Rheolution
AGRI-FOOD

Application note | CoaguSens™ Connect

Yield optimization journey – Phase 2: Cheese yield stabilization through at-line monitoring of coagulation

COAGUSENS™ CONNECT

BACKGROUND

Cheese is obtained by coagulation of milk and subsequent separation of the milk gel into liquid (whey) and solid (curd) phases. An essential step of the cheesemaking process involves cutting the formed milk gel into small cubes to allow whey separation by increasing curd surface/volume ratio. Cutting time selection greatly affects the yield, moisture and quality of cheese. Cutting the gel too soon when the curd is not firm enough leads to lower cheese yield through increased curd fines and fat loss, whereas delayed cutting results in higher cheese moisture content due to reduced collapse of the gel. This may further alter the ripening process and final product quality. In this context, optimizing yield and reducing the variability in quality are of great economical interest. As milk production is responsible for more than 90% of the carbon footprint of the cheese industry, maximizing the yield would also reduce the environmental impact of the industrial manufacturing processes.

Milk gels are usually cut at a predetermined time or according to the cheesemaker's subjective evaluation of gel texture and appearance. These can lead to considerable variation in yield, because many factors affecting the gel strength do not remain constant. There is a pressing need for objective and quantitative real-time milk gelation and cutting time determination that help refine the cheesemaking process, improve process automation, reduce the variations, and maximize yield.

For this purpose, Rheolution Inc. has developed CoaguSens™ Connect the first testing instrument allowing:

— Quantitative measurement of milk gel firmness during coagulation.
— At-line monitoring of milk gel formation in real time.
— Precise monitoring of cutting time.

This application note presents the results of a study performed in a cheese plant to evaluate the impact of controlling milk gel firmness at the cutting step using of CoaguSens™ Connect on the variability of cheese yield. This study was conducted in a Canadian medium-sized cheese plant manufacturing cheddar cheese.

This application note describes in detail the second phase of the yield optimization journey: Cheese yield stabilization through at-line monitoring of coagulation.

COAGUSENS™ CONNECT

CoaguSens™ Connect characterizes in real time the evolution of milk gel firmness during coagulation under the action of enzymes (coagulation) or ferments (fermentation). The patented technological principle behind this instrument is purely mechanical: the dynamic response of the milk sample to small and gentle vibrations is first measured using a contact free laser probe and then processed to obtain a quantitative value for gel firmness (elasticity or shear storage modulus G'). CoaguSens™ Connect has the following main specifications:

— Real time elasticity measurement of milk gel firmness.
— Thermal control between 20°C (68°F) and 50°C (122°F).
— Ingress Protection (IP65).
— Communication protocol with PLCs: Modbus TCP/IP.

CoaguSens™ Connect comes with a modular, user-friendly and connected touchscreen-based user interface, called CoaguTouch™, designed to configure the instrument, set and run a test and analyze data. It has been designed for a simple integration with existing PLC-based control systems for automatic process control. CoaguTouch™ provides user-oriented tools and functions to manage, analyse, display, store and transfer data.

IN-PLANT PILOT STUDY

The objectives of the study were:

1. **To use CoaguSens™ Connect to measure curd firmness during coagulation and specifically at exact cutting time.**
2. **To stabilize the variability of cheddar cheese yield by stabilizing the firmness at curd cutting time.**

The study has been divided into two phases:

PHASE I – LEARNING PHASE

The objectives in this phase were:

— To measure the firmness of milk gels during coagulation for different vats.
— To determine the mean value of firmness at cutting time as controlled by cheesemakers.

In Phase I, cutting time was determined according to the cheesemakers' manual evaluation of milk gel texture and appearance while simultaneously monitoring the milk gel firmness during coagulation using CoaguSens™ Connect. Coagulation kinetics were recorded for different batches during 4 weeks and the mean values and standard deviations of milk gel firmness at cutting step and cutting times were analyzed.

PHASE II – INITIATING CUTTING BASED ON CURD FIRMNESS

The objectives in this phase were:

— To cut the curd when firmness reaches the mean value determined in Phase I.
— To collect data on yield and measure the impact of a better control of cutting firmness on the variability of cheese yield.

In Phase II, the milk gel formation was measured using CoaguSens™ Connect as in Phase I, but now the gel was cut when it reached the mean elasticity obtained in Phase I.

Milk composition (fat, protein and total solids content) was determined using MilkoScan FT2 Infrared Milk Analyzer (FOSS, Denmark). Seasonal variation in milk composition was observed between phases I (February) and II (March-April) as shown in Table 1. Because milk in phase II was less rich than in phase I, it was anticipated that yield decreases in phase II.

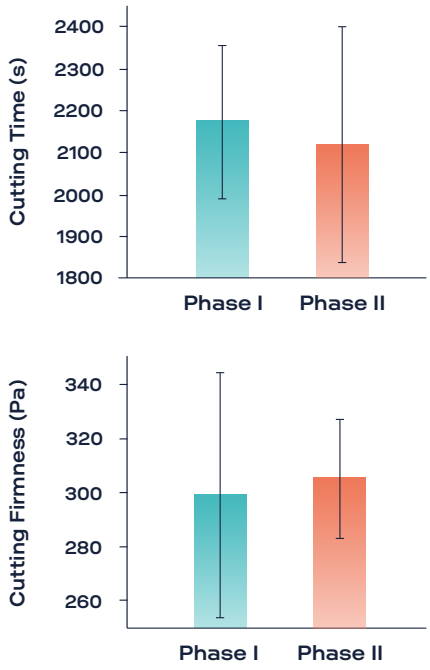

Fig. 1 Mean values and variability of cutting time (above) and cutting firmness (below) in Phase I (blue) and Phase II (red), without and with CoaguSens™ Conncect, respectively.

	Phase I	Phase II
Total solids (%)	12.54 ± 0.15	12.42 ± 0.14
Proteins (%)	3.23 ± 0.05	3.17 ± 0.05
Fat (%)	3.96 ± 0.06	3.90 ± 0.07

Seasonal variation in milk composition between phases I (February) and II (March-April)

RESULTS

In Phase II, the cutting of curd was started when the firmness reached the mean value measured in Phase I. This led to greater variability (+ 51 %) in cutting times due to batch-to-batch variation of coagulation kinetics, but reduced the variability in cutting firmness by -51 % (Fig. 1).

Importantly, the effect of reduced variability in milk gel firmness at cutting was observed in cheese yield: the variability in actual yield decreased from ± 0.47 % to ± 0.25 %, that is, by 45 % (Fig. 2). The mean yield in Phase II remained stable compared to Phase I because the mean cutting firmness was identical in both phases. In addition, the use of CoaguSens™ Connect to monitor the cutting time prevented the expected decrease of yield because of the change in milk composition between phases I and II.

The use of CoaguSens™ Connect had also an impact on the variability of cheese moisture. Moisture variability of white cheddar decreased by 28 %.

CONCLUSION

CoaguSens™ Connect is a new automation instrument for the at-line monitoring of coagulation processes and the determination of cutting time based on the firmness of the milk gel. The results of this study performed in a medium-size cheese plant showed reduced variability in yield after stabilizing the firmness at which the curd is cut. This allows refining the process and leads to considerable savings upon improved quality and enhanced process efficiency. Rapid, simple and quantitative measurement of curd firmness using CoaguSens™ Connect facilitates further automation of the cutting step.

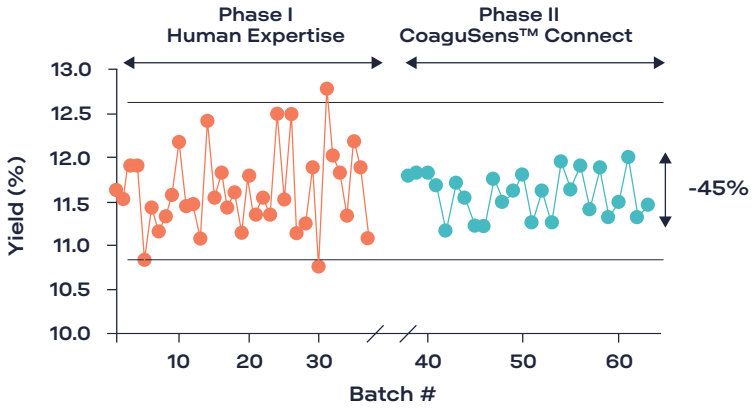

Fig. 2 Cheese yield (actual yield) and its variability in phases I (without CoaguSens™ Connect) and II (with CoaguSens™ Connect)