

**INCORPORATION OF MILK CONTENT TRAITS INTO A BREEDING PROGRAM****E. A. Mäntysaari****Summary**

Although it is commonly agreed that the breeding goal in milk composition should be towards increased (or unaltered) protein-% and decreased fat-%, in most breeding programs high fat percentage is favored either directly or indirectly via selection for high protein-%. Even in single trait selection for protein-%, due to high correlation between content traits and a bigger variability in fat-% the correlated response in fat-% can be larger than direct improvement in protein-%. In Finland the percentage traits have been considered in the national breeding since 1988. The goal to decrease fat-% has been adopted, and as a result bulls born after 1990 have about -.25%-units lower fat content of milk than bulls born 1985-87. In 1990 an open nucleus embryo transfer breeding program was established that employed alternative breeding goal in milk composition. The aim was to raise the protein to fat ration in milk by increasing the protein content while the same time keeping the fat-% unaltered. Relative weights for traits were chosen that gave equal importance to protein yield and percentage, with simultaneous negative weight on fat-%. During the four years of operation 291 cows have been flushed, and 1607 embryos have been transferred. Till now 766 calves have been born. In 1995 first 95 ET-daughters were evaluated with national animal model program. Their protein-% BLUPs were +. 14 above the group of heifers born same year, and the protein yield BLUPs were 12 kg above analogous group mean. The fat-% breeding values were in same level as in the year class.

*Introduction*

The dairy industry world wide has a relatively uniform opinion of desirable goals in milk quality and milk composition. The milk produced should fulfill requirements in microbiological and organoleptic quality, and have a minimum of harmful residues. In the composition of milk the generally accepted goal is to increase the protein-%, but for the fat-% opinions are more diverse. In

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Finland animal breeders and dairy processing industry have reached to an agreement that the desired goal in our conditions would be milk with high protein to fat ratio (P/F) accompanied with fat-% as low as possible. This is based on three reasons: i) The consumption of dairy products has clearly shifted towards lowfat products rich in protein. In retail milk liquids the average fat-% was 3.44 in 1988, while in 1993 only 3.08%. The consumption of cheese has steadily increased, while the use of butter has dropped. In 1993 the average consumption of butter fat in total was 14.8 kg per capita, decreased from 20.3 kg in 1984. ii) The Finnish dairy industry had adopted a strategy to sell the surplus production to world market in high premium cheese products. Naturally butter has been exported as well, but cheese has been favored because of higher price. iii) Compared to average milk produced in Europe the raw milk in Finland has a quite low P/F, being 0.73 (Table 1). This ratio forces cheese manufacturers, as well as dairies packing consumption milk to buy 25 percent more milk fat from producers than what they sell in their main products.

Table 1. - RESULTS FROM MILK RECORDING IN 1994 FOR FINNISH AYRSHIRE, AND FINNISH FRIESIAN (ASSOC. OF RURAL ADVISORY CENTERS, 1995)

	Ayrshire	Friesian
No. Cows	212,225	55,292
Milk kg	6896	7158
Protein kg	227	230
Protein-%	3.29	3.21
Fat kg	309	296
Fat-%	4.48	4.13
Protein/Fat ratio	0.73	0.78

To encourage the breeding for desired milk composition the producer price of milk in Finland gave no value to fat. The base price in 1994 was 3 Fmk per liter and the protein differential 0.5 Fmk per 1 %-unit of protein. As the feeding costs are related to fat content, in theory the economic weight for fat-% became negative. From the beginning of 1995 the producer price dropped to 2 Fmk/liter, the protein differential to 0.40 Fmk/1%, and the fat-% was given a value of 0.125 Fmk/1%. This change returned the positive economic weight of fat-% in breeding goal.

Research on selection response in dairy cattle has shown that typical selection criterion leads into undesired changes in milk composition. Typically fat production is overemphasized thus leading either in larger genetic improvement in fat-% compared to protein, or to no changes in protein-% at all. Even if the selection pressure is given to protein-% it seems that the absolute correlated response can be larger in fat-% than the direct improvement



in protein-%. This leads rather surprising estimates of genetic correlations between component traits. In their review Person et al., (1990) reported a  $r_g$  of -.12 between PF/ and protein-%. Based on the estimates they collected, the selection solely on component yields can decrease the P/F unless relative weight given to protein yield is at least 55% (in actual kg units 88%) more than that for the fat yield. If negative weight is given to milk volume, then even heavier relative weight is required for protein.

*Milk traits in finnish national AI - breeding program*

In Finland the national breeding program attempts to change the protein and fat percentages in milk. The change is directed into lowering the fat-% and slightly increasing the protein-%. Thus, the dry matter content in milk decreases. This goal is implemented by including the percentage traits directly in the total merit index (TMI) of bulls and cows. Table 2 lists the changes in weights of milk production traits in TMI of bulls since 1981. The weights are expressed relative on standard deviations of the traits. Up to 1990 the weights were on protein production and fat corrected milk, but after that the breeding goal in composition has been directly formulated in weights for protein and fat percentages. If the same target would be accomplished using bull breeding value indices of protein, fat, and milk volume yields (without standardization), the comparable coefficients would be 1.7-0.25, and -0.01, respectively. If these are applied into finnish Ayrshire AI bull evaluations, using currently practiced selection intensity, the predicted improvement in protein yield would be 1.3 and the improvement in proten-% would be 0.4 sire standard deviations for each round of selectin. In Figure 1 results using Finnish index weights are compared to outcome of selection using solely protein yield index, or corresponding milk trait weights used in Netherlands (Oldenbroek, et al., 1994).

Table 2 - THE WEIGHTS OF MILK TRAITS IN TOTAL MERIT INDEX OF DAIRY BULLS IN FINLAND. COEFFICIENTS ARE RELATIVE TO THE STANDARD DEVIATIONS OF THE BREEDING VALUE INDICES OF CORRESPONDING TRAITS

Year	Fat Corrected	Protein	Protein-%	Fat-%
1981-1983	1.0			
1983-1987	0.5	0.5		
1987-1988	0.4	0.6		
1988-1990		1.0		
1990		0.8	0.3	-0.3
1990-1991		0.8	0.3	-0.4
1991-1993		1.0	0.3	-0.4
1993-		1.0	0.5	-0.4

Figure 1. - PREDICTED EFFECT OF DIFFERENT SELECTION CRITERIAS OF BULLS  
 Finnish TMI = 1.7 \* Protein -0.25 \* Fat yield -0.1 \* Milk; Protein = 1.0 \* Protein;  
 Dutch 1994 = 1.2 \* Protein +0.20 \* Fat yield -0.015 \* Milk

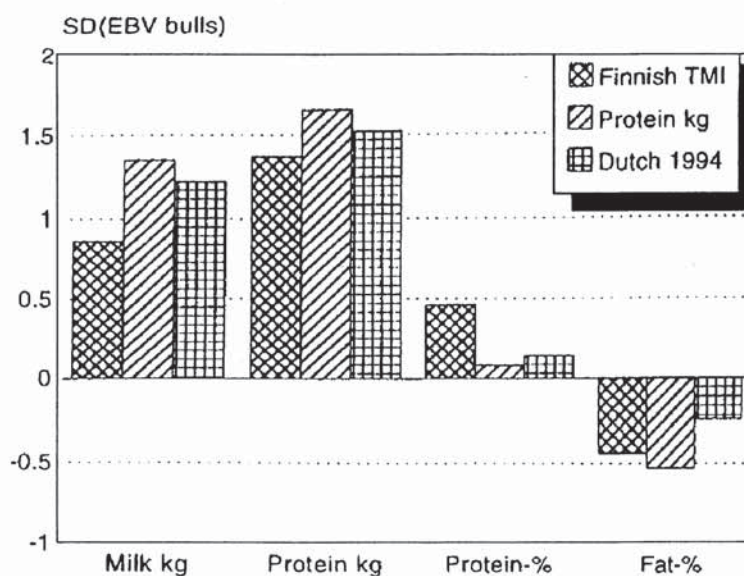
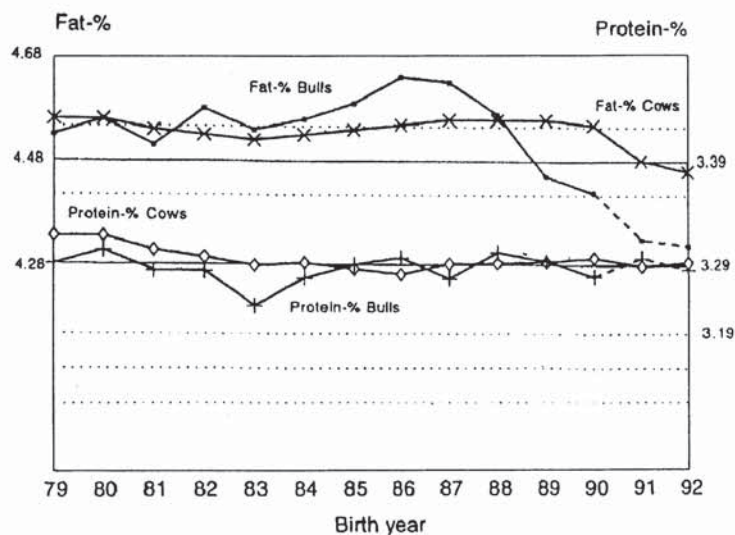


Figure 2. - BREEDING VALUE ESTIMATES FOR BULLS AND COWS BY BIRTH YEAR FROM THE ANIMAL MODEL EVALUATIONS 1994/95. THE PEDIGREE INDICES OF YOUNG BULLS ARE MARKED WITH ...





The effectiveness of selection can be visualized by examining the yearly means of national animal model (AM) breeding value indices for animals (Figure 2). The breeding values for fat-% in bulls were increasing until 1986 but after that the changes in breeding goal started to affect. From 1987 to 1990 the genetic change in fat-% has been -0.21 %-units, and it can still be predicted to decrease another -0.1 %-units in the next two years. In heifers the drop in fat-% follows with a lag of 3 years, and with about half of the size.

#### *ASMO project*

In 1990 the organizations involved with Finnish dairy breeding operations and research (Agricultural Research Center -MTT; Finnish Animal Breeding Association -FABA) and milk marketing (Valio Co-op Dairies' Assoc.) and the Ministry of Agriculture and Forestry established an open nucleus multiple ovulation and embryo transfer (MOET) breeding program (Nicholas & Smith, 1983) called ASMO (see, Hyppänen et al., 1992). The goal was to test effectiveness of MOET program, but also to implement an alternative breeding goal for milk composition. The relative weights for the traits were chosen so that both the protein-% and protein yield would be improved and that the progress in them would be equal in terms of standard deviation of AM indices. Negative weight was given to fat-%, large enough to keep fat content unaltered.

The proposed ASMO breeding program consisted of 100 base cows per year. They were selected using AM indices for protein yield, and protein and fat percentages. These selected cows were superovulated, inseminated with selected ASMO bulls, and flushed for embryos. The mating was with progeny tested AI bulls selected according to milk traits, but considering also the national total merit indices. Each donor was meant to produce eight offspring, from an average of three flushings.

#### *Selection response*

Selection that started in 1990 considered Ayrshire cows only. Friesians were first time accepted into the program in 1993. By December 1994 a total of 293 cows have been selected into the program. Early in the project an additional selection rule was applied to donor candidates to facilitate the further marketing of flushed embryos: The production of chosen cows had to exceed the national average. This rule, and strict selection on AM indices, has resulted in a respectful group of donor cows (Table 3) with average life time production of 8207 kg with protein-% of 3.52% and fat-% of 4.21%.

Table 3 - AVERAGE PRODUCTION RECORDS OF 293 COWS IN ASMO PROJECT

	Ayrshire	Friesian
No. Cows	268	25
Milk kg	8123	9107
Protein kg	286	314
Protein-%	3.53	3.44
Fat kg	345	335
Fat-%	4.26	3.67
Protein/Fat ratio	0.83	0.94

The desired response to selection was achieved, as the breeding value indices of all Ay-donors were on average 111 for protein yield and 111 for protein-% (Table 4). Although no clear change downwards was planned for fat-%, it has slightly gone down. The larger than expected change in fat-% is even more evident in Friesian breed, where the selected animals have clearly been more of the type of the conventional bull dams.

Table 4 - AVERAGE ANIMAL MODEL BLUP INDICES OF 293 COWS FOR MILK TRAITS IN ASMO PROJECT (BASE = AY BULLS BORN 1986-88)

	Ayrshire	(index) <sup>1</sup>	Friesian	(index)
No cows	268		25	
Milk kg	+98	103	+651	108
Protein kg	+10.9	111	+23.0	117
Protein-%	+1.42	111	+0.36	112
Fat-%	-.119	96	-.511	91

<sup>1</sup>Finnish animal model indices are standardized for a mean of 100 and standard deviation 10.

In embryo transfers (ET), 29 different sires have been used for Ay donors and 8 different for Fr donors. Using estimated breeding values for parents, the pedigree indices can be calculated for the recovered embryos (Table 5). Although some slippage towards the national breeding program can be seen, on average the embryos are in terms of the breeding values equally superior in protein yield and protein-%. Of the daughters from the first embryos transferred in 1990 and -91, already 95 have their own production information and thus have obtained breeding value estimates in 1995. Their AM indices agree well with the expectations. The average protein yield index was 111 and the protein-% index 109. For comparison, table 5 lists also the averages of indices for daughters of official bull dams that have calved first time in 1994. The distinction in these groups is clear in protein-% and fat-% both being lower in bull dam daughters. Interestingly the ASMO daughters are comparable to be bull dam daughters also in TMI. The average for the first generation ASMO



cows was 18.8 while for bull dam daughters it was 19.4. The TMI for cows gives a weight of 1.0 for protein yield, +0.5 for protein-%, -0.4 for fat-%, and +0.2 for somatic cell count AM indices.

Table 5 - COMPARISON OF AM INDICES OF ASMO EMBRYOS, ASMO HEIFERS AND DAUGHTERS OF CONVENTIONAL AI-BULL DAMS. ONLY AYRSHIRE ANIMALS IN AVERAGES

	ASMO embryos	ASMO daughters calved	Bull dam daughters
Number	1574	95	306
Milk index	102	104	112
Protein index	110	111	114
Protein-%	111	109	101
Fat-%	95	94	91
Total Merit Index		+18.8	+19.4
Max TMI		+49	+39

#### *ET results*

Of the 293 cows selected to the project 291 were superovulated and flushed 454 times (Table 6). From these flushing, altogether 2,751 embryos were recovered. In 38 cases (not included in 454) the donor did not respond to the superovulation treatment. On average, 66% of the recovered embryos were transferable, thus yielding an average of 3.99 accepted embryos per flush. The figure was slightly higher (4.18) in first the flushing. This average is depressed by the 131 flushing (29%) where no accepted embryos were found. If the average embryo yield were calculated from the successful flushing, the result would become respectively 5.6 accepted embryos per treatment. In 9% of the cases more than 10 embryos was found, and in its best, the superovulation has generated 23 accepted embryos.

Table 6 - FLUSHING RESULTS IN ASMO PROJECT

	Flushing			Total
	1st	2st	3rd	
No flushes	291	128	35	454
No embryos per/flush	6.17	5.91	5.69	6.06
Transferable per/flush	4.18	3.57	3.91	3.99
Percent transferab.	6.77	60.6	68.8	65.8
Percent flushing				

By the end of 1994 the total number of transfers with fresh embryos was 756 with an average pregnancy rate of 60.3%. The rest of the embryos, 1045, were frozen and almost all of these have also been transferred. From the latter, the pregnancy results are available from 846 transfers, where the success rate was 43.5%. Information has been collected from 367 bull calves and 292 heifer calves born alive. During the project, AI cooperatives have bought 76 ASMO bull calves. They have, however, had high culling at the performance test station, and so far only 34 have been accepted to AI usage, while 23 have been removed due to poor growth capacity.

Table 7 - NUMBER OF TRANSFERS AND THE PREGNANCY RATE

	Fresh	Frozen
Transfers	756	1045
Transfers with Percent conceived	60.3	43.5
Calves born		
Heifers	292	

### *Conclusions*

The purpose of the ASMO project was to change the P/F by increasing the protein content. This goal has been well fulfilled. In the Ayrshire breed, the genetic superiority of the first generation ASMO calves (embryos) has been estimated to be +9.9 kg protein, +.15 protein-%, and -.15 fat-%. Due to change in milk yield and fat-%, the fat production of selected material should be slightly less than the population average. Thus, the new P/F can be expected to be at least 0.79, which is a clear improvement over 0.73 found in milk recorded Ayrshire population. Such a change, when extrapolated to the total milk production of Finland, would mean that with a fixed milk protein production about 4.1 million kilograms less milk fat is produced. This change will be disseminated to the commercial population through AI sires. The first daughters of ASMO young bulls are expected to calve in the latter half of 1995.

The management of an open nucleus MOET program has been discovered to be problematic because of an insufficient control over the animals selected. In the original plan, the target was 8 pregnancies per selected donor, but an average of only 3-4 has been realized. This results from the disinterest of farmers to allow their cows to be flushed more than once. Only 35 cows from 291 participating were flushed three times. This reluctance against ET is caused by concern over the possible decrease in milk yield, prolonged calving interval, risks for reproductive health, cost of the superovulation, etc. These



reasons accompanied with the possibility that the superovulation does not result in any transferable embryos, seem to generate too large a risk for a small scale producer.

It seems obvious that the produced alternative breeding material cannot be effectively dispersed nationally and internationally if the top cows are not used more effectively. Improvements are needed in technical efficiency of ET, as well as in possibilities to control the use of selected donors. Thus, we have made a proposal for establishing a centralized MOET herd, that would be formed using the second generation animals provided by the ASMO program.

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#### UKLJUČIVANJE OSOBINA SADRŽAJA MLIJEKA U PROGRAM UZGOJA

##### Sažetak

Iako se općenito priznaje da bi uzgojni cilj u sastavu mlijeka trebalo usmjeriti na povećanje (ili neizmijenjeni) postotak bjelančevina i smanjenje postotka masnoće, većina uzgojnih programa ide u prilog visokih postotaka masnoće, bilo posredno ili neposredno putem selekcije na visoki postotak bjelančevina. Čak pri selekciji na jednu osobinu, na postotak bjelančevina, zbog visoke korelacije između osobina sadržaja i veće varijabilnosti postotka masti odnosna reakcija postotka masnoće može biti veća nego neposredno povećanje postotka bjelančevina. U Finskoj se postotci osobina razmatraju u domaćem uzgoju već od 1988. Prihvaćen je i cilj smanjenja postotka masnoće i kao posljedica toga bikovi rođeni nakon 1990. imaju oko 25% jedinica niži sadržaj masnoće u mlijeku nego bikovi rođeni između 1985. i 1987. Godine 1990. ustanovljen je uzgojni program otvorenog prijenosa jezgre embrija koji je primijenio alternativni uzgojni cilj u sastavu mlijeka. Cilj je bio podići omjer bjelančevina: masnoća u mlijeku, povećavajući sadržaj bjelančevina dok se u isto vrijeme održavao nepromijenjen postotak masnoće. Izabrane su relativne težine za osobine koje su davale jednaku važnost stvaranju i postotku bjelančevina s istovremenom negativnom težinom za postotak masnoće. Za vrijeme od četiri godine rada provedeno je ispiranje 291 krave, te je prenijeto 1607 embrija. Do sada je rođeno 746 telića. Godine 1995. prvih 95 ET kćeri ocijenjeno je prema nacionalnom programu modela životinja. Njihovi BLUP postotci bjelančevina bili su +.14 iznad skupine junica oteljenih iste godine, a BLUP-ovi dobivenih bjelančevina bili su 12 kg iznad srednje vrijednosti analogne skupine. Uzgojne vrijednosti postotka masnoće bile su na istoj razini kao u klasi te godine.