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Sticky cheese smear and natural white mould

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Numerous traditional Swiss cheese varieties are smear-ripened *e.g.* Gruyère, Raclette, Appenzeller and Tilsiter. In recent years, there has been an increase in the occurrence of stickiness of the smear. During ripening, the smear becomes bright and viscous like honey. The consequences are an alteration of the typical flavour and a labour-intensive handling of the cheeses. Different measures, deduced from practical experience, were taken to control the symptoms of stickiness. These measures allowed the cheese producers to control the stickiness, but the cause of the defect still remains unknown. Since practical experience showed that cheeses with a natural growth of white moulds never became sticky, several isolated moulds were screened for their ability to reduce stickiness. The best effect was obtained with the mould "*Anticollanti*" (fancy name). The defect of the sticky smear demonstrates how difficult it is to maintain or recapture the natural balance of a complex ecosystem.

Klebrige Käseschmiere und natürliche weiße Schimmelpilze

Verschiedene traditionelle Schweizer Käse erfahren eine Schmierereifung, so z.B. Gruyère, Raclette, Appenzeller und Tilsiter. In den letzten Jahren trat in der Praxis eine vermehrte Klebrigkeit der Schmiere auf. Die Schmiere begann im Verlaufe der Reifung zu glänzen und wurde klebrig wie Honig. Die Folgen waren ein verändertes Aroma und eine stark arbeitsintensivere Käsepflege. Verschiedene Maßnahmen, die aus praktischen Erfahrungen abgeleitet wurden, ermöglichten den Käseherstellern, den Fehler zu verringern. In der Folge wurden auch natürlicherweise auf der Schmiere auftretende Schimmelpilze auf ihr Vermögen hin untersucht, die Klebrigkeit weiter zu vermindern. Die beste Wirkung wurde dabei mit "*Anticollanti*" (Fantasiename) erzielt. Der Fehler der klebrigen Schmiere zeigt, wie schwierig es ist, das natürliche Gleichgewicht in einem komplexen mikrobiologischen Ökosystem wieder herzustellen.

56 Swiss cheeses (sticky smear, moulds) **56 Schweizer Käse** (klebrige Schmiere, Pilzflora)

1. Introduction

Numerous traditional Swiss cheese varieties are smear-ripened *e.g.* Gruyère, Raclette, Appenzeller and Tilsiter. ELISKASES-LECHNER and GINZINGER (1) showed that the smear is a very complex ecosystem composed of moulds, yeasts and bacteria and that *Brevibacterium linens* is the most important bacterial species. In the studies of WYDER and PUHAN (2) the predominant yeast in all investigated cheese varieties was *Debaryomyces hansenii* regardless of whether it had been added as a starter to the smear or of whether it originated from spontaneous contamination. BOCKELMANN *et al.* (3) reported similar findings. The cell counts of surface smear bacteria found by many authors differ by several orders of magnitude (4). Only a minor fraction of the microscopically visible microorganisms from the smear are culturable (5). Development of red-brown pigments typical for Tilsiter cheese by smear bacteria was studied in milk-based model systems (6). A yellow pigmented Arthrobacter strain was found to be essential. The smear contributes to the typical flavour of these cheese varieties. Single strains of bacteria isolated from the surface of commercial Tilsiter cheeses have been screened for their ability to produce typical Tilsiter flavour and colour (7). In recent years, in Switzerland the occurrence of a defect, the so-called stickiness of the smear, has increased. The problem first arose in May 1998 during an evaluation of semi-hard cheese. During the year 1998/99 many, though not all manufacturers of smear-ripened semi-hard cheese were affected by the problem of sticky smear. Stickiness or sticky smear as it was called from the outset manifests itself as follows:

- The surface of the cheese is much more moist and takes on a typical sheen.
- The affected cheese is clearly more sticky on the contact surface than normal cheese.
- In extreme cases, the whole cheese is covered with a honey-like substance.
- Treatment of the cheese is much more time-consuming.
- The sticky smear has to be removed before the cheese is sold.
- There are major problems with pre-packaging because the cheese bodies can no longer be handled by machine.
- Sale is more difficult and the cheese-maker has to reckon with financial losses.

2. Observations in practice

The following observations were made in practice:

- The lateral side is generally more obviously affected by the defect.
- In extreme cases, there is so much sticky substance on the cheese surface that it begins to run down like honey.
- If the cheese surface is touched, the substance sticks to the fingers. If the substance is allowed to dry on the fingers, it quickly loses its stickiness and forms larger parchment-like scales. When moistened with water, the substance becomes sticky again as before.
- It was very soon realised that the defect was distributed irregularly, *i.e.* some cheese dairies were free of the defect, whilst the incidence was low in others, but yet other dairies were very badly affected.
- Furthermore, it was noted that cheeses which initially remained unaffected during ripening and treatment, gradually became sticky, whereas other cheeses in other cheese dairies showed clear signs of the defect at first, but then lost them during the course of ripening. Some undertakings thought their production was alright again after a period of difficulties, but then the defect unexpectedly reappeared.
- Sticky cheese had a noticeable sheen whereas the surface of cheese which was unaffected looked matt and was often covered in a typical fine growth of natural white mould.
- The surface of cheese with sticky smear was more intensely pigmented. The colour of this cheese had a more intensely orange colouring.
- Cellars in which cheeses with sticky smear were conserved also smelt more strongly of ammonia.

3. Initial hypotheses

Right at the beginning, it was postulated that the cause of the defect had to be microbiological. However, in spite of intensive comparative studies, the cause of the defect did not come to light. It also remained unclear whether the optical and analytical observations were the consequence or cause of the problem. An initial hypothesis stated that an unknown germ spread like an epidemic in cheese dairies and triggered the defect. If that were the case, however, „Koch's Postulates" regarding epidemics would have to come into play. Applied to the problem, this would mean:

The germ must regularly be detectable in the sticky cheese in typical arrangement. It must be possible to isolate the germ and grow it as a pure culture. It must be possible to produce the same defect in the test cheese with the pure culture

Intensive microbiological tests showed that these principles did not apply. In particular, the defect could not be transferred from cheese to cheese or from dairy to dairy. Thus it soon became clear that the presence of a germ could not be the only cause.

A switch in the microbiological balance within the smear flora was also put forward as a possible cause of the stickiness. However, no repeatable differences could be found between healthy and sticky smear. No possible germ cause of the defect could be identified either.

3.1 First glimmers of light

The bacteriological search for the „needle in the haystack" remained fruitless until the finding that a strange germ regularly occurred on the surface of good cheese bodies, but was found distinctly less frequently in the sticky cheeses. The good cheeses also mostly had a whitish growth of natural white mould which was not found on the defective cheeses. The germ was conspicuous by its marked colony form on malt extract agar in Petri dishes. The colonies formed „small volcanoes" with a dip in the middle and furrows radiating outwards. The colour of the colonies was always between beige and light brown and did not change over time (Fig. 1). The germ was called „volcano yeast" on

the assumption that it was actually a yeast which produced a mycelium-like structure. The surface appeared slightly „furry".

However, further tests showed that it was a mould with a genuine mycelium and not a yeast. Broader analysis showed that this mould is widespread. A large amount of it was found in 19 out of 20 examined smear samples of types of Swiss cheese. It was soon discovered that the amount found in so-called „good cheeses" was usually up to 1000 times greater than in sticky cheeses. Since it has not yet been possible to complete type classification and characterisation work with this mould (publication under preparation), the authors initially gave it the fancy name ‚*Anticollanti*'.

4. Pilot plant tests at the FAM

The observation that when a growth of natural white mould occurred naturally, the surface of the cheese dried better and stickiness hardly occurred, led to a change of direction in research work at the Swiss Federal Dairy Research Station (FAM): attention switched from the search for the germ causing the damage to the search for the germ which could control stickiness. The germ had to promote drying of the cheese surface and/or growth of a natural white mould. There had to be no unwanted discolouration either. A first test with *Anticollanti* followed in the model cheese dairy. The isolate used came from a cheese with good smear.

4.1 Test with Anticollanti in the model cheese dairy at the FAM

Two Raclette cheeses each aged 2 d, 3 wk. and 6 wk., respectively, from an operational dairy with sticky smear were treated as follows in 2 ripening cells:
Control cheeses: with 3 % salt water
Test cheeses: with 3 % salt water + *Anticollanti* mould suspension
The climate data in the ripening cells were 9.5–10.5 °C and 96–98% relative humidity. The cheeses were treated once a week. After a ripening period of 3 or 5 months, the cheeses were then assessed:
Control cheeses: The control cheeses remained sticky throughout the whole test phase. As the test progressed, a slight mould growth began, particularly in the older cheeses. The colour of the cheese smear was bright yellow.
Test cheeses: The test cheeses were sticky until the age of about 4 weeks. During the course of the test, the stickiness reduced more and more so that after 3 months the defect had completely disappeared in some of the cheeses. From the 4th week, a mould growth developed which increased with age particularly on the flat sides. The mould growth was most conspicuous on the two cheeses which were brought to the FAM when only two days old. The colour of the cheese smear was reddish.

4.1.1 Conclusions

The addition of *Anticollanti* to the smearing water led to increased mould growth and thus to drying of the cheese surface which reduced stickiness. The sooner the cheeses were smeared with the mould after the salt bath, the quicker the surface dried.

These initial results after a 3-month treatment of the cheeses with the mould were very promising. Ripening for a further 2 months removed any fear of possible discolouration of the cheese surface.

4.2 Test with Geotrichum candidum in the model cheese dairy at the FAM

These encouraging results led to intensification of work in this area. Further tests with *Anticollanti* at the FAM's test cheese dairy in Moudon (Fromex) confirmed the initial results. The search for alternatives to *Anticollanti* led to the isolation of various strains of *G. candidum* from the smear of good quality cheeses. The aim of these tests was to clarify whether these had a similar effect to *Anticollanti*:

Two Raclette cheeses each from 2 different undertakings with the stickiness problem were treated for 5 months with the following suspension (total 12 cheeses):
Control cheeses: with 3 % salt water
Test cheeses: with 3 % salt water and a mould suspension A–D:
A *Anticollanti*
B *G. candidum*, strain 1
C *G. candidum*, strain 2
D *G. candidum*, strain 3
Test-specific production parameters: climate: 10 °C/ 96% relative humidity, new smearing water after 1, 2, 4, 6, 8, 11, 14 weeks

4.3 Results

In both cases, the control cheeses without mould suspension very quickly became extremely sticky and remained so until the end of the test.

In the cheese with *Anticollanti* (mould suspension A) added to the smearing water, the positive effect could clearly be confirmed: the initial stickiness quickly disappeared completely.

Suspension B led to a highly defective smear: very bright, very thin and also very sticky. Only a very weak growth of natural white mould could be discerned.

Suspensions C and D behaved in a very similar way to each other. They grew well on the smear without causing discolouration as ripening progressed. These strains did not make the stickiness disappear, but managed to reduce it. They are therefore a suitable alternative to other commercial *Geotrichum* cultures, but not to *Anticollanti*. So the new culture *G. candidum* 701 was produced, which was then tested in practice before being included in the FAM range of cultures (Chapter 6.1).

5. Field trials

5.1 Geotrichum candidum

The FAM delivered the culture *G. candidum* 701 once a week for 6 weeks to 11 cheese dairies (Gruyère, Bergkäse, Raclette and Tilsiter). The cheese-makers injected the smearing water and treated the cheese with it from the salt bath. As far as the formulation was concerned, the FAM made no further specifications. The cheese-makers assessed and documented the smear development of the cheese once a week.

The trial was overseen by the responsible cheese dairy advisors. These visited the undertakings several times during the trial and finally assessed the smear of the cheeses in the cheese dairy cellar after 8 weeks (Tables 1 and 2).

In 8 out of 11 participating cheese dairies the application of the culture *G. candidum* 701 had a positive effect on the condition of the cheese smear. If it grows on the smear, it dries it out and also prevents stickiness (Fig. 2).

5.1.1 Experience in practice

The culture *G. candidum* 701 has been available from the FAM for the treatment of smear-ripened cheese since the beginning of 2001. However, at present, the FAM is not yet allowed to sell its cultures abroad. The culture has been warmly welcomed by the manufacturers of semi-hard cheeses. Feedback from practitioners is very positive. The culture *G. candidum* 701 has proved successful by forming the desired natural white mould on the cheese surface, thus promoting the drying of the cheese. The culture is extremely well suited to controlling sticky smear in semi-hard cheese.

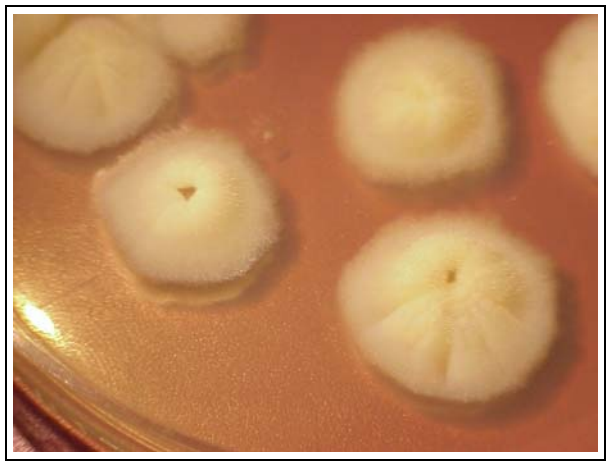

Fig. 1: Colony form of „volcano yeast“

Fig. 2: Growth of *Geotrichum candidum* on the smear

5.1.2 Integration in surface mixed cultures

Experience gained from this work was used to develop surface mixed cultures (SMC). The aim of an SMC is to have a positive effect on smear formation. This cannot and should not prevent the growth of cellar-specific smear flora. The most important germ groups of smear flora should be represented in these mixed cultures. For this purpose, strains from the smear of high quality cheeses were isolated, characterised and identified.

Laboratory tests were carried out with our own liquid medium whose chemical composition matched the cheese surface as far as possible. The selected strains individually and in combination were left to grow in this medium. The lactic acid degradation was assessed together with the colour and smell. However, interpretation of these results proved to be very difficult. In spite of this, an initial SMC was made up and tested in a trial in the pilot plant. This shot in the dark soon turned out to be bang on target: compared with a commercially available culture, the SMC led to a much better development of the cheese smear. The cheese dried out quicker after treatment, a lovely natural white mould growth developed, the smear was generally stronger and, unlike the commercial culture, no stickiness occurred (Fig. 3). In spite of the strong growth of natural white mould, no discolouration (black or grey spots) could be observed during cheese ripening.

Fig. 3: The left-hand cheese with perfect surface was treated with the FAM's test culture, the right-hand, very sticky cheese with a reference culture.

Fig. 4: Growth of *Anticollanti* on the smear

The next step was to test 4 different SMCs on Gruyère and Raclette cheese in the test cheese dairy at Moudon. All 4 SMCs were suitable for the ripening of Gruyère and Raclette cheese. Compared with „normal“ treatment

(without SMC), they led to a stronger smear which also dried out better.

Both cultures SMC 702 and SMC 703 were finally tested in a field trial in a total of 20 cheese dairies (9 Gruyère and 11 semi-hard cheese dairies). In the Gruyère undertakings, it was possible to inhibit tendentially the growth of the natural white mould which is what is wanted. Faster smear development was also noted. The latter also applies to the semi-hard cheese, where at the same time better drying of the surface also occurred. The Gruyère producers preferred SMC 702 (without *G. candidum* 701*)* whereas the semi-hard cheese producers preferred SMC 703 (with *G. candidum* 701).

Table 1: Assessment of stickiness in the individual cheese dairies during ripening

Cheese dairy	Stickiness* before appl.	after 2 wk.	after 4 wk.	after 6 wk.	after 8 wk.	Effect of *Geotrichum candidum*
1	4	1	3	3	2–3	Positive
2	2–3	n.a.	n.a.	2	1	Positive
3	3–4	1	2	2	2	Positive
4	4	4	2	2	2	Positive
5	2–3	2	3	2	1	Positive
6	3	3	3	2	2	Positive
7	3	n.a.	1	1–2	1–2	Positive
8	3	n.a.	1	1–2	1–2	Positive
9	3	3	3	3	3	None
10	5	1	2	3	3	Positive
11	2	1	1	1	1	Positive

n.a.: no assessment. *1 = none, 5 = strong

Table 2: Assessment of mould growth in the individual cheese dairies during ripening

Cheese dairy	Mould growth* before appl.	after 2 wk.	after 4 wk.	after 6 wk.	after 8 wk.	Effect of *Geotrichum candidum*
1	2	1	2	3	3	Positive
2	1–2	n.a.	n.a.	3	3	Positive
3	1–2	1	2	1	2	Positive
4	2	3	4	4	4	Positive
5	1	2	2–3	2–3	3	Positive
6	2	2	3	3	3–4	Positive
7	1	n.a.	1	2–3	3–5	Positive
8	1	n.a.	1	3–5	3–5	Positive
9	2	1	1–2	1–2	3	Positive
10	1–2	1	1	1	2	Positive
11	2	1	1	1	2	None

n.a.: no assessment. *1 = none, 5 = strong

Table 3: Composition of the two surface mixed cultures

Germ group	SMC 702	SMC 703
Yeast	*Debaryomyces hansenii*	*D. hansenii*
Natural white mould	–	*G. candidum*
Staphylococcus	*S. xylosus*	*S. xylosus*
Arthrobacter	*A. protophormiae*	*A. protophormiae*
Brevibacterium	*B. linens*	*B. linens*

5.2 Anticollanti

The culture *Anticollanti* was delivered by FAM to the cheese dairies every week for 4 weeks. The cheese-makers injected the smearing water and treated the cheeses with it from the salt bath. As far as the formulation was concerned, the FAM made no further specifications. The cheese-makers had to assess and document the smear development each week (Tables 4 and 5).

As long as the culture *Anticollanti* grows on the cheese surface, it dries the latter and thereby very clearly prevents stickiness (Fig. 4). Based on experience to date, the risk of unwanted consequences, such as discolouration on the surface, is not increased by application of this mould.

Despite the application of *Anticollanti,* the greatest attention must be paid to the cellar climate. Particular care must be taken to ensure sufficient air circulation and renewal.

Comparison of specific gene sequences with those of natural white moulds, which grow naturally on non-sticky cheeses, showed that *Anticollanti* is widespread.

Table 4: Assessment of stickiness in the individual cheese dairies during ripening

Cheese dairy	Stickiness (1 = none, 5 = strong) Before application	After 1 week	After 2 weeks	After 3 weeks	After 4 weeks	Effect of *Anticollanti*
1	2–3	2–3	2–3	2–3	2–2	None
2	2	2	1	2	2	None
3	3	2	2	2	2	Positive
4	3	1	1	2	2	Positive
5	3	2	2	2	2	Positive
6	1	1	1	1	1	None

Table 5: Assessment of mould growth in the individual cheese dairies during ripening

Cheese dairy	Mould growth (1 = none, 5 = strong) Before application	After 1 week	After 2 weeks	After 3 weeks	After 4 weeks	Effect of *Anticollanti*
1	3	5	3	3	3	None
2	3	2	3	2	2	None
3	1	3	4	3	4	Positive
4	2	2	2	2	2	None
5	2	2	2	3	4	Positive
6	2–3	4	4	5	5	Positive

6. Conclusions

The defect of the sticky smear demonstrates how difficult it is to maintain or recapture the natural balance of a complex microbial ecosystem. Empirical measures combined with the mould have permitted cheese producers to control the stickiness effectively, but the cause of the defect still remains unknown.

7. Further action

In the short term, C*orynebacterium* strains are examined for their suitability for a surface mixed culture, since they represent a major part of smear flora, but are not contained in the two cultures currently on offer. In the medium term, the importance of mould fungi for smear flora was defined as a focal point for research.

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