TABLE 4 Feed intake and production results – Trial 3, 4

Treatments*	Trial 3		Trial 4	
	MSmCm	MShCm	MSCm	MShCm + PGS
DM-intake (kg)				
Maize silage	14.7[a]	14.1[b]	13.4	7.8
Prew. grass silage	-	-	-	6.0
Concentrate	3.4	3.3	3.2	2.9
Total	18.1[a]	17.4[b]	16.6[a]	16.7[a]
Diet content (g/kg DM)				
Starch	233[a]	249[b]	248[a]	155[b]
By-pass starch	50[a]	59[b]	59[a]	36[b]
FOM	563[a]	538[b]	539[a]	551[b]
Nutrient intake				
NEL (MJ)	123[a]	117[b]	112[a]	108[b]
DVE (g)	1406[a]	1336[b]	1299[a]	1176[b]
OEB (g)	64[a]	154[b]	112[a]	269[b]
NEL (% requirements)	114[a]	113[a]	112[a]	105[b]
DVE (% requirements)	114[a]	115[a]	113[a]	101[b]
Production results				
Milk (kg)	20.2[a]	19.2[b]	18.4[a]	19.1[b]
Fat (%)	4.81[a]	4.79[a]	4.75[a]	4.81[a]
Protein (%)	3.52[a]	3.51[a]	3.62[a]	3.55[a]
Fat (g)	974[a]	919[b]	862[a]	910[b]
Protein (g)	714[a]	673[b]	662[a]	677[a]
LW-gain (kg)	0.30[a]	0.15[b]	0.14[a]	0.28[a]

*Treatments: MS = maize silage, C = concentrate, m = moderate, h = high, PGS = prewilted grass silage

[ab] Means within a trial with a same superscript letter are not significantly different ($P > 0.05$)

CONCLUSIONS

Within the studied range, a higher starch content in maize silage and in the total diet would not increase milk yield. Differences in milk yield were better related to differences in NEL-intake than to dietary starch. A higher starch content tended to depress milk fat content, whereas milk protein content remained unchanged.

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TABLE 3. Feed intake and production results – Trial 2

Treatments*	MSmCm	MShCm	MShCh
DM-intake (kg)			
Maize silage	9.8[a]	9.4[a]	9.9[a]
Prew. grass silage	5.2	4.9	5.2
Concentrate	7.2	7.3	7.1
Total	22.2[a]	21.7[a]	22.2[a]
Diet content (g/kg DM)			
Starch	151[a]	159[b]	187[c]
By-pass starch	31[a]	36[b]	46[c]
FOM	582[a]	573[b]	569[c]
Nutrient intake			
NEL (MJ)	152[a]	148[a]	152[a]
DVE (g)	1813[a]	1768[a]	1824[a]
OEB (g)	149[a]	191[b]	187[b]
NEL (% requirements)	107[a]	108[a]	109[a]
DVE (% requirements)	99[a]	100[ab]	103[b]
Production results			
Milk (kg)	31.4[a]	30.5[a]	30.7[a]
Fat (%)	4.30[a]	4.18[a]	4.24[a]
Protein (%)	3.39[a]	3.38[a]	3.38[a]
Fat (g)	1337[a]	1255[b]	1280[ab]
Protein (g)	1057[a]	1024[a]	1031[a]
LW-gain (kg)	0.29[a]	0.27[a]	0.43[a]

*Treatments: MS = maize silage, C = concentrate, m = moderate, h = high
[abc] Means within a row with a same superscript letter are not significantly different (P > 0.05)

Trial 3

Although feed intake had to be restricted in some cows to avoid excessive nutrient supply, DM- and nutrient intake was significantly lower for the diet with MSh (table 4). Because of the relative minor difference in S-content, it is doubtful that the difference can only be attributed to the S-content. Also the somewhat lower OM-digestibility and the lower FOM-level than recommended have to be taken into account. Milk, fat and protein yield were again significantly lower for the ration with MSh, whereas fat and protein content were unaffected. Based on the theoretical considerations concerning the interaction “starch – insulin activity – milk yield – LW-gain” we could expect a higher LW-gain for the diet with MSh, but the opposite has resulted.

Trial 4

Energy intake of the diet with PGS has to be considered as proximate value because NEL of PGS was estimated using an in vitro technic. However, the latter was rather high as compared to the fibre content.
Although DVE- and maybe also NEL-intake were lower for the diet with PGS, milk and fat yield were significantly higher (table 4). Milk fat and protein content were not significantly affected.

FOM-content. However, even the lowest FOM-level was sufficient as compared to current recommendations (550 g/kg DM). A too high S-intake is expected to disturb rumen function, resulting in a lower feed intake. Intake results of this trial do not indicate that. Ingestibility of the maize silage with the higher starch content (MSh) tended to be lower. This resulted in a significantly lower NEL- and DVE-intake, and consequently in a depressed milk (not significant), fat and protein yield for the diet MShCm. Milk fat content was negatively affected by a higher S-content, mainly by the starchy concentrate. Milk protein content remained unchanged.
As energy and protein intake largely exceeded the requirements, cows gained liveweight.

TABLE 2. Feed intake and production results – Trial 1

Treatments*	MSmCm	MShCm	MShCh
DM-intake (kg)			
Maize silage	12.5[a]	12.0[a]	12.3[a]
Pressed beet pulp	2.7	2.7	2.7
Concentrate	5.2	5.0	5.2
Total	20.4[a]	19.7[a]	20.2[a]
Diet content (g/kg DM)			
Starch	183[a]	201[b]	229[c]
By-pass starch	39[a]	47[b]	57[c]
FOM	598[a]	581[b]	577[c]
Nutrient intake			
NEL (MJ)	142[a]	136[b]	140[ab]
DVE (g)	1703[a]	1601[b]	1655[a]
OEB (g)	51[a]	131[b]	156[b]
NEL (% requirements)	111[a]	111[a]	113[a]
DVE (% requirements)	109[a]	108[b]	109[a]
Production results			
Milk (kg)	27.8[a]	26.7[a]	27.4[a]
Fat (%)	4.26[a]	4.21[a]	4.08[b]
Protein (%)	3.32[a]	3.29[a]	3.27[a]
Fat (g)	1174[a]	1108[b]	1119[b]
Protein (g)	919[a]	874[b]	894[ab]
LW-gain (kg)	0.33[a]	0.19[a]	0.29[a]

*Treatments: MS = maize silage, C = concentrate, m = moderate, h = high
[abc] Means within a row with a same superscript letter are not significantly different ($P > 0.05$)

Trial 2

Prewilted grass silage was introduced to lower the S-content. If starch is important, one would expect an effect in the present diet type. However, T2 provides similar results as T1 (table 3). Dry matter and nutrient intake was once more lower for MShCm. Milk, fat and protein yield tended again to be lower for the diets with MSh; the difference in milk fat yield between MSmCm and MShCm was significant.

Both trials with productive cows do not illustrate any positive effect of a higher starch content on milk production parameters.

TABLE 1. Chemical composition, digestibility and nutritive value of the maize silages

Starch content	Moderate	High
Dry matter (g/kg)	303	313
Chemical composition (g/kg DM)		
Starch	269	294
Crude protein	71	71
Crude fibre	226	227
NDF	419	413
Ash	47	45
Starch degradability (%)	78.9	76.3
Digestibility (%)		
Organic matter	76.7	75.4
NDF	56.5	53.2
Starch	97.1	97.8
Nutritive value (DM)		
NEL (MJ)	6.68	6.63
DVE (g)	53	49
OEB (g)	-43	-38
FOM (g)	562	538

Other feeds

Prewilted grass silages were predominantly composed of perennial ryegrass. PGS in T2 and T4 contained 186 and 171 g crude protein, 484 and 500 g NDF, and 108 and 118 g ash per kg DM, respectively. Net energy lactation (NEL) was 6.0 MJ per kg DM for both silages.

The pressed beet pulp was of ordinary quality: 213 g DM per kg, 7.4 MJ NEL.

Nutritive values

- Energy

  Digestibility of the maize silages was determined with lactating Holstein cows, whereas *in vitro* technics were used for the other feedstuffs. NEL was calculated according to van Es (1978) and expressed in MJ.

- Protein

  Protein values of all feedstuffs, expressed as true protein digestible in the small intestine (DVE), and as the degraded protein balance in the rumen (OEB), were determined as described by Tamminga et al. (1994), using *in situ* rumen incubation and the mobile nylon bag technique in Holstein cows fitted with rumen and duodenal cannulas (De Boever et al., 1995).

RESULTS

Trial 1

In this trial maize silage was given as the sole roughage, resulting in high starch levels (table 2). Starch and FOM-concentration were significantly different between the three diets. These data illustrate the negative relationship between starch and

MATERIAL AND METHODS

Trials and diets

Trial 1 and 2 were carried out in the first half of the lactation. Maize silage (MS) was given as the sole roughage in trial 1 (T1), or with prewilted grass silage (PGS) in trial 2 (T2). In T1 and T2, 3 starch (S) levels, originating from the MS-cultivar and the concentrate (C), were compared in a latin square design with 18 Holstein cows: MSmCm, MShCm, MShCh (m, h: moderate, high S-content). To assure a sufficient fermented organic matter (FOM) supply in the rumen, 2.7 kg DM from pressed sugar beet pulp was added to the diets of T1. In T2 MS/PGS ratio was 65/35 on DM-basis.
In trial 3 (T3) only S-content of MS was compared using diets with MS as the sole roughage: MSmCm, MShCm. In trial 4 (T4) the effect of PGS addition to MSh (MS/PGS: 55/45) was studied. T3 and T4 were cross-over trials with 16 Holstein cows in a later lactation stage.
Roughages were fed ad libitum. Concentrate supplies were individually fixed at the beginning of the trial, aiming at 105 % of the energy and protein requirements in T1 and T2 and at 110 % in T3 and T4. The concentrate portion decreased during the trial according to a preconceived scheme. To avoid excessive nutrient intake, roughage intake was somewhat restricted for some cows in T3 and T4. As concentrate supply was low in T3 and T4, 250 g of a mineral supplement was given daily.
T1 and T2 consisted of 3 periods of 5 weeks, each with the first week for adaptation to the diet, whereas T3 and T4 were carried out in 2 periods of 6 weeks, each of which 2 weeks for adaptation.

Feeds

Maize silages

In all trials the same maize silages were used. To increase the chance to dispose of two varieties with a large difference in starch content, 5 varieties were cropped, 2 of which with a high and 3 with a low expected starch content based on the Belgian variety catalogue. All other characteristics would be similar. Based on the analysis at harvest, 2 varieties with an expected difference of 7 %-units (on DM) in starch content were selected. However, analysis at harvest indicated a difference of 4 %-units. Moreover, all maize silage samples taken during the present experiments revealed a mean difference in starch content of hardly 2.5 %-units (table 1). This discouraging experience is supported by other preliminary research at our institute, which demonstrated that starch content in whole crop maize is not a consistent parameter. On the contrary, NDF-digestibility seems to be highly genetically determined.

Concentrates

The two concentrates (Cm, Ch) had a S-content of 96 and 339 g per kg DM, respectively. Sugar beet pulp in Cm was replaced by maize grain and wheat in Ch. Other main ingredients were soybean meal, rapeseed meal, wheat, maize glutenfeed and beet molasses. Additional soybean meal was used as protein corrector.

Effect of starch content of maize silage based diets for dairy cattle[1]

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ABSTRACT

Assuming that the effect of starch content could depend on milk yield level and diet composition, 2 trials were carried out in early lactation (T1, T2) and 2 in mid lactation (T3, T4). Maize silage (MS) was given as the sole roughage in T1, or with prewilted grass silage (PGS) in T2. In T1 and T2, three starch (S) levels, originating from the MS-cultivar and the concentrate (C), were compared in a latin square design with 18 Holstein cows: MSmCm, MShCm, MShCh (m, h: moderate, high S-content). In T3 only S-content of MS was compared: MSmCm, MShCm, whereas in T4 the effect of PGS addition to MSh was studied. T3 and T4 were cross-over trials with 16 Holstein cows.
Milk yield amounted to 27.8 , 26.7 and 27.4 kg in T1, and to 31.4 , 30.5 and 30.7 kg in T2, for MSmCm, MShCm and MShCh, respectively. Differences were not significant ($P > 0.05$). In T3 milk yield was significantly lower for the diet with MSh (19.2 vs. 20.2 kg). Adding PGS to MSh (T4) significantly increased milk yield (19.1 vs. 18.4 kg). Milk composition was almost unaffected.
Generally, differences in milk yield were better related to differences in dry matter and net energy intake, than to the starch content of the diet.

INTRODUCTION

Since several years, a lot of attention is paid to the starch content of maize silage in dairy cattle nutrition. The question remains if maize silage (or a total diet) with a higher starch content but with the same organic matter digestibility (OMD) has a beneficial effect on milk production and net energy value. A starchy whole crop maize with an equal OMD implies a lower digestibility of the NDF-fraction.
Considered theoretically, we could expect both positive and negative effects of a higher starch content. On the one hand, as high yielding cows need a lot of glucose, starch might have a positive effect on milk yield at high milk production levels. Starch, being partly digested in the small intestine directly towards glucose, could be energetically more efficient, resulting in a higher net energy value. On the other hand, by-pass starch depresses the content of fermented organic matter in the rumen wich could have a negative effect on microbial protein production. As the digestive capacity of the small intestine for starch is restricted, high levels of by-pass starch can have a negative effect on total starch digestibility. Through increased insulin secretion, high starch intake could depress milk yield at moderate production levels. Moreover, excess starch can disturb rumen function.
As the effect of starch may depend on its level in the diet and on milk production level, 4 trials were carried out with high and lower producing cows, and with maize silage as the sole roughage or in combination with prewilted grass silage.

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