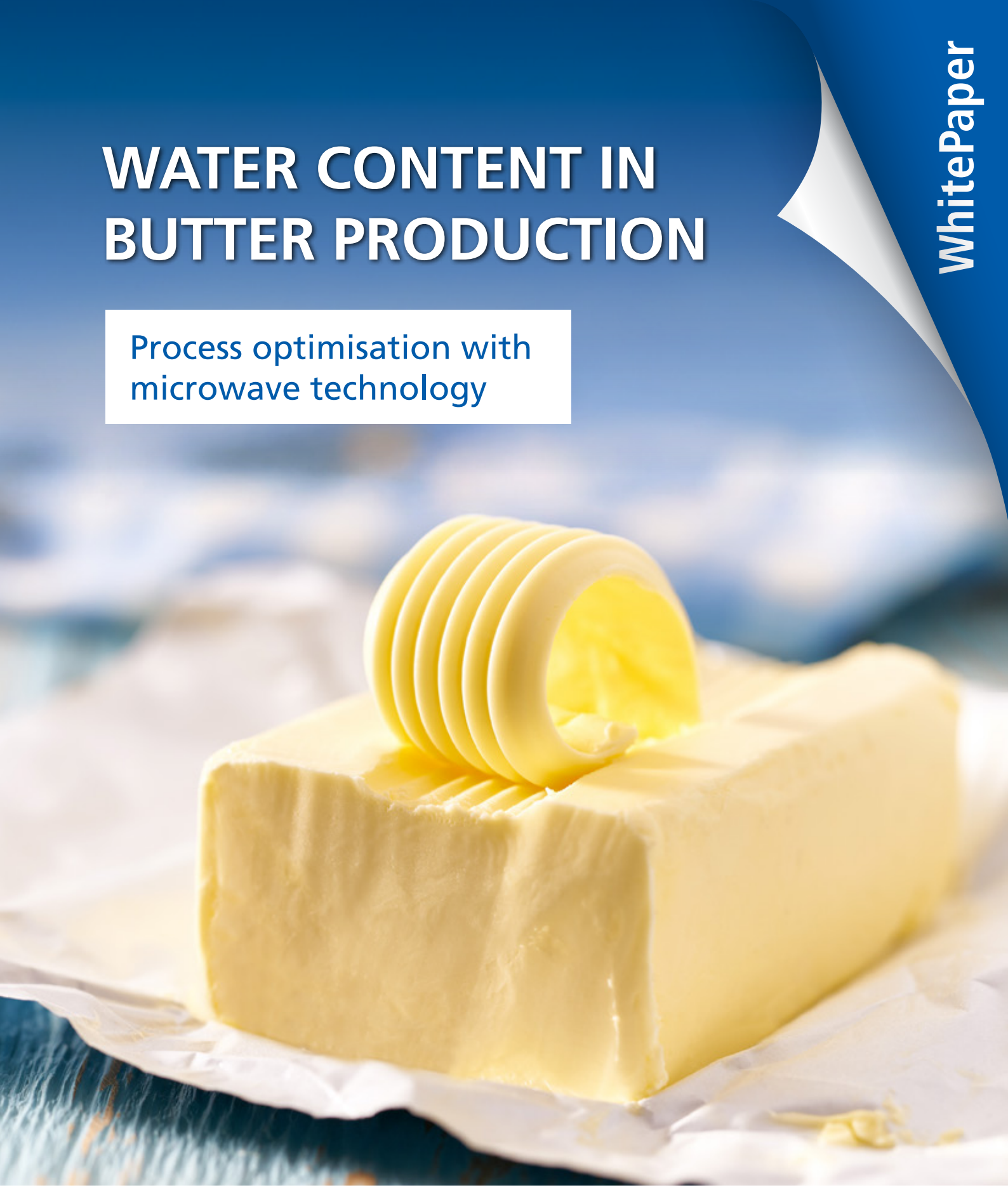
WhitePaper

WATER CONTENT IN BUTTER PRODUCTION

Process optimisation with microwave technology



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Introduction

In modern dairy processing, precision is no longer just a mark of quality but a key economic factor. This is especially evident in butter production, where the moisture content must be carefully balanced. Depending on production conditions and process parameters, the moisture content can vary between 15% and 17%. However, the legal limit in the European Union is 16%. If the moisture content exceeds this threshold, the product cannot be sold.
To avoid exceeding the legal limit, many manufacturers intentionally set a lower target moisture content, typically between 15% and 15.5%. However, this precautionary buffer reduces profitability: even a slight decrease in water content increases the fat proportion in the product, resulting in financial losses. Moreover, insufficient moisture can negatively impact butter quality, compromising spreadability and lead to an undesirable texture.

It is evident that reliable, continuous moisture measurement directly within the production line is essential. Only with real-time monitoring can water addition be automatically regulated, enabling butter production to be optimized for consistent quality and maximum efficiency.

This study examines the practical application of the MicroPolar LB 566, an advanced microwave measurement system designed to determine moisture content in butter. The system delivers precise, non-destructive measurements using microwave technology and is specifically engineered for seamless inline integration into dairy production processes. The goal is to provide manufacturers with an optimal solution to increase yield, ensure product quality, and reliably comply with legal requirements.

Measurement principle
Microwave transmission technology is a reliable and well-established method for rapidly determining the moisture content in dairy products such as butter. The core principle of this technique is based on the interaction of electromagnetic waves with the dielectric properties of the product. Because butter is mostly made up of fat and water, the method takes advantage of the big difference between the electrical behavior of water and fat. Water has a much higher ability to absorb and transmit electromagnetic energy compared to fat, so even small changes in moisture levels can be detected very accurately.

The MicroPolar LB 566 measures both the phase shift and attenuation changes of microwaves transmitted through the product. By evaluating these parameters simultaneously, the system is able to quantify moisture content in real time, non-destructively and with high accuracy.

The system operates within a frequency range where conductivity has minimal impact on measurement accuracy and repeatability. Furthermore, it features a specialized sensor specifically engineered to minimize

Installation and operating principle

The MicroPolar LB 566 is designed for inline applications, ensuring representative measurements across the entire cross-section of the product flow. Its robust design and multifrequency technology enable stable and reliable measurements that are unaffected by factors such as color, viscosity, heterogeneous composition, or salt content.

To achieve precise moisture measurement, a Berthold FlowCell is integrated directly into the butter churn. The FlowCell is EHEDG-certified and compatible with Clean-in-Place (CIP) protocols. Its antenna design has been specifically developed for high-precision dairy applications. The structure is engineered to minimize internal electromagnetic reflections and interferences, thereby maximizing measurement accuracy and repeatability. A specialized hygienic microwave cable provides a secure, contamination-free connection between the FlowCell and the LB 566 device.

The integrated antennas and FlowCell design enable complete microwave penetration of the butter flow, ensuring that measurements are representative of the entire product cross-section. This results in reliable real-time data for effective process control.

The system can be easily installed on existing pipelines with minimal modifications. Operation is carried out on-site via a user-friendly interface, allowing straightforward commissioning and calibration.

If the dielectric properties of different butter varieties vary significantly, separate calibration curves can be stored for each variant. The MicroPolar LB 566 can internally store up to four distinct calibration curves. Additionally, via the serial interface, an unlimited number of calibration datasets can be uploaded to the device. Furthermore, the system can automatically switch to the appropriate calibration dataset using a simple digital control input.

Figure 1
Quality control with the LB 566 and a DN100 FlowCell during butter production before packaging.

System evaluation case study

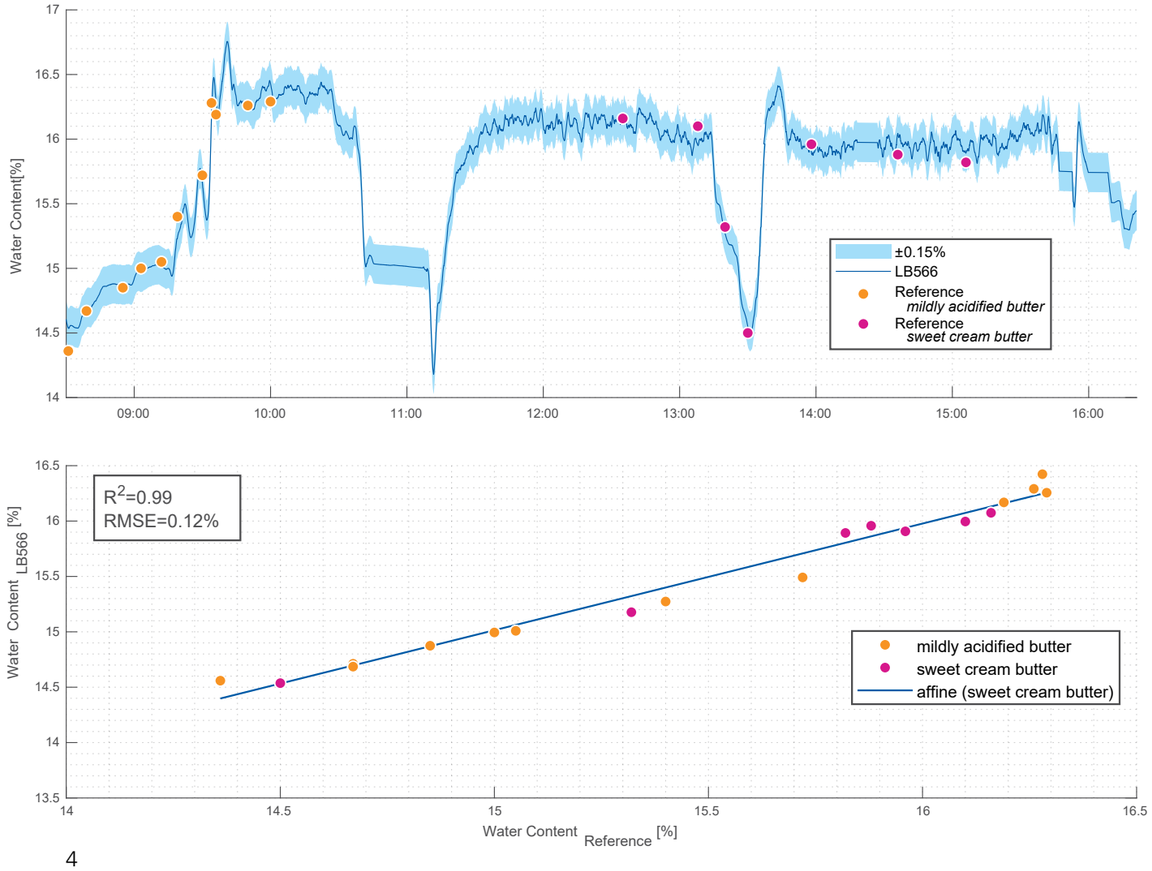
To establish a reliable calibration curve, reference measurements were conducted using a standard laboratory device (e.g., near Infrared spectroscopy) and compared with the microwave moisture values from the MicroPolar LB 566. The calibration is always based on the analysis of butter samples with moisture content within the target range. In this case study, calibration was performed using both mildly acidified butter and sweet cream butter.

The lower graph (Figure 2) shows the continuous moisture measurement during the sampling of calibration specimens. The blue values represent the real-time measurements from the LB 566, while the colored points indicate the corresponding laboratory reference values. The pink shading represents the measurement uncertainty of ±0.15%, within which nearly all reference values fall clearly, demonstrating the system's high measurement stability under actual production conditions.

The lower graph presents the regression analysis of the calibration. With the high coefficient of determination (R^2 = 0.9867), an excellent correlation between the LB 566 measurement values and the laboratory reference data is demonstrated The maximum deviation is only ±0.12%, confirming that the system fully meets the typical requirements for industrial inline moisture measurement.

Notably, no significant offset in measurement characteristics was observed between the two types of butter. The calibration points for both varieties align along the same regression line, indicating that slight differences in pH have no meaningful impact on measurement results. This consistency greatly facilitates the system's application across different product qualities.

Figure 2 Calibration results and analysis



Validation of the LB 566 over several weeks

To assess long-term stability and practical suitability, the system was further validated over a period of several weeks under real production conditions. For Figure 3, measurement data from four randomly selected days were analyzed. The daily profiles include various butter batches, production pauses, water additions, and cleaning cycles.

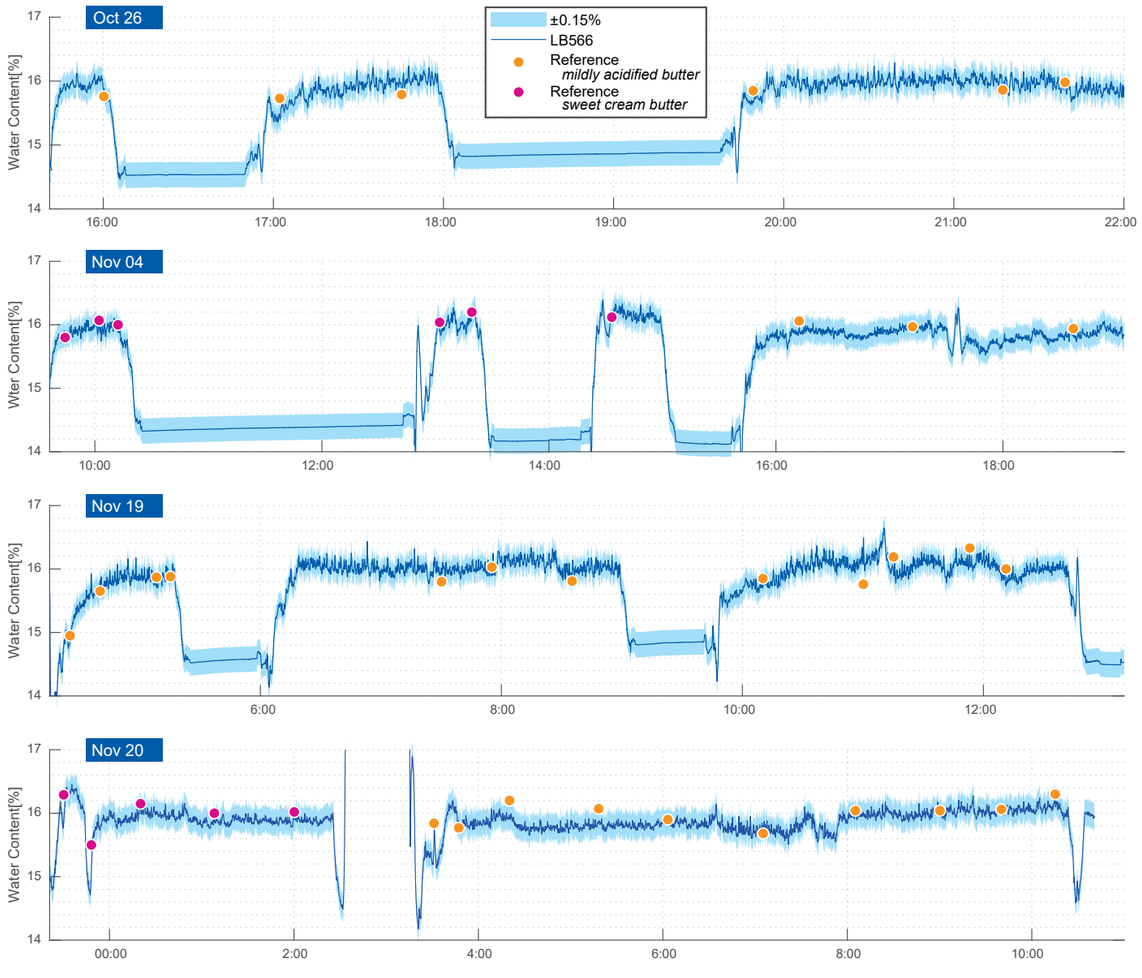
The continuous measurement curves clearly demonstrate that the MicroPolar LB 566 delivers stable and reproducible moisture values even over extended time periods. All recorded daily profiles (see Figure 3) show high reproducibility – despite interim process interruptions or variations in product characteristics.

Validation Result:

The parallel laboratory reference values fall almost entirely within the system's defined tolerance range of ±0.15%. This demonstrates that the initial calibration remains valid not only in the short term but also under varying production conditions – without the need for recalibration.

Notably, no significant drift or systematic error was observed over the course of several weeks. These results clearly indicate the high long-term stability of the measurement system.

Figure 3 Validation results



Economic consideration

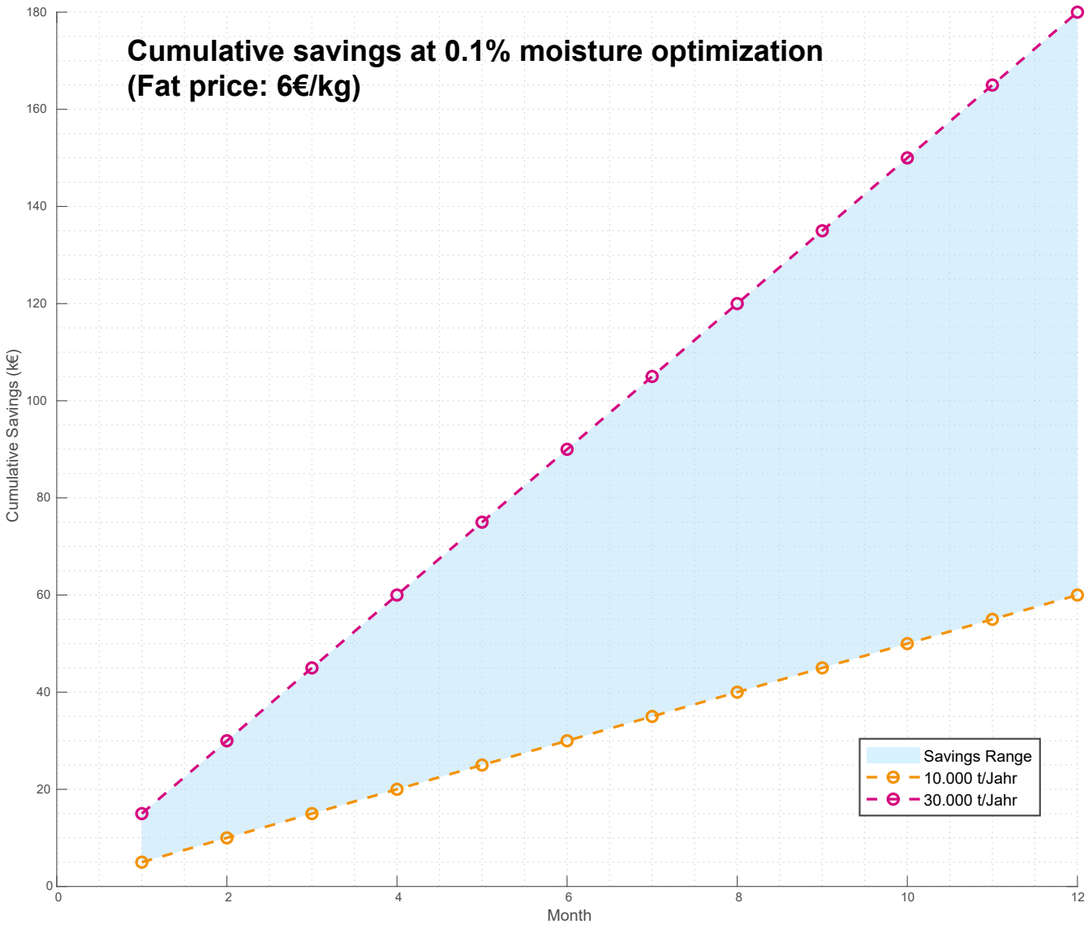
Figure 4 illustrates the cumulative savings potential achieved by optimizing moisture content by just 0.1% (equivalent to 1 kg of fat per ton) at a fat price of 6 € per kilogram. The Y-axis shows the resulting savings in thousands of euros over a 12-month period. Two production scales are considered: a smaller dairy processing 10,000 tons per year and a larger facility producing 30,000 tons annually.

Even at an annual production of 10,000 tons, the savings potential amount to approximately 60,000 €. For 30,000 tons, savings can reach up to 180,000 €. Thanks to its strong return on investment, the system typically pays for itself within just a few months even for smaller dairies, often within as little as three months.

This graphic highlights a key takeaway: even a minimal adjustment to moisture content can significantly increase contribution margins, underscoring the value of precise, automated moisture measurement with the MicroPolar LB 566.

In addition, the MicroPolar LB 566 stands out for its durability: under standard operating conditions, a service life of 15 years is not the exception but the rule.

Figure 4 Economic savings potential



Summary of key benefits

Using the Berthold microwave system LB 566 to monitor water content in butter production delivers several key benefits. It enables continuous process monitoring and allows for a fast response to quality variances. At the same time, it ensures efficient use of resources and provides reliable process control, resulting in consistent quality and optimized efficiency.

Figure 5 Summary of key benefits

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