Prediction of Industry Production of Milk Components, Yields of Dairy Products and Lactose Deficit under the Current Breeding Objective of New Zealand Dairy Cattle

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ABSTRACT: The New Zealand dairy industry is pasture based and over 90% of milk products are exported. The breeding goal is to improve the capability of the cow to convert feed into farmer profit. The breeding objective rewards yields of protein and fat but penalizes milk volume and ignores lactose, despite it being an important component in milk powders. This study investigated the expected response to selection over the next 10 years and its impact on the annual industry production of milk, its components, and yields of dairy products based on expected cow performance, number of cows and a fixed area for dairying. After 10 years of selection (with no increase in herbage production), there was a 5% increase in milk production per hectare. Total milk exports increased by 5.9% and the lactose deficit increased by 14%.
Keywords: lactose; breeding objective**;** milk processing

Introduction

The New Zealand dairy industry feed supply is pasture based and over 90% of milk products are exported. The national herd is composed of 3 main breed groups; Holstein-Friesian (37%), Jersey (11.7%), and Holstein-Friesian x Jersey (42.6%) crossbred cows (LIC and DairyNZ (2013)). The breeding goal is to improve the capability of the cow to convert feed into farmer profit. The breeding objective is called breeding worth (BW) and reflects net farm profit per 5 ton of feed dry matter. The BW index includes 7 traits; milk volume, fat, protein, liveweight, fertility, somatic cell score and residual survival. The selection index is based on the estimated breeding values of the traits in the breeding objective and their economic values, but selection of bull mothers includes restrictions on type traits. Lactose is not currently included as a trait in this national breeding objective. This means that changes in lactose can only be inferred from its correlation with milk yield and excludes any variance in lactose concentration.

Currently the New Zealand dairy industry has a deficit of lactose, which has been caused by a rapid increase in the proportion of milk used for whole milk powder (WMP) production, in concert with the high protein concentrations in the milk. Over the last three years, this deficit has been filled with imported lactose (Fonterra (2012a)). The ratio of protein to protein-plus-lactose (P:PL) can be used as a proxy for the ratio of protein to solids-not-fat and reflects milk's suitability for WMP production. The P:PL of WMP is approximately 0.38 (Geary et al. 2010) whereas the P:PL of milk of New Zealand cows is 0.44. This study aims to investigate the effect of 10 years of expected response to selection on BW on industry production of milk components, yields of dairy products, P:PL ratio, and the lactose deficit in New Zealand.

Materials and Methods

A model was created to estimate annual industry production of milk and its components based on expected cow performance, number of cows and a fixed area for dairying, as in Lopez-Villalobos et al. (2000). Then an industry model (Geary et al. (2010)) was used to simulate the processing of that milk into dairy products.

Breeding objective. The national breeding objective of New Zealand dairy cattle is called BW and includes 7 traits (milk, fat, protein, liveweight, somatic cell score, fertility and residual survival). The economic values used in 2013 were $-0.091 per liter milk, $1.79 per kg fat, $8.63 per kg protein, $-1.52 per kg mature cow liveweight, $-38.57 per unit of somatic cell score (SCS = $\log_2$ (somatic cell count)), $7.35 per 1% fertility (proportion calving in the first 42 days of calving), and $0.148 per day of residual survival (herd life after accounting for genetic effects of the other 6 traits on herd survival) (NZAEL (2013)).

Genetic gains and expected cow performance. The selection scheme is based on four pathways of selection, using progeny testing as the main method to evaluate bulls. Genomic selection of young bulls competes with progeny testing and is leading to an increase in the number of bull mothers, thus increasing genetic diversity. The base cow's expected performance under grazing conditions was calculated to produce an average production similar to that of the average cow in the 2012-13 dairy season (LIC and DairyNZ (2013)), as in Table 1. The expected performance changed by the predicted rate of genetic gain each year of the simulation. Genetic gain per year was predicted to remain as published by NZAEL (2013) at 44 liters of milk, 2.22 kg fat, 1.82 kg protein and -0.039 kg liveweight.

Table 1: Production per cow, per hectare and across the industry for the base and after 10 years of selection for breeding worth.

Trait[¥]	Base	Year 10
Average production per cow		
Milk, liters	3,953	4,351

Fat, kg	195.9	216.1
Protein, kg	149.5	165.9
Lactose, kg	185.8	204.5
Liveweight, kg	420.6	420.3
DM requirements per cow, kg	4,225	4,421
Stocking rate, cows/hectare	2.86	2.73
Production per hectare		
Milk, kg	11,314	11,899
Fat, kg	560.9	590.9
Protein, kg	427.8	453.8
Lactose, kg	531.8	559.3
Industry		
No cows, millions	4.800	4.586
Total hectares, millions	1.677	1.677
Milk, billions liters	18.974	19.955
Fat, %	4.96	4.97
Protein, %	3.78	3.82
Lactose, %	4.70	4.70
P:PL	0.446	0.448

[¥]DM = dry matter, P:PL = protein to protein plus lactose ratio.

Production per hectare and stocking rate. Pasture growth was assumed to comprise 15,110 kg DM per hectare, which with an 80% feed utilization corresponds to an intake of 12,090 kg DM per hectare. To maintain this, the stocking rate was decreased annually to account for the increasing feed demand of individual cows. This was done by reducing cow numbers until annual feed demand per ha equaled 12,090 kg DM.

Industry production of milk components. Production of milk components was estimated using the expected performance per cow and number of cows, accounting for the age structure of the national herd. Production for each age group was calculated using the number of animals in that age group times their production. Those values were then summed across all age groups. The number of ha used to estimate industry production is the effective area from 2012-13 season of 1.677 million ha (LIC and DairyNZ (2013)). The number of cows used to estimate industry production and stocking rates was rounded up to 4.8 million cows (LIC and DairyNZ (2013)) from 2012-13 numbers. All numbers used in predicting gains are in Table 1.

The age structure of the national herd was similar to Lopez-Villalobos et al. (2000) with 22% 2-year-old, 19% 3-year-old, 16% 4-year-old, 13.5% 5-year-old, 11.3% 6-year-old, 9% 7-year-old, 6% 8-year-old and 3.2% at least 9-year-old. The breed composition was 37% Holstein-Friesian, 11.7% Jersey and 42.6% Holstein-Friesian Jersey crossbred animals, which was assumed to remain static over the simulated time period. A maturity weighting factor was used to adjust for animal age, which was as in Lopez-Villalobos et al. (2000) at 75% of mature equivalent for 2-year-old, 88% for 3-year-old, 95% for 4-year-old, 100% for 5-7 year-old, 90% for 8+ year-old. Replacements were 26% of calves born (26/100 cows), resulting in 25% 1-year-old.

Industry production of dairy products. The Moorepark processing sector model (Geary et al. (2010)) was used to estimate yields of dairy products. The product portfolio was estimated to have 60% milk dedicated to WMP, 23.5% to skim milk powder (SMP), 14% to cheese, 0.5% to butter and 2% to casein (Fonterra (2012a); Fonterra (2012b); Fonterra (2012c)). The product portfolio was maintained over the 10 year simulation to avoid confounding compositional changes with product mix changes. Whey protein concentrate (WPC) was produced by this model by removing 75% of the lactose from whey, which was then reincorporated into WMP and SMP. A conservative value of 75% was chosen (Archer (1998); Mollea et al. (2013)).

Results and Discussion

Production per cow. Changes in production per cow are in Table 1. Response to selection was estimated over 10 years to increase average milk production per cow from 3,953 liters to 4,351 liters, an increase of 10%. Similar percentages were estimated for fat and lactose yield. The increase in protein production was slightly greater at 11%, reflecting its greater value in the BW index. In the selection index, over 30% of the weight is on protein yield (Bryant (2012)), compared with 11% for milk volume and 9% for fat yield, while lactose yield has no direct economic value. Average feed demand per cow increased from 4,225 kg DM to 4,421 kg DM per cow per year, a 4.6% increase.

Production per hectare with adjustment of stocking rate. Per hectare changes are summarized in Table 1. Total feed supply was held constant, necessitating a 4.76% decrease in stocking rate from 2.86 cows/hectare to 2.73 cows/ha. Milk production per ha increased from 11,314 to 11,899, protein production increased 6% per ha, while lactose production increased 5% per ha. This was in spite of the decrease in number of cows farmed.

Industry production of milk components and P:PL ratio. Changes in industry production are in Table 1. Assuming a fixed area for dairying with a constant pasture production, the total number of cows decreased from 4.800 million to 4.586 million. Total milk production increased from 18.974 billion liters to 19.954 billion liters over the 10 year period due to gains per cow being greater than decreases in stocking rate. The starting year had a similar total production to the 2012/2013 dairy season (LIC 2013): 18.954 billion liters vs 18.883 billion liters. The greater genetic gain in protein than lactose meant P:PL was estimated to further increase from 0.446 to 0.448. While this was a small increase, it had a large impact with the high volumes in the New Zealand dairy industry. The BW index has proven effective in increasing protein production but this appears to be at the detriment of the P:PL ratio.

Yield of dairy products. Milk product exports on average increased 5.9%, ranging from a 6.8% increase for casein to 3.9% for cheese (Table 2). The increase in WMP and SMP was greater than the average increase at 6.3%. The increase in milk products was less than the increase in milk production, highlighting that most of New Zealand's milk products are exported in reduced water form, such as powders, cheese and butter.

Table 2: Industry production of dairy products ($\times 10^3$ ton) from milk produced in the base and after 10 years of selection for breeding worth.

Product¥	Base year	Year 10	Change
WMP	1,686	1,793	6.3%
SMP	467	496	6.2%
Cheese	329	350	6.3%
Butter	413	429	3.8%
Casein	11.7	12.5	6.3%
WPC	61.5	64.8	5.4%
BMP	50	52	3.9%
Total	3,021	3199	5.9%
Lactose	-117	-134	-14.0%

¥WMP = Whole milk powder. SMP = Skim milk Powder. WPC = Whey protein concentrate. BMP = Butter milk powder.

Deficit of lactose. Assuming a constant milk product portfolio, total lactose deficit increased by 14.0% over the 10 year period. This led to an increase in lactose imports per unit of exported product from 3.8% to 4.2% due to the increase in the P:PL. Recovery of lactose from whey powder partially compensated for the deficit of lactose, reducing it from 228,500 tons to 134,000 tons in the final year.

Future considerations to maximize profitability. It was assumed that lactose percentage remained constant during the simulated 10 year period. It is possible, however, that lactose concentration could change because of low genetic correlations between milk yield and lactose concentration (Welper and Freeman (1992); Vos and Groen (1998); Migilor et al. (2007); Hossei-Zadeh and Ardalan (2011); Sneddon et al. (2012)). Using modeling and simulations, it could be possible to align the breeding objective with potential future product portfolios and reduce the likelihood that the milk produced would require the incorporation of imported products to cover deficits.

Conclusions

This study showed that 10 years of selection using the current breeding objective (with no increase in herbage production) would result in a 5% increase in milk production per ha, total milk exports would increase 5.9%, with increases of 6.3% and 6.2% in WMP and SMP respectively. However the lactose deficit will also increase, leading to increased lactose imports of 17,000 tons over a 10 year period.

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