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ANNALES AGRICULTURAE FENNIAE, VOL. 29: 253—277 (1990)

Seria ANIMALIA DOMESTICA N. 92 — Sarja KOTIELÄIMET n:o 92

COMPARISON OF FINNISH AYRSHIRE, FRIESIAN AND FINNCATTLE ON GRASS SILAGE-CEREAL AND HAY-UREA-CEREAL DIETS

1. Results of the heifer period

ELSI ETTALA and ERKKI VIRTANEN

ETTALA, E. & VIRTANEN, E. 1990. **Comparison of Finnish Ayrshire, Friesian and Finncattle on grass silage-cereal and hay-urea-cereal diets. 1. Results of the heifer period.** Ann. Agric. Fenn. 29: 253—277. (Agric. Res. Centre, Inst. Anim. Prod., SF-31600 Jokioinen, Finland.)

Finnish Ayrshire (Ay), Friesian (Fr) and Finncattle (Fc) heifers aged 4—24 months were compared on grass silage-cereal and hay-urea-cereal diets. The 50 Ay, 50 Fr and 20 Fc calves studied were randomly sampled.

Ad libitum intake of a fresh grass silage ensiled with formic acid was 4.7 kg/calf/d dry matter (DM) (Fr 5.2, Ay 4.5 and Fc 4.2 kg) and that of hay was 4.9 kg DM (Fr 5.2, Ay 4.9 and Fc 4.2 kg). All breeds were fed equal concentrate rations. The mean amount of concentrate for the grass silage diet was 0.7 kg DM and that for the hay diet 1.5 kg DM per day.

The average daily dry matter intake of Friesian heifers was 6.2 kg, that of Ayrshires 5.8 kg and Finncattle 5.3 kg. When dry matter intake was calculated relative to liveweight, very slight differences in intakes were detected among the breeds studied. On the predominantly grass silage diet, the average dry matter intake was 1.7 kg/100 kg liveweight/d and 2.1 kg on the hay-based diet. The corresponding figures per kg metabolic bodyweight were 72 g and 88 g, respectively.

Average energy intake of the animals at age 4—24 months was 4.15 feed units/d (Fr 4.36, Ay 4.08 and Fc 3.82 feed units) or 1.34 feed units/100 kg liveweight/d. Energy intake per kg weight gain was 6.26 feed units (Fr 6.11, Ay 6.21 and Fc 6.71 feed units), that for the predominantly grass silage diet 5.90 feed units, and that for the corresponding hay diet 6.60 feed units. Energy conversion weakened with age. Digestible crude protein intake exceeded the requirement on both diets.

Daily growth rate averaged 672 g (Fr 721, Ay 663 and Fc 576 g), being 703 g on grass silage and 642 g on hay, respectively. Conception rate was good. Of the heifers studied, 75.6 % calved after the first insemination (Fr 70.0, Ay 83.7 and Fc 70.0 %), 71.2 % on grass silage and 80.0 % on hay. The average age and weight of the heifers at conception was 16.1 months and 363 kg, respectively. The average weight of two-year-old heifers was 506 kg (Fr 539, Ay 500 and Fc 443 kg), being 526 kg on grass silage and 487 kg on the hay diet.

Index words: heifer, Ayrshire, Friesian, Finncattle, grass silage-cereal diet, hay-urea-cereal diet.

INTRODUCTION

The systematic breeding of Finncattle and Ayrshire cows in Finland began at the turn of this century. Friesian cattle were imported to Finland from Sweden and Denmark in the beginning of the 1960s. Native breeds, mainly Finncattle, were first incorporated into the Friesian material. During the past decade, the Friesian genotype has been particularly enhanced by imported Friesian semen from North America.

Slightly over 50 % of the recorder cows were Ayrshire and slightly less than half Finncattle (ANON. 1963) when importation of the Friesian breed began. The proportion of Ayrshire and Friesian cows has subsequently increased, and that of Finncattle decreased to the extent that the most recent records (1988) on the composition of the recorder cows indicate that Ayrshire cows account for 80.0 %, Friesians 18.2 % and Finncattle for 1.1 % (ANON. 1989). At that time, the recorder cows accounted for 55 % of all cows.

Replacement of the small Finncattle dairy breed by the large-sized, dairy-meat type Friesian, in addition to the mutual ranking of the Ayrshire and Friesian breeds, gave rise to questions that could not be answered merely on the basis of the results obtained from the recorder herds. The main issues concerned feed utilization and economy. Therefore, in order to obtain more precise comparisons, it was decided to establish a long-term breed experiment under experimental conditions employing a randomly sampled animal material. The experimental design offered the possibility to simultaneously determine the production, feed utilization, fertility, endurance as well as the economic result of the different breeds on the same diet under uniform conditions.

The present experiment was carried out between 1979 and 1987. At the start of the study, Finncattle accounted for no more than 3.7 % of the recorder cows (ANON. 1979). Therefore, less of this breed was included than the other breeds studied. The experiment included 50 Ayrshire and 50 Friesian calves and 20 Finncattle calves, and lasted for two growth years and six production years.

International breed comparisons can serve as a basis for interpreting the results of the present breed experiment on the Friesian and Ayrshire breeds. In Denmark, Finnish Ayrshires have been compared with Danish Friesian and Red Danish purebreds and crosses (CHRISTENSEN et al. 1984, PEDERSEN et al. 1987). In Canada, the offspring of Finnish and Canadian Ayrshire sires have been compared (LEE et al. 1982). Finnish Ayrshire has also served as one sire line in an extensive FAO-organized comparison conducted in Bulgaria on Red and Red and White cattle (8) (HINKOVSKI et al. 1978), as well as in Polish crossing experiments with Red and White (ZIEMINSKI and JUSZCZAK 1986) and Black and White cattle breeds (PASIERBSKI et al. 1982).

The Finnish Friesian breed has not been evaluated elsewhere, but Friesians of its parent countries, Sweden and Denmark, have been included in an extensive study comparing Friesian strains of different countries (10) organized by the FAO and carried out in Poland (JASIOROWSKI et al. 1983, 1987, 1988, STOLZMAN et al. 1988). Swedish Friesians have also participated in a comparison on high-yield level in Friesian strains in Israel (BAR-ANAN et al. 1987). The high-yield Holstein type Friesian strains of the USA and Canada have been included, e.g. in both of the above mentioned studies as well as in Dutch breed experiments (OLDENBROEK 1984 a and b). The genetic influence of North American Friesian sires on the Finnish Friesian material began just after the start of the breed experiment.

The present Finnish breed experiment included both a grass silage and a predominantly hay-based diet. Thus it was possible to investigate the responses of different breeds to grass silage and hay diets. At the same time the study allowed comparison of grass silage and predominantly hay-based diets, using three breeds.

Cattle feeding in Finland must be as self-sufficient as possible because of problems stemming from overproduction. For this reason, home-grown grass silage-based diets have been the subject of extensive research. The prospects of grass silage-cereal as a feed for dairy cows were studied during the 1970s in a series of investigations by professor LAMPILA (ETTALA et al. 1975 a, b, ETTALA 1976, ETTALA and LAMPILA 1978, ETTALA et al. 1978, ETTALA and KOSSILA 1980, ETTALA et al. 1982). Also other types of studies on grass silage have been carried out during the last decades both in Finland and abroad (LAMPILA et al. 1988). However, additional research was considered appropriate in order to determine wether the continuous feeding of a totally home-grown grass silage-cereal diet has any detrimental effects, as well as to estimate the nutritive balance during the high-yield periods after calving. The present breed comparison afforded an opportunity to study continuous grass silage-cereal feeding during all production phases throughout the animals' lifetime.

The use of a hay-cereal diet is not possible in dairy cattle without a protein supplement. Low-cost, domestic urea served as the supplementary protein source in the present experiment. At the same time, the study permitted the clarification on a large scale of the continuous use of urea on dairy cows which had given good results in the experiments by professor A. I. VIRTANEN (VIRTANEN 1967, ETTALA and KREULA 1976).

This paper presents the results of the above investigation on three breeds and two feeding methods, the selection of experimental animals and experimental methods, as well as the results of the heifer period from ages 4 to 24 months. A detailed presentation of the results has been published in Finnish (ETTALA and VIRTANEN 1988).

MATERIAL AND METHODS

Experimental animals

The Department of Animal Breeding of the Agricultural Research Centre of Finland provided the sampling plan for the experimental animals. Random sampling was based on heifer insemination by the greatest possible number of young bulls in recorder herds. The plan was implemented by the Finnish Animal Breeding Association in cooperation with various artificial insemination centres. Inseminations were performed during July-August 1978.

The experiment was carried out at the North Savo Research Station of the Agricultural Research Centre of Finland. Calves from different parts of the country were removed by the Animal Breeding Association. The experimental calves (120) were descended from 97 different sires. The objective was to obtain one calf per bull. However, some bulls had two calves and these were placed into different feeding groups. Of the Friesian (Fr) calves, two-thirds were purebreds and one-third R^3generation individuals. Ayrshire (Ay) and Finncattle (Fc) calves were purebreds.

The average age of the calves on arrival to the research station was 52 days (Ay 51, Fr 53 and Fc 50 d). Average arrival weights were: Ay 54, Fr 57 and Fc 48 kg. The majority of the calves were born between April, and May 1979, and a few during March and June.

The condition of the calves stabilized on the research station's uniform diet. Even the growth of those animals suffering from diarrhea, caused by the long journey to the research station, reached the level of healthy calves before the beginning of the experimental period (LAPPALAINEN and GRÖHN 1981). The animals were weighed immediately upon arrival and thereafter every week until the start of the experiment.

The calves of each breed were allocated into the silage (S) or the hay (H) groups at slightly over 3 months of age. The animals were grouped according to sire, age, weight and growth attained at the research station. Transfer to experimental feeding was accomplished gradually during a two-week period. The average ages and weights of the calf groups at the onset of the experimental period (21.8.1979) were as follows:

Dietary group	Number of calves	Age, days	Weight, kg
Fr-S	25	111	93.5
Fr-H	25	111	93.2
Ay-S	25	121	96.9
Ay-H	25	121	95.7
Fc-S	10	115	88.0
Fc-H	10	115	90.0
Mean	120	116	93.9

The animals were weighed every other week on a specific weekday throughout the experimental period.

Observation of the heat cycle began at age 8—9 months. Observation continued for about 8 months' time until conception. The objective was to have the heifers calve at the same ages and times so that differences in these respects would not interfere with eventual production results.

The heifers were kept winters and summers on individual diets in a cowshed fitted with stalls. The animals were exercised in a yard once a week.

Feeds and their analysis

Silage was fresh, flail-harvested grass silage ensiled with formic acid (AIV 2-solution 4 l/ton). It was composed chiefly of timothy and meadow fescue. The swards for silage were cut three times per season, the first cut mainly at ear emergence. Hay was cut from corresponding swards during the period between heading and flowering, for the most part. The aftermath of the hay harvest was used for silage. Nitrogen fertilization for all the swards was 100 kg/ha pure nitrogen in the spring, another 100 kg/ha for the second cut and 60—70 kg/ha for the third cut. Potassium and phosphorus fertilization was applied as needed. The cereal mixture was composed of two-thirds barley and one-third oats (Table 1).

Hay and concentrate mixtures were sampled in connection with daily weighings. The samples were then pooled to form one sample at four-week intervals. A silage sample representing two weeks' feeding was taken from the silos in advance. The silos were of concrete construction with rounded corners (height 8 m, surface area 6 × 6 m).

Samples were dried at 60 °C. Primary dry matter contents were determined by drying the sample at 105 °C. Analysis of the feeds was performed by standard methods. Digestibility of organic matter was determined in silage and hay samples according to the *in vitro* method of MENKE et al. (1979) adopted to Finnish feeds (ETTALA 1984). Relations between digestibilities of organic matter and its different components were calculated from the results of digestibility experiments (133) on rams with silage at the Department of Animal Husbandry of the Agricultural Research Centre (KOSSILA et al. 1979)

Table 1. Concentrate mixtures.

	Silage groups	Hay groups
Barley, %	62.0	56.0—58.0
Oats, %	30.5—31.0	28.0—28.5
Mineral mixture, %	6.5— 7.5	4.0— 7.0
Whey powder, %	—	7.0— 0
Urea, %	—	1.5— 2.0
Mixture of A, D, E, %	—	0.5

(ETTALA and VIRTANEN 1986). The proportions for hay were calculated from corresponding reference values for hays (SALO et al. 1982). Digestibilities for cereals were taken from corresponding reference values.

Silage quality was determined in an aqueous extract of moist feed. From the extract, volatile fatty acids (HUIDA 1973), lactic acid (BARKER and SUMMERSON 1941), ammonium nitrogen (McCULLOUGH 1967), sugar (SOMOGYI 1945, NELSSON 1944, SALO 1965) were determined and soluble nitrogen by the Kjeldahl method. Sugar was calculated as glucose. Silage pH was measured electrometrically from the sample effluent. An addition of the fatty acids volatilized during oven drying, full strength butyric and propionic acids and 80 % acetic acid, was used to correct silage dry matter content (JARL and HELLEDAY 1948, NORDFELDT 1955). The thus corrected dry matter content of silage was used in composition and intake calculations.

The energy value of the feeds was calculated in feed units (FU = 0.7 kg starch equivalent) (SALO et al. 1982). A value number (80) was applied for determining silage feed value, whereas fibre correction was used for hay. On the basis on earlier digestibility experiments on milking cows (KREULA and ETTALA 1977), 70 % was employed for urea digestibility.

Feeding

The calves were fed a uniform diet before the experimental period. Hay was the roughage, a barley-oats (2 : 1) mixture the concentrate, and the protein supply consisted of milk powder first mixed with water and later mixed with cereal.

The use of milk powder was continually decreased during the feed transition period. Urea and whey powder were added into the cereal mixture of the hay group. Silage gradually replaced hay in the silage group.

During the experimental feeding period the silage groups received silage *ad libitum* and the hay groups hay. By regulating the amounts of concentrate, an attempt was made to provide both diets with an equivalent energy supply and to obtain an average daily growth rate of 600—700 g. The task was difficult as *ad libitum* intakes of silage and hay had to be predicted in advance. The same rations of concentrate were given to all breeds as follows:

Animal weight, kg	Concentrate kg/animal/day	
	Silage groups	Hay groups
70—129	1.3	1.5
130—149	1.4	2.0
150—259	1.5	2.1—2.3
260—329	1.2	2.3
330—429	0.6	1.1
430—	—	1.3

The barley-oats mixture of both dietary groups was supplemented with a mineral mixture enriched with vitamins and the hay group additionally received urea, whey powder and a vitamin preparation (Table 1). The urea was purified feed grade urea at first and later usual fertilizer urea (N 46.3 %). Until age 5.5 months the urea supply was 1.5 % of the concentrate weight, later 2 %. The use of whey powder (7 %) was ceased in the end of the heifer period.

Feeds and residues were individually weighed daily. *Ad libitum* roughage intake was ensured by supplying silage or hay to each animal in excess of the amount consumed the previous day.

Statistical analysis of the data

The experimental design was 3×2 factorial with three breeds and two feeding groups. After the loss of three heifers, the final numbers of animals within treatment groups were as follows:

Friesian grass silage group	(Fr-S)	24
Friesian hay group	(Fr-H)	24
Ayrshire grass silage group	(Ay-S)	24
Ayrshire hay group	(Ay-H)	25
Finncattle grass silage group	(Fc-S)	10
Finncattle hay group	(Fc-H)	10

In the statistical analysis, standard two-way analysis of variance was used for unbalanced data. In addition, differences between breeds, feeding groups and treatment groups were tested with one-way analysis of variance.

RESULTS

Composition of feeds and diets

The average compositions of different feeds and daily diets as well as feed values are based on the animals' daily feed intakes and corresponding analytical results.

The difference in harvest time of silage and hay was clearly seen in their respective fiber and protein contents, digestibilities and energy values (Table 2). Silage was most nutritious during the calf period and when the heifers were 15—18 months of age. At that time, they were fed early summer forages (1979 and 1980). The silage was least nutritious when given at age

Table 2. Mean composition of feeds and feed values.

	Silage	Hay	Cereal mixture	Urea-conc. mixture
Dry matter %	19.7	87.8	87.3	87.7
% in dry matter				
ash	8.7	6.5	8.0	9.4
crude fiber	27.5	34.0	6.8	6.1
crude protein	18.3	12.5	13.3	20.7
Digest. org. matter %	70	63	83[1]	83[1]
DCP %/DM	12.6	7.5	9.9	15.0
DCP g/FU	177	136	94	146
DM kg/FU	1.40	1.83	0.96	0.97
kg/FU	7.1	2.1	1.1	1.1

[1] Cereal digestibility values are reference values (Salo et al. 1982)

Table 3. Mean values indicating silage quality at different ages of animals.

	Age of animals months				Mean
	4—6	6—12	12—18	18—24	
pH	4.10	3.97	3.90	3.89	3.94
% in dry matter					
lactic acid	4.19	5.72	4.83	5.06	5.13
acetic acid	1.00	1.40	1.98	1.72	1.63
propionic acid	0.01	0.01	0.08	0.01	0.03
butyric acid	0.01	0.01	0.03	0.01	0.01
sugar	7.2	4.0	2.9	5.1	4.2
nitrogen	3.1	2.8	3.2	2.8	3.0
% of total N					
NH_4-N	6.2	5.8	6.2	5.8	6.0
Sol. N	75.0	52.8	48.1	50.3	52.9

13—15 months. Silage prepared from the previous late autumn harvest was fed to the animals at that time. The quality of silage remained good during preservation (Table 3). For example, butyric and propionic acids were detected very rarely and in scanty amounts, the share of ammonium nitrogen in total nitrogen was slight and the pH value remained within the optimal range. Hay composition was stable until the animals were 16 months of age. Thereafter, new and more nutritious hay was utilized.

The crude protein content of the urea containing concentrate mixture was considerably higher than that of the cereal mixture alone (Table 2). However, it did not raise the daily dietary protein content of the hay group to the level of the silage group's diet (Table 4). In spite of its lower amount of concentrate, the daily diet of the silage group provided more energy and less fiber than that of the hay group. The daily diets changed greatly with age of the heifers because the share of concentrate de-

Table 4. Mean composition and feed values for daily diets of silage and hay groups at different ages of animals.

Age	Concentrate		% in dry matter			Feed value
	%/DM	%/FU	Crude fiber	Crude protein	DCP	FU/kg DM
Silage groups						
4— 6 mo	30.5	37.1	22.0	17.6	13.0	0.86
6—12 »	25.5	32.9	23.7	16.3	11.5	0.82
12—18 »	11.9	16.4	24.7	18.7	13.1	0.76
18—24 »	1.3	2.0	26.1	17.7	11.9	0.69
4—24 mo	13.2	18.3	24.7	17.6	12.3	0.76
Hay groups						
4— 6 mo	35.1	51.0	24.7	16.5	10.9	0.70
6—12 »	35.0	51.7	24.5	15.5	10.1	0.70
12—18 »	21.7	34.9	28.5	14.1	8.9	0.65
18—24 »	13.6	22.0	29.5	13.5	8.5	0.63
4—24 mo	22.8	35.8	27.6	14.4	9.2	0.66

Table 5. Mean daily roughage intake at different ages of animals.

	Heifers n	Roughage intake DM kg/animal/d				
		Age in months				
		4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo
Silage groups						
Silage		2.6	3.6	5.5	5.9	4.7±0.6
Fr	24	2.6[a]	3.9[b]	6.1[b]	6.5[c]	5.2±0.4[b]
Ay	24	2.6[a]	3.4[a]	5.1[a]	5.6[b]	4.5±0.6[a]
Fc	10	2.5[a]	3.3[a]	4.7[a]	5.0[a]	4.2±0.4[a]
Cereal mixture		1.1	1.2	0.7	0.1	0.7±0.04
Hay groups						
Hay		2.5	3.4	5.4	6.6	4.9±0.6
Fr	24	2.4[a]	3.5[b]	5.7[b]	7.3[c]	5.2±0.4[b]
Ay	25	2.6[a]	3.5[b]	5.4[b]	6.5[b]	4.9±0.6[b]
Fc	10	2.4[a]	3.1[a]	4.7[a]	5.4[a]	4.2±0.6[a]
Urea-conc. mixture		1.3	1.9	1.5	1.0	1.5±0.06

Significance of differences between breeds has been tested by one-way analysis of variance, P = 0.05. Paired comparisons were tested using Tukey's test. Figures (mean values) in columns without the same superscript differ significantly from each other, P = 0.05.

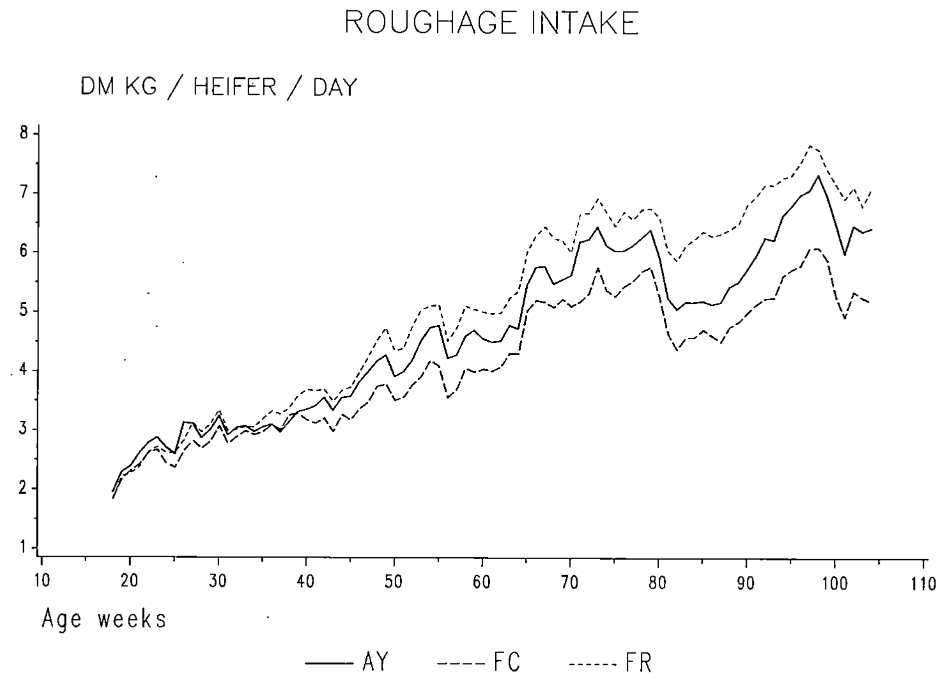

Fig. 1. Roughage intake by different heifer breeds at 4—24 months of age.

creased. The change was especially remarkable in the silage group when the use of cereal was finally discontinued altogether.

Feed intake

A major research objective of the growth period was the clarification of i.e. silage and hay, roughage intake capacity, of various heifer breeds at different ages when the concentrate rations were equal for all breeds at the same weight.

The roughage intakes of different breeds did not deviate during the calf stage (Table 5). Thereafter, Friesian heifers consumed significantly more silage than the other breeds. The silage intake of Ayrshires did not exceed that of Finncattle significantly until the final six-month period of the experiment. Friesians and Ayrshires were very comparable in hay intake until the last six-month period, while heifers of the Finncattle breed were significantly weaker than the above breeds, with the exception of the calf period. Differing responses to the roughages caused a significant interaction in the dry matter intake of the breeds and feeding methods. Differences in roughage intake among the breeds increased with age (Table 5, Fig. 1). Individual differences in intake were more pronounced in Ayrshire heifers than in Friesians. The variation in the silage intake of Finncattle equalled that of Friesians and hay intake was on the same level as that of Ayrshire heifers.

When roughage consumption was calculated in relation to liveweight, the differences among the breeds studied decreased essentially (Table 7). Still, Friesians were better than the others in terms of silage consumption, and Finncattle heifers were among the poorest in hay consumption, whether intake was calculated per 100 kg liveweight or per kg metabolic bodyweight. Ayrshire heifers equalled Finncattle in silage intake and were on the same level as Friesians in hay intake.

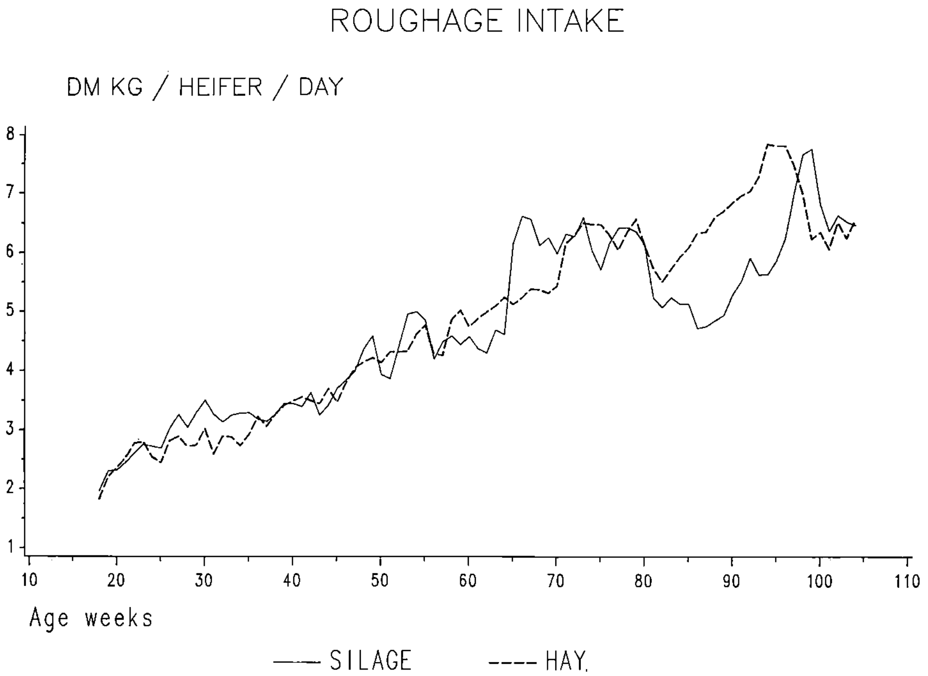

Fig. 2. Mean consumption of silage and hay dry matter by heifers at different ages.

The mean intake of silage and hay dry matter (S 2 880 kg and H 2 976 kg/heifer/growth period) was nearly equivalent in the dietary groups. Intake was uniform until age 15 months (Fig. 2, 65th week). Thereafter, silage intake strongly increased when fresh silage became available. A corresponding rise in hay intake occurred following the new hay harvest at the beginning of age 16 months. The increase in intake might also have been influenced by the fact that (from 330 liveweight, p. 257) concentrate was simultaneously decreased by half. During the last six-month period, silage intake dropped with the transfer to a more fibrous silage. At that time, hay intake exceeded that of silage. All breeds reacted similarly both to compositional and qualitative changes in roughages (Fig. 1). When calculated per 100 kg liveweight and kg metabolic bodyweight, silage intake was significantly less compared to hay (Table 7), because the heifers in the silage group were heavier.

Amounts of concentrate were maximal between 6—12 months of age and decreased with age at which time roughage consumption increased (Table 5). On the silage diet, the use of cereal ended during the final six-month period. Concentrate feed rations were equivalent for all breeds. Cereal intake per heifer throughout the entire growth period on the silage-based diet was half (503 kg) that on the hay diet (1 005 kg).

Due to the higher level of concentrate, the total dry matter intake of the hay group was significantly more abundant than that of the silage group, with the exception of the calf period (Table 6, Fig. 3). Dry matter intake per heifer throughout the growing period was 3 321 kg on the silage diet and 3 859 kg on the hay diet. The difference in intake was accentuated when dry matter intake was calculated relative to liveweight, because the lower intake of the silage groups was divided by their heavier liveweights (Table 7).

When the silage and hay groups were incor-

Table 6. Total daily dry matter intake by breed and dietary group at different ages of animals.

	Heifers n	Dry matter intake kg/animal/day				
		Age in months				
		4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo
Breed						
Fr	48	3.8^{a}	5.3^{e}	6.9^{e}	7.4^{e}	6.2 ± 0.5^{e}
Ay	49	3.8^{a}	5.0^{d}	6.4^{d}	6.6^{d}	5.8 ± 0.8^{d}
Fc	20	3.6^{a}	4.7^{c}	6.0^{c}	5.8^{c}	5.3 ± 0.6^{c}
Diet						
S	58	3.7^{a}	4.8^{f}	6.2^{f}	5.9^{f}	5.5 ± 0.6^{f}
H	59	3.8^{a}	5.3^{g}	6.9^{g}	7.7^{g}	6.3 ± 0.6^{g}
Mean	117	3.8	5.0	6.5	6.8	5.9 ± 0.7
Interaction breed/diet		NS	*	*	NS	NS

S = silage group, H = hay group

Significance of differences between breeds and feeding methods as well as their interaction effects were tested by two-way analysis of variance. For breeds, P = 0.01; for feeding methods, P = 0.001. Paired comparisons were tested by Tukey's test. For c, d, e: P = 0.01; for f, g: P = 0.001.

Table 7. Intakes of roughages and total dry matter per 100 kg liveweight and per kg metabolic bodyweight at different ages of animals.

	DM kg/100 lw kg/d					DM g/$W^{0.75}$ kg/d
	Age in months					
	4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo	4—24 mo
Silage	2.12	1.61	1.56	1.25	1.46	62
Fr	2.12^{a}	1.69^{b}	1.64^{b}	1.29^{b}	1.52^{b}	65^{b}
Ay	2.12^{a}	1.54^{a}	1.52^{a}	1.24^{ab}	1.42^{a}	60^{a}
Fc	2.15^{a}	1.56^{ab}	1.48^{a}	1.19^{a}	1.40^{a}	58^{a}
Hay	2.12	1.71	1.63	1.53	1.62	68
Fr	2.06^{a}	1.69^{a}	1.64^{b}	1.59^{b}	1.65^{b}	69^{b}
Ay	2.17^{a}	1.75^{a}	1.64^{ab}	1.52^{ab}	1.63^{ab}	68^{b}
Fc	2.13^{a}	1.65^{a}	1.55^{a}	1.41^{a}	1.54^{a}	63^{a}
Dry Matter						
Breed						
Fr	3.12^{a}	2.41^{a}	1.93^{a}	1.56^{bd}	1.92^{a}	81^{d}
Ay	3.16^{a}	2.40^{a}	1.93^{a}	1.51^{b}	1.89^{a}	79^{cd}
Fc	3.23^{a}	2.40^{a}	1.94^{a}	1.45^{ac}	1.89^{a}	77^{c}
Diet						
S	3.06^{e}	2.17^{e}	1.78^{e}	1.27^{e}	1.69^{e}	72^{e}
H	3.26^{f}	2.64^{f}	2.08^{f}	1.77^{f}	2.11^{f}	88^{f}
DM $\bar{x}$	3.16	2.41	1.93	1.52	1.90	80
±SD	±0.24	±0.29	±0.20	±0.28	±0.24	±9
Interaction breed/diet	NS	*	*	NS	NS	NS

Differences in silage and hay intake were tested as in Table 5. Differences in dry matter intake were tested as in Table 6. For a, b: P = 0.05; for c, d: P = 0.01; for e, f: P = 0.001.

porated, significant differences in dry matter intake were observed between the breeds studied, beginning from six months of age (Table 6). However, the dry matter intake per kg liveweight was almost the same among the breeds (Table 7). Only in the final half-year

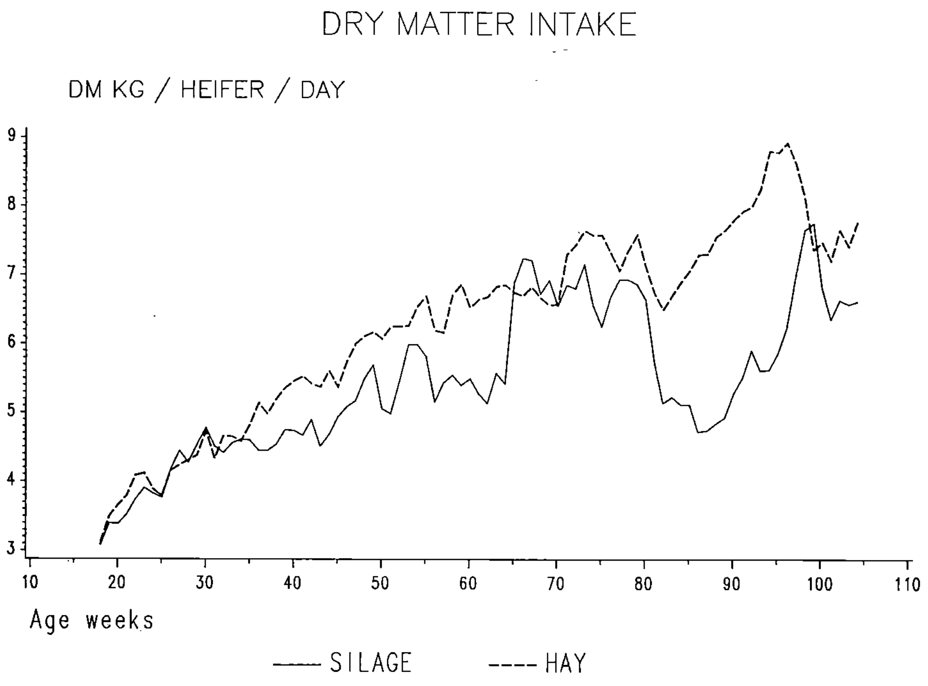

Fig. 3. Dry matter consumption of heifers on silage and hay-based diets at different ages.

period was the dry matter intake of Finncattle per 100 kg liveweight significantly below that of the other breeds. The intake rate of all breeds per 100 kg liveweight decreased with age.

Energy intake

Dissimilarities in the energy intake of the breeds corresponded to differences in intake of rough-

Table 8. Average daily amounts of energy supplied to heifers by different forages at different ages of animals.

	FU/animal/d				
	Age in months				
	4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo
Silage groups					
Silage	2.01	2.64	3.91	4.03	3.37±0.45
Fr	2.05[a]	2.89[b]	4.34[b]	4.43[c]	3.70±0.29[b]
Ay	2.01[a]	2.48[a]	3.69[a]	3.86[b]	3.22±0.41[a]
Fc	1.93[a]	2.41[a]	3.41[a]	3.44[a]	2.98±0.32[a]
Cereal mixture	1.17	1.30	0.77	0.08	0.76±0.05
Hay groups					
Hay	1.31	1.79	2.90	3.78	2.68±0.33
Fr	1.28[a]	1.84[b]	3.07[b]	4.14[c]	2.83±0.21[b]
Ay	1.36[a]	1.82[b]	2.89[b]	3.72[b]	2.68±0.32[b]
Fc	1.25[a]	1.61[a]	2.51[a]	3.09[a]	2.29±0.31[a]
Urea-conc. mixture	1.34	1.92	1.55	1.06	1.50±0.07

Significance of differences was tested as in Table 5. a, b, c: P = 0.05.

ages, because concentrate rations were equivalent for all breeds (Tables 8 and 9, Fig. 4). The interaction among breeds and dietary groups was significant for the major part of the growth period. When the difference in response to silage and hay was removed by combining the various feeding methods, energy intake, as calculated per 100 kg liveweight for Friesians and Ayrshires, was identical, and that for Finncattle differed very slightly from these (Table 10).

Energy intake per heifer between ages 4 months and one year averaged 879 FU (Fr 920, Ay 858 and Fc 831 FU), and by age 2 years it was 2 528 FU (Fr 2 675, Ay 2 469 and Fc 2 319).

The share of roughage in the heifers energy intake averaged 81.7 % for the silage group and 64.2 % for the hay group. In the beginning and in the middle of the growth period, silage provided nearly one feed unit more energy per day than hay, but during the final six-month period this advantage changed (Table 8, Fig. 5). The larger amount of concentrate in the hay groups stabilized the energy intake of the dietary groups especially between ages 8—15 months (Fig. 6). Average energy intake of the silage and hay groups was equally abundant throughout the entire growing period (Table 9), being 2 514 and 2 542 FU per heifer, respectively.

Table 9. Average daily energy intake of heifers by breed and feeding group at different ages.

	FU/animal/d				
	Age in months				
	4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo
Breeds					
Fr	2.94^{a}	3.98^{d}	4.77^{d}	4.84^{e}	4.36 ± 0.24^{e}
Ay	2.94^{a}	3.76^{c}	4.48^{bc}	4.37^{d}	4.08 ± 0.35^{d}
Fc	2.83^{a}	3.62^{c}	4.29^{ac}	3.88^{c}	3.82 ± 0.26^{c}
Diet					
S	3.19^{g}	3.93^{g}	4.68^{g}	4.11^{f}	4.13 ± 0.41^{a}
H	2.65^{f}	3.72^{f}	4.45^{f}	4.84^{g}	4.18 ± 0.28^{a}
Mean	2.92	3.83	4.57	4.48	4.15 ± 0.35
Interaction breed/diet	NS	**	***	NS	*

Significance of differences and interaction were tested as in Table 6. a, b: P = 0.05; c, d, e: P = 0.01, f, g: P = 0.001.

Table 10. Mean daily energy intakes of heifers per 100 kg liveweight at different ages.

	FU/100 lw. kg/d				
	Age in months				
	4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo
Breed					
Fr	2.43^{a}	1.81^{a}	1.34^{a}	1.02^{b}	1.34 ± 0.07^{a}
Ay	2.43^{a}	1.81^{a}	1.34^{a}	0.99^{ab}	1.33 ± 0.09^{a}
Fc	2.51^{a}	1.83^{a}	1.39^{a}	0.97^{a}	1.35 ± 0.11^{a}
Diet					
S	2.63^{d}	1.77^{c}	1.34^{a}	0.88^{c}	1.28 ± 0.07^{c}
H	2.26^{c}	1.86^{d}	1.35^{a}	1.12^{d}	1.39 ± 0.06^{d}
Mean	2.44 ± 0.25	1.81 ± 0.13	1.35 ± 0.10	1.00 ± 0.14	1.34 ± 0.09
Interaction breed/diet	NS	*	**	NS	*

Significance of differences and interaction were tested as in Table 6. a, b: P = 0.05; c, d: P = 0.001.

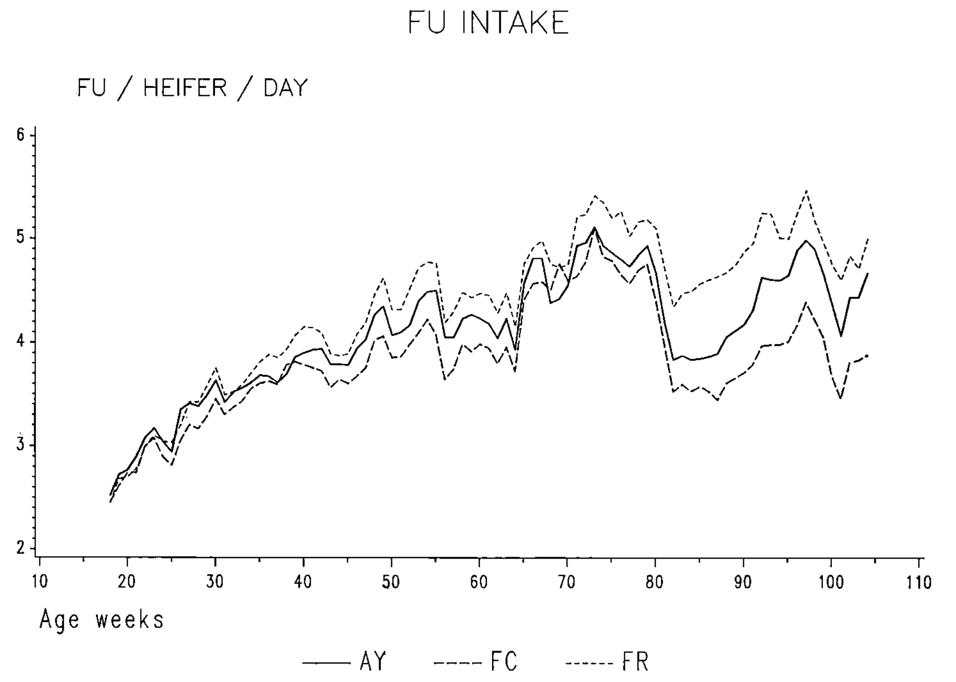

Fig. 4. Energy intake of different heifer breeds at 4—24 months of age.

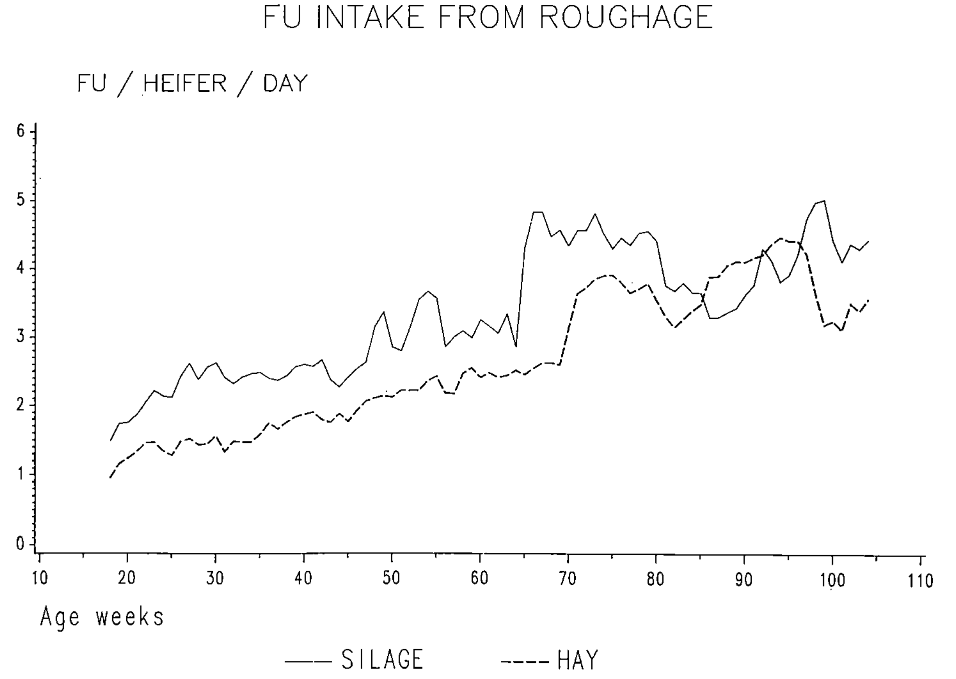

Fig. 5. Amount of energy obtained by heifers from silage and hay at different ages.

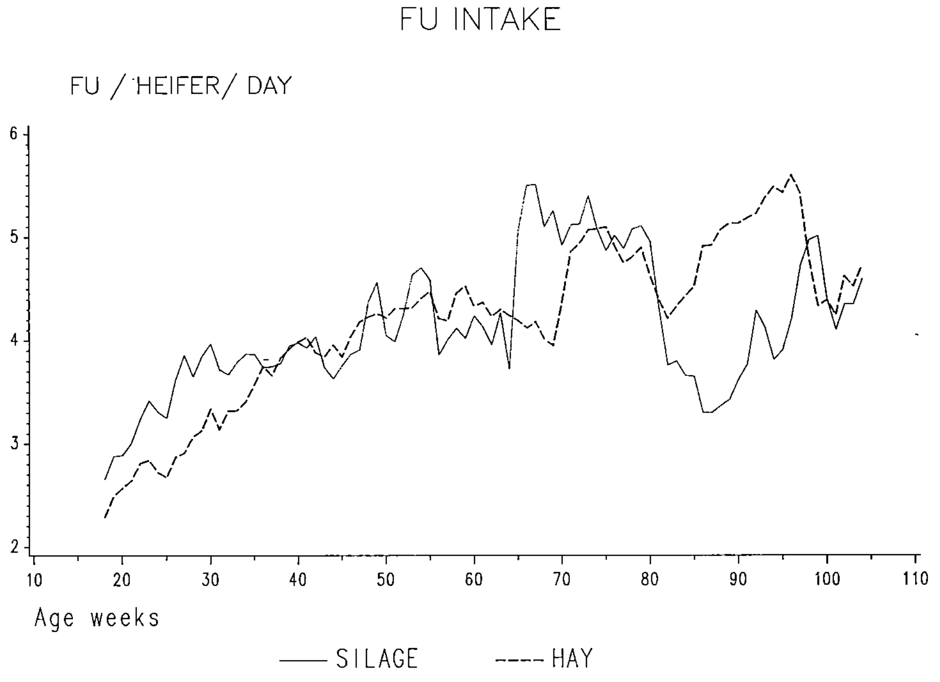

Fig. 6. Energy intake of heifers at different ages on silage and hay-based diets.

Digestible crude protein intake

Silage was the major protein source (89.4 %) of the silage group. The hay group obtained 62.6 % of the digestible crude protein from hay and 37.4 % from a urea-concentrate feed mixture.

Intake of digestible crude protein exceeded the requirement (SALO et al. 1982) at all ages and on both diets. Overfeeding of protein was the most abundant in the silage group during the second year because at that time the diet was almost completely silage-based (Table 11). During the second year, the protein require-

Table 11. Daily digestible crude protein supplied to heifers by different feeds at different ages of animals.

	DCP g/animal/d				
	Age in months				
	4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo
Silage groups					
Silage	367	428	746	699	598 ± 78
Cereal mixture	113	126	68	8	71 ± 4
Total	480	554	814	707	669 ± 75
DCP g/FU	150	141	174	172	162
Hay groups					
Hay	185	255	405	491	365 ± 45
urea-conc. mixture	231	279	209	163	218 ± 8
Total	416	534	614	654	583 ± 38
DCP g/FU	157	144	138	135	140

ment of the hay group would have been well satisfied without the urea supplement. However, the experimental design was adhered to and the urea supplement maintained so that the animals would be used to urea at the start of the production years.

Growth of the animals

Weights of the animals were calculated for each day by interpolating the difference in weight from the weighing results obtained at two-week intervals.

The experimental groups were nearly the same weight at the start of the experiment (p. 256). Gradually the Fr silage group differed, becoming heavier than the others, and the Fc hay group correspondingly lighter (Table 12, Fig. 7). Groups with mutual similarities in weight were the Fr hay group and the Ay silage group and, on the other hand, the Ay hay group and the Fc silage group. Weight dissimilarities of the extreme groups increased with age. In each breed the silage group was heavier than the hay group. This difference was most pronounced in Friesians and the least in Ayrshires.

The average weight difference among the dietary groups was significant at all ages (Table 12). The difference was minimal at 13—15 months of age when poorer late autumn silage was given (Fig. 8). When the dietary groups were combined, significant differences in weight were detected among the breeds studied. These differences increased with age. Ayrshire heifers ranked midway between Friesians and Finncattle (Fig. 9).

The growth target, 600—700 g/d, was reached by both feeding methods, on average (Table 13). The mean growth rate of Ayrshire heifers was midway of the target and Friesians surpassed the upper limit to the same extent that Finncattle fell short of the lower limit. Differences were noted in the growth rates of the different groups. The Friesian silage group exceeded the target, and the Finncattle hay group fell considerably short of it. The growth of Finncattle clearly decreased after 1.5 years of age on both diets. The interaction among breeds and feeding methods was most apparent

Table 12. Weights of heifers at different ages.

	Heifers n	Weight, kg/animal			
		Age in months			
		6 mo	12 mo	18 mo	24 mo
Group					
Fr-S	24	155[c]	305[c]	445[d]	564±36[d]
Fr-H	24	140[ab]	282[b]	400[bc]	514±25[c]
Ay-S	24	146[b]	284[b]	403[c]	513±38[c]
Ay-H	25	139[ab]	268[ab]	382[b]	488±35[bc]
Fc-S	10	141[ab]	269[ab]	380[bc]	465±36[ab]
Fc-H	10	129[a]	248[a]	348[a]	421±35[a]
Breed					
Fr	48	148[f]	294[g]	423[g]	539±40[g]
Ay	49	142[ef]	276[f]	392[f]	500±38[f]
Fc	20	135[e]	258[e]	364[e]	443±41[e]
Diet					
S	58	149[i]	290[i]	416[i]	526±52[i]
H	59	138[h]	271[h]	383[h]	487±45[h]
Mean	117	143	280	400	506±52

Significance of differences between groups was tested as in Table 5. Two-way analysis of variance was employed to compare breeds and feeding methods as in Table 6. a, b, c, d: P = 0.05; e, f, g: P = 0.01; h, i: P = 0.001.

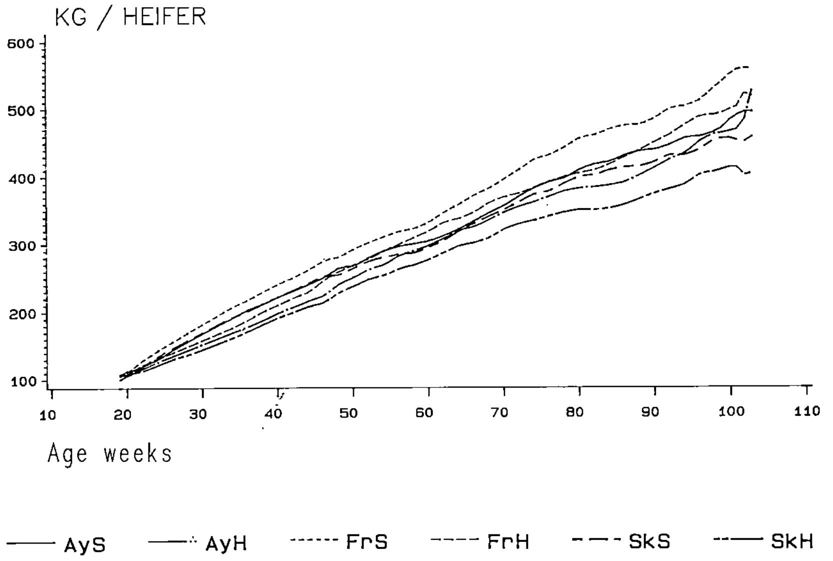

Fig. 7. Weight development of different heifer breeds on silage and hay-based diets.

between one and 1.5 years of age. At that time, Friesians and Finncattle grew at a considerably faster rate on silage than on the hay diet, while, on the other hand, a slight difference was observed in Ayrshires.

In all dietary groups, individual differences in weight and growth rate were similar (Tables 12 and 13). All heifers were in good condition. Excessive overweight in the silage groups during the second year of life was prevented by removing cereal from the diet. Despite this measure, Friesian heifers of the silage group were overweight.

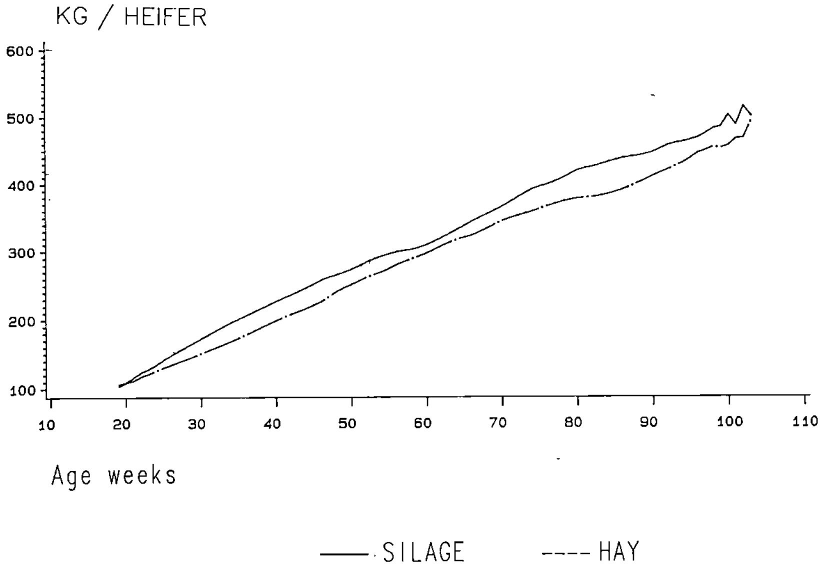

Fig. 8. Median weight development of heifers on silage and hay-based diets.

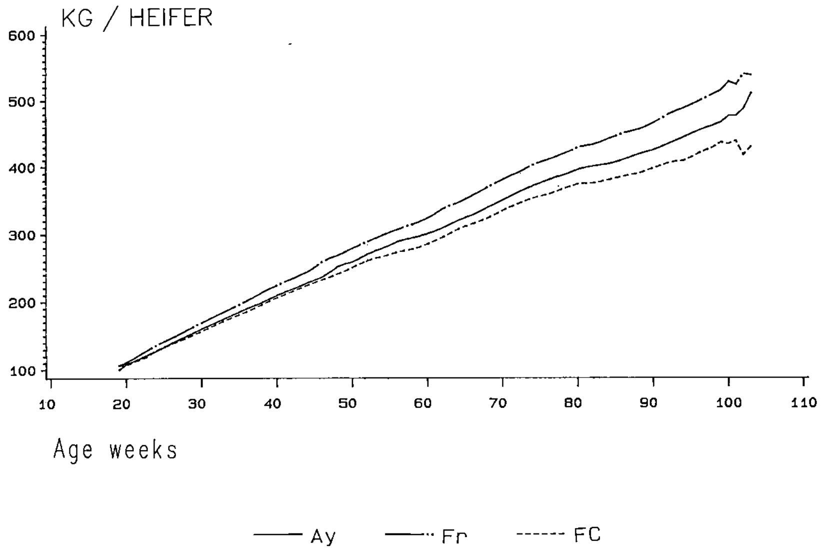

Fig. 9. Weight development of different heifer breeds at 4—24 months of age.

Table 13. Daily growth rate of heifers at different ages.

	Growth rate g/animal/d				
	Age in months				
	4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo
Group					
Fr-S	878^{c}	810^{d}	780^{c}	644^{b}	760 ± 53^{d}
Fr-H	704^{a}	767^{cd}	656^{b}	615^{b}	682 ± 45^{c}
Ay-S	800^{b}	749^{bcd}	659^{b}	596^{b}	681 ± 55^{c}
Ay-H	733^{ab}	700^{ab}	628^{b}	575^{b}	645 ± 48^{bc}
Fc-S	838^{b}	689^{abc}	621^{ab}	458^{a}	614 ± 44^{b}
Fc-H	638^{a}	642^{a}	552^{a}	397^{a}	539 ± 46^{a}
Breed					
Fr	791^{a}	789^{g}	718^{g}	630^{f}	721 ± 63^{g}
Ay	766^{a}	724^{f}	643^{f}	585^{f}	663 ± 54^{f}
Fc	738^{a}	665^{e}	586^{e}	427^{e}	576 ± 58^{e}
Diet					
S	839^{i}	764^{f}	702^{i}	592^{a}	703 ± 75^{i}
H	705^{h}	717^{e}	626^{h}	561^{a}	642 ± 68^{h}
Mean	771	740	664	576	672 ± 78
Interaction breed/diet	*	NS	**	NS	NS

Significance of differences was tested as in Table 12. a, b, c, d: P = 0.05; e, f, g: P = 0.01; h, i: P = 0.001.

Dry matter and energy intake per kg weight gain

The intake of dry matter per kg weight gain was significantly higher in all breeds on the hay diet compared to silage-based feeding (Table 14). The difference between silage and hay groups was very significant at all ages. On the other hand, differences between breeds on the same diets were comparatively slight up to 1.5 years

Table 14. Dry matter intake per kg weight gain at different ages.

	DM kg/kg weight gain				
	Age in months				
	4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo
Group					
Fr-S	4.4[a]	6.4[a]	8.7[a]	10.3[a]	7.8 ± 0.6[a]
Ay-S	4.8[abc]	6.2[a]	9.1[a]	9.7[a]	7.7 ± 0.5[a]
Fc-S	4.3[ab]	6.6[ab]	9.1[a]	11.3[ab]	8.0 ± 0.5[a]
Fr-H	5.4[bc]	7.1[bc]	10.8[b]	13.6[c]	9.7 ± 0.5[b]
Ay-H	5.5[c]	7.7[d]	11.0[b]	13.2[bc]	9.9 ± 0.6[b]
Fc-H	5.8[c]	7.7[cd]	11.6[b]	17.2[d]	10.6 ± 0.5[c]
Breed					
Fr	4.9[a]	6.8[a]	9.8[a]	12.0[e]	8.7 ± 1.1[e]
Ay	5.2[a]	7.0[ab]	10.1[a]	11.5[e]	8.8 ± 1.2[e]
Fc	5.0[a]	7.2[b]	10.4[a]	14.2[f]	9.3 ± 1.4[f]
Diet					
S	4.5[g]	6.4[g]	8.9[g]	10.2[g]	7.8 ± 0.5[g]
H	5.5[h]	7.5[h]	11.0[h]	14.1[h]	9.9 ± 0.6[h]
Mean	5.0	6.9	10.0	12.1	8.9 ± 1.2
Interaction breed/diet	NS	**	NS	*	NS

Significance of differences was tested as in Table 12. a, b, c, d: $P = 0.05$; e, f: $P = 0.01$; g, h: $P = 0.001$.

of age. During the last half-year period, the intake of dry matter per kg weight gain was higher in Finncattle compared to the other breeds studied, because the growth rate of Finncattle essentially slowed down at that time. The difference was most pronounced on the hay diet.

During the calf period, energy intake per kg weight gain was less than half the rate of intake during the final half-year period (Table 15). Dur-

Table 15. Energy intake per kg weight gain at different ages.

	FU/kg weight gain				
	Age in months				
	4—6 mo	6—12 mo	12—18 mo	18—24 mo	4—24 mo
Group					
Fr-S	3.77[a]	5.19[ab]	6.51[a]	7.08[a]	5.85 ± 0.44[a]
Ay-S	4.11[a]	5.10[ab]	6.88[ab]	6.68[a]	5.85 ± 0.36[a]
Fc-S	3.68[a]	5.43[ab]	6.96[ab]	7.86[ab]	6.14 ± 0.39[ab]
Fr-H	3.83[a]	5.03[a]	6.95[ab]	8.57[b]	6.37 ± 0.34[bc]
Ay-H	3.82[a]	5.46[b]	7.18[bc]	8.42[b]	6.56 ± 0.36[c]
Fc-H	4.08[a]	5.58[b]	7.92[c]	11.16[c]	7.27 ± 0.36[d]
Breed					
Fr	3.80[a]	5.11[e]	6.73[e]	7.83[e]	6.11 ± 0.47[e]
Ay	3.97[a]	5.28[ef]	7.03[aef]	7.57[e]	6.21 ± 0.50[e]
Fc	3.88[a]	5.50[f]	7.44[bf]	9.51[f]	6.71 ± 0.69[f]
Diet					
S	3.89[a]	5.20[a]	6.74[g]	7.05[g]	5.90 ± 0.41[g]
H	3.87[a]	5.30[a]	7.21[h]	8.94[h]	6.60 ± 0.47[h]
Mean	3.88 ± 0.82	5.25 ± 0.48	6.98 ± 0.79	8.01 ± 1.71	6.26 ± 0.56
Interaction breed/diet	NS	*	NS	*	*

Significance of differences was tested as in Table 12. a, b, c, d: $P = 0.05$; e, f: $P = 0.01$; g, h: $P = 0.001$.

ing the calf period the level of energy utilization was the same for all breeds and both diets. Thereafter, the energy intake per kg weight gain of the Fc hay group increased at a faster rate than that of the other groups. Energy utilization of Friesians and Ayrshires was very much at the same level. Finncattle did not significantly differ from these on the silage diet. Individual variations within breeds were similar for all dietary groups.

On silage and hay feeding the level of energy utilization was identical during the first year, but during the second year on the silage diet a very significant improvement was found in this regard. The superior nutritive value of silage was also apparent in the considerable fattening of the heifers during the second year, even though feeding was nearly exclusively silage-based at that time. Mean energy utilization throughout the entire growth period was significantly better with the silage-based diet compared to the diet where hay predominated.

Fertility of the heifers

On average, the Friesian and Ayrshire groups weighed the same at first heat (Table 16). Friesian heifers were three weeks younger at the onset of puberty than Ayrshire heifers, and the silage groups were about one month earlier than the hay groups. Finncattle heifers weighed less at puberty and were clearly younger than the others on hay-based diet. Considerably large individual variations in age and weight were found in each group, but these were quite similar.

Table 16. Heifer weight and age at first heat.

	Heifers n	Weight, kg		Age, mo	
		x̄	range	x̄	range
Fr-S	25	264	229—346	10.1	8.3—11.8
Fr-H	25	259	204—300	11.1	9.8—13.0
Ay-S	24*	261	215—323	10.9	9.0—13.6
Ay-H	25	262	221—329	11.8	10.3—13.3
Fc-S	10	233	193—282	10.0	8.3—11.6
Fc-H	10	215	180—243	10.4	8.9—12.3

* One calf died accidentally.

The heat cycle became somewhat regular after the second heat. The intervals between heats were usually 20 days and 21 days (26.4 % and 23.4 % of case, respectively). Also common intervals were 19 and 22 days (18.2 % and 15.6 %, respectively). Breed differences were not apparent in heat quality. The first heats of the hay group heifers were slightly weaker than in the silage groups, but they strengthened with age. Silent and strong heats were found in each breed and on both diets. The length of heat from the beginning until bleeding was followed in the last months (88 findings). Heat generally lasted for 3 days (40.9 % of cases), with every fifth lasting 2 days (20.5 %) and nearly just as often for 4 days (18.2 %).

The insemination plan aimed at calving at age 25 months. Inseminations began from the heat that followed the age of 15 months if the Friesians weighed at least 340 kg, Ayrshires 320 kg and Finncattle 300 kg. Those under the borderline weight were inseminated during the heat that followed the age of 16 months. Usually, the weights in question were surpassed, however, several small individuals occurred in each group, mainly in the Fc hay group (Table 17). Age on insemination leading to calving averaged 16.1 months in all other groups, except for the Fc hay group where it was 16.6 months.

Table 17. Heifer age and weight at insemination.

	Heifers[1] n	Age, d	Weight, kg	
		x̄ SD	x̄	range
Fr-S	24	491 ± 28	398	345—450
Fr-H	24	487 ± 17	367	332—399
Ay-S	24	491 ± 24	363	317—492
Ay-H	25	489 ± 15	350	308—416
Fc-S	10	485 ± 19	340	294—411
Fc-H	10	504 ± 26	327	287—386
Mean	117[1]	491 ± 22	363	

[1] Heifers alive throughout the entire heifer period.

Conception rate was good among the heifers (Table 18). Ayrshires had the best rate of conception, above all, the Ayrshire hay group. Friesian and Finncattle heifers conceived equally well. The hay group had exceptionally high conception rates. However, no significant differences were noted between breeds or dietary groups as to the number of inseminations.

One Fr heifer in the hay group failed to conceive and another Fr heifer in the silage group suffered a prolapsed vagina already in the early stage of pregnancy. These animals had to be removed. Earlier in the study, an Ay calf died accidentally. Every group had spare animals, however. In accordance with the number of stalls available, 96 cows, 20 from the Fr and Ay groups each and 8 from the Fc groups, were included in the production experiment. Spare animals were removed from the study after calving only.

Table 18. Conception rate of heifers.

	Heifers[1] n	Conception % 1. insemination	Heifers[2] n	Inseminations/ calving
Group				
Fr-S	25	68.0	24	1.67
Fr-H	25	72.0	24	1.29
Ay-S	24	75.0	24	1.29
Ay-H	25	92.0	25	1.16
Fc-S	10	70.0	10	1.40
Fc-H	10	70.0	10	1.60
Breed				
Fr	50	70.0	48	1.48
Ay	49	83.7	49	1.22
Fc	20	70.0	20	1.50
Diet				
S	59	71.2	58	1.47
H	60	80.0	59	1.29
Mean	119	75.6	117	1.38

[1] Heifers to be inseminated
[2] Heifers that conceived

Differences between groups, breeds or dietary groups in number of inseminations were not significant.

DISCUSSION

The primary aim in raising the heifers was to obtain strong production animals from each breed to be used in a long-term dairy cow experiment, employing the same feeding as in the coming production years. For that reason, the average growth target was 600—700 g/d which is considered the optimal level (SEJRSEN 1978, FOLDAGER and SEJRSEN 1987), taking into consideration the growth differences of the large- and small-sized breeds (SWANSON 1967).

The average growth target was achieved on both diets, with the silage group being at the upper limit and the hay group falling midway of the target. Friesians exceeded the upper limit to the same extent as Finncattle fell short of the minimum and Ayrshires were midway of the target. The breeds studied were found to have dissimilar growth rythms. The rate of growth during the calf period was at the same level for all breeds. Differences arose and increased with age. At the end of the growth period, Finncattle grew considerably more slowly, while the growth rate of Friesians remained steadier and that of Ayrshires fell in between these two breeds. The growth rythm corresponded to that of the bulls used in the artificial inseminations of the particular breed, although the bulls' rate of growth was nearly twice that of the heifers (JUGA 1989).

In an international comparison performed in Bulgaria, the offspring of Finnish Ayrshire bulls represented the average size of the other Red and Red and White in the group at age 1.5 years. At birth, these animals were in the smaller group, and grew more slowly than the others during the first six months, but their growth was fastest during the second half of the year (HINKOVSKI et al. 1988 a). A Canadian Ayrshire comparison reported equivalent growth for offspring of Finnish and Canadian Ayrshire bulls (LEE et al. 1982). The offspring of Swedish and Danish Friesian bulls, close relatives of the Finnish Friesians, were found to be average in size and rate of growth in a Polish experiment comparing different strains of the Black and White breed (JASIOROWSKI et al. 1987). The offspring of Holstein-type bulls from the USA and Canada generally corresponded to the above average level.

An important research objective of the present experiment on different breeds was the determination of the rate of roughage intake by heifers at different ages. The results showed that the heifers of various breeds were able to intake roughages to the extent that their natural differences in growth became apparent by means of the roughages. During the calf period, intake was identical for all of the breeds, but dissimilarities in intake as well as in growth became more pronounced with age. The breeds studied responded differently to silage and hay. Especially Friesians, but also Finncattle, showed a preference for silage and Ayrshires for hay so that between the breeds and feeding methods a significant interaction was sometimes observed. The abundant silage intake of the Friesian silage group manifested as overweight. SEJRSEN and LARSEN (1978) have found that Friesian heifers can be raised solely on silage from 4 months of age.

Silage and hay intake per animal and per day was similar on average, but changes in composition and quality caused noticeable differences in the intakes at the end of the growing period. Roughage quality does seem to have a decisive effect in the silage-hay comparison of heifers. Using good quality silage ensiled with formic acid, WALDO et al. (1969) obtained better growth results than with hay harvested at the same time, but poorer results using a silage prepared without additives (WALDO et al. 1965, 1969). In relation to liveweight, silage intake was less than that of hay, both in the present study and in the above mentioned heifer comparisons.

The present study also attempted to clarify the amount of concentrate needed as a supplement to *ad libitum* silage or hay diet when aiming at an average daily growth rate of 600—700 grams on both diets. On the basis of the growth results and the condition of the animals, the amount of concentrate given appeared to be very suitable on the hay diet. In the case of silage-based feeding, apparently the amount of cereal could have been decreased already before puberty, beginning at about 8 months. SEJRSEN (1978), on the basis of both his own results and those of other researchers, has concluded that for optimal udder development and assurance of future production, the energy supply should be restricted prior to puberty and in its initial stages so that growth would be 700—750 g per day maximally. The present study operated within the upper limits during the phase in question.

The amounts of concentrate had an equivalent effect on the total dry matter intake in every breed as the use of concentrate was the same for all breeds. Instead, a difference was observed in the dry matter intake of the various dietary groups, as on the silage diet the amount of concentrate given was only half that of the hay groups. In heifer studies it has also been shown that on silage feeding large amounts of concentrate do not increase dry matter intake more than small ones (SEJRSEN and LARSEN 1978, MCCULLOUGH and SISK 1969).

One main objective of the present study was to determine the energy utilization of various breeds and on different diets. In Finncattle this was lower compared to the other breeds studied. However, the difference was significant only on the hay diet and became apparent at the end of the growing period with a deceleration in growth. The result was comparable to that found in Swedish studies on the small-sized hornless cattle (SKB) and in a heifer growth study of Friesian and hornless (SLB × SKB) crossed calves (BRÄNNÄNG et al. 1979, DIM 1977). Friesian and Ayrshire heifers were comparable with regard to energy utilization. The result was on the same level as that found by HAKKOLA (1974) in a heifer study of Ayrshires, although both the growth intervals and the method of feeding were somewhat different. The utilization of feeds weakened with age in all breeds. In the calf period, the amount of energy per kg weight gain was less than half that at the end of the growth period. The result was comparable with that obtained by HANSSON et al. (1967) in the standard feeding of heifers.

In the silage group, energy utilization during the second year of life was significantly superior to that for the hay group. At that time, feeding was nearly exclusively silage-based. The result matched that found by WALDO et al. (1969) employing silage ensiled with formic acid when the feeding of heifers consisted exclusively of silage or hay harvested at the same time. Instead, when silage was ensiled without an additive energy utilization was found to be poorer than that on hay (WALDO et al. 1965, 1969).

Throughout the growing period of the heifers, a protein surplus prevailed at all ages and on both diets. No problems occurred due to this surplus. The growth results showed that the animals utilized silage and urea protein well from 4 months of age.

Friesian and Ayrshire heifers reached puberty on both diets at the weight of about 260 kg on average. The result corresponded to the mean puberty weight obtained by Friesian heifers on average feeding (AMIR et al. 1968, REID et al. 1964, SEJRSEN and LARSEN 1978). Puberty age was dependent on growth rate. Ayrshire heifers were three weeks older than Friesians and the silage groups of both breeds about one month younger than the hay groups when reaching puberty. Finncattle calves were lighter than the others at first heat, and in the hay group they were also younger. Intervals between heats were very similar in different breeds and diets, corresponding well to the results obtained by SÖRENSEN et al. (1959).

One aim of the present research was to have calving take place at the same age and time so that differences in these respects would not interfere with production results. Insemination age leading to calving averaged 16.1 months in all other groups, being only slightly higher (16.6 months) in the Fc hay group, and individual variations were also on the same level.

The conception rate was good, averaging 75.6 % from the first insemination. The best conception rate was found in the Ayrshire breed, especially in the Ay hay group. Dissimilarities between different groups, breeds or diets in number of inseminations were not statistically significant, however. The excellent result of the hay groups (1.29 inseminations/calving), however, showed that urea did not have an adverse effect on conception. Silage-based diets also produced quite a good conception rate (1.47 inseminations/calving). SEJRSEN and LARSEN (1978) also obtained a good conception rate for heifers on a silage diet with low amounts of concentrate.

In an international comparison on Red breeds, the offspring of Finnish Ayrshire bulls were found to have an average conception result and insemination age (HINKOVSKI et al. 1988 b). A Canadian Ayrshire comparison reported an equal conception rate for the offspring of Canadian and Finnish bulls (LEE et al. 1982).

Out of 120 experimental animals, only three were lost during the growing period. Spare animals still numbered 4—5 in both the Friesian and Ayrshire groups and in the Finncattle groups 2, were removed only after calving.

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SELOSTUS

Suomalaisen ayrshiren, friisiläisen ja suomenkarjan vertailu säilörehu-vilja- ja heinä-urea-viljaruokinnalla

1. Hiehokauden tulokset

ELSI ETTALA ja ERKKI VIRTANEN

Maatalouden tutkimuskeskus

Suomalaista ayrshireä (ay), friisiläistä (fr) ja suomenkarjaa (sk) vertaileva tutkimus tehtiin Maatalouden tutkimuskeskuksen Pohjois-Savon tutkimusasemalla vuosina 1979—87. Rotujen edustavuus perustui satunnaisotantaan, jossa hiehoja siemennettiin karjantarkkailutiloilla mahdollisimman monella (97) nuorsonnilla. Vasikat, 50 ay, 50 fr ja 20 sk, tuotiin tutkimusasemalle keskimäärin 52 vrk:n ikäisenä. Vasikoista oli suurin osa (89 %) syntynyt huhti-toukokuulla 1979.

Rotukoe tehtiin sekä säilörehu- että heinävaltaisella ruokinnalla. Säilörehu oli tuoretta, kelasilputtua, muurahaishapolla (AIV 2 4 l/ton) säilöttyä ja pääasiassa tähkälletulovaiheessa korjattua nurmisäilörehua. Heinä niitettiin vastaavanlaisilta nurmilta etupäässä tähkimisen ja kukinnan välisenä aikana. Rotujen vasikat jaettiin säilörehu- ja heinäryhmiin vähän yli 3 kk:n ikäisenä. Ruokintaryhmät olivat iän ja painon suhteen tasavertaisia.

Tässä julkaisussa esitetään kasvatuskauden tulokset 4.—24. ikäkuukausien väliseltä ajalta. Rehut ja rehuntähteet punnittiin yksilöllisesti päivittäin, eläimet joka toinen viikko. Säilörehuryhmä (sr) sai ruokahalun mukaan säilörehua, heinäryhmä (hr) heinää. Väkirehuna oli ohrakauraseos (2 : 1), johon heinäryhmälle sekoitettiin 1,5—2,0 % ureaa. Väkirehumääriä säätelemällä pyrittiin 600—700 g:n keskimääräisiin päiväkasvuihin. Väkirehua annettiin kaikille eläimille samanpainoisena yhtä paljon, säilörehuruokinnalla keskimäärin 0,7 ka kg ja heinäruokinnalla 1,5 ka kg päivässä, joten rotujen erilainen kasvu perustui erilaiseen karkearehujen syöntiin.

Keskimääräiset päiväkasvut olivat: fr 721, ay 663 ja sk 576 g, säilörehuvaltaisella ruokinnalla 703 g ja heinävaltaisella 642 g. Friisiläiset söivät säilörehun ja heinän kuiva-ainetta yhtä paljon, keskimäärin 5,2 kg/vrk, samoin suomenkarja, 4,2 kg/vrk, mutta ayrshiret enemmän heinää, 4,9 kg, kuin säilörehua 4,5 kg/vrk. Kokonaiskuiva-aineen keskimääräiset syönnit olivat: fr 6,2, ay 5,8 ja sk 5,3 kg päivässä (1,92, 1,89 ja 1,89 ka kg/100 elopaino-kg/vrk). Säilörehuvaltaisella ruokinnalla kuiva-ainetta kului keskimäärin 5,5 ja heinävaltaisella 6,3 kg/vrk (1,7 ja 2,1 ka kg/100 elopaino-kg/vrk).

Hiehot saivat energiaa 4.—24. ikäkuukausien välillä keskimäärin: fr 4,36, ay 4,08 ja sk 3,82 ry/vrk eli 1,34 ry/100 elopaino-kg/vrk. Lisäkasvukiloa kohti energiaa kului: fr 6,11, ay 6,21 ja sk 6,71 ry, säilörehuvaltaisella ruokinnalla 5,90 ja heinävaltaisella 6,60 ry.

Tiinehtyminen oli hyvä; 1. siemennyksestä poiki keskimäärin 75,6 % hiehoista, fr 70,0, ay 83,7 ja sk 70,0 %, säilörehuvaltaisella ruokinnalla 71,2 ja heinävaltaisella 80,0 %. Hiehot olivat tiinehtyessään keskimäärin 16,1 kk:n ikäisiä ja 363 kg:n painoisia. Kaksivuotiaana hiehot painoivat: fr 539, ay 500 ja sk 443 kg, säilörehuvaltaisella ruokinnalla 526 ja heinävaltaisella 487 kg.

ANNALES AGRICULTURAE FENNIAE, VOL. 29: 279—302 (1990)

Seria ANIMALIA DOMESTICA N. 93 — Sarja KOTIELÄIMET n:o 93

COMPARISON OF FINNISH AYRSHIRE, FRIESIAN AND FINNCATTLE ON GRASS SILAGE-CEREAL AND HAY-UREA-CEREAL DIETS

2. Intake and nutrient supply during the first three production years

ELSI ETTALA and ERKKI VIRTANEN

ETTALA, E. & VIRTANEN, E. 1990. **Comparison of Finnish Ayrshire, Friesian and Finncattle on grass silage-cereal and hay-urea-cereal diets. 2. Intake and nutrient supply during the first three production years.** Ann. Agric. Fenn. 29: 279—302. (Agric. Res. Centre, Inst. Anim. Prod., SF-31600 Jokioinen, Finland.)

Heifers in a study comparing Finnish Ayrshire (Ay), Friesian (Fr) and Finncattle (Fc) dairy cattle breeds calved at slightly over 25 months of age. Half of the animals of each breed were fed silage *ad libitum,* one kilogram of hay daily and a barley-oats concentrate 0.24—0.30 FU/kg 4 % milk. The other half were given hay *ad libitum* and a urea (2 %)-barley-oats concentrate 0.32—0.38 FU/kg 4 % milk.

The silage was fresh, flail harvested grass silage ensiled with formic acid. It contained on average 1.37 kg DM/FU, digestible crude protein 12.2 % of DM, and its quality was good. Hay contained on average 1.71 kg DM/FU and mean digestible crude protein content was 7.0 % in DM. The silage diet contained during lactations on average 1.20 and the hay diet 1.33 kg DM/FU. Digestible crude protein contents were 10.9 % and 9.2 % in DM, respectively.

The average liveweights of the cows during the first three lactations were: Fr 523, Ay 472, and Fc 426 kg, the grass silage groups averaging 496 kg and the hay groups 474 kg. During lactations, roughage intake on the grass silage diets averaged: Fr 8.7, Ay 7.7, and Fc 7.0 kg DM/cow/d. Significant differences were found. Hay intake by Friesians and Ayrshires was nearly equally high, while that of Finncattle was significantly lower: Fr 9.3, Ay 9.1 and Fc 7.9 kg DM/cow/d.

The total dry matter intake per 100 kg liveweight during the lactations was significantly higher in the Ayrshire breed: Ay 2.70, Fr 2.56 and Fc 2.58 kg DM/d, while that for metabolic bodyweight was significantly lower in the Finncattle: Ay 126, Fr 123 and Fc 118 g/d. On the silage diet the corresponding dry matter intakes in relation to liveweight, 2.35 kg and 111 g/d, were significantly lower than on the hay diet, 2.91 kg and 136 g/d, respectively.

The mean energy supply per 100 kg liveweight during three lactations was: Ay 2.14, Fr 2.02 and Fc 2.03 FU/d, being 1.95 FU/d on the silage diet and 2.19 FU/d on the hay diet. The significance of the differences corresponded to the dry matter intake.

The mean supply of digestible crude protein during the lactations was equivalent on both diets, however, at the beginning of the lactations (10 weeks) it was higher on the hay-urea-cereal diet than on the grass silage-cereal diet (1 410 and 1 322 g/d, respectively). Urea provided an average of 223 g/d of digestible crude protein during lactations, accounting for 17.7 % of the protein supply of the hay group.

During the dry periods, roughage intake was slightly lower than that during lactations. Energy supply during dry periods averaged 1.41 FU/100 kg liveweight/d.

Index words: dairy cows, Ayrshire, Friesian, Finncattle, grass silage-cereal diet, hay-urea-cereal diet, forage intake, multilactation experiment.

INTRODUCTION

The background and objectives of a study comparing the Finnish dairy cattle breeds and two home-grown feeding methods have been described in the first part of the present series which dealt with the heifer period of the experimental animals (ETTALA and VIRTANEN 1990 a).

An important aspect of the present study was the clarification of feed intake by different breeds at various stages of production and age. No comparable fundamental clarification has been performed previously in Finland on any breed. Also in other countries, only few systematic investigations on feed intake during several lactations have been carried out.

The breeds were compared on silage and hay-based diets to determine the feed intake capacities of the cows for both types of roughages. The effects of these diets on three breeds were also compared. The data investigated was especially important with respect to the silage intake, as in Finland the highest possible self-sufficiency in protein supply can be achieved through silage feeding, in which case intake amounts are decisive. According to the results of the Finnish recorder cows, silage accounted for 26.3 %, and hay for 11.7 % on the energy supply in 1988. (ANON. 1989).

This paper presents data on the feed intake and nutrient supply of three breeds during the first three production years. A detailed presentation of the results is available also in Finnish (ETTALA and VIRTANEN 1986).

MATERIAL AND METHODS

Experimental animals

The method employed for the random sampling of the calves and for the formation of silage and hay diet groups, as well as their care for up to 24 months of age, have been described in our paper on the heifer stage (ETTALA and VIRTANEN 1990 a). There were 117 heifers at the end of the heifer stage. In accordance with the number of stalls, 96 cows were included in the lactation experiment. Each group had spare animals. The number of the animals in the experimental groups was as follows:

	Number of heifers at age 24 months	Number of cows in the lactation experiment
Friesian-silage group (Fr-S)	24	20
Friesian-hay group (Fr-H)	24	20
Ayrshire-silage group (Ay-S)	24	20
Ayrshire-hay group (Ay-H)	25	20
Finncattle-silage group (Fc-S)	10	8
Finncattle-hay group (Fc-H)	10	8

The spare animals were needed because right after calving mastitis due to *Staphylococcus aureus* occurred extensively. Eleven cows were excluded because of mastitis. One heifer was excluded before calving because of leg weakness. The majority (80 %) of the 116 heifers calved during May-June 1981.

The mean calving age of the heifers in the lactation experiment was 25 months and 10 days (Table 1). Age differences between groups were small, only the Finncattle hay group was slightly older than the others. The cows were weighed

Table 1. Calving ages of heifers and weights after calving.

Group	Number of heifers	Calving age, d $\bar{x}$ s.d.	Weight, kg $\bar{x}$ s.d.
Fr-S	20	771 ± 32	512 ± 38
Fr-H	20	766 ± 19	462 ± 30
Ay-S	20	766 ± 17	462 ± 31
Ay-H	20	771 ± 17	449 ± 34
Fc-S	8	768 ± 21	416 ± 36
Fc-H	8	787 ± 28	406 ± 35
	96	770 ± 23	461 ± 46

on the sixth day after calving. At that time both intake and changes in the weight of the genital organs were considered to be level. Each group had both light and heavy animals, but mostly animals of average weight, and thus the variation was similar. The silage groups were heavier than the hay groups. The Friesian silage group was both the heaviest and the fattest. The animals of the other groups were also in good condition. During the lactation periods the cows were weighed on two successive days at four-week intervals.

Feeds

The silage was a fresh, flail harvested grass silage ensiled with formic acid (AIV2 4 l/ton) like during the heifer period (ETTALA and VIRTANEN 1990 a). The seed mixture of the grasses consisted of timothy and meadow fescue (3 : 1). When establishing the grass sward, liquid manure was applied for fertilization which reduced the need for potassium and phosphorous fertilization. Calcium and magnesium contents of the grass were raised by liming with dolomite. Nitrogen was applied in the spring at a level of 120 kg/ha on the first silage swards and 100 kg/ha on the hay swards. The nitrogen levels for the second and for the third silage cuts were 100 kg/ha and 60—70 kg/ha, respectively.

Harvesting of the silage started at emergence of ears. An attempt was made to conserve silages of different stages of development in separate silos. In outlying field areas a stack was made. Feeding was planned based on analytical results of the raw material. An effort was made to feed the animals with the most nutritious silages in the spring and summer when the majority of the cows calved. Hay was harvested mainly during the period between heading and flowering. The aftermath of the hay harvest was used for silage. The rainy summer in 1981 caused difficulties and a delay in harvesting the hay. The oestrogenic Fusarium toxin, zearalenone, which causes early abortion (KALLELA and ETTALA 1984) was encountered in a batch of hay fed during the autumn. Hay that was either dampened by rain or that had been harvested later was usually fed in mid-winter when the majority of the cows were either dry or in a low stage of lactation.

A barley-oats (2 : 1) concentrate was employed. The cereal concentrate of the hay group was supplemented with 2 percent by weight fertilizer urea (N 46.3 %). In addition, the cows received a mineral supplement. The quality and the amount of minerals depended on the lactation period of the cows and mineral composition of the forages. Minerals were first mixed into the concentrate, but during the third lactation year we started to feed with individual mineral dosages. The commercial mineral supplements contained vitamins A, D and E. The hay group additionally received an A, D, E vitamin supplement mixed into the concentrate (0.5 weight-%).

The feed analysis has been described in our heifer paper (ETTALA and VIRTANEN 1990 a).

Feeding

Feeds and feed residues were individually weighed every day. Silage was fed *ad libitum* to the cows in the silage groups, as was hay in the hay groups. Voluntary intake was ensured by adding 3 % more feed to the amount eaten on the previous day. The main amount of roughages was fed in the morning and the rest in the afternoon. The cows in the silage group started to receive hay 1 kg/d from the start of the heifers' prelactational period. Eating time for the cows was 12 hours a day.

During the prelactational period the amounts of concentrate were increased by 200 g/d over a 15-day period. Prelactational feeding of the heifers was begun only 15 days before calving as the heifers were in very good condition. After the first lactation, prelactational feeding was started 6 weeks before calving and in subsequent years 4 weeks before calving. The concentrate ration was 3.0—3.5 kg/d for the silage group and 4.3—4.8 kg/d for the hay group, both on the day of calving and for three days thereafter.

After calving, the concentrate rations were increased for a 10-day period. The increase was 200 g/d during the first lactation and 300 g/d during the subsequent lactations. The concentrate ration thus obtained (silage diet: first year 5.0 kg/d, second and third years 6.5 kg/d and hay diet: 6.3 kg/d and 7.8 kg/d, respectively) was calculated to correspond to 18 kg of 4 % milk yields in the first year and 22 kg in subsequent years. If the yields were higher, the concentrate rations were kept at the same level as during normal lactation periods.

The lactation period was considered to begin on the fiftieth day after calving. At that time, concentrate rations were calculated according to the 4 % milk yields as follows:

4 % milk kg/cow/d	Concentrate FU/kg 4 % milk	
	silage groups	hay groups
—15	0.24	0.32
20	0.26	0.34
25	0.28	0.36
30—	0.30	0.38

The concentrate rations were measured steplessly by the computer according to the 4 % milk yield of each cow, comprised of half of the yield until then and half of the previous day's yield. The highest increase in the daily amount was 1 kg, however. The maximum concentrate level on silage diets was 10 kg/d and on hay diets 12.5 kg/d. The concentrate was weighed once a day and divided into 1—3 lots. The concentrate feeding aimed at a similar net energy supply per 1 kg of 4 % milk for on both diets.

The dry period was planned to last for 2 months after the first lactation and for 6 weeks in subsequent years. Two weeks before the dry period the concentrate ration was decreased to 0.5 kg/d. The daily amount in the silage groups was maintained at 0.5 kg/d until prelactational feeding; in the hay groups it was raised to 1.8 kg/d after the cows had dried.

Data collection and statistical analysis

The experimental data were collected on Mikko computer diskettes. The daily recordings consisted of each cow's morning and evening milk yields as well as the quantities of feeds and feed residues entered onto the diskettes at the weighing site. Milk composition data were recorded weekly and the animals' weights at four-week intervals. The data stored on the diskettes were transferred to a VAX computer at the Agricultural Research Centre. The data on feed composition, digestibility and quality were incorporated into the above information. The SPSSX software was employed for the calculations and statistical analysis of the material.

The daily amounts of nutrients obtained by the cows were calculated by combining data on the feed consumption of each cow with the respective analytical data. The liveweights of the cows were interpolated at every two weighings, thus giving daily results of weight loss or weight gain. The data were analysed according to the factorial experimental design (3 × 2) by breed and dietary group using the factorial analysis of variance. Differences between experimental groups and experimental years were also tested. Pairwise (or paired) comparisons were performed with Tukey's test. In addition, the data were analysed employing correlations and the regression analysis.

RESULTS

Composition of feeds and diets

The mean composition of the feeds and diets was calculated since calving by combining the daily intakes of each cow with the feed analysis of the same time, thereafter dividing the nutrient supply by the dry matter intake.

At the beginning of the lactations the protein content of silage was slightly above the mean of the whole lactation (Table 2). In other respects, minor differences were detected during the various production stages. The silages of the first year were poorer in digestibility and lower in calculated net energy value than in subsequent years. This was due to the rainy summer (1981) which made harvesting difficult. The second year was exceptional in respect to the low protein content of the spring harvest. At that time, the cold period during early summer adversely affected nitrogen uptake by grasses. The silage in question was fed 4—6 months after calving. The storage quality of silage during all years and every production stage was good.

At the beginning of the lactations, hay was somewhat higher in protein and energy content as compared to the mean of the whole lactation (Table 3). The digestibility of the hay of the first year, i.e that from the rainy summer of 1981, was considerably poorer and the kg DM/FU higher than in the subsequent years. Also the amount of fiber was higher and that of nitrogen-free extract (NFE) lower than in succeeding years. Instead, the relative proportion of crude protein increased as other soluble nutrients were lost due to rain. The result corresponded to that found by SALO and VIRTANEN (1983) in their experiments on harvesting hay.

The concentrates were quite constant year after year (Table 4). Only the ash content changed in the third year when minerals were no longer mixed into the concentrate. Urea raised the digestible crude protein (DCP) content of DM by approximately 4 % units in dry

Table 2. Numerical values describing silage composition, feed value and quality.

	1st—3rd production years					
	Days after calving		Lactations	Years		
	70	154		1.	2.	3.
Dry matter %	20.2	20.7	20.8	20.3	21.3	20.6
% in dry matter						
ash	8.7	8.8	8.9	9.2	9.0	8.6
crude fiber	28.5	27.9	28.3	29.2	27.0	29.2
crude fat	6.1	5.9	5.7	5.8	5.4	6.0
crude protein	18.4	17.9	17.3	18.3	16.6	17.3
DCP	13.0	12.6	12.2	12.2	11.7	12.8
Dig. % in org. matter	70.5	71.1	70.9	66.5	72.3	75.2
DM kg/FU	1.37	1.36	1.37	1.47	1.35	1.28
pH	3.99	4.03	4.01	4.03	3.99	4.03
% in dry matter						
lactic acid	4.44	4.46	4.55	4.24	4.32	4.63
acetic acid	1.73	1.81	1.67	1.68	1.61	1.56
propionic acid	0.03	0.04	0.02	0.04	0.00	0.01
butyric acid	0.01	0.02	0.01	0.03	0.00	0.01
sugar	4.69	4.67	5.21	4.32	7.29	3.75
nitrogen	3.07	2.98	2.88	2.98	2.79	2.87
% from total nitrogen						
soluble N	50.6	50.2	50.7	50.1	51.1	50.5
NH_3-N	5.2	5.3	5.2	6.2	4.3	5.3

Table 3. Numerical values describing hay composition and feed value.

	1st—3rd production years					
	Days after calving		Lactations	Years		
	70	154		1.	2.	3.
Dry matter %	87.7	88.4	89.2	88.2	89.8	89.7
% in dry matter						
ash	6.4	6.3	6.2	6.4	6.5	5.6
crude fiber	33.3	33.9	34.2	34.7	34.0	33.8
NFE	46.2	46.3	46.4	45.1	46.5	47.9
crude fat	2.0	2.0	1.9	1.9	1.8	1.9
crude protein	12.1	11.7	11.3	11.9	11.2	10.7
DCP	7.5	7.3	7.0	7.1	7.2	6.8
Dig. % in org. matter	65.9	65.8	65.7	62.7	68.1	67.3
DM kg/FU	1.69	1.70	1.72	1.88	1.64	1.64

Table 4. Numerical values describing composition of concentrates and feed value.

	1st year		2nd year		3rd year	
	cereal conc.	cereal — urea conc.	cereal conc.	cereal — urea conc.	cereal conc.	cereal — urea conc.
Dry matter %	87.7	87.6	86.3	86.5	86.8	86.8
% in dry matter						
ash	6.4	7.5	6.1	7.7	3.9	6.1
crude fat	2.8	2.7	2.9	2.9	3.2	3.0
crude protein	12.5	17.9	11.9	18.1	12.3	17.9
DCP	9.2	13.0	9.0	13.3	9.5	13.3
DM kg/FU	0.94	0.95	0.93	0.95	0.90	0.92

Table 5. Numerical values describing dietary composition and feed value at different stages of production.

	1st—3rd lactations					
	Silage groups			Hay groups		
	Days after calving		Lactations	Days after calving		Lactations
	70	154		70	154	
% in dry matter						
crude fiber	19.7	20.6	22.0	20.5	22.6	24.6
NFE	53.1	51.9	50.5	58.5	56.8	55.3
crude protein	15.4	15.5	15.3	14.9	14.3	13.6
DCP	11.0	11.0	10.9	10.2	9.7	9.2
DM kg/FU	1.16	1.18	1.20	1.23	1.29	1.33
Proportion of concentrate						
%/DM	42.1	36.8	31.3	47.8	41.1	34.7
%/FU	52.2	46.5	40.8	61.9	55.5	49.3
%/DCP	35.8	31.4	26.5	61.2	55.4	50.0

matter. Urea digestibility was 70 % based on earlier digestibility experiments performed on dairy cows (KREULA and ETTALA 1977). The effects of urea were also a higher ash content and a slightly lower energy value of the concentrate.

In spite of the lower concentrate levels of the

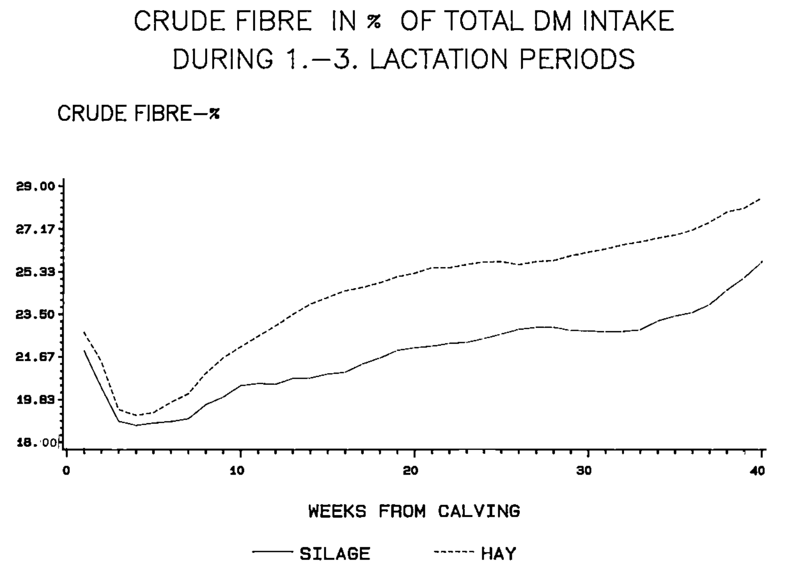

Fig. 1. Mean fiber contents of hay and silage diets during the first three lactations.

silage groups, this diet provided a lower fiber content and a better estimated net energy value than the diet of the hay groups (Table 5, Fig. 1). At the beginning of the lactations these differences were minor, however. The silage group's dietary protein content remained at a constant level throughout the entire lactation period, because it was dependent on the silage. Instead, the hay group's diet was richest in protein at the beginning of lactation when the concentrate containing urea was most commonly fed. In the first production year, the diets were higher in fiber and lower in energy contents than in the subsequent years of the study (Table 6). This was due not only to the roughages that provided a lower energy supply because of the rainy summer, but also to the decreased concentrate rations given on account of lower milk yields. The DCP of the diets remained constant year after year; on the silage diet it was about 2 % units higher than on the hay diet.

Table 6. Numerical values describing dietary composition and feed value in different production years (lactation and dry period).

	Silage groups			Hay groups		
	1st yr	2nd yr	3 rd yr	1st yr	2nd yr	3rd yr
% in dry matter						
crude fiber	23.3	21.6	22.4	25.6	24.9	24.3
NFE	47.8	51.1	50.6	53.7	54.8	56.7
crude protein	16.1	14.9	15.3	13.8	13.5	13.2
DCP	11.0	10.6	11.3	9.0	9.2	9.1
DM kg/FU	1.28	1.21	1.15	1.42	1.32	1.29
Proportion of concentrate						
%/DM	28.8	29.1	31.6	32.6	33.3	34.5
%/FU	39.3	37.7	40.2	48.9	46.3	48.4
%/DCP	24.3	24.7	26.6	47.1	47.9	50.6

Table 7. Number of cows and lengths of lactations and dry periods from 1st to 3rd production years. Cows eliminated in the middle of lactation are not included.

	Number of cows/lactation			Lactation period, days			Dry period, days		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Breeds									
Fr	40	38	30	306^{a}	311^{a}	297^{a}	69^{a}	54^{a}	62^{a}
Ay	40	38	34	313^{a}	318^{a}	295^{a}	71^{a}	65^{b}	62^{a}
Fc	16	16	15	326^{a}	309^{a}	297^{a}	77^{a}	61^{ab}	65^{a}
Dietary groups									
S	48	44	40	313^{a}	323^{a}	299^{a}	71^{a}	62^{a}	67^{b}
H	48	48	39	312^{a}	304^{a}	293^{a}	71^{a}	59^{a}	58^{a}
Mean	96	92	79	312	313	296	71	60	62
S.D.				±56	±39	±25	±12	±18	±19

a, b $P = 0.05$

Table 8. Mean liveweights of the cows during three production years.

1st—3rd production years	Weight kg/cow				$W^{0.75}$ kg/cow
	70 d after calving	lactation period	dry period	production years $\bar{x}$ s.d.	production years $\bar{x}$ s.d.
Groups					
Fr-S	532^{f}	547^{g}	632^{g}	562 ± 64^{f}	115 ± 9.9^{f}
Fr-H	478^{c}	500^{bf}	571^{f}	512 ± 48^{bc}	107 ± 7.6^{bc}
Ay-S	473^{c}	473^{ac}	551^{cf}	486 ± 50^{ac}	103 ± 7.9^{ac}
Ay-H	465^{c}	472^{c}	535^{c}	483 ± 48^{ac}	103 ± 7.6^{ac}
Fc-S	434^{bd}	436^{d}	495^{bd}	445 ± 53^{d}	97 ± 8.5^{d}
Fc-H	411^{ad}	415^{d}	464^{ad}	424 ± 59^{d}	93 ± 9.7^{d}
Breeds					
Fr	505^{f}	523^{f}	601^{f}	536 ± 62^{f}	111 ± 9.6^{f}
Ay	469^{e}	472^{e}	542^{e}	484 ± 48^{e}	103 ± 7.7^{e}
Fc	423^{d}	426^{d}	480^{d}	435 ± 56^{d}	95 ± 9.2^{d}
Diets					
S	490^{i}	496^{i}	574^{i}	509 ± 72^{i}	107 ± 11.4^{i}
H	461^{h}	474^{h}	537^{h}	485 ± 58^{h}	103 ± 9.3^{h}
Years					
1st	444^{d}	447^{d}	517^{d}	460 ± 53^{d}	99 ± 8.6^{d}
2nd	479^{e}	496^{e}	569^{ac}	508 ± 61^{e}	107 ± 9.7^{e}
3rd	509^{f}	517^{f}	588^{bc}	528 ± 67^{f}	110 ± 10.4^{f}
Mean	475	485	555	497	105
Interaction effect Breed/diet	***	***	**	***	***

Significance of differences between groups and years as well as their interaction effects were tested by two-way analysis of variance. Significance of differences between breeds, diets, years and their interaction effects were tested by three-way analysis of variance. Paired comparisons were tested by Tukey's test. Figures for groups, breeds, diets or years in the same columns without the same superscript differ significantly from each other. Significance of the difference has been tested between diets at the 0.1 and others at the 1 % level of risk. a, b: $P = 0.01$; h, i: $P = 0.001$.
** $P = 0.01$; *** $P = 0.001$.

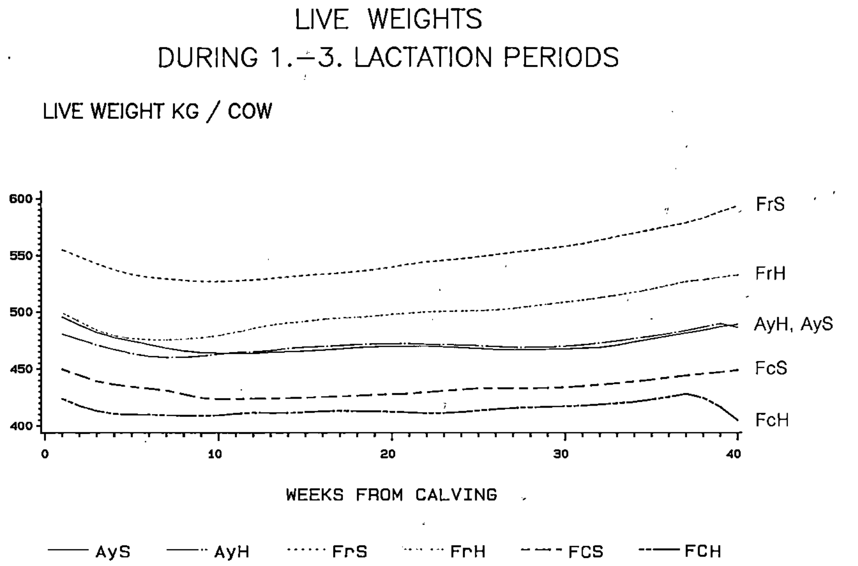

Fig. 2. Mean liveweights of breeds on silage and hay diets during the first three lactations.

Weights of the cows

The number of cows totalled 96 in the first lactation, 92 in the second and 79 in the third (Table 7). The average length of the lactations was 308 d and that of the dry period 65 d.

The mean weights of the cows increased significantly yearly (Table 8). The Friesian silage group was the heaviest. This group differed from the Friesian-hay group during the three production years as much as (50 kg) at age two years (ETTALA and VIRTANEN 1990 a). Also the Finncattle silage group was heavier than the hay group. The Ayrshire silage group gained more weight during the dry periods than did the hay group, but each year the weight returned to the level of the hay group during ten weeks after calving (Fig. 2). The liveweights of all groups were lowest then. The Friesians gained weight considerably during lactations also.

Intake

Similar results for the intake of the cows were obtained every year. The intake of the first production year differed from those of the second and third years (Table 9). On account of their similarity, the differences and likenesses found among the groups were more prominent when the results of three years were pooled.

At the beginning of the lactations, r o u g h a g e intake was relatively low for about one month, but increased rapidly thereafter (Fig. 3). The hay intake of the hay group exceeded the roughage intake of the silage group (silage + 0.8 kg/d hay DM), attaining its maximum level about 3.5 months after calving. It stayed on that level until the end of lactation. The roughage intake of the silage group reached its maximum 3.5—5.5 months after calving. It was significantly lower than that of the hay group throughout all phases of production (Table 10).

The breeds responded dissimilarly to silage and hay. The roughage intake of Friesians was nearly equally high on both diets (Table 9, Fig. 4). Instead, the Ayrshire and Finncattle breeds consumed significantly more hay. The hay intake of Ayrshires was nearly as high as that of Friesians. The dissimilar responses of the breeds to the roughages caused a significant

Table 9. Mean daily dry matter (DM) intake in different stages of production during the first three production years.

1st—3rd production years	DM intake kg/cow/d: 70 d after calving, roughage $\bar{x}$ s.d.	cereal/ u-cereal $\bar{x}$	total intake $\bar{x}$ s.d.	154 d after calving, rough-age $\bar{x}$	cereal/ u-cereal $\bar{x}$	total intake $\bar{x}$	lactation periods, roughage $\bar{x}$ s.d.	cereal/ u-cereal $\bar{x}$	total intake $\bar{x}$ s.d.	dry periods, rough-age $\bar{x}$	cereal/ u-cereal $\bar{x}$	total intake $\bar{x}$
Groups												
Fr-S	7.5 ± 1.5^{g}	5.3^{e}	12.9 ± 2.1^{bf}	8.5^{f}	4.8^{e}	13.3^{f}	8.7 ± 1.4^{f}	3.9^{e}	12.6 ± 1.9^{f}	8.3^{bf}	1.8^{d}	10.2^{f}
Ay-S	6.7 ± 1.2^{ef}	5.0^{bde}	11.7 ± 1.9^{e}	7.6^{e}	4.6^{e}	12.2^{e}	7.7 ± 1.1^{e}	3.7^{e}	11.4 ± 1.6^{e}	7.7^{aef}	1.8^{d}	9.5^{e}
Fc-S	6.0 ± 1.2^{ad}	4.6^{ad}	10.5 ± 1.8^{d}	6.9^{d}	4.0^{d}	10.9^{d}	7.0 ± 1.0^{d}	3.2^{d}	10.2 ± 1.6^{d}	6.6^{d}	1.8^{d}	8.4^{d}
Fr-H	7.2 ± 1.1^{fg}	6.8^{g}	14.0 ± 2.2^{g}	8.5^{f}	6.1^{f}	14.6^{g}	9.3 ± 1.2^{g}	5.0^{f}	14.2 ± 2.1^{g}	8.6^{g}	2.7^{e}	11.3^{g}
Ay-H	7.4 ± 1.3^{g}	6.8^{g}	14.2 ± 1.9^{g}	8.6^{f}	6.1^{f}	14.7^{g}	9.1 ± 1.2^{fg}	5.0^{f}	14.1 ± 1.8^{g}	8.7^{g}	2.7^{e}	11.4^{g}
Fc-H	6.5 ± 1.4^{bde}	5.6^{f}	12.2 ± 1.9^{af}	7.4^{e}	4.8^{e}	12.3^{e}	7.9 ± 1.4^{e}	3.9^{e}	11.8 ± 1.9^{e}	7.4^{e}	2.5^{e}	9.9^{ef}
Years		S/H			S/H			S/H				
1st	5.9 ± 1.0^{d}	$4.1^{d}/5.5^{d}$	10.7 ± 1.5^{d}	7.0^{d}	$3.6^{d}/4.8^{d}$	11.2^{d}	7.3 ± 1.1^{d}	$3.0^{d}/3.9^{d}$	10.7 ± 1.5^{d}	7.7^{d}	2.4^{bc}	10.1^{d}
2nd	7.7 ± 0.9^{e}	$5.5^{e}/7.1^{e}$	14.1 ± 1.6^{e}	8.9^{e}	$5.0^{e}/6.3^{ae}$	14.5^{e}	9.2 ± 1.1^{e}	$3.9^{e}/5.2^{e}$	13.8 ± 1.9^{e}	8.4^{e}	2.2^{ade}	10.6^{e}
3rd	7.6 ± 1.2^{e}	$5.7^{e}/7.4^{e}$	14.2 ± 1.9^{e}	8.6^{e}	$5.3^{e}/6.8^{be}$	14.6^{e}	9.0 ± 1.1^{e}	$4.3^{e}/5.5^{e}$	13.9 ± 1.9^{e}	8.3^{e}	2.1^{d}	10.4^{de}

The roughage included also 0.8 kg/cow/d hay DM in silage groups in every stage of production.

Significance of differences betweeen groups and years as well as their interaction effects were tested by two-way analysis of variance. Paried comparisons were tested by Tukey's test. Figures for groups or years in the same columns without the same superscript differed significantly from each other. a, b: P = 0.05; d, e, f, g: P = 0.01. No significant interaction was found between groups and years.

Table 10. Mean daily dry matter (DM) intake in different stages of production by breeds and diets during the first three production years.

1st—3rd production yrs	DM intake kg/cow/d: 70 d after calving, roughage	cereal/ u-cereal	total intake	154 d after calving, roughage	cereal/ u-cereal	total intake	lactation periods, roughage	cereal/ u-cereal	total intake	dry periods, roughage	cereal/ u-cereal	total intake
Breeds												
Fr	7.4^{e}	6.1^{e}	13.4^{be}	8.5^{f}	5.5^{e}	14.0^{e}	9.0^{f}	4.4^{e}	13.4^{f}	8.5^{e}	2.3^{a}	10.8^{e}
Ay	7.1^{e}	5.9^{e}	13.0^{ae}	8.1^{e}	5.4^{e}	13.5^{e}	8.4^{e}	4.4^{e}	12.8^{e}	8.2^{e}	2.3^{a}	10.5^{e}
Fc	6.2^{d}	5.1^{d}	11.3^{d}	7.2^{d}	4.4^{d}	11.6^{d}	7.4^{d}	3.6^{d}	11.0^{d}	7.0^{d}	2.1^{a}	9.2^{d}
Diets												
S	6.9^{a}	5.0^{g}	12.0^{g}	7.8^{g}	4.6^{g}	12.4^{g}	8.0^{g}	3.7^{g}	11.6^{g}	7.8^{g}	1.8^{g}	9.6^{g}
H	7.2^{b}	6.6^{h}	13.8^{h}	8.4^{h}	5.9^{h}	14.3^{h}	8.9^{h}	4.8^{h}	13.8^{h}	8.4^{h}	2.7^{h}	11.1^{h}
Mean	7.0	5.8	12.9	8.1	5.2	13.3	8.5	4.3	12.7	8.1	2.3	10.4
Interaction												
breed/diet	***	*	***	***	NS	***	***	NS	***	*	NS	*
diet/year	*	NS	NS	*	NS	*	NS	NS	NS	NS	NS	NS

Significance of differences between breeds, diets, years and their interaction effects were tested by three-way analysis of variance. Significance of the differences of breeds has been tested at the risk level of 1 % and between diets at the 0.1 % risk level. Paired comparisons were tested by Tukey's test. a, b: P = 0.05; d, e, f: P = 0.01; g, h: P = 0.001. * P = 0.05; ** P = 0.01; *** P = 0.001.

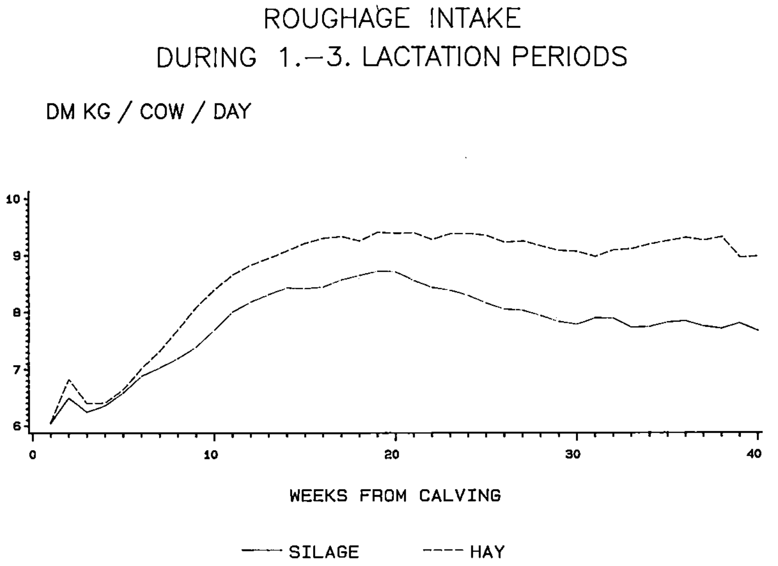

Fig. 3. Mean roughage intakes on hay and silage diets during the first three lactations.

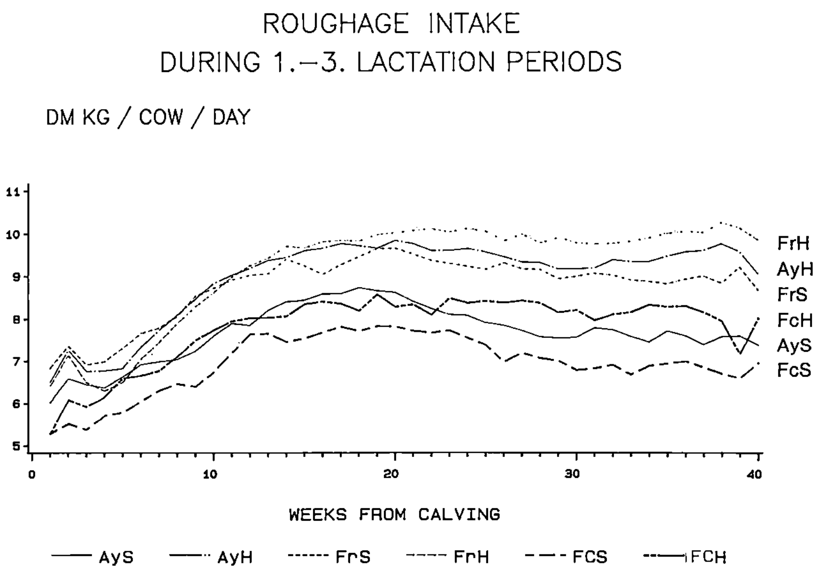

Fig. 4. Mean roughage intakes in experimental groups during the first three lactations.

interaction between breeds and diets, both in roughage and in total dry matter intake (Table 10). Considerable individual differences in roughage intake were noted for all breeds, most prominently in the Friesian-silage and Finncattle-hay groups (Table 9). The variation was of the same level at the beginning of the lactations and throughout all lactations.

When the roughage intakes were combined, the Ayrshires' intake approached the Friesian

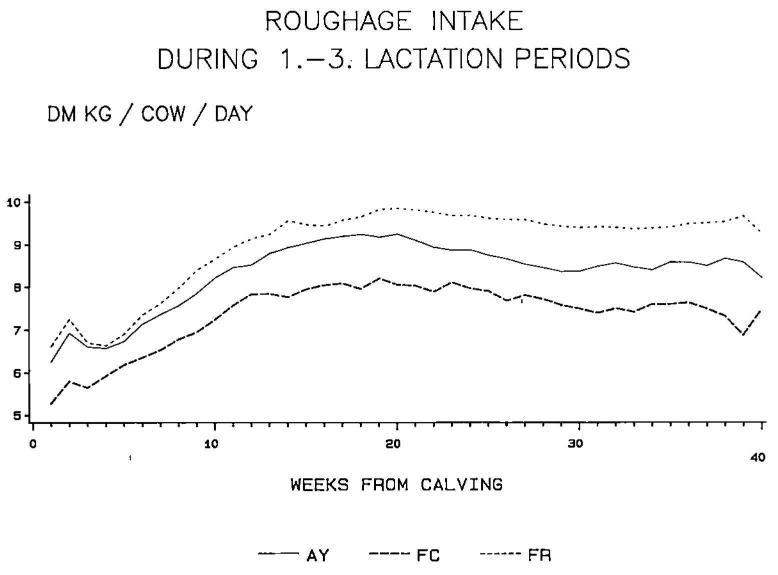

Fig. 5. Mean roughage intakes of Friesians, Ayrshires and Finncattle during the first three lactations.

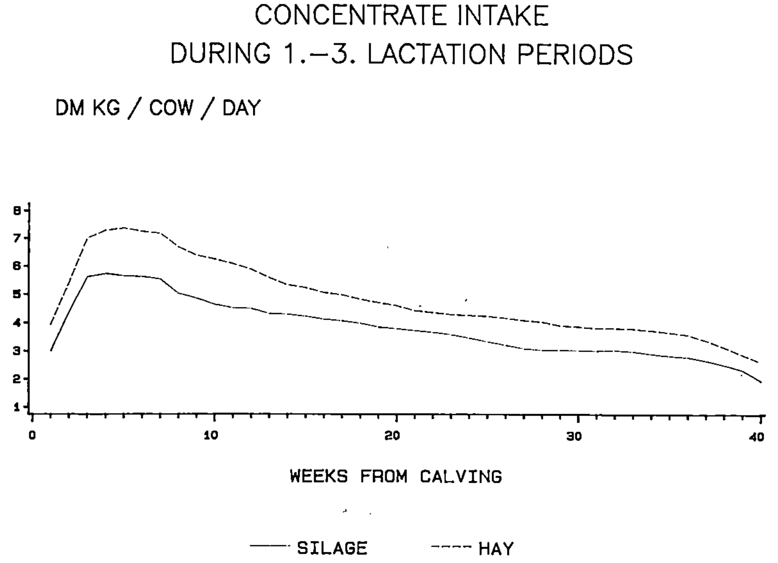

Fig. 6. Mean concentrate levels on hay and silage diets during the first three lactations.

level in the first half of the lactation, but thereafter it was midway of the intakes of the Friesians and the Finncattle (Fig. 5, Table 10). Roughage intake during the dry period of the first year was slightly higher than that during lactation, being lower in the subsequent years (Table 9).

The intake of concentrate was, as planned, higher on the hay diet than on the silage diet (Tables 9 and 10). The difference was

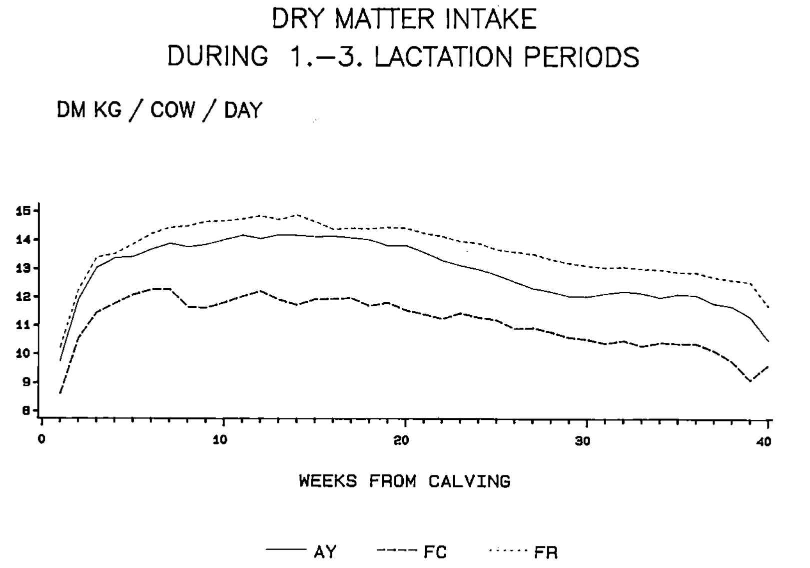

Fig. 7. Mean dry matter intakes of Friesians, Ayrshires and Finncattle during the first three lactations.

greatest at the beginning of lactation (Fig. 6). The concentrate rations of the first lactation were significantly smaller than those of the second and third lactations because the concentrate ration was determined according to 4 % milk yields. For the same reason, the concentrate rations of the Finncattle were significantly smaller than those of the Ayrshires and the Friesians which were very similar.

Total dry matter intake increased sharply during the first three weeks (Fig. 7). Maximum intake occurred at 2—5 months after calving. Mean dry matter intake during the first 10 weeks was of the same level as during the whole lactation on average. The diets at the beginning contained higher amounts of concentrate (Tables 10 and 5).

The Friesian and the Ayrshire hay groups had the highest and similar dry matter intakes (Table 9). The mean dry matter intake of Friesians exceeded that of the Ayrshires due to their more abundant silage intake (Table 10). The difference was minor at the beginning of the lactations (Fig. 7). The dry matter intake of Finncattle was significantly lower than that of the other breeds on both diets and throughout all production stages. The dry matter intake of the hay group was significantly higher than that of the silage group, as both roughage and concentrate intakes were higher in the hay group (Fig. 8, Table 10). During the dry period, dry matter intake was lower than during the lactations, mainly because of smaller concentrate rations.

Table 11 presents the quantities of feeds calculated for the lactation and dry period of the cows.

When intake was calculated per 100 kg liveweight, the Friesians and the Finncattle were comparable whereas the Ayrshires exceeded these. While the superiority of the Ayrshires in roughage intake was only indicative, it was, however, significant in terms of total dry matter intake (Table 12). When calculated per kg metabolic bodyweight, the intake of Friesians approached the level of Ayrshires and the intake of Finncattle was significantly lower than these. The interaction between breeds and diets was significant only at the beginning of lactation for roughage intake when intakes were cal-

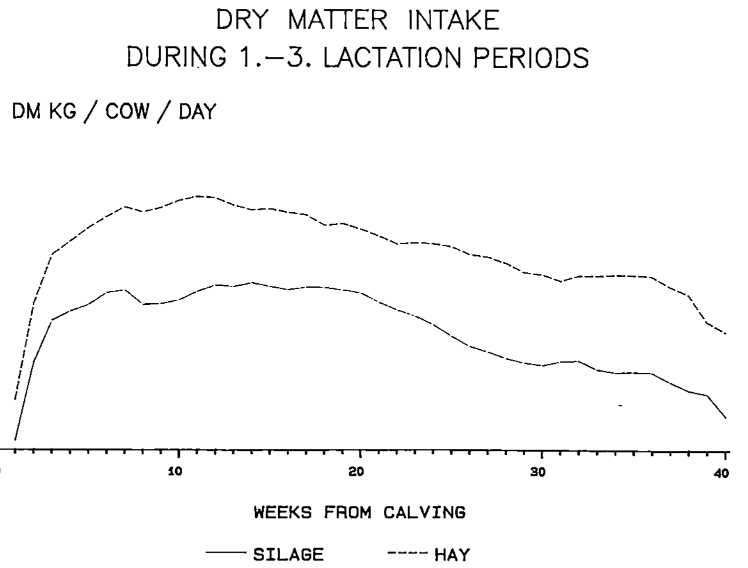

Fig. 8. Mean dry matter intakes on hay and silage diets during the first three lactations.

culated in relation to liveweight. A significant interaction in roughage intake was observed also between diets and years as the increase from the level of the first year to that of the subsequent years was higher for silage than for hay intake. No significant interaction was found between breeds and years at any stage.

Differences in the intakes of the hay and silage groups were more prominent when intakes were calculated in relation to liveweight, because the lower intake of the silage group was divided by higher liveweights. During dry periods, the dry matter intake per 100 kg liveweight averaged 1.89 kg/d.

Table 11. Mean dry matter (DM) intake during lactations and dry periods during the first three production years.

	DM intake kg/cow/lactation period				DM intake kg/cow/dry period			
	Silage	Hay	Cereal/ u-cereal	Total intake	Silage	Hay	Cereal/ u-cereal	Total intake
Groups								
Fr-S	2 407^{be}	248	1 169^{bd}	3 824^{e}	494^{e}	55	119^{d}	668^{e}
Ay-S	2 162^{ade}	253	1 159^{ad}	3 574^{bde}	486^{e}	57	127^{d}	670^{e}
Fc-S	2 002^{ad}	247	1 034^{ad}	3 283^{ad}	386^{d}	49	118^{d}	552^{d}
Fr-H		2 838^{e}	1 517^{e}	4 355^{f}		529^{a}	171^{e}	700^{e}
Ay-H		2 742^{e}	1 514^{e}	4 256^{f}		535^{a}	174^{e}	709^{e}
Fc-H		2 342^{d}	1 164^{ad}	3 506de		524^{a}	170^{e}	694^{e}
Years		S/H	S/H			S/H	S/H	
1st	1 910^{d}	228^{d}/2 424^{d}	936^{d}/1 221^{d}	3 360^{d}	478^{a}	55^{a}/563^{a}	137^{e}/205^{e}	719^{b}
2nd	2 562^{e}	261^{e}/2 924^{e}	1 247^{e}/1 569^{e}	4 291^{e}	456^{a}	53^{a}/519^{a}	111^{d}/155^{d}	648^{a}
3rd	2 253^{e}	263^{e}/2 809^{e}	1 269^{e}/1 604^{e}	4 095^{e}	482^{a}	57^{a}/504^{a}	117^{d}/150^{d}	655^{a}
Mean	2 231	250/2 713	1 141/1 456	3 898	472	55/531	123/172	677

Significance of differences and interaction were tested as in Table 9. ^{a,b}: $P = 0.05$; ^{d,e,f}: $P = 0.01$. No significant interaction was found between groups and years.

Table 12. Mean daily dry matter (DM) intake per liveweight and metabolic bodyweight during the first three lactations.

1st—3rd lactations	Daily DM intake kg/100 kg liveweight						Daily DM intake g/kg $W^{0.75}$	
	70 d after calving		154 d after calving		Lactations		Lactations	
	roughage	total intake	roughage	total intake	roughage	total intake	roughage	total intake
Groups								
Fr-S	1.42[ef]	2.42[e]	1.60[e]	2.50[e]	1.59[e]	2.30[e]	77[be]	111[e]
Ay-S	1.42[ef]	2.48[e]	1.63[e]	2.61[e]	1.62[e]	2.41[e]	76[abe]	112[e]
Fc-S	1.37[e]	2.43[e]	1.60[e]	2.53[e]	1.60[e]	2.34[e]	73[ae]	107[e]
Fr-H	1.50[af]	2.93[af]	1.76[af]	3.02[f]	1.85[f]	2.85[af]	88[cdf]	135[bfg]
Ay-H	1.60[bf]	3.07[bf]	1.84[bf]	3.15[bf]	1.92[f]	2.99[bf]	90[df]	139[g]
Fc-H	1.59[bf]	2.97[f]	1.81[f]	2.99[af]	1.90[f]	2.84[af]	86[cf]	129[af]
Breeds								
Fr	1.46[a]	2.67[ae]	1.68[a]	2.75[e]	1.72[a]	2.56[ae]	82[f]	123[f]
Ay	1.51[a]	2.77[bf]	1.73[b]	2.88[f]	1.77[a]	2.70[bf]	83[f]	126[f]
Fc	1.48[a]	2.68[aef]	1.70[ab]	2.75[e]	1.74[a]	2.58[a]	79[e]	118[e]
Diets								
S	1.41[h]	2.44[h]	1.61[h]	2.55[h]	1.61[h]	2.35[h]	76[h]	111[h]
H	1.55[i]	2.99[i]	1.80[1]	3.07[i]	1.89[i]	2.91[i]	88[i]	136[i]
Lactations								
1st	1.33[e]	2.42[e]	1.58[e]	2.53[e]	1.63[e]	2.42[e]	75[e]	111[e]
2nd	1.62[g]	2.96[g]	1.85[g]	3.03[g]	1.87[g]	2.80[f]	88[g]	132[f]
3rd	1.51[f]	2.81[f]	1.70[f]	2.91[f]	1.76[f]	2.71[f]	84[f]	129[f]
Mean	1.48	2.71	1.71	2.80	1.75	2.64	82	123
Interaction								
Breed/diet	*	NS	NS	NS	NS	NS	NS	NS
Diet/year	**	NS	**	NS	NS	NS	NS	NS

Significance of the differences and interaction were tested as in Table 8. [a, b, c, d]: P = 0.05; [e, f, g]: P = 0.01; [h, i]: P = 0.001.

Factors affecting roughage intake

The factors affecting the intake of roughages were clarified by means of stepwise regression analysis. For the first analysis of silage intake the independent variables were the cows' characteristics, time elapsed since calving and the main characteristics describing silage composition. The factors that significantly affected intake are presented below in order of significance:

	Silage DM kg/cow/d	
Variable	b	Cumulative R^2 %
1. Liveweight, kg	+0.42***	25.5 %
2. Silage fiber-% in DM	—0.23***	33.2
3. Dig.% of silage org. mat.	+0.15***	36.7
4. Time since calving	+0.24***	38.3
5. 4 % milk yield, kg/d	+0.18***	39.6

The decisive effect of liveweight on silage intake has already been described above, likewise, the effect of time since after calving. The curvilinearity of intake can be seen in the regression analyses as the time squared having increased the coefficient of determination, but not significantly. The fiber content of silage limited feed intake, while improved digestibility increased it. Furthermore, higher milk yields increased silage intake which is natural since cereal replaced only a part of the amount of energy required for milk production.

Through the second regression analysis an attempt was made to clarify only the effect of conservational quality on feed intake. Fermentation and degradation results were very closely correlated. The stepwise regression analysis set the following as significant factors:

Variable	Silage DM kg/cow/d b	Cumulative R^2 %
1. Silage NH_4-N/ total N	—0.40***	6.3
2. Silage pH	+0.40***	11.5
3. Silage DM %	+0.17***	14.2
4. Silage propionic acid %/DM	—0.16***	15.8

Ammonium nitrogen was such a clear taste factor that, of the fermentation acids strongly correlating with it, only the negative effect of propionic acid became apparent. The result was unexpected, as ammonium nitrogen contents were low and variation slight; the extreme contents were 3.7—7.9 % of total nitrogen. Also the pH variation was slight, 3.90—4.30. The dry matter content was included in the analysis, because it affected fermentation. An increase in dry matter increased feed intake.

The quality factors of silage increased the coefficient of determination by only about 3 % units, as all factors affecting feed intake were included in the same regression analysis. Then, by varying the factors which have a significant effect, 46.3 % of the variation in silage intake could be explained. The effect of concentrate in feed intake could not be clarified by the present study, because different levels were not used in the same stage of lactation. The effect of the individual differences in feed intake was not investigated.

The factors significantly affecting hay intake were about the same as those for silage. Variation of liveweight, time since calving and its square, organic digestibility of hay and 4 % milk yields of the cows explained a total of 63.8 % of the variation in hay intake.

Energy supply

Digestibility determinations for feeds and the calculation of net energy value (FU) have been presented in our heifer paper (ETTALA and VIRTANEN 1990 a).

The calculated amount of net energy of the cows rose rapidly during the first three weeks. An equal, higher energy level group was formed by both Friesian groups and by the Ayrshire hay group, a lower level by both Finncattle groups while the energy supply of the Ayrshire silage

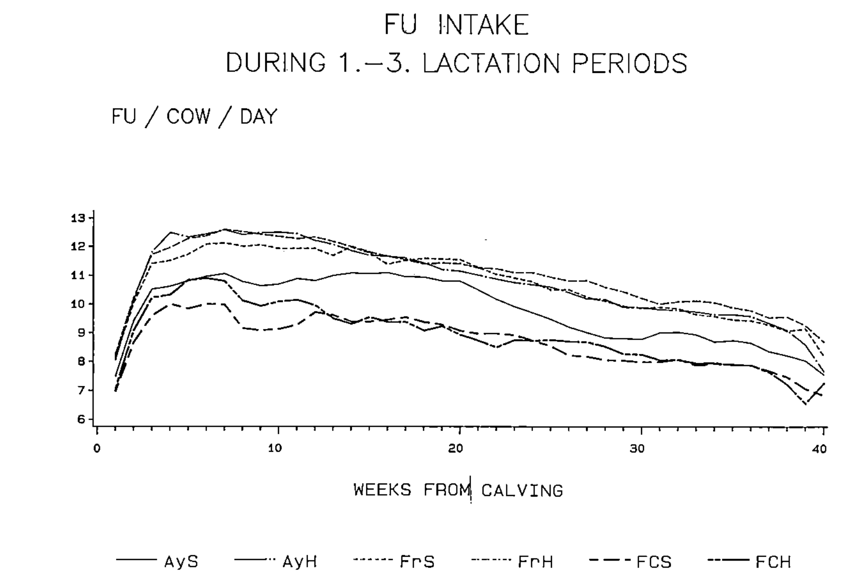

Fig. 9. Mean net energy supply of the experimental groups during the first three lactations.

group was in between these (Fig. 9). The mean Friesian energy supply during three lactations was 0.5 FU/d greater than that of the Ayrshires and that of the Ayrshires, on the other hand, was 1.4 FU/d greater than that of the Finncattle (Table 13, Fig. 10). When energy supply was calculated per 100 kg liveweight, the Friesians and the Finncattle were equal and the Ayrshires were significantly superior (Table 14). Differences between individuals in energy supply were greatest among Friesians and least among Finncattle. Significant interactions were due to differences in the intake of roughages (Table 13).

The mean supply of energy calculated from silage and hay was equal (5.24 and 5.21 FU/cow/d, respectively) during the three lactations. In addition, the silage group received energy 0.5 FU/d from hay (Table 13). The calculated total net energy supply was significantly greater in the hay group than in the silage group, because the amount of concentrate was higher in the hay group. The difference was maximal at the beginning of the lactation period (Fig. 11). Only at mid-lactation, when silage intake was highest, was the energy supply at the same level on both diets. The difference in energy supply of the diets increased when the supply of energy was calculated in relation to liveweight, as the lower supply of energy in the silage group was divided by a higher liveweight (Table 14).

The cows' energy supply increased significantly yearly (Table 13). A notable difference was observed between the first and subsequent lactations. Inversely, the level of energy supply for different dry periods was very similar, averaging 7.7 FU/cow/d.

The mean supply of net energy calculated during the lactation period was 3 073 FU/cow (Fr 3 217, Ay 3 102 and Fc 2 678 FU/cow) and

Table 13. Daily net energy supply at the beginning of the lactations and during the whole lactation.

1st—3rd lactations	FU/cow/d					
	70 d after calving			during lactation		
	roughage	cereal/ u-cereal	total supply	roughage	cereal/ u-cereal	total supply
Groups						
Fr-S	5.39^{g}	5.72^{e}	11.12±2.1^{af}	6.24^{g}	4.16^{e}	10.40±2.0^{f}
Ay-S	4.81^{cf}	5.38^{bde}	10.19±2.0^{e}	5.49^{f}	4.02^{e}	9.52±1.8^{e}
Fc-S	4.29^{bde}	4.95^{ad}	9.24±1.8^{d}	5.02^{e}	3.50^{d}	8.52±1.6^{d}
Fr-H	4.25^{bde}	7.26^{g}	11.51±2.1^{f}	5.39^{f}	5.31^{f}	10.70±2.1^{f}
Ay-H	4.42^{bef}	7.23^{g}	11.65±1.8^{bf}	5.28^{ef}	5.36^{f}	10.64±1.8^{f}
Fc-H	3.86^{ad}	5.99^{f}	9.85±1.8^{de}	4.63^{d}	4.19^{e}	8.82±1.7^{d}
Breeds						
Fr	4.81^{e}	6.51^{e}	11.32±2.1^{be}	5.81^{f}	4.75^{e}	10.55±2.0^{f}
Ay	4.61^{e}	6.32^{e}	10.93±2.0^{ae}	5.38^{e}	4.70^{e}	10.09±1.8^{e}
Fc	4.08^{d}	5.46^{d}	9.54±1.8^{d}	4.83^{d}	3.84^{d}	8.67±1.6^{d}
Diets						
S	4.95^{i}	5.44^{h}	10.39±2.1^{h}	5.71^{i}	3.98^{h}	9.69±1.9^{h}
H	4.26^{h}	7.03^{i}	11.29±2.0^{i}	5.21^{h}	5.14^{i}	10.35±2.0^{i}
Lactations						
1st	3.53^{d}	5.10^{d}	8.63±1.0^{d}	4.29^{d}	3.68^{d}	7.97±0.9^{d}
2nd	5.09^{ae}	6.76^{e}	11.84±1.3^{e}	6.07^{e}	4.84^{e}	10.91±1.4^{e}
3rd	5.33^{be}	7.03^{e}	12.36±1.5^{f}	6.16^{e}	5.33^{f}	11.48±1.4^{f}
Mean	4.60	6.24	10.84	5.46	4.57	10.03
Interaction						
breed/diet	***	*	***	***	NS	**
diet/year	***	NS	*	NS	NS	NS

Significance of differences and interaction were tested as in Table 8. a, b, c: $P=0.05$; d, e, f, g: $P=0.01$; h, i: $P=0.001$.

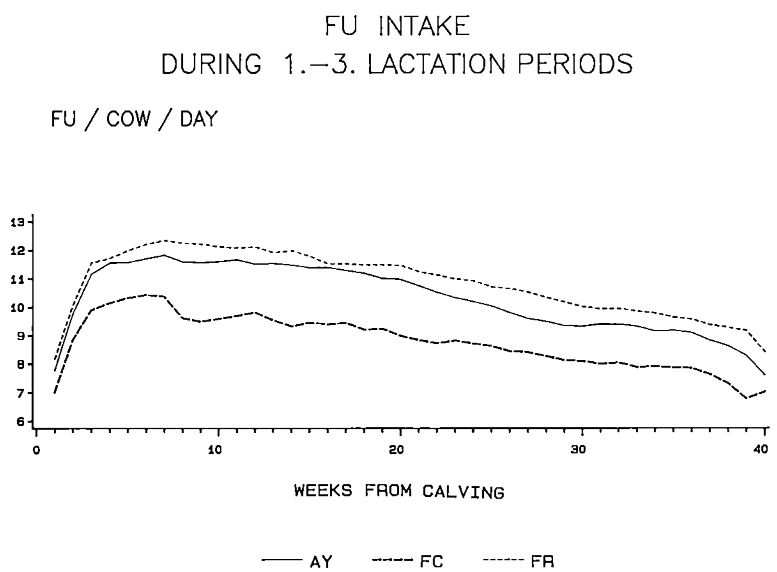

Fig. 10. Mean net energy supply of Friesians, Ayrshires and Finncattle during the first three lactations.

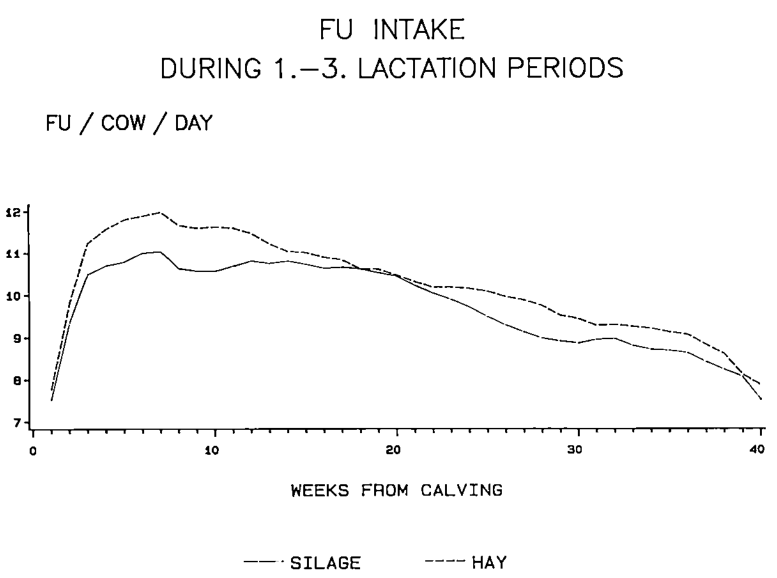

Fig. 11. Mean net energy supply on silage and hay diets during the first three lactations.

that during the dry period 505 FU/cow. During the first lactation the energy supply was about 900 FU lower than subsequently.

Digestible crude protein supply

Differences between the breeds in digestible crude protein supply was due to either their silage intakes or their intake of urea-cereal con-

Table 14. Daily net energy supply per 100 kg liveweight during the first three production years.

1st—3rd production years	FU/100 kg liveweight/d							
	Lactations			Dry periods			Production years	
	roughage	cereal/ u-cereal	total supply	roughage	cereal/ u-cereal	total supply	roughage	total supply
Breeds								
Fr	1.11^{a}	0.91^{d}	2.02^{d}	0.92^{d}	0.41^{ad}	1.33^{d}	1.08^{a}	1.90^{d}
Ay	1.14^{a}	1.00^{e}	2.14^{e}	0.99^{e}	0.45^{bde}	1.44^{e}	1.11^{a}	2.00^{e}
Fc	1.13^{a}	0.90^{d}	2.03^{d}	0.97^{de}	0.48^{e}	1.45^{e}	1.10^{a}	1.93^{de}
Diets								
S	1.15^{g}	0.80^{f}	1.95^{f}	0.97^{b}	0.35^{f}	1.32^{f}	1.12^{g}	1.84^{f}
H	1.10^{f}	1.09^{g}	2.19^{g}	0.94^{a}	0.53^{g}	1.47^{g}	1.07^{f}	2.06^{g}
Mean	1.12	0.95	2.07	0.96	0.45	1.41	1.09	1.95

Significance between differences and interaction were tested as in Table 10. $^{a, b}$: P = 0.05; $^{d, e}$: P = 0.01; $^{f, g}$: P = 0.001. No significant interaction was found.

Table 15. Mean daily supply of digestible crude protein (DCP) from different feeds at different stages of production during the first three production years.

1st—3rd production years	DCP g/cow/d								
	70 d after calving			Lactations			Dry periods		
	roughage	cereal/ u-cereal	total supply	roughage	cereal/ u-cereal	total supply	roughage	cereal/ u-cereal	total supply
Breeds									
Fr	740^{be}	696^{e}	1 436 ^{be}	828^{f}	509^{e}	1 338^{f}	789^{e}	263^{a}	1 052^{e}
Ay	699^{ae}	681^{e}	1 380 ^{ae}	765^{e}	507^{e}	1 272^{e}	750^{e}	263^{a}	1 014^{e}
Fc	598^{d}	579^{d}	1 177 ^{d}	684^{d}	405^{d}	1 089^{d}	653^{d}	249^{a}	902^{d}
Diets									
S	858^{h}	464^{g}	1 322 ^{g}	929^{h}	340^{g}	1 269^{a}	911^{h}	167^{g}	1 078^{h}
H	541^{g}	869^{h}	1 410 ^{h}	627^{g}	637^{h}	1 264^{a}	597^{g}	349^{h}	946^{g}
Years									
1st	550^{d}	554^{d}	1 104 ^{d}	666^{d}	394^{d}	1 060^{d}	734^{a}	276^{e}	1 009^{a}
2nd	811^{f}	730^{e}	1 541 ^{be}	832^{e}	525^{e}	1 357^{e}	761^{a}	251^{d}	1 011^{a}
3rd	745^{e}	738^{e}	1 483 ^{ae}	846^{e}	565^{f}	1 412^{f}	756^{a}	253^{d}	1 008^{a}
Mean	698	669	1 367	776	490	1 266	749	261	1 010
Interaction									
Breed/diet	***	***	***	***	**	***	NS	NS	NS
diet/year	***	***	**	***	***	NS	**	**	***

Significance of differences and interaction were tested as in Table 8. $^{a, b}$: P = 0.05; $^{d, e, f}$: P = 0.01; $^{g, h}$: P = 0.001.

centrate rationed as to 4 % milk yield. Thus the protein supply of the silage group was mainly from silage (68.7 %), over one-fourth (26.5 %) from cereals and the rest from hay, whereas in the hay group half came from the urea-cereal concentrate and half from hay (Table 15, Figs. 12 and 13). The DCP supply from urea during the lactations averaged 223 g/d and accounted for 17.7 % of the protein intake of the hay group.

Digestible crude protein supply during the lactations was equal on both diets (Table 15).

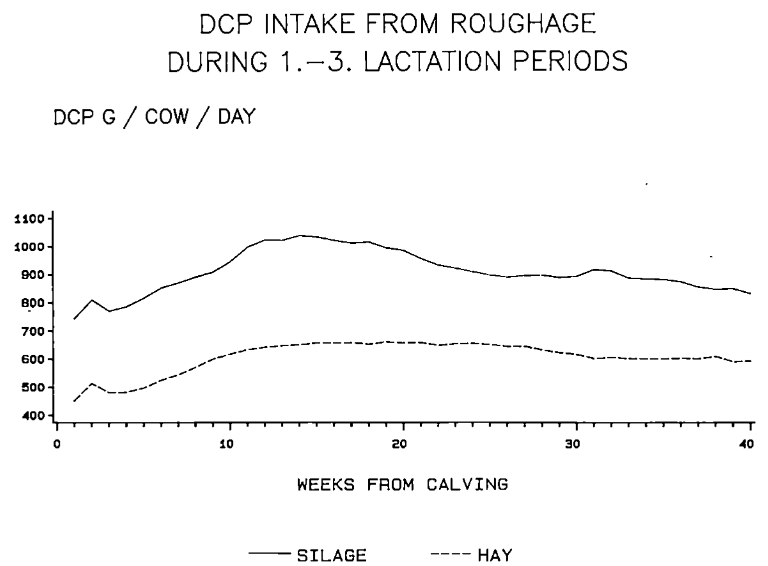

Fig. 12. Mean digestible crude protein supply from roughages on silage and hay diets during the first three lactations.

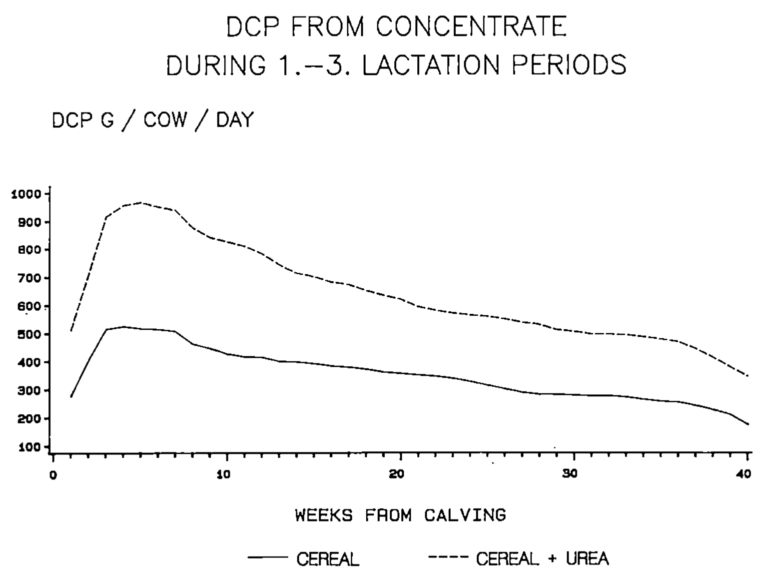

Fig. 13. Mean digestible crude protein supply on cereals and urea-cereal concentrate during the first three lactations.

On the other hand, at the beginning of the lactations the hay group received more protein than the silage group (Fig. 14). The difference was due to the protein sources. Silage intake was not highest at the beginning of the lactations, but the amount of urea concentrate was.

Significant interaction among breeds and diets in DCP intake were due both to rough-

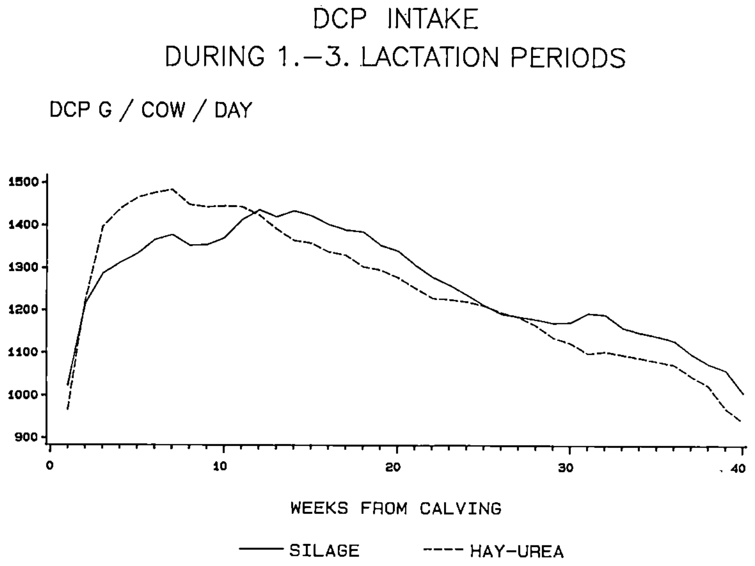

Fig. 14. Mean digestible crude protein supply on silage and hay diets during the first three lactations.

ages as well as to the different protein contents of the concentrates (Table 15). The concentrate rations fed to the breeds studied were calculated based on 4 % milk yields. The same factors caused significant interactions also between diets and years. No significant interaction was found between breeds and years.

During the dry periods the protein supply on the silage diet was considerably higher than on the hay diet, because feeding was primarily based on roughages.

DISCUSSION

The mean feed intake was quite similar for all of the breeds studied when the results were calculated in relation to the liveweights of the cows. When calculated per 100 kg liveweight during the three lactations, the heavy Friesian and the small Finncattle had a dry matter intake that was practically the same, 2.56 and 2.58 kg/d, respectively. Only the Ayrshire breed was a significant exception to these with 2.70 kg/d. When calculated per metabolic bodyweight, the intakes of Friesians and Ayrshires were 123 and 126 DM g/d, respectively, while Finncattle differed from them significantly with 118 g/d.

There is no comparative basis for the present results from other breed experiments, because in extensive breed experiments the feed intake of the cows has not been investigated (Bar-Anan et al. 1987, Christensen et al. 1984, Jasiorowski et al. 1987, Lee et al. 1982).

According to this study, the dry matter intakes of cows essentially depended on the energy value of the feed or diet. The mean dry matter intake of hay during the three lactations was so much higher than that of silage (8.9/7.2 kg/d) that the same amount of energy was obtained from both sources (5.21/5.24 FU/d). Likewise, the intake of the hay diet was significantly greater than that of the silage diet (13.8/11.6 DM kg/d) while the corresponding energy values were 0.75 and 0.83 FU/kg DM, respectively.

The difference in intake between hay and silage was not uniform for all breeds. The Ayrshires preferred hay, the Friesians silage and the Finncattle were in between these. The interaction was significant between breeds and diets when calculated per cow but not per 100 kg liveweight.

Feeding experiments have been conducted in many countries in order to compare silage and hay intake. Particularly quality differences in silage have been shown to have an effect on the results. At best, the Finnish intake rersults can be compared with the results from other Nordic countries as grass species are chiefly the same and fresh silages are preserved with formic acid. Actually, such comparisons are difficult to make, because other experiments have been conducted during different stages of lactation and have employed different levels of concentrate. These experiments have usually lasted a short time and have been conducted during the best stage of production. In Sweden, BERTILSSON and BURSTEDT (1983) compared silage and hay harvested simultaneously from the same cut during the first 4.—10. weeks of lactation. Silage intake was 1.56 and that of hay was 1.85 kg DM/100 kg liveweight/d. The results approach the mean intakes found in our experiment during the first part of lactation (1.—154. d). At that time, the silage group consumed 1.45 kg/d of silage and 0.16 kg/d of hay, or altogether 1.61 kg DM/100 kg liveweight/d of roughage and the hay group 1.80 kg hay DM. In Norway, the experiments of PRESTHEGGE (1959) presented equivalent silage and hay intakes of 1.5—1.6 kg DM/100 kg liveweight/d.

The total dry matter intake during three lactations per 100 kg liveweight averaged 2.35 kg/d on silage diets and 2.91 kg/d on hay diets. During the first half of the lactations the corresponding intakes were 2.55 and 3.07 kg/d, respectively. Especially the DM intakes of the first half of the second and third lactations, 2.70 and 3.23 kg DM/100 kg liveweight/d on average, respectively correspond to the results of short experiments conducted when intake has been maximal. In Finnish short-term experiments performed on silage diets the mean intake was 2.70 kg DM/100 kg liveweight/d (ETTALA and LAMPILA 1978). In other experiments on corresponding silage the dry matter intake has varied between 2.70—3.33/100 kg liveweight/d (BERTILSSON and BURSTEDT 1983, CASTLE and WATSON 1970, EKERN 1972). The mean intakes of dry matter on hay diets have varied between 2.81—3.37 kg/100 kg liveweight/d (BERTILSSON and BURSTEDT 1983, WIKTORSSON 1973).

The highest intakes were attained during the first half of the second lactation. Some individual in every breed had an average dry matter intake of 3.2 kg on the silage diet and 3.7 kg on the hay diet, being in some weeks as much as 4 kg/100 kg liveweight/d. Differences between individual intakes were similar to those found in other corresponding experiments (EKERN 1972, ETTALA and LAMPILA 1978, STONE et al. 1960).

When planning the present investigation, an attempt was made to achieve an equal net energy supply per 4 % milk kg on both diets through the use of different levels of concentrate. The different maintenance requirement of breeds was estimated to be satisfied by differences in intakes of the roughages. The last mentioned was realized quite well, as the energy supplies calculated for roughages were quite the same during three lactations per 100 kg liveweight, being Fr 1.11, Ay 1.14 and Fc 1.13 FU/d.

On silage diets, the energy supply was significantly lower than on the hay diets, averaging during three lactations 1.95 and 2.19 FU/100 kg liveweight/d, respectively. Perhaps the concentrate ration on the silage diet could have been increased somewhat more sharply during the peak lactation. In the best production stages, during the first 10 weeks, the roughage-concentrate ratio (FU/FU) on silage diets averaged 48 : 52, while on hay diets it was 38 : 62. However, it was feared that silage intake would decrease just when the protein supplied by silage would be decisive. According to earlier research, an additional kilogram of cereal DM decreased silage DM intake by 638 g/d (ETTALA and LAMPILA 1978).

Digestible crude protein supply during the lactations was equal on both diets, averaging 1 269 and 1 264 g/d, respectively. During the more critical period at the beginning of the lactations, the protein supply on silage diets was, however, lower than on hay diets (1 322 and 1 410 g/d/10 weeks). The difference was due to the fact that on hay diets the urea protein supply increased rapidly with higher concentrate rations, whereas the protein supplied by silage was maximal only when the intake was highest after the first 10 weeks. The proportion of silage protein in the DCP supply of silage diets during the first 10 weeks was 60.3 %, when corresponding proportion during the whole lactation was 68.7 %.

During the first 10 weeks, the average supply of urea was 152 g/cow/d and the supply of digestible crude protein from urea was calculated to be 307 g/d which was 21.8 % of the total DCP at that time on hay diets. Seventy percent was used for urea digestibility as obtained in other dairy cow experiments (KREULA and ETTALA 1977). The present experiment attempted to clarify what results can be achieved with urea supplement when its use is continuous and intended to last for years. The idea was based on the good results obtained in the experiments of professor VIRTANEN (1967) in which 36—74 % of the digestible crude protein was replaced by urea (ETTALA and KREULA 1976).

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SELOSTUS

Suomalaisen ayrshiren, friisiläisen ja suomenkarjan vertailu säilörehu-vilja- ja heinä-urea-viljaruokinnalla

2. Lehmien syönti ja ravinnonsaanti kolmena ensimmäisenä tuotantovuonna

ELSI ETTALA ja ERKKI VIRTANEN

Maatalouden tutkimuskeskus

Suomalaisia lypsykarjarotuja, ayrshireä (ay), friisiläistä (fr) ja suomenkarjaa (sk) vertailevan tutkimuksen hiehot poikivat vähän yli 25 kk:n ikäisinä. Tuotantokokeeseen otettiin 96 lehmää (ay 40, fr 40 ja sk 16). Puolet joka rodusta (sr) sai vapaasti säilörehua, kilon päivässä heinää ja ohrakauraseosta 0,24—0,30 ry/kg 4%-maitoa. Puolet (hr) sai vapaasti heinää ja ureapitoista (2 %) ohra-kauraseosta 0,32—0,38 ry/kg 4%-maitoa.

Säilörehu oli tuoretta, kelasilputtua ja muurahaishapolla (AIV 2 4 l/tn) säilöttyä nurmirehua. Sen täyttävyys oli keskimäärin 1,37 ka kg/ry, sulava raakavalkuaispitoisuus 12,2 %/ka ja laatu hyvä. Heinän täyttävyys oli keskimäärin 1,71 ka kg/ry ja sulava raakavalkuaispitoisuus 7,0 %/ka.

Tässä julkaisussa esitetään lehmien syönti- ja ravinnonsaantitulokset kolmelta ensimmäiseltä tuotantovuodelta (1981—84). Karkearehua kului säilörehuvaltaisella ruokinnalla lypsykausina keskimäärin 8,0 ka kg/vrk (fr 8,7, ay 7,7 ja sk 7,0 ka kg/vrk). Heinäryhmien heinän kulutus oli vastaavasti 8,9 ka kg/vrk (fr 9,3, ay 9,1 ja sk 7,9 ka kg/vrk). Lehmien keskipainot olivat tällöin: fr 523, ay 472 ja sk 426 kg, säilörehuryhmillä 496 kg ja heinäryhmillä 474 kg.

Kokonaiskuiva-aineen syönti oli suhteessa elopainoon ayrshirellä merkitsevästi runsaampaa kuin muilla roduilla, kolmen lypsykauden aikana keskimäärin ay 2,70, fr 2,56 ja sk 2,58 kg/100 elopaino-kg/vrk, samoin energian saanti ay 2,14, fr 2,02 ja sk 2,03 ry/100 elopaino-kg/vrk. Säilörehuvaltaisella ruokinnalla kuiva-aineen kulutus oli merkitsevästi vähäisempää kuin heinävaltaisella, keskimäärin 2,35 ja 2,91 kg/100 elopaino-kg/vrk, samoin energian saanti, 1,95 ja 2,19 ry/100 elopaino-kg/vrk. Ruokintaryhmien erot energian saannissa olivat suurimmillaan lypsykausien alussa.

Sulavan raakavalkuaisen saanti oli koko lypsykausina molemmilla ruokinnoilla yhtä runsasta, mutta lypsykausien alussa heinävaltaisella ruokinnalla merkitsevästi runsaampaa kuin säilörehuvaltaisella. Ureasta tuli sulavaa raakavalkuaista kolmen ensimmäisen lypsykauden aikana keskimäärin 223 g lehmää kohti päivässä, mikä oli 17,7 % heinäryhmän valkuaisen saannista.

Ummessaolokausina karkearehun kulutus oli hieman vähäisempää kuin lypsykausina. Energian saanti ummessaolokausina oli keskimäärin 1,41 ry/100 elopaino-kg/vrk.

ANNALES AGRICULTURAE FENNIAE, VOL. 29: 303—318 (1990)

Seria ANIMALIA DOMESTICA N. 94 — Sarja KOTIELÄIMET n:o 94

COMPARISON OF FINNISH AYRSHIRE, FRIESIAN AND FINNCATTLE ON GRASS SILAGE-CEREAL AND HAY-UREA-CEREAL DIETS

3. Production of the cows during the first three lactations

ELSI ETTALA and ERKKI VIRTANEN

ETTALA, E. & VIRTANEN, E. 1990. **Comparison of Finnish Ayrshire, Friesian and Finncattle on grass silage-cereal and hay-urea-cereal diets. 3. Production of the cows during the first three lactations.** Ann. Agric. Fenn. 29: 303—318. (Agric. Res. Centre, North Savo Res. Sta., SF-71750 Maaninka, Finland.)

The milk yields of the first three lactations of a comparative study conducted on the Finnish Ayrshire (40 Ay), Friesian (40 Fr) and Finncattle (16 Fc) dairy cattle breeds are presented. The animal material was collected by random sampling from recorder herds during the calf stage. Cows were removed from the experiment only on account of sickness. Half of each breed (S) received *ad libitum* fresh grass silage preserved with formic acid, one kilogram of hay per day and a barley-oats concentrate 0.24—0.30 FU/kg 4 % fat corrected milk (FCM). The other half (H) got *ad libitum* hay and a urea (2 %)-barley-oats concentrate 0.32—0.38 FU/kg 4 % FCM.

The Friesians produced slightly more regular milk (3.3 %) and less 4 % FCM (1.7 %) than Ayrshires. The milk yield of the Finncattle was significantly lower. The yield differences between Finncattle and Friesians were 20.2 % and between Finncattle and Ayrshires 17.6 % in terms of regular milk and 15.9 % and 17.3 % in terms of 4 % FCM, respectively. The differences noted for Finncattle narrowed when the yields were calculated in relation to liveweights (Fr 523, Ay 472 and Fc 426 kg). The Ayrshires had the highest yield then. The average yield of the Ayrshires calculated per 100 kg liveweight was significantly better than that of the Finncattle (Ay 3.11, Fr 2.91 and Fc 2.84 kg/d) and the amount of 4 % FCM differed significantly from that of the other two breeds (Ay 3.47, Fr 3.09 and Fc 3.18 kg). Finncattle and Ayrshires had equally high milk fat contents and the Friesians significantly lower contents (Fr 4.43, Ay 4.79, Fc 4.81 %). This was also true for milk protein content (Fr 3.19, Ay 3.28, Fc 3.31 %).

No significant interactions were detected between breeds and diets, between breeds and years, or between diets and years. The average annual yields during three lactations on the silage and hay diets were the same (4 698 and 4 694 kg/305 d 4 % FCM). In relation to liveweight, the average yield of the silage group was smaller than that of the hay group, and the difference was significant when calculated per 100 kg liveweight (S 3.17 and H 3.36 kg/d 4 % FCM), because the silage group was heavier (S 496 and H 474 kg). Minor differences in milk composition were found between the dietary groups.

Index words: dairy breeds, Ayrshire, Friesian, Finncattle, grass silage-cereal diet, hay-urea-cereal diet, milk production.

INTRODUCTION

A comparison of Finnish Ayrshire, Friesian and Finncattle dairy cows conducted in a research station environment has been presented in two earlier publications (ETTALA and VIRTANEN 1990 a, b). The first paper described the background and objective of the study and the random sampling of the experimental animals as well as their allocation into two dietary groups. It also included the results of the heifer stage. The second paper dealt with the diet, feed intakes and nutrient supplies of the cows during the first three production years on grass silage-cereal and hay-urea-cereal diets.

This paper presents the production results of the cows during the first three lactations. The results show the production capacity of cows nonselectively sampled from recorder herds. By comparing our results with those of the recorder cows, both the success of the random sampling method employed can be seen and the effect of selection and elimination practiced in the recorder herds can be explained. The productivity of the breeds may also be compared with the results of international breed comparisons (BAR ANAN et al. 1987, CHRISTENSEN et al. 1984, HINKOVSKI et al. 1985, 1988, JASIOROWSKI et al. 1987, LEE et al. 1982).

The production of the breeds at different ages and productive phases on two predominantly home-grown diets was studied. Of special interest were the weeks following calving, a time when both the production ability of the cows as well as the effects of diet on production become apparent. A detailed presentation of the results has been published earlier in Finnish (ETTALA and VIRTANEN 1986).

MATERIAL AND METHODS

At the beginning of the production period experiment the experimental material consisted of: 40 Friesians (Fr), 40 Ayrshires (Ay) and 16 Finncattle (Fc). Seventy-six percent of the heifers calved within a two-month period (May—June 1981) and 95 % within three months. The average calving age of the breeds studied was nearly the same, and age differences were slight also during subsequent calvings.

	Number of cows and age at calving					
	1st calving		2nd calving		3rd calving	
	n	age	n	age	n	age
Fr	40	25 mo 8 d	40	3 yr 48 d	34	4 yr 43 d
Ay	40	25 » 8 »	39	3 » 57 »	38	4 » 75 »
Fc	16	25 » 17 »	16	3 » 85 »	15	4 » 91 »

The mean length of three lactations was 308 days. Length of lactation for different breeds and lactations was as follows:

	1st lactation		2nd lactation		3rd lactation		mean
	n	days	n	d	n	d	d
Fr	40	306	38	311	30	297	306
Ay	40	313	38	318	34	295	309
Fc	16	326	16	309	15	297	310

On the silage diet the duration of lactation averaged 313 days, and on the hay diet 304 days. The average dry period lasted 65 days (1st year 71 d, 2nd year 60 d and 3rd year 62 d). The last milking day served as the cut-off point between the lactation and dry periods.

The cows in the silage group (S) were fed *ad libitum* fresh, good quality silage, flail-harvested at the ear emergence stage and preserved with formic acid (4 l/tn), one kilogram hay per day and a barley-oats concentrate 0.24—0.30 FU/kg 4 % FCM (ETTALA and VIRTANEN 1990 b). The cows in the hay group (H) were fed *ad libitum* hay, harvested before flowering and a barley-oats concentrate with urea (2 %) 0.32—0.38 FU/kg 4 % FCM. In addition, the cows received a vitamin-supplemented mineral mixture, and the hay group received additionally a separate vitamin supplementation.

Milk was weighed at every milking. Morning and evening milk was sampled once a week. The morning and evening milk samples were analysed separately by an Infra Red Milk Analyser (IRMA) at the Eastern Finland Regional Laboratory of Valio Ltd. The fat and protein contents were analysed, and weekly contents were used for calculation of the fat and protein yields of the cows. The mean fat and protein contents of the groups, breeds and years were obtained by dividing the amounts of accumulated fat and protein by the corresponding milk yields. Four percent FCM was calculated using the formula (0.15 × fat % + 0.4) × milk yield (SALO et al. 1982). Cows were not eliminated from the experiment due to poor production, only in the case of sickness.

The calculations and statistical analyses of the results were the same as those used for calculation of feed intake and nutrient supply of the cows (ETTALA and VIRTANEN 1990 b).

RESULTS

Production in early lactations

Each year the mean daily peak yield was the highest for Friesians, being slightly lower for Ayrshires and distinctly lower for Finncattle (Table 1). There were considerable individual differences within each breed. Great variation was expected due to the random sampling method employed. Cows that milked 30 kg or more during the second lactation totalled

Table 1. Daily peak yields of cows during the first three lactations.

	1st lactation			2nd lactation			3rd lactation		
	Cows	Milk kg/d		Cows	Milk kg/d		Cows	Milk kg/d	
	n	$\bar{x}$	variation	n	$\bar{x}$	variation	n	$\bar{x}$	variation
Group									
Fr-S	20	19.9	(12.8—26.2)	20	26.5	(20.3 —33.1)	17	27.5	(17.7*—35.2)
Fr-H	20	21.7	(17.4—26.7)	20	27.5	(11.3*—33.3)	17	30.2	(20.3 —38.0)
Ay-S	20	18.5	(15.0—23.6)	19	25.2	(19.2 —30.6)	18	26.6	(21.0 —31.0)
Ay-H	20	21.6	(17.7—27.5)	20	25.8	(13.6*—32.4)	20	27.8	(20.1*—34.4)
Fc-S	8	15.3	(11.0—23.8)	8	21.6	(16.7 —26.9)	8	23.6	(18.3 —29.7)
Fc-H	8	17.1	(11.4—21.9)	8	20.3	(15.9 —24.3)	7	24.1	(17.6 —29.2)
Breed									
Fr	40	20.8		40	27.0		34	28.9	
Ay	40	20.0		39	25.5		38	27.2	
Fc	16	16.2		16	21.0		15	23.8	
Diet									
S	48	18.5		47	25.1		43	26.4	
H	48	20.9		48	25.6		44	28.1	
Mean	96	19.7		95	25.4		87	27.3	

* Premature calving

18.9 %, during the third lactation 25.3 %. On the silage-based diet the mean peak yield was somewhat lower than on the hay diet. The mean number of days from calving to peak yield was 35 days for the silage group and 30 days for the hay group. Individual differences were considerable. A short interval from calving to peak yield usually occurred in low-yielding cows, but also some high-yielding cows attained their peak yields rapidly.

Milk yields were highest generally between 4 and 8 weeks after calving (Fig. 1), taking slightly longer during the third lactation. A clear drop in production occurred after the tenth week. The mean daily milk yield during the first 10 weeks was somewhat higher for Friesians than for Ayrshires, but the 4 % FCM yields were equal (Table 2, Fig. 2). The milk yields of Finncattle were significantly below these. Variation was similar in both dietary groups of the breeds. Variation was wide in all breeds, being the widest among the Friesians.

On the hay-urea-cereal diet the milk yield of the first 10 weeks was significantly higher compared to the grass silage-cereal diet (Table 2, Fig. 3). The cut-off point of the lactation curves was about 12 weeks after calving. At that point, the energy supply of the silage group nearly equalled that of the hay group, as silage intake increased and differences in cereal intakes decreased (ETTALA and VIRTANEN 1990 b). Thereafter, the milk yield was slightly higher on the

Table 2. Mean daily milk yields of the cows during the first three lactations, 70 and 154 days after calving.

	Milk kg/cow/d		4 % FCM kg/cow/d	
	70 d	154 d	70 d	154 d
	$\bar{x}$ s.d.	$\bar{x}$	$\bar{x}$	$\bar{x}$
Group				
Fr-S	20.4 ± 4.6[bc]	18.6[c]	21.4[b]	19.5[c]
Fr-H	21.8 ± 4.6[c]	19.2[c]	21.8[b]	19.5[c]
Ay-S	19.2 ± 3.7[ab]	17.8[bc]	20.7[ab]	19.3[bc]
Ay-H	21.1 ± 3.7[bc]	18.6[c]	22.2[b]	19.9[c]
Fc-S	16.6 ± 4.1[a]	15.4[ab]	17.8[a]	16.6[ab]
Fc-H	16.9 ± 3.7[a]	14.6[a]	18.0[a]	15.9[a]
Breed				
Fr	21.1 ± 4.6[e]	18.9[e]	21.6[e]	19.5[e]
Ay	20.2 ± 3.8[e]	18.1[e]	21.5[e]	19.6[e]
Fc	16.8 ± 3.9[d]	15.0[d]	17.9[d]	16.3[d]
Diet				
S	19.3 ± 4.3[a]	17.7[a]	20.5[a]	18.9[a]
H	20.7 ± 4.4[b]	18.1[a]	21.4[b]	19.0[a]
Lactation				
1st	16.4 ± 2.9[d]	14.6[d]	17.1[d]	15.5[d]
2nd	20.9 ± 3.7[e]	18.8[e]	21.7[e]	19.9[e]
3rd	22.9 ± 3.8[f]	20.8[f]	24.3[f]	22.2[f]
Mean	20.0 ± 4.4	17.9 ± 4.1	20.9 ± 4.5	19.0 ± 4.1

Significance of differences between groups was tested by one-way analysis of variance at the 5 % risk level. Significance of differences between breeds, diets and lactations and their interaction effects were tested by three-way analysis of variance. Differences between breeds and lactations were tested at the 1 % risk level and between diets at the 0.1 % risk level. Paired comparisons were tested by Tukey's test.

Means for groups, breeds, diets and lactations in the same columns without the same superscript differ significantly from each other.

a, b, c: P = 0.05
d, e, f: P = 0.01

No significant interactions were found.

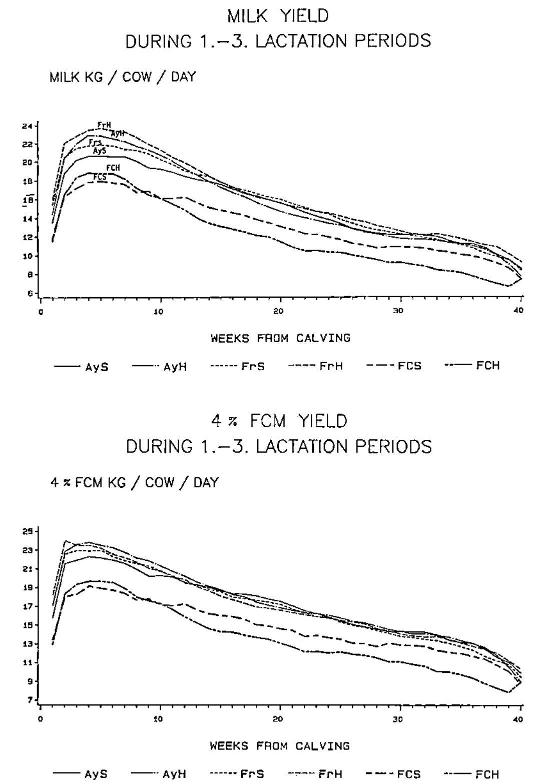

Fig. 1. Mean milk yield of the experimental groups during the first three lactations.

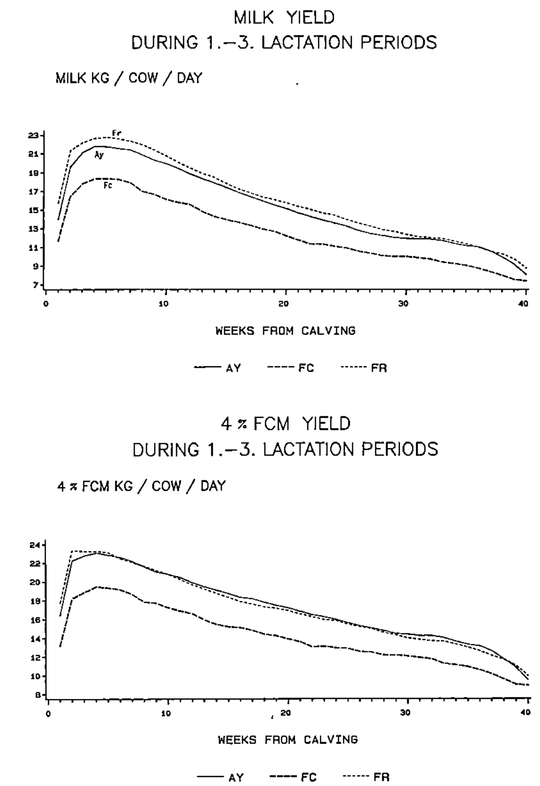

Fig. 2. Mean milk yield of the breeds during the first three lactations.

silage diet. At the halfway point through the lactation period (154 d) the mean daily yields of the dietary groups had reached almost equal levels (Table 2).

Annual yields

Annual yields have been calculated for 305 days and for all lactations. The difference is quite minor because the average length of the lactations was 308 days. When studying the results, the yields of all lactations have been used as the nutrient supply of the cows calculated from both the lactations and dry periods.

The annual lactation curves of the groups were relatively similar. However, the milk yield level increased from the first to the third lactation. The yield of the first lactation was low (Table 3). The yield of the second lactation (305 days) was 31.6 % higher and that of the third lactation still 6.2 % higher.

The mean milk yield of the Friesians during the first three lactations (305 days) were somewhat higher and the 4 % FCM yields slightly lower compared to those of the Ayrshires (Table 3). Equality was most apparent in the middle and at the end of the lactations (Figs. 1 and 2). By way of comparison, Finncattle had a significantly lower average milk yield. The Finncattle hay group had the lowest yield.

Variation was wide in all groups (Table 3). During the first lactation it was similar in all breeds, but in subsequent lactations variation was wider among the Friesians than among the

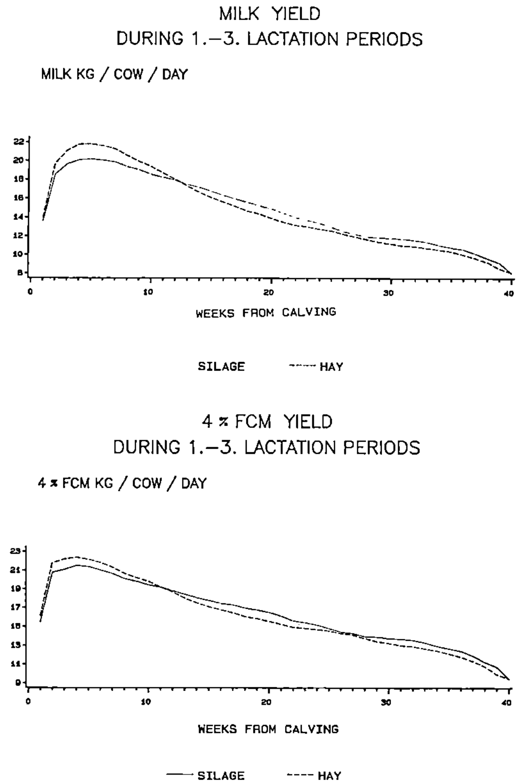

Fig. 3. Mean milk yield on the silage and hay diets during the first three lactations.

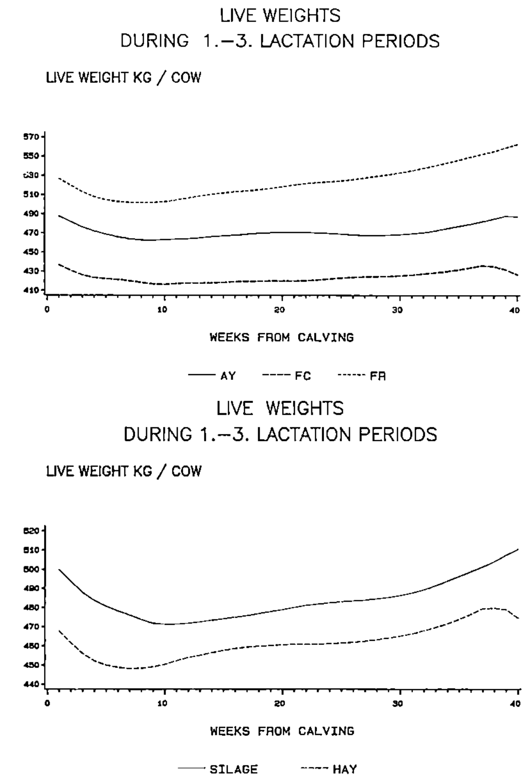

Fig. 4. Mean live weights of the breeds and dietary groups during the first three lactations.

other breeds. The high-yielding Friesian cows were able to increase their production considerably more than the low-yielding cows, whereas the other breeds had a steadier development in this regard (ETTALA and VIRTANEN 1986).

The average annual yields of the silage and hay groups during the three lactations were almost similar (Table 3, Fig. 3). They were quite equal for Ayrshires. Friesians had slightly higher production on hay, as did the Finncattle on the silage diet. No significant interactions were found between breeds and diets, between breeds and years, or between diets and years.

The peak yields of the cows indicated the corresponding lactation yield relatively well. In the first lactation, the correlation coefficient between peak yields and annual yields was +0.57*** and in the second lactation +0.63***. Variation in peak yield during the first lactation explained the variation in the annual yields of the second lactation (R^2-% 11.8***) more than the variation in the yield throughout the first lactation (R^2-% 6.2). When both were taken as independent variables, the coefficient of determination rose to 12.2 %. The follow-up examination showed that the very low peak yields in the first lactation would have been reliable exclusion criteria.

Yields in relation to live weight

The live weights of the cows have been presented in our previous paper (ETTALA and VIRTANEN 1990 b). The mean live weight of the cows during the three lactations was 485 kg (Fr

Table 3. Mean milk yields of the cows during the first three lactations, for 305 days and throughout the lactation periods.

	Milk kg/cow				4 % FCM kg/cow		
	305 d		lactation	d	305 d	lactation	
	x̄	s.d.	x̄	x̄	x̄	x̄	variation
Group							
Fr-S	4 409 ±	1 065[bc]	4 551[b]	15.0[b]	4 756[b]	4 911[b]	(3 719—7 013)
Fr-H	4 598 ±	1 154[c]	4 695[b]	15.3[b]	4 835[b]	4 941[b]	(3 582—6 349)
Ay-S	4 331 ±	870[bc]	4 493[b]	14.3[b]	4 835[b]	5 014[b]	(4 366—6 389)
Ay-H	4 393 ±	876[bc]	4 496[b]	14.8[b]	4 917[b]	5 041[b]	(4 049—5 899)
Fc-S	3 807 ±	881[ab]	3 995[ab]	12.4[ab]	4 257[ab]	4 475[ab]	(3 405—5 894)
Fc-H	3 379 ±	820[a]	3 457[a]	11.6[a]	3 803[a]	3 900[a]	(2 798—4 559)
Breed							
Fr	4 505 ±	1 110[c]	4 625[c]	15.1[c]	4 796[c]	4 926[c]	
Ay	4 363 ±	870[c]	4 494[c]	14.5[c]	4 877[c]	5 028[c]	
Fc	3 597 ±	870[d]	3 731[d]	12.0[d]	4 035[d]	4 194[d]	
Diet							
S	4 267 ±	974[a]	4 426[a]	14.1[a]	4 698[a]	4 875[a]	
H	4 304 ±	1 074[a]	4 400[a]	14.5[a]	4 694[a]	4 806[a]	
Lactation							
1st (96)*	3 495 ±	574[d]	3 673[d]	11.8[d]	3 859[d]	4 062[d]	
2nd (92)*	4 598 ±	944[ac]	4 745[e]	15.2[ae]	5 002[e]	5 167[e]	
3rd (79)*	4 883 ±	942[be]	4 925[e]	16.6[be]	5 357[f]	5 404[e]	
Mean	4 286 ±	1 024	4 413 ± 1 100	14.3	4 696 ± 1 034	4 840 ± 1 125	

* Cows that produced throughout the whole lactation period.

Significance of the differences and interactions were tested as in Table 2. [a, b, c]: $P = 0.05$; [d, e, f]: $P = 0.01$. No significant interactions were found.

523, Ay 472 and Fc 426 kg). The Friesian silage group was notably heavier than the hay group (547/500 kg). The corresponding weight difference was smaller for the Finncattle (436/415 kg). The live weights of the Ayrshire dietary groups were similar (473/472 kg). Average weight differences between the breeds and dietary groups remained quite stable throughout the whole lactation period (Fig. 4).

The milk yields of the Ayrshires in relation to live weight were somewhat higher each year compared to the other two breeds (Table 4). However, the difference was significant only in the first lactation for Finncattle when calculated per kg metabolic body weight. The differences became apparent after the results of three lactations had been combined. The 4 % FCM yield of the Ayrshires then differed significantly from that of the other two breeds and the regular milk from the yield of the Finncattle. The yields in relation to live weight of the Friesians and the Finncattle did not differ significantly from each other. The Friesian yields decreased due to the considerable heaviness of the silage group.

At the beginning of the lactations, during the 70-day period after calving, Ayrshire and Friesian yields in relation to their live weights approximated each other, averaging Fr 4.17, Ay 4.28 and Fc 3.95 kg/100 kg live weight/d and 198, 199 and 180 g/kg metabolic live weight/d, respectively.

The mean milk yield of the silage group per 100 kg live weight was significantly lower than that of the hay group, as the equal milk yield was divided by a higher live weight (Table 4). The difference was not significant per kilogram metabolic body weight, because weight dissimilarities were minor when measured as metabolic body weights. At the beginning of the lactations (70 days) the differences of the dietary groups were maximal (S 3.92 and H 4.46 kg milk/100 kg live weight/d); because also a clear difference in the total yields occurred.

The milk yield of the cows was not found to be dependent on live weight, when the results were examined within breeds. The correlations between live weights and yields during the three lactations were minor, and mainly negative. Apparently, the result merely indicated that the better cows utilized their fat stores more for production, thus losing weight, whereas the poorer ones accumulated new stores earlier. Production was thus determined by the inherited milk-producing ability.

Milk composition

Ayrshires and Finncattle had equal average milk fat contents (Table 5). This equality was seen throughout the entire lactation period (Fig. 5). The contents were repeatedly at the same level lactation after lactation. The milk fat content of the Friesians was significantly lower than that of the Ayrshires and the Finncattle. The lowest fat content was found in the Friesian hay group. Friesians showed somewhat less variation compared to the other breeds.

The fat contents were lowest 4—9 weeks after calving (Fig. 5). A distinct increase was observed after the tenth production week. The

Table 4. Mean daily yields of the cows per 100 kg liveweight and per kg metabolic body weight during the first three lactations.

	Cows	kg/100 kg lw/d		g/kg $W^{0.75}$/d	
	n	milk	4 % FCM	milk	4 % FCM
		$\bar{x}$ s.d.	$\bar{x}$	$\bar{x}$ s.d.	$\bar{x}$
Breed					
1st year	96				
Fr	40	2.59 ± 0.43^{a}	2.80^{a}	121 ± 19^{ab}	131^{dc}
Ay	40	2.73 ± 0.35^{a}	3.08^{a}	125 ± 15^{b}	141^{c}
Fc	16	2.49 ± 0.59^{a}	2.80^{a}	111 ± 25^{a}	125^{d}
2nd year	92				
Fr	38	2.97 ± 0.73^{a}	3.14^{a}	143 ± 33^{a}	151^{a}
Ay	38	3.20 ± 0.55^{a}	3.56^{a}	150 ± 25^{a}	167^{a}
Fc	16	2.92 ± 0.75^{a}	3.27^{a}	133 ± 32^{a}	149^{a}
3rd year	79				
Fr	30	3.17 ± 0.75^{a}	3.37^{a}	154 ± 35^{a}	164^{a}
Ay	34	3.33 ± 0.52^{a}	3.73^{a}	158 ± 23^{a}	177^{a}
Fc	15	3.07 ± 0.76^{a}	3.47^{a}	142 ± 32^{a}	160^{a}
Mean		2.95 ± 0.64	3.25 ± 0.67	138 ± 30	152 ± 31
Group					
Fr-S		2.74 ± 0.64^{a}	2.95^{a}	133 ± 30^{a}	143^{a}
Fr-H		3.08 ± 0.69^{ab}	3.24^{ab}	146 ± 33^{a}	154^{ab}
Ay-S		3.04 ± 0.58^{ab}	3.39^{b}	142 ± 27^{a}	158^{ab}
Ay-H		3.17 ± 0.50^{b}	3.55^{b}	148 ± 24^{a}	165^{b}
Fc-S		2.86 ± 0.68^{ab}	3.20^{ab}	131 ± 30^{a}	146^{ab}
Fc-H		2.82 ± 0.82^{ab}	3.17^{ab}	127 ± 35^{a}	143^{ab}
Breed					
Fr		2.91 ± 0.68^{ab}	3.09^{d}	139 ± 32^{dc}	148^{d}
Ay		3.11 ± 0.54^{b}	3.47^{bc}	145 ± 26^{c}	162^{c}
Fc		2.84 ± 0.74^{a}	3.18^{adc}	129 ± 32^{d}	145^{d}
Diet					
S		2.88 ± 0.63^{a}	3.17^{a}	136 ± 29^{a}	150^{a}
H		3.08 ± 0.65^{b}	3.36^{b}	144 ± 30^{a}	157^{a}

Significance of the differences and interactions tested as in Table 2. $^{a, b}$: P = 0.05, $^{d, c}$: P = 0.01. No significant interactions were found.

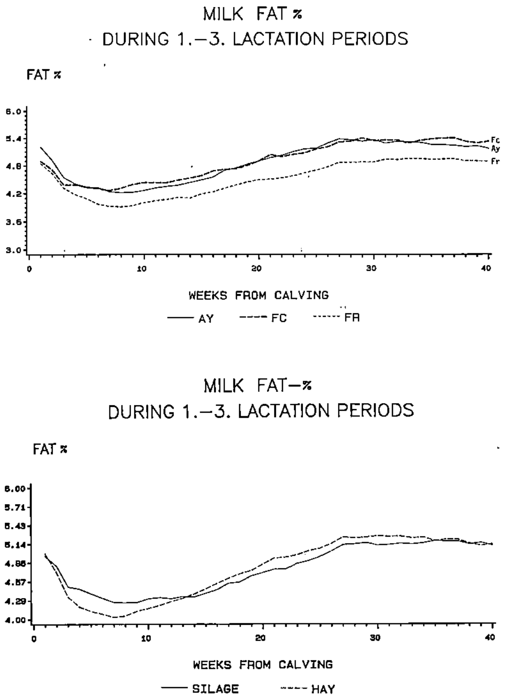

Fig. 5. Mean milk fat content of the breeds and dietary groups during the first three lactations.

mean fat contents of the dietary groups were inversely proportional to their milk yields at different stages of lactations (Figs. 3 and 5). For the whole lactation period, the fat content of the silage group was slightly higher than that of the hay group (Table 5). This difference was significant at the beginning of the lactation. The variation in fat content was quite similar in the different dietary groups and during different lactations.

The mean protein contents of the Ayrshires and the Finncattle over three lactations were on the same level, while those of the Friesians were significantly lower (Table 5). At the beginning of the lactation there was a significant difference only between Friesians and Finncattle. The protein content was high for all breeds after calving, but during the subsequent 3-week period it decreased by approximately one percentage unit (Fig. 6). It began to increase after the tenth production week, but the increase was less than that of the fat content.

Table 5. Mean milk fat and protein contents during the first three lactations.

	Fat %		Protein %	
	70 d $\bar{x}$	305 d $\bar{x}$ s.d.	70 d $\bar{x}$	305 d $\bar{x}$ s.d.
Group				
Fr-S	4.31^{b}	4.53 ± 0.41^{ab}	3.14^{a}	3.19 ± 0.28^{a}
Fr-H	4.00^{a}	4.34 ± 0.30^{a}	3.09^{a}	3.19 ± 0.19^{a}
Ay-S	4.53^{b}	4.78 ± 0.43^{c}	3.20^{a}	3.26 ± 0.18^{ab}
Ay-H	4.37^{b}	4.79 ± 0.47^{c}	3.15^{a}	3.30 ± 0.21^{ab}
Fc-S	4.46^{b}	4.79 ± 0.42^{bc}	3.24^{b}	3.27 ± 0.21^{ab}
Fc-H	4.42^{b}	4.84 ± 0.57^{c}	3.20^{a}	3.36 ± 0.25^{b}
Breed				
Fr	4.15^{d}	4.43 ± 0.37^{d}	3.12^{d}	3.19 ± 0.24^{ad}
Ay	4.44^{e}	4.79 ± 0.45^{e}	3.17^{de}	3.28 ± 0.20^{b}
Fc	4.44^{e}	4.81 ± 0.49^{e}	3.22^{e}	3.31 ± 0.24^{be}
Diet				
S	4.42^{b}	4.67 ± 0.44^{a}	3.18^{a}	3.23 ± 0.23^{a}
H	4.22^{a}	4.60 ± 0.49^{a}	3.13^{a}	3.26 ± 0.22^{a}
Lactation				
1st (96)	4.29^{ab}	4.70 ± 0.46^{a}	3.09^{d}	3.15 ± 0.21^{d}
2nd (92)	4.25^{a}	4.59 ± 0.45^{a}	3.19^{e}	3.30 ± 0.22^{e}
3rd (79)	4.42^{b}	4.65 ± 0.48^{a}	3.18^{e}	3.27 ± 0.22^{e}
Mean	4.32 ± 0.45	4.64 ± 0.46	3.16 ± 0.21	3.25 ± 0.23

Significance of the differences and interactions tested as in Table 2. $^{a, b, c}$: P = 0.05; $^{d, e}$: P = 0.01. No significant interactions were found.

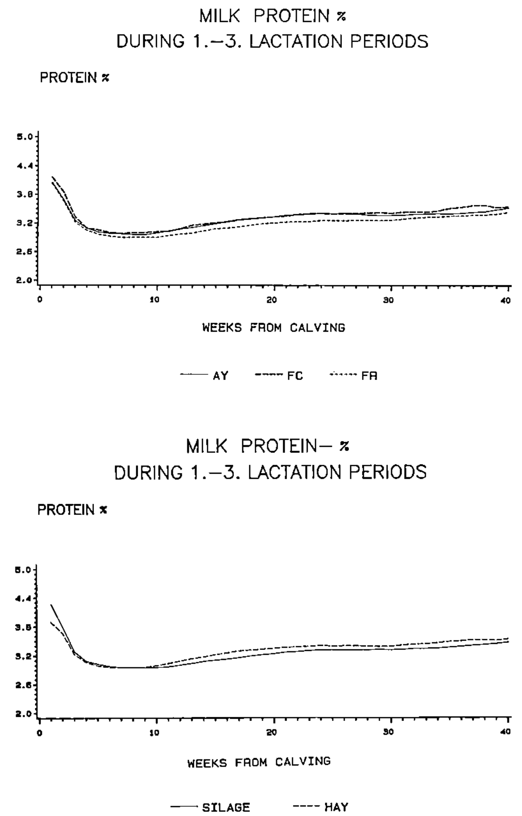

Fig. 6. Mean milk protein content of the breeds and dietary groups during the first three lactations.

The difference in the protein content of milk produced on the different diets was slight, but it remained a little higher on the hay diet after the first ten production weeks, extending through the whole lactation period (Fig. 6). During the first lactation, the milk protein content was significantly lower than in the subsequent lactations.

The variation in protein contents was much less compared to that in fat content. It was somewhat less among the Ayrshires compared to the other breeds. The variation in protein content for the different dietary groups and different lactations was quite similar.

The composition of morning and evening milk was determined separately. The normal interval between evening and morning milking was 15.5 hours, that between morning and evening milking 8.5 hours. The relation was 1.82. Morning and evening milk yields followed the same relation, being 1.81 during the first and second lactations and 1.88 during the third lactation. Even small differences in the yield of the groups were notable in both morning and evening yields.

The fat content of evening milk was 1.37 times higher, on average, than that of morning milk (5.68 % and 4.14 %). The lower fat content of Friesians compared to that of the others was apparent at both milkings, but the superiority of Ayrshires and Finncattle alternated in the morning and evening milk. The average protein content of evening milk was 1.03 times higher compared to morning milk (3.31 % and 3.21 %, respectively).

Table 6. Mean fat and protein yields of the cows during the first three lactations.

	kg/cow/year				
	Fat			Protein	
	305 d $\bar{x}$	s.d.	lactation $\bar{x}$	305 d $\bar{x}$ s.d.	lactation $\bar{x}$
Group					
Fr-S	200 ± 45[b]		206[b]	140 ± 32[bc]	145[b]
Fr-H	200 ± 47[b]		204[b]	147 ± 37[c]	150[b]
Ay-S	207 ± 38[b]		214[b]	141 ± 29[bc]	147[b]
Ay-H	211 ± 35[b]		216[b]	145 ± 30[bc]	149[b]
Fc-S	182 ± 44[ab]		192[ab]	125 ± 28[ab]	131[ab]
Fc-H	163 ± 38[a]		168[a]	113 ± 25[a]	117[a]
Breed					
Fr	200 ± 46[e]		205[e]	144 ± 35[e]	148[e]
Ay	209 ± 36[e]		215[e]	143 ± 30[e]	148[e]
Fc	173 ± 42[d]		180[d]	119 ± 27[d]	124[d]
Diet					
S	199 ± 43[a]		207[a]	138 ± 31[a]	144[a]
H	198 ± 44[a]		203[a]	140 ± 34[a]	144[a]
Lactation					
1st (96)	164 ± 26[d]		173[d]	110 ± 16[d]	117[d]
2nd (92)	211 ± 38[e]		218[e]	152 ± 27[ae]	157[e]
3rd (79)	227 ± 37[f]		229[e]	160 ± 28[be]	161[e]
Mean	199 ± 43		205	139 ± 32	144

Significance of the differences and interactions tested as in Table 2. [a, b, c]: P = 0.05; [d, e]: P = 0.01. No significant interactions were found.

Fat and protein yields

The mean fat yield of three lactations was the highest among Ayrshires, but it did not differ significantly from the fat yield of Friesians (Table 6). The fat yield of Finncattle was significantly lower. The mean fat yields of the different dietary groups were nearly identical. Among Friesians they were exactly the same. The Ayrshires produced slightly more fat on the hay diet and the Finncattle considerably more on the silage diet. Fat yields increased significantly at each lactation.

The average protein yield of three lactations was similar for Friesians and Ayrshires, while that of Finncattle was significantly lower (Table 6). The protein yields obtained through different diets were equal on average, as Friesians and Ayrshires produced more on the hay diet, Finncattle on the silage diet. The protein yield of the first lactation was notably lower compared with subsequent lactations, as both milk yield and milk protein content were low then.

Fat and protein yields maintained a very close correlation with milk yield, $+0.86^{***}$ and $+0.94^{***}$ when the results were calculated on the basis of the average yields of three lactations of all cows. The correlation between milk yield and fat content was -0.48^{***} and that between milk yield and protein content -0.53^{***}. When examined by breed, it appeared that a low milk yield in Ayrshires was often associated with a high fat content, in the other breeds with a high protein content. Fat and protein contents did not have a positive effect on fat and protein yields ($r = +0.02$, $r = -0.23^{*}$). The correlation coefficient between fat and protein contents was $+0.65^{***}$, while that for fat and protein yields was $+0.90^{***}$.

DISCUSSION

The representative sample of experimental cows displayed the same breed differences in milk-producing ability as the entire cow population of the recorder herds. The average annual yield of the Friesians in the experiment was 142 kg higher and the 4 % FCM yield 81 kg lower than that of the Ayrshires, while the respective differences for the recorder cows during the same years were 79 kg and 143 kg, respectively (ANON. 1983, 1984, 1985). The average yield of Finncattle was less than that of Friesians, being 908 kg for the experimental cows and 896 kg for the recorder herds, that for Ayrshires 766 kg and 817 kg, respectively. The breed differences of the experimental cows corresponded well with the recorder results also over a longer period (TURKKI 1986 a). The reliability of the small sample improved by the uniformity of the environmental factors, i.e. uniform feeding under the same conditions throughout the year as well as equal calving age and calving times.

Inversely, the milk yield of the experimental cows was lower than that of the recorder cows. The average annual yield of three lactations of the experimental cows was 4 413 kg milk; that for the recorder cows was 5 678 kg. This difference was to be expected, as the randomly sampled animal material included also poor producers that were not removed from the experiment, as the aim was to study the development, endurance and economic result of poor producers, too. The animal material in recorder herds, on the other hand, is chosen from the best possible parents, and weak producers are eliminated already during the first lactation year. Low yield has proved to be the main reason for eliminations during the first lactation (KUOSMANEN 1983). There were differences also in the diets of the experimental and recorder cows. Silage-based feeding is common in Finland, but commercial supplements rich in protein are often fed along with silage and cereal (TURKKI 1986 b). In practice, hay-urea-cereal feeding is rare.

The average yield of the experimental cows decreased due to the low yield of the first lactation. At that time the cows also got thinner. It is apparent that during the first lactation more easily digestible energy would have been needed for growth, because roughage intake was remarkably lower than during subsequent lactations (ETTALA and VIRTANEN 1990 b). For the next generations this was corrected by giving a kilogram of cereal per day to enhance growth. This normalized the condition of cows during the first lactation.

Variation was wide in all breeds. For Friesians it was wider than for the other two breeds, starting from the second lactation when good producers were able to increase their yield much more than poor producers. The wide variation among Friesian cows could have been due to the fact that in recent years Friesian material imported from Sweden and Denmark had absorbed genotype from native breeds, chiefly that of Finncattle. About one-third of the experimental Friesian cows were R^3 generation individuals. The proportion of these was, however, quite similar in groups above and below average.

The milk fat content was similar for Ayrshires and Finncattle, while that of Friesians was about 0.3—0.4 percentage units lower both in the experimental and recorder herds. Inversely, the fat content was notably higher in the experimental cows (mean 4.64 %) than in the recorder cows (mean 4.38 %). The difference cannot be explained solely by the lower yields of the experimental cows, as the fat content was high also in the above average cows of the breeds (over 4.5 %). The home-grown, roughage-based diet may have been a reason for the high fat content. The roughage-concentrate ratio (FU/FU) during three lactations on the silage diet was 59:41, on average, on the hay diet 51:49 (ETTALA and VIRTANEN 1990 b). On the silage diet the fat content was somewhat higher than on the hay diet.

The milk protein content of the experimental cows during the second and third lactations was similar (3.30 % and 3.27 %, respectively) to that of the recorder herds during corresponding years (3.32 % and 3.27 %, respectively) (ANON. 1985), whereas during the first lactation the milk protein content of the experimental cows was low (3.15 %). This might have been partly due to the low energy supply at that time. In earlier experiments with silage-based feeding and in grazing experiments, it was found that energy, mainly a cereal supplement, raised the protein content of milk (ETTALA 1976, ETTALA et al. 1986). Similar results were obtained in Sweden when a large body of experimental material (SPÖRNDLY 1986) was analyzed, as well as in many other experiments (EMERY 1978).

Finnish Ayrshires have been quite successful in international breed comparisons. In an FAO-organized comparison of eight Red and Red-and- White breeds in Bulgaria, the F 1 offspring of Finnish Ay bulls were placed fourth during the first lactation, during the second lactation they were placed third and during the reporting stage those that had calved three times or more were placed first (HINKOVSKI et al. 1985, 1988). The differences between the higher yielding cross-breeds were not statistically significant. Milk fat contents were low in all groups and the differences were small. In Denmark, the yield of the purebred Finnish Ayrshire was better than the yields of Danish Friesian and Red Danish, but only the difference in fat yield between the Finnish Ayrshire and the Red Danish was significant (CHRISTENSEN et al. 1984). In Canada, the offspring of Canadian Ay bulls produced more milk, fat and protein than the offspring of Finnish Ay bulls, but the differences were not significant (LEE et al. 1982). In Polish crossbreeding experiments, Finnish Ay bulls did not increase the F 1 generation's milk yield as much as did the Holstein-Friesian bulls of the USA, regardless of whether the experiment was performed on Red and White cattle or on Black and White cattle, but the fat content of Ay crossbreeds was higher (PASIERBSKI et al. 1982, ZIEMINSKI and JUSZCZAK 1986).

Friesian strains of Sweden and Denmark, the parent countries of the Finnish Friesian breed, were included in a comparison of ten Friesian strains in Poland organized by the FAO (JASIOROWSKI et al. 1987). Swedish Friesians were also included in a comparison of the five best strains with selected high-yielding animal material and with intensive feeding conducted in Israel (BAR ANAN et al. 1987). In all of the experiments, the crossbred offspring of Swedish and Danish bulls were inferior to the Holstein-type Friesian strains (USA, Canada, Israel) in milk yield, but their milk fat and protein contents were higher (BAR ANAN et al. 1987, JASIOROWSKI et al. 1983, JASIOROWSKI et al. 1987, JASIOROWSKI et al. 1988). The differences were not always statistically significant. The Holstein-Friesian strain has been imported to Finland from North America only during the last decade, and therefore it had not yet influenced the experimental cows.

No statistically significant interactions in the production abilities were found between breeds and diets, though a significant interaction was observed in the intake of roughages and in the amounts of energy and protein supplied from them (ETTALA and VIRTANEN 1990 b). The abundant silage intake of Friesians increased the weight of the cows, and a high live weight, on the other hand, decreased the yield calculated per live weight.

The mean 4 % FCM yields during three lactations were similar on silage and hay-based diets (4 698 and 4 694 kg/cow/yr, respectively). However, the calculated energy supply was significantly lower on silage-based feeding than on hay-based diets (9.69 and 10.35 FU/cow/d, respectively) (ETTALA and VIRTANEN 1990 b). The result is in agreement with the results of studies in which better production results were obtained with a good quality silage than with hay (BERTILSSON and BURSTEDT 1983 a, b, EKERN and VIK-MO 1979, KERR and BROWN 1962, PRESTHEGGE 1959, STONE et al. 1960).

One of the aims of the present study was to establish the production abilities on home-grown diets. The highest daily peak yield was 35.2 kg on the silage-cereal diet and 38.0 kg on the hay-urea-cereal diet. The best average yields during the first 10 weeks on the silage-based diet were nearly 30 kg per day and on the hay-based diet over 30 kg per day. The highest annual yields (305 days) obtained by the silage-cereal diet were: Fr 7 508, Ay 7 103 and Fc 6 350 kg 4 % FCM, on the hay-urea-cereal diet 7 764, 6 354 and 5 442 kg, respectively. During the whole lactation (351 and 396 days, respectively) the best Friesian cows exceeded a 8 000 kg annual yield on both diets.

The results are difficult to compare with those of the silage-based feeding experiments of other countries, as their concentrates usually contain protein supplements. In our own short-term, 2—3 month experiments, carried out with silage, cereal and a small hay supplement, the best cows attained average daily yields of about 30 kg (ETTALA et al. 1978, ETTALA et al. 1982). A corresponding diet was used also in practical conditions at the North Savo research station during 1969—1978. The mean yield of the herd (34 cows) was slightly over 5 500 kg and the best cows produced 6 700—7 000 kg per year (ETTALA 1978).

In the long-term urea experiments of A.I. VIRTANEN (1967) the best individuals exceeded a 6 000 kg annual yield, although the basic diet was very poor in protein, and urea replaced 36—74 % of the digestible crude protein supply (ETTALA and KREULA 1976). In an 18-month experiment on urea-concentrate feeding with high-yielding cows (28), HOLTER et al. (1968)

obtained an annual yield of 8 028 kg, on average, which was equal to the yield of a group fed only with a plant protein supplement. ERB et al. (1976), using urea as the supplementary protein source (1.8 % in concentrate DM) during four lactations, reached an average of 6 968 kg 4 % FCM, which was 97 % of that obtained with a soya supplement. Also in the experiment of WOHLT and CLARK (1978), the urea group exceeded a 6 000 kg average annual yield. Hence, good results have been obtained with urea as a protein supplement in long-term experiments.

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SELOSTUS

Suomalaisen ayrshiren, friisiläisen ja suomenkarjan vertailu säilörehu-vilja- ja heinä-urea-viljaruokinnalla

3. Lehmien tuotanto kolmena ensimmäisenä lypsykautena

ELSI ETTALA ja ERKKI VIRTANEN

Maatalouden tutkimuskeskus

Suomalaisia lypsykarjarotuja, ayrshireä (40 ay), friisiläistä (40 fr) ja suomenkarjaa (16 sk) vertailevan tutkimuksen tuotantotulokset esitetään kolmelta ensimmäiseltä lypsykaudelta. Puolet joka rodusta (sr) sai vapaasti tuoretta, kelasilputtua, hyvälaatuista nurmisäilörehua, kilon päivässä heinää ja ohra-kauraseosta 0,24—0,30 ry/kg 4 %-maitoa. Puolet (hr) sai vapaasti heinää ja ureapitoista (2 %) ohra-kauraseosta 0,32—0,38 ry/kg 4 %-maitoa.

Yksilölliset tuotoserot olivat joka rodulla suuria, koska eläinaines otettiin satunnaisotannalla eikä eläimiä karsittu heikon tuotannon vuoksi. Sellaisia lehmiä, jotka heruivat 30 kg:aan tai yli sen, oli toisena lypsykautena 18,9 % ja kolmantena 25,3 % lehmistä. Toisen lypsykauden (305 vrk) maitomäärä oli 31,6 % korkeampi kuin ensimmäisen. Toisen ja kolmannen lypsykauden välillä nousu oli 6,2 %.

Friisiläiset tuottivat maitoa vähän enemmän (3,3 %) ja 4 %-maitoa vähemmän (1,7 %) kuin ayrshiret. Suomenkarjan tuotos oli niitä merkitsevästi pienempi, ero friisiläisiin oli 20,2 % ja ayrshireen 17,6 % tavallisena maitona ja vastaavasti 15,9 % ja 17,3 % 4-prosenttisena. Erot suomenkar-

jaan pienenivät, kun tuotokset laskettiin suhteessa elopainoihin (fr 523, ay 472 ja sk 426 kg). Ayrshirellä kolmen lypsykauden keskituotos 100 elopainokiloa kohti laskettuna oli merkitsevästi parempi kuin suomenkarjalla (ay 3,11, fr 2,91 ja sk 2,84 kg/vrk) ja 4-prosenttinen maitomäärä erosi merkitsevästi molemmista muista (ay 3,47, fr 3,09 ja sk 3,18 kg). Maidon rasvapitoisuus oli ayrshirellä ja suomenkarjalla yhtä korkea ja merkitsevästi alempi friisiläisillä (ay 4,79, sk 4,81 ja fr 4,43 %), samoin maidon valkuaispitoisuus (ay 3,28, sk 3,31 ja fr 3,19 %).

Keskimääräiset vuosituotokset kolmen ensimmäisen lypsykauden ajalta olivat säilörehu- ja heinävaltaisella ruokinnalla yhtä suuria (4 698 ja 4 694 kg/305 vrk 4 %-maitoa). Suhteessa elopainoon säilörehuryhmän keskituotos oli pienempi kuin heinäryhmän; 100 elopainokiloa kohti laskettaessa merkitsevästi (sr 3,17 ja hr 3,36 kg/vrk 4 %-maitoa), koska säilörehuryhmä oli painavampi. Erot maidon koostumuksessa olivat ruokintaryhmien välillä pieniä (rasvaa sr 4,67 ja hr 4,60 %, valkuaista 3,23 ja 3,26 %).

ANNALES AGRICULTURAE FENNIAE, VOL. 29: 319—342 (1990)

Seria ANIMALIA DOMESTICA N. 95 — Sarja KOTIELÄIMET n:o 95

COMPARISON OF FINNISH AYRSHIRE, FRIESIAN AND FINNCATTLE ON GRASS SILAGE-CEREAL AND HAY-UREA-CEREAL DIETS

4. Energy and protein balances, and feed utilization during the first three production years

ELSI ETTALA and ERKKI VIRTANEN

ETTALA, E. & VIRTANEN, E. 1990. **Comparison of Finnish Ayrshire, Friesian and Finncattle on grass silage-cereal and hay-urea-cereal diets.** Ann. Agric. Fenn. 29: 319—342. (Agric. Res. Centre, North Savo Res. Sta., SF-71750 Maaninka, Finland.)

Feed utilization of Finnish Ayrshire (40 Ay), Friesian (40 Fr) and Finncattle (16 Fc) was investigated using silage and hay diets during the first three production years. Half of the cows in each breed (S) were fed *ad libitum* fresh grass silage preserved with formic acid, one kilogram hay per day and a barley-oats concentrate 0.24—0.30 FU/kg 4 % fat corrected milk (FCM). The other half (H) was fed *ad libitum* hay and a urea (2 %) barley-oats concentrate 0.32—0.38 FU/kg 4 % FCM.

The energy utilization of the breeds per kg 4 % FCM was equal when the calculations according to the standards took into account the amount of energy caused by the differences in maintenance and changes in weight of the breeds. In contrast, if feed efficiency was evaluated only according to the relationship between the energy supplied from feeds and milk yields, the feed efficiency of Ayrshires was superior to that of the other breeds, and was statistically significantly better than that of Friesians during the lactations (Ay 0.62, Fr 0.65 and Fc 0.64).

The energy supply was below the standard requirement during the first lactation. The mean deficit was about one feed unit per first-lactation heifer per day. At that time, energy utilization was only 0.32 FU/kg 4 % FCM when other energy requirements were calculated in accordance with the standards. During the second and third lactations, the energy supply corresponded to the standard requirement; the energy utilization then averaged 0.39 FU/kg 4 % FCM. Both calculations took into account the amount of energy released and required in changes of body weight. An energy deficit at the beginning of the lactations caused body weights to decrease over a ten-week period, afterwhich body weights began to rise.

The calculations showed that energy utilization was significantly better for the silage than for the hay diet; averaging S 0.37 FU and H 0.41 FU/kg 4 % FCM during the second and third lactations. This difference was apparent in all breeds. Therefore it was concluded that the silage diet had a higher energy content than indicated by the analytical methods and feed value calculations employed.

The supply of digestible crude protein (DCP) at the start of the lactations remained below the level of the standard for about 10 weeks on average. Then, the mean DCP was 52 g/kg 4 % FCM when other requirements were calculated in accordance with the standards. The protein balances were positive with both diets throughout the course of the lactations (S 62 and H 61 DCP g/kg 4 % FCM). During dry periods, the DCP-intake considerably exceeded the standard requirement. The positive protein balances of the cows were reflected in their growth. The mean weights during the first, second and third production years were 460, 508 and 528 kg, respectively.

Index words: dairy cows, dairy breeds, grass silage feeding, hay feeding, urea feeding, home-grown feedstuffs, feed utilization.

INTRODUCTION

The comparison of Finland's dairy cattle breeds, Ayrshire, Friesian and Finncattle, employing two diets, has been described earlier in three publications (ETTALA and VIRTANEN 1990 a, b, c). The first presented the experimental background and design as well as the results for the cows at 4—24 months of age. The second dealt with the intakes and nutrient supply of the cows, and the third gave the production results from the first three production years. In the present paper, the results for nutrient supply and production have been combined by examining the cows' energy and protein balances in addition to feed utilization.

There are very few reports describing the feed efficiency of different breeds. In the present experiment such a clarification was possible, because the intake of feeds and the production results were individually weighed daily, feeds and milk analysed regularly and the cows weighed every month. The investigation was possible to carry out on both main roughages, silage and hay diets.

The diets included in the breed experiment could thus simultaneously serve as the topics of comparison. Both diets consisted of home-grown feeds; the commercial feeds consisted only of mineral and vitamin concentrates and fertilizer urea. The objective was to clarify the long-term effects of home-grown feeds. The main protein source of the silage-cereal diet was good-quality, protein-rich silage. Urea served as the supplemental protein source in the hay-cereal diet. Calculating the energy and protein balances for the cows at different ages and production stages enabled critical evaluation of the possibilities of the home-grown diets. The results have earlier been presented in detail, in Finnish (ETTALA and VIRTANEN 1986).

MATERIAL AND METHODS

The experimental animals were randomly sampled as small calves. At the beginning of the production experiment, the sample included 40 Friesians (Fr), 40 Ayrshires (Ay) and 16 Finncattle (Fc) cows. Half of the cows of each breed were fed a silage diet (S) and the other half a hay diet (H). The cows on the silage diet were fed *ad libitum* fresh high-protein (mean CP 17.3 %/DM) grass silage, flail-harvested at ear emergence and preserved with formic acid (4 l/tn), one kilogram hay per day and a barley-oats concentrate (2 : 1) 0.24—0.30 FU/kg 4 % FCM. The cows on the hay diet received *ad libitum* hay harvested before flowering (mean CP 11.3 %/DM) and a urea (2 %) barley-oats concentrate 0.32—0.38 FU/kg 4 % FCM. The objective of both diets was to reach the most uniform calculated amounts of energy and protein per product unit.

Feeds, residues and milk yields were individually weighed daily. The method employed for feed sampling and analysis has been presented in our previous paper (ETTALA and VIRTANEN 1990 a). Milk composition was analysed once a week (ETTALA and VIRTANEN 1990 c). The digestibility of organic matter in hay and silage was determined by the *in vitro* method of MENKE (MENKE et al. 1979, ETTALA 1984). The relationship between the digestibilities of organic matter and its different components were calculated for silage according to the results of a digestibility experiment on wethers (133) (KOSSILA et al. 1979) and according to table values for hay (SALO et al. 1982). Cereal digestibilities were obtained from the corresponding tables. A digestibility of 70 % was used for urea (N 46.3 %) based on earlier digestibility experiments on dairy cows (KREULA and ETTALA 1977).

The volatile fatty acids, evaporated during oven-drying, were added to the silage dry matter content; all of the propionic and butyric acid and 80 % of acetic acid (JARL and HELLEDAY 1948, NORDFELDT 1955). The net energy value of the feeds was calculated as feed units (FU = 0.7 kg starch equivalent) (SALO et al. 1982). Fibre correction was used for hay and the value number of 80 for silage when calculating the energy values (LAMPILA et al. 1988).

The cows were weighed on the sixth day after calving and thereafter at four-week intervals on two successive days the mean of which was used. The liveweights of the cows were interpolated between two weighings, resulting in a daily loss or a daily gain in weight.

The nutrient requirement of the cows was calculated according to the standards used in Finland (SALO et al. 1982). Milk production was calculated as 0.40 FU/kg 4 % FCM. A 4 % FCM conversion was calculated according to the formula (0.15 × fat % + 0.4) × milk yield. The formula (liveweight$^{0.75}$/500$^{0.75}$) × 4.0 FU was used to determine the energy needed for maintenance. One kilogram weight gain was calculated to need 2.5 FU and the same amount of energy was calculated to be used for milk production during weight loss. During the seventh, eighth and ninth gestation months 0.8, 1.4 and 2.2 FU/day were needed for pregnancy, respectively. The need for digestible crude protein was 60 g/kg 4 % FCM and 75 g/maintenance feed unit and 120 g/pregnancy feed unit.

The data were analysed in the same way as described in the previous papers (ETTALA and VIRTANEN 1990 b, c).

RESULTS

Changes in liveweights

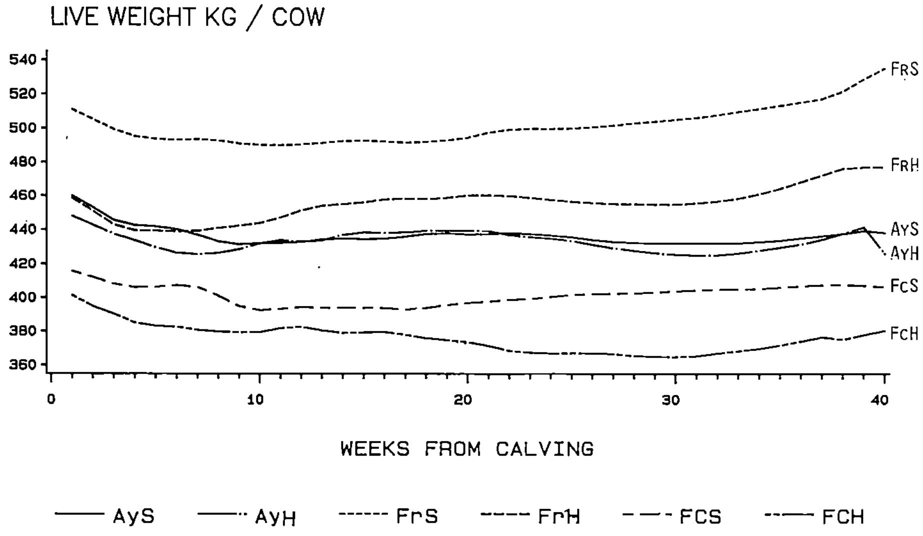
The mean weight of all cows was 460 kg during the first production year, 508 kg during the second year and 528 kg during the third year (ETTALA and VIRTANEN 1990 b). The respective mean weights during the lactations were 447, 496 and 517 kg. Thus the cows' weight increased each year.

At the start of the lactations, a loss of weight occurred over a ten-week period (Fig. 1). When weight loss was calculated according to the

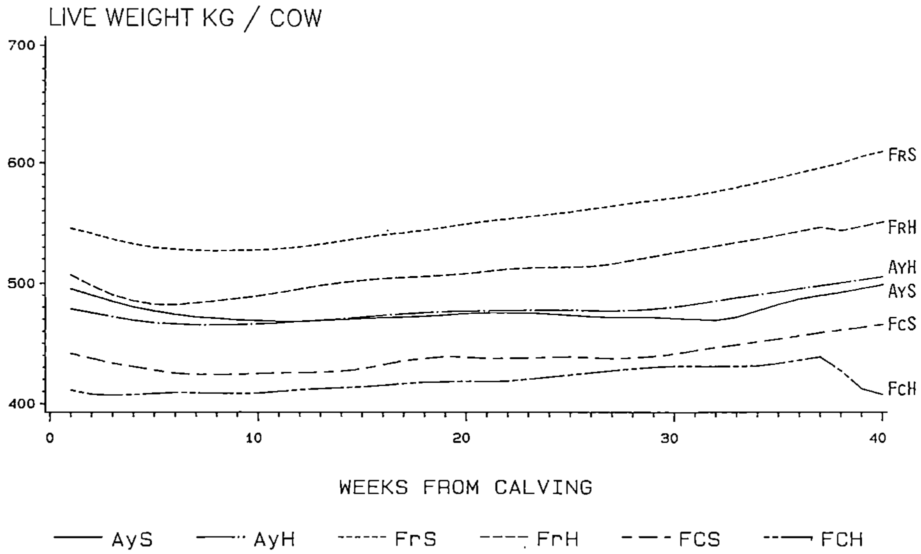
Table 1. Loss in liveweight of the cows during the weeks after calving, first-third lactations.

	First lactation			Second lactation			Third lactation		
	Calving weight kg	Weight loss		Calving weight kg	Weight loss		Calving weight kg	Weight loss	
		kg	%		kg	%		kg	%
Group									
Fr-S	512	34	6.7	546	30	5.6	607	53	8.7
Fr-H	462	33	7.0	511	34	6.7	538	34	6.3
Ay-S	462	38	8.2	497	38	7.6	534	53	10.0
Ay-H	449	31	6.9	478	21	4.3	522	40	7.7
Fc-S	416	29	6.9	445	30	6.6	493	58	11.7
Fc-H	406	38	9.4	415	16	3.9	464	33	7.1
Mean	461	34	7.3	495	30	6.0	534	45	8.5

LIVE WEIGHTS DURING 1ST LACTATION PERIOD



LIVE WEIGHTS DURING 2ND LACTATION PERIOD



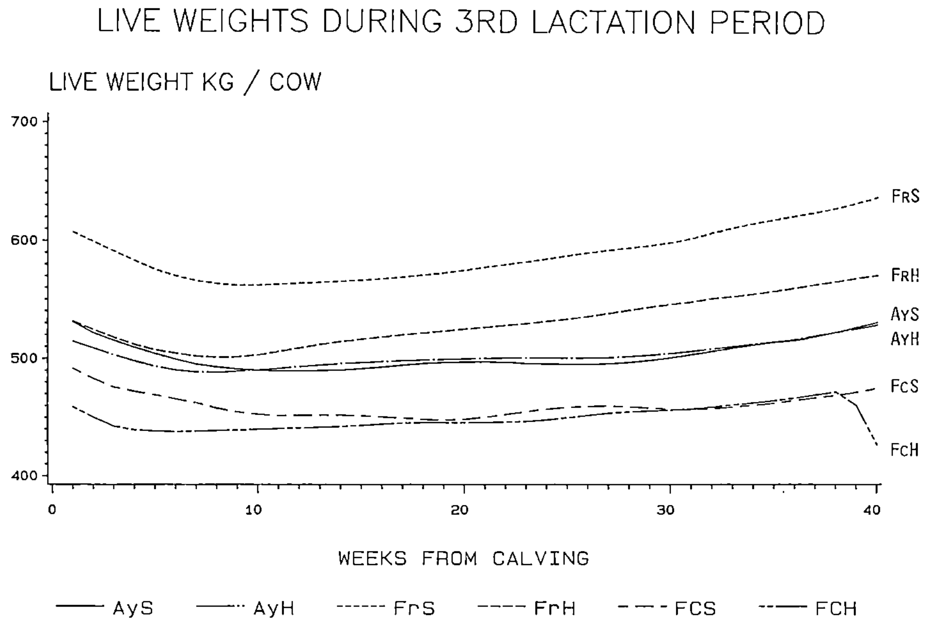
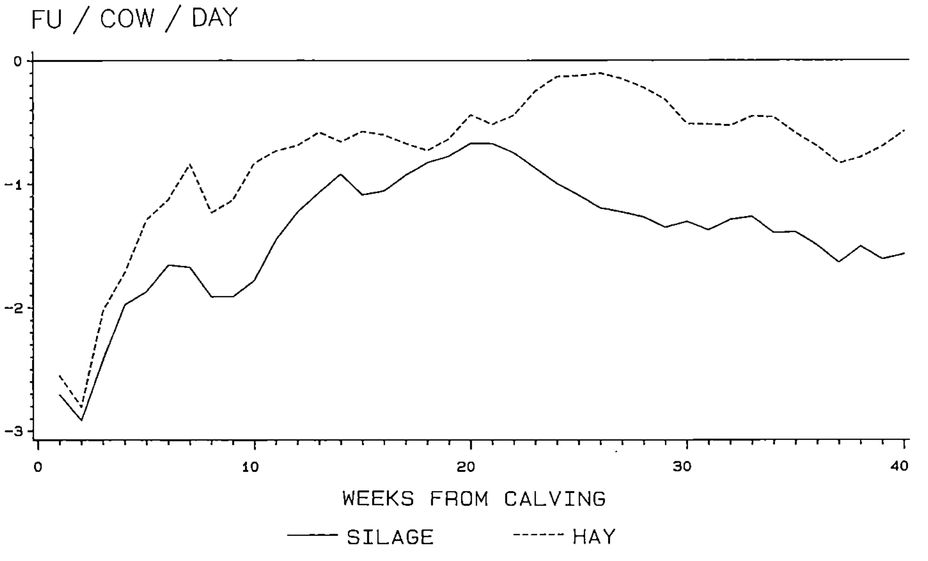


Fig. 1. Changes in liveweights of the experimental groups during the first, second and third lactations.

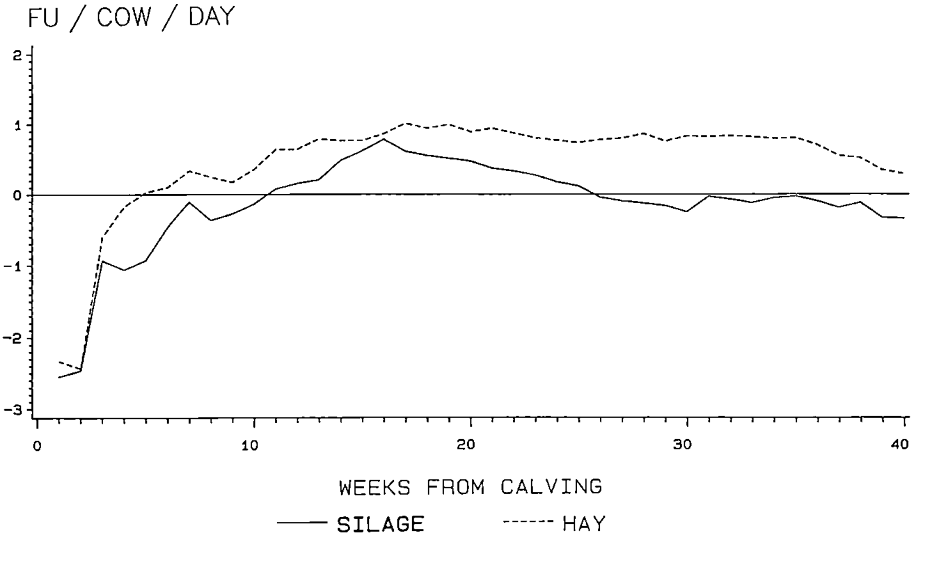
lowest weight of each cow, the greatest loss was during the third lactation (Table 1). However, the cows remained quite stout during the third lactation. Their condition was also good during the second lactation (KOMULAINEN 1986). In contrast, first-lactation heifers got thinner. The strong change among first-lactation heifers from a very heavy condition at calving time to thin general condition during the lactation was not, however, evident in the average loss of weight (7.3 %). Apparently, first-lactation heifers gained and lost weight simultaneously, and changes in weights were partly eliminated.

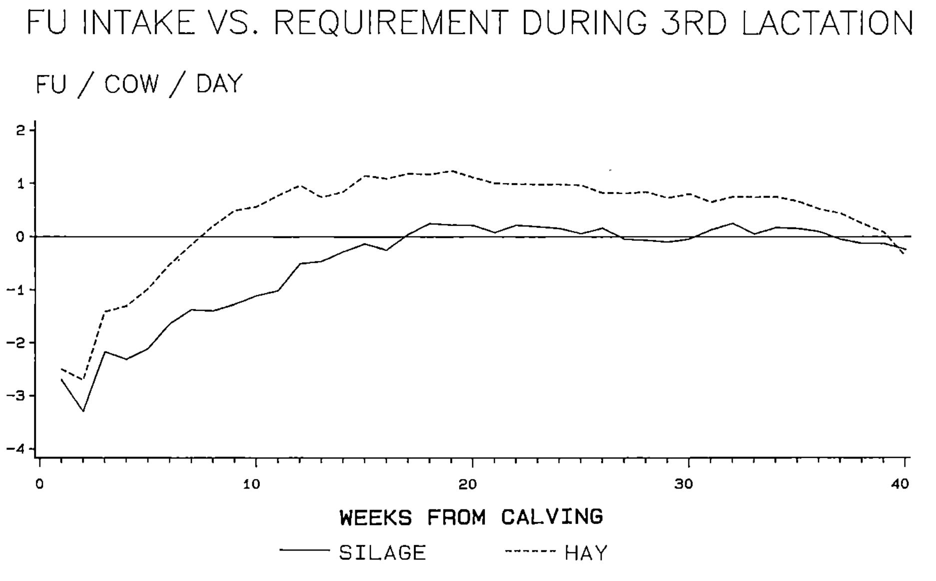
The weight development of the experimental groups recurred quite similarly from one year to the next (Fig. 1). The Friesians were the first to gain weight, at the latest ten weeks after calving. The Friesian silage group was both the heaviest and stoutest, but weight loss among this breed was below average. The weight of the Ayrshire groups rose very slightly during the lactations. They gained weight mainly during the dry periods. The weight of the silage-fed Ayrshire group rose more during the dry periods than did the weight of the hay-fed groups, but returned to the level of the hay-fed group every year during the first ten weeks. A slight weight gain was found also for Finncattle during the lactations. During the first lactation the weights of the hay-fed groups were lower after the middle part of the lactation, most clearly among the Finncattle. At that time, the animals were fed with hay from the rainy summer of 1981 (ETTALA and VIRTANEN 1990 b).

FU INTAKE VS. REQUIREMENT DURING 1ST LACTATION



FU INTAKE VS. REQUIREMENT DURING 2ND LACTATION





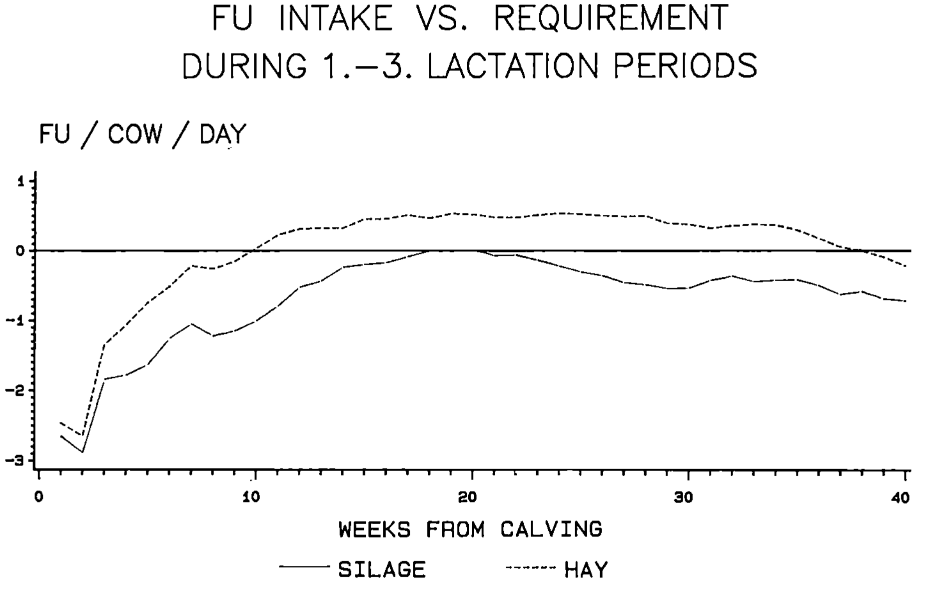


Fig. 2. Daily energy supply from feeds vs. the requirement (0-line) on silage and hay diets during the first, second and third lactation and the average for first-third lactations.

Energy balances at the start of the lactations

The amount of energy supplied by the feeds was below the requirement calculated according to the standards at the outset of all lactations (Fig. 2, Table 2). The energy deficit was greatest during the first lactation and least at the beginning of the second lactation. The highest energy deficit occurred during the first two weeks because the cereal ration could not be increased correspondingly with the rise in production, and roughage intake was still low (ETTALA and VIRTANEN 1990 b). When the amount of energy released from tissues was added to the energy supply from the feeds, the energy balance stabilized at the start of the second and third lactation (70 d), but was still negative at the start of the first lactation.

At the beginning of the lactations the energy deficit was significantly greater among cows on the silage diet than among cows on the hay diet. The greatest amount of energy supplied from feeds was below the standard requirement in the Ayrshire silage-fed group, but respectively the supply of energy from the body tissues was highest in that group (Table 2).

At the start of the lactations the average energy deficit of the different breeds was quite simi-

Table 2. Mean supply of energy per cow per day from feeds and the standard requirement as well as energy balance when the energy source was a) feeds exclusively, b) feeds and body stores in weight loss during the first-third lactations for the first 70-day period.

First-third lactation 70 days	FU/cow/day			
	Energy from feeds $\bar{x}$	Standard requirement $\bar{x}$	Supply-requirement	
			a) $\bar{x}$ s.d.	b) $\bar{x}$ s.d.
Group				
Fr-S	11.12^{af}	12.71^{e}	-1.59 ± 1.4^{de}	-0.60 ± 1.2^{de}
Ay-S	10.19^{e}	12.10^{e}	-1.92 ± 1.0^{d}	-0.69 ± 1.0^{d}
Fc-S	9.24^{d}	10.71^{d}	-1.46 ± 1.0^{df}	-0.46 ± 0.7^{de}
Fr-H	11.51^{f}	12.57^{e}	-1.05 ± 0.9^{efg}	-0.29 ± 0.9^{de}
Ay-H	11.65^{bf}	12.62^{e}	-0.97 ± 0.9^{fg}	-0.36 ± 0.9^{de}
Fc-H	9.85^{d}	10.65^{d}	-0.79 ± 0.9^{g}	-0.14 ± 0.7^{e}
Breed				
Fr	11.32^{be}	12.64^{e}	-1.32 ± 1.2^{a}	-0.44 ± 1.1^{a}
Ay	10.93^{ae}	12.37^{e}	-1.44 ± 1.1^{a}	-0.52 ± 0.9^{a}
Fc	9.54^{d}	10.68^{d}	-1.14 ± 1.0^{a}	-0.30 ± 0.7^{a}
Diet				
S	10.39^{h}	12.09^{a}	-1.70 ± 1.2^{h}	-0.61 ± 1.0^{h}
H	11.29^{i}	12.26^{a}	-0.98 ± 0.9^{i}	-0.29 ± 0.8^{i}
Lactation				
First yr (70 days)	8.63^{d}	10.51^{d}	-1.88 ± 0.8^{d}	-1.10 ± 0.7^{d}
Second yr (70 days)	11.84^{e}	12.52^{e}	-0.68 ± 0.9^{f}	-0.03 ± 0.7^{e}
Third yr (70 days)	12.36^{f}	13.80^{f}	-1.44 ± 1.3^{e}	-0.14 ± 1.0^{e}
Mean	10.84	12.18	−1.34	−0.45
Interaction				
Breed/diet	***	NS	NS	NS
Breed/year (70 days)	NS	NS	NS	NS
Diet/yr (70 days)	*	NS	NS	NS

The significances of differences between groups and years as well as their interaction effects were tested by two-way analysis of variance. The significances of differences between breeds, diets, years and their interaction effects were tested by three-way analysis of variance. Paired comparisons were tested by Tukey's test. The significance of differences were tested between diets at the 0.1 % and others at the 1 % level of risk. Figures for groups, breeds, diets or years in the same columns without the same superscript differ significantly from each other. $^{a, b}$: P = 0.05; $^{d, e, f, g}$: P = 0.01; $^{h, i}$: P = 0.001. NS, not significant; * P = 0.05; *** P = 0.001.

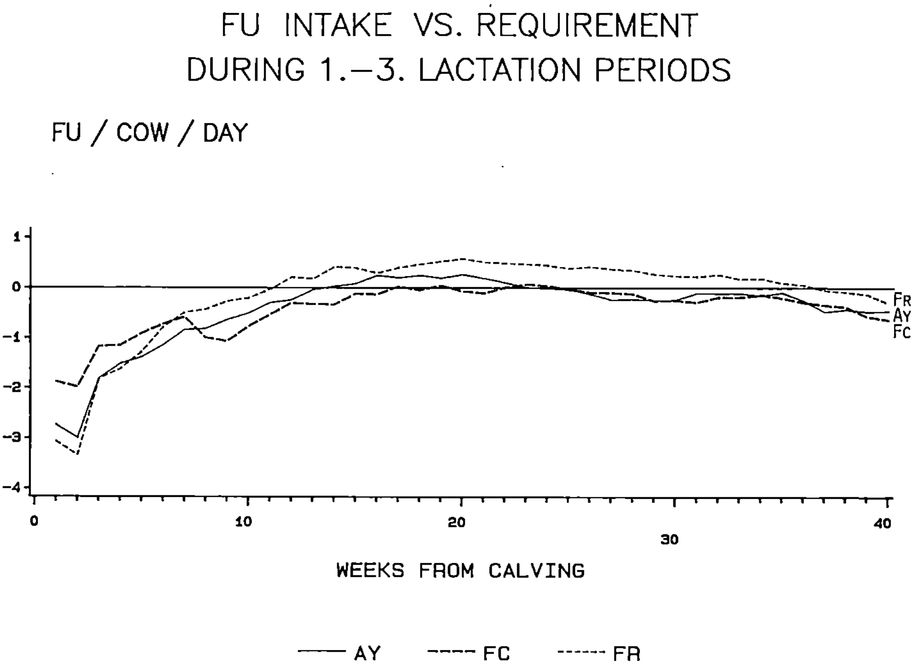


Fig. 3. Daily energy supply from feeds vs. requirement (0-line) of the different breeds during the first three lactations.

lar (Fig. 3, Table 2). In contrast, considerable differences were found between the individuals of each breed. Friesians had the widest range of variation and Finncattle the least. High-yielding cows generally had a substantial energy deficit when calculated by on the basis of the energy supply only from feeds. However, most of the high-yielding cows stored much energy during the dry periods, releasing it readily for milk production after calving. The animals with a considerable energy deficit also when the energy supplied from feeds and from the body tissues were calculated together were usually of the silage-fed groups which released body energy slowly.

Energy balances during the total lactations

The mean amount of energy supplied from the feeds during the three lactations was close to the requirement when calculated according to the standards (Table 3). A distinct difference in the energy balances of the different lactations was detected, however. During the first lactation the mean energy deficit was one feed unit per cow per day, and the standard level was not reached during any production stage (Fig. 2). The mean energy balance during the second lactation was slightly positive, and in the third it corresponded to the standard requirement.

There was a significant difference between the energy balances of the hay and silage diets

(Table 3). The energy supplied by the hay diets during the three lactations corresponded to the standard requirement on average, because the energy deficits during the first weeks and the first lactation were compensated by the surplus amounts of energy supplied later on during the second and third lactations (Fig. 2). In contrast, the mean energy balance was negative on the silage diet, and even at its best the supply corresponded mainly to the standard requirement.

Differences in energy balance on the silage and hay diets were observed in all breeds. The energy balance of the Friesian silage-fed group was less negative than that of the other breeds, owing to a high silage intake.

When the calculations included the amounts of energy caused by the changes in weight, the energy balances became more negative (Table 3). The gain in weight after the first weeks was in fact greater than the decrease in weight during the first weeks. However, the mean negative energy balance was caused by the negative energy balances of the first lactation and the silage diet. During the second and third lactation the energy balance of cows on the hay diet was even slightly positive (mean + 0.1 FU/cow/d), but it was still negative among cows on the silage diet (−0.57 FU/cow/d). However, the liveweights of the cows rose equally well on the silage diet as on the hay diet (Fig. 1), and the 4 % FCM yields were equal on both diets (ETTALA and VIRTANEN 1990 c).

Table 3. Mean supply of energy per cow per day from feeds and the standard requirement as well as energy balance when released or bound energy amounts caused by changes in liveweights a) have not, b) have been taken into account during the first-third lactations.

First-third lactations	FU/cow/day			
	Energy from feeds $\bar{x}$	Standard requirement $\bar{x}$	Supply-requirement a) $\bar{x}$ s.d.	Supply-requirement b) $\bar{x}$ s.d.
Group				
Fr-S	10.40[f]	10.84[e]	−0.44 ± 1.0[e]	−0.84 ± 0.9[d]
Ay-S	9.52[e]	10.35[e]	−0.83 ± 0.7[d]	−0.92 ± 0.6[d]
Fc-S	8.52[d]	9.28[d]	−0.77 ± 0.4[d]	−0.88 ± 0.4[d]
Fr-H	10.70[f]	10.59[e]	+ 0.11 ± 0.7[f]	−0.31 ± 0.6[e]
Ay-H	10.64[f]	10.64[e]	± 0.00 ± 0.6[f]	−0.22 ± 0.6[e]
Fc-H	8.82[d]	8.83[d]	−0.01 ± 0.6[f]	−0.14 ± 0.5[e]
Breed				
Fr	10.55[f]	10.71[e]	−0.16 ± 0.9[e]	−0.57 ± 0.8[a]
Ay	10.09[e]	10.49[e]	−0.41 ± 0.8[d]	−0.57 ± 0.7[a]
Fc	8.67[d]	9.06[d]	−0.40 ± 0.6[d]	−0.52 ± 0.6[a]
Diet				
S	9.69[g]	10.35[a]	−0.66 ± 0.8[g]	−0.88 ± 0.7[g]
H	10.35[h]	10.31[a]	+ 0.04 ± 0.7[h]	−0.24 ± 0.6[h]
Lactation				
First yr	7.97[d]	8.98[d]	−1.00 ± 0.5[d]	−1.15 ± 0.5[d]
Second yr	10.91[e]	10.72[e]	+ 0.20 ± 0.6[bc]	−0.22 ± 0.5[e]
Third yr	11.48[f]	11.53[f]	−0.04 ± 0.7[ac]	−0.23 ± 0.7[e]
Mean	10.03	10.33	−0.31	−0.56
Interaction				
Breed/diet	**	*	NS	NS
Breed/lactation	NS	NS	NS	*
Diet/lactation	NS	NS	NS	NS

The significances of the differences and interactions were tested as in Table 2. [a, b]: P = 0.05; [d, e, f]: P = 0.01; [g, h]: P = 0.001.

Energy balances during the dry periods and during all production years

During the dry periods the energy supplied from the feeds was greater in all of the groups than that needed for maintenance and pregnancy (Table 4). This surplus, or the energy used to maintain condition and for growth, was the highest among Ayrshires and the lowest among Finncattle. The difference was caused by the intake of the roughages, since all breeds had the same cereal ration. Energy supply calculated per day during the first dry period was lower than that during successive periods, but owing to the longer dry and prelactational period, the total energy intake exceeded that of the others at that time (519, 496 and 499 FU/cow/dry period). The cows remained adequately stout after the dry periods. Also the condition of the first-lactation heifers was good, and at the start of the second lactation, 87 % of the cows were either in average condition or fat (KOMULAINEN 1986).

The mean energy balance for the three production years studied (lactations + dry periods) was ±0 (Table 4). The same amount of energy had been supplied by the feeds per production year as that needed according to the standards for milk production, maintenance and pregnancy (Table 5). During the first production year, the energy balance was still negative, but in the other years it was correspondingly positive.

Table 4. Mean supply of energy per cow per day and the standard requirement as well as the difference between supply and requirement during dry periods and the entire first-third production years.

	FU/cow/day					
	Dry period			Entire production year		
	Energy from feeds	Standard requirement	Supply-requirement	Energy from feeds	Standard requirement	Supply-requirement
Group						
Fr-S	7.9^{f}	6.7^{h}	$+1.3^{de}$	10.0^{f}	10.2^{f}	-0.1^{e}
Ay-S	7.5^{ef}	6.2^{fg}	$+1.3^{de}$	9.1^{e}	9.6^{e}	-0.5^{d}
Fc-S	6.8^{d}	5.9^{e}	$+0.9^{d}$	8.3^{d}	8.8^{d}	-0.5^{d}
Fr-H	8.1^{f}	6.3^{g}	$+1.8^{ef}$	10.3^{f}	9.9^{ef}	$+0.4^{f}$
Ay-H	8.1^{f}	6.1^{f}	$+2.0^{f}$	10.2^{f}	9.9^{ef}	$+0.3^{f}$
Fc-H	7.1^{de}	5.6^{d}	$+1.5^{ef}$	8.5^{d}	8.3^{d}	$+0.3^{f}$
Breed						
Fr	8.0^{e}	6.5^{f}	$+1.5^{de}$	10.2^{f}	10.1^{f}	$+0.1^{e}$
Ay	7.8^{e}	6.1^{e}	$+1.7^{e}$	9.7^{e}	9.7^{e}	$\pm 0.0^{de}$
Fc	7.0^{d}	5.7^{d}	$+1.2^{d}$	8.4^{d}	8.5^{d}	-0.1^{d}
Diet						
S	7.6^{d}	6.3^{j}	$+1.2^{i}$	9.3^{i}	9.7^{a}	-0.3^{i}
H	7.9^{e}	6.1^{i}	$+1.8^{j}$	10.0^{j}	9.6^{a}	$+0.3^{j}$
Year						
First	7.3^{d}	5.9^{d}	$+1.3^{d}$	7.8^{d}	8.4^{d}	-0.6^{d}
Second	8.1^{e}	6.3^{e}	$+1.8^{e}$	10.5^{e}	10.0^{e}	$+0.4^{e}$
Third	7.9^{e}	6.4^{e}	$+1.5^{de}$	10.9^{e}	10.7^{f}	$+0.2^{e}$
Mean	7.74	6.20	+1.54	9.66	9.66	±0.00
Interaction						
Breed/diet	NS	**	NS	**	*	*
Breed/years	NS	NS	NS	NS	NS	NS
Diet/years	**	NS	**	NS	NS	NS

The significances of differences and interactions were tested as in Table 2. ^{d,e,f,g,h}: P = 0.01; ^{i,j}: P = 0.001.

The energy balance calculated for the silage group was also negative during the production years. In the hay group, it was positive to the same extent. The difference was seen in the energy balances of all the breeds. A negative energy balance and simultaneous increase in body weight is not possible, however. On the basis of the results, one may suspect that the silage was higher in energy than indicated by the analytical methods and calculations employed.

Protein balances

The supply of digestible crude protein (DCP) did not correspond to the standard requirement during the first weeks after calving (Table 6). At the start of the first lactation, 70 days after calving, the protein deficit with respect to the standard requirement averaged 15.2 % being 3.0 %, at the start of the second lactation and 16.1 % for the third. The deficit was greatest the second week after calving (Fig. 4), when production exceeded feed intake the most. During the first lactation, the protein deficit lasted longer on the hay diet than during successive lactations, because at that time the urea-cereal ration was increased in smaller daily amounts than in other years (ETTALA and VIRTANEN 1990 b). The protein supply of the silage group depended mainly on the amount of silage intake and its DCP content.

The mean protein deficits at the start of the lactations were on the same level for all breeds

Table 5. Mean supply of energy per cow per year from feeds and the standard requirement as well as the difference between supply and requirement during the first-third production years.

First-third production years	FU/cow/yr				
	Energy from feeds	Requirement			Supply-requirement
		For milk	Maintenance	Total[1]	
Group					
Fr-S	3 646^{e}	1 964^{e}	1 590^{f}	3 699^{f}	— 54^{e}
Ay-S	3 490^{e}	2 006^{e}	1 494^{ef}	3 655^{f}	—165^{d}
Fc-S	3 127^{d}	1 790de	1 388de	3 320de	—193^{d}
Fr-H	3 729^{e}	1 976^{e}	1 477^{ef}	3 593^{ef}	+ 136^{f}
Ay-H	3 713^{e}	2 016^{e}	1 418de	3 588^{ef}	+ 126^{f}
Fc-H	3 086^{d}	1 560^{d}	1 289^{d}	2 997^{d}	+ 89^{f}
Breed					
Fr	3 688^{e}	1 970^{e}	1 532^{e}	3 645^{e}	+ 43^{be}
Ay	3 604^{e}	2 011^{e}	1 455^{e}	3 621^{e}	— 17^{ade}
Fc	3 107^{d}	1 678^{d}	1 340^{d}	3 162^{d}	— 55^{d}
Diet					
S	3 486^{a}	1 950^{a}	1 513^{h}	3 612^{b}	—125^{g}
H	3 613^{a}	1 922^{a}	1 420^{g}	3 489^{a}	+ 124^{h}
Year					
First	3 006^{d}	1 625^{d}	1 434^{a}	3 214^{d}	—208^{d}
Second	3 866^{e}	2 067^{e}	1 494^{a}	3 706^{e}	+ 160^{f}
Third	3 845^{e}	2 161^{e}	1 473^{a}	3 777^{e}	+ 68^{e}
Mean	3 550	1 936	1 466	3 550	± 0
Interaction					
Breed/diet	NS	NS	NS	NS	*
Breed/years	NS	NS	NS	NS	NS
Diet/years	NS	NS	NS	NS	NS

[1] Also includes the amount of energy required for pregnancy, mean 152 FU/yr.

The significances of differences and interactions were tested as in Table 2. $^{a, b}$: P = 0.05; $^{d, e, f}$: P = 0.01; $^{g, h}$: P = 0.001.

(Table 6). In contrast, the differences between the individual animals of each breed were considerable. The greatest protein deficits (400—600 g/d) were found at the start of the third lactation in the high-yielding cows of the silage group who milked their peak yields soon after calving. No harmful effects were found as a result of the protein deficits, however.

After the first weeks, the DCP intake usually exceeded the requirement (Fig. 4). By the middle of the lactation (154 days after calving) the standard level had nearly been reached (Table 6). The protein surplus was necessary indeed as the lactation progressed, because for the standard requirement the amount of protein needed for growth was not included in the calculations. The protein balances were balanced in all breeds and on both diets during all the lactations (Table 7).

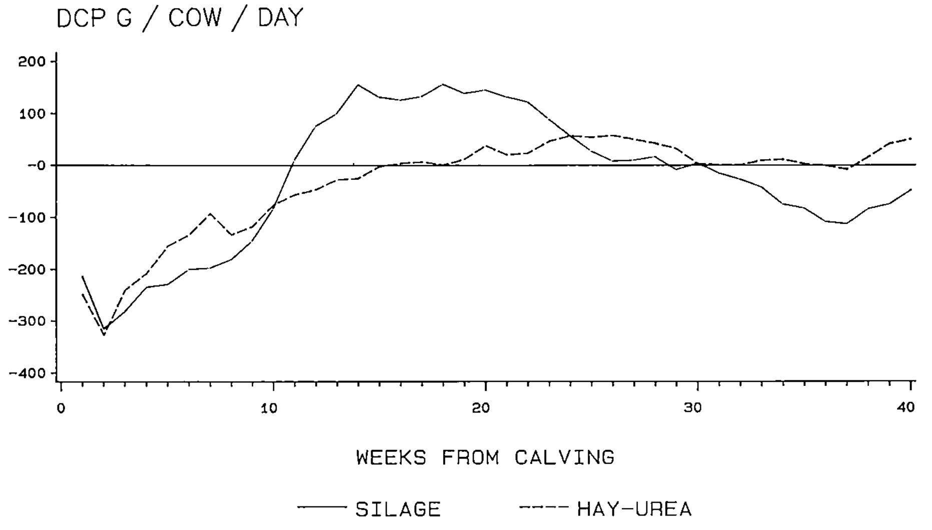
During dry periods, the digestible crude protein supply was notably more abundant than that required for maintenance and pregnancy (Table 7). The protein surplus in the silage groups resulted from an abundant silage intake which, in turn, was caused by the scanty amount of cereal concentrate (ETTALA and VIRTANEN 1990 b). In addition, during the dry periods the silage was rich in protein as some of the cows had already calved at that time and two silages could not be used simultaneously. The hay groups would not have required urea during the dry periods. However, the urea level of the concentrate was kept the same (2 %), because the present investigation was based on

Table 6. Mean supply of digestible crude protein per cow per day and the standard requirement as well as protein balance for 70 and 154 days after calving during the first three lactations.

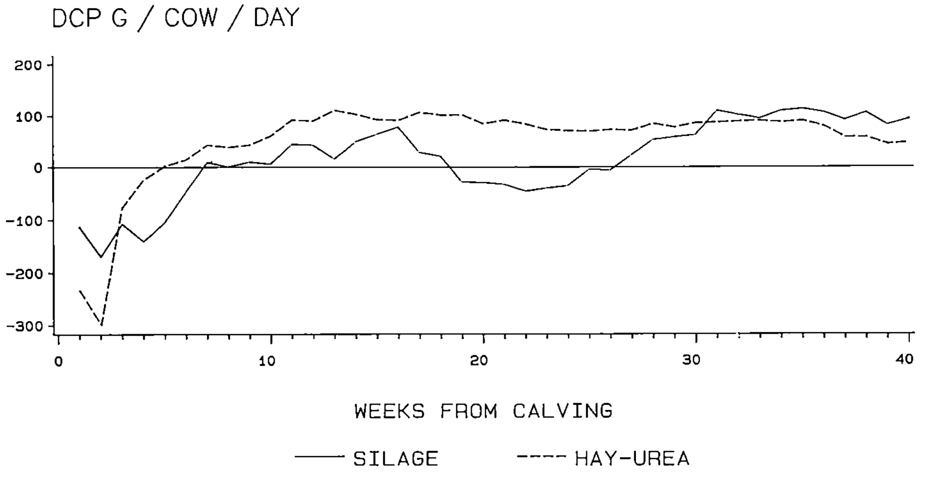
	DCP g/cow/day				
	70 days			154 days	
	From feeds DCP x̄	Standard requirement x̄	Supply-requirement x̄ s.d.	From feeds DCP x̄	Supply-requirement x̄ s.d.
Group					
Fr-S	1 427[f]	1 592[e]	—165 ± 275[a]	1 472[f]	— 8 ± 193[b]
Ay-S	1 299[e]	1 528[e]	—229 ± 220[a]	1 354[e]	—90 ± 178[a]
Fc-S	1 146[d]	1 336[d]	—190 ± 204[a]	1 183[d]	—82 ± 141[a]
Fr-H	1 445[f]	1 595[e]	—150 ± 157[a]	1 430[ef]	—30 ± 93[ab]
Ay-H	1 458[f]	1 609[e]	—151 ± 144[a]	1 436[ef]	—45 ± 91[ab]
Fc-H	1 209[d]	1 339[d]	—130 ± 137[a]	1 169[d]	—42 ± 95[ab]
Breed					
Fr	1 436[be]	1 594[e]	—157 ± 222[a]	1 450[e]	—19 ± 150[a]
Ay	1 380[ac]	1 569[e]	—190 ± 189[a]	1 396[e]	—67 ± 142[a]
Fc	1 177[d]	1 337[d]	—161 ± 175[a]	1 176[d]	—62 ± 121[a]
Diet					
S	1 322[g]	1 519[a]	—196 ± 241[a]	1 370[a]	—56 ± 181[a]
H	1 410[h]	1 557[a]	—147 ± 148[b]	1 388[a]	—38 ± 92[a]
Lactation					
First yr	1 104[d]	1 302[d]	—198 ± 128[e]	1 147[d]	—56 [d]
Second yr	1 541[be]	1 588[e]	— 47 ± 190[f]	1 495[e]	+ 14 [e]
Third yr	1 483[ac]	1 767[f]	—284 ± 208[d]	1 526[e]	—106[d]
Mean	1 367	1 538	—171	1 379	—47
Interaction					
Breed/diet	***	NS	NS	**	NS
Breed/years	NS	NS	NS	NS	NS
Diet/years	**	NS	NS	NS	*

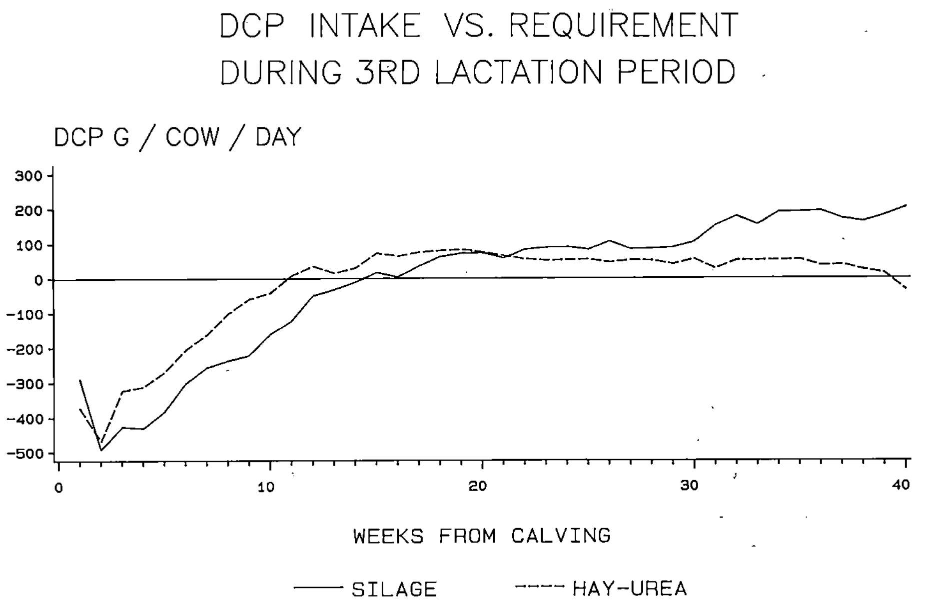
The significances of differences and interactions were tested as in Table 2. [a, b]: P = 0.05; [d, e, f]: P = 0.01; [g, h]: P = 0.001.

DCP INTAKE VS. REQUIREMENT
DURING 1ST LACTATION PERIOD



DCP INTAKE VS. REQUIREMENT
DURING 2ND LACTATION PERIOD





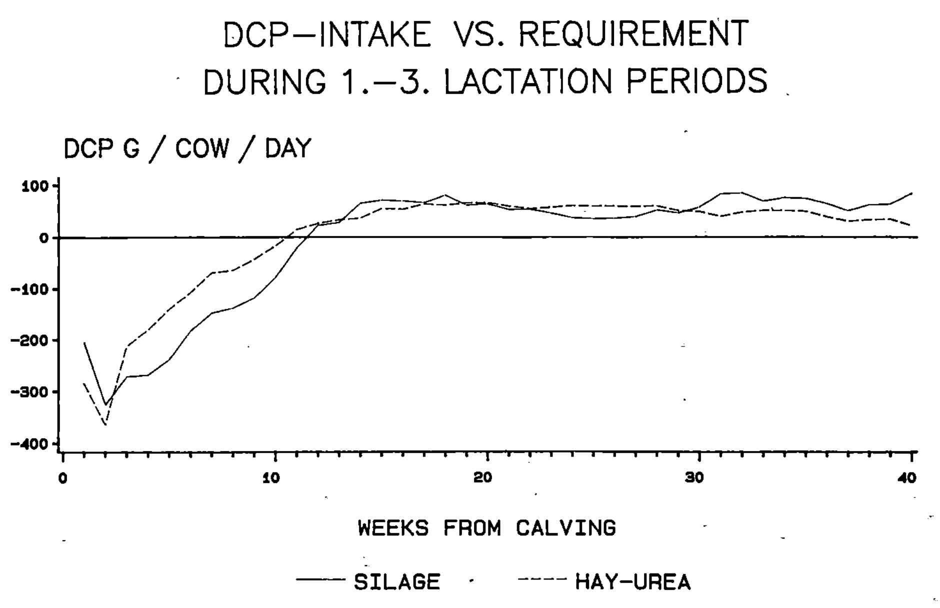


Fig. 4. Daily digestible crude protein supply from feeds vs. the requirement (0-line) among cows on silage and hay diet during the first, second and third lactations and the average for the first-third lactations.

the continuous use of urea. At the same time, the diets became more equalized with respect to protein surplus. A part of the calculated protein surplus was necessary because of the substantial growth of the cows during the dry periods. Some of the nitrous substances of the protein were apparently lost in urine.

The digestible crude protein supplied to the cows during the whole production year averaged 452 kg/cow/yr.

Energy utilization

At the start of the lactations, the energy used for milk production was derived from the feeds and body energy stores (Fig. 5, Table 8). At the beginning of the second and third lactations, this total quantity of energy was exactly in accordance with the standard requirement when the energy for maintenance was calculated according to the standards. In contrast, the energy supply per 4 % FCM at the beginning of the first lactation was significantly lower. There was also a significant difference in energy utilization between the silage and hay diets. The energy utilization of the different breeds was equal.

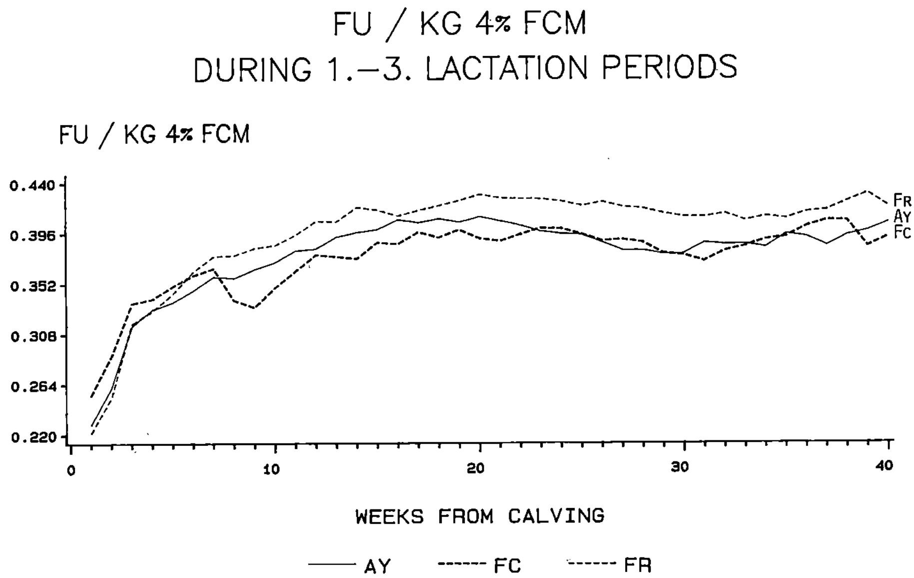
By mid-lactation (154 d) the mean energy utilized per kg 4 % FCM was stable, but it was nearly totally derived from the feeds (Table 8). The energy supply released from the body tissues at the start of the lactations was eliminated, nearly totally, by a later gain in body weights (Fig. 1).

The gain in body weights also continued through the last half of the lactations. When the energy for maintenance and also for weight

Table 7. Mean supply of digestible crude protein per cow per day and the standard requirement as well as protein balance for the first-third lactations and dry periods.

	DCP g/cow/day				
	Lactation			Dry period	
	DCP from feeds $\bar{x}$	Standard requirement $\bar{x}$	Supply-requirement $\bar{x}$ s.d.	DCP from feeds $\bar{x}$	Supply-requirement $\bar{x}$
Group					
Fr-S	1 370^{f}	1 303^{e}	+67 ± 149^{e}	1 141^{f}	+557^{g}
Ay-S	1 243^{e}	1 262^{e}	—19 ± 112^{d}	1 064^{f}	+515^{fg}
Fc-S	1 107^{d}	1 119^{d}	—12 ± 75^{d}	965^{e}	+438^{ef}
Fr-H	1 307^{ef}	1 285^{e}	+22 ± 74de	966^{e}	+409de
Ay-H	1 300^{ef}	1 305^{e}	— 5 ± 71^{d}	968^{e}	+426^{def}
Fc-H	1 071^{d}	1 061^{d}	+10 ± 67de	842^{d}	+341^{d}
Breed					
Fr	1 338^{f}	1 294^{e}	+44 ± 119^{e}	1 052^{e}	+481^{e}
Ay	1 272^{e}	1 284^{e}	—12 ± 93^{d}	1 014^{e}	+469^{e}
Fc	1 089^{d}	1 091^{d}	— 1 ± 71^{d}	902^{d}	+388^{d}
Diet					
S	1 269^{a}	1 252^{a}	+17 ± 129^{a}	1 078^{i}	+518^{i}
H	1 264^{a}	1 255^{a}	+ 8 ± 72^{a}	946^{h}	+405^{h}
Year					
First yr	1 060^{d}	1 069^{d}	— 9 ± 83^{d}	1 009^{a}	+481^{a}
Second yr	1 357^{e}	1 306^{e}	+51 ± 109^{e}	1 011^{a}	+451^{a}
Third yr	1 412^{f}	1 418^{f}	— 7 ± 110^{d}	1 008^{a}	+443^{a}
Mean	1 266	1 254	+12	1 010	+460
Interaction					
Breed/diet	***	NS	*	NS	NS
Breed/years	NS	NS	NS	NS	NS
Diet/years	*	NS	NS	***	***

The significances of differences and interactions tested as in Table 2. $^{a, b}$: P = 0.05; $^{d, e, f, g}$: P = 0.01; $^{h, i}$: P = 0.001



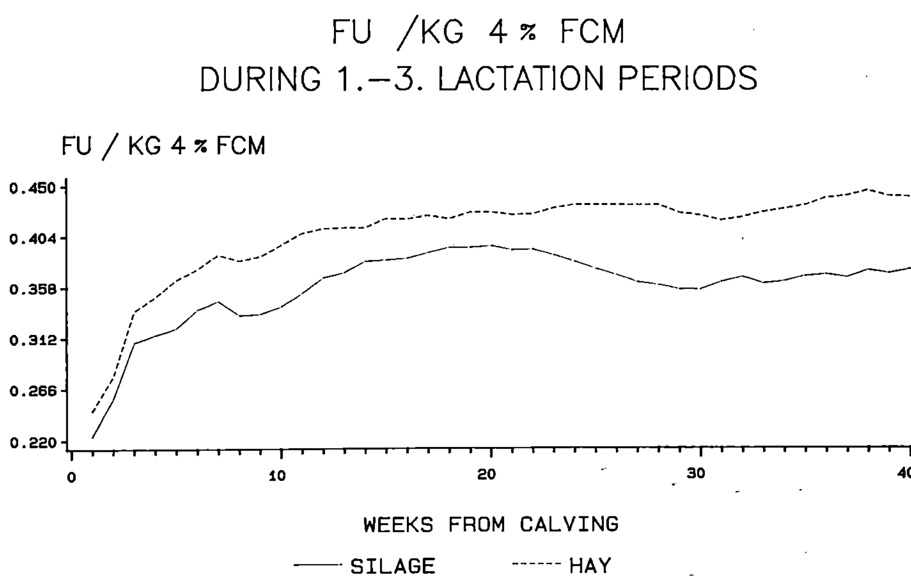


Fig. 5. Feed energy utilization per kg 4 % FCM of Friesian, Ayrshire and Finncattle cows (figure above) and on silage and hay diets (figure below).

gain were taken into account according to the standards during the whole lactation periods, the energy used per kg 4 % FCM cows on the silage diet was 0.35 FU and that on hay 0.39 FU. The mean values were decreased by the advantageous energy utilization of the first lactation on scanty feeding. During the second and third lactations, the energy consumed averaged 0.37 FU among cows on the silage diet and 0.41 FU/kg 4 % FCM among cows on the hay diet. The difference between the silage and hay diets was evident throughout all lactations (Fig. 5) and recurred among every breed each year.

The breeds used as much energy per kg 4 % FCM when, in addition to the different amount of energy for maintenance, the Friesians' greater energy consumption for weight gain in body weights was taken into account (Table 8). If the amount of energy needed for the greater gain in the weight of Friesians was not calculated, the Friesian energy utilization appeared to be more disadvantageous in comparison with the other breeds (Fig. 5). The variation in energy utilization was similar for all breeds. Most of the cows represented the average feed utilization level. Most of the high-yielding cows fell into this category. On examination of the extreme cases, mostly the same animals made up the exceptional group every year. These animals were quite the same, whether feed efficiency was calculated according to the energy supplied from the feeds only or together

Table 8. Energy utilization per kg 4 % FCM during different phases of three lactations when the energy for maintenance is calculated according to the standards. Released or bound energy amounts caused changes in liveweights a) have not, b) have been taken into account. The feed utilization ratio is the relationship between the amount of energy from the feeds and the 4 % milk yield during the lactations.

First-third lactations	FU/kg 4 % FCM						Feed utilization ratio
	70 days		154 days		Lactation		
	a) $\bar{x}$	b) $\bar{x}$	a) $\bar{x}$	b) $\bar{x}$	a) $\bar{x}$	b) $\bar{x}$ s.d.	$\bar{x}$
Group							
Fr-S	0.33^{de}	0.38^{de}	0.37^{ef}	0.38^{d}	0.38^{e}	0.36 ± 0.06^{d}	0.64^{e}
Ay-S	0.31^{d}	0.37^{d}	0.35^{de}	0.37^{d}	0.35^{d}	0.35 ± 0.04^{d}	0.59^{d}
Fc-S	0.32^{d}	0.38^{de}	0.34^{d}	0.37^{d}	0.35^{d}	0.34 ± 0.04^{d}	0.61^{de}
Fr-H	0.35^{ef}	0.39^{de}	0.39^{g}	0.39^{e}	0.41^{f}	0.39 ± 0.05^{e}	0.66^{ef}
Ay-H	0.36^{f}	0.39^{de}	0.39^{g}	0.40^{e}	0.41^{f}	0.39 ± 0.04^{e}	0.64^{e}
Fc-H	0.36^{f}	0.40^{e}	0.38^{fg}	0.40^{e}	0.41^{f}	0.40 ± 0.04^{e}	0.67^{ef}
Breed							
Fr	0.34^{a}	0.38^{a}	0.38^{e}	0.38^{a}	0.40^{e}	0.37 ± 0.05^{a}	0.65^{e}
Ay	0.33^{a}	0.38^{a}	0.37^{de}	0.39^{a}	0.38^{d}	0.37 ± 0.05^{a}	0.62^{d}
Fc	0.34^{a}	0.39^{a}	0.36^{d}	0.38^{a}	0.38^{d}	0.37 ± 0.05^{a}	0.64^{de}
Diet							
S	0.32^{h}	0.37^{h}	0.35^{h}	0.37^{h}	0.36^{h}	0.35 ± 0.05^{h}	0.62^{h}
H	0.35^{i}	0.39^{i}	0.39^{i}	0.40^{i}	0.41^{i}	0.39 ± 0.04^{i}	0.66^{i}
Lactation							
First yr	0.29^{d}	0.34^{d}	0.32^{d}	0.34^{d}	0.33^{d}	0.32 ± 0.03^{d}	0.62^{d}
Second yr	0.37^{f}	0.40^{e}	0.41^{f}	0.41^{e}	0.42^{f}	0.39 ± 0.03^{e}	0.67^{e}
Third yr	0.34^{e}	0.40^{e}	0.38^{e}	0.40^{e}	0.40^{e}	0.39 ± 0.04^{e}	0.63^{d}
Mean	0.34 ± 0.06	0.38 ± 0.05	0.37 ± 0.05	0.38 ± 0.04	0.38 ± 0.06	0.37 ± 0.05	0.64 ± 0.08
Interaction							
Breed/diet	NS	NS	*	NS	*	*	NS
Breed/years	NS	NS	NS	NS	NS	NS	NS
Diet/years	NS	NS	*	NS	NS	NS	NS

The significances of differences and interactions tested as in Table 2. $^{a, b}$: $P = 0.05$; $^{d, e, f, g}$: $P = 0.01$; $^{h, i}$: $P = 0.001$.

with the energy amount released from body tissues and bound to the body. Apparently, these particular animals were truly either good or poor feed users.

Feed utilization is also expressed by the ratio between the amount of energy supplied from feeds and the 4 % FCM milk yields. Calculated in this way, Ayrshires had a better feed utilization ratio than the others (Table 8). It differed significantly from the feed utilization ratio of the Friesians during the lactations. The best feed utilization ratio was found for the Ayrshire silage-fed group and the weakest was the hay-fed Finncattle group. The mean feed utilization ratios of Friesians and Finncattle were nearly equal. When the amount of energy supplied during the dry periods was included, the differences in the feed utilization ratios of the breeds were not significant (Fr 0.75, Ay 0.71, Fc 0.74).

The feed utilization ratio was significantly better among cows on the silage diet than among cows on hay. The difference remained significant also when the calculation included the amount of energy of the dry periods (S 0.71 and H 0.75).

Protein utilization per kg 4 % FCM

At the beginning of the lactations (70 days), 52 g digestible crude protein (DCP) per kg 4 % FCM was supplied by the feeds when use for maintenance was calculated according to the standard requirement (Table 9). At the beginning of the second lactation, the amount of DCP was nearly at the standard level and was significantly better than during the beginning of the first and third lactations. The hay diet had a significantly better DCP supply than the silage diet. The wide range of variation found in all of the groups demonstrates that at the beginning of the lactations some animals in each group had to utilize much of their body protein stores.

By mid-lactations the amount of DCP per kg 4 % FCM was already close to the standard level. Nearly equal protein utilization was also found in the different dietary groups when the cows of the silage-fed groups increased their silage intake (ETTALA and VIRTANEN 1990 b).

During the whole lactation the amount of DCP per kg 4 % FCM supplied by the feeds corresponded to at least the standard requirement in every lactation and breed and on both of the diets. The surplus mainly concerned the Friesian silage-fed groups and the second lactation. Hence protein was available for growth, too.

Table 9. Amount of digestible crude protein from the feeds per kg 4 % FCM when the amount of DCP needed for maintenance has been calculated according to the standards. Mean results from the first three production years in different stages of the lactation.

First-third lactations	DCP g/kg 4 % FCM		
	70 days x̄ s.d.	154 days x̄ s.d.	Lactation x̄ s.d.
Group			
Fr-S	52 ± 13[a]	60 ± 11[b]	65 ± 10[e]
Ay-S	49 ± 10[s]	55 ± 8[s]	60 ± 7[d]
Fc-S	49 ± 10[a]	55 ± 8[a]	60 ± 6[d]
Fr-H	53 ± 12[a]	58 ± 8[ab]	62 ± 6[de]
Ay-H	53 ± 7[a]	58 ± 5[ab]	61 ± 5[d]
Fc-H	53 ± 7[a]	57 ± 6[ab]	62 ± 6[de]
Breed			
Fr	53 ± 12[a]	59 ± 9[b]	63 ± 8[e]
Ay	51 ± 9[a]	57 ± 7[ab]	60 ± 6[d]
Fc	51 ± 9[a]	56 ± 7[a]	61 ± 6[de]
Diet			
S	50 ± 11[a]	57 ± 9[a]	62 ± 9[a]
H	53 ± 9[b]	58 ± 6[a]	61 ± 6[a]
Lactation			
First	48 ± 7[d]	57 ± 14[d]	61 ± 6[d]
Second	58 ± 11[e]	62 ± 14[e]	64 ± 8[e]
Third	48 ± 9[d]	56 ± 13[d]	61 ± 7[d]
Mean	52	58	62
Interaction			
Breed/diet	NS	NS	NS
Breed/years	NS	NS	NS
Diet/years	NS	*	NS

The significances of differences and interactions tested as in Table 2. [a, b]: P = 0.05; [d, e]: P = 0.01.

DISCUSSION

The results demonstrated that all breeds had equal energy utilization per kg 4 % FCM when the amount of energy caused by the different maintenance requirements and changes in weights of the breeds calculated according to the standards. On the other hand, if energy utilization was examined only by the ratio between the amount of energy supplied from the feeds and the milk yields, then the feed utilization ratio of the Ayrshire was the best. During the lactations it differed significantly from the feed utilization of the Friesian cows, which were about as productive, but heavier. The difference was parallel, but insignificant when the amounts of energy supplied from the dry periods were included in the calculation. The ratio between feed energy and milk production of Friesians and Finncattle was nearly equal.

The results are supported by the study of DICKINSON et al. (1969) in which the feed utilization ratios of Ayrshires and Holstein-Friesians approximated each other, and the significance of the differences depended on whether or not liveweights, weight gains or other measures of size were taken into consideration. The feed utilization ratio of both breeds was superior to that of Brown Swiss.

The energy balances showed that with the voluntary roughage intake and the cereal rations used in the present study it was possible to reach a level in accordance with the standards during the second and third lactation, but not during the first. The roughage intake of first-lactation heifers was lower than estimated. The mean energy deficit per first-lactation heifer was one feed unit per day. For growth, the first-lactation heifers ought to have received an additional kilogram of cereal per day, as was the practice for the next first-lactation heifers. The milk yields of the first-lactation heifers on scanty diets were modest (ETTALA and VIRTANEN 1990 c), and the animals became thin, but at the same time their energy utilization was very advantageous, averaging 0.32 FU/kg 4 % FCM. The result is in agreement with experimental results concerning scanty energy levels (EKERN 1970, NORDFELDT and CLAESSON 1964, WIKTORSSON 1971).

With respect to the standard requirements, there was an energy deficit during the first weeks of every lactation because milk yield increased more rapidly than feed intake. The cows utilized the body energy reserves acquired during the dry periods, and lost weight. The period of weight loss lasted about 10 weeks on average, afterwhich a gain in weight began again. The total amount of energy supplied from the feeds and the body tissues at the beginning of the second and third lactations corresponded to the standard requirements, but remained below the standards during the first lactation.

The amount of energy supplied from the feeds during the whole lactation corresponded to the standard requirement on the hay diet, but remained below the standard level on the silage diet. The energy balances during the second and third lactations were +0.1 on the hay diet and −0.57 FU/cow/day on the silage diet. In line with this difference, the amount of energy calculated per kg 4 % FCM was significantly lower among cows on the silage diet than among cows on the hay diet; during the second and third lactations 0.37 FU and 0.41 FU/kg 4 % FCM. The reason cannot be the improved energy utilization resulting from the scanty diet, because the increase in the liveweight of the silage group was equal with that of the hay group; the difference between the mean body weights of the first and third lactations was 69 kg in both groups. Also the 4 % FCM milk yields were equal (mean 4 698 and 4 694 kg/305 d). Apparently the energy content of silage was higher than that indicated by the analytical methods and calculation techniques employed.

The advantages of good-quality silage as compared to hay of corresponding quality have also been shown in other experiments and by different energy calculation techniques, e.g.: net energy (Scandinavian FU) (NORDFELDT and CLAESSON 1964), metabolizable energy (MJ ME) (BERTILSSON and BURSTEDT 1983), starch equivalent (S.E.) (KERR and BROWN 1962) and total digestible nutrients (TDN) (STONE et al. 1960). Metabolic experiments in Norway compared fresh silage preserved with formic acid and in Holland prewilted silage with barn dried hay from the same cut. In Holland, these four roughages were investigated in a metabolic experiment with dairy cows and in Norway with sheep. No significant differences were found in energy utilization in either experiment (EKERN and SUNDSTOL 1973, van der HONING et al. 1973). In contrast, the total energy content and metabolizable and net energy content of organic matter were higher especially in fresh silage than in hay. One of the reasons was found to be the nutrients volatilized from the silages during oven-drying. Other explanations for the better energy value of silage than that calculated have also been proposed (BREIREM et al. 1959, EKERN and MACLEOD 1978, STONE et al. 1960).

Eighty percent of acetic acid and the total amount of butyric and propionic acid were added to the dry matter content of oven-dried silage in the present investigation (JARL and HELLEDAY 1948, NORDFELDT 1955). More recently, this subject has also been investigated in Finland (HUIDA et al. 1986). That study found volatility to be in proportion with the pH value of silage. In silages with a low pH, the volatilization of volatile fatty acids (excluding formic acid) and that of lactic acid were more abundant and the volatility of ammonium nitrogen less than that in high pH silages. pH-binding has also been reported by BERG and WEISSBACH (1976) and NØRGAARD PEDERSEN and MØLLER (1965) but not, however, in the volatility of lactic acid. In the pH range within which Finnish silages fall ($pH < 4.2$) considerable (31.2 %) volatility of lactic acid occurred according to the study of HUIDA et al. (1986). In the correction equations for dry matter contents they presented that besides the volatile fatty acids the volatility of lactic acid, ethanol and ammonium nitrogen to be included. These corrections would have raised the energy value of silage in the present study, at least to some extent.

The sufficiency of protein was examined by calculating the utilization of digestible crude protein per kilogram 4 % FCM when the amounts reserved for maintenance and pregnancy were reserved as the standards. At the beginning of the lactations during the first ten-week period, the digestible crude protein supply was, 52 g/kg 4 % FCM (S 50 and H 53 g), on average, thus the supply of protein was less than the standard requirement (60 g). At the beginning of the second lactation, the amount of DCP approached the standard level (58 g), but at the start of the first and third lactations it was significantly lower (48 g). The significance of a protein deficit of this quantity was clarified by LINDELL (1982) with high-yielding cows in a long-term experiment involving research on protein levels (45, 60, 75 and 60/45 g DCP/kg 4 % FCM). There was no significant difference in milk production, health or fertility between the lowest and the standard level. In contrast, the loss of liveweights of the cows was faster on the lower protein level and the gain in weights was slower than on other levels. From this it can be concluded that a short-term deficit at the mean levels hardly affected the results of this experiment. On the other hand, it is evident that high-yielding cows, especially at the beginning of the third lactation, had to utilize considerably body protein stores in addition to feed protein. According to the study BOTTS et al. (1979), the available protein reserves in dairy cattle can be as much as 25—27 % of the amount of body protein.

After the first weeks, the DCP supply exceeded the standard requirements on both diets. At this time, the protein was sufficient also for supplementing body protein stores and for the animals' growth. During the whole lactation the amount of DCP per kg 4 % FCM was 62 g (S 62 and H 63 g).

On the basis of the results of the present experiment, it can be concluded that the utilization of urea protein, too, was quite good. The extensive clarifications presented in the urea experiments of VIRTANEN show that the utilization of urea protein can be good in milk production (VIRTANEN 1967, KREULA and ETTALA 1977).

Digestible crude protein supply was remarkably higher during dry periods than that needed for maintenance and pregnancy. During this time, the main gain in weight of Ayrshires and Finncattle took place, while among Friesians a gain was notable also during the lactations. The major part of the weight gain naturally involved the recovery of energy stores and weight due to pregnancy. However, growth also occurred. This can be demonstrated by the increase of the cows' average weights from one year to the next: 460, 508 and 528 kg.

The results showed that the protein requirement of the cows could be satisfied with mainly home-grown diets. It might be justified to feed the high-yielding cows with a supplemental protein concentrate during the first ten weeks, especially on the silage diet, although the present research found no harmful effects caused by the protein deficit. Thereafter, supplemental protein did not appear to be needed by the high-yielding cows either, because silage intake rose rapidly (ETTALA and VIRTANEN 1990 b). However, it is essential that the silage used is not only of good quality and palatable, but also comparatively high in protein.

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SELOSTUS

Suomalaisen ayrshiren, friisiläisen ja suomenkarjan vertailu säilörehu-vilja- ja heinä-urea-viljaruokinnalla

4. Lehmien energia- ja valkuaistaseet sekä rehun hyväksikäyttö kolmena ensimmäisenä tuotantovuonna

ELSI ETTALA ja ERKKI VIRTANEN

Maatalouden tutkimuskeskus

Suomalaisen ayrshiren (40 ay), friisiläisen (40 fr) ja suomenkarjan (16 sk) rehun hyväksikäyttöä tutkittiin säilörehuvaltaisella ja heinävaltaisella ruokinnalla kolmen ensimmäisen tuotantovuoden aikana. Puolet joka rodusta (sr) sai vapaasti tuoretta, kelasilputtua, hyvälaatuista säilörehua, kilon päivässä heinää ja ohra-kauraseosta 0,24—0,30 ry/kg 4 %-maitoa. Puolet (hr) sai vapaasti heinää ja ureapitoista (2 %) ohrakauraseosta 0,32—0,38 ry/kg 4 %-maitoa.

Lypsykausien alussa oli energiavajausta ja sen seurauksena elopainot alenivat noin 10 viikon ajan. Senjälkeen elopainot alkoivat nousta. Energian saanti oli ensimmäisellä lypsykaudella alle normitarpeen. Keskimääräinen vajaus ensik-

koa kohti oli rehuyksikkö vuorokaudessa. Silloin energiaa kului vain 0,32 ry/kg 4 %-maitoa, kun muut energiatarpeet laskettiin normien mukaisina. Toisella ja kolmannella lypsykaudella energian saanti vastasi normitarvetta ja energian hyväksikäyttö oli keskimäärin 0,39 ry/kg 4 %-maitoa. Molemmissa laskelmissa otettiin huomioon painonmuutosten vapauttamat ja vaatimat energiamäärät.

Rotujen energian käyttö 4-prosenttista maitokiloa kohti oli yhtäläistä, kun laskelmissa otettiin normien mukaisesti huomioon rotujen erilaiset elatuksen ja painonmuutosten aiheuttamat energiamäärät. Jos sensijaan rehuhyötysuhdetta tarkasteltiin vain rotujen rehuista saaman energiamäärän ja maitotuotoksen välisellä suhteella, oli ayrshiren rehuhyötysuhde muita parempi, friisiläisiin nähden lypsykausien aikana merkitsevästi (ay 0,62, fr 0,65 ja sk 0,64).

Energian hyväksikäyttö oli laskelmien mukaan säilörehuvaltaisella ruokinnalla merkitsevästi parempi kuin heinävaltaisella; toisella ja kolmannella lypsykaudella keskimäärin sr 0,37 ja hr 0,41 ry/kg 4 %-maitoa. Ero ilmeni kaikilla roduilla. Johtopäätökseksi tuli, että säilörehu oli energiarikkaampaa kuin mitä käytetyt analyysimenetelmät ja rehuarvolaskelmat osoittivat.

Sulavan raakavalkuaisen saanti jäi lypsykausien alussa alle normitason noin 10 viikon ajan. Silloin keskimääräinen srv-määrä oli 52 g/kg 4 %-maitoa, kun muut osatarpeet laskettiin normien mukaisina. Koko lypsykausina valkuaistaseet olivat positiivisia molemmilla ruokinnoilla (sr 62 ja hr 61 g srv/kg 4 %-maitoa). Ummessaolokausina srv-saanti oli huomattavasti yli normitarpeen. Positiiviset valkuaistaseet näkyivät lehmien kasvuna; keskipainot olivat 1., 2. ja 3. tuotantovuonna: 460, 508 ja 528 kg.

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Seria ANIMALIA DOMESTICA N. 96 — Sarja KOTIELÄIMET n:o 96

COMPARISON OF FINNISH AYRSHIRE, FRIESIAN AND FINNCATTLE ON GRASS SILAGE-CEREAL AND HAY-UREA-CEREAL DIETS

5. Reproduction, milking ability, diseases and removals

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The management traits of Finnish Ayrshire (40 Ay), Friesian (40 Fr) and Finncattle (16 Fc) were clarified during the first three lactations. The cows of the present breed comparison were fed silage-cereal or hay-urea-cereal diets.

The breeds conceived equally well on average. There was annual variation in the conception rates of Ayrshires and Finncattle fed on the silage diets. On average more inseminations per calving were necessary among cows on the silage than on the hay diet (1.89/1.61), but the difference was insignificant. The average calving intervals during the three-year production period were: Fr 368, Ay 375 and Fc 378 days, for all breeds on the silage diet 379 days and on the hay diet 367 days. Heats were usually good and regular.

Calvings were easy or normal for 93.5 % of the cows. Difficult calvings occurred mainly among first-lactation Friesian heifers. Udder conformation and milking ability was somewhat better among first-lactation Ayrshire heifers than among other breeds. Mastitis was the most common disease. Mastitis and foot diseases were more prevalent among Friesians than among the other breeds. Ketosis affected 6.7 % of the cows. These were mainly Finncattle and Ayrshires fed the silage diet. The only criteria for removals were diseases in the three production years as follows: sex organ disturbances 8.3 %, foot diseases 5.2 %, mastitis 4.2 % and 4.2 % of the cows were removed for other reasons.

Index words: dairy cows, dairy breeds, grass silage feeding, hay feeding, urea feeding, home-grown feedstuffs, reproduction, diseases.

INTRODUCTION

A comparative study of Finland's dairy cattle breeds, Ayrshire, Friesian and Finncattle, on two home-grown diets lasted for two growth years and six production years. The results for the heifer stage and the intakes, nutrient supply, production and feed utilization as well as the energy and protein balances of the cows for the first three production years on silage-cereal and hay-urea-cereal diets during different lactational stages have been presented in our previous papers (ETTALA and VIRTANEN 1990 a, b,c,d). The present paper examines the management traits of the cows during the first three production years.

The cows conception was the most important of the traits clarified. Artificial insemination statistics have shown that the conception rate of cows in Finland has gradually declined. During the period 1981—1988 the mean number of inseminations per cow increased from 1.65 to 1.78 and the non return rate for 60 days decreased from 66.5 to 64.5 % (ANON. 1981, 1988). The decrease was observed in all breeds. In seeking the reasons for the above, it was also necessary to determine the role of diet in conception. A primary aspect of studying Finnish diets was to clarify the effect of an abundant silage diet. Such results could be expected from the present long-term experiment because cows of each breed in the silage dietary group got silage as the only protein feed from one year to the next. A three-year comparison of silage and hay diets performed in Sweden did not find differences in the conception rates of cows (BERTILSSON and BURSTEDT 1983). Their diets also contained protein concentrates.

The long-term experimental period was designed primarily to determine the endurance and economic result with the breeds. The final results will be available when the results for the last years of study have been analysed. However, the most common diseases and reasons for removals became apparent during the first three production years. Detailed results have been presented in Finnish (ETTALA and VIRTANEN 1986).

MATERIAL AND METHODS

The random sampling of the calves and the diets used in the study are described in the previous publications (ETTALA and VIRTANEN 1990 a, b, c, d). In order to observe the cows and ensure uniform milking, the animals were divided into four groups, each comprised of 24 animals, each of which had one caretaker of its own. The breeds were distributed evenly into each group, half were on silage and half were on the hay diets. Heat observation in the cows was performed three times a day. The cows were also checked in connection with other tasks, and in cases of unconfirmed heat they were checked in the exercise yard. Examination was continued after conception in order to detect all early abortions. Insemination was started for the next heat when 60 days had elapsed after calving. A veterinarian performed a pregnancy ecamination 5—6 weeks after insemination. Calvings were followed and, when necessary, assisted.

In addition, a separate fertility study was carried out on those Ayrshire and Friesian cows that calved mainly during the calving season (April—August) (HEINONEN 1988 a, b, HEINONEN et al. 1988 a,b). Veterinarians followed sex organ activity by means of clinical trials and milk progesterone tests (LAITINEN 1983) during the interval between calving and conception.

Udder conformation and milking ability of the first-lactation heifers were investigated. The tests were done at 30 days and 90 days after calving. The tests of milking ability determined the average and maximum milk flow per minute (AMF and MMF).

For clarification of diseases, the cows were observed and their daily amounts of feed and milk followed by a computer. Milk was tested by CMT tests. The cell number in the milk sample was determined weekly by an automatic FOSSOMATIC cell counter, from the same morning and evening milk samples from which the fat and protein contents were determined (ETTALA and VIRTANEN 1990 c). Samples of mastitis milk were examined and the susceptibility assays were performed by the National Veterinary Institute in the Kuopio Regional Laboratory. Also stillborn fetuses and calves were examined there.

RESULTS AND DISCUSSION

Heats

The occurrence of heat in the early stage (18—40 days after calving) increased with the lactations (Table 1). Early heat was detected most often in Finncattle. The majority of the cows (about 70 %) had their first heat earlier than 50 days since calving. If the first heat was detected only after 60 days had passed since calving; the cow was inseminated for that heat.

The heat interval was usually 21 days, being 20—22 days in half of the cases and between 19—22 days in two-thirds of the cases. The heat intervals of 23, 24 and 25 days were in 10 %, 8 % and 8 % of the cases, respectively. Differences in the length of the heat cycle owing to breed or diet were not found. Silent and difficult-to-detect heats occurred mainly during autumn and early winter.

In the study of HEINONEN et al. (1988 a), it became apparent that external signs during the first heat were rare, especially during the first lactation, and that the following heat interval was most often shorter than 18 days. The second heat interval for the majority (89 %) lasted 18—24 days, and a regular heat cycle began 41.3 days after calving, on average.

Heat length could be examined only in those cases for which the dates from the first heat signs until bleeding were obtained. In the majority of cases the heat lasted four days, but also three and five-day heats were also common (Table 2). The heat lengths were distributed in quite the same manner among the different breeds and on both diets. Heats lasting five days occurred slightly more among Friesians and in the silage-fed groups than in the others. The heats lengthened somewhat in accordance with the lactations.

Table 1. Detection of first heats after calving by means of external signs, and distribution of cows into different time intervals.

	First heat after calving, days			
	18—39	40—49	50—59	over 60
	% of the cows			
Breed				
Fr	46.7	20.6	16.8	15.9
Ay	50.4	16.5	17.4	15.6
Fc	60.9	23.9	13.0	2.2
Diet				
S	51.6	18.0	17.2	13.3
H	50.0	20.9	15.7	13.4
Lactation				
First (96 cows)	31.6	24.2	21.0	23.1
Second (95 cows)	57.6	16.3	16.3	9.8
Third (87 cows)	66.7	17.3	10.7	5.3

Table 2. Lengths of heats and their percentage distribution.

	Heat length, days					
	2	3	4	5	6	≥7
	% of cases					
Breed						
Fr	9	20	29	26	11	6
Ay	10	22	39	16	10	4
Fc	9	18	39	18	6	9
Diet						
S	7	20	34	23	10	6
H	11	21	35	18	9	6
Lactation						
First	9	28	40	17	5	2
Second	11	21	34	20	11	4
Third	8	15	32	24	12	10
Mean	9	21	35	21	10	6

Pregnancy

The time between calving and the first insemination was somewhat shorter among Finncattle than among the other breeds (Table 3). The interval was quite similar for different diets and different lactations.

During the first lactation, on average 64.6 % of the first-lactation heifers became pregnant after one insemination, but due to early abortions only 57.3 % calved (Table 3). During late autumn, two-three early abortions, altogether 13, occurred in all of the other groups except in the Friesian silage group. The reason for the early abortions was the oestrogenic Fusarium toxin, zearalenone (KALLELA and ETTALA 1984), that had formed in the hay during the extremely rainy summer of 1981 (ETTALA and VIRTANEN 1990 b). The toxin also affected the silage groups, because they were given one kilogram of hay daily. Conception was complicated after early abortions. When the total number of inseminations before and after early abortions was calculated, during the first lactation year, an average of 1.91 inseminations per calving were necessary (Table 4).

During the second lactation, Ayrshire and Finncattle cows conceived more poorly when fed on the silage diets than on hay (Table 4). The difference was significant for Ayrshires, and also notable for Finncattle. No reason for this was found. The number of inseminations increased because the cows were not excluded from the study because of poor conception rate. Therefore it was possible to follow the same individuals during subsequent years. During the third lactation, the conception rate among the hay-fed cows was excellent. It was also very good among the silage-fed cows, though this group included animals that had conceived poorly during the previous year. The conception results for the third lactation were on the same level as those for the heifer stage (ETTALA and VIRTANEN 1990 a).

The reasons for different annual conception results among cows on the silage diets were sought with regression analyses, in which the explaining factors were the milk yields of the cows, changes in liveweights, deficits of energy and protein supplies, composition of diet at that time, as well as silage composition and quality. These analyses explained the number of inseminations and the length of the empty period. The proportion and coefficient of determination of the factors having significant effects were:

Significant independent variables	Number of inseminations		Empty periods	
	b	Cum. R^2	b	Cum. R^2
Deficit in energy supply, FU/day	+0.26***	4.8 %	+0.24***	4.5 %
4 % milk yields, kg/day	+0.13***	6.3 %	+0.10***	5.5 %

The result did not clarify the poor conception rate during the second lactation among cows on the silage diets, because the energy deficit at the beginning of the lactation was significantly less at that time than during other lactations (ETTALA and VIRTANEN 1990 d).

During the three lactations the breeds conceived equally well, on average. Friesians did not display the annual variation found in the other breeds. The average inseminations for the silage and hay groups per calving (1.89/1.61) did not differ significantly from each other. The mean lengths of empty periods varied very little between the breeds and diets (Table 3).

In a clarification of their conception results, HEINONEN et al. (1988 a) obtained better results than the present study, because the findings were calculated per pregnancy and not per

Table 3. Time from calving to the first insemination, length of the empty period and percentage share of cows that calved after different numbers of inseminations.

	Time after calving, days		Cows' calving-%			
	First insem.	Empty period	First insem.	Second	Third	Fourth
Breed						
Fr	71	92	55.5	23.6	10.9	7.3
Ay	72	93	62.3	18.4	7.9	7.9
Fc	66	96	55.3	19.1	12.8	8.5
Diets						
S	71	97	49.3	26.1	11.2	8.2
H	70	89	67.2	15.3	8.8	7.3
Lactation						
First (96 cows)	70	102	57.3	16.7	13.5	11.5
Second (95 cows)	69	95	49.5	28.7	10.6	9.6
Third (87 cows)	72	81	70.4	16.0	4.9	1.2
Mean	71	93	58.5	20.6	10.0	7.7

calving, and the study only included Ayrshire and Friesian cows that calved mainly during the calving season. HEINONEN et al. (1988 b) showed that those cows that lost more than 10 % of their body weight within 60 days after calving conceived significantly more poor-

Table 4. Number of inseminations leading to calving during the first three lactations.

	Inseminations/calving			
	First lactation $\bar{x}$ s.d	Second lactation $\bar{x}$ s.d.	Third lactation $\bar{x}$ s.d.	Mean $\bar{x}$ s.d.
Group				
Fr S	1.70 ± 1.6^{a}	1.89 ± 1.1^{ab}	1.64 ± 0.6^{a}	1.75 ± 1.2^{a}
Fr H	1.85 ± 1.0^{a}	1.89 ± 1.3^{ab}	1.47 ± 1.1^{a}	1.76 ± 1.2^{a}
Ay S	1.89 ± 1.3^{a}	2.72 ± 2.0^{b}	1.31 ± 0.7^{a}	2.00 ± 1.6^{a}
Ay H	1.85 ± 1.5^{a}	1.35 ± 0.6^{a}	1.12 ± 0.3^{a}	1.46 ± 1.0^{a}
Fc S	2.25 ± 1.3^{a}	2.13 ± 1.1^{ab}	1.33 ± 0.5^{a}	1.95 ± 1.1^{a}
Fc H	2.38 ± 1.6^{a}	1.50 ± 1.1^{ab}	1.00 ± 0.0^{a}	1.65 ± 1.2^{a}
Breed				
Fr	1.78^{a}	1.89^{a}	1.55^{a}	1.75 ± 1.2^{a}
Ay	1.87^{a}	2.00^{a}	1.21^{a}	1.72 ± 1.3^{a}
Fc	2.31^{a}	1.82^{a}	1.15^{a}	1.80 ± 1.2^{a}
Diet				
S	1.87^{a}	2.27^{b}	1.44^{a}	1.89 ± 1.3^{a}
H	1.94^{a}	1.59^{a}	1.23^{a}	1.61 ± 1.1^{a}
Mean	1.91 ± 1.4	1.92 ± 1.4	1.33 ± 0.7	1.75 ± 1.2
Interaction				
Breed/diet	NS	NS	NS	NS

The significances of differences between groups, breeds and diets and their interaction effects were tested by two-way analysis of variance, and paired comparisons were tested by Tukey's test. Figures in the same columns without the same superscript differ significantly from each other.

$^{a, b}$: P = 0.05
NS = not significant.
The difference between the years was significant P = 0.01.

ly than others after the first insemination. Conception had thus been weakened by the substantial deficit in energy.

The calving intervals of the different breeds did not differ significantly from each other during any year (Table 5). Also the average age of the breeds at different calvings remained quite similar (ETTALA and VIRTANEN 1990 c). The average calving intervals during the three production years were shorter than those for the recorder herds during corresponding years (1981—84): Fr 376, Ay 383 and Fc 381 days (ANON. 1982, 1983, 1984, 1985). Perhaps the difference stemmed from the systematic and thorough observation of heats and the pregnancy examination carried out in the present study. The calving intervals in the silage group during the last two years were significantly longer than among cows of the hay groups, but the mean difference was not significant.

The good conception rate of cows on the hay diet demonstrated that urea did not impair fertility. The same finding has been reported, among others, by HOLTER et al. (1968) and RYDER et al. (1972).

Table 5. Mean calving intervals up to the fourth calving.

	Calving intervals, days			
	First-second $\bar{x}$ s.d.	Second-third $\bar{x}$ s.d.	Third-fourth $\bar{x}$ s.d.	Mean $\bar{x}$
Group				
Fr S	369 ± 50[a]	371 ± 51[a]	368 ± 24[a]	369[a]
Fr H	381 ± 50[a]	361 ± 27[a]	355 ± 52[a]	367[a]
Ay S	386 ± 49[a]	401 ± 65[a]	366 ± 22[a]	385[a]
Ay H	380 ± 65[a]	366 ± 32[a]	348 ± 21[a]	366[a]
Fc S	408 ± 70[a]	381 ± 35[a]	364 ± 19[a]	387[a]
Fc H	397 ± 65[a]	361 ± 41[a]	347 ± 13[a]	370[a]
Breed				
Fr	375[a]	366[a]	361[a]	368[a]
Ay	383[a]	383[a]	357[a]	375[a]
Fc	403[a]	372[a]	354[a]	378[a]
Diet				
S	383[a]	385[b]	367[b]	379[a]
H	383[a]	363[a]	351[a]	367[a]
Mean	383 ± 56	374 ± 46	358 ± 31	373
Interaction Breed/diet	NS	NS	NS	NS

The significances of differences and interactions were tested as in Table 4. [a, b]: P = 0.05.

The effect of the silage diet on the conception of Ayrshire and Finncattle cows remained controversial throughout the three production years studied, as the results of the second and third lactations were totally different. In contrast, Friesians conceived similarly on silage and hay diets. A uniform conception result among cows on silage or hay diets in Sweden was obtained with Swedish Red and White cattle (BERTILSSON and BURSTEDT 1983). Apparently, the next production years will reveal whether the question is one of breed differences or other factors.

The conception of Finnish Ayrshire has also been studied in experiments carried out in other countries. In Canada, the daughters of Finnish and Canadian Ayrshire bulls conceived equally well (LEE et al. 1982). In Denmark, the calving intervals and empty periods of Finnish Ayrshire cows, as compared to Holstein Friesians and Red Danish, were in between these, and did not differ significantly from them (CHRISTENSEN et al. 1984). In a Bulgarian comparison of Red and Red and White strains (8), the daughters of Finnish Ayrshire bulls conceived somewhat better than the average level (HINKOVSKI et al. 1985, 1988). Finnish Friesian has not been examined elsewhere, but the daughters of bulls of the other parent country, Swedish Friesian, were found in an Israeli comparison (BAR-ANAN et al. 1987) to have the best conception rates of the Friesian strains (5).

Calving and calves

The majority of the cows calved in the spring and summer; during the first lactation, 95 % of calvings occurred within three months time, and during the third lactation, 81.6 % of calvings occurred within five months (April—August). The length of gestation was slightly longer among Ayrshires than among the other breeds (Table 6). The difference was recurred every year on both diets. In a Danish breed experiment, the length of gestation among Finnish Ayrshire (279.6 days) was shorter than that found in this experiment, but the lengths of gestation among Friesians corresponded to each other (CHRISTENSEN et al. 1984). The length of gestation in the silage-fed group was somewhat longer than that of the hay-fed group (Table 6). Premature calvings ($\leq$260 days) were not included in the calculations.

Calving was easy or normal for 93.5 % of the cows (Table 7). Rapid, unassisted calvings occurred mainly in Finncattle, while Ayrshires had the least number of difficult calvings. Difficult calvings occurred mostly in the first-lactation heifers of the Friesian silage group (35 %). Apparently, the main reason was their copious silage intakes which led to obesity (ETTALA and VIRTANEN 1990 a). During the first lactation year, many very heavy calves were born, to such an extent that the mean weights of heifer calves during the first lactation were higher than in succeeding ones (Table 6). During the calving of first-lactation heifers, 7.3 % of the calves died (Fr 6, Ay 1). Later on, none of the calves died in connection with calving.

During the three lactations altogether 4.7 % of the cows had stillborn calves. These were usually in connection with premature calving. These disturbances occurred mostly among the hay-fed cows at the end of the third lactation. The highest number of retained placentas also occurred at that time (Table 7). No reasons were found, though the calves were examined. The feeds were the best possible at that time, because some of the cows had already calved.

Disturbances in connection with calving did not permit us to draw any conclusions related to the breeds on the basis of the present experiment, because the number of animals was small and the effect of outside factors apparent. The results were, however, surprisingly similar to those of both the recorder herd and other experiments. Using a large animal material, the milk recording results for 1971—74, it was shown that Friesian first-lactation heifers had significantly higher calf mortality rates than did Ayrshire first-lactation heifers (3.8/2.9 %), with Finncattle falling midway of these, but in subsequent calvings, the differences were small (LINDSTRÖM and VILVA 1977). On the basis of the recorder results for 1977, the mean calf

Table 6. Average length of gestations of the cows and birth weights of calves during the first three lactations.

	Length of gestation days $\bar{x}$	Birth weights of the calves, kg			
		Heifer calves		Bull calves	
		n	$\bar{x}$	n	$\bar{x}$
Breed					
Fr	279	66	37.8	53	41.5
Ay	283	56	34.6	68	38.2
Fc	280	23	26.8	29	29.9
Diet					
S	282	74	35.8	72	37.9
H	280	71	33.8	78	37.6
Year					
First	281	55[1]	35.2	64[1]	36.5
Second	280	46	34.3	47	38.3
Third	282	44	34.9	39	39.1
Mean	281	145	34.8	150	37.7

[1] Calves of the spare animals included.

Table 7. Easy, normal or difficult calvings and retained placentas during the first three lactations.

	% of the cows			
	calving[1]			Retained placentas
	Easy	Normal	Difficult	
Breed				
Fr	27.7	61.6	10.7	8.9
Ay	29.9	67.5	2.6	10.3
Fc	42.6	51.1	6.4	2.1
Diet				
S	27.9	63.2	8.8	6.6
H	34.3	61.4	4.3	10.0
Calving				
First	40.6	47.9	11.5	6.3
Second	27.4	66.3	6.3	7.4
Third	24.7	74.1	1.2	11.3
Mean	31.2	62.3	6.5	8.3

[1] easy: fast calving, no problems, no assistance
normal: no assistance or 1—2 assistants, calving within 2 hours.
difficult: many assistants, prolonged calving.

mortality rates of heifers and cows was 2.41 % and no significant differences were found between the breeds (LINDSTRÖM and SYVÄJÄRVI 1978).

Few calving difficulties and a low calf mortality of Finnish Ayrshire cows have been reported also in Danish and Canadian breed experiments (CHRISTENSEN et al. 1984, LEE et al. 1982). In a group of Bulgarian Red and Red and White breeds (8), the ranking of daughters of Finnish Ayrshire bulls varied with lactations, while difficult calvings were few or on the average level, and calf mortality was either average or higher (HINKOVSKI et al. 1985, 1988). The Swedish Friesian strain, in turn, proved to be weaker than the other four Friesian strains with respect to difficult calvings and calf mortality when Holstein-heifers were inseminated in Israel (BAR-ANAN et al. 1987). First-lactation Swedish Friesians had considerably more calving difficulties and higher calf mortality rates than Red and White cattle (SRB) first-lactation heifers, but the differences diminished during subsequent calvings (PHILIPSSON 1976). The same result has been reported in studies on English Friesian and Ayrshire breeds (DONALD 1963, MONTEIRO 1969).

Udder conformation and milking ability of first-lactation heifers

A spherical udder conformation was the most common in first-lactation heifers (Table 8). The best udder conformation, a flat udder, was mainly found in Ayrshires. On the other hand, Ayrshires had the shortest teats. Teat position and thickness were normal in all of the breeds. Milk leakage was evident, especially during the peak lactation period. Leaky udders were found mostly in Finncattle first-lactation heifers, the least in Friesians (Fc 31.3 %, Ay 19.5 % and Fr 2.5 %). During later lactations, the udder conformations became more baglike in shape. Pendulous udders were then common, especially among Friesians.

Milking time varied the most among Friesians and the least among Finncattle (TENHUNEN and ETTALA 1982). The variation was due to both different amounts of milk and differences in ease of milking. The average milk flow (AMF) obtained in a minute was the lowest among Friesians and the highest among Ayrshires (Table 9). The difference was significant in an test performed 90 days after calving. A good milk flow rate (AMF over 2.0 kg/min.) was found in one-third of the Ayrshire and Finncattle first-lactation heifers (34.2 and 31.8 %), but in only 17.5 % of Friesian first-lactation heifers. The maximal milk flow per minute (MMF) was also lowest in Friesian first-lactation heifers. Those animals whose MMF exceeded 3 kg/min, were 22 % of the Ayrshire first-lactation heifers and 10—15 % of the other breeds.

When tested on recorder farms, the ease of milking of Friesians was somewhat better than that of Ayrshires: in 1974—1976 AMF Fr 1.76, Ay 1.71 and Fc 1.78 kg/min. (LINDHOLM 1979) and in 1982—1987 AMF Fr 1.85 Ay 1.72 and Fc 1.64 kg/min (UKKONEN 1989). These tests were performed at different stages of the first lactation, but the results of LINDHOLM had been corrected in relation to the amount of milk and the lactational stage. Perhaps the tightly-milking

Table 8. Udder conformation of the first-lactation heifers of different breeds.

	Fr	Ay	Fc
Udder shape			
flat udders, %	2.5	22.5	—
spherical udders, %	87.5	75.0	81.3
spherical udders with heavy rear quarters, %	7.5	2.5	18.7
pendulous udders, %	2.5	—	—
Teats			
distance from the floor, cm, fore teats	49.5	49.7	45.6
distance from the floor, cm, rear teats	48.6	49.3	45.1
length, cm, fore teats	5.3	4.3	5.1
length, cm, rear teats	4.9	3.7	4.2
thickness, cm	2.6	2.5	2.5

Friesian first-lactation heifers in our small animal material received an excessively large share. In fact, the good milking ability of Friesians in their parent countries, Sweden and Denmark, was not found in a comprehensive Polish comparison of Friesian strains (10), they were ranked second and third from last (JASIOROWSKI et al. 1983). In an Israeli comparison of Friesian strains (5) the daughters of Swedish bulls had the weakest udder conformation (BAR-ANAN et al. 1987).

Diseases

Mastitis was the most common disease. It appeared immediately after the first calving. In the group of 116 heifers, 33.6 % suffered from mastitis. Excluding a few exceptions, the inflammation appeared at the first milking time. The bacteria was almost always *Staphylococcus aureus*. The most severely afflicted (11) were removed as spare animals. Of the heifers remaining in the production experiment (96) 28.1 % suffered from mastitis.

During the second lactation 35.8 % had mastitis, during the third 35.6 % of the cows. Cows with a renewed inflammation during two lactations totalled 11.5 %, and during the three lactations 6.7 %. Many had a repeated inflammation even during the same lactation. Cows (4) with damaged udder tissue or whose milk yields decreased substantially were removed. The low removal rate increased the number of repeated cases of mastitis. *S. aureus* remained the most common bacterial cause. The next most common were *Streptococcus uberis* and *Str. dysgalactiae*. Susceptibility assays were used to find the most effective medications for cows receiving treatment.

Friesians had the highest incidence of mastitis, 48.4 % on average. A contributing factor in the Friesian susceptibility to the inflammation apparently was enlarged, pendulous udders. Inflammation of the rear udder quarters was more common than in the fore udder quarters. In some cases, the inflammation was caused by treading on the teat. About one-fourth of the Ayrshire and Finncattle cows (25.6 and 25.5. %) had mastitis. The milk cell count was the highest among Friesians (Table 10). The cell count of the lower evening milk amount was over 1.5 times higher than in the 1.84 times higher morning milk amount.

Data on mastitis for the entire country do not deviate much from the results of the present experiment. Randomly sampled udder quarters (3 708 cows) showed mastitis in 34.8 % of the milking cows, on average (KOIRA-

Table 9. Mean milking time of first-lactation heifers, milk yield and average milk flow per minute (AMF) and maximum milk flow (MMF) at 30 and 90 days after calving.

	Milking time min. sec.	Milk yield kg	AMF kg/min.	MMF kg/min.
30 days after calving				
Fr	6.55	10.4	1.61	2.17
Ay	5.36	9.9	1.84	2.44
Fc	4.58	8.6	1.76	2.43
90 days after calving				
Fr	7.10	9.3	1.48	2.05
Ay	5.34	9.1	1.74	2.36
Fc	4.44	7.6	1.61	2.16

Table 10. Mean cell counts in morning and evening milk.

	Cells 1000/ml	
	Morning milk	Evening milk
Breed		
First lactation		
Fr	116	153
Ay	105	158
Fc	88	139
Second lactation		
Fr	133	228
Ay	83	126
Fc	98	166
Third lactation		
Fr	188	336
Ay	150	211
Fc	98	194
Diet		
S	137	214
H	106	171
Mean	121	192

NEN 1976). The inflammations were almost always chronic and subclinical. They were detected either in bacterial assays or on the basis of a cell count (CMT test). A rear quarter inflammation was more common than one located in the fore quarter. In samples collected by SALONIEMI (1980), hidden mastitis was present in 36.5 % of the cows, on average, and in the study of LINDSTRÖM et al. (1981) 23.6 %, mostly in the rear quarters of Friesians. The most common bacteria were also the same as in the present experiment. The proportion of *S. aureus* was by far the highest in every determination. The proportion of this bacteria increased over time, from 38.5 % to 47.3 % and 61 % (KOIRANEN 1976, LINDSTRÖM et al. 1981, KANGASNIEMI 1986). Mastitis was the most common illness also in a Danish breed experiment, nor did Finnish Ayrshire differ from the Danish breeds in that experiment (CHRISTENSEN et al. 1984).

Ketosis affected 6.7 % of the cows. Subclinical cases of ketosis were not included; these were all symptomatic ketoses treated by a veterinarian. Its distribution among the cows of the different dietary groups was as follows:

Fr	S1	H1
Ay	S7	H1
Fc	S5	H3

Cases of ketosis in Finncattle were mainly in small, good-yielding cows. Most cases of ketosis in the Ayrshire and Finncattle silage-fed groups (7) affected cows whose calving had occurred in late autumn or mid-winter owing to conception difficulties. Ketosis did not occur from early spring to early summer, when the majority of the cows calved and when the most nutritious silage was fed, being that from the harvest of the previous year.

The considerable difference in cases of ketosis found in the Ayrshire groups fed silage or hay may have been due to the energy balance difference (about 1 FU/day) at the start of the lactations (ETTALA and VIRTANEN 1990 d). In Friesians this difference was smaller than in the other breeds, owing to their good silage intake. The extent of the negative energy balance at the start of the lactations was found by a Norwegian study to be the most important cause of ketosis (DALE et al. 1978). When the energy supply has been equal, no differences in metabolic disturbances have been found between silage and hay diets (BERTILSSON and BURSTEDT 1983). In a breed experiment done in Denmark, Finnish Ayrshire and Danish Friesian cows had significantly fewer nutritional disturbances than did Danish Red (CHRISTENSEN et al. 1984).

With regard to **foot diseases**, hoof inflammations in Friesians were the most common. Heavy cows, weak hooves and little exercise (once a week in an exercise yard) apparently were the main reasons for hoof inflammations. A low incidence of hoof diseases in Ayrshires was also detected in a Danish breed experiment (CHRISTENSEN et al. 1984). In contrast, no differences were found regarding other foot diseases.

Other diseases. Milk fever occurred after the third calving (Ay 1, Fr 2 and Fc 3). Loss of appetite was manifest mainly in the weeks after calving. Bloat was the cause for the removals of two cows of the hay-fed group. The reason was an overly large intake of the cereal ration at one time. Thereafter, large cereal rations were broken up into three or even four smaller rations a day. No symptoms of urea poisoning appeared at all.

Removals

Cows were not removed from the experiment on account of a low production level, because the feed utilization of poor-yielding cows, endurance and economy were also examined. Removals were done only due to diseases, and one cow because of a character disorder (kicker Fr) (Table 11).

Friesians were removed the most, as they had

Table 11. Removals or losses of cows and the reasons during the first three production years.

	Number of cows							
	Fr		Ay		Fc		Total	
	S	H	S	H	S	H	n	%
Sex organ disturbances[1]	1	2	3	—	2	—	8	8.3
Foot diseases	3	1	—	1	—	—	5	5.2
Mastitis	2	1	—		—	1	4	4.2
Bloat			—	2	—	—	2	2.1
Other reasons		1	1	—	—	—	2	2.1
Total	6	5	4	3	2	1	21	
losses	30 %	25 %	20 %	15 %	25 %	12.5 %		21.8

[1] Reasons: prolapse of the vagina, 3 cows; abortion, 3 cows; infertility, 2 cows.

more foot and udder diseases than the other breeds. Disturbances in sex organs comprised the largest removal group, the main reasons being prolapse of vagina during early pregnancy and cases of early abortions after mid-lactation. In all, 21.8 % of the cows were removed during the three production years studied, 25 % of the silage group and 18.8 % of the hay group. Removals were quite evenly distributed between better than average and weaker producers (10 and 11 cows).

The annual removal percentage on the recorder farms during corresponding years was 23.4 % on average (ANON. 1982, 1983, 1984, 1985). The main reasons for the removals were fertility disturbances (26.6 %) and udder diseases (20.9 %). The average age of the cows removed on recorder farms was then 5.8 years, being slightly lower among Friesians than among Ayrshires and Finncattle. The age of the experimental cows after three production years was 5 years, on average. The experiment continued for another three years so that the endurance of the breeds on two home-grown diets would become clear.

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SELOSTUS

Suomalaisen ayrshiren, friisiläisen ja suomenkarjan vertailu säilörehu-vilja- ja heinä-urea-viljaruokinnalla

5. Lisääntyminen, lypsettävyys, sairaudet ja poistot

ELSI ETTALA ja ERKKI VIRTANEN

Maatalouden tutkimuskeskus

Suomalaisen ayrshiren (40 ay), friisiläisen (40 fr) ja suomenkarjan (16 sk) käyttöominaisuuksia selvitettiin kolmen ensimmäisen tuotantovuoden aikana. Koe tehtiin Maatalouden tutkimuskeskuksen Pohjois-Savon tutkimusasemalla säilörehu-vilja- (sr) ja heinä-urea-viljaruokinnalla (hr).

Keskimäärin rodut tiinehtyivät yhtä hyvin. Ayrshirellä ja suomenkarjalla oli säilörehuvaltaisella ruokinnalla vuosittaista vaihtelua. Heikosti tiinehtyneitä yksilöitä ei karsittu kokeesta, mikä lisäsi siemennysten lukumäärää. Keskimäärin siemennyksiä tarvittiin kolmen vuoden aikana poikimista kohti säilörehuvaltaisella ruokinnalla enemmän kuin heinävaltaisella (1.89/1.61), mutta ero ei ollut suuren vaihtelun vuoksi merkitsevä. Tyhjäkausi oli keskimäärin 93 vrk (sr 97 ja hr 89 vrk). Keskimääräiset poikimavälit kolmen vuoden ajalta olivat: ay 375, fr 368, sk 378 vrk, säilörehuvaltaisella ruokinnalla 379 vrk ja heinävaltaisella 367 vrk. Kiimat olivat yleensä hyviä ja säännöllisiä.

Poikimiset olivat helppoja tai normaaleja 93.5 %:lla lehmistä. Vaikeita poikimisia oli lähinnä friisiläisillä ensikkovuonna. Utaremalli ja lypsettävyys oli ayrshire-ensikoilla jonkin verran parempi kuin muilla roduilla. Utaretulehdus oli yleisin sairaus. Friisiläiset sairastivat utaretulehdusta ja sorkkasairauksia enemmän kuin muut rodut. Ketoosia sairasti 6.7 % lehmistä. Ne olivat pääasiassa suomenkarjan ja ayrshiren säilörehuryhmistä. Lehmiä poistettiin vain sairauksien vuoksi, kolmen tuotantovuoden aikana yhteensä 21.8 %: sukuelinhäiriöiden vuoksi 8.3 %, jalkasairauksien tähden 5.2 %, utaretulehduksen 4.2 % ja muiden syiden vuoksi 4.2 % lehmistä.

ANNALES AGRICULTURAE FENNIAE, VOL. 29: 357—367 (1990)

Seria ANIMALIA DOMESTICA N. 97 — Sarja KOTIELÄIMET n:o 97

COMPARISON OF FINNISH AYRSHIRE, FRIESIAN AND FINNCATTLE ON GRASS SILAGE-CEREAL AND HAY-UREA-CEREAL DIETS

6. Economic comparison

AIMO TURKKI, ELSI ETTALA and MARJATTA SUVITIE

TURKKI, A., ETTALA, E. and SUVITIE, M. 1990. **Comparison of Finnish Ayrshire, Friesian and Finncattle on grass silage-cereal and hay-urea-cereal diets. 6. Economic comparison.** Ann. Agric. Fenn. 29: 357—367. (University of Helsinki, Dept. Agric. Econ., SF-00710 Helsinki, Finland.)

The mutual profitability of Ayrshire (40 Ay), Friesian (40 Fr) and Finncattle (16 Fc) dairy cattle breeds given silage and hay-based diets was studied. The material consisted of the results of a dairy cattle experiment conducted at the North Savo Research Station of the Agricultural Research Centre in 1979—1987. The experimental period consisted of the first five milk production years. The animal material for the long-term experiment was collected by random sampling from recorder herds during the calf stage. In the first lactation the material included 96 cows and at the end of the fifth lactation 51 cows.

Of the different breeds, the Ayrshire breed was slightly more economic than the Friesian breed and clearly more profitable than the Finncattle. The annual gross margin of the Ayrshire breed during the five production years was on average FIM 341/cow higher than that of the Friesian breed and FIM 1 678/cow higher than that of the Finncattle. The annual gross output of the Ayrshire and Friesian breeds during the experimental period averaged FIM 3 110—3 370/cow higher than that of the Finncattle. Inversely, the variable costs of the Finncattle were on average FIM 1 089—1 772/cow lower than those of the Ayrshire and Friesian breeds. The physical and monetary feed conversion rate was best for the Ayrshire breed.

The silage-cereal diet was a more profitable feeding alternative than the hay-urea-cereal diet. On these diets, the mean annual gross margins differed by FIM 867/cow in favour of the silage-based diet. There were no differences in the gross output of the cows on silage and hay diets, but the annual variable costs were on average FIM 673/cow lower for the silage groups than for the hay groups.

Index words: economics, dairy cattle, comparison of breeds, comparison of home-grown feedstuffs.

INTRODUCTION

In 1979, an experiment on dairy cattle was started at the North Savo Research Station of the Agricultural Research Centre entitled Economic comparison of Finnish dairy cattle breeds and feed types. The experiment which included two rearing years and six production years ended in 1987. This long-term study which lasted several years compared cattle breeds on home-grown feed-based diets. The study included the dairy cattle breeds used in

Finnish farms: the Ayrshire, the Friesian and the Finncattle breeds. The cows of each breed were on two, home-grown feed-based diets, i.e. the fresh grass silage-cereal diet and the hay-urea-cereal diet.

The experiment was the first experiment, which covered the entire life of a cow, carried out on an economic scale in Finland. Evaluation of the efficacy of home-grown feeds as well as the endurance of the cows requires a long-term experiment. Moreover, possible diet-related diseases and fertility disturbances appear only after several years.

Detailed and individual recording of feeds used in the diet with respective milk yields throughout the experiment (8 years) was relevant for the successful accomplishment of the present study. In other respects, too, the material allowed reliable calculations. A detailed presentation of the results is available also in Finnish (TURKKI 1987).

MATERIAL AND METHODS

At the beginning of the production experiment the number of experimental animals was: 40 Ayrshires (Ay), 40 Friesians (Fr) and 16 Finncattle (Fc). Throughout the experiment, half of the cows in each breed were on a silage-based diet (S) and the other half on a hay-based diet (H). Because of the detailed trial procedures it was possible to collect accurate data for each cow. The feed intake and milk yield were weighed on each feeding and milking occasion. The liveweights, conceptions and diseases of the cows were followed on a regular basis. The slaughter properties of the cows removed from the experiment were evaluated.

The results of the study were affected by genetic factors of the breeds; of the environmental factors, only feeding had any effect. The effect of other environmental factors was eliminated by placing the cows in a new cow stable in similar conditions throughout the year. The reliability of a relatively small sample (experimental cows) was improved also by uniform feeding and equal calving age of heifers. Animal care and follow-up were the same for all the experimental cows throughout the experiment.

The present study used the gross margin analysis to calculate the mutual profitability of the breeds and diets. According to REISCH and ZEDDIES (1977), the mutual profitability of methods applicable to produce a certain product is calculated by considering only the changes in the gross output and costs related to these methods. The present economic comparison of breeds and diets (methods) included only the output and costs of milk production which were closely affected by breed and diet. This gross output included milk sales and calf value as well as slaughter value of cow. Variable costs included feed, insemination, veterinary and replacement costs as well as interest on livestock capital.

The gross margin was calculated by reducing from the gross output the variable costs. The gross margin is in this context the return on fixed costs (building, animal care and overhead costs), and it includes also eventual net profit. The calculation criteria were chosen so as to be suitable for a cattle herd of 15—20 cows. The output and input items were calculated according to the 1987 price level. The reasons for the differences in the profitability between breeds and diets were analysed by calculating the correlation coefficients between gross margin, output and costs. The significance of differences between the experimental groups was tested with the t-test. The variation of the results was described as standard deviation.

Gross output

Milk output was calculated according to milk yield (305-day milk yield) and the price paid for the milk. The milk yields of the first three lactations have been presented in detail by ETTALA and VIRTANEN (1990 c). The average annual milk yields by breed, diet, lactation and throughout the experiment used in the calculations are presented in Table 1.

There was a clear negative correlation between milk yield and milk price. The average milk price was for the Finncattle and the Ayrshire breed FIM 0.08—0.09/kg higher than that for the Friesian breed. The difference of the milk price was due to the lower milk fat and protein contents of the Friesian breed.

The annual milk output of the experimental herd during the five lactations averaged FIM 12 824/cow and the producer price for milk FIM 2.73/kg. The annual milk output of the Ayrshire and the Friesian cows was the same and was FIM 2 300/cow higher than that of the Finncattle on average (Table 2). The differences between the Ayrshire and the Finncattle were in each experimental year highly significant ($P < 0.001$). The mean milk output of the Friesians was in the first, second and third lactations significantly ($P < 0.01$) and in the subsequent years almost significantly ($P < 0.05$) higher than that of the Finncattle. On silage and hay diets the mean milk output (also milk yield) was almost the same each year. The average annual milk output of all cows was 57.2 % higher in the fifth lactation than in the first lactation.

Calf output was FIM 837/cow/yr on average. The mean annual calf output was FIM 104/cow higher for the Friesian than for the Ayrshire breed and FIM 342/cow higher than for the Finncattle. On silage and hay-based diets the mean calf output was of the same magnitude. The calf output was affected by the number of

Table 1. Mean milk yield (kg/cow) of breeds and diets during five lactations.

	Lactation					Mean 1st—5th
	1st	2nd	3rd	4th	5th	
Breed						
Ayrshire	3 529	4 740	4 922	5 135	5 677	4 801
Friesian	3 686	4 798	5 227	5 298	5 464	4 895
Finncattle	2 931	3 785	4 108	4 206	4 624	3 931
Diet						
Silage-cereal	3 477	4 576	4 875	5 037	5 496	4 692
Hay-urea-cereal	3 512	4 618	4 892	5 088	5 456	4 713

Table 2. Mean milk output (FIM/cow) of breeds and diets during five production years.

	Production year					Mean 1st—5th
	1st	2nd	3rd	4th	5th	
Breed						
Ayrshire	9 727	13 102	13 646	14 129	15 606	13 242
Friesian	9 849	12 846	13 993	14 196	14 675	13 112
Finncattle	8 081	10 520	11 447	11 460	12 856	10 873
Diet						
Silage-cereal	9 459	12 483	13 395	13 701	15 007	12 809
Hay-urea-cereal	9 547	12 606	13 325	13 834	14 881	12 839

calves sold (pcs/yr) and the sales value of the calves. The calf yield varied, depending on calf mortality and calving intervals.

Slaughter output of the experimental cows averaged FIM 1 262/cow/yr. The mean slaughter output for the Friesians was FIM 376/cow higher than that for the Ayrshire breed and FIM 528/cow higher than that for the Finncattle. The difference was due to the higher slaughter weight and the lower endurance of the Friesian breed. The annual slaughter output was on average FIM 260/cow higher on silage than on hay feeding.

Gross output of the experimental herd was on average FIM 14 921/cow/yr, with an increase from the first to the fifth production year of 47.2 %. The average annual gross output of the Friesians was FIM 260/cow higher than that of the Ayrshire breed because of higher calf and slaughter output (Table 3). The annual gross output of the Finncattle was FIM 3 110—3 370/cow lower than that of the Ayrshire and Friesian breeds on average ($P < 0.001$). On silage and hay-based diets the gross output was almost similar. Milk output accounted for 86 % and meat output for 14 % of the gross output on average. The ranking of the cows according to gross output in the first lactation changed significantly as compared to the second and third experimental years.

Variable costs

Feed costs were calculated according to the feed quantities consumed and average feed prices. ETTALA and VIRTANEN (1990 b) presented in their publication the feed intake by cows during the first three production years. The average feed costs of different breeds on different diets during the first five lactations and throughout the experiment are presented in Table 4. The feed costs of each cow were calculated for the same period as the milk output (maximum 305 days).

The annual feed costs of the experimental herd during the first five lactations averaged FIM

Table 3. Mean gross output (FIM/cow) of breeds and diets during five production years.

	Production year					Mean 1st—5th
	1st	2nd	3rd	4th	5th	
Breed						
Ayrshire	11 741	15 091	15 643	16 080	17 534	15 218
Friesian	12 189	15 357	16 458	16 565	17 231	15 560
Finncattle	9 648	12 161	13 009	13 072	14 344	12 447
Diet						
Silage-cereal	11 591	14 721	15 579	15 934	17 317	15 028
Hay-urea-cereal	11 567	14 664	15 323	15 751	16 841	14 829

Table 4. Mean feed costs (FIM/cow) of breeds and diets during five lactations.

	Lactation					Mean 1st—5th
	1st	2nd	3rd	4th	5th	
Breed						
Ayrshire	4 995	6 418	6 635	6 868	7 432	6 470
Friesian	5 238	6 835	7 040	7 065	7 328	6 701
Finncattle	4 262	5 465	5 715	5 938	6 471	5 570
Diet						
Silage-cereal	4 587	6 088	6 213	6 157	6 830	5 975
Hay-urea-cereal	5 361	6 733	7 025	7 367	7 622	6 822

6 420/cow. The feed costs of the fifth production year was 46 % higher than for the first year, i.e. the feed costs increased slightly less than milk output. The positive correlation of feed costs and milk output during the experimental years varied between 0.40 and 0.59 for the Ayrshires, between 0.61 and 0.85 for the Friesians and between 0.64 and 0.74 for the Finncattle.

The annual feed costs for the Friesian cows were on average FIM 370/cow higher than for the Ayrshire cows and FIM 1 130/cow higher than for the Finncattle ($P < 0.01$). The difference in feed costs between the Ayrshire breed and the Finncattle, too, was statistically significant ($P < 0.01$) in each experimental year. The annual feed costs of the silage groups were on average FIM 850/cow lower than that of the hay groups ($P < 0.001$). The difference was due to the lower intake of concentrate and the lower prices of roughage in the silage groups.

The feed costs were on average half of the milk output, i.e. the monetary feed conversion rate was 0.50. The feed cost/milk output ratio was best (lowest) for the Ayrshire breed (0.49) and for the silage groups (0.47). The feed costs during the dry period, which lasted 66 days on average and which was not taken into consideration in these calculations, was for the entire experimental cattle FIM 1 000/cow.

Insemination costs were FIM 150/cow/yr on average. The experimental cows required 1.72 inseminations on average per gestation. The insemination costs by breed were almost the same. In the hay groups the mean annual insemination costs were FIM 20/cow lower than for the less fertile silage groups. There was no statistically significant correlation between insemination costs and any of the output and cost items.

Veterinary costs included expenses related to treatment and veterinarian visits due to mastitis, ketosis and downer syndrome. These amounted to FIM 147/cow/yr on average. These costs increased with aging of the cows. The veterinary costs were lowest for the Ayrshires and on hay diet and highest for the Finncattle and on silage diet. There was no significant correlation between these costs and any of the output and cost items either.

Replacement costs of the experimental herd averaged FIM 2 222/cow/yr. The mean annual replacement costs were FIM 608/cow lower for the Finncattle than for the Friesian breed and FIM 244/cow lower than for the Ayrshire breed. There was a difference in replacement costs of FIM 122/cow/yr on average between cows on silage and those on hay-based diet. These costs varied according to the endurance of cows and differences in heifer price. The Friesian breed was clearly less enduring than the other breeds. A Finncattle heifer was considerably less expensive than the Ayrshire and Friesian heifers.

Interest on livestock capital consists of costs related to livestock capital (interest) during the production period. This averaged FIM 395/cow/yr at an interest rate of 5 %. The livestock capital was defined as half of the sum of the heifer price and the cow's slaughter value. The interest on livestock capital was lowest for the Finncattle and highest for the Friesian breed.

Total variable costs of the experimental herd during the five production years amounted to FIM 9 334/yr on average. The variable costs were in the fifth production year 31 % higher than in the first production year mainly due to increased feed costs. Thus the variable costs increased during the experimental period clearly less than the gross output. On average, feed costs accounted for 68.8 %, insemination costs for 1.6 %, veterinary costs for 1.6 %, replacement costs for 23.8 %, and interest on livestock capital for 4.4 % of the total variable costs.

The variable costs by breed and diet are presented in Table 5. The annual variable costs for the Friesian breed were on average FIM 683/cow higher during the experimental years than for the Ayrshire cows ($P < 0.01$) and FIM 1 772/cow higher than for the Finncattle ($P < 0.01$). The differences in total variable costs were mainly due to feeding and herd replacement. The lowest feed and replacement costs of the Finncattle were due to the lower feed requirement, lower liveweight, lower heifer price and high endurance of the cows as compared to the other breeds. For opposite reasons the feed and replacement costs for the Friesian breed were highest.

The annual variable costs were on average FIM 673/cow lower on the silage groups than in the hay groups ($P < 0.01$), mainly because of the lower feed costs. The other variable cost items were slightly higher for the silage groups than for the hay groups, but they affected the differences in the total variable costs very little.

Gross margin

The annual gross margin of the experimental cows during the five production years averaged FIM 5 587/cow and the annual margin of milk output over feed costs was FIM 6 403/cow. In the different production years these economic measures of the experimental cattle are presented in Fig. 1. The gross margin was in the fifth production year 81.5 % higher than in the first year on average. The gross margin increased most in the second year (44 %) and least in the fourth year (2 %). Cows were not removed from the experiment due to poor milk yield, only in the case of sickness. Great individual variation was thus expected. The gross margin of five production years of the best cow averaged FIM 8 432/yr and that of the poorest cow FIM 2 753/yr.

The gross margin by breed and diet in the different production years and throughout the experimental period is presented in Table 6. The Ayrshire breed had the best average annual gross margin in each year and the Finncattle the poorest. The annual gross margin of the Ayrshire cows was on average FIM 1 678/cow higher than that of the Finncattle ($P < 0.001$). The overall annual gross margin of the Friesian breed was only FIM 341/cow lower than that of the Ayrshire breed, but FIM 1 337/cow

Table 5. Mean variable costs (FIM/cow) of breeds and diets during five production years.

	Production year					Mean 1st—5th
	1st	2nd	3rd	4th	5th	
Breed						
Ayrshire	7 736	9 148	9 404	9 628	10 268	9 238
Friesian	8 383	10 029	10 256	10 345	10 591	9 921
Finncattle	6 754	7 934	8 191	8 659	9 220	8 149
Diet						
Silage-cereal	7 532	9 032	9 189	9 208	9 968	8 979
Hay-urea-cereal	8 152	9 547	9 814	10 236	10 491	9 652

Table 6. Mean gross margin (FIM/cow) of breeds and diets during five production years.

	Production year					Mean 1st—5th
	1st	2nd	3rd	4th	5th	
Breed						
Ayrshire	4 005	5 943	6 239	6 452	7 266	5 981
Friesian	3 806	5 328	6 202	6 220	6 640	5 640
Finncattle	2 894	4 227	4 818	4 413	5 124	4 303
Diet						
Silage-cereal	4 059	5 689	6 391	6 726	7 349	6 046
Hay-urea-cereal	3 415	5 117	5 508	5 515	6 350	5 179

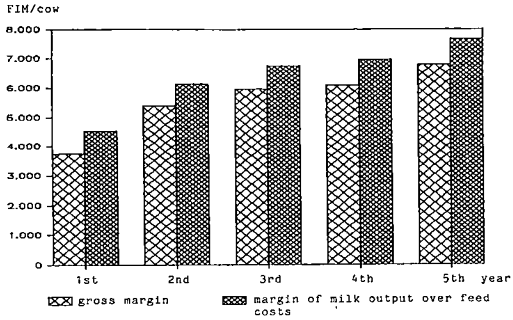

Fig. 1. Average annual gross margin and margin of milk output over feed costs (FIM/cow) during five experimental years.

higher than that of the Finncattle ($P<0.05$).

The annual gross margin for cows was throughout the production years higher on the silage-cereal diets than in the hay groups, the difference being on average FIM 867/cow ($P<0.05$). The gross margin of the Ayrshire cows increased most during the experimental years (FIM 3 261/cow, 81.4 %) and that of the Finncattle least (FIM 2 230/cow, 77.1 %). On silage and hay diets the gross margin of the cows increased almost equally (Table 6).

The factors affecting the profitability of the experimental groups are presented in Table 7 which shows the average annual gross output, variable costs and gross margins by breed and diet (FIM/cow) during five production years. The output of Ayrshire cows was on average 2.2 % lower and the variable costs 7.4 % lower than those of the Friesians. The slaughter value as well as the feed and replacement costs of the Friesian cows were higher than those of the Ayrshire cows. The slightly higher gross margin of the Ayrshire breed as compared to the Friesian breed was mainly due to the lower variable costs of the Ayrshire cows.

The variable costs of the Finncattle were on average 13.4 % lower than those of the Ayrshire cows and 21.7 % lower than those of the Friesian breed. Despite this the Finncattle had the lowest profitability of the breeds investigated, because the gross output of the Finncattle was 22.2 % lower than that of the Ayrshire cows and 25 % lower than that of the Friesian breed. For the Finncattle the variable costs accounted for 65.4 %, for the Friesian breed for 63.8 % and for the Ayrshire breed for 60.7 % of the gross receipts.

On the silage-cereal diets the annual gross output of the cows was on average 1.3 % higher but the variable costs were 6.3 % lower than those of the hay groups. The variable costs accounted for 61.5 % of the gross receipts in the silage groups and for 66.2 % in the hay groups. Thus, even the diets, mainly their costs, caused a difference in profitability between the feeding groups, because the output of the cows was similar on both diets.

The reasons for the differences in profitability between the experimental groups (breeds and diets) were analysed also with the correla-

Table 7. Mean annual output, costs and gross margin (FIM/cow) of breeds and diets during five production years.

	Ay	Fr	Fc	S	H
Milk sales	13 242	13 112	10 873	12 809	12 839
Sales value of calf	839	935	593	820	854
Slaughter value	1 138	1 514	986	1 396	1 138
Gross receipts	15 219	15 561	12 452	15 025	14 831
Feed costs	6 470	6 701	5 570	5 975	6 822
Insemination costs	151	149	148	160	140
Veterinary and medicine costs	110	173	203	158	138
Replacement costs	2 117	2 481	1 873	2 286	2 162
Interest on livestock capital	390	417	355	400	390
Variable costs	9 238	9 921	8 149	8 979	9 652
Gross margin, FIM	5 981	5 640	4 303	6 046	5 179

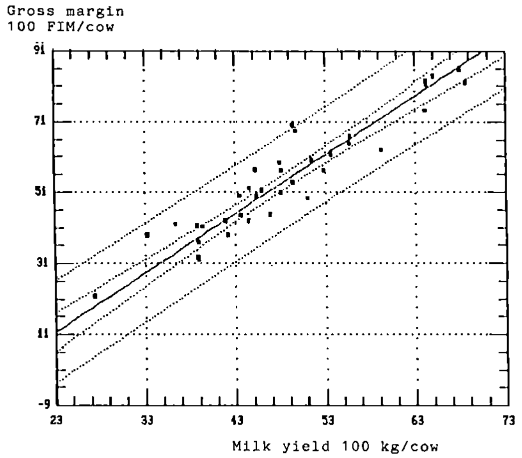

Fig. 2. Relationship of gross margin to milk yield for Friesian cows in the second lactation.

tion analysis. The milk yield, milk output and gross receipts correlated positively with the gross margin in all groups ($P<0.001$). The correlation between variable costs and gross margin was not equally consistent. With increasing variable costs as well as feed costs of the Friesian breed and the Finncattle, the gross margin also increased, but these correlations were statistically significant only for the Friesian cows ($r = 0.53$—0.70). In some years for the Finncattle also the veterinary and medicine costs and insemination costs were positively correlated with the gross margin ($r = 0.35$—0.50). For the Ayrshire cows there was no significant correlation between costs and gross margin.

The gross margin and correlation analyses showed consistently the factors which had caused the differences in profitability of the experimental groups. The differences in the gross margins of the diets (hay/silage) were almost only due to different feed costs. Inversely, within in the different breeds both the output and costs affected the differences in the gross margin. For the Ayrshire breed the variable costs were of an average size, but output was higher than average. Thus the total variable costs/gross output ratio (0.58—0.60) as well as the monetary feed conversion rate (0.45—0.49) were the best (lowest) for the Ayrshire cows.

Of the individual characteristics, the milk yield and the feed conversion rate correlated most closely with gross margin. Fig. 2 shows the gross margin of the Friesian breed in the second production year as a function of milk yield (the estimated linear equation was: $y = -2663 + 1.67x$, y = gross margin, x = milk yield, $R^2 = 0.88$).

In all groups the ranking of cows in terms of milk yield was almost the same as the ranking of cows in terms of gross margin. Thus the milk yield describes quite reliably the mutual profitability of cows. The high-yielding cows were clearly more enduring (longer living) and slightly less diseased than the low-yielding cows. Moreover, good producer cows were in general able to increase their milk yield more than poor producer cows.

DISCUSSION

The cows included in the present study were randomly selected from the whole cow population of recorder herds. The production characteristics the experimental cows (sample) were compared with those of recorder cows (population). In this comparison the breed-related characteristics were quite consistent and the sample was thus representative of the population.

According to calculations, the heavier breeds (Ay and Fr) are more economic than the slightly lighter Finncattle which is characteristically a milk breed. The production characteristics of the Finncattle (milk- and meat-producting ability) are so much lower than those of the Ayrshire and Friesian breeds that despite the low costs the profitability of the Finncattle was lowest.

HUHTANEN (1982) reached the same conclusion in a profitability study on recorder cows of the same breeds. The slightly lighter native dairy cattle breed was shown also in Swedish studies less profitable than the heavier dual purpose breeds and cross-breeds (BRÄNNÄNG et al. 1979, OSCARSSON 1979). Also in Sweden the lowest gross margin of the native breed was due to the lower milk yield and lower beef production as compared to the cross-bred cows. Consideration of fixed costs did not affect the differences in the profitability of pure-bred and cross-bred cows. Also in other foreign studies (e.g. MARINKOV et al. 1974, OLDENBROEK 1984) the profitability ranking of the breeds has been the same as the average milk yield ranking. Thus the production characteristics of the cows (milk and beef production) affect the breed differences clearly more than other characteristics (fertility, health, endurance) and play a decisive role in an economic comparison of breeds.

The present study confirms the conception of the profitability of grass silage as a basic feed for dairy cows in Finland. The economic superiority of silage-cereal diet was only due to the lower feed costs, because the milk yield and milk output were of the same magnitude both on silage and hay-based diets. The feed conversion rate of the silage groups was better than that of the hay groups.

The milk production ability and feed conversion rate are in economic terms the most important single production characteristics. These alone quite reliably describe the mutual profitability of cows. In practice it is important also that the margin of milk output over feed costs measures almost equally reliably the relative profitability of cows as the gross margin. For the calculation of gross margin, gross receipts and total variable costs are taken into consideration.

The order of mutual profitability of cows grouped by breeds and diets was the same in each production year. Moreover, in each group the development of the cows was quite similar with advancing experiment and thus they maintained quite well the ranking of the first year according to milk yield and gross margin. Also BALAINE et al. (1981) stated that the milk output, gross receipts, feed costs and veterinary costs of the first lactation cows predict significantly the effect of these factors on the profitability in the overall production of cows. This information is important with respect to buying and selling of cows and their selection.

According to the present study, cows should be kept in production longer than is the practice today. The milk yield, milk output and gross margin of most experimental cows were highest in the last year of the experiment. The result is consistent with the study on an optimum herd life by ZEDDIES (1972).

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SELOSTUS

Suomalaisen ayrshiren, friisiläisen ja suomenkarjan vertailu säilörehu-vilja- ja heinä-urea-viljaruokinnalla

6. Taloudellinen vertailu

Aimo Turkki, Elsi Ettala ja Marjatta Suvitie

Helsingin yliopisto ja Maatalouden tutkimuskeskus

Ayrshiren, friisiläisen ja suomenkarjan suhteellinen kannattavuus selvitettiin kahdella, maatiloilla tuotettuihin rehuihin perustuvalla ruokinnalla. Aineistona olivat Maatalouden tutkimuskeskuksen Pohjois-Savon tutkimusasemalla vuosina 1979—1987 suoritetun lypsykarjakokeen tulokset. Tutkimusperiodi käsitti viisi ensimmäistä maidontuotantovuotta. Lehmiä oli ensimmäisellä lypsykaudella 96 ja viidennen lypsykauden lopussa 51.

Koeryhmien (rodut ja ruokinnat) keskinäistä kannattavuutta arvioitiin katetuottolaskelmalla. Sitä varten määritettiin rodun ja ruokinnan mukaan vaihtelevat tuotot ja kustannukset. Laskelmat laadittiin eri tuotantovuosille sekä koko koekaudelle keskimäärin lehmää ja vuotta kohti. Panokset ja tuotokset hinnoiteltiin vuoden 1987 hintatason mukaan. Laskentaperusteet valittiin 15—20 lehmää käsittävälle karjalle soveltuvina.

Roduista ayrshire osoittautui hieman taloudellisemmaksi kuin friisiläinen ja selvästi kannattavammaksi kuin suomenkarja. Ayrshiren katetuotto oli keskimäärin 341 mk/lehmä/v parempi kuin friisiläisen ja 1 678 mk/lehmä/v suurempi kuin suomenkarjan. Ayrshiren ja friisiläisen tuotot olivat 3 110—3 370 mk/lehmä/v korkeammat kuin suomenkarjan. Suomenkarjan muuttuvat kustannukset olivat 1 089—1 772 mk/lehmä/v ayrshireä ja friisiläistä alhaisemmat. Fyysinen ja markkamääräinen rehuhyötysuhde oli roduista paras ayrshirelehmillä.

Ruokintamuodoista säilörehu-viljaruokinta oli jokaisena lypsykautena heinä-urea-viljaruokintaa kannattavampi vaihtoehto. Näillä ruokinnoilla katetuotto erosi tutkimuskaudella keskimäärin 867 mk/lehmä/v. Ruokintamuotojen tuotot olivat yhtäläiset, mutta säilörehuryhmän lehmien muuttuvat kustannukset olivat alhaisempien rehukustannusten johdos-

ta keskimäärin 673 mk/lehmä/v pienemmät kuin heinäryhmän lehmillä.

Koelehmien tuotot olivat viiden tutkimusvuoden aikana keskimäärin 14 921 mk, muuttuvat kustannukset 9 334 mk ja katetuotto 5 587 mk lehmää ja vuotta kohti. Katetuotto parani lehmien ikäännyttyä ollen viidentenä tuotantovuonna 81,5 % ensikkovuotta korkeampi. Edistyminen oli suurinta toisella lypsykaudella.

Tuotokset, tuotot, muuttuvat kustannukset ja katetuotto vaihtelivat suuresti lehmien kesken kussakin koeryhmässä. Lehmien ominaisuuksista maitotuotos ja rehuhyötysuhde olivat kiinteimmässä vuorosuhteessa katetuoton kanssa. Lehmän tuotanto-ominaisuudet olivat käyttöominaisuuksia tärkeämmät kannattavuuden näkökulmasta.

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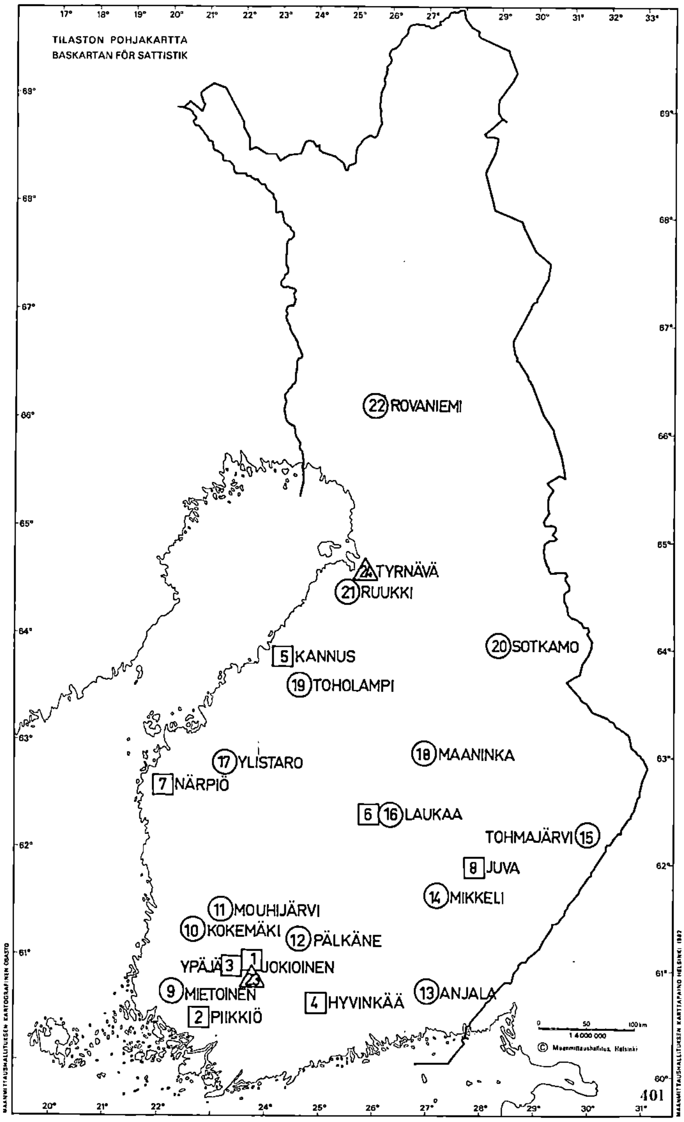

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