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A comparison of the composition, coagulation characteristics and cheesemaking capacity of milk from Friesian and Jersey dairy cows

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Twenty-nine multiparous cows of each of the Jersey and Friesian breeds, all κ-casein AB phenotype, were grazed together and managed identically. On three occasions during 10 d in spring (early lactation), milk was collected from all cows at four consecutive milkings and bulked according to breed. On a separate occasion, milk samples were also collected from each cow at consecutive a.m. and p.m. milkings to form one daily sample per cow. The bulked milks (800–1000 l per breed on each occasion) were standardized to a protein : fat (P : F) ratio of 0·80, and 350 l from each breed was made into Cheddar cheese. The solids content of the remaining Friesian milk was then increased by ultrafiltration to a solids concentration equal to that of the Jersey milk. This solids-standardized Friesian milk and a replicate batch of P : F standardized Jersey milk were made into two further batches of Cheddar cheese in 350-l vats. Compared with Friesian milk, Jersey milk had higher concentrations of most milk components measured, including protein, casein and fat. There were few difference in milk protein composition between breeds, but there were differences in fat composition. Friesian milk fat had more conjugated linoleic acid (CLA) than Jersey milk fat. Jersey milk coagulated faster and formed firmer curd than Friesian milk. Concentrations of some milk components were correlated with coagulation parameters, but relationships did not allow prediction of cheesemaking potential. Jersey milk yielded 10% more cheese per kg than Friesian milk using P : F standardized milk, but for milks with the same solids concentration there were no differences in cheese yield. No differences in cheese composition between breeds were detected. Differences in cheesemaking properties of milk from Jerseys and Friesians were entirely related to the concentrations of solids in the original milk.

Keywords: Cheddar cheese, standardized milk, breed, κ-casein AB phenotype.

Milk composition influences the yield and quality of subsequent dairy products (Dalgleish, 1993). Farm management practices that affect milk composition could therefore be used to optimize milk processing properties. One way to manipulate milk processing properties on farm might be to select breeds of cows that produce milk especially suited to the manufacture of specific products, as reported for several overseas breeds (Malossini et al. 1996; Chiofalo et al. 2000; Auldist et al. 2002). However, detailed comparison of processing properties of the two most common dairy breeds in New Zealand, Jerseys and Friesians, is rare.

Previous experiments show that concentrations of total fat and protein are higher for Jerseys than for Friesians (Mackle et al. 1996; Thomson et al. 2001) and these differences are confirmed by national New Zealand herd testing records (Livestock Improvement Corporation, 2000). These differences in gross milk composition suggest similar differences in the profiles of fatty acids and individual proteins and, consequently, the processing properties of the milk. Furthermore, in New Zealand, there is anecdotal evidence of breed-related differences in the

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potential of milk for cheese manufacture. Such evidence is founded on perceived differences in rates of moisture expulsion during syneresis in regions where Jersey milk forms a high proportion of the bulk supply. In support of this, Gilles & Lawrence (1985) report that elevated fat levels in the rennet coagulum decrease the rate of syneresis, which inhibits moisture expulsion, such that milk fat adds more than its own weight to the yield of cheese.

Previous comparisons of breed-related differences in milk composition and manufacturing properties have not accounted for inherent differences in the frequencies of specific protein phenotypes that exist between breeds (Buchberger, 1995). In New Zealand, as in most of the world, the B variant of κ-casein is prevalent amongst Jerseys (frequency = 0·50–0·66) while in Friesians the A variant predominates (frequency = 0·70–0·93) (Hill et al. 1993; Buchberger, 1995). Effects of κ-casein phenotype on milk composition and cheese quality are well known (Ng-Kwai-Hang & Grosclaude, 1992; Puhan & Jakob, 1994). Thus, in any breed comparison, it is important to remove the known effects of κ-casein phenotype to identify true, underlying breed-specific effects.

The objectives of the current experiment were: to compare the composition and coagulation properties of milk and the yield and quality of Cheddar cheese from Jersey and Friesian cows in the absence of the potentially confounding effect of κ-casein phenotype; and to determine whether there were any effects of breed on these parameters that were not related to concentrations of total fat and protein in the original cheesemilk. At the same time, relationships between milk composition and coagulation properties were investigated in milk samples that varied widely in composition. The variation in milk composition and coagulation properties between individual cows was measured to gauge the scope for using natural variation to select cows producing milk especially suited to cheesemaking.

Materials and Methods

Cows and their management

All available cows at the Dexcel research farms were typed for milk protein variants using polyacrylamide gel electrophoresis of skim milk under non-reducing conditions (Singh & Creamer, 1991). Twenty-nine multiparous cows of each breed, Jersey and Friesian, were selected. All cows were selected for the κ-casein phenotype AB, and β-lactoglobulin phenotypes were recorded but not balanced. Numbers of cows of the β-lactoglobulin phenotypes AA, AB and BB were 9, 17 and 3 respectively for the Friesians and 2, 13 and 14 for the Jerseys. Cows grazed together as a single herd from one month prior to the trial and were offered a generous pasture allowance as their sole feed. All cows were offered fresh pasture twice daily and were milked through a common dairy at approximate times 7.00 and 16.00.

Table 1. Composition of cheesemilk from Friesian and Jersey cows when raw and after standardization of milk to constant protein : fat (P : F) ratios and total solids (TS) concentrations

Values are means for each milk type for the three cheesemaking occasions

	Friesian			Jersey		
	Raw	P : F	TS	Raw	P : F	TS
Fat (g/kg)	43·9	43·1	48·4	56·0	47·6	48·1
Protein (g/kg)	35·3	35·2	39·7	39·4	39·0	39·3

Milk and sample collection

On three occasions during 10 d in spring (early lactation), 2-days' milk was collected from each cow and bulked according to breed. This produced 800–1000 l per breed for each collection, which was chilled and transported to the pilot-scale cheesemaking facility at Anchor Products, Hautapu. Samples of this bulk milk were collected before any standardization, and again at both stages of the standardization procedure (see below). On one occasion during the same 10-d period, a milk sample was collected from each cow at two consecutive milkings. Samples from the afternoon and morning milkings were bulked to form one daily sample for each cow. These samples were chilled and either analysed immediately or frozen for analysis later.

Cheesemaking

Four vats of cheese were made on each of 3 d. Bulk milk from each breed was standardized to a protein : fat (P : F) ratio of 0·80, by adding the appropriate amount of fat or skim, centrifugally separated from the same batch of milk. Approximately 400 l of each milk was put aside (Vats 1 and 2). The solids content of the remaining Friesian milk was increased by ultrafiltration to a concentration approximating that of the Jersey milk. The remaining Jersey milk and the Friesian milk with the equivalent solids concentration were processed as Vats 3 and 4, respectively. Hence while all four vats contained milk with the same protein : fat ratio (0·80), Vats 1 and 2 contained milk with different solids levels due to breed and Vats 3 and 4 contained milk with the same solids level but originating from different breeds. Vats 1 and 3 contained duplicate Jersey milks. Mean concentrations of the fat and protein in the four vats of cheesemilk are presented in Table 1.

After pasteurization, cheesemilks were pumped to the cheesemaking vats. Milks were warmed to 32 °C before the addition of bulk mesophilic starter at a rate of 1·90–2·05% (w/w). Australian Double Strength calf rennet was added at 10 ml/100 l milk. The rennet was blended thoroughly and the whole was left to coagulate under quiescent conditions until judged by the cheesemaker to be sufficiently firm to cut (approximately 40 min). When ready, the coagulum was cut and agitation commenced while the curds and whey were heated to 38 °C. The drain target was pH 6·25 and, after draining, the curd was allowed to mat and cheddared for ~3 h until the pH reached 5·25. Curd was then milled and salted at a rate of 25 g/kg. Salted curd was mellowed for 25 min, filled into rectangular 20-kg cheese moulds and pressed overnight.

Milk compositional analyses

Bulk milk and individual cow milk samples were analysed for fat, protein, casein and lactose using an infra-red milk analyser (FT-120; Foss Electric Hillerød, Denmark). Concentrations of individual milk proteins (β-casein, α-casein, κ-casein, α-lactalbumin, β-lactoglobulin) were measured using the SDS-PAGE method of Manderson et al. 1998, as modified by Mackle et al. (1999). The serum proteins bovine serum albumin (BSA) and immunoglobulin G_1 (IgG_1) were measured by radial immunodiffusion using commercial kits according to the manufacturer's instructions (The Binding Site Ltd., Birmingham B29 6AT, UK). Concentrations of Ca and Mg were measured by atomic absorption spectrophotometry, and concentrations of Na and K were determined by flame photometry. Fatty acid profiles were measured using gas chromatography (MacGibbon, 1988). Raw (unstandardized) bulk milk from each breed from each cheesemaking occasion was analysed for somatic cell count (SCC) using an automated cell counter (Fossomatic 215; Foss Electric, Hillerød, Denmark).

Assessment of milk coagulation

Rennet coagulation properties of milk samples (10·0 ml) were measured using a Formagraph (Foss Electric, DK-3400, Hillerød, Denmark) by the method of McMahon & Brown (1982). The following parameters were obtained from the displacement/time output signal:

RCT = rennet coagulation time, the time at which the time/displacement signal begins to bifurcate at the onset of gelation.

K_{20} = time at which the bifurcated signal attains a width of 20 mm; the reciprocal, $1/K_{20}$ (1/min) is an index of curd firming rate.

A_{60} = the width of the bifurcation at 60 min after rennet addition; this is an index of curd firmness.

Measurement of cheese yield and composition

Cheese from each vat was weighed on removal from the moulds. Cheese blocks were then sampled for measurement of pH and concentrations of fat, protein, moisture, salt and ash, using standard methods (Ng-Kwai-Hang et al. 2002).

Statistical analyses

Results from individual cows were analysed using ANOVA and the bulk milk data using REML (residual maximum likelihood) to use both the between-collection and within-collection variation. For individual cows, means were statistically adjusted using the overall effect of β-lactoglobulin phenotype on milk composition to account for the slight bias of β-lactoglobulin phenotype between breeds. For the bulk results, the two vats of Jersey milk (Vats 1 and 3) were treated as replicates on each cheesemaking day. Partial Least Squares Regression and Principal Component Regression were used to investigate the prediction of milk coagulation characteristics from milk composition. Genstat Release 4.2 was used for all statistical analyses.

Results

Milk composition

Within breeds, individual cows varied markedly for most milk components measured. Means, ranges and SD for each breed are presented in Tables 1–3. There were also differences between the breeds in milk composition. Jersey cows produced milk with higher concentrations of nearly all milk components measured (Tables 3 and 4). The exceptions were lactose, α-casein, α-lactalbumin and β-lactoglobulin, for which there were no differences between breeds, and IgG, which was higher in Friesian milk than Jersey milk. There were differences in the composition of milk fat between the breeds (Table 5). Generally, Jerseys had higher proportions of long-chain saturated fatty acids and lower proportions of long-chain unsaturated fatty acids than Friesians. There were lower levels of conjugated linoleic acid (CLA) in Jersey milk fat than in Friesian milk fat (Table 5). Mean milk SCC for raw Jersey and Friesian milk was 121 000 and 161 000 cells/ml, respectively (SED = 61, $P > 0·05$).

Milk coagulation characteristics

Curd formation (K_{20}) was faster for Jersey milk than for Friesian milk, as measured using a Formagraph (Table 2). This effect was apparent in milk from individual cows and in bulk milk, both raw and standardized for protein : fat ratios, but did not persist when bulk milk was additionally standardized to constant concentrations of total solids (results not presented). No other effects of breed on milk coagulation were detected.

Relationships between milk composition and coagulation characteristics

K_{20} and A_{60} were correlated with nearly every milk component measured, but particularly with the concentrations of fat, protein, casein and total solids (Table 4). Despite these correlations, only a small amount of the total variation in coagulation characteristics was explained by milk composition (as indicated by the correlation coefficients, R, not greater than ~0·50). When analysed separately, results from the two breeds showed that milk composition

Table 2. Variation in concentrations of milk components (g/kg unless stated otherwise), rennet coagulation time (RCT), rate of curd formation (K_{20}) and curd firmness after 1 h (A_{60}) amongst individual cows and between breeds

Values are breed means ($n=29$)

	Friesian				Jersey					
	Mean	Min.	Max.	SD	Mean	Min.	Max.	SD	SED	*P*
Fat	44·7	36·2	53·5	4·86	58·2	48·4	67·6	3·89	1·34	**
Protein	35·5	30·6	41·1	2·12	39·8	36·7	45·6	2·00	0·62	**
Casein	27·4	24·0	30·8	1·39	31·2	29·2	34·9	1·24	0·40	**
Lactose	50·4	46·4	54·3	2·01	51·0	48·8	53·6	1·17	0·50	NS
Casein : protein	0·771	0·749	0·790	0·010	0·785	0·765	0·806	0·011	0·003	**
α-casein	11·5	7·5	16·8	2·18	11·9	8·0	19·5	3·06	0·75	NS
β-casein	11·0	4·7	16·1	2·61	13·5	4·9	17·3	3·16	0·85	**
κ-casein	3·8	3·1	4·7	0·39	4·1	3·3	5·4	0·51	0·14	*
α-lactalbumin	1·3	0·4	1·8	0·38	1·5	0·8	2·1	0·36	0·11	NS
β-lactoglobulin	4·9	3·5	7·0	0·93	5·3	3·4	6·9	0·93	0·19	*
BSA† (mg/kg)	183	145	242	23·7	151	99	232	34·4	8·9	**
IgG‡ (mg/kg)	634	337	1097	162·1	590	410	1080	158·4	48·0	NS
Mg (mg/kg)	109	94	126	81	117	97	137	98	27	**
Ca (mg/kg)	1262	1130	1470	794	1490	1340	165·0	661	217	**
Na (mg/kg)	353	290	500	468	280	250	340	291	116	**
K (mg/kg)	1512	1260	1730	112	1410	1320	1500	559	267	**
RCT (min)	31·4	17·5	42·2	6·1	32·2	17·5	47·5	5·6	1·69	NS
K_{20} (min)	12·9	7·2	25·2	3·9	10·3	6·0	18·9	2·6	0·99	*
A_{60} (mm)	50·2	35·9	58·6	4·8	52·7	37·4	60·2	5·2	1·51	NS

* $P<0·05$; ** $P<0·01$; NS, not significant ($P>0·05$)
† Bovine serum albumin
‡ Immunoglobulin G

Table 3. Variation in proportions of fatty acids (% of total fat) in milk fat amongst individual cows and between breeds

Values are breed means ($n=29$)

	Friesian				Jersey					
Fatty acid	Mean	Min.	Max.	SD	Mean	Min.	Max.	SD	SED	*P*
4 : 0	4·92	4·29	5·41	0·335	5·07	4·21	5·83	0·370	0·100	*
6 : 0	3·00	2·64	3·27	0·122	3·14	2·74	3·42	0·177	0·043	**
8 : 0	1·73	1·58	1·90	0·089	1·81	1·53	2·06	0·130	0·034	**
10 : 0	3·62	3·05	4·20	0·342	3·86	3·13	4·73	0·407	0·113	**
10 : 1	0·32	0·24	0·43	0·046	0·28	0·18	0·38	0·046	0·013	NS
12 : 0	3·79	3·09	4·42	0·426	3·99	2·96	5·24	0·525	0·143	NS
12 : 1	0·08	0	0·17	0·046	0·05	0	0·17	0·051	0·014	**
14 : 0	11·03	8·90	12·61	0·862	11·42	9·57	12·56	0·633	0·224	*
14 : 1	0·86	0·49	1·45	0·186	0·73	0·52	1·08	0·136	0·048	*
15 : 0	1·97	1·46	2·41	0·243	1·58	1·28	1·88	0·155	0·061	**
16 : 0	25·5	22·06	32·93	2·563	26·69	23·59	30·30	1·648	0·645	NS
16 : 1	1·17	0·90	1·53	0·156	0·99	0·70	1·42	0·174	0·050	**
17 : 0	1·44	1·14	1·73	0·140	1·32	1·14	1·48	0·086	0·035	**
17 : 1	0·22	0·08	0·33	0·046	0·17	0·05	0·28	0·055	0·015	**
18 : 0	10·96	8·67	13·40	1·192	12·62	10·04	14·15	0·961	0·321	**
18 : 1	23·83	17·73	28·13	2·721	21·63	17·59	25·03	1·557	0·666	**
18 : 2	1·69	1·40	2·28	0·219	1·54	0·91	1·92	0·182	0·061	**
18 : 3	0·77	0·58	1·11	0·136	0·69	0·50	0·94	0·085	0·034	**
20 : 0	0·09	0·05	0·12	0·015	0·10	0·08	0·14	0·015	0·004	**
CLA†	1·53	0·97	2·41	0·325	1·08	0·60	1·47	0·177	0·0763	**

* $P<0·05$; ** $P<0·01$; NS, not significant ($P>0·05$)
† Conjugated linoleic acid

Table 4. Correlations between coagulation parameters (rennet coagulation time (RCT), curd firming rate (K_{20}) and curd firmness after 1 h (A_{60})) and milk components for milk from individual cows. Results are shown only for components correlated significantly ($P<0·05$) with at least one coagulation parameter

Milk component	RCT		K_{20}		A_{60}	
	R	*P*	R	*P*	R	*P*
Fat	0·12	NS	−0·46	**	0·29	*
Protein	0·10	NS	−0·51	**	0·45	**
Casein	0·08	NS	−0·53	**	0·44	**
Total solids	0·12	NS	−0·50	**	0·36	**
C8 : 0	−0·12	NS	−0·36	**	0·27	*
C10 : 0	−0·09	NS	−0·39	**	0·30	*
C12 : 0	−0·08	NS	−0·33	*	0·26	*
C18 : 1	−0·020	NS	0·35	**	−0·23	NS
C18 : 2	−0·083	NS	0·26	*	−0·14	NS
Ca	0·24	NS	−0·34	**	0·22	**
Na	0·08	NS	0·40	**	−0·39	**
K	−0·05	NS	0·36	**	−0·14	**
IgG	−0·13	NS	0·08	NS	−0·26	*
β-casein	−0·10	NS	−0·41	**	0·44	**
κ-casein	0·13	NS	−0·29	*	0·21	NS

* $P<0·05$; ** $P<0·01$; NS, not significant ($P>0·05$)

was still not a good predictor of coagulation properties, even within breed (results not shown). Furthermore, principal component analyses detected no reliable method for predicting milk coagulation characteristics from milk composition (results not shown).

Breed effects on cheese

When Cheddar cheese was manufactured using P : F standardized milk that had not been adjusted for total solids (TS) concentration, the Jersey milk yielded >10% more cheese per kg (Table 5). Cheese made from Friesian milk adjusted to the same solids concentration as the Jersey milk (for gross composition of cheesemilks, see Table 2), yielded the same amount of cheese per kg as the Jersey milk. Similarly, when yields of cheese were expressed as a proportion of the original amount of milk solids, there were no differences between breeds.

There was no difference in the moisture concentrations of cheeses made with milk from the two breeds (Table 5). Furthermore, there were no other differences in cheese composition between breeds, except that Jersey cheese had a higher pH and higher ash content.

Discussion

All cows were selected to be of the κ-casein variant AB because the frequencies of the A and B alleles for the κ-casein variants vary markedly between breeds (Buchberger, 1995). Thus when deducing breed-related differences in manufacturing properties of milk from previously published literature, effects of κ-casein are confounding. The current experiment provides the first controlled comparison of the composition, coagulating properties and cheesemaking potential of milk from Jerseys and Friesians, in the absence of confounding effects of κ-casein (Ng-Kwai-Hang & Grosclaude, 1992; Puhan & Jakob, 1994).

Jersey cows produced milk with higher concentrations of nearly all the milk components measured. Similar observations for the major milk components have been reported previously both for grazing cows in New Zealand (Mackle et al. 1996; Thomson et al. 2001), and for ration-fed cows overseas (Bitman et al. 1996; White et al. 2001). These differences imply an advantage for farmers who are paid on the basis of protein and fat concentrations, but it must be remembered that Jerseys are also lower yielding. It is reported (Davis et al. 2001) that Jersey milk has a higher Ca : protein ratio, perhaps due to higher proportions of phosphorylated caseins such as α-casein, but this was not observed in the current study. In fact Jersey milk had a lower proportion of total casein present as α-casein.

In milk from individual cows, there were significant differences in the composition of milk fat between the breeds. Generally, Jerseys had higher proportions of long-chain saturated fatty acids and lower proportions of long-chain unsaturated fatty acids, which agrees well with previous data from ration-fed cows in the USA (Beaulieu & Palmquist, 1995; Morales et al. 2000; White et al. 2001). Our results also support reports that Friesian milk fat is softer than Jersey milk fat (MacGibbon, 1996), given the correlation of fat hardness with saturation of long-chain fatty acids (MacGibbon & McLennan, 1987).

Townsend et al. (1997) suggest that there is a less active delta-9-desaturase enzyme in Jerseys, which is supported by the current results. In the present study the calculated ratios of 10 : 0 to 10 : 1, 12 : 0 to 12 : 1 and 14 : 0 to 14 : 1 reflect substrate to product ratios for this enzyme, and were all lower in Jersey milk, indicating that less substrate is being converted. This might be one reason for the lower levels of CLA in Jersey milk fat than in Friesian milk fat.

Higher concentrations of solids in milk from Jerseys were probably responsible for the greater rate of curd formation in Jersey milk, as measured using a Formagraph. Previous studies show that protein concentration is an important factor influencing coagulation rate (Guinee et al. 1997). This effect was apparent in milk from individual cows and in bulk milk standardized for protein : fat ratio. The effect of breed on milk coagulation did not persist, however, when bulk milk was standardized to constant concentrations of solids. Thus no differences in coagulation rate between breeds were observed that were not due to the higher concentrations of protein and fat in Jersey milk.

In milk from individual cows, milk components correlated with coagulation characteristics. RCT was not related to any milk component, but K_{20} and A_{60} were correlated with nearly every milk component measured. In particular, K_{20} and A_{60} were most strongly correlated with

Table 5. Cheese yield and composition for Cheddar cheese manufactured from milk from Friesian and Jersey cows, after standardization of milk to constant protein : fat (P : F) ratios and total solids (+TS) concentrations

Values are means for each milk type for the three cheesemaking occasions

	Jersey	Friesian			*P*	
	P : F	P : F	+TS	SED	P : F	+TS
Cheese yield (kg/100 l)	12·0	10·8	12·0	0·13	**	NS
Moisture-adjusted cheese yield (kg/100 l)	11·9	10·7	12·0	0·07	**	NS
Cheese yield (kg/100 kg solids)	135·9	136·5	135·1	1·10	NS	NS
Moisture-adjusted cheese yield (kg/100 kg solids)	134·8	134·8	134·5	0·58	NS	NS
Moisture (%)	33·3	33·4	33·2	0·28	NS	NS
MNFS (%)	52·3	52·7	52·0	0·56	NS	NS
Fat (%)	36·4	36·6	36·3	0·28	NS	NS
FDM (%)	54·5	54·9	54·3	0·53	NS	NS
Salt (%)	1·93	1·82	1·89	0·041	*	NS
Ash (%)	4·28	3·94	4·10	0·041	**	*
pH	5·55	5·38	5·45	0·026	**	*

* $P<0·05$; ** $P<0·01$; NS, not significant ($P>0·05$)

concentrations of fat, protein, casein and total solids. This concurs with the observation that Jersey milk coagulated more quickly than Friesian milk. It is also consistent with data of Christian (1996) and Auldist et al. (2002) showing similar correlations between coagulation parameters and milk protein and casein content.

Interestingly, milk coagulation parameters also correlated with particular fatty acids of milk. Proportions of 8 : 0, 10 : 0 and 12 : 0 were negatively correlated with K_{20}, and positively correlated with A_{60}. Proportions of 18 : 1 and 18 : 2 were positively correlated with K_{20}. A relationship between milk fat composition and the manner in which milk coagulates has not previously been reported.

Despite the correlations between milk composition and milk coagulation properties in individual cow samples, only a small percentage of the total variation in coagulation characteristics could be explained by milk composition (as indicated by correlation coefficients, R, not greater than ~0·50). Furthermore, principal component analyses could detect no reliable method for accurately predicting milk coagulation characteristics from milk composition. Clearly, milk coagulation is controlled by a more complex combination of factors than those measured in this study.

The composition and coagulation properties of milk varied markedly between individual cows within breeds, even though all cows were subjected to the same management and were at a similar stage of lactation. This variation between cows was even greater if the effect of breed was ignored, which points to a possible opportunity for selecting milk from individual cows (or herds) to optimize the functionality of milk for the manufacture of specific dairy products.

When Cheddar cheese was manufactured using bulked milk that had been P : F standardized but not adjusted for total solids (TS) concentration, the Jersey milk, as expected, yielded more cheese per kg of milk. The yield advantage to the Jerseys was greater than 1 kg per 10 kg milk (>10%). When Friesian milk was adjusted to the same solids concentration as the Jersey milk, however, the two breeds yielded the same amount of cheese per kg. Similarly, when yields of cheese were expressed as a proportion of the original amount of milk solids, there were no differences between breeds. Thus there were no breed-related differences in cheese yield that were not related to the concentrations of fat and protein in the original milk.

No difference was detected in the moisture concentrations of any of the cheeses made from the two breeds. Thus anecdotal evidence of breed-related differences in the syneretic properties of milk was not substantiated in this study. Furthermore, few other differences in cheese composition between breed could be found. The higher pH in the Jersey cheese can be explained by the buffering capacity of ash, which was also higher in the Jersey cheese. It is not known, however, if the higher ash content was due to a higher ash content of the original cheese-milks, or to increased salt retention in the curd, or both. Salt concentration in the cheeses was numerically, but not significantly, greater in cheese from Jersey milk.

In summary, compared with Friesian milk, Jersey milk had higher concentrations of most major milk components including protein, casein and fat. Milk protein composition was similar between breeds, but there were differences in milk fat composition. In particular, Friesian milk fat had higher proportions of the anticarcinogen, CLA. In milk from individual cows, Jersey milk coagulated more quickly and formed a firmer curd than Friesian milk, probably because of higher concentrations of solids in the original milk. Concentrations of milk components were correlated with some coagulation parameters, but relationships were too weak to allow reliable prediction of cheesemaking potential. Jerseys yielded 10% more cheese per kg milk than Friesians using milk standardized to a constant P:F ratio, but this difference disappeared for cheesemilks also standardized to a constant solids ratio. There were no differences between breeds in the quality and yield of Cheddar cheese that were not related to the fat and protein concentrations in the original milk.

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