted in greater losses for sprouted wheat (11.6 ± 0.30%) than for sound wheat (10.1 ± 0.30%). This indicates that the greater fermentation of the sprouted wheat at 12 h was partially the result of its greater solubility in the fermentation media.

CONCLUSION

Overall, nutrient losses from the wheat that occurred because of sprouting were not great enough to significantly affect its digestibility for sheep, in vitro or in vivo. Results of the feedlot trial indicated that sound and sprouted soft, white wheats, when included at 25 or 50% of the diet, were similar in feeding value for finishing beef cattle.

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