Healthy People, Healthy Cows

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Summary

- A method to accurately predict the different types of fats, in particular, the saturated fats (apparently bad fats) and unsaturated fats (apparently good fats – associated with health promoting factors) in cow milk has recently been developed. The method uses the same technology (i.e., Mid-Infrared Spectrometry), that is currently used by milk recording organisations to routinely determine the content of protein, total fat and lactose in all milk samples.
- We already know that the ratio of bad to good fats in milk is not consistent across all animals and that the genetics to produce healthier milk (more good than bad fats) is passed from parent to offspring. Using this new method on all milk recorded cows will allow us to breed for improved milk quality.
- We are satisfied that the equations are robust across different breeds and production systems. However, before implementation nationally, we must first investigate the implications of selecting for healthier milk fatty acid profiles including the effects on milk processing ability, as well as the relationships between a healthier milk fatty acid profile and other performance and welfare traits of the cow herself.
- The potential to predict the energy balance of a cow using the same mid-infrared spectrometry procedure is also being investigated. Energy balance is known to be associated with the health and reproductive status of the cow. Initial analyses show large promise.
- Because our approach uses already collected milk samples (either from individual cows or bulk milk tanks) the outcomes of the research can be exploited by farmers for management and breeding purposes at little or no extra cost. The potential benefit of producing healthier milk is significant.

Introduction

Bovine milk has traditionally been viewed as a nutritious, healthy product, largely due to its abundance of naturally present vitamins and minerals. However, in recent times, with the shift in consumer demand for "healthier" and "lower fat" foods, dairy products, among others have come under scrutiny in relation to the types of fats they contain. The question both dairy consumers and producers alike now ask is "*Can we make milk an even healthier product?*"

However, we do not want to improve the quality of milk for human consumption at the expense of the cow's own health and wellbeing. So the question we at Moorepark are working towards answering is "*How can we make milk an even healthier product without impacting on the cows own health and wellbeing?*"

Current research at Moorepark in collaboration with other European research institutions is investigating the potential to select cows to produce a healthier milk fatty acid profile, and to simultaneously select cows that do not reach severe negative energy balance. The first step in any such study requires the collection of a large quantity of data for the trait(s) in question from an unbiased cross section of the national herd. Despite their obvious importance to any breeding programme, these traits (milk fat composition and energy balance) to-date have not been included in breeding goals, such as the EBI, due to the associated prohibitively expensive costs of measurement.

The first step in this on-going research is directed at investigating the use of mid-infrared spectrometry as an inexpensive tool to monitor both the types of fat which individual cows produce in their milk as well as the energy balance status of the cows producing the milk. If successful, this tool could be used on all routinely milk recorded cows nationally as part of milk-recording operations, providing the data necessary to facilitate the direct or indirect inclusion of milk fat composition and cow energy status in the national breeding programme. This in turn could provide the information needed by farmers and breeders to make improved selection decisions regarding milk fat composition and cow health in commercial herds thereby increasing the value of milk.

What is Mid Infrared Spectrometry?

Currently in Ireland, over 400,000 cows are milk recorded a minimum of four times per year. The vile of milk taken during milking is sent to a laboratory for analysis to determine the fat, protein and lactose content of the milk. The same analysis is performed on all bulk milk samples. All samples are put through a mid-infrared spectrometry machine where light is shone through each milk sample. The absorbance of the light at different wavelengths in the mid-infrared region is recorded, and it is the combination of different absorbance levels of the individual wavelengths (known as the spectrum) which enables the determination of fat, protein and lactose contained in the samples.

Mid-infrared spectrometry is the method of choice worldwide for a quick and relatively inexpensive determination of fat, protein, lactose, casein and urea content in milk.

Research is now focussing on how mid-infrared spectrometry can assist as a tool in the measurement of other important aspects of milk quality and indeed on other measures such as animal health.

Measuring milk fat composition

Gas chromatography is the standard method to measure milk fat composition, yet is timely and expensive, and thus is not a procedure regularly undertaken on commercial animals. However, access to large quantities of up-to-date data is necessary for routine genetic evaluations. This is where mid infrared spectrometry plays an important role.

Using the spectrum data from hundreds of individual milk samples, we have derived equations to predict the different groups of fats in milk, for example, the content of saturated, monounsaturated and polyunsaturated fats in milk. The approach is similar to how the overall content of fat and protein is currently routinely predicted. Accuracy of predicting saturated fat content in milk is 98%. Although equations were also developed to predict the individual fats in milk, such as the beneficial Conjugated Linoleic Acid (CLA), the accuracy of predicting individual fats is not strong enough to be used at this time.

The equations were developed using data from Ireland, Belgium and Scotland and incorporates data from several different breeds and from animals maintained on different production systems, including European concentrate systems and Irish grass-based systems of production. The equations are robust having provided accurate results when tested on animals of different breeds including the Holstein-Friesian, Norwegian Red, Jersey, Montbelliarde, Normande and dual-purpose Belgian Blue. The equations were also successfully tested on a group of randomly collected commercial Irish cows.

Why are we interested in milk fat composition?

Bovine milk fat can be broken into two general categories; saturated fats, which are thought to be linked to deleterious health defects such as coronary heart disease, cancer and obesity, and unsaturated fatty acids which are less harmful and may be beneficial for human health. For example, Conjugated Linoleic Acid (CLA), an unsaturated fat present in milk has been shown to have cancer inhibiting as well as cholesterol reducing properties.

The milk fat breakdown of the average dairy cow is approximately 70% saturated fatty acids (bad fats) to 30% unsaturated fatty acids (good fats). This ratio is not optimal; a preferable ratio would be to have a greater proportion of unsaturated fats than saturated fats in the milk. In addition, although only up to 25% of the fat in our diet arises from consuming dairy products, up to 35% of the saturated (bad) fats arise from dairy products.

The good news is that the ratio of saturated to unsaturated fats in milk is not consistent across our national herd. In fact the Irish national herd has a more favourable saturated to unsaturated fat ratio than other countries due partly to our grass based system of production which promotes the production of CLA in the milk and meat of our animals. The milk of the average cow in the Curtains Moorepark herd has approximately 65% saturated fats and 35% unsaturated fats, which is more favourable than for the typical cow as mentioned above.

Milk fat composition is also under genetic control. Approximately 42% of the variation among animals for saturated fats in milk is due to genetics. This means that if we have the power to know which animals produce healthier milk, we can identify sires and dams with a more optimal milk fatty acid profile. If included in the EBI then this may be achievable without impacting on performance in other traits.

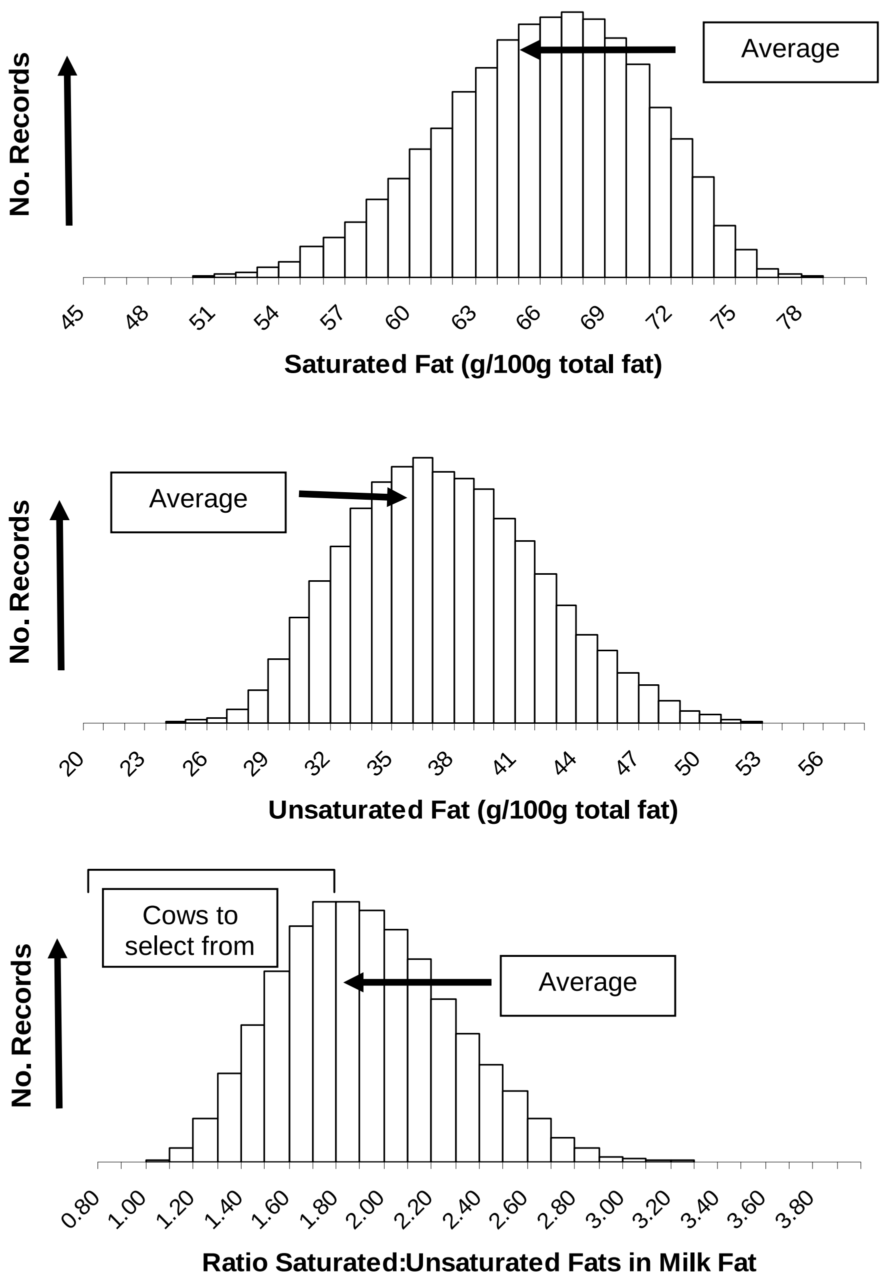

Figure 1. Distribution of the total percentage of saturated fat, unsaturated fat and the ratio of saturated to unsaturated fat in milk fat of cows in the Moorepark Curtains herd. The average content across the herd is depicted as well as the range of animals with more favourable milk profiles.

A recent study investigated the differences in milk fat composition among the three groups of Holsteins involved in the selection experiment at the Moorepark Curtains farm. The animals comprise a group of high genetic merit cows of North American ancestry (average EBI = €77), a group of North American ancestry cows of national average genetic merit (average EBI = €49) and a group of high genetic merit cows of New Zealand ancestry (average EBI = €89). That study found that cows of New

Zealand ancestry produced more saturated fats per kg milk fat than either group of North American ancestry cows; however differences were biologically small. Also, there was no difference between the two groups of North American ancestry Holstein-Friesians. These results indicate that although selection practices may alter the fatty acid profile of milk (differences between cows of North American and New Zealand ancestry) to date in Ireland, selection for improved EBI has not adversely affected the fatty acid composition of milk (no difference between cows of different genetic merit).

The distribution of the percentage of saturated fat and unsaturated fat in fat and the ratio of saturated to unsaturated fat in fat are graphed in Figure 1 for the Moorepark Curtains herd. The graphs show a normal distribution for all traits, but more importantly, the existence of considerable variation. This variation exists even with no conscious selection pressure on this trait. Therefore the natural variation in ratio of saturated to unsaturated fats in milk varied from [44% saturated fats: 56% saturated fats] to [79% saturated fats: 21% unsaturated fats]. These graphs highlight the large range in fat composition present even in a single herd. It is this variation which we will attempt to exploit through breeding.

Energy balance as an indicator of cow health

The energy balance of an animal refers to the difference between the animal's energy intake and utilisation and is considered an important indicator of dairy cow health and fertility. The extent and duration of negative energy balance in early lactation is well known to be linked to subsequent health and performance. 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.

Energy balance is also prohibitively expensive to measure routinely. A correct gauge of energy balance requires accurate information on all energy intake and energy outputs, for example, milk fatty acids from the cow.

Using mid infrared spectrometry to measure energy balance

Research at Moorepark is also investigating the potential of mid-infrared spectrometry to predict the energy balance of a cow, based on the same routinely collected milk samples and the procedure described above. The ratio of fat to protein in milk is sometimes used as an indicator of energy balance status. We also know that the milk fat composition changes relative to the energy status of the cow. 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. 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.

Work is on-going on the development of these equations to make them more robust across breeds and production systems, although they currently show promise to be used, at least, as an accurate indicator of energy balance. The accuracy of prediction is not as high as for the fatty acids but very high accuracies are not expected since energy balance itself, is not exact.

What are we waiting for??!!

Unfortunately, having accurate prediction equations is only the first step in breeding for a trait. Important questions yet to be answered include: What impact does producing healthier milk have on milk processing ability? What impact does producing healthier milk have on the cows own health? What impact does producing healthier milk have on all of the other traits currently included in the EBI?

To answer these questions, it is important to collect large quantities of data from the national herd on traits such as milk fat composition and energy status and then to quantify the associations between these traits and others. Such traits to be investigated include those related to milk processing ability, for example rancidity and cheese making ability, as well as traits of the cow herself, for example fertility and overall production.

Where will the research lead to?

Once the research is complete and we are satisfied that we know the impact of selection on fatty acid composition on other traits of economic importance, we can begin to produce breeding values for milk quality, and a decision can be made on whether or not this trait should be included in the EBI.

Once the equations to predict energy balance have been made more robust and research is complete, energy balance could be considered as a useful indicator of fertility. Data on energy balance could also contribute towards a very useful on-farm management tool, whereby warnings could be issued with the regular milk report to indicate which cows are in negative energy balance, and to what extent they are in negative energy balance and thus require attention before the breeding season begins.

Acknowledgements

This work was undertaken as part of the European-wide RobustMilk project. 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). The authors also wish to thank Dan Curtain and the Dairygold Co-Operative Society Limited for allowing access to milk samples.