
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

ISSN 0370-2731/2001 Proceedings of the New Zealand Society of Animal Production **61:** 213-216

Effect of stage of lactation on the efficiency of Jersey and Friesian cows at converting pasture to milk production or liveweight gain

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ABSTRACT

A study comparing Jersey (J) and Friesian (F) cows in early (EL), mid (ML) and late (LL) lactation and offered either *ad libitum* pasture (P) or restricted pasture allowance + a concentrate (PC) was conducted. Breeds were grazed at a similar live weight (LWT)/ha (1340 and 1850 kg LWT/ha for P and PC respectively). F cows produced 10% more MS/cow/day than J cows. DM intake (DMI) on P was 13.6 kg DM/cow/day for F and 11.3 kg DM/cow/day for J cows but if expressed at constant LWT, J consumed more than F cows (30.3 versus 28.0 $\pm$ 0.8 g DMI/kg LWT). During EL, J cows gained less live weight than F cows but in LL the reverse occurred. An interaction between breed and stage of lactation also occurred for the conversion efficiency of pasture DM to milkfat, protein, casein and MS. For the yield of milkfat, protein and casein J cows in EL were more efficient than F cows but in LL no breed effect on the conversion efficiency of pasture to these components occurred. The difference between breeds in partitioning feed to milk solids and liveweight gain at different stages of lactation suggests different management opportunities for each breed to more efficiently convert pasture to MS.

Keywords: Friesian & Jersey cows; stage of lactation; dry matter intake; milk; milkfat; protein; casein; milksolids; feed conversion efficiency.

INTRODUCTION

The benefits of a particular breed of cow are often debated by dairy farmers and within the processing sector of the dairy industry. There is, however, little definitive evidence on the relative efficiencies of Jersey (J) or Friesian (F) cows for milk production from pasture, for processing, or on product characteristics. Comparative whole-farm studies conducted in New Zealand by Bryant *et al.* (1985) and Ahlborn & Bryant (1992) produced conflicting evidence on the relative efficiency of J and F cows for milk and milksolids (MS) production. Nevertheless component studies by L'Huillier *et al.* (1988) and Mackle *et al.* (1996) reported a greater efficiency of J cows for milkfat production and similar efficiency of the two breeds for protein production (Mackle *et al.*, 1996). Composition of J milk differs considerably from F milk (Bryant *et al.*, 1985) but there is little documented evidence on the relative differences in milk processing or product characteristics. Anecdotal evidence suggests, particularly in early lactation that J milk has a more undesirable flavour. To test this, a study comparing the flavour characteristics of J and F cows on different feeds was conducted during the 1999/2000 dairying season. As part of this study, the opportunity was taken to evaluate the productivity of J and F cows.

MATERIALS AND METHODS

The performance of F and J cows on two different types of feed, ad libitum pasture (P) and restricted pasture + concentrate (PC) were compared in a 2 x 2 factorial trial. Twenty-four cows of each breed were selected to have a similar mean age and days in milk (DIM). Within each breed, 12 cows, balanced for age, DIM, live weight (LWT), milk yield, MS yield, breeding worth (BW) and production worth (PW), were allocated to the two feed treatments. The cows selected were the progeny from a range of sires. The 24 J cows and the 24 F cows were the progeny of 19 and 17 sires respectively. J cows had an average BW of 60 and F cows 42. Three experimental periods were conducted during the season: early lactation (EL), 23 August – 21 September (33-54 DIM), mid lactation (ML), 22 November – 20 December (121-152 DIM), and late lactation (LL), 13 March – 11 April (233-247 DIM). Experiments run in EL and ML comprised a 1-week preliminary period, during which the 48 cows grazed together on a pasture allowance of 40 kg DM/cow/day, followed by a 3-week experimental period. Because of a prolonged summer dry period, insufficient pasture was available to run the trial in LL for the full duration. As a result the experimental period in LL was reduced to 2 weeks.

The 2 breeds were compared at equal LWT/unit area. For the P treatments a stocking rate based on 2.8 F cows/ha, or, 1340 kg LWT/ha and for the PC treatments, 3.8 F cows/ha, or, 1850 kg LWT/ha was adopted. The supplement was fed at 1.0% (DM basis) of the average breed LWT recorded during each preliminary period. The pasture allowance for F cows on the P treatment was 40 kg DM/cow/day and the PC treatment, 25 kg DM/cow/day. On average, throughout the trial, F cows were 22% heavier than J cows. Thus, the stocking rate of the J cows was 22% higher, e.g., the equivalent stocking rates on the P treatments were 3.4 and 2.8 cows/ha for J and F cows respectively and the amount of concentrate fed, 22% less (3.7 verses 4.8 kg DM/cow/day: J versus F).

The supplement comprised a mix of 80% pellet (85% maize, 15% lucerne) and 20% cottonseed. Half the daily ration was fed after the morning milking at *c*. 0730 h and half after the evening milking at *c*.1530 h. Throughout the experimental periods each treatment group was grazed separately within the same paddock. Each day a new paddock was grazed.

Measurements

Herbage mass of pasture before grazing was estimated daily using the rising plate meter (Thomson and Blackwell, 1999) and the area allocated to each treatment adjusted to achieve the predetermined herbage allowance. On three occasions each week, the residual herbage mass for each treatment was recorded and, from the next paddock to be grazed, pasture samples were collected, bulked weekly and analysed for DM, crude protein, ADF, and *in vitro* digestibility (DDM) by reference procedures. Samples were also analysed for alkane content (Dove & Mayes, 1991).

During the preliminary and experimental periods, milk yield and composition were recorded twice weekly. Milk yields (pm & am) were recorded using in-line milk meters and milk composition (fat, crude protein and casein) was determined using the Milkoscan FT120 milk analyser (Foss Electric, Denmark). Separate calibration procedures of the FT120 results with reference procedures for milkfat and protein for J and F milk were adopted for each herd test. Cow LWT was measured on two consecutive days immediately before and at the completion of each experimental period. For the P treatment only, individual cow DM intake was estimated during the last 5 days of each experimental period using an alkane technique (Dove & Mayes 1991).

Statistical analyses

LWT, milk production, MS production, and milk composition were analysed separately for each period using analysis of variance. The values for each component recorded during the preliminary period were used as a covariant for values recorded during the experimental period. Pasture DM consumed/ha was analysed across the three periods using analysis of variance. Breed efficiency comparisons were undertaken using only the P treatments. These analyses were conducted across the three periods using residual maximum likelihood (REML).

RESULTS

No breed effect on pasture DM consumption expressed as kg DM/ha/day was observed. The average pasture consumption recorded during the three experimental periods was 1550 and 1530 ± 19 kg DM/ha for J and F cows respectively. As the dairy season advanced (spring – autumn), the chemical composition of pasture changed: DM% and ADF% increased, and DDM% and crude protein% declined (Table 1). Chemical composition of the concentrate remained constant throughout the trial.

TABLE 1: Chemical composition of pasture and concentrate feeds offered to Jersey and Friesian cows in early (EL), mid (ML), and late (LL) lactation.

	DM %	ADF	Digestible DM %	Crude protein %	ME* MJME/ kg DM
Pasture					
EL	16.7	20.4	86.5	21.6	12.9
ML	19.0	24.0	78.1	17.2	11.6
LL	34.8	28.2	55.4	16.3	8.1
Concentrate**	89.1	15.2	83.0	15.0	12.5

* ME pasture estimated from the relationship between DDM and ME (SCA 1990) ME=DDM x 0.156–0.5

** Concentrate = 80% pellet (85% maize grain & 15% lucerne) + 20% cottonseed with lint. (ME of concentrate was estimated from published values for each component (NRC, 1989))

Within breeds, no relationship between BW and the production and efficiency indices presented in Tables 2 & 3 could be established. From this information the assumption was made that differences between J and F cows was a true breed effect and not a BW effect.

Milk yield and composition differed markedly between breeds (Table 2). Across the P and PC treatments the average milk yield was 41% greater for F than J cows. J cows produced more concentrated milk and the average MS yield/cow over the three periods favoured F cows by 10%.

During EL and ML, cows grazing the P treatments produced milk with higher concentrations of fat, protein and casein than cows grazing the PC treatment. In LL the effect of feed on milk composition was only apparent for milkfat concentration. This effect of feed on milk composition was similar for J and F cows. In EL, feed type

TABLE 2: Effect on cow performance to feeding Jersey and Friesian cows on restricted pasture with a concentrate supplement (+ concentrate) or *ad libitum* pasture (pasture) in early 33 DIM), mid (121 DIM) and late (233 DIM) lactation.

	J		F			P values		
	PC	P	PC	P	s.e.d.	Breed	Feed	Breed x Feed
EL (spring)								
LWT (kg/cow)	369	375	473	479	4.1	0.000	0.03	0.99
Milk yield (kg/cow/day	18.3	18.4	26.7	25.2	1.19	0.000	0.42	0.34
Fat%	5.63	5.79	3.97	4.4	0.16	0.000	0.01	0.25
Protein%	3.98	4.19	3.42	3.57	0.07	0.000	0.000	0.55
Casein%	3.11	3.23	2.52	2.7	0.08	0.000	0.007	0.63
MS Yield (kg/cow/day)	1.76	1.82	1.95	2.01	0.1	0.02	0.41	0.98
ML (summer)								
LWT (kg/cow)	380.9	382.2	493.5	493.6	2.73	0.000	0.73	0.75
Milk yield (kg/cow/day	14.7	12.3	19.8	17.3	0.66	0.000	0.000	0.63
Fat%	5.31	5.82	3.89	4.18	0.16	0.000	0.001	0.35
Protein%	3.79	3.99	3.27	3.46	0.04	0.000	0.000	0.72
Casein%	3.02	3.21	2.57	2.76	0.03	0.000	0.000	0.11
MS Yield (kg/cow/day)	1.34	1.21	1.40	1.32	0.05	0.03	.009	0.53
LL (autumn)								
LWT (kg/cow)	377.1	379.5	488.6	474.9	2.68	0.001	0.04	0.68
Milk yield (kg/cow/day	8.8	6.2	12.8	9.3	0.40	0.000	0.000	0.15
Fat%	6.08	6.40	4.35	5.15	0.25	0.000	0.003	0.16
Protein%	4.48	4.52	3.71	3.82	0.12	0.000	0.38	0.67
Casein%	3.52	3.58	2.92	3.02	0.09	0.000	0.23	0.76
MS Yield (kg/cow/day)	0.94	0.66	1.03	0.81	0.05	0.001	0.000	0.44

TABLE 3: Intake and efficiency estimates for Jersey and Friesian cows in early, mid, and late lactation.

	EL		ML		LL		s.e.d.		P values		
	J	F	J	F	J	F	Breed	Period	Breed	Period	Br x per.
Live weight	371.5	481.7	382.0	500.1	379.0	473.4	8.71	6.16	0.000	0.049	0.17
Lwt. Gain	0.93	1.65	0.27	0.68	0.53	-0.07	0.2	0.14	0.24	0.000	0.000
DMI	11.4	14.9	12.6	14.4	10.0	11.4	0.02	0.43	0.000	0.000	0.07
g DMI/kg LWT	31.2	30.8	32.9	29.0	26.9	24.3	0.84	0.92	0.008	0.000	0.15
g DMI/Kg $LWT^{0.75}$	136.7	144.4	145.4	136.7	117.7	112.6	3.51	4.08	0.57	0.000	0.12
kg milk/kg DMI	1.60	1.72	0.98	1.24	0.63	0.79	0.05	0.05	0.000	0.000	0.48
g milkfat/kg DMI	100.9	71.4	55.5	51.4	40.4	41.9	1.99	2.75	0.000	0.000	0.000
g protein/kg DMI	65.8	58.9	38.9	42.0	28.7	30.7	1.48	1.83	0.60	0.000	0.018
g casein/kg DMI	50.9	46.0	31.3	33.4	22.8	24.2	1.18	1.44	0.62	0.000	0.039
g MS/kg DMI	166.6	129.7	94.2	94.1	68.6	73.2	3.08	4.33	0.004	0.000	0.000

had no effect on milk or MS yield but in ML and LL, feed type had a greater effect on these yield components. In ML, the average increase due to the PC treatment was 17% for milk yield and 8% for MS yield. In LL, the PC treatment increased milk yield by 25% and MS yield by 13%. No breed effect on the response of PC on milk and MS yield with advancing lactation was noted.

Table 3 compares the efficiency for milk and MS production of J and F cows offered pasture only. DMI determined by the alkane method was used as the basis to compare efficiencies for production during each of the three stages of lactation. Friesian cows consumed more pasture than J cows, but the degree of difference in favour of F cows was less in ML and LL than in EL. When DMI was expressed per unit of LWT, J cows consumed more pasture than F cows (30.3 versus 28.0 $\pm$ 0.8 g DMI/kg LWT; J versus F). As lactation advanced, the efficiency of milk and milk solids production (fat, protein, and casein yield) as expressed as kg milk or g milk solids/kg DMI, decreased. This decrease in efficiency was greater for J than F cows. During EL, F cows gained more live weight than J cows whereas in LL the opposite occurred.

DISCUSSION

Differences in productivity between J and F cows grazing pasture in this study were greater than those previously reported in New Zealand. On average, over the three periods, J cows produced 40% less milk and 10% less MS than F cows. Nation-wide statistics for 1998/99 (LIC, 1999) show that J cows produced 27% less milk and 8% less MS. Similarly, a farm systems comparison by Ahlborn and Bryant (1992) reported J cows produced 29% less milk and 9% less MS than F cows. The greater difference between J and F cows found in this study may be the result of the management criteria adopted to compare the two breeds at equivalent LWT/unit area and the amount of supplement fed at equivalent DM/kg LWT. In the farm systems trials and in the national dairy statistics reported, this was not the case.

In the few studies conducted in New Zealand, comparing performance from grazing J and F cows, there are conflicting results. Bryant et *al.* (1985) reported, for a whole lactation, that F cows were more efficient at converting pasture to milkfat (40 versus 45 g milkfat/kg DMI; J versus F). For cows, 98-119 DIM, L'Huillier *et al.* (1988) reported J cows to be more efficient (67 versus 61-g milkfat/kg DMI: J versus F). A similar advantage to J cows for milkfat production over the whole lactation (79 versus 67 g milk fat/kg DMI for J and F respectively) was reported by Mackle *et al*. (1996). These authors also reported that J were less efficient than F for milk production (1.3 versus 1.4 kg milk/ kg DMI; J versus F) and expressed similar efficiency for protein production (50 versus 49 g protein/kg DMI; J versus F). In the study of (Mackle *et al*. 1996) the efficiency parameters presented were the average of six assessments made during lactation. No mention was made of a stage of lactation effect on the efficiency parameters presented. The data presented in Table 3 shows a considerable decline in the efficiency of milk, milk solids and MS production with advancing lactation. In addition, a significant breed x period interaction occurred for all milk solids efficiency indices measured. In EL (33-51 DIM) J cows were less efficient for milk production but more efficient for milkfat, protein, casein, and MS production. As lactation advanced, breed effects on efficiency of conversion of pasture to milk solids declined and in LL (233-247 DIM) the two breeds had similar efficiencies for milk solids production but the efficiency for milk production still favoured the F cow. A significant breed effect on the efficiency of milk protein yield was not reported by Mackle *et al*. (1996). The fact that the breed effect on the efficiency of protein and casein production was only observed in EL (Table 3) could have been masked in the study by Mackle *et al*. (1996) because these authors only reported the average efficiency parameters for the whole lactation.

F cows consumed daily more pasture per cow than J cows with a trend for the advantage to F to be greater in EL than in ML or LL. The highest intake (Table 3) for F cows occurred in EL and J cows in ML. Mackle *et al.* (1996) also reported peak intake for J cows being later than F cows. When intake was expressed on a common LWT basis (DMI/ kg LWT) J cows on average consumed 8% more (30.3 versus 28.0 g DMI/kg LWT: J versus F) than F cows. L'Huillier *et al*. (1988) and Mackle *et al*. (1996) reported a similar advantage to J cows in DMI of pasture per unit live weight. This difference between breeds in intake per kg LWT was not reflected in total DM consumed as determined from pasture measurements made before and after grazing. In these assessments, no breed effect was noted for the total amount of pasture consumed. The breed effects on intake/ kg LWT were, however, small and may not have been detectable considering the errors associated with herbage mass estimation (L'Huillier & Thomson, 1988).

During EL, J cows gained less live weight than F cows. In LL, the reverse occurred. In EL, J cows apparently diverted a higher proportion of the energy in their daily intake to milk solids production and less to LWT gain than F cows. In LL, F cows converted energy to milk production at the expense of LWT gain. Blake *et al*. (1986) reported a higher N balance for J cows compared to Holsteins in the 2nd trimester of lactation, suggesting at this later stage of lactation, J cows were replenishing adipose tissue and Holsteins weren't. This is supportive of the significant breed x period interaction for LWT gain presented in Table 3. These data suggest that J cows may perform better in situations in which pasture production is only sufficient to support a short lactation, i.e., in summer dry environments.

J and F cows, when grazed at a similar LWT/ha, responded in EL, ML and LL in a similar manner to the PC ration. The change in feed from P to PC resulted in a decline in composition of milkfat, protein and casein in EL and ML and in only milkfat composition in LL. Also, in ML and LL, the change in feed from P to PC resulted in an increase in milk and MS yield. The increase in yield components was greater in LL. Time-of-year effects on pasture quality most likely influenced this effect. The quality of pasture declined from EL (spring) to LL (autumn) (Table 1) and in ML and LL the concentrate had a higher energy content than pasture (ME of the concentrate was 12.5 compared to 11.6 and 8.1 MJ/kg DM for pasture in ML and LL respectively). Oldenbroek (1998) reported a breed x diet interaction with J cows utilising feed more efficiently on a roughage-only diet comprising dried grass and maize silage than a roughage & concentrate diet. Holstein-Friesians utilised feed energy to a similar level of efficiency on both diets. No breed differences on the effect of feed type on milk yield and composition were noted in this study (Table 2).

CONCLUSION

Jersey cows in EL utilised a higher proportion of their intake than F cows for milkfat, protein, casein and MS production. This advantage, however, declined with advancing lactation and in LL (200+ DIM) J cows compared to F cows utilised a higher proportion of their pasture intake for LWT gain than for milk or MS production. In LL, F cows partitioned energy to milk and MS production at the expense of LWT gain. This suggests that, with advancing lactation, particular attention would need to be given to an F herd to minimise LWT loss. Also, greater advantage could possibly be made of the greater efficiency of J cows in early lactation to produce milkfat and protein. The response in the later half of lactation, or during summer/autumn, to supplementing pasture with a concentrate feed, clearly demonstrated that during summer and early autumn pasture quality in terms of energy content was insufficient to meet the energy requirements for milk production.

ACKNOWLEDGMENTS

The authors thank Pat Laboyrie, Dave Wildermoth and Ewan Spencer for herd management and data recording and Barbara Dow for statistical analyses and advice on interpretation. The New Zealand Dairy Research Institute is acknowledged for funding the project.

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