



A Voyage of Discovery into the World of Raw-Milk Cheeses

A Production System with a Future

Author

Hans-Peter Bachmann



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Summary

We already have access to the knowledge and experience needed to produce cheese from raw milk with a level of food safety comparable to that of cheese made from pasteurised milk. However, the standards that must be met by all those involved in the value chain are significantly higher and more complex for the former than for the latter.

Based on the experience gained from seven expeditions to artisan cheesemakers upholding the tradition of raw-milk cheesemaking, we identified fourteen requirements for a future-oriented raw-milk cheese production system. These can be broken down into four categories: people, milk, technology and framework conditions.

A comparative study of cheese made from raw vs. thermised milk (where the milk is heated to 68 °C for 15 seconds) showed that proteolysis was significantly more intense in raw-milk cheese, with thermisation leading to a significant decrease in non-starter lactic-acid bacteria in the metagenome of mature cheese. It is plausible that the non-starter lactic-acid bacteria contribute to a more intense proteolysis and a more-nuanced flavour in raw-milk cheeses. This was confirmed by the determination of the volatiles, which allowed a clear distinction to be made between cheeses made from raw vs. thermised milk. The relative abundance of non-lactic-acid bacteria in the metagenome was very low in all cases examined, indicating a high level of food safety.

Elevated histamine levels were measured in individual raw-milk cheeses from two of the seven cheese dairies, indicating gaps in the monitoring of raw-milk quality. For this reason, Agroscope recommends that producers of raw-milk cheese in particular include *Lentilactobacillus parabuchneri* as a quality criterion when assessing milk quality. Elevated levels of propionic acid and histamine were also found in individual cheeses made from thermised milk, which can most likely be explained by recontamination.

Producing well-rounded, truly authentic raw-milk cheeses with unique organoleptic characteristics and a strong connection to *terroir* is a highly satisfying and rewarding experience for all those involved in the process.

Zusammenfassung

Das Wissen und die Erfahrung für die Herstellung von Käse aus Rohmilch mit einer vergleichbar hohen Lebensmittelsicherheit wie Käse aus pasteurisierter Milch sind vorhanden. Die Anforderungen an alle Beteiligten in der Wertschöpfungskette sind jedoch wesentlich höher und komplexer als bei Käse aus pasteurisierter Milch.

Auf der Grundlage der Erfahrungen aus sieben Entdeckungsreisen zu handwerklichen Käserinnen und Käsern, welche die Tradition der Rohmilchkäse hochhalten, wurden vierzehn Anforderungen an ein zukunftsorientiertes Produktionssystem für Rohmilchkäse abgeleitet. Diese Anforderungen lassen sich vier Bereichen zuordnen: Menschen, Milch, Technologie und Rahmenbedingungen.

Bei einer vergleichenden Untersuchung von Käse aus roher und thermisierter Milch (auf 68 °C während 15 Sekunden) zeigte es sich, dass die Proteolyse in den Käsen aus roher Milch wesentlich intensiver verlief. Die Thermisierung führte zu einer deutlichen Abnahme von Nicht-Starter-Milchsäurebakterien im Metagenom der ausgereiften Käse. Es ist plausibel, dass die Nicht-Starter-Milchsäurebakterien zur intensiveren Proteolyse in den Rohmilchkäsen und zu einem facettenreicheren Aroma beitragen. Dies wurde bestätigt durch die Bestimmung des Volatils, die eine klare Trennung zwischen den Käsen aus roher und thermisierter Milch erlaubte. Die relative Häufigkeit von Nicht-Milchsäurebakterien im Metagenom war bei allen untersuchten sehr tief, was auf eine hohe Lebensmittelsicherheit hinweist.

Bei einzelnen Rohmilchkäsen aus zwei von sieben Käsereien wurden erhöhte Gehalte an Histamin gemessen, was auf Lücken bei der Überwachung der Rohmilchqualität hinweist. Aus diesem Grund empfiehlt Agroscope insbesondere den Herstellern von Rohmilchkäse, bei der Beurteilung der Milchqualität auch *Lentilactobacillus parabuchneri* als Qualitätskriterium einzubeziehen. Bei einzelnen Käsen aus thermisierter Milch waren die Gehalte an Propionsäure und Histamin ebenfalls erhöht, was am ehesten mit einer Rekontamination erklärt werden kann.

Die Herstellung von Rohmilchkäse mit einzigartigen sensorischen Eigenschaften, grosser Vielfalt, echter Authentizität und einer starken Verbindung zum Terroir bietet allen Beteiligten ein hohes Mass an Zufriedenheit und ein tiefes Gefühl der Erfüllung.

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Résumé

Le savoir-faire et l'expérience nécessaires à la fabrication de fromages à partir de lait cru offrant un niveau de sécurité sanitaire comparable à celui des fromages produits à base de lait pasteurisé existent. Les exigences imposées à tous les acteurs de la chaîne de valeur sont toutefois nettement plus élevées et plus complexes que pour les fromages au lait pasteurisé.

Sur la base des expériences acquises lors de sept voyages à la découverte des fromagers artisanaux qui perpétuent la tradition du fromage au lait cru, quatorze exigences ont été définies pour un système de production de fromage au lait cru tourné vers l'avenir. Ces exigences peuvent être classées en quatre catégories: les humains, le lait, la technologie et les conditions-cadre.

Une étude comparative entre des fromages au lait cru et au lait thermisé (à 68°C pendant 15 secondes) a montré que la protéolyse était nettement plus intense dans les fromages au lait cru. La thermisation a entraîné une diminution significative des bactéries lactiques non-starter dans le métagénome des fromages affinés. Il est plausible que les bactéries lactiques non-starter contribuent à une protéolyse plus intense dans les fromages au lait cru et à un arôme plus riche. Cela a été confirmé par la détermination du volatilome, qui a permis d'établir une distinction claire entre les fromages au lait cru et ceux au lait thermisé. La fréquence relative des bactéries non lactiques dans le métagénome était très faible pour tous les fromages étudiés, ce qui indique un niveau élevé de sécurité sanitaire des aliments.

Des teneurs élevées en histamine ont été mesurées dans certains fromages au lait cru provenant de deux des sept fromageries, ce qui indique des lacunes dans le contrôle de la qualité du lait cru. C'est pourquoi Agroscope recommande en particulier aux fabricants de fromages au lait cru d'inclure *Lentilactobacillus parabuchneri* comme critère de qualité dans l'évaluation de la qualité du lait. Certains fromages à base de lait thermisé présentaient également des teneurs élevées en acide propionique et en histamine, ce qui s'explique très probablement par une recontamination.

La fabrication de fromages au lait cru présentant des propriétés sensorielles uniques, d'une grande diversité, d'une véritable authenticité et fortement liés au terroir procure à toutes les personnes impliquées une grande satisfaction et un profond sentiment de plénitude.

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Riassunto

Il know-how e l'esperienza necessari per produrre formaggi da latte crudo paragonabili, per sicurezza alimentare, ai formaggi da latte pastorizzato sono già disponibili. Tuttavia, i requisiti imposti a tutti gli attori della catena del valore sono molto più elevati e complessi.

Sulla base delle esperienze raccolte durante sette viaggi presso le casare e i casari artigiani che mantengono viva la tradizione dei formaggi a latte crudo, sono stati individuati quattordici criteri per un sistema di produzione dei formaggi a latte crudo orientato al futuro. Tali criteri possono essere classificati in quattro categorie: persone, latte, tecnologia e condizioni quadro.

Da uno studio comparativo tra formaggi prodotti con latte crudo e latte termizzato (a 68 °C per 15 secondi) è emersa una proteolisi molto più intensa nei primi. La termizzazione porta a una significativa riduzione dei batteri lattici non starter nel metagenoma dei formaggi stagionati. È plausibile che, nei formaggi a latte crudo, i batteri lattici non starter

contribuiscano a una proteolisi più intensa e a un aroma più sfaccettato. Tale ipotesi è stata confermata dalla determinazione del volatiloma, che ha evidenziato una chiara separazione tra formaggi a base di latte crudo e a base di latte termizzato. La frequenza relativa dei batteri lattici non starter nel metagenoma è risultata molto bassa in tutti i campioni esaminati, il che indica un elevato livello di sicurezza alimentare.

In certi formaggi a latte crudo provenienti da due dei sette caseifici sono stati rilevati elevati livelli di istamina, che segnalano lacune nel controllo della qualità del latte crudo. Per questo motivo, Agroscope raccomanda in particolare ai produttori di formaggi a latte crudo di usare anche il *Lentilactobacillus parabuchneri* come criterio di valutazione della qualità del latte. In determinati formaggi prodotti con latte termizzato sono stati invece riscontrati livelli elevati di acido propionico e istamina che possono essere spiegati più verosimilmente con una ricontaminazione.

La produzione di formaggi a latte crudo che si caratterizzano per proprietà organolettiche uniche, la grande varietà, l'autenticità e il forte legame con il territorio è fonte di grande soddisfazione e di un profondo senso di appagamento per tutti i soggetti coinvolti.

1 Introduction

Raw-milk cheeses are made from milk that has not been heated above 40 °C or subjected to any treatment with the same effect prior to the start of the cheesemaking process. The well-rounded taste and traditional production methods of these cheeses account for their great popularity among cheese lovers.

Until a few decades ago, raw milk was generally used in cheese production. With the industrialisation of cheese production, factories became larger and transport routes and storage times for milk became longer, meaning that the microbiological quality of raw milk and the cheese produced from it often varied greatly from batch to batch. Since the mid-20th century, raw milk has increasingly been subjected to heat treatment to improve process control and standardisation in cheese production, but also due to increasing food safety requirements. However, the chemical and enzymatic changes in the milk caused by heat treatment and the significant reduction in the microbiota of raw milk have a considerable impact on cheese production and the maturing process, resulting in cheese with altered organoleptic qualities. It is generally acknowledged that cheeses made from raw milk develop a more intense and complex flavour than those made from pasteurised milk. For this reason, a considerable proportion of cheese is still made from raw milk, especially traditional cheeses with a protected designation of origin. In addition, innovative cheesemakers around the world have revived the tradition of using raw milk (Bachmann et al., 2011).

To safeguard their future prospects, raw milk cheeses must meet the same high food safety requirements as cheeses made from pasteurised milk. The fact that the milk is not heated must be offset by a balanced raft of interlinked measures. The 2023 scientific conference of the FACEnetwork (Farmhouse and Artisan Cheese & Dairy Producers European Network) in Grangeneuve demonstrated the availability of the knowledge and experience needed to produce raw-milk cheeses of comparable food safety to that of cheeses made from pasteurised milk, and revealed that such knowledge is increasingly being used to produce superior cheeses with multifaceted flavours (Bachmann et al., 2024). Achieving these important and ambitious goals requires comprehensive and forward-looking production systems. Given that raw-milk cheeses represent an important cultural asset, enable value creation in peripheral regions, are uniquely sensorially rewarding and are attracting ever-growing interest due to their potentially promising positive effects on human health, the considerable effort associated with achieving these aims should more than pay off.

From the valuable experience gained from visiting seven cheese dairies producing cheese from raw milk, we were able to formulate requirements for a future-oriented raw-milk cheese production system.

The reports on the visits were also published in a newsletter ('Roh – Cru – Crudo – Raw') on the LinkedIn platform.

2 Mountain Dairy in Seelisberg

A Journey of Discovery to Seelisberg to meet Selina and Sämi

Everyone sees the 'big picture'

Our first trip is to Selina and Sämi in Seelisberg. The duo give us a fascinating insight into their traditional mountain cheese dairy.

The Mutschli experts

It was incredibly impressive to watch this perfectly coordinated team conjure up 432 individual Mutschlis from 1900 litres of milk in record time. Selina asked me to make suggestions on what could be improved. Try as I might, I couldn't spot the smallest fault. The dairy is simply and functionally equipped and kept in great shape; the 40-year-old cheese vat is still in top-notch condition.



Fourth generation now in charge at the Aschwanden mountain dairy

Their grandfather began making cheese in the 1970s. Prior to this, their great-grandfather had centrifuged the milk to produce cream. Under their father (Hans, who is the Chairman of Fromarte, the umbrella organisation of Swiss cheese specialists), there was a dramatic increase in production. Instead of the previous one batch, two to three batches are now processed daily. Since the start of 2022, Selina has been running the company together with her husband Sämi Raschle. Today, 1.8 million kg of milk per year are made into Mutschli (70%) and Bergkäse, or mountain cheese (30%).

The wall of fame

Photos of the 14 staff members are displayed on the 'wall of fame' beside the table where they have their morning coffee. "We operate according to the 'everyone does everything' principle" explains Selina. "This leads to a varied working day and allows for great flexibility in the planning of work. It also means that everyone 'sees the big picture', thinks for themselves accordingly, and takes responsibility." Two of the 14 are still being trained and earn a significantly higher wage than the stipulated apprentice paypacket.



New ways to safeguard the quality of raw milk

Impeccable raw-milk quality is the alpha and omega of raw-milk products, which is why milk quality is closely monitored in Seelisberg, with regular microbiological analyses in the laboratory of the extension organisation LaBeCo, and with a selection of practical tests performed daily. In addition, the cheese-vat milk of each production run is tested for *Escherichia coli* content using a novel Petrifilm method. If elevated *E. coli* concentrations are found, the retained samples of the individual suppliers are immediately tested to find the source of contamination, so that the farmers in question can be informed and advised. Since the introduction of the method seven months ago there have been three occasions when *E. coli* concentrations have been slightly elevated, and the defects were found and eliminated very quickly.

The lower the somatic cell count – a high somatic cell count being a possible indication of mastitis – the higher the price paid for the milk. This policy actively promotes the cows' health and contributes substantially to increased food safety.

Pressing? – Thanks to Selina, it's no longer essential

Selina's openness to new approaches, mettle, and mastery of cheesemaking skills were impressively displayed by her reorganisation of the manufacturing process so that cheese is now only pre-pressed in the vat. The tedious and time-consuming pressing of the cheeses with stone weights after portioning into the moulds is no longer necessary, and the quality of the cheese is as high as ever. Turning the cheeses once or twice and rapid acidification lead to good coalescence of the curd granules.



Liebefeld cultures – what else?

Today the cultures are still made by their grandfather, which by his own admission keeps him young. One mesophilic and two thermophilic acidification cultures from Liebefeld are used. The fourth culture used was a lovely 'blast from the past' for me, as it was successfully tested in various research projects around 20 years ago. Unfortunately, it did not make it into the Liebefeld Kulturen AG range of cultures. The extension organisation LaBeCo stepped into the breach as a supplier. A Liebefeld culture is also used in the ripening cellar. This culture supports the development of the cheese smear and forms a fine downy mould. In France this would be called a *croûte mixte*.

This 'mixed rind' allows the surface of the cheese to dry properly so that it doesn't begin to smell unpleasant in its packaging.



Pioneers of online sales

Aschwanden was one of the first cheese dairies to recognise the potential of online sales, establish an attractive web presence and create various gift-packaging options. Selina intends to further expand the online channel and is currently busy adapting internal processes accordingly. Rather than seeing other online suppliers as competitors she sees them as partners helping to raise the profile of online sales and change people's purchasing behaviour. In addition to online sales, they cultivate further mainstays such as direct sales (in the form of a shop, self-service huts and a market stall), deliveries to the catering trade and onward selling via village shops and retailers in the region. Great importance is attached to not becoming too heavily dependent on a single sales channel.



A clever milk collection system

Aschwanden processes the milk from Seelisberg, Emmetten, Beckenried, and in the summer also from Klewenalp. Naturally, collection from the farm makes the most sense. For this, they use a small lorry that can be driven with a category B driving licence. This means that all employees have the opportunity to do the odd run, thereby keeping in touch with the farmers. The two milk tanks allow the simultaneous collection e.g. of the organic milk and the conventional milk. Because of the limited capacity, milk must be offloaded in-between times, which allows for an early production start. This means that a good two batches can be produced before noon.



Sämi looking for new ways to use the whey

I was able to accompany Sämi on a milk-collection run. We had a deep, earnest discussion on the issue of the need for qualitative rather than quantitative growth in future. We agreed that value-added from whey needs to be substantially increased. Current research findings indicate that raw whey could have a very positive effect on human health, e.g. by reducing the occurrence of childhood allergies. Sämi was enthusiastic. Heating the whey can cause the health benefits to be lost.



Related but with their own individual characters

We tasted four different cheeses in Liebfeld. Their similarity was obvious: all four were smooth and creamy.

They wowed us with their understated saltiness, a lovely umami note, a hint of caramel, and buttery and oniony flavours.

There were subtle differences, however:

- 'Miudä': Refreshing, yoghurt, green notes in the nose, a real "family cheese".
- 'Wirzigä': Full-flavoured, slightly piquant, a hint of toasted bread, a long, pleasant finish.
- 'Griänä': Milder than 'Wirzigä', a pleasant bitter note, refreshing citrus flavours, a rather short finish.
- The mountain cheese 'Klewenalp': Melts on the tongue, earthy, nutty, flavour fireworks, spicy, long-lasting finish.

All cheeses will have you coming back for seconds.



We also did pairings ('marriages') with eight different iced teas. On the whole, we preferred the combinations with those that weren't overly sweet, and which had a distinctive acidity.

The maté iced tea and the mountain cheese 'Klewenalp' make for an exciting pairing, since they tame each other to an extent and together create a lovely harmony with a long-lasting finish.

The unsweetened alpine herbal tea is superbly complemented by the 'Miudă'. Both products give each other plenty of elbow room and are shown off to their best advantage in combination.

Our 'high-flyer' was the combination of the ginger iced tea and 'Grănă' – such Eastern promise in the bouquet! Spicy, exotic, with a distinctive vanilla note. A fabulous sensory experience straight out of *A Thousand and One Nights*.

3 Cheese Dairy in Oberegg

A Journey of Discovery to Hans and Johannes in Oberegg

A passion for tradition and innovation

Our second trip takes us Oberegg, to Hans and Johannes Eberle's cheese dairy. Their respect for tradition and passion for innovation is truly inspiring.

The Nachtwächter cheese – a hat-tip to a great tradition

Night watchmen (*Nachtwächter*) were on the payroll of the Baroque town of Bischofszell until 1940. In remembrance of this tradition, the Bischofszell Guild of Night Watchmen and Tower Watchmen was founded in 2004 with over 30 night- and tower watchmen from all over Europe in attendance. The Guild remains active to this day, offering e.g. its popular Night Watchman tours. The founding of the Guild inspired Hans to launch his unique 'Nachtwächter' cheese in 2006, to great success.

From Emmentaler, to Appenzeller, to Nachtwächter

In 1980, Hans's father, who ran the Oberegg cheese dairy, switched from the production of Emmentaler to Appenzeller cheese. Hans took over the dairy in 1987 and contributed in no small measure to the Appenzeller success story. Success brought increasingly vocal demands from the dairy's market partners to ensure maximum quality and consistency of the cheese. This led to the increased importance of milk thermisation, and the Appenzeller cheese went from being a cheese from raw milk to a cheese with raw milk.

In 2006, Hans developed the 'Nachtwächter' cheese with the twin aims of continuing to preserve as much of the traditional craft as possible and launching a new type of cheese that clearly differed from Appenzeller.

In 2010, Hans took over the cheese dairy in the neighbouring village of Muolen, since which time the Oberegg dairy has manufactured Nachtwächter cheese exclusively. In 2018, he handed over the reins of the successful family business to his son Johannes.

The Eberles are Fettsirten-Magenlab specialists

In the past, before the advent of rennet extract and commercially available starter-cultures, *Fettsirten-Magenlab* (a natural whey starter-culture produced by adding cut-up calves' 'vells' before incubation) was indispensable for the curdling and fermentation processes. Nowadays, few professionals are experienced in the use of *Fettsirten-Magenlab*. Hans and Johannes are recognised far and wide as specialists, and use it in most of their cheeses as well as in their Appenzeller. Naturally, it plays a key role in the manufacture of Nachtwächter cheese.

To make the cheese, immediately after the coagulum (curd) is cut, a cauldronful of whey and curds is removed and heated slightly. A portion of the whey is then filled into a cauldron with cut-up calf vells from France (photo), some casol (a mixture of acetic and propionic acid) is added, and the mixture is incubated in the incubator. The rest of the whey is cooled in the cold store. After two hours both mixtures are recombined, inoculated with a raw mixed culture and an 'eye'-formation culture from the Liebefeld cultures and incubated overnight in the incubator. The following morning the



Photo: City of Bischofszell



vells and curds should be floating at the top. After stirring and sieving, the acidity of the *Fettsirten-Magenlab* is measured and the mixture is placed in cold store until use. According to Johannes, a good *Fettsirten-Magenlab* should have at least 60 degrees of acidity and four times as many 'rods' (lactobacilli) as 'chains' (streptococci), which is significantly higher than for other starter cultures. These lactobacilli come from the starter-cultures, from the raw milk and the vells, and are responsible for the unique flavour and greater degree of maturity of the cheese. The curd plays an important role with the *Fettsirten-Magenlab*, buffering the lactic acid formed and thus preventing a too-rapid drop in pH and encouraging greater proliferation of the lactobacilli.

High level of craftsmanship required

The Nachtwächter cheesemaking process is highly conventional up to the point where rennet is added to curdle the milk. From then on, much is done rather differently than expected. The renneted curd is cut into surprisingly small pieces; the rapid acidification and addition of hot water ensure that a fine skin forms on the curd grains so that they dry out less. After a first pressing the cheese is portioned. The cheese mass is still very soft, and the use of the traditional cheesecloths proves highly advantageous here.

While Nachtwächter was being developed, a lively exchange of knowledge and advice took place between Hans and legendary cheese consultant Werner Friedli. Back in the day, Herr Friedli and his colleagues were referred to as 'cheese dairy inspectors' and worked for the cantonal dairy inspection and advisory services. "Werner has certainly left his stamp on Nachtwächter" enthuses Hans, with an admiring hat-tip to Friedli.



Lactic-acid bacteria from the raw milk help with fermentation

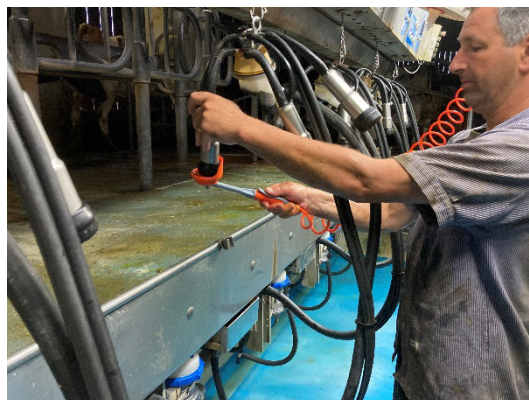
Before and after the addition of the rennet a sample is taken from the cauldron, filled into test tubes, incubated in the incubator and the acidity of the mixture measured. Until coagulation there are no essential differences between the manufacture of Appenzeller and Nachtwächter cheese, save the fact that only raw milk is used to make Nachtwächter. Interestingly, the acidity levels of Nachtwächter are always somewhat higher than Appenzeller's, strong evidence of the influence of the raw-milk microbiome on lactic-acid fermentation in the cheese. In the sample taken after the addition of rennet, a little 'cheese log' is formed which is thoroughly examined for important indications on the progress of the rennet coagulation, lactic-acid fermentation and syneresis (contraction of the lactoproteins) processes (Photo).



In these 'journeys of discovery', the respective raw-milk products were always brought back to Agroscope Liebefeld for further testing – both for the sensory description and to take samples for analysis at Agroscope. In addition to the chemical and biochemical composition, the microbiome and aroma components were also studied. The declared aim was to publish the analysis results scientifically and thus document the diversity of raw-milk cheeses.

No effort spared to achieve impeccable raw-milk quality

The Eberles have very high standards for the microbiological quality of the raw milk. The milk from each farmer is tested daily by means of a fermentation test and additionally every two days using a pre-incubated reductase test. These two samples cover a wide range of undesirable microorganisms, thus ensuring the very high quality and safety of the cheese. These high standards require a considerable additional expenditure of money and effort by the farmers – for example, the teat cups used in the milking parlours are rinsed after each cow (photo), or teats are cleaned before milking with two rather than just one damp cloth. Additionally, the entire milking system is thoroughly cleaned twice daily, alternating an alkaline solution with an acid one. The effort and expense are worth it, given that farmers are paid up to 6.5 centimes more per litre for meeting the high standards. “Sometimes the farmers need a bit of motivation”, Hans says with conviction. It is also important, he feels, for the cheesemaker to be familiar with the specific weak points of the individual farms, in order to be able to provide them with targeted support.



“We’re ‘vegional’

‘Aus Liebe zum Käse’ (For the love of cheese) is the motto in the Oberegg and Muolen dairies. It may surprise some that Johannes is the prime mover behind the manufacture of vegan alternatives from lupin. ‘Lupighurt’ has already won its share of fans. They continue to tinker zealously with products to improve quality and expand the range.

The aim is for raw materials to be produced regionally, unlike many vegan alternatives on the market today. According to Johannes, there are many commonalities between the manufacture of dairy products and their plant-based alternatives: “The technology is comparable, fermentation is key, and the same lactic-acid bacteria are needed”.

Cheesemakers already have plenty of experience of the high expectations placed on the raw materials, hygiene, quality management and good manufacturing practice. There is also the odd new challenge to be tackled, however, such as undesirable aerobic spore-forming bacteria that may be present on the plant-based raw materials.



Black as a new-moon night

A defining characteristic of the Nachtwächter cheese is its black rind – a natural result of its weekly washing with red wine. At Agroscope Liebefeld we’ve produced sensory descriptions of the ‘mild’ (4 months’ ripening), ‘mature’ (8 months) and ‘extra-mature’ (12 months) Nachtwächter cheeses. All three cheeses have their own unmistakable character:

- The ‘mild’ has already reached a nice degree of maturity: velvety, refreshing and even a bit tingly on the palate, with flavours of onions, caramel, butter and a whiff of pepper. This is the cheese that will have most people coming back for seconds.
- With its earthy, woody, smoky and mushroomy characteristics, the ‘mature’ variant sparks memories of an invigorating walk in the woods after a summer shower. The noticeable crystals make it surprisingly crunchy, and a delight to chew.
- The ‘extra-mature’ will perk up even the weariest night watchman. The cheese is very crumbly and melts wonderfully on the tongue. It probably owes its dark-yellow colour to the fresh grass grazed by the cows on the pasture. Interestingly, the crystals have largely vanished. A variety of toasted flavours predominate, some of them slightly tangy. This cheese can easily hold its own with any full-bodied red wine.

All three cheeses boast a long-lasting, well-rounded and harmonious finish.



On their home page, the Eberles write that Nachtwächter not only goes well with wine but is also excellent with beer and cider. This inspired us to choose eight different sweet and sour ciders from the region for our cheese-and-drink pairings:

- Spritzer was our favourite drink pairing with the ‘mild’ variant of Nachtwächter. The two warm to each other instantly whilst leaving one another plenty of space to show their individual flavours off to best advantage.
- Apple juice drives the ‘mature’ Nachtwächter cheese out of the forest. Instead of the woodsy notes, toasty flavours like caramel and vanilla come to the fore, and maple syrup and dried-fruit flavours were repeatedly noted. The cheese flavour lingers appealingly on the palate even after a further sip of apple juice – very invigorating. Indisputably the finest pairing for us.
- With ‘extra-mature’ Nachtwächter, we were wowed by the pairing with sour cider. Our favourite here was the dry-hopped version. The savoury note is incorporated nicely, taming the cheese somewhat for a milder flavour. Sweet and fruity notes are reinforced, and a whiff of citrus refreshes. Various green, vegetal characteristics are an enhancement. Though clearly identifiable, the hops do not dominate. Ultimately, the various flavours converge beautifully, for a long, lingering, harmonious finish.

4 Alpine Dairy La Duchatte

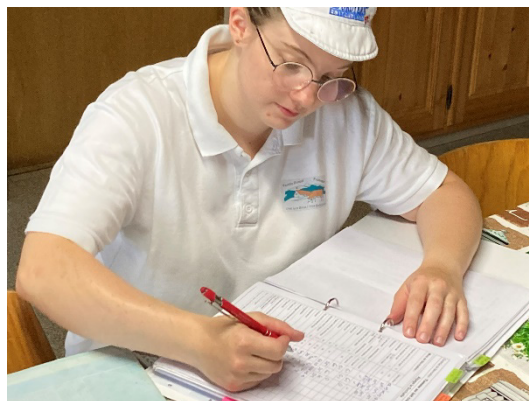
A Journey of Discovery to the Poncet Family on the Alp La Duchatte

A Loving Eye for Detail

Our third trip takes us to Les Bioux in the Vallée de Joux, to the Poncet family's alpine cheese dairy La Duchatte. Here, they demonstrate that it is also possible to make outstanding soft cheeses from raw milk.

Food safety has top priority

Making soft cheese from raw milk requires the application of very high standards to the premises, raw materials and way of working. In 1970 the Poncet family took over the running of Alp La Duchatte, switched over from the production of Gruyère d'Alpage to Tommes, and applied these high standards to the potential offered by an alpine cheese dairy, to impressive effect. Scientific and technical support for this endeavour were provided by the regional extension advisor from Arqha and the national extension advisor from Agroscope. A constructive dialogue was also established with the Cantonal Enforcement Authority. The open exchange of experience with other producers of raw-milk soft cheeses has also been key for success.



When producing soft cheese from raw milk, the essential thing is to have the entire production process as well under control as possible, since end-product inspections quickly become prohibitively expensive for small-and-smallest businesses. Systematic recording of the production dates and day-to-day observations are important tools for the rapid detection of abnormalities.

The entire Poncet family – father Guillaume, mother Nathalie, daughter Élodie and son Damien – as well as employee Natalia Kinga Walczak from Poland, are fully aware of how high the standards are which they have clearly taken on board, heart and soul.

Food safety begins with the cows

The Poncet family swears by purebred Simmental cows. Though not high-yielding cows, they are ideally suited to alpine farming. In their breeding, great importance is always attached to health, robustness and temperament.



Simmentals are also a so-called dual-use breed, since the quality of their meat is good – an obvious plus with the current challenges of sustainable livestock production. The milk of Simmental cows is characterised by its high protein and fat content, and is ideal for cheese production.

Having observed that it may be more difficult to make cheese from the milk of cows in oestrus, Guillaume Poncet decided that only cows in calf would be summered on Alp La Duchatte. Here too, we can see the systematic effort to keep the entire process as much under control as possible.

State-of-the-art milking parlour

It's surprising to find such a modern eight-unit milking parlour on an alp and it's striking how clean and dry it is everywhere. The cows are very clean when they come for milking, since there is no boggy ground around the alpine hut. Their teats are cleaned with a damp cloth before the teatcups are attached. Teat-dipping in a disinfection solution is deliberately forgone, however, so as not to destroy desirable microflora. The clear separation of the milking and processing processes is exemplary. When moving from one area to the other, clothes and shoes are changed as a matter of course.



An almost reverential quiet during production

Cheese dairies are normally quite noisy places. Not so on the Alp La Duchatte. There's not a single machine that might disturb the calm. The milk flows silently from the milking parlour through a pipe with a natural gradient into the cheese dairy and is distributed via an ingenious system among the eight kettles to produce a mix of the various milkings. Prior to this, a proportion of the previous evening's milk stored overnight at 10 °C had been distributed between the kettles. A substantial percentage of the evening milk is pasteurised and sold as full-fat milk or yoghurt, however.



In addition to the quiet, one is struck by the very calm, deliberate and focused way in which the entire family works.

Hand-ladled

To keep well on top of the entire production process, the cheesemakers work with eight small kettles instead of one large vat. The process is optimally coordinated, and there would have to be a very compelling reason to change it in any way.



Fresh yoghurt is added to kick off lactic-acid fermentation. An additional thermophilic starter-culture ensures a stable acidification process.

The curd is cut with a flattened metal rod (narrow edge), then gently stirred (wide edge) ([Video](#)). An important signature feature is that the cheese curd is scooped by hand into the draining moulds. When the whey draining off runs clear and the curd granules coalesce quickly, this is strong evidence of successful production and active lactic-acid fermentation. During the draining process the cheeses are flipped twice.



An impressive tidiness and cleanliness prevails on the entire alp, which is equipped in an extremely functional manner. Everything has its place and is cleaned and tidied away after use. There is nothing superfluous lying around. Before all contact with food, the cheesemakers wash and disinfect their hands.

The high art of dry-salting

As soon as the lactic-acid fermentation – measured by the pH level – is sufficiently advanced, the Tommes are removed from their moulds and rubbed on both sides with salt. A great deal of experience and a sure instinct are required to achieve the desired salt content. Timing is also crucial, since salting puts an end to lactic-acid fermentation and causes the

Photo: Élodie Poncet

formation of a rind that reduces whey drainage. A major advantage of dry-salting over immersion in a salt bath is that it can help prevent possible infection with undesirable foreign microorganisms.

On the day of our visit, 541 Tommes were made. By the end of the alp season, the figure will have risen to over 70,000.

A week in the ripening cellar

The Tommes are ripened at around 17 °C at a relative humidity of over 90% for one week, during which time they are turned regularly to allow the formation of an even bloomy rind. Initially the cheeses are placed on a linen cloth to aid drying and to prevent whey dripping onto the cheeses below. Each time the cheeses are turned the linen cloths are changed and the used ones washed. After a week, a fine, even bloomy rind has developed on the Tommes. The cheeses can now be packaged, then further ripened in the cold store at 4 °C. They are best eaten within a month.

Interestingly, it is not a mould that is responsible for the bloomy rind covering the cheese, as with e.g. *Penicillium camemberti* for Camembert. With Tommes, *Geotrichum candidum* is added to the milk for rind formation. Taxonomically a yeast, *Geotrichum candidum* breaks down the lactic acid in cheese like *Penicillium* does, but forms a considerably finer bloomy rind than the latter.



An ingenious system with 3 alps

The five cousins of the extended Poncet family – the sons of four brothers – together run a savvy farming collective, as part of which they stock three seasonal mountain pastures with cows. On Alp La Duchatte, only cows that are in calf are summered. Young cattle are summered on Alp La Racine and the largest herd is on Alp La Poyette, where Le Gruyère d'Alpage AOP is produced. The Poncet families also fatten pigs, so that the whey by-product can be fed directly to pigs on the two alps with cheese dairies.

Products of exceptional quality and a large number of loyal customers are two key pillars of their successful marketing, mainly within the Canton of Vaud.



An aroma of fresh mountain milk

La Duchatte Tommes will wow you with their beautiful, super-creamy consistency. The cheeses melt wonderfully on the palate, leaving many adverts for French soft cheeses looking rather old-hat.

The fresh mountain milk is surprisingly to the fore in the aroma. The pleasure lifts the spirits, like a hike in the Jura mountains with a backdrop of grazing cows. In addition to the characteristic mushroomy note, you'll also get pops of citrusy flavours. The yoghurt culture lends an agreeable freshness. The milky-buttery notes provide ample harmony in the rather short finish.



Guillaume Poncet's preferred accompaniment to his Tommes is a glass of red wine, so we've decided to choose a selection of new and traditional reds from Agroscope's research for the 'marriages' or pairings. We divided the red wines into three groups:

- In this first category, neither the cheese nor the wine benefits from the pairing. All wines possessing a lively and distinctive acidity belong to this group.
- All tannic wines were assigned to the second group. Here, the pairings with the Tomme redound strongly to the advantage of the wine, which becomes decidedly sweeter and considerably less astringent. This means that the fruity, berry-like notes are showcased, bringing a palpable increase in drinking pleasure.
- Our favourite, of course, was the third group, in which the flavours of both the cheese and wine develop in tandem, to their mutual enhancement. In some cases it can be quite tricky to distinguish where the individual flavours actually come from. All in all, these are the best circumstances for a sizzling-hot flirtation and a long-term harmonious relationship. This third group includes rather delicate, multifaceted wines such as Humagne Rouge, and – with minor reservations – Merlot or Divico as well.

5 Girenbad Dairy

Journey of Discovery to Christa's Girenbad Dairy

Christa's Dairy of Delights

Our fourth journey takes us to Girenbad in the Zurich Oberland, to the cheese dairy of Christa Egli, who cossets her customers and dazzles the experts with her creations.

Clever new-build

The planning phase took ages, partly because of the difficulty in obtaining a permit to extend the still-small cheese dairy, which is located in the agricultural zone. Christa made the best possible use of the time, enthusiastically developing a unique concept for producing a wide variety of cheeses. The new building has been in operation since 2020, and has lived up to the high expectations surrounding it. Large windows and a cheese tour provide for transparency, allowing for a direct and authentic appreciation of the passion that goes into cheese artisanship.

The construction of the cheese dairy is also exemplary in terms of food safety. There is slight excess pressure in the production area to prevent the entrance of undesirable microorganisms or insects when the doors are opened.

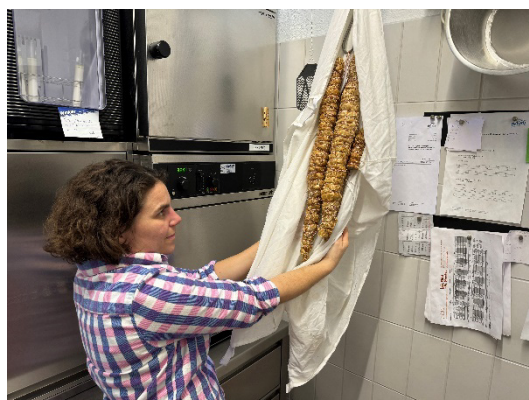
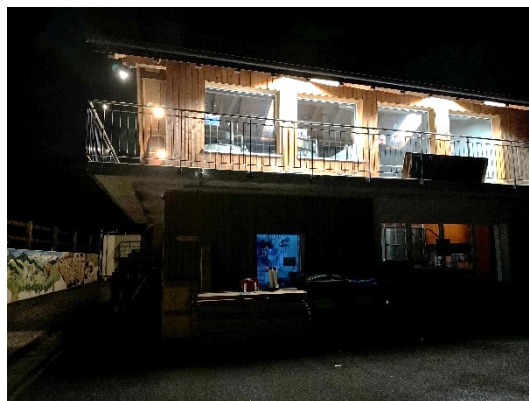
Minimising mechanical load

The milk is pumped only once at the time of delivery, with gravity then responsible for its conveyance along a natural gradient for all further stages of the process.

The fat content of the cheeses is not adjusted by the usual means of a centrifuge. Instead, the evening milk settles overnight in two vats, and the following morning the cream is skimmed off by hand with a ladle and the milk distributed to the various cheese vats – the same process that Christa learned from her grandfather. Since most of the microflora are to be found in the cream, the microbiological balance can be adjusted during the skimming process.

Maximum differentiation from the industry

Christa places great store in cultivating traditional artisanship and in maximum differentiation of her operation from industrial cheese production. In addition to the processing of raw milk, this involves the use of traditional microbial cultures. Except for 'Felsbrocken' (a planing cheese) and 'Crème' (for fondue mixtures), portions of *Fettsirten* culture and *Fettsirten-Magenlab* (a natural whey starter-culture produced by adding cut-up calf 'vells' or stomachs to the milk prior to incubation) are always added to each cheese variety. Both of these cultures are incubated for 1 to 2 days at 32 °C. This temperature promotes the growth of mesophilic lactic-acid bacteria, which are beneficial for soft and semi-hard cheeses whose curd is not heated to as high a temperature in the vat. In the photo, Christa is showing the calf vells used to produce the *Fettsirten-Magenlab*. To achieve curdling of the milk within the desired time, rennet powder is also used.



Variety is the watchword

Depending on the season, 12 to 15 different cheese varieties are produced at the Girenbad Cheese Dairy, or a multiple thereof if the different ingredients and formats are taken into account. This is only possible because Christa designed the dairy for precisely this purpose. The dairy has a total of 11 finishing vats of different sizes, all of them relatively small. They are all fitted at a height, so that gravity-filling is possible. The smallest batches of cheese, such as the raw-milk 'Tomml', are made in a small tub. Although she sets great store by tried-and-tested methods, Christa is also open to trying new approaches. Thus, for example, with 'Heuhuufe', which is actually a semi-hard cheese, she has also adopted important process steps from fresh-cheese technology – and the 'Sparflamme' variety boasts an impressive, particularly energy-saving production process, in which e.g. the cheese curd is heated solely with water from heat recovery.



Creative ripening

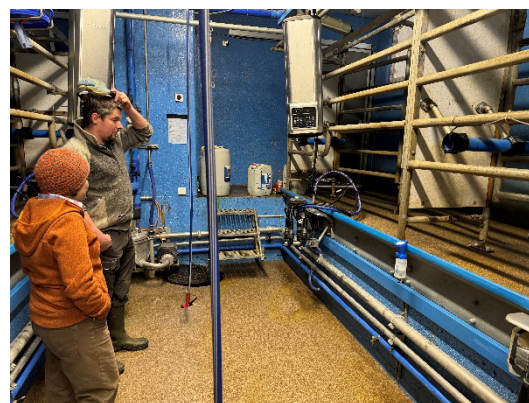
A wide variety of ripening methods are an integral part of this cheese-lover's paradise. The water used to wash the rind of the cheese is enriched with a wide array of ingredients. The nut cheese ripens hanging in fabric sacks, and there is a small vaulted cellar for the mould-ripened varieties.



Some of the cheeses are ripened in the village of Saland (Tösstal, Canton of Zurich), at the cheese dairy natürl zürioberland AG.

Strict on raw-milk quality

The six farmers bring their unchilled milk twice daily to the cheese dairy. Christa pays them an above-average price in return for their meeting the high quality standards. The procedure for dealing with milk that falls short of these standards is very strict; the milk cannot be used for cheesemaking until a subsequent investigation confirms that the defects have been identified and remedied.



A visit to a dairy farmer revealed the impressive wealth of knowledge and experience to which special attention must be paid in milk production. It comes as no surprise that Christa's Girenbad milk suppliers almost never fail to meet her quality standards. This close collaboration between farmer and cheesemaker is an important foundation for producing safe, flavourful, high-quality raw-milk products.

An urban clientele

Three-quarters of the cheeses are sold under the 'natürl' brand. Since 1995, natürl zürioberland AG has offered its urban customer base a wide and varied range of high-quality cheeses and dairy products from small regional cheese dairies with the aim of promoting production and sales in the Zurich mountain region ([Link](#)). Christa is very aware of the fact that her customers are on the one hand looking for original products, but on the other have increasingly high standards regarding animal welfare and ecological footprint.



She is also a very interesting and competent discussion partner on these topics, and clearly holds the view that cows should be fed as

high a proportion as possible of grass and hay produced on permanent grasslands. These permanent grasslands include natural meadows and pastures, which in Switzerland account for 58% of the utilised agricultural area ([Link](#)). It is only thanks to ruminants that food production on this land is at all possible. Christa acknowledges the reasoning behind vegan cheese alternatives, but notes that Swiss agricultural resources are used in their production and that these should be processed in an environmentally sound manner. She has herself conducted initial experiments in her kitchen with these alternative products.

Responsibility is shared by all

The variety of products and processes involved requires all employees to assume a high degree of responsibility. The team consists of 15 people, many of them part-timers. Two-thirds are women, and Christa feels that this is a good balance, since “men primarily see the work and women tend to see the product”. Men therefore mainly make suggestions for increasing efficiency, and women for improving the product.

The training of dairy technologists is a high priority here. The Girenbad cheese dairy is an exceptionally attractive training farm due to the wide variety of products produced here and its diverse team with their unique expertise and palpable passion for high-quality cheese.



Another thing that stood out was that things never became hectic during the cheesemaking process; rather, employees worked in a calm and focused manner.

Precocious personalities

Although the rule is to select no more than four types of cheese for the sensory description, we were utterly spoilt for choice and only managed to narrow the tasting down to five cheeses.

All of the cheeses are exceptionally precocious for their age, melt wonderfully on the tongue and boast a harmonious, lingering finish. It is highly likely that the added *Fettsirte* cultures and *Fettsirtenmagenlab* are key influences on the character of the cheeses.

- The ‘Bachtelstei(n)’ (semi-hard cheese, ripened 2 months) delights with a lovely edge, a milky, buttery flavour and a pleasant tingle on the palate.
- The ‘Heuhuufe’ (= ‘Haystack’; semi-hard cheese, ripened 3 months) stands out with a crisp, refreshing acidity, revealing more and more dimensions of flavour over time. The hay is clearly in evidence and blends harmoniously into the overall picture.
- ‘Sparflamme’ (= ‘Pilot flame’; semi-hard cheese, ripened 8 months) is produced via an energy-saving process, but there has been no skimping in terms of flavour. Savoury, spicy, incisive oniony notes. The full-bodied taste is characterised by a pleasant bitterness and umami, the fifth dimension of taste. Sparflamme’s distinctive crystals make for a spectacular experience on the palate.
- The ‘Ur-Eiche’ (= ‘Primeval Oak’; hard cheese, ripened 9 months) delights with its slightly crumbly texture and flavour reminiscent of dried fruit (plums), walnuts, vanilla, caramel, and floral, grassy echoes.
- The ‘Felsbrocken’ (‘Rock’; planing cheese, ripened 15 months) was planed for the tasting. The texture is ideal for making cheese logs. Showing oodles of pep on the palate, it is very piquant and peppery, with refreshing citrus notes and a lingering bitterness. Experimenting with Felsbrocken in warm dishes is tremendous fun.

The sensorial description also evoked various childhood memories, all without exception positive. Artisan cheeses elicit positive emotions.



Christa's magic can be continued in your own home, since all of these cheeses are ideally suited to a wide range of pairings. We tested a total of 11 different fruit mustards and chutneys with the cheeses and identified many delightful 'marriages'. Common to them all was a softening of the sharpness of the cheese and a rounding-out of its flavour, as well as the emergence of many new dimensions of flavour. The combination of Bachtelstei with the Cassis de Dijon mustard was a riotous roller-coaster ride with fruity, spicy and floral flavours. Paired with the fig-lavender chutney, 'Heuhuufe' whisked us off on holiday with a visit to a Provençal market. Together with 'Sparflamme', the chilli-tomato chutney lit a veritable firework on the palate without coming across as burning or pungent. Teamed with the apricot-chilli chutney, the 'Ur-Eiche' conjured up Christmassy flavours of citrus fruits (especially orange), cinnamon and gingerbread. All these flavours were absent from both chutney and cheese when sampled on their own. Raspberry mustard also greatly enhanced the Ur-Eiche, with notes of a wide range of garden berries and fruits of the forest. With 'Felsbrocken' we were most delighted by the pairing with pear mustard, yielding a gorgeous caramel note, a touch of rhubarb and various culinary herbs.

Common to all these pairings was a stunning, long-lasting finish that invited one to indulge and dream. If only it were possible to stop time. What magic! Many thanks to Christa and her team.

6 O'lait Cheese Dairy

Voyage of Discovery to Agnès's O'lait Cheese Dairy in St-Imier

Agnès and Michel – a source of mutual Inspiration

Our fifth voyage of discovery leads us to St-Imier in the Bernese Jura, where Agnès Spielhofer-Beroud's infectious enthusiasm, strong sense of conviction and impressive skill are carving out a promising future for her father Michel's cheesemaking tradition.

A dynamic duo

In 1988 Michel Beroud took over the cheese dairy in Rougemont in the Pays-d'Enhaut District (Canton of Vaud), developing it into a flourishing small business. His raw-milk Tomme Fleurette earned him a reputation beyond the Swiss border. Michel won many awards, proving beyond a doubt that Switzerland is also capable of producing outstanding soft cheeses. Today, his experience serves as a unique source of inspiration for his daughter Agnès. The inspiration is entirely mutual, however, as Michel is an enthusiastic supporter of Agnès's many new creations and feels that he can also learn a great deal from his daughter.



A new cheese dairy in the former tinsmithy

Agnès purchased the old tinsmithy in the heart of St-Imier right next to the railway station in 2020, converting it into a modern cheese dairy where she has given free rein to her creativity since November 2021. The dairy is very functionally equipped, meets modern hygiene standards and has enough spare space to allow a significant increase in production over the next few years.



Working with nature

The processing of raw milk allows, and indeed requires, close cooperation with nature. For Agnès, this is the strongest motivating factor for dispensing with the approach of heating the milk to reduce the natural microbiota.

All the milk used by Agnès comes from mountain farms in the immediate vicinity. She buys both cow's and goat's milk from farmer Mikaël Zürcher from Mont-Crosin. As with all the cheese dairies we have visited to date, in St-Imier the raw milk also undergoes a thorough daily inspection. This is mainly done via tried-and-tested practical methods such as the reductase and fermentation tests. These methods are extremely sensitive, can detect even the smallest changes in the microbiota, and are ideally suited to goat's and cow's milk, as confirmed – yet again – by current Agroscope research findings.



Sensory organs more important than the clock

What stands out most at the O'lait cheese dairy? Without a doubt, it's the incredibly frequent and intense use that the cheese artisans make of their senses. It starts with the overnight incubation of a sample of raw milk, and is followed by thorough testing with the nose and palate. Rather than after a specific length of time, rennet is added when the milk is deemed to be ready. This too is determined by smell and taste. This is truly what working with nature means. In Agnès's case, this is not an empty cliché but lived reality. The time when the coagulum is cut or the cheese curd is ladelled into moulds is also determined by the sensory organs. A great deal of experience is clearly required here, as it is not something one can look up in a primer.



Confirmation by pH measurement

Also striking is the continuous measurement of pH. The aim here is to confirm that fermentation is progressing as aimed for and as suggested by the sensory tests. In some cases, the various cheese varieties differ significantly in their production in terms of e.g. when rennet is added or how firm the coagulum is before cutting. This clearly highlights Agnès's virtuosic skill in juggling the different factors.



The high art of producing semi-hard goat cheese

The goat's milk is sampled after delivery and processed directly. Agnès's success in producing outstanding fresh goat cheese and soft goat cheeses continues to grow. These products cannot be stored for long periods, however. That's why it's important for Agnès to expand the range with a semi-hard cheese in order to better cope with fluctuations in sales and enable the farmers who supply her to put things on a professional footing. However, there is a risk of bacterial spores germinating and cheese bloating during the ripening process. This is somewhat more of an issue with goat's milk than cow's milk, since these spores are naturally present in the soil and grazing goats crop the grass much shorter than cows. This means that they also consume more soiled grass, as the closer the grass is to the ground, the greater the degree of soiling. Particularly during wet weather, this can cause more bacterial spores to find their way into the milk. After all, we've really had more than our fair share of rain this year so far. Perhaps the new Liebefeld cultures Helv.01 and Contra C1 can remedy this to an extent, as experiments at Agroscope have shown that these cultures are capable of inhibiting the growth of the germinated bacterial spores.



Cheese ripening, Agnès-style

Because she does not want the rinds on her cheeses to be too firm or the microbiota of the rinds to overpower the flavour of the cheeses, Agnès regularly brushes her cheeses by hand with water in which a little salt has been dissolved ([Video](#)). With this procedure she destroys the mycelium of the lactic mould, thereby preventing the mould from dominating the character of the cheese too strongly. Her cheese creations 'Galait' and 'Boulait' are the embodiments of this perfected ripening process. 'Galette', however – the little sister of 'Galait' produced from goat's milk – has such a



delicate texture that hand-treatment is ruled out. This results in a much-more-compact bloomy rind on the surface of the cheese.

Safety and quality: two sides of the same coin

For a scientist, it is always deeply satisfying to see scientific findings confirmed in practice. Last year's Farmhouse and Artisan Cheese & Dairy Producers European Network ([FACEnetwork](#)) scientific conference on raw-milk products underscored the fact that with raw-milk cheeses, food safety and food quality are two sides of the same coin ([Link](#)). This truism is borne out by Agnès's day-to-day experience. Her uncompromising pursuit of top quality also ensures the ability of her cheeses to meet ever-more-stringent food-safety standards.



A small aside from a personal perspective: Unfortunately, the ever-stricter food-safety standards are not always based solely on scientific considerations. Thus, for example, the limits for coli bacteria in cheese made from heat-treated milk make sense, since coli bacteria cannot survive the heat treatment. The presence of coli bacteria in cheese made from heat-treated milk is a sign that either the heat treatment was faulty or that hygiene post-heat treatment was inadequate. With raw-milk cheese, however, the detection of coli bacteria is not indicative of inadequate hygiene during manufacture, since coli bacteria may be naturally present in small quantities in even the 'cleanest' raw milk. Coli bacteria are environmental microbes the vast majority of whose strains are completely harmless for us humans. The law recognises this. It is a pity that some market participants make demands that go beyond the legal requirements. This can put raw-milk cheese manufacturers at an unfair competitive disadvantage. An interesting talk ([Link](#)) on this subject was actually given at the above-mentioned conference. Agnès, however, is clear about wanting to meet all the standards with her cheeses, even when these standards exceed the legal requirements.

Lactic flavours are meant to develop

Wherever possible, the artisan cheeses are wrapped in see-through film. As a sign of transparency, Agnès wants consumers to be able to see and check the cheeses before buying them.

For Agnès, it's very important for the lactic, creamy and buttery flavours of her cheeses to develop to their full potential, and she is outstandingly successful in achieving this aim. Common to all the sampled cheeses are their marvellous creaminess, delightful melt-in-the-mouth quality and lingering echo on the palate.



- With 'Galette', the fresh goat's milk is unmistakable without being overpowering. The flavours recall a walk in Jura in the spring across blooming meadows and through damp woods. The cheese's rind is pleasantly fuzzy. 'Galette' will no doubt appeal to many people who might otherwise prefer to give goat's cheese a wide berth.
- 'Galait' – 'Galette's' brother cheese – is made from cow's milk. Its amazingly delicate rind is a delight. The flavour is very mellow and extremely well-rounded, redolent of warm raw milk fresh from the cow, herbs, roses, and even a bit of honey. The mushroomy, ammoniacal smell that is otherwise typical of quite a few soft cheeses is absent in 'Galait', which is no bad thing.
- A chameleon of a cheese, 'Écru' is a bit mystifying, since it behaves like a young Gorgonzola on the palate despite not being a blue-veined cheese. It is also very fruity with a perceptible vanilla flavour.
- 'Fort A1652' whisks you away to the Med. This cheese would shine on any Mediterranean cheese platter; no one would suspect that it was made in the Swiss Jura and ripened in a bunker in the Vaud Prealps. Very spicy with flavours of nuts and of very ripe and dried fruits.

In keeping with the season, we decided on a selection of berries for the pairings.

- Mild-flavoured soft cheeses such as 'Galait' pair well with blueberries. The combination intensifies the vegetal flavours (grassy, herby, mossy and woody), and the finish is prolonged.
- Spicy soft cheeses such as 'Fort A1652' and blackberries file down each other's sharp edges: the spiciness of the cheese and the tartness of the berries are lowered a notch, better showcasing the variety of flavours and even possibly revealing new facets, such as a subtle barrique-matured note.
- By contrast, strawberries and raspberries resisted pairings with the different cheeses. Even so, another very exciting effect was noted: the berries cleansed and refreshed the palate. This 'cleansing' intensified the berries' flavours, as with a syrup – probably because the nerves are wide awake due to the cheese. The refreshed palate was then ready to enjoy the next cheese. This discovery creates a space for ideas on new ways to enjoy cheese, such as cheese-berry skewers for an apéro or new dessert creations. And yes – strawberries and raspberries can make a contribution to any cheese platter – and not just optically.

The pairings with the berries have confirmed for us yet again the amazing versatility of cheese in combination with other foods, with new and sometimes surprising discoveries always being possible.

7 Experiential Cheese Dairy in Goldingen

Voyage of Discovery to Wisi's Experiential Cheese Dairy in Goldingen

An outstanding master teacher

Our sixth journey takes us to the See-Gaster District in the Canton of St. Gallen to the experiential cheese dairy in Goldingen, where Alois ('Wisi') Pfister proves daily that sustainability and superb dairy and meat products are by no means mutually exclusive.

100 years of circular economy

Wisi feeds the leftover whey from cheese production to his herb-reared pigs ([Link](#)). The animals' feed is supplemented with a natural herb mixture, yielding high-quality meat with an outstanding taste. The cows' and pigs' slurry is used to fertilise the meadows, resulting in a closed-loop supply chain that Wisi's grandfather and great-uncle maintained when they took over the cheese dairy in Goldingen in 1924. Today, they also know just how to spread the slurry without putting undue strain on the climate or our nostrils. Very little sorrel grows on the meadows in Goldingen – a sign that there is no overfertilisation with slurry. For Wisi, the daily interlude with his pigs is a treasured counterbalance to his work in the cheese dairy.



Wisi considers himself one of the "old guard", since upholding tried-and-tested traditions is important to him. However, the way he handles his smartphone demonstrates that he also appreciates and knows how to take advantage of the benefits of progress.

Mutual trust between farmers and cheesemaker

Wisi has a great deal of sympathy for the farmers who supply him. He is aware that their job nowadays is exceptionally demanding and that they have to meet a wide range of (sometimes contradictory) requirements. By the same token, the farmers know the importance of high milk quality in the production of raw-milk cheeses. The friendly banter during the twice-daily milk deliveries is testimony to their mutual appreciation.



In Goldingen there is a seasonally adjusted pricing system for the milk. This is intended to prevent too much milk being supplied in the spring, as experience has shown that less cheese is consumed in summer.

No 'anonymous' milk

It is simply not possible to produce high-quality and safe raw-milk cheeses from just any raw milk supplied by road tankers from an unspecified place. The cheesemakers need to know the farmers really well, and the farmers must know their cows equally well. It is important to identify and voice any discrepancies – no matter how small – in a timely manner, and to look for a solution together.

Wisi always hangs the board with the milk-quality test results next to the doors, where it can easily be seen by all.

Säureprobe	
5.	130
7.	100
8.	110
12.	130
14.	100
17.	100
20.	130

Inspired by Fredy Bieri

Fredy Bieri was *the* pioneer of raw-milk cheese in the Zurich Oberland. He was also the inventor, personification and trailblazer of the 'natürli' quality label ([Link](#)). His goal was to ensure the livelihoods of village cheese dairies and preserve the associated traditional cheese culture in the region. Since 1995, 'natürli zürcherland ag' has offered an extensive and varied range of high-quality cheeses and dairy products from small regional cheese dairies.

Fredy Bieri also convinced Wisi to forgo the thermisation (subpasteurisation) of the evening milk and to bank on the benefits of raw-milk cheese. At first, Wisi only took the plunge with his semi-hard cheese specialities. Encouraged by his success here, he then also followed suit with his Appenzeller cheese. Today, Wisi is probably the only cheesemaker to produce Appenzeller from, and not just with, raw milk.

Natürli is Wisi's main sales partner. The glut of cheeses in Switzerland and in the main export countries also poses major problems for natürli. To remain successful in future, Fredy Bieri's vision must be developed further. Raw-milk products have a wide range of health benefits that are still not given their due, as shown by an overview of the literature (Bachmann et al., 2020) and a scientific conference (Bachmann et al., 2024).

Wisi sends a large proportion of his cheeses to ripen in natürli's amazing vaulted cellars in Saland, Canton of Zurich (photo), which further strengthens their close partnership.



Fermentation takes time

As Wisi is fond of saying, "fermentation takes time". Unsurprisingly, we discovered the odd quirk or two in his methods. For example, he doesn't add water to the milk, as this dilutes not only the lactose but also quite a few more valuable constituents. He adds significantly less rennet than normal, so the coagulation time is correspondingly longer. This has the side benefit of allowing us to enjoy breakfast together in peace. The temperatures and times are appropriately adjusted so that syneresis (curd-particle contraction and whey expulsion) and the acidification process still occur within the intended timeframe. The parameters for producing Appenzeller cheese and its specialities have the odd subtle nuance for the creation of unique products. There

is, however, one thing they all have in common: Wisi swears by the use of Liebefeld raw mixed cultures, virtuosically combining four at once. A bit of yoghurt, which he has made himself from past batches for years, is also always added. All of this takes place at an incubation temperature that you won't find in any manual on the subject.

In Wisi's opinion, the rennet-whey test is the most informative analysis. For it, after the addition of rennet to the kettle, a milk sample is taken and incubated for 1 day, during which time a cheese stick forms in the test tube (Photo). The consistency of this cheese stick, the measurement of the acidity level and a small swig of the whey impart valuable information to Wisi on milk quality and fermentation progress. Occasionally the rennet-whey is incubated for a second day and examined once more, allowing further conclusions to be drawn.



Not all tools disinfected immediately after each use

All equipment and facilities coming into contact with the milk or with the fermenting cheese are spick-and-span, as they are thoroughly cleaned after use. Otherwise it would be impossible to produce such outstanding cheese.

Despite this, Wisi is aware that he is also reliant on the existence of a healthy house microbiota and would never disinfect his saltwater bath or the wooden boards in the cheese cellar. The house microbiota occupies ecological niches which could otherwise be usurped by adventitious, possibly undesirable microorganisms.

Four strong mainstays

Three mainstays have already been mentioned in the above paragraphs: the herb-fed pigs, marketing via natürli and the Appenzeller cheese, whose production volume, quality assessment and marketing are managed by a trade association.

The fourth mainstay is direct sales on an impressive scale. By his own account, Wisi does not just have customers, but a veritable fan club as well.

Raw-milk cheese dairies make excellent teaching operations

Wisi is also fond of saying that producing raw-milk cheese requires a keen feel. You are working with nature; every day is special. He feels certain that separation of the cream in the evening milk overnight in the kettle can vary according to the phase of the moon. There may also be minor deviations in curdling, acidification or syneresis requiring slight adjustments in the production process. This keen feel is best learnt from seasoned professionals. Wisi also attaches great importance to the training of apprentices. Currently he is master to an apprentice, Kevin, whom he is wholeheartedly committed to initiating into the fascinating art of cheesemaking.

Successors wanted

To judge by the obvious pleasure that Wisi takes in his work, the Goldingen cheese dairy is the ideal employer and workplace and represents a unique opportunity for any cheesemakers who are keen to take their destiny into their own hands and who prefer to work from home.

Unfortunately, Wisi's search for a successor has been unsuccessful to date. It would be a brilliant result if this report encouraged a suitable candidate to apply.

The Pfister family and their cheese dairy were portrayed in the series 'Wohl bekomms: Käse, Laib und Leben' ['Bon Appétit: A Day in the Life of a Cheese Dairy'] from Servus TV ([Link](#)). This highly watchable film gives us a glimpse of Wisi's fascinating craftsmanship and fulfilling life.



The most important things in life

We chose Goldinger 'Gourmet' cheeses for the sensorial description. The cheeses were ripened for 4, 9 and 14 months respectively in natürli's vaulted cellars in Saland (Canton of Zurich).

- After 4 months' ripening, Goldinger Gourmet delights with a very agreeable mouth feel and a mild taste composed of milky and flowery facets. Very refreshing (crème fraîche) as well as a touch on the sweet side (honey). It's a cheese that will have you coming back for another piece, where just a little is not enough. It's also a cheese that promises great potential for an extended ripening.
- After 9 months the cheese is very savoury, even slightly piquant. The flavour has gained a great deal of complexity and now also encompasses smoky facets, bacon, onion and caramel. A distinctive umami note now enriches the taste. The cheese mentally transports us to an alpine cheese dairy.
- The 14-month Goldinger Gourmet is a big surprise. We had expected it to be even more savoury, perhaps even a bit too savoury. How wrong we were! The cheese delights us with its lovely harmoniousness. As we chew, the crystals crunch seductively. The cheese melts wonderfully on the palate, and the flavour is incredibly well-rounded. In addition, nutty, fruity (e.g. dried apricots), earthy and woody flavours can now also be detected.

For the pairings ('marriages') we plumped for a selection of regional beers, since beer is also Wisi's preferred tipple with his cheeses.

- The Pale Ale (beer too dominant) and the Pilsner (overpowering flavour of hops, too bitter) refused to marry with any of the cheeses.
- We really liked the wheat beer with the 4-month-matured cheese: the pairing was highly invigorating, refreshing and fruity, and with a surprising vanilla note. The ideal combination for the first half of a football match, quelling hunger and thirst like a charm and lending increased dynamism to the atmosphere with each bite and sip.
- For the second half of the match, we recommend the combination of a pale beer with the 9-month-old Goldinger Gourmet. The beer tones down the cheese's pungency and the cheese tempers the bitterness of the beer, with a marvellous caramel flavour soaring above it all. A combination that awakens all the senses and has a wonderfully long echo, so that one's attention is now completely focused on the match.
- And after the match, there's either cause for celebration, or a disappointment will need to be digested. For both scenarios, the combination of the 14-month Goldinger and a lager is ideal. What brilliant flavour fireworks – leading to the abiding realisation that there are far more important things in life than football.



8 Organic Cheese Dairy in Burgrain

Voyage of Discovery to meet Martin at the Burgrain organic cheese dairy

Experience the value chain up close

Our seventh journey takes us to the Erlebnishof Agrovision Burgrain AG educational farm in Alberswil, Canton of Lucerne, where visitors can experience the entire value chain for organic foods at close hand. Promoting rural and artisan occupations is an important part of the ethos here.

Grass-fed dairy cows and winter calving

The cows on the Burgrain organic farm are entirely grass-fed and calve seasonally. In late autumn they are dried off ready for calving early in the year. In winter their diet consists entirely of hay, then from April onwards they graze on pasture. No supplementary feed is provided, except for hay in times of drought. To ensure a year-round supply of milk for processing, a group of 20 cows are dried off earlier in the season for calving in December.

Whilst 100%-grass-fed cows may not produce exceptionally high milk yields, this method of feeding is very natural, simple and low-cost. No feed is supplied that could be fed directly and much more efficiently to humans, such as cereals or soy. Smaller Holstein cows efficiently convert pasture grass into milk with a high fat and protein content.

Dora, born 2014

In the milking parlour is a list of the names of the cows and their sires, dams and granddams, along with their years of birth and number of lactations. What is particularly striking is that half of Burgrain's cows boast four or more lactations. Top of the leader board is Dora with nine lactations to her name. Extensive rearing means that the cows here live much longer. A typical Swiss dairy cow has an average lifespan of five or six years and has 3.5 lactations in this time before being removed from the production process. In some countries, the average number of lactations is even lower, although cows can live for up to twenty years (Source: bio-aktuell, [Link](#)).

Another striking aspect of the milking parlour is the level of professionalism on evidence. Strict routines are followed to ensure that the high standards of hygiene for milk used in the production of raw-milk cheese are scrupulously upheld. It thus comes as no surprise that routine monitoring in the cheese dairy confirms the high microbiological quality of the milk.

Large fluctuations in yield and content

Over the course of the lactation, milk yields generally decrease whilst fat and protein content increase. Since all the Burgrain cows calve in late winter, this means that considerably less milk is produced in winter, the cows are 'awash with milk' in spring, and fat and protein content are usually at their highest in autumn.

Forage quantity and quality are also important factors. With a fully grass-fed herd, this of course means the quantity and quality of the grass and hay. Here, the weather plays a key role, as shown by the fact that over the past four years, the milk content (fat + protein) on the Burgrain farm in August has ranged between 8.52% (2021) and 7.38% (2023).



Annual milk yield is approximately 350,000 litres. Right after milking, the milk, still warm from the cow, is taken on foot to the cheese dairy in the electrically-powered milk tank. Chilled overnight to 6°C, it is reheated the following morning, then added to the freshly-milked morning milk for processing.

High degree of flexibility and expertise

Organic cheese dairy manager Martin Stadelmann and his team have plenty of challenges to contend with: large variations in the milk (quantity and content) on the one hand, and in sales on the other. The growing popularity of raclette and fondue have significantly boosted demand for cheese in the cold season.

A great deal of experience is required to decide which type of cheese to produce when, so that the cheeses are always ready for sale at the ideal degree of maturity. Because of the variations in fat and protein content, a sure instinct is also needed to guarantee that coagulation and fermentation are in the right range. Important control parameters at this stage in the milk pre-ripening process are temperature and length of time between the addition of starter cultures and renneting. Pre-ripening controls the lactic-acid fermentation process and largely determines coagulation properties. Both factors influence subsequent syneresis – i.e. curd-particle contraction and whey expulsion. Here too, temperature and duration can have a major bearing on cheese characteristics.



Spectators welcome

At Burgrain, the production of organic foodstuffs is appealingly showcased. There are no secrets here, and visitors are allowed to watch (almost) everything – on the pastures, in and around the cow shed, and of course in the organic cheese dairy.

Built ten years ago, the dairy still looks spanking new. Everything is on one level, and the set-up is highly functional. Another striking thing about the Burgrain dairy is its spotlessness. Impeccable hygiene, and hence thorough cleaning, is clearly part and parcel of artisan raw-milk product manufacture here.



Spoilt for choice

Visitors can experience at close quarters a dozen or so different organic cheeses, a fondue mix, butter, and a assortment of yoghurts, yoghurt drinks and quark (a type of curd cheese) being made largely by hand using artisan methods. A conscious effort is made to use the most environmentally friendly manufacturing processes as well as regional raw materials wherever possible. Working in harmony with nature and forging connections with rural culture clearly lie at the heart of everything they do. For example, milk from Jersey cows from a neighbouring farm is specifically used for yoghurt production. This very rich milk produces a deliciously creamy yoghurt without the need to add industrially manufactured milk powder.



Burgrain dairy products are served on site in the farm restaurant and in its own farm shops, as well as in organic shops and supermarkets throughout German-speaking Switzerland through its own distribution platform.

A keen eye for detail

Martin and his team are eager to further enhance the quality of their products. Currently, they are working on making to make the texture of the cheese a little creamier and the flavour a little richer. A keen eye for detail makes all the

difference, as impressively demonstrated by the precision with which a pre-pressed block of cheese is cut into eleven cheeses of equal weight.



A microbial coagulating agent is used instead of calf rennet so that the cheese can be labelled 'vegetarian' – another area where a great deal of specialist knowledge and expertise are required.

Milk leaves its mark

For the sensory description, we chose three semi-hard cheeses and one hard cheese, all made from 100% raw milk, as you would expect. The four cheeses have very distinct characters. You can easily spot the influence of variations in the milk composition. The Burgrain farm has taken a bold and commendable stance in refusing to make any compromises within their grass-fed dairy system in order to produce cheese of more uniform quality. Quite the opposite, in fact: they aspire to being able to make high-quality dairy products from any sort of milk, and acknowledge that seasonal variations are simply part of the equation. To ensure success here, highly skilled cheesemakers are required, as are consumers who understand the importance of working hand-in-hand with nature at Burgrain.

- The Mutschli (aged for two months) was made in mid-November, at a time when the cows are coming to the end of their lactation period. And it's not just the experts who can spot this influence. All in all, the flavours are slightly tangier and more rustic. Despite this, the Mutschli wows us with a fresh acidity, a buttery note and pleasantly sweetish flavours like caramel and vanilla. The cheese melts deliciously on the tongue and has a slightly sticky, floury finish that is not at all unpleasant.
- The mild Bläsi (aged for four months) has a pronounced oniony flavour which is quite unexpected, very spicy notes and a fresh, palate-cleansing acidity.

- The stronger Bläsi (aged for nine months) spoils us with its cornucopia of flavours: floral, grassy, citrusy notes, bouillon (umami) and even dried fruit (plums). The presence of a few crystals creates an exciting crunch that adds to the delight.
- The mountain cheese (a twelve-month-old hard cheese) is at peace with itself. The flavours are less intense than we expected, but all the more eclectic. Every bite unearthed a new flavour, including ones not normally associated with cheese, such as cooked vegetables, morels and forest floors. This treasure trove of flavours adds up to a delicate and beautifully balanced triumph.

For the pairings, we decided on a selection of homemade jams and jellies that are on sale in the farm shop.

- The dandelion jelly has its work cut out competing with the cheeses, and its delicate flavour is soon overpowered. Interestingly though, the cheeses taste slightly more mellow and mature when paired with it.
- The spruce-tip jelly intensifies the Mutschli's rustic notes wonderfully, with the combination of the two energetically waltzing around our mouths.
- The elderflower jelly pairs wonderfully with all the cheeses. Its distinctive flavour shines through without masking the flavours of the cheese, creating a deliciously harmonious effect. The sweetness of the jelly and the acidity of the cheeses complement each other perfectly. Children of all ages will be delighted by the tastebud-tickling gummy bears forming on the palate when the elderflower is paired with the stronger Bläsi.
- The quince jelly is not picky either: it pairs well with all the cheeses, contributing plenty of freshness and a lovely harmony.
- The damson jelly pairs beautifully with the stronger Bläsi. It tempers the cheese's sharpness, seduces you with its oriental flavours and is reminiscent of a walk in the autumn sunshine. Then comes the finish – and the finish is simply 'awesome': very fruity (not just damsons), redolent of freshly baked muffins, biscuits or similar, and incredibly persistent, without losing any of its magic.



9 Comparative Study of Cheeses from Raw and Thermised Milk

From the seven expeditions to artisan cheesemakers, a total of 24 raw-milk cheeses were selected for sensory description and analytical testing. To better rank the analytical results, 24 cheeses made from thermised milk were also tested in parallel. These cheeses were also produced in artisan cheese dairies throughout Switzerland. All dairies stated that their milk was thermised at 68 °C for 15 seconds. When selecting the cheeses for comparison, care was taken to ensure that the cheeses in both groups were as comparable as possible in terms of milk provenance (cow, goat), cheese firmness (hard, semi-hard, soft), milk fat content (all full-fat) and degree of maturity. This comparability was only achieved in part, however, as the cheeses made from raw milk had matured for an average of 1.6 months longer than those made from thermised milk (Table 1).

Table 1: Degree of maturity of the cheeses [mean values ± standard deviation]

Factor	Level	N	Degree of maturity [months]
Milk	Raw	23	6.1 ± 4.5
	Thermised	23	4.5 ± 3.1
Firmness of cheese	Hard	5	9.6 ± 4.2
	Semi-hard	33	5.7 ± 3.4
	Soft	8	1.0 ± 0.7
Soft goat's-milk cheeses		2	0.9 ± 0.2

Semi-hard cow's-milk cheeses were the largest group by far, since very few cheese dairies in Switzerland produce soft cheeses from raw milk. Conversely, hard cheeses are rarely made from thermised milk, as heating the curd to temperatures above 50 °C has a similar effect on the microbiota.

On average, raw-milk cheeses had a higher fat content and lower water content than those made from thermised milk. The lower water content is most likely the result of raw-milk cheeses being matured for longer on average. Overall, fat content was significantly above the minimum 45% in dry matter for full-fat cheese. The raw-milk cheeses averaged a maximum fat content of just under the maximum of 55%. The high fat content can be explained by efforts to produce cheeses of peak deliciousness.

Table 2: Composition of the cheeses [mean values $\pm$ standard deviation]

Factor	Level	N	Moisture [g / kg]	Fat [g / kg]	FDM ¹⁾ [g / kg]	MFFB ²⁾ [g / kg]	Salt [g / kg]	Calcium [g / kg]	pH value
Milk	Raw	23	366.0 $\pm$ 58.6	344.1 $\pm$ 28.8	543.5 $\pm$ 18.3	555.6 $\pm$ 65.3	15.2 $\pm$ 3.3	6.5 $\pm$ 1.3	5.97 $\pm$ 0.37
	Thermi- Sed	23	394.0 $\pm$ 56.3	319.9 $\pm$ 28.0	529.0 $\pm$ 30.7	577.6 $\pm$ 63.4	16.9 $\pm$ 5.3	6.6 $\pm$ 1.1	5.82 $\pm$ 0.33
Firm- ness of chee- se	Hard	5	316.2 $\pm$ 41.1	361.8 $\pm$ 19.4	529.6 $\pm$ 6.9	494.2 $\pm$ 50.5	13.0 $\pm$ 5.0	8.5 $\pm$ 0.6	5.67 $\pm$ 0.14
	Semi- hard	33	364.5 $\pm$ 29.0	337.1 $\pm$ 24.7	530.1 $\pm$ 24.1	549.3 $\pm$ 29.4	17.3 $\pm$ 3.6	6.7 $\pm$ 0.7	5.87 $\pm$ 0.31
	Soft	8	483.6 $\pm$ 30.1	292.5 $\pm$ 22.3	566.1 $\pm$ 21.2	683.4 $\pm$ 26.1	12.6 $\pm$ 5.0	4.6 $\pm$ 0.5	6.13 $\pm$ 0.51
Soft goat's-milk cheese ³⁾		2	545.5 $\pm$ 3.5	232.5 $\pm$ 6.4	511.5 $\pm$ 17.7	710.5 $\pm$ 10.6	8.4 $\pm$ 0.6	4.3 $\pm$ 4.5	5.88 $\pm$ 1.33
<i>Analysis of variance</i> ⁴⁾									
Milk			**	*		**			
Firmness			***	***	***	***	**	***	+
Milk x Firmness					+		*		

1) Fat content in dry matter

2) Moisture content on a fat-free basis

3) Excluded from the analysis of variance

4) p-value: *** = < 0.001, ** = < 0.01, * = < 0.05, + = < 0.1

Cheese calcium content was higher with increasing firmness. This is because pH value decreases less during lactic acid fermentation, so less calcium is washed out of the cheese curd via the whey.

In mature cheeses, however, pH value rose as firmness decreased, which can be explained by the more-rapid breakdown of lactic acid by the microbiota on the surface of the cheese.

Soft cheeses made from goat's milk had a higher water content than those made from cow's milk, as experience shows that syneresis is significantly less intense in goat's milk.

The lactic-acid content confirms the slower breakdown of lactic acid by the microbiota on the surface of firmer cheeses, as suggested by the higher pH (Table 2). As expected, galactose could not be detected in either the semi-hard or hard cheeses, as the milk sugar in these types of cheeses is normally completely fermented.

Table 3: Content of fermentation products [mean values $\pm$ standard deviation]

Factor	Level	N	Total lactate [mmol/kg]	D-lactate [mmol/kg]	L-lactate [mmol/kg]	L-lactate [% of total]	Galac- tose [mmol/kg]	LAP ¹⁾ [IU/kg]	OPA ²⁾ [mmol/kg]	Citrate [mmol/kg]
Milk	Raw	23	73.8 $\pm$ 38.3	30.9 $\pm$ 24.6	42.9 $\pm$ 20.7	64.3 $\pm$ 21.0	0.1 $\pm$ 0.3	36.3 $\pm$ 34.1	344.2 $\pm$ 163.6	1.9 $\pm$ 2.2
	Ther- mised	23	74.6 $\pm$ 46.1	26.4 $\pm$ 21.0	48.2 $\pm$ 34.0	56.9 $\pm$ 28.0	0.1 $\pm$ 0.4	12.1 $\pm$ 9.5	205.4 $\pm$ 140.5	1.4 $\pm$ 2.2
Firm- ness of chee- se	Hard	5	128.1 $\pm$ 38.1	63.2 $\pm$ 26.8	65.0 $\pm$ 38.8	49.3 $\pm$ 17.0	0.0 $\pm$ 0.0	17.3 $\pm$ 23.4	320.1 $\pm$ 175.2	2.8 $\pm$ 3.3
	Semi- hard	33	74.5 $\pm$ 36.0	27.2 $\pm$ 17.5	47.3 $\pm$ 26.4	60.1 $\pm$ 22.1	0.0 $\pm$ 0.0	22.6 $\pm$ 29.8	305.1 $\pm$ 158.0	1.4 $\pm$ 2.1
	Soft	8	39.1 $\pm$ 32.9	12.8 $\pm$ 18.8	26.4 $\pm$ 17.3	69.5 $\pm$ 36.8	0.4 $\pm$ 0.7	34.9 $\pm$ 18.8	121.3 $\pm$ 115.5	2.1 $\pm$ 1.6
Soft goat's- milk cheese ³⁾		2	19.8 $\pm$ 27.9	0.0 $\pm$ 0.0	19.8 $\pm$ 27.9	100.0 $\pm$ 0.0	0.2 $\pm$ 0.3	21.9 $\pm$ 23.4	57.3 $\pm$ 34.7	0.8 $\pm$ 0.0
Analysis of variance ⁴⁾										
Milk								*	**	
Firmness			**	***	+		**		**	
Milk x Firmness										

1) Leucine aminopeptidase

2) o-Phthaldialdehyde (a method for measuring free-amino-acid content)

3) Excluded from the analysis of variance

4) p-value: *** = < 0.001, ** = < 0.01, * = < 0.05, + = < 0.1

Proteolysis was more advanced in raw-milk cheeses, as shown by the LAP and OPA values. Given that the differences were highly significant, this cannot be explained solely by the greater maturity of the raw-milk cheeses; rather, it is an indication that the raw-milk microbiota contributed significantly to proteolysis in the cheeses.

A counteracting effect was measured in the firmness levels. With increasing firmness, the LAP value was lower and the OPA value higher. This can be explained by the fact that the OPA value measures a product of proteolysis with free amino acids, whilst the LAP value measures the activity of the enzyme leucine aminopeptidase, which is released during the lysis of bacteria. Consequently, the OPA value is lower in soft cheeses due to their shorter maturation times, whilst the LAP value is higher in soft cheeses due to the use of cultures with higher LAP activity and more-rapid lysis. In addition, the influence of the raw-milk microbiota is greater. Despite lower LAP values in hard cheeses, the OPA values rise to higher levels over the longer ripening period.

The most striking difference in volatile carboxylic acids was the significantly more intense lipolysis in soft cheeses, a direct effect of mould growth on the cheese surface. The lipase from the mould led to the release of n-butyric and n-caproic acids, which then diffused into the cheese.

Table 4: Content of volatile carboxylic acids [mean values $\pm$ standard deviation]

Factor	Level	N	Total volatile carboxylic acids [mmol/kg]	Formic acid [mmol/kg]	Acetic acid [mmol/kg]	Propionic acid [mmol/kg]	Iso-butyric acid [mmol/kg]	n-butyric acid [mmol/kg]	Iso-valeric acid [mmol/kg]	n-caproic acid [mmol/kg]
Milk	Raw	23	35.8 $\pm$ 24.3	2.7 $\pm$ 1.9	24.1 $\pm$ 14.3	5.1 $\pm$ 10.9	0.2 $\pm$ 0.3	2.5 $\pm$ 4.0	0.4 $\pm$ 0.7	0.7 $\pm$ 1.3
	Thermised	23	31.8 $\pm$ 27.2	2.0 $\pm$ 1.5	19.9 $\pm$ 13.2	6.1 $\pm$ 14.3	0.6 $\pm$ 1.6	1.7 $\pm$ 3.4	1.0 $\pm$ 2.8	0.5 $\pm$ 1.4
Firmness of cheese	Hard	5	31.2 $\pm$ 15.3	3.3 $\pm$ 2.2	25.5 $\pm$ 12.9	0.5 $\pm$ 0.7	0.2 $\pm$ 0.2	1.2 $\pm$ 0.8	0.2 $\pm$ 0.2	0.2 $\pm$ 0.2
	Semi-hard	33	37.3 $\pm$ 28.3	2.6 $\pm$ 1.6	24.3 $\pm$ 13.8	7.7 $\pm$ 14.4	0.5 $\pm$ 1.3	1.0 $\pm$ 0.6	0.9 $\pm$ 2.4	0.2 $\pm$ 0.2
	Soft	8	21.0 $\pm$ 11.8	0.7 $\pm$ 1.0	10.1 $\pm$ 7.6	0.1 $\pm$ 0.3	0.1 $\pm$ 0.1	7.1 $\pm$ 7.0	0.2 $\pm$ 0.4	2.6 $\pm$ 2.4
Soft goat's-milk cheeses ¹⁾		1	19.7 $\pm$ 13.8	0.6 $\pm$ 0.6	10.4 $\pm$ 5.9	0.2 $\pm$ 0.3	0.0 $\pm$ 0.0	5.3 $\pm$ 4.3	0.0 $\pm$ 0.0	3.1 $\pm$ 2.7
<i>Analysis of variance ²⁾</i>										
Milk										
Firmness				**	*			***		***
Milk x Firmness										

1) Excluded from the analysis of variance

2) p-value: *** = < 0.001, ** = < 0.01, * = < 0.05, + = < 0.1

Contrary to expectations, thermisation of the milk did not lead to lower propionic acid levels in the cheeses. Prevention of secondary fermentation is one of the main reasons for thermising milk.

In the case of raw-milk cheeses, propionic acid content was elevated at two cheese dairies (X and Y). Some of these cheeses also had an elevated histamine content (Figure 2), indicating gaps in the monitoring of raw-milk quality.

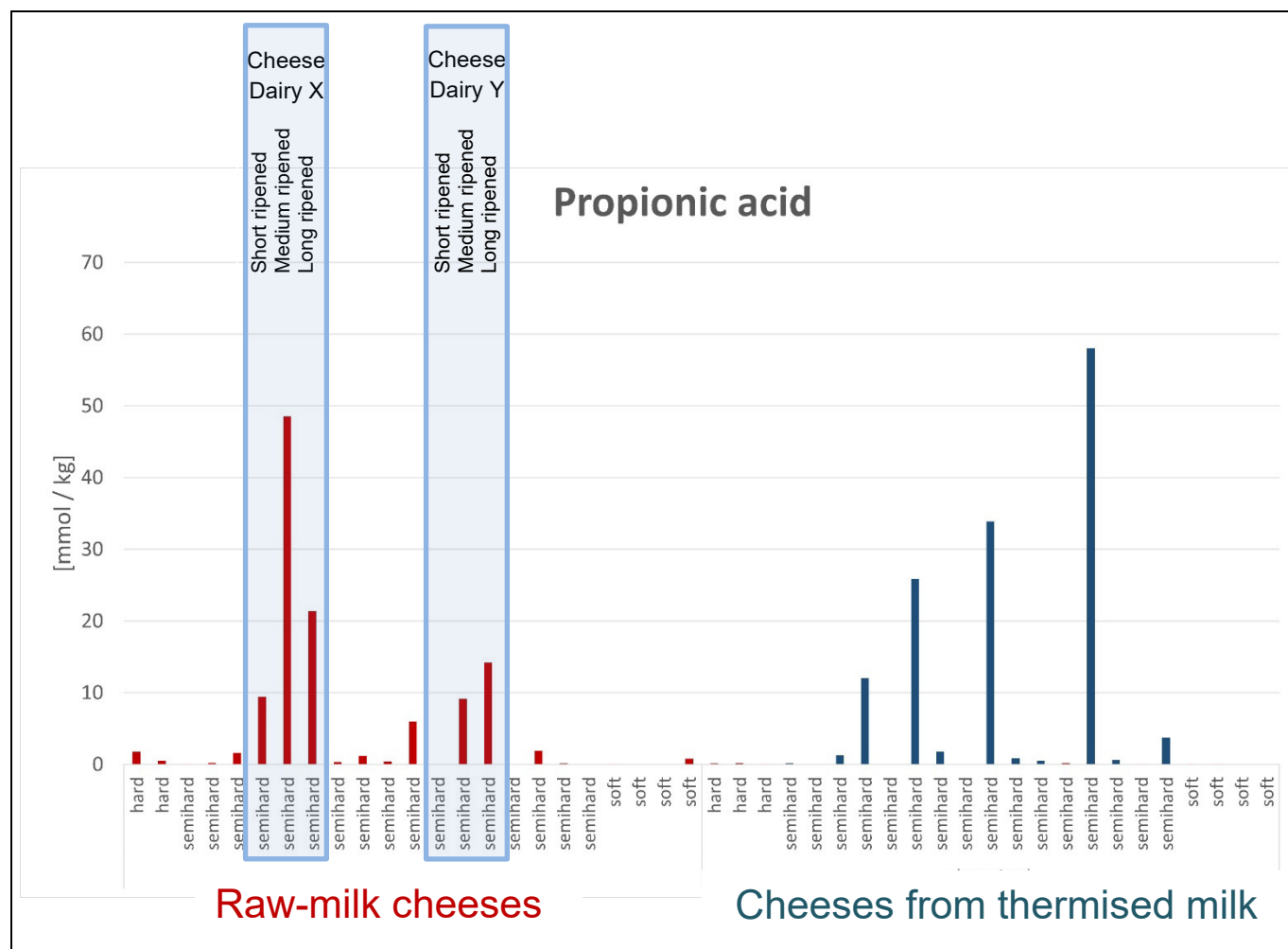


Figure 1: Propionic acid content

Thermisation at 68 °C for 15 seconds should actually be sufficient to completely eliminate the propionic acid bacteria. Nevertheless, significant secondary fermentation was measured in four cheeses, which can be explained either by a very high propionic acid bacteria content in the raw milk, faulty thermisation, or recontamination after thermisation.

No statistically significant differences were found for biogenic amines. However, it is striking that total biogenic amines in raw milk cheeses were higher by a factor of three, which cannot be explained solely by their somewhat longer average maturation period.

Table 5: Content of biogenic amines [mean values $\pm$ standard deviation]

Factor	Level	N	Total biogenic amines [mg/kg]	Histamine [mg/kg]	Tyramine [mg/kg]	Cadaverine [mg/kg]	Isopentylamine [mg/kg]	Phenylethylamine [mg/kg]	Putrescine [mg/kg]	Tryptamine [mg/kg]
Milk	Raw	23	459.3 $\pm$ 468.7	174.1 $\pm$ 337.0	177.3 $\pm$ 215.9	78.1 $\pm$ 125.9	0.0 $\pm$ 0.0	16.8 $\pm$ 33.9	12.8 $\pm$ 30.9	0.0 $\pm$ 0.0
	Thermised	23	153.6 $\pm$ 306.9	62.6 $\pm$ 123.5	25.7 $\pm$ 52.1	58.5 $\pm$ 193.6	3.1 $\pm$ 14.9	0.6 $\pm$ 2.9	2.5 $\pm$ 6.8	0.6 $\pm$ 2.8
Firmness of cheese	Hard	5	92.2 $\pm$ 133.8	62.9 $\pm$ 132.1	16.2 $\pm$ 18.9	13.2 $\pm$ 29.6	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0
	Semi-hard	33	364.6 $\pm$ 447.3	153.5 $\pm$ 293.2	118.3 $\pm$ 180.8	70.3 $\pm$ 168.1	2.2 $\pm$ 12.4	12.1 $\pm$ 29.1	7.5 $\pm$ 23.4	0.4 $\pm$ 2.3
	Soft	8	200.8 $\pm$ 391.9	7.9 $\pm$ 15.2	85.2 $\pm$ 190.5	94.5 $\pm$ 188.7	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	12.8 $\pm$ 27.4	0.0 $\pm$ 0.0
Soft goat's-milk cheeses ¹⁾		2	229.4 $\pm$ 307.8	20.9 $\pm$ 29.5	173.9 $\pm$ 229.3	18.9 $\pm$ 26.7	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	15.4 $\pm$ 21.7	0.0 $\pm$ 0.0
Analysis of variance ²⁾										
Milk										
Firmness										
Milk x Firmness										

1) Excluded from the analysis of variance

2) p-value: *** = < 0.001, ** = < 0.01, * = < 0.05, + = < 0.1

Levels of all biogenic amines were lower in the hard cheeses than in the semi-hard cheeses, despite the hard cheeses being matured for an average of four months longer. Many biogenic amine-forming bacteria were therefore unable to survive the above-50 °C scalding temperature and/or to compete with the thermophilic starter cultures. For this reason, hurdle technology has also proven effective in reducing the risk posed by biogenic amines.

With soft cheeses, the ripening period is usually too short for significant amounts of biogenic amines to form.

Histamine is the most relevant of the biogenic amines. Cheeses with an elevated histamine content are perceived as piquant and burning in the mouth, as histamine irritates the mucous membranes. Many consumers find such cheeses unpleasant and give them a wide berth. In about one per cent of the population, the consumption of histamine-rich foods – especially in combination with alcoholic beverages – can lead to pseudoallergic reactions with symptoms such as diarrhoea, malaise, skin redness and nausea. In cases of contamination with *Lentilactobacillus parabuchneri*, cheese histamine content increases steadily during maturation, leading to serious cheese defects, since histamine formation also produces gas (CO₂). For this reason, Agroscope recommends that producers of raw-milk cheese in particular include *Lentilactobacillus parabuchneri* as a quality criterion when assessing milk quality.

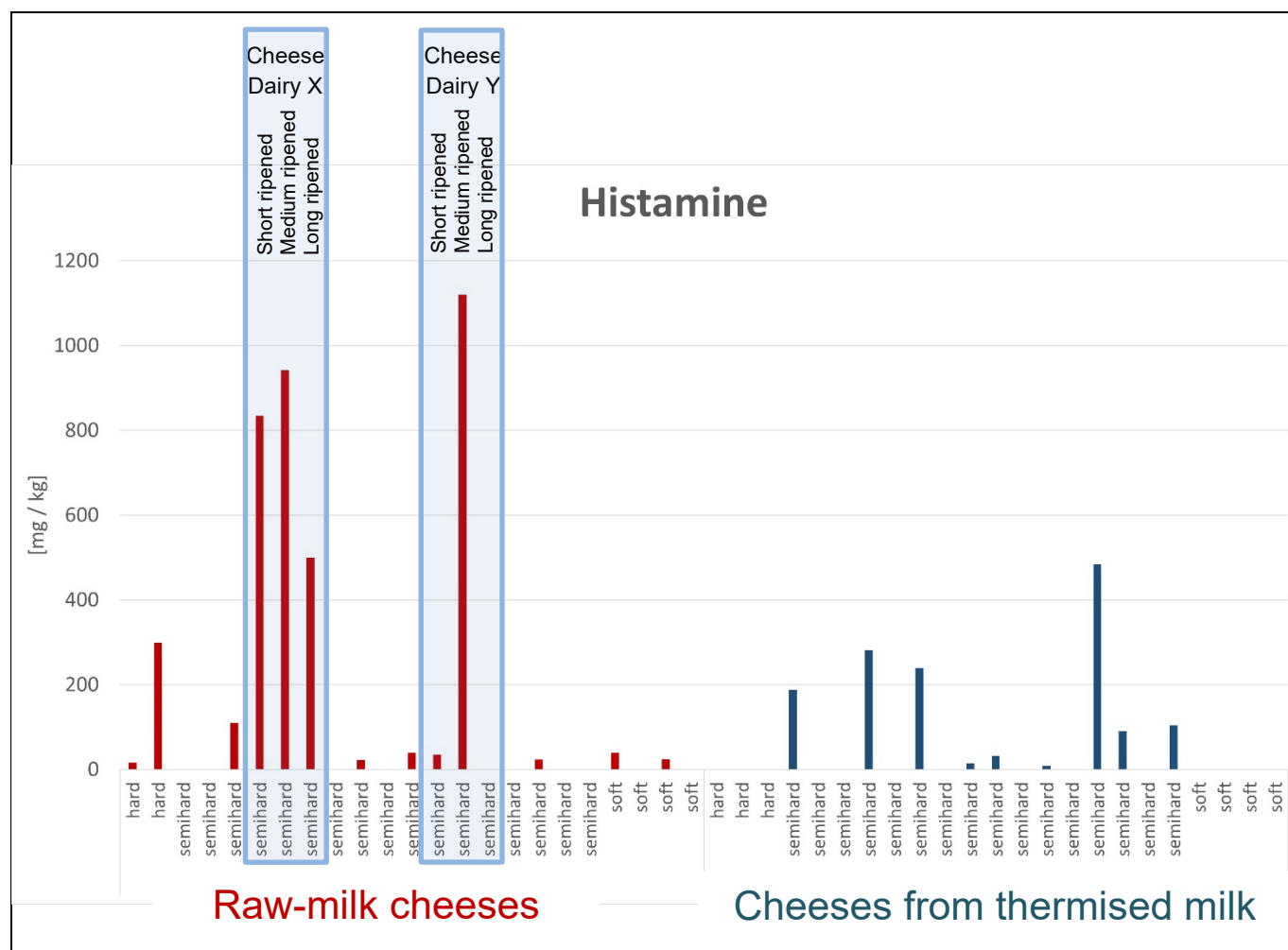


Figure 2: Content of histamine

Monitoring of raw-milk quality at cheese dairies X and Y was inadequate. Unsurprisingly, individual cheeses from both of these dairies also had higher propionic acid levels (Figure 1).

Experience from various practical studies shows that there are cheese dairies whose cheeses chronically exhibit elevated histamine levels. In such cases, milk samples from all farmers should be tested for the presence of histamine-producing bacteria to identify suppliers whose milk is contaminated with *Lentilactobacillus parabuchneri*. Agroscope has developed new biochemical and molecular-biological methods for this purpose. Only through the systematic decontamination of milking equipment at such suppliers is it possible to reduce the histamine content and eliminate the associated problems with cheese quality (Ascone et al., 2017).

The results presented here show that it is possible to produce cheese of any firmness from raw milk that contains very little or no histamine. However, thermisation of the milk alone is not sufficient to prevent the formation of histamine.

Using *16S rRNA gene amplicon sequencing*, the metagenome of each of the 24 cheeses made from raw and thermised milk was also determined. The different species from which a signal could be measured were subdivided into four groups (Table 6):

- Thermophilic-starter lactic-acid bacteria were detected in all firmness levels, but their relative abundance was highest in the hard cheeses.
- Mesophilic-starter lactic-acid bacteria were rare in the five hard cheeses examined, as they were unable to survive the scalding temperature of above 50 °C and/or compete with the thermophilic starter-cultures. The proportion of mesophilic cultures was higher in cheeses made from thermised milk than in those made from raw milk.
- Non-starter lactic-acid bacteria, which can contribute significantly to the development of a well-rounded flavour, were very significantly reduced by thermisation.
- The relative abundance of non-lactic-acid bacteria was very low overall and there were no significant differences.

Table 6: Relative abundance of bacterial groups in the metagenome [mean values $\pm$ standard deviation]

Factor	Level	N	Thermophilic-starter lactic-acid bacteria [%]	Mesophilic-starter lactic-acid bacteria [%]	Non-starter lactic-acid bacteria [%]	Non-lactic-acid bacteria [%]
Milk	Raw	23	69.47 $\pm$ 32.90	13.41 $\pm$ 27.60	17.08 $\pm$ 25.55	0.04 $\pm$ 0.05
	Thermised	23	63.99 $\pm$ 30.45	31.92 $\pm$ 31.52	3.93 $\pm$ 6.02	0.15 $\pm$ 0.41
Firmness	Hard	5	90.18 $\pm$ 7.79	1.17 $\pm$ 1.88	8.61 $\pm$ 7.52	0.03 $\pm$ 0.05
	Semi-hard	33	64.65 $\pm$ 33.34	22.53 $\pm$ 33.64	12.71 $\pm$ 22.02	0.11 $\pm$ 0.34
	Soft	8	70.84 $\pm$ 31.33	25.41 $\pm$ 27.52	3.71 $\pm$ 7.57	0.03 $\pm$ 0.02
Soft goat's-milk cheeses ²⁾		2	25.45 $\pm$ 35.75	72.84 $\pm$ 38.15	1.40 $\pm$ 1.98	0.31 $\pm$ 0.42
<i>Analysis of variance</i> ³⁾						
Milk				+	*	
Firmness				*	+	
Milk x Firmness				*		

1) Excluded from the analysis of variance

2) p-value: *** = < 0.001, ** = < 0.01, * = < 0.05, + = < 0.1

The most common species within the group of non-starter lactic-acid bacteria was *Lactocaseibacillus paracasei*, which typically ferments citrate in the cheese, thereby influencing flavour- and eye formation (Table 7).

The second-most common species within this group, especially in semi-hard cheeses, was *Lentilactobacillus parabuchneri*, which can lead to the undesirable formation of histamine in cheese. In the 48 cheeses examined, the correlation coefficient R^2 was 0.37 between the relative abundance of *L. parabuchneri* and the histamine content. Only in two cheeses with an increased frequency of *L. parabuchneri* was no histamine measured. A single cheese showed an increased histamine content without *L. parabuchneri* being detected in the metagenome.

Enterococci, which can act as a hub for the transmission of antibiotic-resistance genes, were rarely detected. Only goat's-milk cheese made from raw milk exhibited a significant relative abundance (0.5%).

Table 7: Relative abundance of non-starter lactic-acid bacteria in the metagenome

Species	Relative abundance (%)	Cheeses from raw milk				Cheeses from thermised milk			
		Cow's milk			Goat's milk	Cow's milk			Goat's milk
		Hard (n=2)	Semi-hard (n=17)	Soft (n=4)	Soft (n=1)	Hard (n=2)	Semi-hard (n=17)	Soft (n=4)	Soft (n=1)
<i>Lactocaseibacillus paracasei</i>	> 10	1	7	1		1	2		
	1-10	1	4	1	1	1	6		
	0.1-1		2	1			6		
	0.01 - 0.1		3	1		1	1	4	
	< 0.01		1				1		1
<i>Lentilactobacillus parabuchneri</i>	> 10		1						
	1-10		5	1			2		
	0.1-1	1	5	1			3		
	0.01 - 0.1	1	2	1			5		
	< 0.01		4	1	1	3	6	4	1
<i>Lactiplantibacillus plantarum</i>	1-10		2	2			3		
	0.1-1		6	1					
	0.01 - 0.1	1	4						
	< 0.01	1	5	1	1	3	13	4	1
<i>Lactiplantibacillus pentosus</i>	1-10		2	2					
	0.1-1	1	3	1			3		
	0.01 - 0.1		1				3		
	< 0.01	1	11	1	1	3	10	4	1
<i>Levilactobacillus brevis</i>	1-10			2					
	0.1-1								
	0.01 - 0.1								
	< 0.01	2	17	2	1	3	16	4	1
<i>Weissella spp.</i>	0.1-1		4				1		
	0.01 - 0.1	1	6	1					
	< 0.01	1	7	3	1	3	15	4	1
<i>Pediococcus spp.</i>	0.1-1		2	1					
	0.01 - 0.1	1	6	1			1		
	< 0.01	1	9	2	1	3	15	4	1
<i>Limosilactobacillus fermentum</i>	0.1-1	1	2						
	0.01 - 0.1								
	< 0.01	1	15	4	1	3	16	4	1
<i>Loigolactobacillus coryniformis</i>	0.1-1		1						
	0.01 - 0.1		2	2					
	< 0.01	2	14	2	1	3	16	4	1
<i>Enterococcus spp.</i>	0.1-1				1				
	0.01 - 0.1	1	1	1			1		
	< 0.01	1	16	3		3	15	4	1
<i>Lactiplantibacillus paraplantarum</i>	0.01 - 0.1		2						
	< 0.01	2	15	4	1	3	16	4	1

The relative abundance of non-lactic-acid bacteria in the metagenome was very low overall, suggesting a high level of food safety. *Escherichia coli*, coagulase-positive staphylococci or other potentially pathogenic bacteria were not detected in any of the 48 cheeses. Metagenome analysis is also not the most suitable method of analysis for this purpose.

Propionibacterium freudenreichii, *Acidipropionibacterium jensenii* and *Acidipropionibacterium thoenii* were the most abundant non-lactic-acid bacteria and were detected in cheeses with an elevated propionic acid content (Figure 1).

Table 8: Relative abundance of non-lactic-acid bacteria in the metagenome

Species	Relative abundance (%)	Cheeses from raw milk				Cheeses from thermised milk			
		Cow's milk			Goat's milk	Cow's milk			Goat's milk
		Hard (n=2)	Semi-hard (n=17)	Soft (n=4)	Soft (n=1)	Hard (n=2)	Semi-hard (n=17)	Soft (n=4)	Soft (n=1)
<i>Propionibacterium</i> spp. and <i>Acidipropionibacterium</i> spp.	1-10 0.1-1 0.01 - 0.1 < 0.01		2 2 13	4	1	3	1 2 13	4	1
<i>Corynebacterium</i> spp.	0.1-1 0.01 - 0.1 < 0.01		1 16	4	1	3	1 1 14	1 3	1
<i>Staphylococcus</i> spp.	0.1-1 0.01 - 0.1 < 0.01		2 15	4	1	3	1 15	4	1
<i>Hafnia</i> spp.	0.1-1 0.01 - 0.1 < 0.01				1				
		2	17	4		3	16	4	1

Among the staphylococcus species, *Staphylococcus xylosus* and *Staphylococcus sciuri* were each detected once in semi-hard cheeses made from raw milk. In semi-hard cheeses made from thermised milk, the species detected was *Staphylococcus equorum*.

The species *Hafnia alvei* was found in the metagenome of goat's cheese made from raw milk. These are commensal bacteria of the gastrointestinal tract that are not normally pathogenic. *Hafnia alvei* is listed by the EFFCA (European Food & Feed Cultures Association) as a microorganism suitable for use in food.

In terms of the volatilome findings, there was a statistically significant difference between cheeses made from raw and thermised milk. Using OPLS-DA (orthogonal partial least-squares discriminant analysis), it was possible to clearly separate the 24 cheeses (Figure 3). This means that thermising the milk leads to a changed volatilome in the cheese and thus also to different organoleptic characteristics. Raw-milk cheeses also exhibited a greater spread (variance), suggesting a greater heterogeneity of the products.

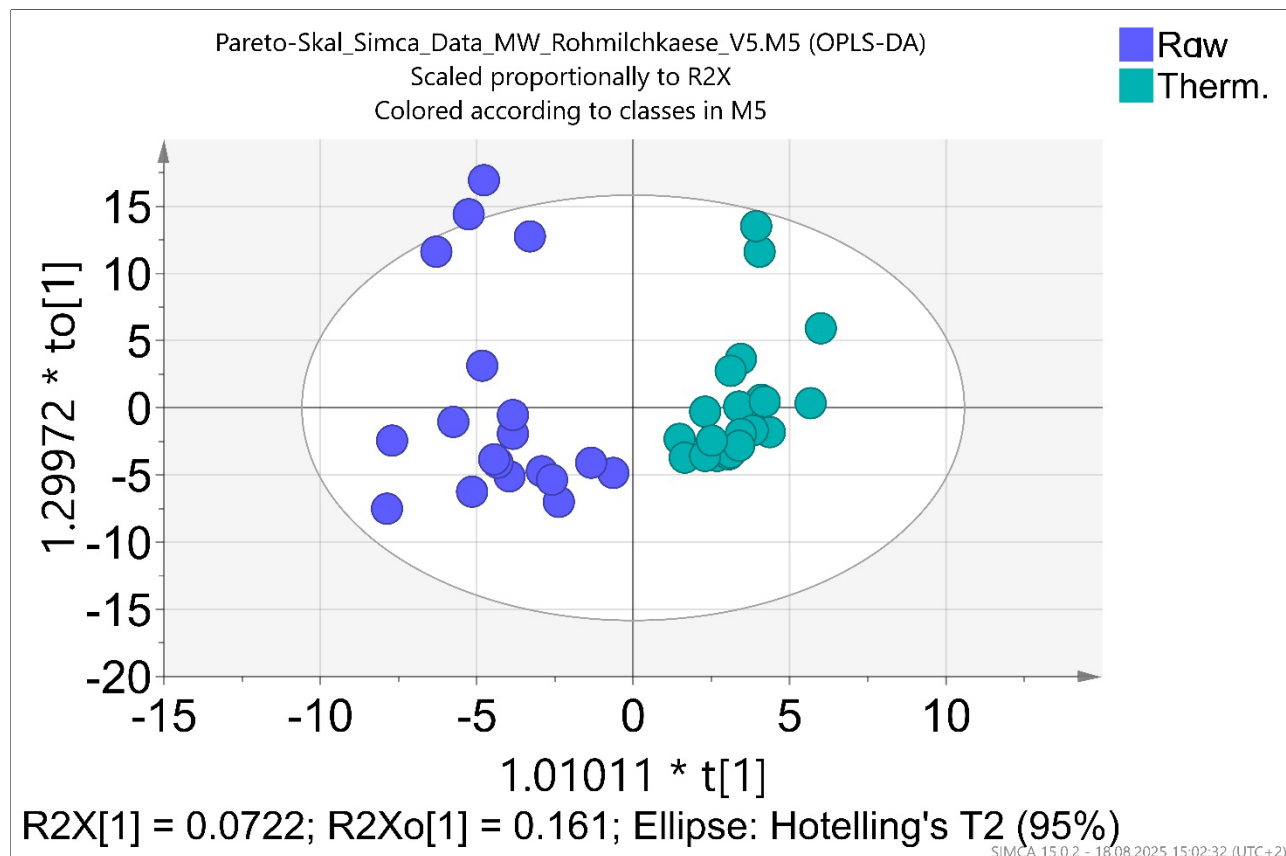


Figure 3: Separation of cheeses from raw (Raw) and thermised (Therm.) milk in the volatilome

OPLS-DA is a controlled statistical method for group separation and identification of key attributes that differ between predefined sample categories, often used to identify biomarkers and analyse complex datasets. It separates the total variability into a predictable and an orthogonal component, resulting in better class separation and interpretable results that can be visualised in so-called score plots.

10 Requirements for a Future-oriented Production System for Raw-Milk Cheeses

Based on findings from the literature (Bachmann et al., 2020), from the scientific conference on raw-milk products (Bachmann et al., 2024) and from the seven excursions we made to artisan cheesemakers, we identified a total of fourteen requirements that must be complied with when producing raw-milk cheeses to ensure that they have a comparable level of food safety to those made from pasteurised milk. These requirements can be broken down into four categories: people, milk, technology and framework conditions.

Conscious consumers	Framework conditions	Requirements for the production of raw milk cheeses	People	People with a compelling mission
Practice-oriented research				Well-trained professionals at all levels
Networks for sharing experiences				Thorough cleanliness along the entire value chain
Efficient and effective monitoring programs				Sensory quality checks with trained senses
Active cultures with high biodiversity	Technology		Milk	Healthy animals
Freshly processed every day				Trust between farmers and cheesemakers
Proven hurdle technology				Daily quality tests

Figure 4: Requirements for a future-oriented production system for raw-milk cheeses

These requirements are described in detail in the chapter ‘REQUIREMENTS FOR A FUTURE-ORIENTED PRODUCTION SYSTEM FOR RAW-MILK CHEESES’ in the second edition of the reference book ‘Cheeses and Microbes’ by the American Society for Microbiology, due to be published by Wiley in 2027.

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