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SORGHUM GRAIN AS SUBSTITUTE FOR MAIZE IN FATTENING DIETS FOR BEEF STEERS

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OPSOMMING: GRAANSORGHUM AS PLAASVERVANGER VIR MIELIES IN AFRONDINGSDIËTE VIR VLEISRASOSSE

Die vervangingsmoontlikheid van mielies deur graansorghum in afrondingsdiëte is ondersoek aan die hand van 'n verteringsproef met hamels en 'n groeitoets met ossies. In die verteringsproef is 'n 6 x 6 Latynse vierkantontwerp met mielies, voëlbestande- en nie-voëlbestande graansorghum as energiebron gebruik en sonneblomoliekoek of ureum as proteïensupplement. In die groeitoets is diëte waarin mielies vir onderskeidelik 0, 33, 67 en 100%verplaas is deur of voëlbestande- of nie-voëlbestande graansorghum uitgetoets. In die massa-interval 200 tot 300 kg is sonneblomoliekoek as proteïensupplement gebruik en tussen 300 en 400 kg ureum. Alle diëte is in die meelvorm aangebied.

Skynbare VOM het nie betekenisvol tussen die mieliebehandelings en die nie-voëlbestande graansorghumbehandelings verskil nie, terwyl die voëlbestande graansorghumbehandelings hoogs betekenisvol laer was. Soortgelyke waarnemings het ten opsigte van skynbare VRP en N-retensie gegeld alhoewel die persentasie reduksie in skynbare VRP vir voëlbestande graansorghum proporsioneel baie meer drasties was as in die geval van skynbare VOM.

In die groeitoets het die nie-voëlbestande graansorghumbehandelings nie betekenisvol van die mieliebehandelings ten opsigte van inname, massatoename, kg voer/kg lewende massa en kg voer/kg karkasmassa geproduseer, verskil nie. Die voëlbestande graansorghum is hoogs betekenisvol ($p < 0{,}01$) meer ingeneem. Daar was geen betekenisvolle differensiële effekte toe te skryf aan proteïensupplement in of die verteringsproef of groeitoets nie.

SUMMARY:

The possibility of substituting maize for sorghum grain in fattening diets was studied in a digestibility trial with wethers and a growth study with steers. In die digestibility trial a 6 x 6 Latin square design was used with maize, bird-resistant and non bird-resistant sorghum grain as energy sources and sunflower oil cake or urea as protein supplement. In the growth study diets in which maize was replaced by either 0, 33, 67 or 100% bird-resistant or non bird-resistant sorghum grain, were tested. In the mass interval 200 to 300 kg sunflower oil cake was used as protein supplement and between 300 and 400 kg, urea. All diets were supplied in the ground form.

Apparent DOM did not differ significantly between the maize and non bird-resistant sorghum grain treatments, while the bird-resistant sorghum grain treatments were highly significantly lower. Similar results were obtained with regard to apparent DCP and N-retention although the percentage reduction in apparent DCP for bird-resistant sorghum grain was proportionally more drastic than in the case of apparent DOM.

In the growth study there were no significant differences between the maize and non bird-resistant sorghum grain treatments in intake, gain, kg feed/kg live mass or kg feed/kg carcass mass produced. The bird-resistant grain sorghum realized a highly significantly ($p < 0{,}01$) higher intake. Protein supplement did not have a significant differential effect in either the digestibility trial or the growth study.

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The efficiency of utilization of sorghum grain appears to be either the same as that of maize (Brown, Tillman & Totusek, 1968; Hall, Absher, Totusek & Tillman 1968; Taraboanta, Cucu, Vacuru, Halga & Popa, 1971; Hale & Prouty, 1980; Mies & Summers, 1980) or slightly lower – 5 to 15% (Hale, Taylor, Saba, Cuitum & Theurer, 1965; Loyacano, Nipper, Pontif & Hembry, 1973; Newland, Reed, Cahill & Preston, 1973), apparently depending on processing method or amount of polyphenol in the pericarp (Maxson, Shirley, Bertrand & Palmer, 1973). Hale (1973) and Morgan (1975) demonstrated that different methods of processing may affect both the site of starch digestion and the extent of digestion with marked effects on overall efficiency of utilization. The amount of polyphenol could affect the efficiency of utilization of the so-called bird-resistant varieties in particular, because it might decrease the digestibility of starch (Waldo, 1973), structural components in the diet (Ben-Ghedalia & Tagari, 1977) and crude protein (Ford, 1977; White & Hembry, 1978) while intake may also be lowered (Ben-Ghedalia & Tagari, 1977). On the other hand, Pienaar & Renton (1980) did not find any differences between formalin treated bird-resistant sorghum grain and the untreated control.

It would appear therefore, that with all things being equal, even a 15% lower efficiency of utilization of sorghum grain compared to maize would still economically favour the use of sorghum grain in feedlot diets, because of the 20% price differential between maize and non bird-resistant sorghum grain. A further 5 to 10% might be spared if bird-resistant sorghum grain realized the same efficiency as non bird-resistant types. The quoted price differentials were effective in South Africa during the 1980/81 financial year.

With this in mind the current study was undertaken to evaluate both bird-resistant and non bird-resistant sorghum grain as substitutes for maize in fattening diets for beef cattle.

Materials and Methods

Digestibility trial

Six mature wethers were allocated to diets containing either maize (M), bird-resistant sorghum grain (BR) or non bird-resistant sorghum grain (NBR) as sole concentrate source with either sunflower oil cake (S) or urea (U) as protein supplement, according to a 6 x 6 Latin square design. They received 900 g DM per day. At every change-over period a fortnight was allowed for adaptation before commencement of faeces and urine collection. The collection period lasted 8 days.

The effects of 2 protein supplements were investigated because source of protein might affect the extent of decline in microbial growth in the presence of polyphenols (Ben-Ghedalia & Tagari, 1977) and consequently the decline in digestibility. The diets were not compiled on an isocaloric basis but maize was simply replaced by sorghum grain on a mass basis. The diets also were not intended to contain the same amount of protein. The crude protein content of maize and sorghum grain did not differ significantly, but the diets due to protein supplements did ($p < 0{,}05$). The S-diets were slightly higher, 122 g/kg feed vs 113 g/kg for the U-diets. The possible effect of protein supplement on digestibility should therefore be qualified as really an effect of supplement x protein feeding level. The reasons for the difference in feeding level of protein are described under the heading 'Growth Trial'.

The diets tested are shown in Table 1.

Faeces and urine collections were done according to conventional procedures. Representative samples of the diets and faeces and aliquots of the urine were analysed for N while the diet and faeces samples were also analysed for DM, ash, Ca, P and crude fibre according to A.O.A.C. procedures (A.O.A.C., 1970).

Growth trial

Thirty five homogenous Sussex type weaner steers were allocated at rondom to one of 7 diets in which M meal was replaced by either 0, 33, 67 or 100% NBR or BR sorghum grain meal. The diets were similar in all other respects to those in Table 1 except that sunflower oil cake meal plus urea were incorporated as protein supplement when the steers grew from 200 to 300 kg live mass, and only urea when they grew from 300 to 400 kg. The intention was two fold, to establish whether source x protein feeding level influences the efficiency of utilization of BR sorghum grain and to simulate the commercial feedlots where normally only urea is used as protein supplement.

Ad lib intake and mass changes of every individual steer were recorded weekly and all steers were slaughtered on reaching 400 kg live mass. The mass of the carcass and the grade realized were recorded.

A two-way analysis of variance procedure was used with concentrate type and protein source x feeding level as variables to establish whether the latter influenced the results differentially. Within growth interval tests for significance were done by t-test following a procedure of minimizing measurement error by fitting a descriptive function to the data (Roux, 1976; Meissner, 1977).

Table 1

Composition of diets in g/kg feed

Ingredient	S			U		
	M	NBR	BR	M	NBR	BR
Maize	723	–	–	742	–	–
NBR sorghum meal	–	723	–	–	742	–
BR sorghum meal	–	–	723	–	–	742
Wheat straw	100	100	100	110	110	110
Eragrostis curvula hay	100	100	100	110	110	110
Sunflower oil cake	40	40	40	–	–	–
Urea	12	12	12	13	13	13
Salt	10	10	10	10	10	10
Dicalcium phosphate	8	8	8	8	8	8
Calcium carbonate	7	7	7	7	7	7
Commercial mixture of minerals & vitamins	1	1	1	1	1	1

Chemical analysis.

	Range
Crude protein (g/kg)	113 – 122
Calcium (g/kg)	52 – 58
Phosphorus (g/kg)	34 – 45
Crude Fibre (g/kg)	119 – 136
Energy apparently digested (MJ/kg)	11,5 – 13,0

Table 2

Apparent digestibility of OM, N and crude fibre, and N-retention of sheep on diets containing either M, NBR or BR as energy source and either S or U as N-source

	M–S	M–U	NBR–S	NBR–U	BR–S	BR–U
DOM (%)	$81{,}6_a$*	$79{,}0_a$	$79{,}3_a$	$80{,}5_a$	$71{,}1_b$	$71{,}4_b$
DCP (%)	$80{,}8_a$	$79{,}1_a$	$77{,}5_b$	$74{,}1_b$	$52{,}9_c$	$51{,}0_c$
Faeces N (g/day)	$3{,}42_a$	$3{,}95_a$	$4{,}26_b$	$4{,}46_b$	$7{,}15_c$	$7{,}31_c$
N retention (g/day)	$8{,}60_a$	$8{,}94_a$	$10{,}8_a$	$8{,}40_a$	$5{,}45_b$	$5{,}43_b$
Urine N (g/day)	$5{,}76_a$	$6{,}02_a$	$3{,}84_a$	$4{,}38_a$	$2{,}78_b$	$2{,}17_b$
DCF (%)	$61{,}5_a$	$64{,}8_a$	$56{,}3_a$	$60{,}3_a$	$55{,}9_a$	$53{,}4_a$

* Figures in the same line bearing the same subscript letters do not differ significantly.

Results and Discussion

The results of the digestibility trial are shown in Table 2.

None of the measures were significantly influenced by N-source. DOM was not significantly different between the M and NBR treatments, while both differed by about 11 percentage units from the BR treatments. If it is accepted that the DOM of the roughage source of wheat straw and *Eragrostis curvula* was about 50% and that there was no interaction between energy and roughage source, it follows that the DOM of M, NBR and BR must have been 87,9; 87,4 and 76,6% respectively.

DCP differed significantly ($p < 0{,}05$) between the M and NBR treatments while both differed highly significantly ($p < 0{,}01$) from the BR treatments. The lower digestibilities in comparison to maize could be a function of the polyphenol content of the sorghum types, 0,65 and 1,64% for NBR and BR respectively. This would be in accordance to the findings of Ford (1977) and White & Hembry (1978). Presumably the polyphenols influence the degradability of feed protein. In the presence of polyphenols it is expected that feed protein would become less degradable in the rumen, but the very low overall digestibility would suggest that the undegradable portion was not readily digested in the lower intestine. Ben-Ghedalia & Tagari (1977) suggested that microbial growth in the rumen declines in the presence of polyphenols. If this is the case there must have been compensatory fermentation in the hindgut because the influence on apparent DOM was much less than on apparent DCP, results which are substantiated by those of Maxson *et al.* (1973) and White & Hembry (1978). Nitrogen of course, would not be absorbed in the hindgut.

The low apparent DCP of BR sorghum in comparison to maize and NBR sorghum was partly compensated for by a highly significant ($p < 0{,}01$) reduction in excretion of N in the urine (Table 2). This was also apparent in the case of NBR sorghum ($0{,}05 < p < 0{,}1$) in comparison to maize. The compensation however, was not absolute because N retention for the BR treatment was still highly significantly ($p < 0{,}01$) less than the NBR or M treatments. This is in accordance to the results of White & Hembry (1978). The percentage DCF did not differ significantly between treatments, although the BR treatments tended to be lower. Crude fibre excretion in the faeces in this study was very much a function of individual variation.

The results of the growth trial are shown in Table 3. The table is split into two parts. In the A-portion of Table 3 the results of the steers are those between 200 and 300 kg live mass when sunflower oil cake was used as protein supplement and a B-portion depicting the results between 300 and 400 kg live mass when urea was the protein supplement.

Table 3

Intake, gain in live mass and feed conversion ratio of steers on different proportions of M to NBR or BR treatments

	100M §	33NBR	33BR	67NBR	67BR	100NBR	100BR
A. 200 to 300 kg							
Gain							
DM intake (kg/day)	5,7$_a$*	5,4$_a$	6,2$_{ab}$	5,0$_a$	5,2$_a$	5,3$_a$	7,1$_b$
Gain (kg/day)	1,0$_{ab}$	1,0$_{ab}$	1,0$_{ab}$	0,97$_{ab}$	0,85$_a$	1,0$_{ab}$	1,2$_b$
Kg feed per kg gain	5,7$_a$	5,4$_a$	6,2$_a$	5,2$_a$	6,1$_a$	5,9$_a$	5,3$_a$
B. 300 to 400 kg							
Gain							
DM intake (kg/day)	6,8$_a$	7,1$_a$	7,1$_a$	6,7$_a$	7,0$_a$	7,3$_a$	9,7$_b$
Gain (kg/day)	0,78$_{ab}$	0,83$_{ab}$	0,77$_{ab}$	0,70$_a$	0,76$_{ab}$	0,70$_a$	0,98$_b$
Kg feed per kg gain	8,7$_a$	8,6$_a$	9,2$_a$	9,6$_{ab}$	9,2$_a$	10,4$_b$	9,9$_{ab}$
Kg feed per kg carcass	10,6$_{ab}$	9,7$_a$	11,6$_{ab}$	10,6$_{ab}$	–	11,2$_{ab}$	11,9$_b$

§ In the treatments maize (M) was replaced by 0,33, 67 or 100% of non bird resistant (NBR) or bird-resistant (BR) sorghum grain.

* Figures in the same line bearing the same subscript letters do not differ significantly.

The results indicate the following: There was no significant interaction between protein and energy source, which is in accordance to what was found in the digestibility study. The 100 BR treatment in both growth intervals realized a highly significantly ($p < 0,01$) higher intake than all other treatments. There were no significant differences between treatments in both growth intervals with respect to live mass gain, kg feed per kg live mass gain or kg feed per kg carcass mass produced. The 100 BR group however, tended to gain more which accounts for the non significant difference in kg feed per kg gain.

The results of the digestibility trial serve as basis to interpret the findings in the growth trial: To compensate for the lower digestibility of BR sorghum the steers consumed about 30% more. This higher intake could be interpreted as even an overcompensation because a slight growth response was realized which lead to very similar efficiencies of feed conversion to those realized on the M and NBR treatments. Since there were no significant treatment differences in carcass mass, dressing percentage or grade, it can be concluded that both NBR and BR sorghum could be economically very competitive in fattening diets. One should however, take cognizance of the fact that both NBR and BR varieties may vary considerably in nutritional value which could have a substantial effect on performance. For example, White & Hembry (1978) reported DE values in the USA for NBR varieties between 66,1 and 77,8% and for BR varieties between 54,3 and 68,3%.

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