The value of malt distillers' grains ensiled with molassed sugar beet pellets as a feed for dairy cows

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Abstract

In one experiment twenty-four Holstein Friesian cows, average 43 d post-partum, were used in a changeover design experiment to evaluate the replacement of a cereal-based concentrate supplement (C) by an ensiled mixture (MGBP) of malt distillers' grains and molassed sugar beet pellets. The cows were offered grass silage *ad libitum* [dry matter (DM) content 170 g kg^{-1}, crude protein (CP) concentration 160 g kg DM^{-1}, metabolizable energy (ME) concentration 10·9 MJ kg DM^{-1}] and either C or MGBP at one of three levels (3, 6, 9 kg DM d^{-1}). The composition of C and MGBP were DM content: 853 and 296 g kg^{-1}, CP concentration: 202 and 187 g kg DM^{-1}, ME concentration: 12·6 and 10·8 MJ kg DM^{-1} respectively. The cows ate all the C supplement but the intakes of MGBP were 2·7, 4·9 and 6·4 kg DM d^{-1} for the 3, 6 and 9 kg DM d^{-1} levels of MGBP respectively. Total DM intakes (kg d^{-1}) were 12·5, 15·6, 18·2 for treatments 3-C, 6-C and 9-C and 13·1, 14·4 and 15·9 (s.e., 0·90) for treatments 3-MGBP, 6-MGBP and 9-MGBP respectively. Milk yields (kg d^{-1}) for treatments 3-C, 6-C and 9-C were 19·9, 23·2 and 24·2, respectively, and for treatments 3-MGBP, 6-MGBP and 9-MGBP were, 20·3, 21·3 and 23·0 respectively (s.e., 1·05). Milk fat contents (g kg^{-1}) for treatments 3-C, 6-C and 9-C were 42·8, 42·3, 43·5 respectively and for treatments 3-MGBP, 6-MGBP and 9-MGBP were 39·5, 38·7 and 38·2 (s.e, 1·86), respectively, and milk protein contents (g kg^{-1}) for treatments 3-C, 6-C and 9-C were 30·5, 30·6, 31·8, respectively, and for 3-MGBP, 6-MGBP and 9-MGBP were 30·0, 30·8 and 31·2 (s.e., 0·66) respectively. Milk yield and milk protein contents were significantly higher for the higher levels of supplementary feeding but there was no difference between the types of supplement. The milk fat contents were significantly lower on the MGBP than C supplements.

In a second experiment fifteen Holstein Friesian cows, average 126 d post-partum, were used in a changeover experiment to evaluate the replacement of all (treatment M) or half (treatment MS) of the grass silage (S) in their diet by a mixture of MGBP and straw. All cows received 5·1 kg DM d^{-1} of concentrate feed. Forage DM intakes were 8·3, 11·2 and 14·2 kg DM d^{-1} for the S, MS and M treatments respectively. Milk yields (kg d^{-1}) for S, MS and M treatments were 17·0, 19·4 and 20·0 (s.e., 0·56) respectively. Corresponding contents of milk fat and protein (g kg^{-1}) were 42·0, 41·4, 38·6 (s.e., 0·37) and 33·8, 34·1, 34·2 (s.e., 0·42).

Ensiled mixtures of malt distillers' grains and molassed sugar beet pellets can be used to replace some of the conventional concentrates or grass silage for dairy cows giving moderate yields without a loss of production.

Keywords: wet distillers' grains, sugar beet pulp, dairy cows, concentrate

Introduction

Malt distillers' grains are a wet by-product from the whisky industry and are derived when the parent cereal, barley, undergoes a water extraction process. During the 1960s there was a trend for distillers to produce dried products, such as dark grains, but with increased drying costs there has since been a renewed interest in marketing wet distillers' grains (Lilwall and Smith, 1983). In an attempt to minimize feed costs in dairying, several studies have considered the use of brewing or distilling by-products to replace conventional concentrates in dairy cow diets. Murdoch *et al.* (1981) fed rations in which wet brewers' grains constituted 0·30 of the ration on a dry matter (DM) basis without any significant decline in milk production. Castle and Watson (1982) noted an increase in milk yield when dairy cows were fed a mixture of malt distillers' grains and pot ale syrup as a concentrate

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in three feeds daily compared with a conventional concentrate diet. The storage of malt distillers' grains was evaluated by Hyslop *et al.* (1989) and the most successful method, in terms of reduction of DM losses, was their ensilage with molassed sugar beet shreds. This method involved uniform mixing of the two feeds, compacting layers of 60 cm and effective sheeting of the silo. Hyslop and Roberts (1990) replaced barley and soya bean meal in complete diets with malt distillers' grains and molassed sugar beet pellets up to the level of 0·47 of the total DM intake. Milk yield was maintained but, at this level of incorporation, both milk fat and protein content declined.

The objectives of the current experiments were to evaluate the potential of an ensiled mixture of malt distillers' grains and molassed sugar beet pellets as an alternative to either concentrates or grass silage in diets for dairy cows.

Materials and methods

Experimental design and diets

Experiment 1

Twenty-four Holstein Friesian dairy cows were selected on the basis of the number of days post-partum [mean 43 d (range 24–73)]. The experiment commenced with a 16-d covariance period during which all cows were offered 7 kg d^{-1} concentrate in two feeds daily and silage *ad libitum*. The cows were then allocated to four blocks of six cows, balanced for milk yield, live weight and number of days post-partum. The mean milk yield and live weight were 26·0 (s.d., 4·76) kg d^{-1} and 583 (s.d., 48·2) kg respectively. The supplement treatments comprised concentrate (C) or an ensiled mix of malt distillers' grains and molassed sugar beet pellets (MGBP). The ingredients in C (in g kg^{-1} DM) were: barley (250), wheat (200), maize gluten (200), soya bean meal (150), wheat feed (80), molasses (50), fish meal (20), fat supplement (20) and mineral and vitamin supplement (30). Both supplements were offered at three levels of feeding (3, 6 or 9 kg DM d^{-1}). The cows in each block were allocated at random to the C and P treatments. The experiment consisted of three periods each of 3-week duration and cows were changed from one level to another over a 4-d period (the first 4 d of each period). During the experiment, cows changed the levels but not the type (C or MGBP) of supplement offered. Each level of supplement was tested in each period and the changeovers occurred in a random order for cows fed each supplement. The C or MGBP supplements were offered daily in three equal feeds at 08·30, 12·30 and 15·30 hours in separate bins from the grass silage. The feeding bins were removed after 30- and 45-min feeding periods for C and MGBP supplement respectively. Refusals were recorded and supplement intake was calculated. The time allowed for feeding was based on a suitable period for feeding a supplement of 45 min. Silage was fed *ad libitum* with a 0·10 refusal level.

Experiment 2

Fifteen multiparous Holstein Friesian dairy cows were used [mean 126 d post-partum (range 108–142)], with a mean milk yield of 19·8 kg d^{-1} and live weight of 557 kg. Cows were allocated to five blocks of three cows on the basis of milk yield and days post-partum. Three treatments were evaluated: silage (S), a mixture of MGBP and straw (M) and a 50:50 mix (on a DM basis) of silage and M (MS). The forages were provided *ad libitum* with a 0·10 refusal level and all cows also received 6 kg d^{-1} of the same concentrate feed. The experiment consisted of three periods, each of 4-week duration, and was of a complete fully randomized changeover design. Within each block, cows were randomly allocated to one of the three treatments.

Silage for both experiments was made from the primary growth of a predominantly perennial ryegrass (*Lolium perenne*) sward cut on 22–25 May 1989 at SAC Dairy Research Centre, Dumfries, UK (55°3′N, 3°53′W). The herbage was wilted for 6–12 h before being harvested with a precision-chop forage harvester. Sulphuric acid was used as an additive at a rate of 3·5 l t^{-1} before ensiling in an unroofed silo. In mid-July the malt distillers' grains were mixed with molassed sugar beet pellets. The mixture contained 0·18 molassed sugar beet pellets on a fresh weight (FW) basis (0·41 on a DM basis) and was left overnight before being ensiled in an unroofed silo. The mixture was rolled using a two wheel-drive tractor with dual wheels.

A mineral mix was added to the MGBP prior to feeding at the rate of 50 g kg^{-1} DM and contained (in g kg^{-1}) calcium (100), phosphorus (50), magnesium (35), sodium chloride (60) and potassium (150). The concentrate feed contained (in g kg^{-1} FW) barley (250), wheat (200), maize gluten (200), soya bean meal (150), wheat feed (80), molasses (50), fish meal (20), fat supplement (20) and mineral supplement (30) and was fed as a pellet.

Management and measurements

Cows were group-housed with access to individual feeding boxes fitted with transponder-operated Calan gates (Broadbent *et al.*, 1970). Water was always available to all cows.

Feeds were sampled daily in the last 4 d of each period for the determination of chemical composition.

Oven DM determinations at 98°C for 12 h were performed daily. Digestibility of DM of the feeds was determined by the *in vitro* technique of Alexander (1969) and Alexander and McGowan (1969). The metabolizable energy (ME) concentration (MJ kg DM^{-1}) of the feeds was estimated using the following equations (J. Dixon, pers. comm.):

$$\text{ME concentration of silage} = 0{\cdot}16(0{\cdot}907\,\text{IVD} + 6{\cdot}03),$$

$$\text{ME concentration of MGBP} = \text{A} + \text{B},$$

where $\text{A} = 0{\cdot}0155\ \text{IVD}\ [(1000 - \text{EE})/1000]$ and $\text{B} = 0{\cdot}0308\ \text{EE}$.

$$\text{ME concentration of concentrate} = 0{\cdot}14\ \text{NCD} + 0{\cdot}25\ \text{AHEE},$$

where IVD is the concentration of digestible organic matter in the DM (g kg^{-1} DM) and NCD is the neutral cellulase digestibility (g kg^{-1} DM) (Thomas *et al.*, 1988). EE is the ether extract and AHEE is the acid-hydrolysed ether extract (both expressed as g kg^{-1} DM).

Feed intakes were recorded during the last 4 d of each period. Milk yields of individual cows were recorded twice daily on the last 4 d of each period. Milk samples were taken twice daily during milking on the last 4 d of each period and analysed for the contents of fat, protein and lactose (Biggs, 1979). Milk samples were taken for fatty acid analysis during the last day of each period and each of the feeds were analysed for their fatty acid profile using the method described by Offer *et al.* (1999).

Live weight of the cows was recorded at *c.* 08·00 hours three times per week. Liveweight change was estimated from linear regression of live weight on time. A line of best fit was calculated from individual cow live weights for each period. The liveweight change results for each cow for each period were then statistically analysed as described below.

Statistical analysis

The data were examined by analysis of variance using the Genstat V statistical package (Genstat V Committee, 1980). The main factors in the analysis of Experiment 1 were block and period and the interactions of block × cow, block × period and block × cow × period. Effects of supplement type were estimated within the block × cow stratum (error degrees of freedom = 18) while supplement level and its interaction with supplement type were evaluated using the block × cow × period stratum (error degrees of freedom = 34). Data recorded in the covariance period of Experiment 1 for milk yield, milk composition and feed intake were used as covariates in the analysis of the respective data. Experiment 2 was a complete changeover design. The main factors in the analysis for Experiment 2 were as described for Experiment 1 and the effect of treatment was estimated within the block × cow × period stratum using an error degrees of freedom of 13 (there were five missing values, total degrees of freedom = 38).

Results

The composition of the feeds is shown in Table 1. The MGBP supplement was a moist, bulkier feed compared with supplement C and had lower crude protein (CP)

Table 1 The chemical composition of feeds (g kg^{-1} DM unless otherwise stated).

	Experiment 1			Experiment 2			
	Silage	MGBP/ MSBN††	Concentrate	Silage	MGBP/ MSBN	Straw	Concentrate
Dry-matter content (g kg^{-1})	170	296	853	182	288	821	861
Crude protein concentration	160	187	202	152	181	30	201
Ash concentration	85	72	86	72	76	44	91
DOMD* *in vitro*	690	610	–	725	616	44	–
Ether extract	–	63	42	–	69	–	57
Estimated ME (MJ kg^{-1} DM)	10·9	10·8	12·6	11·4	11·0	6·5	12·7
Ca concentration	5·5	5·7	8·9	–	–	–	
P concentration	3·6	5·4	7·3	–	–	–	
Mg concentration	2·1	2·0	8·2				
Ammonia N concentration (g kg^{-1} total N)	122	–	–	114	–	–	–
pH	4·0	–	–	3·8	–	–	–

ME, metabolizable energy.

*DOMD, digestible organic dry matter in the dry matter.

††Malt distillers' grains ensiled with molassed sugar beet pellets.

Table 2 Daily dry matter (DM) intakes (kg d^{-1}) and metabolizable energy (ME) intake (MJ d^{-1}) in Experiment 1.

	Treatments						s.e.d.		Level of significance	
	C			MGBP						
Level of supplement	3	6	9	3	6	9	Supplement	Level	Supplement	Level
Supplement DM intake	3·0	6·0	9·0	2·7	4·9	6·4	0·33	0·24	***	***
Silage DM intake	9·6	9·7	9·4	10·4	9·5	8·7	0·51	0·39	***	***
Total DM intake	12·5	15·6	18·2	13·1	14·4	15·0	0·76	0·46	n.s.	***
ME intake	138	180	212	142	155	160	8·3	4·8	**	***

C, cereal-based concentrate supplement; MGBP, malt distillers' grains and molassed sugar beet pellets; n.s., not significant.
$^{**}P < 0{\cdot}01$, $^{***}P < 0{\cdot}001$.

and ME concentrations. The DM content, estimated ME and CP concentrations of the MGBP and straw treatment (M) in Experiment 2 were 328 g kg^{-1}, 10·0 MJ kg^{-1} DM and 153 g kg^{-1} DM respectively.

Mean daily DM intakes are shown in Tables 2 and 3. In Experiment 1, cows consumed less MGBP than C supplement and the differences were significant at $P < 0{\cdot}05$ at the 6- and 9-kg levels. There was a trend of reduced silage DM intake with increasing level of MGBP supplement, although this difference was not significant. There was no significant effect of type of supplement on total DM intake, but both level of supplement and the interaction between supplement and level showed significant effects ($P < 0{\cdot}001$ and $P < 0{\cdot}01$ respectively). In Experiment 2, replacement of 0·50 of silage by MGBP and straw (treatment MS) increased DM intake proportionately by 0·35 compared with the silage treatment (treatment S). There was a further increase of 0·27 with treatment M.

Table 3 Daily dry matter (DM) intakes (kg d^{-1}) and metabolizable energy (ME) intake (MJ d^{-1}) in Experiment 2.

	Treatments			
	S	MS	M	s.e.d.
Concentrate DM intake	5·1	5·1	5·1	
Basal diet DM intake	8·3	11·2	14·2	0·48***
Total DM intake	13·4	16·4	19·3	0·48***
ME intake	162	176	196	8·1*

S, silage; M, a mixture of malt distillers' grains, molassed sugar beet pellets and straw; MS, 50:50 mix of M and S.
$^{*}P < 0{\cdot}05$, $^{***}P < 0{\cdot}001$.

Mean daily milk yields, milk composition and component yields are shown for the treatments in Tables 4 and 5. Daily milk yield increased significantly ($P < 0{\cdot}001$) with increasing level of supplement in

Table 4 Dairy cow performance in Experiment 1.

	Treatment						s.e.d.		Level of significance	
Level of supplement	Concentrate			MGBP						
(kg d^{-1})	3	6	9	3	6	9	Supplement	Level	Supplement	Level
Milk yield (kg d^{-1})	19·9	23·2	24·2	20·3	21·3	23·0	0·88	0·51	n.s.	***
Milk composition (g kg^{-1})										
Fat	42·8	42·3	43·5	39·5	38·7	38·2	1·47	0·98	*	n.s.
Protein	30·5	30·6	31·8	30·0	30·8	31·2	0·39	0·46	n.s.	*
Lactose	48·1	48·6	48·7	47·9	48·0	48·4	0·38	0·32	n.s.	n.s.
Component yield (g d^{-1})										
Fat	855	984	1054	796	823	876	30·4	26·7	***	***
Protein	605	710	763	602	646	709	25·0	17·5	n.s.	***
Lactose	968	1130	1184	974	1027	1114	43·5	27·0	n.s.	***
Estimated liveweight gain (kg d^{-1})	0·71	0·49	0·73	0·25	0·70	0·50	0·159	0·199	n.s.	n.s.

MGBP, malt distillers' grains and molassed sugar beet pellets; n.s., not significant.
$^{*}P < 0{\cdot}05$, $^{***}P < 0{\cdot}001$.

Experiment 1 but there was no significant effect of type of supplement. Milk protein content was not influenced by type of supplement, but there was a significant increase with level of supplement ($P < 0{\cdot}05$). The yields of milk fat, protein and lactose increased with increasing level of supplement ($P < 0{\cdot}01$). Yields of milk protein and lactose were not influenced by type of supplement but milk fat yield was significantly ($P < 0{\cdot}001$) higher for cows fed the conventional concentrate. In Experiment 2, treatment S had a significantly ($P < 0{\cdot}001$) lower milk yield than the other treatments, and milk fat content was significantly ($P < 0{\cdot}05$) lower for the M treatment. There were no significant differences in fat yield, but protein yield was significantly higher ($P < 0{\cdot}05$) for treatments MS and M than for S. The liveweight change results, estimated by regression of live weight on time, are also shown in Tables 4 and 5. In Experiment 1, liveweight change was unaffected by supplement type or level of supplement. In Experiment 2, liveweight gain was significantly lower for treatment S than for the other treatments ($P < 0{\cdot}05$).

Dietary and milk fatty acid profiles are shown in Tables 6 and 7 respectively. Diets containing the MGBP supplement had higher contents of long chain fatty acids and unsaturated fatty acids compared with the concentrate C diets in Experiment 1 and with the S diet in Experiment 2. Milk fat from cows receiving diets containing MGBP had significantly higher proportions of unsaturated fatty acids, but lower proportions of short-chain (≤C14) fatty acids, than milk fat from those receiving silage and conventional concentrates ($P < 0{\cdot}05$).

Table 5 Dairy cow performance in Experiment 2.

	Treatment			
	S	MS	M	s.e.d.
Milk yield (kg d^{-1})	17·0	19·4	20·0	0·56***
Milk composition (g kg^{-1})				
Fat	42·0	41·4	38·6	1·29*
Protein	33·8	34·1	34·2	0·37 n.s.
Lactose	47·0	47·8	47·3	0·42 n.s.
Component yield (g d^{-1})				
Fat	694	790	761	36·5 n.s.
Protein	552	638	659	23·2***
Lactose	785	911	927	29·2***
Estimated live-weight change (kg d^{-1})	0·12	0·90	0·89	0·110***

S, silage; M, a mixture of malt distillers' grains, molassed sugar beet pellets and straw; MS, 50:50 mix of M and S; n.s., not significant.
*$P < 0{\cdot}05$, ***$P < 0{\cdot}001$.

Table 6 Fatty acid composition and other fat in the total diet of treatments in Experiments 1 and 2 (g kg^{-1} fat).

Experiment 1	Concentrate			MGBP mix		
Level of supplement (kg d^{-1})	3	6	9	3	6	9
Total short chain ≤ C14·1	10	11	12	5	5	5
Total long chain ≥ C16·0	990	989	987	996	995	995
Total unsaturated	701	659	629	767	759	756
Experiment 2	**S**			**MS**		**M**
Total short chain ≤ C 14·1	35			20		10
Total long chain ≥ C 16·0	965			980		990
Total unsaturated	601			639		659

MGBP mix, malt distillers' grains and molassed sugar beet pellets;
S, silage; M, a mixture of malt distillers' grains, molassed sugar beet pellets and straw; MS, 50:50 mix of M and S.

Table 7 Fatty acid composition of milk fat of cows given experimental diets in Experiments 1 and 2 (g kg^{-1} fat).

	Treatment									
Experiment 1	Concentrate			MGBP mix			s.e.d.		Level of significance	
Level of supplement (kg d^{-1})	3	6	9	3	6	9	Feed	Level	Feed	Level
Total short chain ≤ C14·1	277	292	300	262	264	265	6·450	4·610	***	*
Total long chain ≥ C16·0	686	674	664	692	692	690	6·290	4·430	**	*
Total unsaturated	259	251	253	280	287	295	8·640	5·540	**	n.s.
Experiment 2	**S**			**MS**			**M**			
Total short chain ≤ C14·1	281			263			224			
Total long chain ≥ C16·0	676			691			729			
Total unsaturated	279			310			367			

MGBP mix, malt distillers' grains and molassed sugar beet pellets; S, silage; M, a mixture of malt distillers' grains, molassed sugar beet pellets and straw; MS, 50:50 mix of M and S; n.s., not significant.
*$P < 0{\cdot}05$, **$P < 0{\cdot}01$, ***$P < 0{\cdot}001$.

Discussion

Dry-matter intake

Experiment 1 examined the effect of replacing a cereal-based concentrate with MGBP in grass silage-based diets for dairy cows. Hyslop and Roberts (1988) reported no effect on performance when malt distillers' grains were used to replace cereal-based concentrates up to the level of 2·1 kg DM d^{-1} when the supplement was fed twice daily in a grass silage-based ration. However, at higher replacement rates, total DM intake was greatly reduced. The intake of 4·9 kg DM d^{-1} MGBP in the current experiment did not reduce total intake compared with the C-6 treatment. This may be due to the presence of the molassed sugar beet pellets as an absorbent in the ensiled material. Several possible explanations for this observation may be proposed. First, addition of molassed sugar beet pellets increased the DM content of the mixture substantially which is known to increase intake (Offer *et al.*, 1998). Secondly, Hyslop *et al.* (1989) showed that the incorporation of molassed sugar beet with malt distillers' grains improved fermentation in the silo as shown by the pattern of fermentation acids. This led to increased feed intake by young Friesian steers in comparison with ensiled malt distillers' grains offered either without cereal-based supplementation or supplemented at feeding with an equivalent amount of molassed sugar beet. Thirdly, the unsaturated fat found in malt distillers' grains depresses the activity of rumen bacteria leading to reduced digestibility, low intakes and poor ruminal performance (Lewis, 1991). In the current experiment, the incorporation of molassed sugar beet pellets would have diluted the fat concentration and thus, may have had an ameliorating effect on ruminal microbial activity. The provision of a steady supply of nutrients to rumen micro-organisms associated with three times daily feeding may also have been a contributing factor to the higher intakes of the MGBP. Thus, ensiling malt distillers' grains with molassed sugar beet pellets leads to substantial increases in intake. However, intakes of the MGBP supplement, especially at the highest level, were lower than that found for conventional concentrates. This is probably caused by physical (bulk) effects as the MGBP has a substantially lower DM content and DM density.

Although the effect of type of concentrate on silage intake was not significant, this could have been due to the difference between actual and planned levels of consumption of the distillers' grains supplement. When substitution rates were calculated, the substitution rate increased with the level of concentrate feeding for both forms of supplement. The substitution rate between the 3- and 6-kg levels of supplement for the concentrate was 0·03 and between the 6- and 9-kg levels of supplement was 0·11. The corresponding substitution rate values for the MGBP supplements were much higher at 0·46 and 0·53. The unexpectedly low substitution rates for the conventional concentrate may have been caused by the relatively low intake potential of the grass silage. The higher substitution rates associated with MGBP may have been caused by physical 'fill' effects arising from its lower DM content per unit volume and also possible lower rate of digestion in the rumen due to its higher concentration of fibre and unsaturated fatty acids.

In Experiment 2, inclusion of mixtures containing MGBP in place of grass silage led to a higher total DM intake. Roberts (1988) reported a similar increase when a forage consisting of a straw mix and silage replaced silage in diets for dairy cows. In a partial storage feeding system, Aston *et al.* (1987) fed a 1:1 mix of silage and brewers' grains and reported an increase of 2·0 kg DM cow day^{-1} compared with cows fed silage overnight. The DM of the diets fed for treatments S, MS, and M were 182, 235 and 328 g kg^{-1} respectively. McDonald *et al.* (1990) reported a positive relationship between voluntary intake of forages and forage DM content. In the present experiment, total intake of DM increased by 2 kg d^{-1} as DM content increased from 235 to 328 g kg^{-1}, which is comparable with increases reported by Phipps (1990) with maize silage.

Milk yield and composition

Milk yield increased in Experiment 1 as the level of supplement increased. However, there was no significant effect of the type of supplement, despite the fact that total DM intakes by cows of the diets containing MGBP were lower, particularly at the higher level of inclusion of MGBP. This finding probably reflects the relatively small numbers of cows used in the experiment and differences in liveweight change which are difficult to detect in a short-term experiment.

In Experiment 2 replacement of all (M) or half of the silage (MS) by the MGBP-straw mix led to higher DM intakes and milk yields. An average increase in milk yield of 2·7 kg d^{-1} was achieved for treatments MS and M compared with yields for treatment S. Additionally, there was evidence of higher liveweight gain from the diets containing MGBP indicating that the extra 39 MJ of ME consumed was partitioned to liveweight gain as well as milk production, which is consistent with the cows being 18 weeks post partum at the start of the experiment.

There was a reduction in milk fat content in both experiments as the proportion of MGBP in the diet increased, although this trend was not statistically significant in Experiment 1. A similar trend was also reported by Hyslop and Roberts (1990) when the concentrate component of a complete diet was replaced with a malt distillers' grain/sugar beet pulp/mineral mix to the level of 0·46 of the total DM intake. The depression in milk fat content occurring on diets containing malt distillers' grains may be related to the fatty acid composition of the feed. Malt distillers' grains contain fat, which characteristically consists of a high proportion of unsaturated fatty acids (see Table 6), which would be expected to lead to a depression of milk fat content as a result of changes in microbial metabolism in the rumen leading to increased production of propionate and *trans* fatty acids and isomers of conjugated linoleic acid (Offer *et al.*, 1999). Individual *trans* fatty acids were not measured but evidence from many experiments (discussed by Offer *et al.*, 1999) shows that this is the main mechanism for depression in milk fat content arising from dietary unsaturated fatty acids. The observed reduction of the proportion of short-chain fatty acids (≤C14) in milk fat when MGBP is added to the diet is consistent with this theory and arises partly because of increased transfer of dietary long-chain fatty acids to milk and partly because of inhibition of *de novo* synthesis of fatty acids in the mammary gland by *trans* fatty acids and conjugated linoleic acid isomers. It is likely that the health properties of the milk produced from diets containing MGBP would be improved as a result of these effects, although more detailed fatty acid analysis would be needed to confirm this.

Conclusions

Ensiled mixtures of malt distillers' grains and molassed sugar beet pellets can be used to replace conventional concentrates for cows giving moderate yields without serious loss of production. A probable practical limit to their use is the replacement of 5 kg d^{-1} of a cereal-based concentrate. At levels of replacement above this, the increased substitution rates observed for the diets containing MGBP would be expected to lead to reduced performance in the long term. However, there may be no such limit for the use of a MGBP and straw mix to replace grass silage in the diet of mid-lactation cows. In this case, increases in DM intake, milk yield and liveweight gain can be expected.

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