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Maize Silage For Milk Production

2. Effect of concentrate quality and quantity fed with maize silage based forages on milk production

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SUMMARY

In some of the studies outlined in Part 1 of this report, mixed forages containing grass silage and a high proportion (60%) of maize silages varying in maturity and starch content were supplemented with concentrates at different levels to compare the response in milk production with a maize silage based forage and with good quality grass silage as the sole forage. The most suitable type of energy ingredient in the concentrate, i.e. high starch or low starch, high fibre ingredients, as supplements to maize silage based forages or grass silage was investigated. A range of levels of crude protein in the concentrate were examined in one study to determine the optimum level of crude protein in the supplement for maize silage based forages compared with grass silage.

Main Findings :

- With a mixed forage containing immature low starch maize silage, the response to increased concentrate supplementation (4 to 8 kg/cow/day) was less in terms of milk yield than that obtained with a good quality grass silage (0.43 v 0.92 kg milk/kg concentrate DM). However, due to improved milk protein concentration on the maize silage based forage, the response in terms of fat and protein yield was similar for both types of forage (58 v 65 g/kg concentrate DM). A similar level of concentrate supplementation would be required with both types of forage to achieve the same yield of milk solids.

- The response in milk production to increased concentrate supplementation (4-8 kg/day) was less with a mixed forage based on mature maize silage (60%) containing a good level of starch (242 g/kg DM) than with a good quality grass silage (0.58 v 0.83 kg milk/kg concentrate DM). However, a higher level of milk production was achieved with the maize silage based forage.

- With a more mature maize silage containing a higher level of starch (293 g/kg DM), but which produced a lower level of milk, the response in milk production to increased concentrate supplementation was similar to grass silage (0.92 v 0.83 kg milk/kg concentrate DM). The same yield of fat and protein (1.64 kg/day) obtained with grass silage and 8 kg concentrates/day could be achieved with the mixed forages containing the good or high starch maize silages when supplemented with 5.9 or 6.7 kg concentrates/day, respectively.

- Thus, a saving of 1.3 to 2.1 kg concentrates/day is possible with mature maize silages as the major part of the forage compared with good quality grass silage.

- Concentrates containing low starch, highly digestible fibrous ingredients produced more milk (+0.9 kg/day) compared with concentrates based on high starch cereal ingredients when supplementing grass silage or maize silage based forages. However, milk protein concentration was less on the low starch concentrate.

- Increasing the level of crude protein in the concentrate supplement for grass silage or maize silage based forages increased milk production on all forages without affecting forage intake or milk composition. The optimum level of crude protein in the concentrate for maize silage based forages is about 250 g CP/kg freshweight.

INTRODUCTION

In Part 1 of this report, the results of studies which examined the role of maize silage in the diet of dairy cows and the effects of variation in the starch content and digestibility of maize silage on forage intake and milk production when maize silage partially replaced grass silage were presented. Good quality maize silage, with over 200 g starch/kg DM, was shown to be a superior forage to good quality grass silage in terms of forage intake, milk production and milk protein concentration. Maize silage with a low starch content and/or reduced digestibility due to delayed harvesting was equivalent in terms of milk solids production to moderate or good quality grass silage.

In some of these studies, the forages were supplemented with different levels of concentrates to establish the responses in milk production and composition to increased concentrate supplementation compared with grass silage. The type of ingredients used in the concentrate i.e. starchy or fibrous ingredients, was investigated to determine the most suitable type of concentrate to supplement maize silage based forages containing low or high levels of starch compared with a grass silage based forage.

The level of crude protein in the concentrate was also investigated in order to establish the optimum level in the supplement for maize silage based forages. The results of these studies are presented in this Part (2) of the report.

EXPERIMENT 3:

Effect of concentrate supplemention of a forage containing low starch maize silage or grass silage on milk production

The response in milk production to increased concentrate supplementation of grass silage based forages has been well established from previous studies. However, very little information was available on the response to increased concentrate supplementation of a maize silage based forage, the effect that variation in the level of starch in maize silage might have on the response and the optimum level of concentrate to feed with maize silage based forages. In this study, the objective was to determine the response in milk production to increased levels of concentrate supplementation with a maize silage based forage containing a low level of starch compared with a good quality grass silage.

Materials and Methods

An immature maize silage containing very little starch, due to a poor season for growing maize, but with a good digestibility, having been harvested in a green state after a frost kill, was used in this study. It was fed as part of a mixed forage (LSM) in combination with a good quality grass silage (60% maize silage, 40% grass silage on a DM basis) and was compared with all grass silage (GS) as the forage component of the diet.

Both forages were supplemented with concentrates at three levels of supplementation (4, 6 and 8 kg /cow/day). The concentrates, based on barley, unmolassed beet pulp and soyabean meal, contained a high level of crude protein (250 g CP/kg freshweight), and were fed from out -of - parlour feeders. Cows in early or mid-lactation were allocated to the treatments (8 cows/treatment) for a period of 7 weeks. The digestibility of the total diets were determined with cows from the experiment.

Results

The maize silage was well preserved with a good digestibility (DMD 703 g/kg DM) but contained very little starch (15 g/kg DM). The grass silage was highly digestible (DMD 755 g/kg DM), well preserved and was higher in digestibility than the maize silage (see Table 5 in Part 1 of report).

Increasing the level of concentrate supplementation reduced the intake of grass silage with a substitution rate of 0.31 kg silage DM/kg concentrate DM (Table 1). On the other hand, increasing the level of concentrates from 4 to 6 kg/day with the LSM forage increased forage intake and there was only a small reduction in forage intake when concentrates were fed at 8 kg/day. Consequently, total DM intake was increased to a greater extent by increased concentrate supplementation for the LSM based forage compared with the GS silage.

Milk yield was increased to a greater extent with the GS forage when supplemented with extra concentrates compared with the LSM forage. However, yields of fat and protein were increased to a similar extent on both types of forage. Milk fat concentration was not affected by increased concentrate supplementation but milk protein concentration was increased with both forages, and to a greater extent with the LSM forage.

Cows gained more weight on the higher levels of supplementation (6 or 8 kg/day) compared with the low level (4 kg/day) on both types of forage. While the in vivo DM digestibility of the total diet was not affected by the level of concentrate supplementation, the differences in DM digestibility between the GS and LSM based diets were reduced at the higher level of supplementation.

The response in milk yield to increased concentrate supplementation was linear over the range of levels fed for both types of forage and was greater for the GS silage compared with the LSM forage (0.92 v 0.43 kg milk /kg concentrate DM). However, the greater response in milk composition, particularly milk protein concentration, to increased concentrate supplementation with the LSM based forage resulted in similar responses in the yield of fat and protein for the GS and LSM forages (65 v 58 g fat + protein/kg concentrate DM).

Feed conversion efficiency to milk was not affected by increased supplementation of the GS forage as both feed intake and milk production were increased to a similar extent. However, increased concentrate supplementation of the LSM forage reduced feed efficiency to milk by 10-15% as the increase in feed intake was not matched by a corresponding increased in milk production.

Table 1 : Effect of increased concentrate supplementation of grass silage (GS) or low starch maize silage based forage (LSM) on feed intake and milk production in Experiment 3

	Type of Forage	Concentrate Level (kg/d) 4	6	8	sem
Feed Intake (kg DM/d)					
Silage	GS	10.2	9.3	9.1	0.43
	LSM	10.7	11.9	11.0	
Total diet	GS	13.7	14.5	16.1	0.43
	LSM	14.2	17.1	17.9	
Production (kg/d)					
Milk	GS	19.8	21.2	23.0	0.49
	LSM	20.6	21.3	22.1	
Fat	GS	0.83	0.89	0.93	0.024
	LSM	0.84	0.87	0.95	
Protein	GS	0.61	0.66	0.73	0.018
	LSM	0.64	0.69	0.73	
Composition (g/kg)					
Fat	GS	42.4	42.5	41.5	0.78
	LSM	42.0	41.6	43.0	
Protein	GS	31.1	31.3	32.1	0.31
	LSM	31.7	32.8	33.4	
Liveweight gain (kg/d)	GS	0.13	0.38	0.30	0.11
	LSM	-0.05	0.54	0.53	
Diet DMD (g/kg)	GS	740	738	743	6.8
	LSM	713	719	737	

sem = Standard error of the mean

Conclusions

Increased concentrate supplementation tended to increase forage and total DM intake with the LSM based forage in contrast to the grass silage based forage. While milk yield was increased by increased concentrate supplementation to a greater extent with the GS silage compared with the LSM forage, the yield of fat and protein was increased to a similar extent with both types of forage.

EXPERIMENT 5:

Effect of type and level of concentrate supplement with good quality maize silages on milk production

In the previous study (Experiment 3), the response in milk production to increased concentrate supplementation of a mixed forage containing an immature, low starch maize silage was established compared with a good quality grass silage. In this study, more mature maize silages containing a good or high level of starch were used in mixed forage diets to determine the response in milk production to increased concentrate supplementation compared with good quality grass silage for cows in mid-lactation. The most suitable type of concentrate containing either high starch, cereal based ingredients or low starch, high fibre by-product ingredients to supplement maize silage based forages was also examined.

Materials and Methods

Two early maturing varieties of maize (Melody and Hussar) were grown either conventionally or under a photodegradable polythene film to increase soil temperature and enhance early growth. Following a good season for growing maize, the crops were harvested in late September when deemed mature with well developed cobs but differing in grain hardness and starch content. The grass silage was cut from a perennial ryegrass sward in late May and was treated with a formic acid based additive.

Three forage treatments were compared : (1) all grass silage (GS), (2) a mixed forage (MSM) of moderate starch maize silage (60%) and grass silage (40%) and (3) a mixed forage (HSM) of high starch maize silage (60%) and grass silage (40%). Each forage was supplemented with two types of concentrate at two levels i.e. 4 or 8 kg /cow/day in two equal feeds per day. The concentrates were made from either high starch ingredients (HS) i.e. barley and wheat or low starch high fibre by product ingredients (HF) i.e. citrus pulp and corn gluten feed as energy sources. Soyabean meal and rapeseed meal were used as protein sources in both concentrates to provide an overall level of 230 g CP/kg freshweight in the concentrate.

Forty eight autumn calved cows in mid-lactation were allocated to the three types of forage and two levels of concentrate for a period of 10 weeks. The cows on each treatment were fed either the HS or HF concentrate at the same level of feeding in two successive periods of 5 weeks. Data for the final three weeks of each period were analysed.

Results

The composition and digestibility of the grass silage and the maize silages were presented in Part 1 (Table 8) of this report. The grass silage was well preserved and was highly digestible (DMD 743 g/kg DM). The MSM and HSM silages were mature with a high DM content (275 and 310 g/kg), good to high levels of starch (242 and 293 g/kg DM) but were lower in DM digestibility (655 and 686 g/kg DM) compared with the grass silage. The HS and HF concentrates contained similar levels of crude protein (274 v 282 g CP/kg DM) but contained different levels of starch (417 v 124 g /kg DM) and neutral detergent fibre (110 v 205 g/kg DM).

Increasing the level of concentrate supplementation across the three types of forage slightly reduced forage intake but increased total DM intake, milk yield, fat and protein yield and cow liveweight gain (Table 2). Milk protein concentration was increased but milk fat concentration was not affected by extra concentrate feeding. However, there were some divergent trends between the three types of forages.

Increased concentrate supplementation had the least effect on intake of the MSM forage with substitution rates of 0.29, 0.14 and 0.37 kg forage DM/kg concentrate DM for the GS, MSM and HSM forages, respectively, and resulted in the lowest response in milk production with the MSM forage (0.83, 0.58 and 0.92 kg milk/kg concentrate DM).

The poorer milk yield response with the MSM forage was probably due to the better level of milk production achieved on that forage compared with the GS or HSM forages at the low level of concentrate supplementation. However, a lower level of concentrate supplementation would suffice with the MSM and HSM forages to produce the same level of milk solids compared with the GS silage. For example, the same yield of fat and protein (1.64 kg/day) could be achieved with 8.0, 5.9 or 6.7 kg concentrates/day when supplementing the GS, MSM or HSM forages, respectively. Thus, a potential saving of 1.3 to 2.1 kg concentrates/day could be achieved with the maize silage based forages compared with grass silages.

Table 2 : Effect of increased concentrate supplementation of forages containing mature maize silages (MSM and HSM) or grass silage (GS) on feed intake and milk production in Experiment 5

Concentrate level (kg/d)	4			8			
Forage type	GS	MSM	HSM	GS	MSM	HSM	sem
Feed intake (kg DM/d)							
Silage	9.5	11.4	12.3	8.4	10.9	11.1	0.45
Total diet	13.0	14.9	15.8	15.4	17.9	18.1	0.45
Production (kg/d)							
Milk	17.2	19.5	17.9	20.1	21.5	21.1	0.99
Fat	0.80	0.88	0.81	0.91	0.95	0.95	0.042
Protein	0.60	0.69	0.64	0.73	0.77	0.79	0.035
Composition (g/kg)							
Fat	46.9	45.1	45.4	45.5	44.3	46.5	1.31
Protein	35.0	35.3	35.7	36.4	35.8	38.2	0.79
Liveweight gain (kg/d)	0.14	0.11	0.33	0.55	0.43	0.65	0.08
Diet DMD (g/kg)	773	733	729	775	744	733	9.3

The effect of the type of concentrate on feed intake and milk production when averaged across the three types of forage is shown in Table 3. Forage intake, milk yield and yield of fat and protein were marginally but significantly higher on the HF concentrate compared with the HS concentrate. Milk fat concentration was similar for both types of concentrate but milk protein concentration was higher on the HS concentrate.

Cow liveweight gain, body condition score and digestibility of the total diet was similar for both types of concentrate. There were slight differences between the three types of forage in relation to the type of concentrate supplement. The benefit to feeding the HF concentrate was most evident with the GS and HSM forages and was least evident with the MSM forage.

The overall improvement to feeding the HF concentrate was 0.9 kg milk/day or 60g fat and protein/day compared with the HS concentrate. A similar improvement in milk production (1.0kg/day) was obtained in another study (Experiment 4, Part 1) when forages containing maize silages with little or no

starch were supplemented with concentrates based on high fibre ingredients compared with high starch ingredients.

Table 3 : Effect of type of concentrate supplement fed with grass silage or maize silage based forages on forage intake and milk production in Experiment 5.

Type of concentrate	High starch (HS)	High fibre (HF)	sem
Feed intake (kg DM/day)			
Silage	10.4	10.8	0.11
Total diet	15.6	16.1	0.11
Production (kg/d)			
Milk	19.1	20.0	0.13
Fat	0.86	0.90	0.009
Protein	0.69	0.71	0.005
Composition (g/kg)			
Fat	45.8	45.4	0.40
Protein	36.3	35.8	0.11
Liveweight gain (kg/d)	0.39	0.35	0.06
Diet DMD (g/kg)	747	748	5.4

sem = Standard error of the mean

Conclusions

Milk production was increased on all forages by increasing the level of concentrate supplementation from 4 to 8 kg/cow/day. Milk protein concentration, liveweight gain and body condition score were improved on all forages by the higher level of concentrate feeding.

The response in milk production was less for the MSM forage which supported the highest level of milk production compared with the GS or HSM forage. A saving of 2.1 or 1.3 kg concentrates/day could be achieved with the MSM or HSM forages compared with the GS silage while producing the same yield or fat and protein.

The high fibre concentrate increased forage intake and milk yield compared with the high starch concentrate on all forages and particularly on the GS and HSM forages, but milk protein concentration was less on the HF concentrate.

EXPERIMENT 6:

Effect of crude protein level in the concentrate to supplement maize silage based diets on milk production

The crude protein level in maize silage is less than in grass silage. Consequently, forages containing a high proportion of maize silage require supplementation with a high level of crude protein in the concentrate compared with grass silage to provide sufficient protein in the total diet for lactating dairy cows. The optimum level of crude protein in the concentrate has not been established for maize silage based forages. It is likely to vary with the proportion of maize silage in the forage, its starch content and the crude protein level in grass silage.

In this study, three levels of crude protein in the concentrate were examined when supplementing forages based on grass silage or mixed forages containing maize silages differing in starch content.

Materials and Methods

Three types of forage were compared : (1) all grass silage (GS), (2) a mixed forage (LSM) of low starch maize silage (60%) and grass silage (40%) or (3) a mixed forage (MSM) of moderate starch maize silage (60%) and grass silage (40%). The forages were fed to dairy cows in early lactation (12 cows/forage) over a period of 10 weeks. Each forage was supplemented with concentrates (6 kg/cow/day) based on barley, molassed beet pulp and soyabean meal to provide three levels of crude protein (CP) in the concentrate i.e. 180, 230 or 280 g CP /kg fresh weight, according to a Latin Square experimental design for periods of 3-4 weeks.

Table 4 : Chemical composition and in vitro digestibility of the grass and maize silages in Experiment 6 (g/kg DM unless stated)

	Grass Silage	Low Starch Maize Silage	Moderate Starch Maize Silage
Dry matter (g/kg)	191	214	295
Cr. Protein	172	131	123
Starch	0	0	197
In vitro DMD	728	658	725
pH	3.93	3.7	3.68
Ammonia N (g/kg Total N)	119	74	51
Lactic acid	101	87	73

Results

The grass silage was well preserved with good digestibility and a high level of crude protein (Table 4). The low starch maize silage was low in DM content, contained no starch and was of moderate digestibility. The moderate starch maize silage was higher in DM content, contained a reasonable level of starch with a good digestibility. Both maize silages contained moderate levels of crude protein and were well preserved.

As was found in previous studies, intake of the LSM forage was higher than that of the GS silage but milk production was similar for both types of forage (data not shown). Forage intake and milk production on the MSM forage was better than that obtained with the GS or LSM forages while milk protein concentration was also higher. When averaged across the three types of forage, increasing the level of crude protein in the concentrate had no effect on forage intake but did increase the yields of milk, fat and protein without affecting milk composition (Table 5).

Table 5 : Effect of crude protein level in the concentrate supplement with grass silage or maize silage based forage on feed intake and milk production in Experiment 6

	Concentrate Cr. Protein (g/kg)			
	180	230	280	s.e.m.
Feed Intake (kg DM/d)				
Silage	10.5	10.5	10.6	0.24
Total diet	15.7	15.8	15.8	0.24
Production (kg/d)				
Milk	23.7	24.4	24.7	0.22
Fat	0.92	0.92	0.96	0.011
Protein	0.75	0.77	0.78	0.006
Composition (kg/d)				
Fat	39.1	38.2	39.3	0.38
Protein	31.9	31.6	31.9	0.28
Mean liveweight (kg)	558	562	560	2.3
Diet DMD (kg/d)	734	722	740	0.43

Different trends in the response in milk production to increased protein levels were evident between the forages even though there was no overall significant interaction between the level of protein in the concentrate and the type of forage. With the GS and MSM forages milk yield increased curvilinearly with increasing crude protein level while the yield of fat and protein increased linearly (Table 6). In the case of the LSM forage there was little response in milk production to the first increment of crude protein (180 - 230 g CP/kg) while there was a good response to the second increment (230 - 280 g CP/kg) in terms of milk yield and yield of fat and protein.

Table 6 : Effect of increasing the crude protein level in the concentrate on yield of milk and fat and protein for the individual forages in Experiment 6.

	Type of forage	Concentrate CP level (g/kg)		
		180	230	280
Milk yield (kg/d)	GS	22.6	23.8	24.2
	LSM	23.0	23.1	23.7
	MSM	25.4	26.2	26.2
Fat + protein yield (kg/d)	GS	1.53	1.57	1.60
	LSM	1.67	1.65	1.73
	MSM	1.80	1.85	1.91

GS = Grass silage;
LSM = Low starch maize silage based forage;
MSM = Moderate starch maize silage based forage

Conclusions

The benefit in terms of forage intake and milk production to feeding maize silage containing a moderate level of starch compared with material containing a low level of starch or all grass silage was again evident in this study. Increasing the level of crude protein in the concentrate increased milk production on all forages without affecting forage intake or milk composition. While the response in milk production to increased protein supplementation differed somewhat between the types of forage a level of 250 g crude protein/kg freshweight in the concentrate would appear to be optimum for forages containing a high proportion of maize silage.

OVERALL CONCLUSIONS

1. A linear increase in milk yield was obtained with cows in early or mid-lactation when a mixed forage containing immature, low starch maize silage (60%) was supplemented with increasing levels of concentrates (4, 6 or 8 kg/day). The response was less than with all grass silage in terms of milk yield but was similar in terms of milk solids (fat and protein) yield. Similar levels of supplementation would be needed for both types of forage to achieve the same level of milk production.

2. A mixed forage based on mature maize silage (60%) containing a good level of starch (242 g/kg DM) produced more milk than a high quality grass silage when fed to cows in mid lactation. The response in milk production to increased concentrate supplementation (4 to 8 kg/day) was less for the mixed forage containing maize silage than for grass silage. Milk production from a mixed forage containing a more mature high starch maize silage (293 g starch kg DM) was intermediate between the grass silage and the mixed forage containing a lower level of starch. The response in milk production to extra concentrates with this mixed forage was similar to that obtained with the grass silage.

3. A saving in concentrate supplementation of between 1.3 and 2.1 kg/day could be achieved with the maize silage based forages containing a good or high level of starch compared with good quality grass silage supplemented with 8 kg concentrates/day to achieve the same level of milk solids production.

4. A concentrate based on low starch, high fibre ingredients produced more milk but with a lower protein concentration compared to a concentrate based on high starch cereal ingredients when fed to supplement grass silage or mature maize silage based forages. A similar result was obtained with immature maize silage based forages containing low levels of starch.

5. Increasing the level of crude protein in the concentrate from 180 to 280 g CP/kg fresh weight to supplement grass silage or maize silage based forages increased milk production without affecting forage intake or milk composition. The optimum level of crude protein for maize silage based forages was about 250 g CP/kg fresh weight.

PUBLICATIONS

Fitzgerald, S., Murphy, J. and O'Mara F. (1994). Effect of replacing grass silage with low or moderate quality maize silage on milk production of dairy cows. Proceedings Irish Grassland and Animal Production Association 20th Annual Research Meeting, UCD, March 1994. pp. 93-94.

Fitzgerald, S. and Murphy, J. (1996). Concentrate supplementation of forages based on maize silage or grass silage for milk production. Proceedings Irish Grassland and Animal Production Association 22nd Annual Research Meeting, UCD, March, 1996, pp. 177-178.

Fitzgerald, S., Murphy, J.J., Culleton, N. and Murphy, J. (1996). Influence of harvesting date of immature maize silage and type of concentrate supplement on milk production. Proceedings Irish Grassland and Animal Production Association 22nd Annual Research Meeting UCD, March 1996, pp. 107-108.

Fitzgerald, S. and Murphy, J. (1996). Concentrate supplementation of forages based on maize silage or grass silage for milk production. Proceedings XIth International Silage Conference, Aberystwyth, Wales, September 1996, pp. 82-83.

O'Kiely P., Fitzgerald, S., Murphy, J. and Moloney A., 1996. Ensiling and feeding maize silage. Proceedings Irish Maize Growers Association Meeting, Cahir, January 1996, pp. 19-31.

Fitzgerald, J.J. (1997). Effect of variation in the quality of forage maize in Ireland on forage intake and milk production of dairy cows. Proceedings XVIII International Grassland Congress, Canada (June 1997), Session 17, pp. 31-32.

Fitzgerald, S. and Murphy, J.J. (1998). Effect of the starch content in maize silage and the level of crude protein in the concentrate supplement on milk production. Proceedings Irish Grassland and Animal Production Association 24th Meeting, UCD, March 1998, pp. 217-218.

Fitzgerald, J.J. and Murphy, J.J. (1998). Effect of maize silage quality in a mixed forage diet and the crude protein level in the concentrate supplement on milk production of dairy cows. Proceedings British Society of Animal Science Winter Meeting, Scarborough, March 1998, p. 149.

O'Mara, F.P., Fitzgerald, J.J. Murphy, J.J. and Rath, M. (1998). The effect on milk production of replacing grass silage with maize silage in the diet of dairy cows. Livestock Production Science, 55 : 79-87.

Fitzgerald, S. and Murphy, J. (1996). Effect of the starch content of maize silage in a mixed forage, concentrate feeding level and type of ingredients on forage intake and milk production of dairy cows. Teagasc, Moorepark Research and Development Centre Research Report, 1996, pp. 25-27.

Fitzgerald, S. and Murphy, J. (1994). Role of maize silage for milk production. In : Dairying, Improving the Competitive Edge. Moorepark Open Day Book, pp. 53-55.

Fitzgerald, S. (1996). Maize silage as a feed for dairy cows. Irish Grassland Association 50th Summer Tour Booklet, pp. 11-14.