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Effect on milk characteristics to supplementing cows on a restricted pasture allowance with different amounts of either turnips or sorghum.

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ABSTRACT

The effect of supplementary feeding 0, 4 or 8 kg DM/cow/d of turnips or sorghum to cows offered a restricted pasture allowance (25 kg DM/cow/d) on milk characteristics (fat, protein and lactose, N fractions, serum proteins, fatty acids (FAP) and solid fat content (SFC)) was investigated. Thirty identical twinsets were used (10 cows/treatment) in a partial cross-over designed experiment comprising two, 10-day periods. Sorghum was higher in fibre (NDF, 65% v 23%), total lipid (3.5% v 1.5%) and similar for crude protein (9.6% v 12.0%) than turnips. Lipid composition differed between crops; turnips had more lauric ($C_{12:0}$) and less linolenic ($C_{18:3}$) fatty acids than sorghum. Differences in the chemical composition of the crop were reflected in different milk compositions. Milkfat content was lower for cows fed turnips than sorghum and the effect was greater (P<0.001) with increasing amount of turnips fed (5.5%, 5.1% and 5.0% for 0, 4, and 8 kg DM/cow/d respectively). Milkfat composition also differed for cows fed turnips compared to sorghum. With an increased amount of turnips fed, short, medium and long-chain fatty acids increased (P<0.001) and total unsaturated fatty acids decreased (P<0.001). As a consequence, SFC (an indication of milkfat hardness) also increased. Conjugated linoleic acid (*cis*-9-*trans*-11-$C_{18:2}$) declined (P<0.001) as the level of supplementation with crop increased. The effect was greater (P<0.001) with turnips than sorghum. Compared with the fat components in milk the treatments had minimal effect on milk protein and nitrogen fractions. Feeding cows turnips compared to sorghum decreased (P<0.001) milk urea levels and increased (P<0.001) casein: whey protein ratio. This ratio declined (P<0.05) with increasing rates of supplementation with sorghum.

These results show that different feed types can change milk components that influence the efficiency of milk processing, physical characteristics and nutritive value of the final dairy products.

Keywords: Milk characteristics, summer forage crops, pastoral dairying

INTRODUCTION

The major limitation to New Zealand dairy production is pasture growth during summer and autumn (Penno *et al.* 1995). The variability in pasture production between years and especially during summer not only affects milk production but variation in milk composition and processing properties. In the North Island, the decline in milk production during summer can be as much as 20% per month compared to a 4-7% decline in fully fed cows. The suitability of milk for processing can also be influenced by level of feeding (Lucy, 1996; Auldist *et al*. 1998a; Mackle *et al*. 1999:) as well as stage of lactation, and time of year (Auldist *et al*. 1998b).

In New Zealand there is limited availability of high quality, low-cost supplements, but there is the option for farmers to meet feed deficits in times of low pasture availability by growing forage crops. Some alternatives for summer are brassicas and C4 green-feed crops such as sorghum and maize (Clark *et al.* 1997). Before summer forage crops become accepted as a means of cost-effectively overcoming deficits of summer pasture, their influences on milk composition and the suitability of the milk for processing need to be determined.

MATERIALS AND METHOD

Clark *et al.* (1997) has reported details of the trial and milksolids production. Briefly, milk was collected from the trial conducted in March 1997. Thirty monozygous twin-sets (approximately 200 days in milk) balanced for current MS yield, age, breed and liveweight were allocated to six treatment groups (10 cows/treatment) in a 2 x 3 factorial experiment. Two forage crops, Barkant turnips and Superchow sorghum, were fed at 0, 4, and 8 kg DM/cow/day to cows grazing a restricted pasture allowance of 25 kg DM/cow/day. The experiment comprised two treatment periods of 10 days duration, during which cows received the assigned rate of supplement. After the first treatment period, cows were reassigned to treatments such that they received the same treatment but at a different amount. This design allowed for the detailed milk composition response to different levels of crop supplementation to be assessed in replicate herds.

Milk samples were collected from each cow using in-line milk meters at six consecutive milkings towards the end of each of the experimental periods. The individual milk samples from each cow collected at each milking were stored separately at 4°C and at the end of the three-day collection period the individual cow samples were bulked, mixed and sub-sampled for the different assays. Samples were analysed for fat, protein, lactose, nitrogen fractions, and serum proteins (immunoglobulin G (IgG), bovine serum albumin (BSA)), fatty acid profile (FAP) and solid fat content (SFC).

Fat, protein and lactose concentrations in milk were measured using an infrared milk analyser (Milkoscan 133B; Foss Electric). FAP and SFC were analysed by the methods described by Mackle *et al.* (1997) and milk proteins and plasma proteins by the methods described by Mackle *et al.* (1999).

The data were analysed as a 2 x 3 crossover design using the Mixed Models Procedure in SAS. Least square means are presented for each treatment group. Statistical analyses of main effects for crop type, amount of crop fed and the interaction between crop type and amount of crop fed are

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also presented.

Clark *et al*. (1997) described the measurement of crop and pasture yields and collection of samples for chemical analyses. In addition to the analyses undertaken by these authors, sub-samples of total crop and pasture were freeze dried and analysed for total fat and fatty acid composition by the method of Garces and Mancha (1993).

RESULTS

Chemical composition of feeds

Turnips had lower NDF and ADF than either sorghum or pasture, and higher digestibility (Table 1). For turnips and sorghum crude protein levels were below the 16-18% recommended for the lactating cow in mid-late lactation NRC (1998). Pasture crude protein level was higher and slightly above the recommended level. Turnips had lower total fat and the fatty acid composition differed to that of sorghum and pasture. Turnips had more lauric ($C_{12:0}$) and less linolenic ($C_{18:3}$) and linoleic ($C_{18:2}$) fatty acids.

TABLE 1: Mean chemical composition (g/kg DM) and fatty acid composition (% of total fat) of whole plant turnip, sorghum and pasture used in the study.

	Turnips	Sorghum	Pasture
DM	108	142	-
NDF	230	650	559
ADF	220	358	282
Digestibility	870	690	680
Crude protein	120	96	197
Total fat	15	35	36
Fatty acids			
$C_{12:0}$	32.2	7.7	5.9
$C_{16:0}$	13.0	13.9	13.7
$C_{18:2}$	7.8	14.9	14.4
$C_{18:3}$	36.8	55.9	57.1

Milk yield and composition

Milk yield increased with increased amounts of forage crop offered and the increase was similar for turnips and sorghum (Table 2). Supplementing a restricted pasture allowance with turnips depressed milkfat concentration to a greater extent than supplementary feeding with sorghum. True protein, casein and whey protein concentrations were unaffected by type of crop. Casein:whey ratios were affected differently by the type and rate of crop fed. The ratio increased with increased amount of turnips and was unaffected by feeding 4 or 8 kg DM/cow/d of sorghum. Feeding turnips reduced urea levels in milk, whereas feeding sorghum had no effect. Serum proteins (BSA and IgG) declined with increased amount of crop fed. Feeding turnips increased short, medium and long-chain fatty acids and unsaturated fatty acids declined. Feeding sorghum had less effect on milkfat composition than feeding turnips. Conjugated linoleic acid (CLA) decreased with feeding both crops but declined more with turnips than sorghum. The SFC at 10^0C also changed with increasing amounts of crop fed. Again the effect on SFC of milkfat was greater with turnips than sorghum.

TABLE 2: Treatment means for milk yield and composition for cows on a restricted pasture allowance of 25 kg DM/cow/d (0 rate of crop) and supplemented with either turnips or sorghum at 4 or 8 kg DM/cow/d.

Crop	Turnips			Sorghum			Significance		
Rate of feeding (kg DM/cow/day)	0	4	8	0	4	8	Crop	Rate	Int.[1]
Milk yield (kg/cow/d)	8.3	10.8	11.4	8.6	10.7	11.1	NS	***	NS
Fat (g/kg)	55.2	50.7	49.7	54.3	51.5	51.4	NS	***	***
Crude protein (g/kg)	38.5	37.2	37.5	37.5	37.2	37.3	NS	NS	NS
Lactose (g/kg)	47.6	48.1	48.2	47.6	47.7	47.8	NS	*	NS
True protein (g/kg)	34.64	34.13	34.90	34.58	33.94	33.62	NS	NS	NS
Casein (g/kg)	25.47	25.71	27.12	26.54	25.58	25.39	NS	NS	NS
Whey protein (g/kg)	9.17	8.42	7.78	8.04	8.36	8.23	NS	NS	NS
Casein:whey	2.78	3.05	3.49	3.30	3.06	3.09	NS	NS	*
Urea (mM)	7.83	4.84	3.48	7.87	7.62	8.17	***	***	***
Plasma proteins									
BSA (mg/l)	317	214	210	303	239	225	NS	***	NS
IgG (mg/l)	709	606	572	672	589	562	NS	***	NS
Milkfat composition (% total fatty acids)									
Short ($C_{4:0}$-$C_{8:0}$)	6.5	7.3	7.4	6.7	7.0	6.9	***	***	***
Medium $C_{10:0}$-$C_{12:0}$)	4.9	6.6	7.7	5.0	5.6	5.7	***	***	***
Long ($C_{14:0}$-$C_{18:0}$)	51.3	55.0	55.7	50.9	53.1	53.1	***	***	***
Total unsaturated	33.6	27.6	25.5	33.7	30.6	30.6	***	***	***
CLA	1.36	1.04	0.98	1.54	1.39	1.36	***	***	***
SFC_{10}[2]	54.6	58.8	60.1	53.6	56.5	56.9	***	***	***

NS, not significant; * (P>0.05); ** P<0.05; ** P<0.01; *** P<0.001. [1] significance of interaction between forage crop and rate of feeding.

[2] Solid Fat Content, % solid at 10^0C

DISCUSSION

Supplementing a restricted pasture allowance with either turnips or sorghum had a similar effect on increasing milk yield. From the increased milk production due to supplementary feeding it was assumed a pasture allowance of 25-kg DM/cow/d was insufficient to sustain milk production for cows in mid-late lactation. The decrease in the serum proteins (BSA and IgG) with increased amount of crop fed was also consistent with insufficient pasture to meet cow requirements. Auldist *et al*. (1998a) and Mackle *et al*. (1999) reported increased levels in BSA and IgG with restricted feeding in mid-late lactation. Restricted nutrition, especially on the 0 kg crop DM/cow/d treatments, may have also influenced milk composition and confounded the interpretation of crop effect. Petch *et al*. (1997) reported, for cows in late lactation, no effect of pasture allowance or type of feed on individual milk proteins. From this it was assumed that any effect on milk proteins in mid/late lactation would be due to the type of crop and not level of feeding. For fatty acid composition the effect of level of feeding could influence interpretation of results. When cows are in negative energy balance, the synthesis of short and medium-chain fatty acids in the mammary gland declines, while the mobilisation of long-chain unsaturated fatty acids from the adipose tissue increases (Palmquist *et al*. 1993). Mackle *et al.* (1999) reported similar effects on milkfat composition for cows grazing restricted and *ad libitum* pasture allowances in summer. The effects on milkfat composition that result from an increase in crop intake of 0 to 4 kg DM/cow/day differ from those reported when restricted and *ad libitum* pasture allowances were compared (Table 2). Thus, when interpreting crop effects on milkfat composition, the consequence of underfeeding, especially between the 0 and 4 kg DM/cow/d treatments, must be given consideration.

Rate of supplementation with crop had no effect on crude protein content or the composition of individual milk proteins. Turnip treatments produced milk with higher crude protein concentrations than the sorghum treatments. This difference, however, was not apparent for true protein, casein and whey protein. Petch *et al*. (1997) similarly reported for cows in mid to late lactation, no effect of type of feed or level of feeding on milk protein concentrations. There was however an effect of crop on the casein:whey protein ratio. The ratio increased with increased increasing amount of turnips but decreased when more sorghum was fed. Casein:whey protein ratio has been used to indicate the suitability of milk for cheese making (Lucey, 1996). Milk with high casein:whey ratio forms a firmer curd and a lower moisture cheese, which indicates that the potential of milk for cheese making may improve with feeding turnips but would be unaffected by feeding sorghum.

Unlike milk protein, crop type and rate of feeding affected milk fat concentration and fatty acid composition. Feeding turnips had a greater influence on these components than did sorghum. Turnips influenced milk fat composition to a greater extent than just overcoming an underfeeding effect. Total fat and the composition of individual fatty acids resulting from feeding turnips differed from pasture and sorghum (Table 1). Murphy *et al*. (1995) and Chouinard *et al*. (1998) demonstrated that milkfat composition was influenced by lipid composition of diet. In these studies, feeding oilseeds high in linoleic acid increased both long-chain and total unsaturated fatty acid concentrations in milk. Turnips had lower levels of linolenic and linoleic acid and more lauric acid compared to sorghum or pasture. From the fatty acid concentrations found in turnips and the known effects of feeding high levels of linoleic acid on milkfat composition, it would be expected that the milkfat composition resulting from feeding turnips would differ to feeding cows sorghum. This was the case, with an increase in the amount of turnips fed, short, medium, and long-chain fatty acids increased and unsaturated fatty acids declined. Associated with these changes were changes in the physical characteristics of the milkfat expressed as SFC. In particular, with increasing rate of turnips fed the SFC at 10^0C (SFC_{10}) increased. MacGibbon & McLennan (1987) reported a positive correlation between SFC_{10} and the sectility hardness of butter, which reflects spreadability of the product. This suggests that butter made from milk originating from turnip feeding would be harder and less spreadable than from cows fed sorghum.

Conjugated linoleic acid (CLA) has in recent years received much attention because of the reported anticarcinogenic properties (Parodi 1999). Kelly *et al*. (1998) reported higher CLA concentrations in milkfat resulting from pasture, than TMR diets. Current understanding is that CLA is formed during rumen biohydrogenation of linoleic acid. However, pasture is high in linolenic acid (Table 1) and TMR higher in linoleic acid but the reason why pasture diets produce higher CLA has not been elucidated. Compared with pasture and sorghum, turnips produced milk with less CLA. This was not surprising given the very different fatty acid profile for turnips compared with pasture and sorghum.

CONCLUSION

This study showed that the detailed composition of milk and the suitability of milk for processing different products changed with what was fed on-farm. Feeding turnips as a supplement to cows subjected a shortfall in summer pasture may have resulted in milk more suitable for the manufacture of cheese but less suitable for butter than feeding sorghum.

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