Accuracy results from on-farm Ekomilk-AMP measurement for somatic cells, fat and protein content in cow milk

July 25, 2017Animal health, Laboratory automation, On-farm measurementaccuracy, AMP, AMPI, certification, comparison, Ekomilk, reliability, repeatability

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From March till June 2017, 2 evaluation users have used Ekomilk Horizon Unlimited on 4 dairy farms in Europe. For an introduction on the Ekomilk – AMP (Animal Monitoring) solution, please see this video (<3min):

In this post I give an overview of the accuracies and correlations achieved and the according on-farm test conditions.

As a brief summary, during official lab comparisons the average correlation coefficients were 98.7% for fat content, to 96% for SCC (somatic cell count), to 89% for protein content. In other words, over 90% accuracy can easily be achieved for each milk component or parameter measured over its full range, once a full initial calibration has been performed for that specific farm (also for total solids or dry-rest, conductivity etc). Since the Ekomilk – AMP solution is improving every month, with more integration and automation options being added, it is realistic to say that a correlation coefficient of over 95% will be typical from H2 2019 for common breeds and farm conditions. Already the current 90-99% accuracy range seems more than sufficient for on-farm individual and bulk tank analysis.

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On-farm testing procedures and conditions:

Of the 4 dairy farms visited, the farm size varied from 35 to 105 dairy cows. Cow breeds were Holstein, cross breds and a local breed (Normande) which goes sometimes higher in fat content, over 6% (over 60 g/kg). Official ICAR approved samplers from the milking parlor manufacturer or from TruTest were used in order to create two representative and identical samples per cow (individual). The ambient temperatures varied from 16°C (early morning) to 28°C (sheltered room for milk analysis next to the milking parlor).

The individual milk samples were analysed by Ekomilk-AMP within 6 hours on average after the end of the milking process in the milking parlor. Sometimes the milk samples were composed 50% evening and morning milk (samples one night in fridge, sample mixing proved essential).

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General background: official milk control labs are for instance the DHIA in the US and the Control Lechero in Spain and the Conseil Elevage (Controle Laitier) in France. Such official milk quality lab (Bretagne) also analyzed each individual milk sample.

On the Cloud platform (AMP), a full calibration can optionally be performed if the end-user provides accurate official lab comparisons. "Full calibration" means that the full measurement range which the official lab (i.e. a reliable, consistent and highly accurate reference method such as Fossomatic) can provide and which is physically possible for Ekomilk (for instance no butter or cream over 12% fat content unless diluted), can also be used for each milk component (parameter).

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Milk components, measurement ranges and calibration:

The main milk components measured by Ekomilk-AMP and the according measurement ranges are (preliminary; custom ranges on request):

- SCC (somatic cell count) from 50 000 cells/ml till 15 000 000 cells/ml,

- F (fat content) from 0.1% till 12%,

- P (protein content) from 0.5 till 9%,

- S (solids, dry rest) from 4 till 24% (preliminary info).

"Full calibration" also means that the calibration can be performed in the Cloud on multiple levels: per bulk tank, per farm and per animal if a consistent animal identification is present for

consecutive (periodic) measurements. Combining these levels holds serious potential for further improvement of the accuracies.

While at this moment there is a manual intervention (doublecheck) implying a 3 working day delay for a new calibration profile to be deduced (after detailed data verification of lab and Ekomilk raw results) and activated, by October 2019 this process can be completely automated thanks to concepts inspired by neural networks (NNets) and artificial intelligence (AI). The AMP calibration algorithms are self-learning and will in near-future better understand the influence of certain factors on the calibration – and hence improve the accuracy further and reduce the frequency of required calibrations. At this early stage, every 3 months, a full calibration (with more than 60% of the population i.e. almost all dairy cows on the farm sampled) is recommended in order to obtain similar accuracy results. Besides, at this early stage a quick partial calibration check with a few samples of the population (e.g. 10% of cows) is recommended every month for the most important milk components but this is only a temporary requirement. Studies are being conducted on the calibration frequency topic: the AMP self-learning algorithms (AI) will be able to reduce the recommended calibration frequency and the required number of samples (percent of the population).

Reliability of the measurements:

In 100% of the measurements, a wrong measurement on a milk component due to an instrument measurement error could be detected 100% reliably thanks to coherence checks which happen on tank, farm and animal level. In other words, there was never an error in the final measurement result which shifted the result into another measurement range. Measurements flagged as erroneous on AMP, were not taken into account for the correlation and standard error calculations. Often, errors from wrong sampling (not ICAR, too much air or bubbles in the sample), sample preparation (not enough mixed) or measurement conditions (too low temperatures) were also detected by Ekomilk-AMP.

For these farms, 1082 physical measurements were available from analyzing composite (individual, 4 quarters) milk samples. The coherence checks excluded 7 measurements which were probably due to insufficient milk sample preparation (fat separation? see below) which was still manual (operator dependent) at this stage.

In this context, it is important to mention the new **AMPI Sample Feeder (SF)**. This automation accessory does not only automate; it also important because it verifies and prepares every milk sample. Depending on your SF model, the SF can:

- level check: if the sample vial is empty or insufficiently filled, it will be detected automatically

- mixing: butter fat or milk cream separation occurs already after 10 mins at room or lab temperatures around 24°C. The influence of fat separation can create large measurement errors. Correct sample mixing before measuring is crucial, the SF usually handles mixing for samples <24h old.

These farm trials were preceded by over 130 000 tests in the Ekomilk-AMP design labs and tests on other continents with earlier prototypes.

Results transfer options:

About using real-time results in the milking parlor and in the lab: the measurement results of Ekomilk-AMP, after applying the right calibration in the Cloud (AMP), can be received per SMS , via email, on the AMP web app on the browser or on any approved external database (DB) via the AMP APIs. In each AMP user account, it's easy to add a few phone numbers or email addresses. Similarly, it's just a click to share results with your preferred lab or vet so that your contact can follow in real-time, wherever he or she is located.
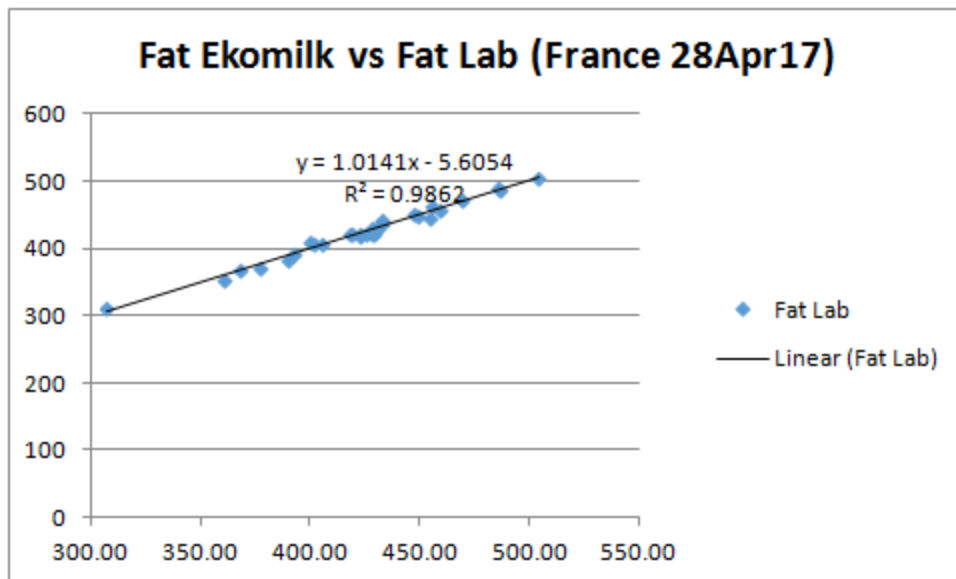

Laboratory comparisons, accuracy figures:

For these specific evaluations per farm, the Ekomilk-AMP results after calibration have been compared to the official lab results. The official labs often use analysis equipment from companies like Foss , Bentley or CEM. They have regular (more than once per 2 months) official calibration and certification procedures. In the graphs below, the correlation coefficients (more in general, coefficient of determination) are shown. Standard errors (like the theoretical standard deviation) are also summarized. RMSE figures are available in certain cases; RMSE were usually doublechekcs for our way of working using different algorithms from NNets or AI.

After lab comparisons, the average correlation coefficients varied from 98.5% for butter fat content, to 96% for SCC (somatic cell count), to 89% for milk protein content. In other words, over 90% accuracy can easily be achieved for each milk component or milk parameter measured over its full range. Less important ones such as solids or dry-rest, conductivity, on request also pH etc in any case achieve very high accuracy as well. Over 95% is realistic as a minimum for all milk components in mid-term (2019?) for this new Ekomilk – AMP solution. Roughly summarising the parallel developments going on for Ekomilk – AMP, we could say that every 3 months, the accuracy of Ekomilk – AMP is improving significantly. The examples below are only indicative; for a guarantee about the accuracy please contact us.
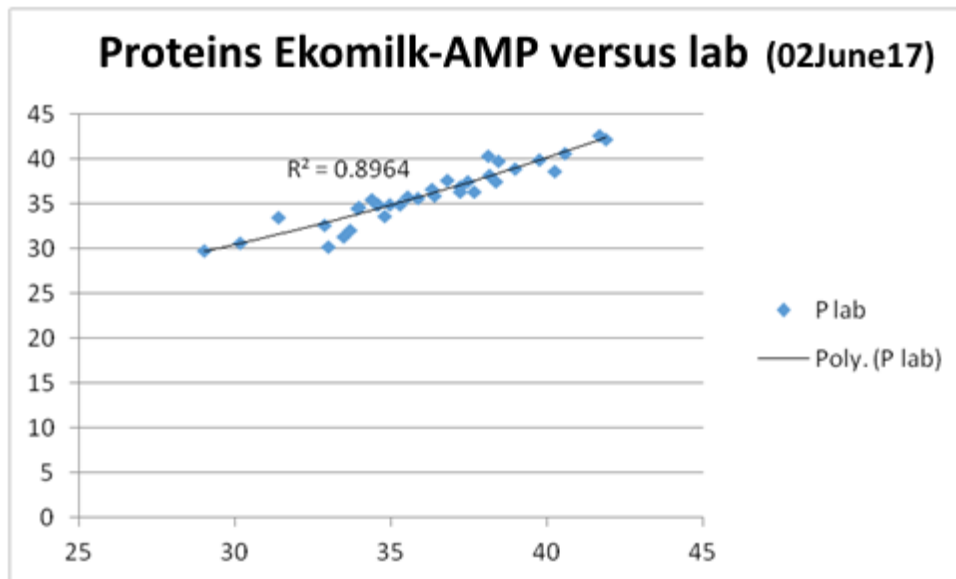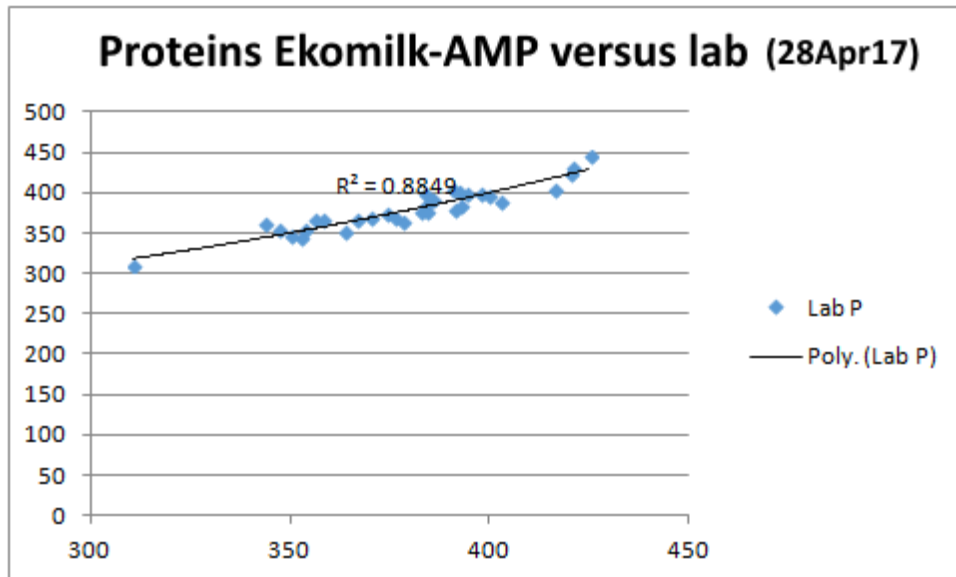

Butter fat content:

The lowest correlation result for milk fat content analysis by Ekomilk AMP in terms of correlation coefficient was 98.6%. The standard error of the fat content was well below 0.1% for all milk farms analyzed. A good sample preparation is essential for reliable fat measurement results, especially when thinking about fat separation which can occur within 30 mins at room temperature. The AMPI Sample Feeder also automates the sample preparation process so the biggest preparation and measurement mistakes are eliminated. Every sample is also verified (for instance via liquid level check, see above, besides temperature verification and in future also temperature compensation).

Fat Ekomilk vs Fat Lab (France 28Apr17)

$$y = 1.0141x - 5.6054$$
$$R^2 = 0.9862$$

- ◆ Fat Lab
- —— Linear (Fat Lab)
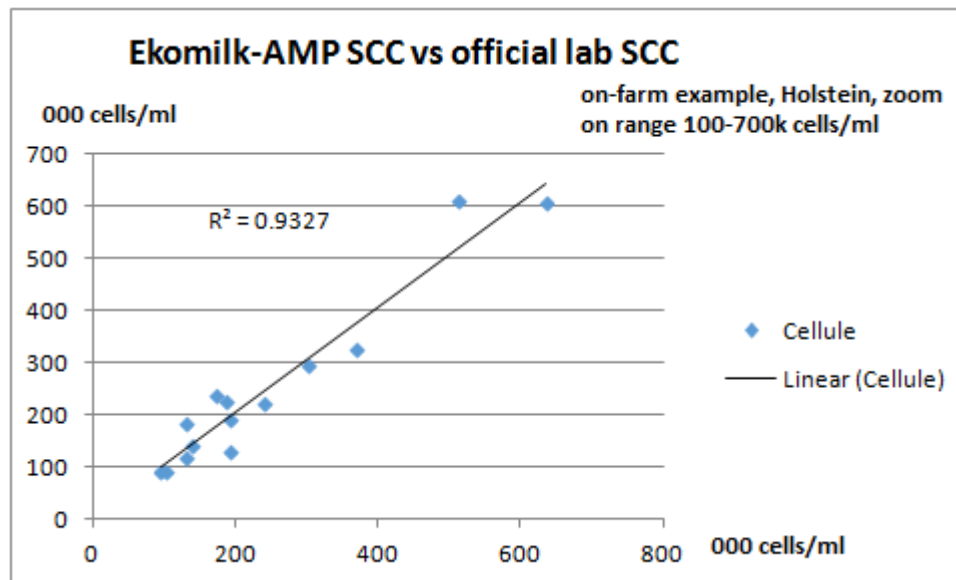
Protein content:

The protein accuracy on all dairy farms visited never went below 88%, together with a standard error around 0.12%. In near future, this accuracy will increase further thanks to AI and NNet algorithms on AMP (Cloud).

Proteins Ekomilk-AMP versus lab (02June17)

$$R^2 = 0.8964$$

- ◆ P lab
- —— Poly. (P lab)

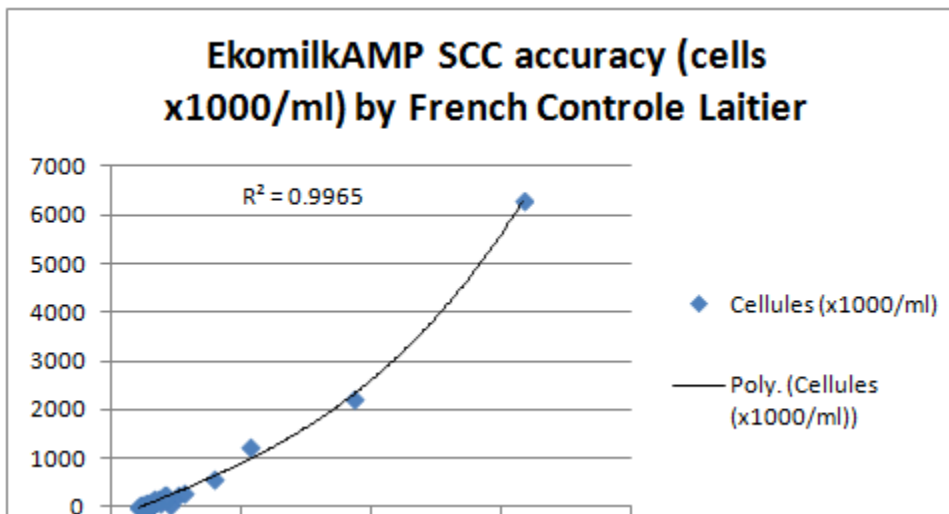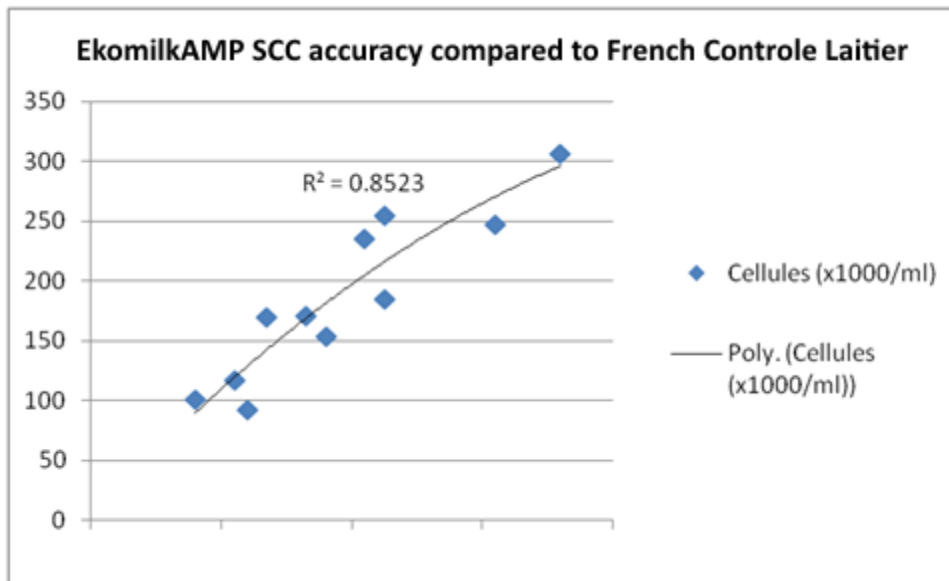**Proteins Ekomilk-AMP versus lab** (28Apr17)

$R^2 = 0.8849$

SCC (somatic cell count) level:

When measuring the SCC in fast measurement mode, automatically the Ekomilk-AMP configuration settings will be chosen which prioritise to increase measurement speed over measurement accuracy. The below graphs are examples of the accuracy which can be achieved in typical user scenarios after calibration on that dairy farm via the AMP user account. The unit in the graphs is usually kcells/ml (k for 1000, M for 1 000 000).

Ekomilk-AMP SCC vs official lab SCC

on-farm example, Holstein, zoom on range 100-700k cells/ml

$R^2 = 0.9327$

EkomilkAMP SCC accuracy compared to French Controle Laitier

$R^2 = 0.8523$

EkomilkAMP SCC accuracy (cells x1000/ml) by French Controle Laitier

$R^2 = 0.9965$

Milk SCC or subclinical mastitis, udder health and milk quality detection via Ekomilk AMP vs official lab for SCC from 0 to 6000k cells per ml

The most critical SCC (somatic cell count) level is usually around 250 000 cells/ml. Also around this zone or level, Ekomilk AMP usually achieves very good accuracy around 90% compared to the official lab values:

Milk SCC or subclinical mastitis, udder health and milk quality detection via Ekomilk AMP vs official lab for SCC from 100 to 600k cells per ml

Finally, Ekomilk-AMP can now also measure from around 40 000 cells/ml and in future from even lower SCC values:

The accuracy of the measurement results of the milk analysis can be increased via selecting "standard" or "high accuracy" measurement mode. This measurement mode is recommended when for instance measuring bulk tank milk. In this mode, the measurement duration will increase, together with the accuracy and calibration fine-tuning. Large milk processors have evaluated and approved Ekomilk-AMP for its high accuracy and reliability.

Future plans and next steps ahead:

While the dairy farms in this example were usually small (below 100 dairy cows), evaluations of Ekomilk – AMP is also going on on large farms (>200 cows). Future studies and comparisons will give more certainty and background (limitations of test conditions?) about the above accuracy figures.
Integration of Ekomilk – AMP on milking robots is also possible.

http://animalmonitoring.com/