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Møller, Cleide Oliveira de Almeida; Czárán, Tamás László; Christensen, Bjarke Bak; Siegumfeldt, Henrik; Rattray, Fergal Patrick

Publication date:
2016

Citation for published version (APA):
Reduction of Cheddar cheese ripening time through the addition of glucose

Cleide O. de A. Møller1, Tamás Czárán2, Henrik Siegumfeld1, Bjarke B. Christensen1 and Fergal P. Rattray1

1 University of Copenhagen, Department of Food Science, Frederiksberg, Denmark
2 University of Copenhagen, Niels Bohr Institute, Copenhagen, Denmark

Introduction
Ripening of cheese consists of complex microbial interactions between starter lactic acid bacteria (SLAB) and non-starter lactic acid bacteria (NSLAB). One of the key microbial interactions is growth of NSLAB by utilization of metabolites (various sugars) released from SLAB during cell death. The establishment of a high NSLAB level in cheese is slow, taking several months, but it is a prerequisite for high quality. Therefore, significant cost saving would be achieved if a high level of NSLAB could be established in a shorter time. This study, using broth models and cheese trials, was performed to optimize and accelerate the SLAB cell death-NSLAB growth interaction.

Materials and Methods
Broth models (adapted from Adamberg et al, 2005) as well as studies in cheese (based on Ortskii et al, 2015) were developed.

1) Broth models were developed by investigating the growth of a commercial SLAB containing Lactococcus lactis subsp. cremoris and subsp. lactis culture (10⁶ CFU/mL), in LM17 broth with and without supplementation of glucose for 48h, by measuring the optical density (OD) at 600 nm every hour using a microtiter plate reader (Biotek).

2) Cheddar cheese was manufactured using the same commercial SLAB, with fast cell lysis and properties. Glucose was added (0.5 %) at the milking stage in an attempt to increase the growth of NSLAB. Cheeses were vacuum packed and ripened at 10°C.

3) Cheddar cheeses were analyzed using standard methods (Figure 2) to measure different levels of NaCl, moisture (7 days after manufacturing).

Furthermore, lysed cells, pH, Aw, and microbial counts of SLAB and NSLAB were also measured (immediately after manufacturing and after 5, 9, 13 and 17 weeks ripening).

Cheddar Cheese manufactured with glucose addition

Figure 2: Overview of methods applied to investigate bacterial interactions in cheddar cheese manufactured with different levels of Salt in Moisture (S/M) and supplementation with glucose.

Results

The broth models showed that the 5 % salt in moisture (S/M) was sufficient to inhibit the utilisation of glucose by the SLAB (Figure 3).

Figure 3: Optical Density (OD) measured during growth of SLAB on LM17 broth (black line), with supplementation of 0.5 % glucose (open symbols) and with 0.5 % glucose plus 0.5 % NaCl (closed symbols).

Interestingly, when the cheeses supplemented with glucose were tested 24 h after manufactured, only cheeses with a level of salt in moisture greater than 5.0 % had 1/3 of the glucose added (Figure 4).

However, after one week’s ripening, the glucose was gone even in the cheeses with a level of salt in moisture greater than 5.0 %, which indicates that it has been used by the starter, since the level of NSLAB was still under the detection limit (10⁶ CFU/g of cheese). This suggests that the level of salt by itself is not enough to inhibit the utilization of the added glucose by SLAB and promote the faster growth of NSLAB during ripening.

Bacterial cell lysis was estimated by assaying for intracellular X-prolyl dipeptidylaminopeptidase activity (PepX) in aqueous extracts of the cheese (Figure 6). Results indicated no increase of the level of lysed cells during ripening until week 13, which supports the findings of the microbiological analyses.

Figure 4: Levels of Salt in Moisture (after 7-days of manufacturing of cheeses) and glucose detected in the cheeses after 1 and 7 days of manufacturing.

NSLAB increased from levels under detection limit (10⁶ CFU/g of cheese) to levels comparable with other cheesemakers (Rattray et al, 2015). Results indicated no differences on the microbiota in cheeses supplemented with 0.5 % glucose (Figure 5).

Despite the fact that levels of SLAB did not decrease significantly by week 17, changes in aroma of the cheeses were noted, which may be related to the increase of NSLAB levels.

Nevertheless, it seems that cheeses supplemented with glucose may have a relatively higher lysis until it became stable and at the same level of the related controls, with no glucose added. Lysis was lower and became stable faster on the cheeses with higher level of salt.

A certain degree of instability was also noted by investigating the pH as well as the water activity (Aw) of the cheeses during the ripening period (Figures 7 and 8, respectively).

Lessons learned by supplementing Cheddar cheese with glucose:

Results indicate that in order to accelerate the cheese ripening by supplementing with sugars, it is necessary to screen for sugars exclusively utilized by the NSLAB:

At the curd milking, glucose was added to increase the growth rate of NSLAB. One third of the added glucose was retained in the curd (when salt-in-moisture = 6.0 - 6.3 %); however, 1 week post-manufacture, no detectable glucose was present in the cheese. As NSLAB levels were still under the detection limit (10⁶ CFU/g of cheese) after 1 week post-manufacture, it is concluded that SLAB were responsible for the glucose depletion.

Surprisingly, the broth models showed that at 5 % salt-in-moisture, SLAB were unable to utilize glucose.

However, the pH became at similar levels, independently of the cheese. After 13 weeks all cheese had pH values inside the desired range for premium quality of Cheddar cheese.

Interestingly, values of Aw for cheeses supplemented with 0.5 % of glucose became close to its respective control, with no glucose added, in weeks 9 and 13 of ripening at 10°C for cheeses with S/M lower and higher than 5 %, respectively.

Therefore, values of Aw for cheeses supplemented with 0.5 % of glucose became close to its respective control, with no glucose added, in weeks 9 and 13 of ripening at 10°C for cheeses with S/M lower and higher than 5 %, respectively.

References

Future perspectives

Despite the fact that glucose was depleted from the supplemented cheeses by SLAB, investigation will still be performed using those cheeses, in order to understand the dynamics involved in bacterial interaction when adding the selected SLAB.

Since one of the key microbial interactions is growth of NSLAB by utilization of metabolites (various sugars) released from SLAB during cell death, cheeses supplemented with sugars exclusively utilized by the NSLAB are already under investigation.

For further details, please contact
Cleide O. de A. Møller
email: cleide@food.ku.dk

Acknowledgements
The present study has been financed by the Innovation Fund Denmark and Arla Foods.

Understanding the dynamics involved in bacterial interactions