NUTRITIVE VALUE OF WEATHER-DAMAGED SORGHUM GRAIN FOR PIGS

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SUMMARY

Mycotoxin status, apparent digestibility and growth assay procedures were used to compare the nutritive value of three weather-damaged batches of sorghum grain with an undamaged batch. None of the sorghums contained aflatoxins, ochratoxin, sterigmatocystin, T-2 toxin or deoxynivalenol. The weather-damaged sorghums contained zearalenone, alternariol and alternariol mono-methyl ether mycotoxins. The apparent digestibility and nutritive value of two of the weather damaged sorghums were lower than that of the undamaged grain. An even greater depression of pig performance occurred with the third batch of weather-damaged grain. The apparent digestibilities of that grain were equal or superior to those of the undamaged batch. Mycotoxin levels were highest in this sorghum batch and the implications of this are discussed. (Key words: sorghum, weather-damaged, nutritive, mycotoxins, pigs).

INTRODUCTION

Sorghum deteriorates when maturation and harvest co-incides with wet and warm weather. Water uptake by the grain initiates germination and assists mould invasion. Storage starch and protein of the grain are hydrolysed leading to increased fibre content. Consequently, digestible energy (DE) content may be decreased and the nutritive value lowered. The extent will depend on the severity of the weathering, whether deterioration continues during storage and whether mycotoxins are present. This paper reports experiments assessing the nutritive value of three batches of severely weather-damaged sorghum grain grown in the Callide and Burnett districts of central Qld during 1983 when rain damage to sorghum crops was extensive throughout southern Qld and northern N.S.W.

MATERIALS AND METHODS

(i) Sorghum grain Batches of weather-damaged sorghum were obtained from the Baralaba and Gladstone receival depots of the Central Queensland Grain Sorghum Marketing Board and from the D.P.I. Biloela Research Station. All batches were dark and discoloured and most of the grain was either split or sprouted. The sorghum had been artificially dried upon receival for storage and there was no evidence of any on-going deterioration of the grain. Undamaged sorghum harvested earlier in the season was used for comparison.

(ii) Mycotoxin analyses The following mycotoxins were analysed by the 2-dimensional thin-layer chromatographic method of Blaney et al. (1984b) with negative findings (detection limits in parenthesis): Aflatoxins B1, B2, G1 and G2 (each <0.001 mg/kg); ochratoxin A (<0.01 mg/kg); sterigmatocystin (<0.02 mg/kg); and T-2 toxin (<0.1 mg/kg). Deoxynivalenol was assayed by high performance liquid chromatography (HPLC) with negative results (<0.1 mg/kg). Zearalenone (ZEN), alternariol (AOH) and alternariol mono-methyl ether (AME) were extracted with acetonitrile : 4% aq. KCl: 4N HCl (90:10:2) and lipids removed with hexane. The mycotoxins were partitioned into methylene chloride and, after clean-up on a silica-gel column, were assayed by HPLC using a C-18 column at 35°C. The mobile phase was methanol:water (60:40) at a flow rate of 2 ml/min. Eluted mycotoxins (Table 1) were detected with a F.S. 970 fluorescence detector fitted with a 418 nm emission filter with excitation at 236 nm.

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(iii) Proximate, amino acid and combustible energy analyses The individual feedstuffs and faecal samples were analysed as described by Williams et al. (1984). The composition of the major dietary ingredients is given in Table 1.

Table 1 Chemical content and mycotoxin analysis of the feedstuffs (as fed)

Analyte		Sorghum				Soybean meal
		Undamaged	Baralaba	Biloela	Gladstone	
Dry matter	(%)	88.9	89.0	88.9	89.1	89.9
Ash	(%)	1.7	1.6	1.7	1.7	6.4
Crude Protein	(%)	8.3	12.0	12.6	11.0	45.4
Crude fibre	(%)	1.9	2.9	2.6	3.4	5.1
Gross energy	(MJ/kg)	16.12	16.68	16.47	16.47	17.78
Lysine	(%)	0.240	0.300	0.228	0.241	2.710
Meth. + cyst.	(%)	0.336	0.414	0.421	0.392	1.105
Threonine	(%)	0.322	0.495	0.414	0.380	1.795
ZEN	(mg/kg)	<0.01	0.20	0.09	1.26	
AOH	(mg/kg)	<0.1	6.2	10.8	10.8	
AME	(mg/kg)	<0.1	1.6	5.0	5.4	

(iv) Statistical analysis Data were subjected to an analysis of variance using prepared programmes on a C.D.C. CYBER 76 computer.

(v) Digestibility study - Expt 1 The apparent digestibility of the four sorghums was determined by substitution procedures (50%) in a 5 x 5 latin square design. Male pigs were confined individually in crates and fed daily an amount of feed equal to 5% of live weight$^{0.75}$. Total faecal collections were made over 5 d periods with 5 d periods being allowed between diet changes. Live weights, ± SD, of the pigs at the start and finish of the experiment were 18.3 ± 0.98 and 25.0 ± 1.47 kg respectively.

(vi) Pig growth assay - Expt 2 Grains were compared at identical dietary inclusion levels and at one of two energy concentrations; differences in lysine content of the grains were corrected by synthetic lysine supplementation. Diet formulation is given in Table 2.

Table 2 Formulation (g/kg) of the diets in the growth assay

Feedstuff	Diets 1	2	3	4	5	6	7	8
Sorghum-undamaged	710	-	-	-	710	-	-	-
Sorghum-Baralaba	-	710	-	-	-	710	-	-
Sorghum-Biloela	-	-	710	-	-	-	710	-
Sorghum-Gladstone	-	-	-	710	-	-	-	710
Soyabean meal	220	220	220	220	220	220	220	220
Lysine HCl	0.5	-	1	1	0.5	-	1	1
Starch	30.5	31	30	30	0.5	1	-	-
Vegetable oil	5	5	5	5	35	35	35	35
Vitamins and minerals	34	34	34	34	34	34	34	34

Twenty-four male and 24 female pigs were stratified on live weight at 10 weeks of age into groups of eight of like sex. Within groups, pigs were assigned at random to one of the eight diets and the experiment analysed as a

4x2x2 factorial design. Pigs were fed restrictively. The daily allowance provided 0.9 kg feed for a 20 kg pig which was increased by 0.1 kg feed for each 2.5 kg live weight thereafter until the pig attained 30 kg live weight and then by 0.15 kg feed for each 5 kg live weight up to 60 kg live weight: above 60 kg live weight, pigs were given 2.25 kg feed. Adjustments to the daily feeding allowance were made following the weekly weighing of the pigs. Live weights, $\pm$SD of the pigs at the start and finish of the growth assay were 23.3 $\pm$ 0.84 and 80.7 $\pm$ 3.04 kg respectively. At the finish of the growth assay, pigs were sent for slaughter and standard measurements of midline backfat, P2 backfat, ham weight and dressed weight percentage were made on the chilled carcase.

RESULTS

The apparent digestibilities of the sorghum batches derived by substitution procedures are in Table 3. The digestibilities of the Gladstone sorghum were higher ($P<0.05$) than those of the Baralaba batch and different from the undamaged batch only in respect of a higher crude protein digestibility; digestibilities of the Biloela batch were intermediate.

Table 3 Apparent digestibility (%) of dry matter (DM), organic matter (OM), crude protein (CP) and energy (E) and DE content (MJ/kg) of the sorghum

	Sorghum batches				$\pm$ SEM of
	Undamaged	Baralaba	Biloela	Gladstone	diets
DM	88.3^{a}	80.5^{c}	83.7^{b}	87.3^{a}	0.48
OM	88.0^{a}	81.2^{c}	85.1^{b}	88.1^{a}	0.40
CP	67.4^{b}	67.7^{b}	70.5^{ab}	71.4^{a}	0.75
E	83.6^{ab}	77.5^{c}	81.7^{b}	84.5^{a}	0.48
DE	13.5^{b}	12.9^{c}	13.5^{b}	13.9^{a}	0.08

a,b,c - Means not having a common superscript differed ($P<0.05$).

In the growth assay, no signs of illness or marked feed refusal were observed. The interactions between main effects were not significant. Apart from average midline backfat where males were leaner ($P<0.05$) than females (23.6 cv. 26.6, SEM $\pm$ 0.67 mm respectively), there was no significant sex effect. The only traits significantly ($P<0.05$) affected by sorghum batch or energy level were growth rate, feed:gain and ham weight (Table 4).

Table 4 Effects of sorghum batch and energy level on pig performance

Trait	Sorghum batch				$\pm$ SEM	Energy level		$\pm$SEM
	Undamaged	Baralaba	Biloela	Gladstone		Low	High	
Growth (g/d)	652^{a}	612^{a}	628^{a}	547^{b}	16.4	594^{x}	625^{x}	11.4
Feed:gain	2.68^{a}	2.83^{a}	2.77^{a}	3.06^{b}	0.055	2.89^{y}	2.78^{x}	0.038
Ham (kg)	9.0^{a}	9.3^{a}	9.0^{a}	9.1^{a}	0.08	9.0^{y}	9.2^{x}	0.06

a,b; x,y - Means not having a common superscript differed ($P<0.05$).

Growth rate and feed:gain of pigs given the Gladstone sorghum were inferior ($P<0.05$) to those of all other sorghum batches; performance on the Baralaba and Biloela sorghum batches tended to be inferior to the undamaged sorghum. Carcase measurements were unaffected by the sorghum fed. The energy supplement improved ($P<0.05$) ham weight and feed:gain; growth rate tended to be higher ($P=0.07$).

DISCUSSION

Weather-damaged grain often show decreased digestibility, reduced DE content and, consequently, low nutritive value (Williams and Rao 1978). This occurred with the Baralaba sorghum and, to a lesser extent, with the Biloela sorghum although the DE content of the latter was no less than that of the undamaged grain. The low pig productivity of these two sorghums was overcome by energy supplementation. However, the absence of any interaction between energy supplementation and sorghum batch implies that this was simply a generalised response to an increased supply of energy.

An unexpected result was that the Gladstone sorghum was highly digestible and yet pig performance in the growth assay was extremely poor. This result cannot be explained as being due to amino acid deficiencies as levels of those amino acids likely to influence productivity (Table 1) were as high or higher in the Gladstone sorghum than in the undamaged grain. One possible explanation was that the poor pig productivity on the Gladstone sorghum was due to mycotoxins.

The mycotoxins AOH and AME are produced by Alternaria species of fungi which produce a number of other toxins such as tenuazonic acid, not yet readily assayed. The toxicity of AOH and AME appear to be low. Sauer et al. (1978) fed diets containing 39 mg AOH/kg and 24 mg AME/kg to rats and chickens without signs of toxicity although diets containing tenuazonic acid were lethal. That pig productivity on the Biloela and Gladstone sorghums was markedly different while their AOH and AME levels were almost identical implies that these mycotoxins had little effect.

The higher ZEN concentration in the Gladstone sorghum is most significant indicating greater growth of Fusarium species of fungi than in the other sorghums. ZEN by itself is unlikely to have been the cause of the poor pig growth. Although ZEN can have oestrogenic effects in immature gilts at levels of about 1 mg/kg (Blaney et al. 1984a), these effects were not observed during the experiment. In addition, Smith (1980) found only slightly impaired growth rate and feed conversion at about 50 mg ZEN/kg. However, Fusarium species can produce a large number of toxins in addition to those assayed, including moniliformin, and others still to be identified. The impaired pig performance of the Gladstone sorghum may have been due to these.

Although we cannot be certain as to the reason for the poor performance of pigs given the Gladstone sorghum, the available evidence does not suggest that it was due to changes in chemical composition or nutrient digestibility but rather due to mycotoxins. This underlines the importance of mycotoxin screening in the assessment of nutritive value of weather-damaged sorghum.

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