**Supplement Table 1.** Dairy nutrition, automatic milking systems and milk production variable and analysis list.

|  |  |  |
| --- | --- | --- |
| **#** | **Variable** | **Variable analysis** |
| 1 | Fat and Protein Corrected Milk (FPCM) kg | Network and regression analysis |
| 2 | Total Dry Matter Intake (DMI) kg | Network and regression analysis |
| 3 | FPCM/DMI kg | Network and regression analysis |
| 4 | Total Diet Crude Protein (CP) % | Network and regression analysis |
| 5 | Total Diet Acid Detergent Fiber (ADF) % | Network and regression analysis |
| 6 | Total Diet Amylase Neutral Detergent Fiber (aNDF) % | Network and regression analysis |
| 7 | Partially Mixed Ration (PMR) Lignin % | Network and regression analysis |
| 8 | Total Diet Starch % | Network and regression analysis |
| 9 | Total Diet Ash % | Network and regression analysis |
| 10 | Total Diet Fat % | Network and regression analysis |
| 11 | Total Diet Non-fiber Carbohydrate (NFC) % | Network and regression analysis |
| 12 | % Energy Cosumed @ Robot | Network and regression analysis |
| 13 | PMR Mcal Conc. | Network and regression analysis |
| 14 | Mcal Conc. of Robot Feed | Network and regression analysis |
| 15 | Milk Speed kg/minute | Network and regression analysis |
| 16 | Log # Refusals | Network and regression analysis |
| 17 | # Milkings/Cow/Day | Network and regression analysis |
| 18 | kg Conc./100kg Milk | Network and regression analysis |
| 19 | Average Boxtime minutes/visit | Network and regression analysis |
| 20 | Average Fat % Indication | Network and regression analysis |
| 21 | Average Protein % Indication | Network and regression analysis |
| 22 | Average Fat Protein Ratio (FPR) | Network and regression analysis |
| 23 | Log Free Time minutes | Network and regression analysis |
| 24 | Cows/Robot | Network and regression analysis |
| 25 | FPCM/Milking | Network and regression analysis |
| 26 | Average Feeding Rate | Network and regression analysis |
| 27 | Log Rest Feed Conc. % | Network and regression analysis |
| 28 | Rumination minutes | Regression analysis/removed from network analysis (missing data) |
| 29 | # Connection Attempts | Regression analysis/removed from network analysis (missing data) |
| 30 | kg Concentrates at 60 Days in Milk | Regression analysis/removed from network analysis (missing data) |
| 31 | Treatment Time seconds | Regression analysis/removed from network analysis (missing data) |
| 32 | Log # Failures | Regression analysis/removed from network analysis (missing data) |
| 33 | Energy Corrected Milk (ECM) kg | Removed (high correlation) |
| 34 | kg Butterfat and Protein Yield | Removed (high correlation) |
| 35 | ECM/DMI kg | Removed (high correlation) |
| 36 | Total Mcals consumed | Removed (high correlation) |
| 37 | Mcals Consumed @ Robot | Removed (high correlation) |
| 38 | Mcals Consumed in PMR | Removed (high correlation) |
| 39 | Percent of Energy Consumed in PMR | Removed (high correlation) |
| 40 | Ratio of Refusals to Percent of Energy at the Bunk | Removed (high correlation) |
| 41 | Log kg Rest Feed | Removed (high correlation) |
| 42 | Total Diet Mcal Concentration | Removed (high correlation) |
| 43 | Milk Production/Cow/Day | Removed (high correlation) |
| 44 | kg Concentrates/100 kg Milk at 60 Days in Milk | Removed (high correlation) |
| 45 | kg Fat | Removed (high correlation) |
| 46 | kg Protein | Removed (high correlation) |
| 47 | Total Butterfat and Protein kg | Removed (high correlation) |
| 48 | ECM/Milking | Removed (high correlation) |
| 49 | Less Rest Feed kg | Removed (high correlation) |
| 50 | kg Crude Protein from PMR | Removed (kg) |
| 51 | kg Crude Protein @ Robot | Removed (kg) |
| 52 | kg ADF Consumed | Removed (kg) |
| 53 | kg aNDF Consumed | Removed (kg) |
| 54 | kg Lignin from PMR Consumed | Removed (kg) |
| 55 | kg Starch from PMR | Removed (kg) |
| 56 | kg Starch @ Robot | Removed (kg) |
| 57 | Number of Robots | Removed (farm level) |
| 58 | Milk/Robot | Removed (missing data) |
| 59 | Total Amount of Milk Produced kg | Removed (farm level) |
| 60 | Number of Visit | Removed (farm level) |
| 61 | Amount of Milk Separated kg | Removed (farm level) |
| 62 | Number of Cows Milk Separation | Removed (farm level) |
| 63 | kg Concentrates Fed | Removed (farm level) |
| 64 | kg Rest Feed Concentrates | Removed (farm level) |
| 65 | Number of Cows Milking | Removed (farm level) |

1Production data were derived from AMS databases, collected from a variety of breeds and the data includes every single milking from any cow in the herd from the first milking after calving, to the last one before dry-off or culling of the cow.

2Variable definitions:

Fat and Protein Corrected Milk (FPCM) kg: (0.337 + 0.116 × Fat % + 0.06 × Protein %) × milk yield (kg/d).

Total Dry Matter Intake (DMI) kg: represents the combined total of PMR intake and robot concentrate offered.

FPCM/DMI: fat and protein corrected milk per total dry matter intake.

Total Diet Crude Protein (CP) %: percentage of crude protein from the combined total of PMR intake and robot concentrate offered.

Total Diet Acid Detergent Fiber (ADF) %: percentage of acid detergent fiber from the combined total of PMR intake and robot concentrate offered.

Total Diet Amylase Neutral Detergent Fiber (aNDF) %: percentage of amylase neutral detergent fiber from the combined total of PMR intake and robot concentrate offered.

Partially Mixed Ration (PMR) Lignin %: percentage of lignin for the partially mixed ration intake.

Total Diet Starch %: percentage of starch from the combined total of PMR intake and robot concentrate offered.

Total Diet Ash %: percentage of ash from the combined total of PMR intake and robot concentrate offered.

Total Diet Fat %: percentage of fat from the combined total of PMR intake and robot concentrate offered.

Total Diet Non-fiber Carbohydrate (NFC) %: percentage of non-fiber carbohydrate from the combined total of PMR intake and robot concentrate offered.

% Energy Offered at the Robot: % Mcal offered at robot of total ration.

PMR Mcal Conc.: amount of energy from the partially mixed ration.

Mcal Conc. of Robot Feed: amount of energy from the offered robot concentrate.

Milk Speed kg/minute: average speed of milk flow during the milking.

# Milkings/Cow/Day: average number of milkings per cow per day.

kg Conc. Offered/100 kg Milk: amount of concentrate feed offered to the cows per 100 kg of milk produced.

Average Boxtime minutes/visit: average time spent by the cow in the robot per milking.

Average Fat % Indication: average percentage of fat in the milk.

Average Protein % Indication: average percentage of protein in the milk.

Average Fat Protein Ratio (FPR): the average percentage ratio of fat/protein in the milk.

Cows/Robot: number of cows per robot.

FPCM/Milking: fat and protein corrected milk per milking.

Average Feeding Rate kg concentrate Offered/100 kg milk: average feeding rate of the amount of concentrate feed offered to the cows per 100 kg of milk produced.

Log # Refusals: log-transformed average number of times that a cow visits the robot before she is allowed to be milked per day.

Log Rest Feed Conc. %: log-transformed percentage of the allowed concentrate robot feed which was not dispensed to the cow during the day.

Log Free Time %: log-transformed average percentage of time during the day that the milking robot is doing ‘nothing’ (no milking or cleaning).

Rumination minutes: average daily time spent for rumination per cow.

# Connection Attempts: average number of connection attempts per cow per visit to the robot before she is milked per day.

kg Concentrates at 60 Days in Milk: amount of concentrate feed offered to the cows at 60 days in milk.

Treatment Time seconds: average time spent per cow for pre-milking per visit to the robot.

Log # Failures: log-transformed average number of times that a cow visits the robot and fails to be milked per day.

Energy Corrected Milk (ECM) kg: amount of energy in the milk based upon milk, fat and protein and adjusted to 3.5% fat and 3.2% protein. ECM kg formula = Milk production (kg) × (383 ×fat% + 242 × protein% + 783.2)/3140.

kg Butterfat and Protein Yield: average total amount of kg of fat and protein produced per cow.

ECM/DMI kg: energy corrected milk per total dry matter intake.

Total Mcals consumed: amount of energy consumed from the combined total of PMR intake and robot concentrate offered.

Mcals Consumed @ Robot: amount of energy consumed from the offered robot concentrate.

Mcals Consumed in PMR: amount of energy consumed from the partially mixed ration.

Percent of Energy Consumed in PMR: the percentage of energy consumed from the partially mixed ration.

Ratio of Refusals to Percent of Energy at the Bunk: ratio between the average amount of feed refused in the robot compared to % Mcal offered at the bunk.

Log kg Rest Feed: log-transformed amount of the allowed concentrate robot feed which was not dispensed to the cow during the day.

Total Diet Mcal Concentration: amount of energy from the combined total of PMR intake and robot concentrate offered.

Milk Production/Cow/Day: the average amount of milk produced per cow per day.

kg Concentrates/100 kg Milk at 60 Days in Milk: amount of concentrate feed offered to the cows per 100 kg of milk produced at 60 days in milk.

kg Fat: amount of fat from the combined total of PMR intake and robot concentrate offered.

kg Protein: amount of protein from the combined total of PMR intake and robot concentrate offered.

Total Butterfat and Protein kg: average amount of butterfat and protein in milk.

ECM/Milking: the average energy corrected milk per milking.

Less Rest Feed kg: average amount of feed remaining in the robot.

kg Crude Protein from PMR: amount of crude protein from the PMR intake.

kg Crude Protein @ Robot: amount of crude protein from the robot concentrate offered.

kg ADF Consumed: amount of acid detergent fiber from the combined total of PMR intake and robot concentrate offered.

kg aNDF Consumed: amount of amylase neutral detergent fiber from the combined total of PMR intake and robot concentrate offered.

kg Lignin from PMR Consumed: amount of lignin for the partially mixed ration intake.

kg Starch from PMR: amount of starch from the PMR intake.

kg Starch @ Robot: amount of starch from the robot concentrate offered.

Number of Robots: number of robots per farm.

Milk/Robot: amount of milk collected per robot.

Total Amount of Milk Produced kg: average total amount of milk per day.

Number of Visit: average number of visits to the robot per cow per day.

Amount of Milk Separated kg: amount of milk separated for quality reasons in kg per day

Number of Cows Milk Separation: number of cows of which milk is separated for quality reasons.

kg Concentrates Fed: amount of concentrate offered at the robot.

kg Rest Feed Concentrates: amount of the allowed concentrate robot feed which was not dispensed to the cow during the day.

Number of Cows Milking: number of lactating cows on farm.