Dairy Cattle Fit for Diverging Purposes

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Summary

Dairy cattle in Interbull member countries occupy their place in the global food supply chain principally to supply milk for manufacturing of dairy products. Fluid consumption is a secondary destination for the milk. There are high energetic costs associated with incremental milk volume for given yields of fat and protein, but ICAR data shows that cows with high concentrations of fat and protein in their milk are sparsely represented in North American and European dairy production systems. There are also high energetic costs associated with incremental body size. The purposes of this commentary are: (i) to summarise the energetic costs associated with incremental milk volume or body size for the farm production of fat and protein for the food processing industry; and (ii) to suggest that selection of "fit for purpose" dairy cattle should include the purposes for which milk is produced. Policy implications for national and international genetic evaluations are briefly discussed.

Purposes of milk production

In the countries that fully participate in Interbull, approximately seventy per cent of the milk is destined for some form of dairy manufacture (manufacturing milk), with thirty per cent destined for processing for liquid consumption. The International Dairy Federation annually reports milk-processing data for forty-seven countries.

The reports include quantities of cows' milk delivered to dairy processing plants (dairies), and quantities of milk for liquid consumption processed in dairies (International Dairy Federation, 2008).

For the European Union countries twenty-five percent of the milk is processed for liquid consumption. In North America thirty per cent of the milk is processed for liquid consumption. Ten per cent of milk is processed for liquid milk consumption in Oceania. Consequently, over seventy per cent of milk supplied in Interbull member countries has explicit value only for its contents of protein plus fat. In contrast, the milk supplied for liquid consumption has explicit value principally for its volume.

These alternative purposes for milk production have major implications for energetic demands in the food supply chain.

Compositions of milk supplies

The International Committee for Animal Recording (ICAR) reports national average compositions for milk recorded cows for member countries (www.icar.org accessed 8 August 2009). USA, Germany, and France are the countries with the largest milk recorded populations. Weighted by numbers of milk-recorded cows, and transforming the USA data to crude protein, the average concentrations for reported lactations in these countries are 3.91% fat and 3.36% protein (Table 1).

Table 1. Fat and crude protein concentrations of milk recorded cows.

Country	Fat %	Crude Protein %	N lactations	Year
USA	3.70	3.29	4,478,447	2008
DEU	4.13	3.42	3,422,769	2007
FRA	3.99	3.39	3,799,000	2007
Weighted averages	3.91	3.36		

Weighted average yields for these lactations were 8,601 kg milk, 334 kg fat and 288 kg protein. There is a sense in which this is a notionally representative ICAR phenotype. For this phenotype, every kilogram of combined dairy fat and protein is associated with 13.82 kg of milk.

A sub-population of interest is the USA Jersey population, for which the average yields for 208,251 lactations in 2008 were 7451 kg milk, 344 kg fat and 282 kg crude protein, with concentrations of 4.62% and 3.79% respectively. For this USA JER phenotype, every kilogram of combined dairy fat and protein is associated with 11.89 kg of milk.

Energy demands

For the purposes of a simple model, energetic demands for annual lactation performance of dairy cows can be assumed to be: 56.1 megajoules (MJ) of metabolisable energy (ME) per kilogram (kg) of fat yield; 31.8 MJ ME per kg of protein yield; and 1.8 MJ.ME per kg of incremental milk for given yields of fat and protein. Energetic demands for annual body maintenance and support of pregnancy are a function of cow size. For the purposes of a simple model they can be assumed to be 231 MJ ME per unit of metabolic live weight ($kg^{0.75}$) (Holmes *et al*., 2002).

The energetic demands for lactation imply that if the notional ICAR phenotypic yields of combined dairy fat and protein were produced with a thousand kilograms less milk per lactation, the energetic saving in the farm production system would be 1.8 gigajoules (GJ) of ME per lactation. The means to achieve this energetic saving would be to breed cows for manufacturing milk supply whose milk averaged 4.4% fat and 3.8% crude protein, and which yielded 7600 kg of milk. This phenotype is similar to the USA JER phenotype, indicating that the genetic resources for achieving this energetic saving on farms have been conserved. However, the Interbull Jersey population is a dwindling resource.

The seventy per cent of milk supply destined for dairy manufacture in Europe and North America represents approximately twenty million lactations annually. The on-farm diversion of feed supply to milk volume (and associated lactose that dairy manufacturers do not pay for) costs energy. The inference from the "high concentration manufacturing milk" scenario is that this cost is in the order of thirty-six thousand terajoules of ME annually. In terms of initial feedstock at the first stage of the food supply chain this can be represented as twenty million big round bales of high quality baleage annually. This feedstock is converted by dairy herds into milk components that are, at best, unvalued at the next processing stage. At worst, the water and lactose incurs net costs for the food processors.

Body size of cows

The energetic demands for maintenance and pregnancy of cows also have implications for fitness for purpose. Groen (1989) and Visscher *et al*. (1994) derived relative economic weights, expressed in genetic standard deviations, for production systems in which total supply of roughage was constrained (Groen) or total farm feed supply was constrained (Visscher). In each of these studies standardised economic weights for body size relative to protein yield exceeded fifty per cent in magnitude, and were negative.

Feed resources for livestock are under pressure from increasing human feed demands, and from the energy sector's demand for feedstock for bio fuel production. In this context, it is instructive to define a standard feed unit as one GJ ME; then to estimate yields of fat and protein per feed unit for the notionally representative phenotypes derived from the ICAR data. For this simple model, the average mixed age cow's body size can be taken as 600 kg of live weight for the representative ICAR lactation, and 450 kg for the representative USA Jersey lactation. Live weight Differences between modern breed populations are not extensively recorded despite the importance of this trait for energetic demands. New Zealand live weight data indicates that Holstein-Friesians are thirty per cent larger than Jerseys, but accuracy of extrapolation to other countries is uncertain.

This comparison indicates that the notional ICAR phenotype converts one GJ ME into 8.72 kg combined fat and protein, while the USA Jersey phenotype converts one GJ ME into 9.75 kg combined fat and protein. If the USA Jersey phenotype is seventeen per cent smaller in terms of live weight than the ICAR phenotype (rather than twenty-five per cent smaller) then the USA JER phenotype is converting one GJ ME into 9.48 kg combined fat and protein.

Confounding of production system effects and breed effects might compromise this simple comparison. Comparing the USA HOL phenotype with the USA JER phenotype might be less subject to this confounding. In this comparison, the USA HOL phenotype converts one GJ ME into 9.1 kg combined fat and protein, while the USA JER phenotype converts one GJ ME into 9.75 kg combined fat and protein.

Discussion

These comparisons have been conducted on a deliberately simplified basis, and ignore factors such as energy requirements for growth and differential pricing for the fat and protein components of milk. They are in accordance with feed conversion efficiency observations summarised by Grainger and Goddard (2004).

To the extent that these energetic utilisation issues are important for the global food supply chain, they raise questions about communication between food processors and dairy cattle breeding agencies, between dairy cattle breeding agencies and national genetic evaluation centres, and between national genetic evaluation centres and their milk producers.

The national genetic evaluation centres have tended to summarise genetic information for farmers in each country by producing a selection index tailored for a notional average production circumstance within the country, or a single index tailored for the breed within the country. The USA Department of Agriculture's provision of selection indices for specific fluid milk or manufacturing milk processing do not appear to have had much impact on selection decisions.

Similar limitations to the service provided by national genetic evaluation centres arise with respect to genotype by environment interactions within country borders. While the dairy cattle breeding community understands the potential for more precise genetic information for milk producers (Zwald *et al.*, 2003), structural features associated with national centres and breeding companies have made it impossible to provide estimation of breeding values for identifiable environmental clusters defined by features other than national boundaries.

These limitations to information services provided by national centres should be regarded as a medium term strategic issue for the dairy cattle breeding community embodied in Interbull. The twenty-first century will provide challenges, as human demands for food increase and change simultaneously –and as the energy sector imposes competing demands for plant materials for bio fuel production.

Dairy cattle breeding is structurally slow to change, due to long bovine generation intervals. There are associated incentives for breeding companies to influence breeding objectives to preserve the value of their current investments in seed stock already in their genetic pipeline. In this context, and with the potential for more rapid changes associated with emerging genomic technology, the national genetic evaluation centres have a leadership challenge, for which they are well positioned due to their history of trusted communication with the milk producers in their countries.

References

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