Breeding for healthier milk from healthier cows

Sinead Mc Parland[1], Helene Soyeurt[2,3], Eileen Wall[4], Donagh Berry[1], Nicolas Gengler[2,3], Mike Coffey[4] and Roel Veerkamp[5]

[1] Animal & Bioscience Research Department, Animal & Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland.
[2] Animal Science Unit, Gembloux Agro-Bio Tech, University of Liège, 5030 Gembloux, Belgium
[3] National Fund for Scientific Research, 1000 Brussels, Belgium
[4] Sustainable Livestock Systems Group, Scottish Agricultural College, Bush Estate, Penicuik, Midlothian, EH26 0PH, United Kingdom
[5] Animal Breeding and Genomics Centre, Wageningen UR Livestock Research, Lelystad, 6708WC, The Netherlands

When cows use more energy than they eat they are said to be in negative energy balance, and consequently they compromise their own health as well as changing the type of fats they produce in milk. As part of the EU study, RobustMilk, researchers in The Netherlands, Ireland, Belgium, and Scotland are developing techniques to routinely determine, at no extra cost, the energy balance status of cows and the relative proportion of different fats in the milk. The aim is to produce healthier milk from healthier cows.

In recent years, consumer concern over the impact of the food they eat on their own health and wellbeing has increased. Concern over animal welfare in modern day dairy production systems is also growing. Consumers wish to consume high quality products from disease free, "happy" and healthy animals. However, as dairy producers strive to increase milk production to meet revenue targets, there is often a consequential deterioration in product quality and animal health or robustness.

Cows milk is often criticised as being a high fat product despite being only around 2%, and many of the fats found in milk are actually beneficial for human health. In fact, cows milk can be broken into two distinct groups of fats; saturated fats which are deemed to be bad for human health and unsaturated fats which are thought to be more favourable. For example, conjugated linoleic acid (CLA) is found in cows milk and has been shown to have anti-carcinogenic properties. Dairy products only contribute about 15 to 25% of the total fat in the human diet, however up to 35% of the total saturated (or bad) fat in the human diet arises from cows milk fat. This is due to the relatively large proportion of saturated fatty acids found in dairy cow milk relative to the unsaturated fatty acids. In fact, the milk fat breakdown of the average dairy cow is approximately 70% saturated fatty acids (bad fats) to 30% unsaturated fatty acids (good fats). Lactoferrin is a natural bioactive for human health found in cow milk and is thought to be favourable for human health. There is accumulating interest in cows producing more lactoferrin because of its favourable properties for cow and human health.

The energy balance of an animal refers to the difference between the animal's energy intake and its utilisation. Energy balance has long been considered an important

indicator of dairy cow health and fertility. Throughout lactation, energy balance status may change from negative (cow is using more energy than ingesting) to positive energy balance (cow is ingesting more energy than using). Not only has negative energy balance implications for cow health and fertility, but it has also been shown that cows in negative energy balance produce an increased proportion of saturated fat in their milk.

RobustMilk (http://www.robustmilk.eu) is a European-wide project which brings together animal scientists from six leading European agricultural research institutes. The overall objective of the RobustMilk project is to use genetic and genomic tools, to determine if we can breed cows to produce healthier milk for human consumption, while simultaneously ensuring that the cows producing the healthier milk are themselves healthy.

How do we know if our cows are producing the right kind of milk?

Accurate quantification of the fat content of milk is costly and time consuming; quantifying lactoferrin content is also time consuming albeit not to the same extent. As a result, neither the fat nor lactoferrin content of the milk is routinely available. However, milk samples from all milk recorded cows and bulk milk samples are all subjected to what is called *mid-infrared spectrometry* to determine the total fat, protein and lactose content in the milk for normal management and payment purposes. These results, accompanied also by somatic cell count, are returned to farmers to help monitor their herd performance. The aim of this study was to confirm the ability of the mid-infrared spectrometry to predict other components of milk such as individual fatty acids and lactoferrin content. The routine availability of the infrared spectral data on all milk recorded cows implies that any favourable results obtained can be easily implemented into possible milk payment systems and national breeding programmes at a minimal marginal cost. Milk quality at a herd level can be assessed by already collected bulk milk tank samples.

The experimental design involved collecting milk samples from cows of several dairy breeds including Holstein-Friesians, Jerseys, Normandes, Montbelliardes, dual-purpose Belgian Blues and Norwegian Reds from Ireland, Belgium and Scotland. In summary, the accuracy of predicting the saturated and unsaturated fatty acid content in the milk based on average 517 milk samples was 100% and 99%, respectively. The accuracy of separating the fatty acids into long chain, medium chain, or short chain fatty acids was 98%. The accuracy of predicting the content of some individual fatty acids like C14:0 was high (97%) although it was lower for other fatty acids like C18:2 cis-9, trans-11 (74%). These results suggest that at least groupings of fatty acids can be accurately predicted using mid-infrared spectroscopy. Milk fatty acid content has already been shown by Gembloux University (i.e., Belgian partner in RobustMilk) to be under genetic control implying that breeding for improved milk fatty acid content will be fruitful. Research on the prediction of lactoferrin content of the milk is on-going.

Quantifying energy balance in dairy cows

Unfortunately, energy balance is also very difficult and expensive to measure. Research is currently underway to evaluate the potential use of mid-infrared spectrometry technology to also determine the energy balance status of cows at the time of milk recording. The ratio of fat to protein in milk is often used as an indicator of energy balance status. Since both fat and protein fractions of milk are predicted using mid-infrared spectrometry, it makes sense that the same technology could be used to predict energy balance directly without the accumulation of errors in the prediction process. Similarly, the milk fatty acid content of the milk changes depending on the energy status of the cow and we now know that we can accurately predict milk fatty acid content from the mid-infrared spectrum.

Data from Crichton research farm in Scotland and Moorepark, Ireland will be used in this experiment. Although research into the prediction of energy balance from the mid-infrared spectrum has only recently begun, the initial predictive models developed show promise. The accuracy of prediction is not as high as for the fatty acids but very high accuracies are not expected since energy balance itself, as defined in this study, is not exact. Instead, energy balance has been predicted using measures of intake and utilisation and so intrinsically contains error.

Benefits to industry

Tools developed in this study are immediately applicable and can be implemented nationally at a low marginal cost; the data is already there it's just a matter of using it better. The developed tools have implications for both farmers and industry including milk processors, breed societies, and AI organisations. Genetic merit measures for milk quality are generated for animals in the Walloon part of Belgium and this could soon become reality in other countries that are partners in RobustMilk such as the UK and Ireland. We can then identify bulls that produce healthier cows who themselves produce healthier milk for human consumption. Measures of milk quality and energy balance may well enter national breeding programs to direct the entire national herd for increased profitability. Also, as well as facilitating management decisions at an individual cow level through individual milk samples, the developed tools can also be applied to bulk tank milk samples facilitating herd management strategies as well as payment strategies for milk processors.

The RobustMilk project is financially supported by the European Commission under the Seventh Research Framework Programme, Grant Agreement KBBE-211708. The content of this article is the sole responsibility of the authors, and it does not necessarily represent the views of the Commission or its services. (http://www.robustmilk.eu),

ROBUSTMILK