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Development of a Process based milk processing sector Model for the Irish Dairy Industry

Key external stakeholders:

Milk processors, Farmers, Enterprise Ireland, Consultancy agencies

Practical implications for stakeholders:

- The current density factor used in the industry has not been updated in many years with the milk produced today substantially different from the milk produced in the past. The density factors developed in this study change by breed, with temperature and across season of the year.
- The density used in the industry should be updated based on this study for mass balance calculations and Milk payment purposes.
- Milk fat losses found within the butter manufacture processes have the potential if reduced to generate greater returns within the dairy industry as a whole.

Main results:

- The mass balance of milk fat was represented as fat intake = fat in products + fat losses + recycled fat. Milk fat losses were calculated based on fat intake less fat recovered in products. Total fat losses at the end of butter production ranged between 1.90-2.25% which were then included in a simulation model.
- Milk density (ρ) was affected by milk temperature. In general, as temperature increased, milk density decreased. The mean density calculated at 5 °C was 1.0334 g/cm3, with corresponding figures of 1.0330, 1.0320 and 1.0305 g/cm3 at 10, 15 and 20 °C, respectively.
- Density levels were affected by cow breed and Holstein Friesian genotype. The Jersey breed had highest density (1.03296 g/cm^3) with the Elite and National Holstein Friesian genotypes having lower densities (1.03218 and 1.03209 g/cm^3)
- Mean density values were different by season, with, spring, summer and autumn having densities of 1.0304±0.00008 g/cm3, 1.0314±0.00005 g/cm3 and 1.0309±0.00007 g/cm3, respectively.

Opportunity / Benefit:

Losses inside the processing plant pose a significant cost to the dairy industry. Measuring the losses, identifying the causes and implementing solutions can reduce these losses.

Collaborating Institutions:

UCC & UL

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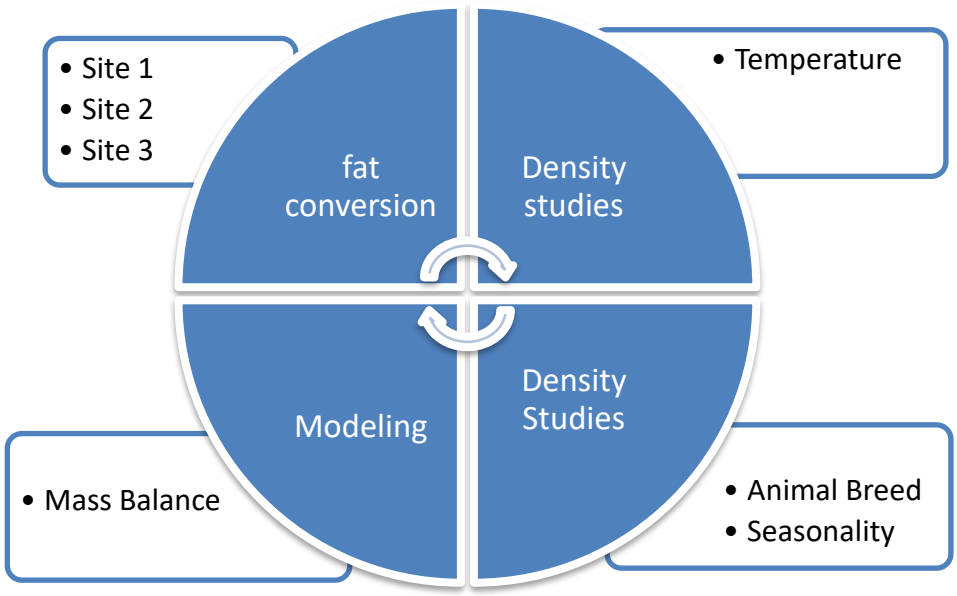
1. Project background:

Many options exist for Irish dairy processors when it comes to valorizing milk. The diverse range of dairy products includes relatively simple products such as cheese or skim milk powder as well as more process-intense products such as demineralised whey or nutritional beverages. Therefore, development of processing models of suitable scope for the Irish Dairy industry can be difficult due to the array of processing options. Previously at Teagasc, models have been developed to simulate the mass balance of milk into its various components. This study was focused on determining the fat mass balance of milk across a number of butter plants and to use the outputs of the on site work to further develop a mass balance model of milk processing. After initial discussions with a number of industry partners it quickly became apparent that fat losses were a key concern. The ultimate aim of the project then became focused on overall mass balance with a particular focus on milk fat. As the research progressed it became evident that one of the limitations of completing mass balance calculations centred on the levels of Fat that was in the milk in the first place. That led the research to look at milk density.

2. Questions addressed by the project:

- Determine levels of milk fat loss across different aspects of the butter manufacture process
  - Develop mass balance model for the dairy industry
  - Identify key gaps in the quantification of mass balance
- Density
  - Determine impact of season on milk density
  - Determine the effect of breed and genotype on milk density
  - Determine the impact of temperature on milk density

3. Studies



4. Main results:

- Errors associated with weight-volume calculations have been observed as a common issue for dairy processors. Data analysis based on a mass balance approach helped to identify loss points in the process and also enabled processors to reconcile their test results with actual data across a number of sites studied.

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- The intake temperature of milk on farm significantly affects whole milk density, along with other external factors such as composition and processing conditions. There is an inverse relationship between temperature and density, i.e., density of milk decreases with increasing temperature, and there is also a quadratic effect of temperature on milk density.
- This study has shown that Holstein Friesian genotype and animal breed impact on milk density, which is an integral parameter in weight-volume calculations in a dairy processing environment.
- Seasonal and annual factors for density conversion used in weight-volume relationships were determined, with an emphasis on usage of a periodic, rather than an average, conversion factor evident from the strength of linear regression models. The distribution of density and individual constituents of milk over the different seasons showed a similar trend, with higher fat and protein content observed in the autumn and winter season and lowest during summer.

5. Opportunity/Benefit:

There has been significant increases in milk solids concentrations in Irish milk over the past ten years. There has been significant investment both at the farm and at processor level to facilitate expansion. There is a requirement to ensure that the maximum return is being achieved for the milk that is being produced. This study has highlighted the impact of reduced losses in the production of butter as well as identifying new density factors that should be included for Irish milk.

6. Dissemination:

Throughout the lifetime of this project there has been very open dialogue with the dairy industry on a continuous basis. There has been a significant amount of the research carried out within the milk processor settings with individual reports furnished back to the processors on an on-going basis as well as a close out report at the end of the project. There has been four scientific papers that are either published, In Press or accepted. There is a PhD thesis that is currently being put together and this will be submitted before the end of 2020.

Main publications:

Parmar P., Lopez-Villalobos N, Tobin J. T, Murphy E, McDonagh A.,Crowley S.V, Kelly A, Shalloo 2020 . The Effect of Compositional Changes Due to Seasonal Variation on Milk Density and the Determination of Season-Based Density Conversion Factors for Use in the Dairy Industry. Foods 9 (8) 1004

Parmar P., Lopez-Villalobos N, Tobin J. T, Murphy E, Crowley S.V, Kelly A, Shalloo L (2020) Development and Evaluation of a processing sector model for butter manufacture using mass balance technique at two dairy processing sites. International Journal of Dairy Technology. In Press

Parmar P., Lopez-Villalobos N, Tobin J. T, Murphy E, Crowley S.V, Kelly A, Shalloo L (2020) Effect of temperature on raw whole milk density and its potential impact on milk payment in the dairy industry. International Journal of Food Science and Technology. Accepted.

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