Cheese with whey proteins – innovative and economical

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1 Summary

The incorporation of precious whey proteins into the cheese matrix of semi-hard cheeses is a widespread aim of cheese research. ALP has developed an attractive new procedure for assimilating whey proteins into Cheese. This new technology permits the manufacture of high quality, ripe Cheese with good melting properties. The raw milk undergoes thermal treatment followed by partial concentration (approximately 17% DM) by microfiltration before the proper cheese manufacturing process begin. The optimal pasteurisation conditions for pre-treatment of the milk lie between 80°C (optimal quality) and 85°C (optimal yield) for 30 seconds..

2 Theory

2.1 Incorporation of whey protein into cheese

Whey proteins are of special interest because of their functional properties (effect on product properties, technology, cheese ripening). They are particularly valuable from the nutritional point of view and have a high water retention capacity. Whey proteins are therefore used in many product groups such as baby and sports foods, dietetic foods, nutraceuticals, milk products, meat products, ice cream products, soft drinks etc. /6/. Separation of the whey proteins by means of filtration operations has the advantage over other separation processes that the whey proteins mostly remain in their native state when this property is desired in the product.
For many reasons (yield, water retention, refinement of texture, nutrition), incorporation of whey proteins is a declared aim of cheese research. To date cheese manufacturers have been able to choose from four different technologies for incorporating whey proteins into the cheese matrix :

(1) **Incorporation of Ricotta cheese into the vat milk (Ricotta technology)** – The studies by Bachmann (2002) show the positive potential (quality, yield, water content) of incorporating whey proteins (WP) into the cheese by adding Ricotta cheese to the vat milk. The incorporated WP create a soft, smooth cheese body with high water retention capacity. The technology is particularly suited to traditional production of high quality, reduced fat, semi-hard cheeses.
(2) **Addition of particulated whey proteins** (in the form of powder or concentrate) **to the vat milk** –The Technical University of Munich /4/ developed a procedure for incorporating particulated whey proteins into soft and semi-hard cheeses.
(3) **Manufacture of UF- cheeses** (partial or full concentration of the whey proteins) – Numerous processes and technologies /2/ have been used for years in the cheese dairy sector. UF-partial concentration in particular (5-50 nm pore size) has become established for making soft and feta cheeses. Thermal treatment of the UF vat milk makes it possible to transfer some of the WP into the cheese.

(4) **Addition of special casein powder to the vat milk:** special MF-fractionated casein powders with a defined whey protein content have been on the market for some years. These protein powders are well suited to standardization of vat milk and to improving cheese yield.

Most of the four technologies described above require several operations with cost- and energy-intensive process stages, some of which even have to be carried out after the cheese making process proper. Simplification of the process procedure for incorporating whey proteins would be the wish of both traditional and industrial cheese manufacturers.

2.2 Development of process stages

Protein fractionation /3/ using a 0.1 µm MF-membrane is gaining more and more importance in the dairy industry. The retentate of the milk after filtration is a casein concentrate with a low percentage of whey proteins. Most whey proteins remain in the permeate. Little is known in the literature about the fractionation of thermally treated milk before microfiltration (MF). The stated technology aim would be: to partially denature the whey proteins (aggregate formation) by means of specific thermal treatment, thus concentrating the denatured and larger WP-aggregates in the MF-stage and incorporating them in the cheese matrix in the subsequent coagulation process.

Development and optimization of the filtration stages, the formulation, were carried out in an earlier study /7/. The protein and fat content of the partially concentrated vat milk (dry matter around 17%) is 6% for each and is standardized for all trial variants. The trial design in the current ALP research experiments differs simply in the thermal treatment of the raw milk before microfiltration. The thermal variants are: 70°C (30 sec), 75°C (30 sec), 80°C (30 sec), 85°C (30 sec) and 90°C (30 sec).

Thermal pre-treatment (pasteurisation) of the raw milk is carried out with a continuous tube exchanger system by the heat exchanger method. The subsequent filtration process is a microfiltration procedure (MF) with a filter pore size of 0.1 µm (= 100 nm). ALP's pilot equipment (Tetra Pak AG, Alcross M type) for conducting the MF trials is fitted with a UTP system (uniform transmembrane pressure) and is very well suited to the fractionation /7/ of casein micelles of the whey proteins. Large molecules such as fat and casein are held back and concentrated in the retentate. If whey proteins are thermally treated before the filtration stage and aggregate according to the model (Fig. 2) into tri- and polymer molecules or are already adsorbed by casein molecules, they are concentrated in the retentate (=vat milk). Selective enrichment of whey protein in the MF concentrate is possible by means of this process stage. Depending on the thermal pre-treatment, the WP content in the vat milk and the cheese can be set relatively well to the desired value using this process.

3 Results

3.1 Protein transfer into the cheese

The denatured whey proteins (WP) first form aggregates from temperature level 75°C („ball formation“), which, instead of single protein molecules, produces whey protein complexes with increasing particle size. During MF treatment, these WP are partially concentrated in the concentrated phase. This reduces the casein percentage in the partially concentrated vat milk.
The measured amounts of native whey protein (WP) in the treated and concentrated vat milk are clearly higher than in the untreated tank milk. From level 85°C, the WP amount decreases dynamically (Fig. 1), because more and more denatured WP-aggregates /9/ are adsorbed by casein micelles. These denatured proteins are determined fully as casein fraction in N-analysis (Kjeldahl method). At level 90°C the casein-adsorbed WP percentage is so high that, in spite of higher protein concentration, no intact casein structure is produced during rennet coagulation. The WP percentage in the whey decreases with increasing thermal denaturation.

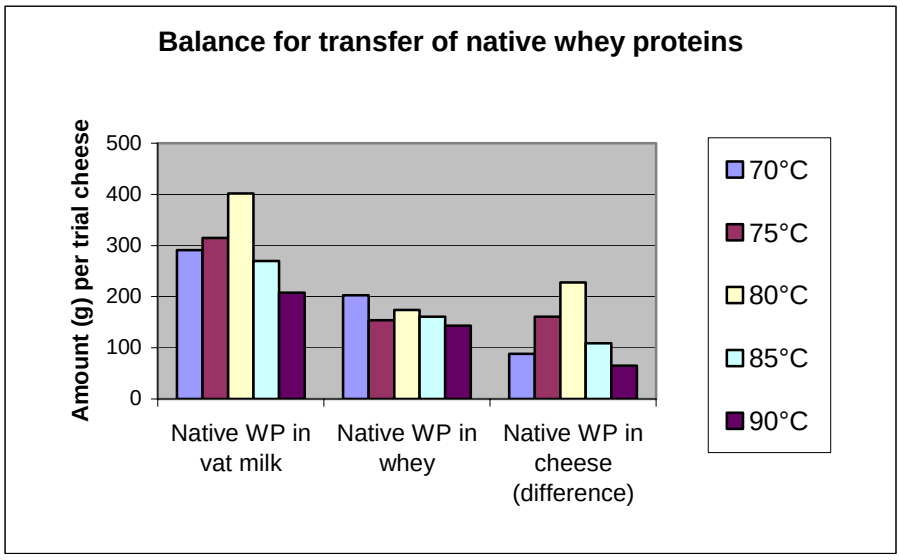


Fig. 1: Incorporation of native whey protein in the cheese matrix

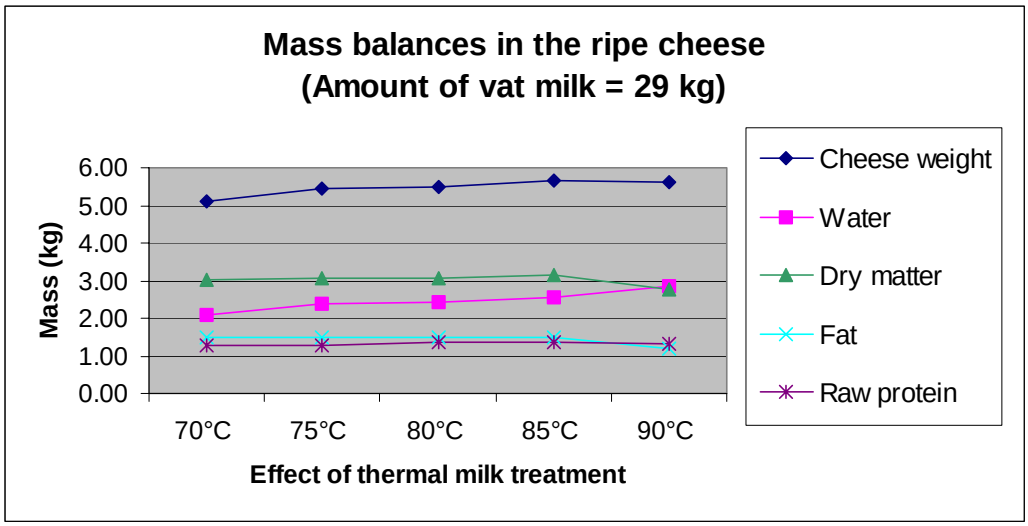
3.2 Yield and losses

As Fig. 2 shows, the weight and water content of the cheese noticeably increase with incorporation of whey protein.
The total amounts of fat, raw protein and dry matter (DM) remain constant in the ripe cheese up to and including level 85°C. Variant 90°C clearly differs in the chemical composition of the cheese (greatly reduced fat and consequently also DM percentage).
The calculated amounts of native whey proteins (WP) provide the following information:

1. Native whey proteins are already present in the cheese at level 70°C.

2. With pre-treatment of the MF-milk to 75 – 85°C, between 100 and 200 g WP (native or denatured) per cheese can be transferred (Fig. 1). Due to their high water retention capacity, the whey proteins can greatly influence the water content of the cheese as well as the properties of the cheese body.
3. Up to level 85°C there is a successive increase in the calculated percentage of WP in the cheese. These are probably WP-aggregates with a larger particle size (3 - 15 µm), which can thus be incorporated into the cheese matrix /5/. There is little WP-adsorption by casein micelles in these trial variants. From level 85°C the WP percentage noticeably falls: the WP are more and more denatured by the thermal load and have been adsorbed by the caseins.

Fig. 2: Total amounts of the main ingredients in the ripe cheese (90 days)



Yield figures of 10.5% and more for cheese made from partially concentrated vat milk with 6% protein are very good compared with MF-Raclette without thermal treatment /7/ or conventionally produced cheeses. Based on the results of mass balances (Fig. 2) and protein transfer, the optimal protein-, fat- and DM-yields should lie at level „85°C thermal pre-treatment“ of the MF-vat milk.

3.3 Effect of whey proteins on cheese quality

As already indicated by the results of the chemical cheese composition, lactic acid fermentation and cheese ripening, thermal pre-treatment of the raw milk to 80-85°C before MF-concentration is possible without serious loss of quality and melting properties of the manufactured cheese. Optimal quality lies at 80°C. Thermal pre-treatment of the milk to >85°C is not recommended for reasons of quality. The sectional views show the good quality properties of the trial cheeses 1-4 (70-85°C) with regard to shape, body and eye formation. The sensorial results of quality assessment are very informative. Up to and including level 85°C, the MF trial cheeses received good to satisfactory quality marks. The trial cheese for temperature level 90°C displays much poorer sensorial qualities. Inadequate coagulation, curd formation and synaeresis of the curd and as a result too high water content and too low fat content of the

cheese led to unsatisfactory development of the quality criteria eye formation, body and flavour.
The melting properties /8/ differ depending on the degree of incorporation and denaturation of the WP in the cheese matrix. Structure and consistency of the melted cheese develop in the same way as the body firmness and become shorter or softer with increasing water content and WP percentage in the cheese. Further tests are necessary to optimize the viscosity of the melted cheese.

4 Attractive practical application?

Controlled thermal pre-treatment of the raw milk makes it possible to incorporate a specifically defined percentage of whey proteins into the cheese matrix (Fig. 6). If more whey proteins (WP) are present in the cheese, then there is a marked increase in the water content of the MF-cheese. The main effects are comparable with those described in ALP-Technology „Incorporation of Ricotta cheese into vat milk“/1/. With conventional manufacturing equipment, processing of partially concentrated MF-milk is possible up to a DM of 15-17% without extensive technical adjustments. Manufacturers of partially concentrated MF-cheeses should therefore select pasteurisation conditions (heat treatment for 30 sec) between 80°C (optimal quality) and 85°C (optimal yield) for pre-treatment of the milk. The new procedure using the technology described can be used for making soft and semi-hard cheeses. It is important that processing units determine the thermal treatment curves of the manufacturing milk correctly and product-specifically before the filtration stages and carry them out precisely. Apart from better yield figures, the whey proteins incorporated into the cheese matrix also produce clear improvements in quality under the headings cheese body and flavour. The sensorial advantages are ideal especially in the case of low fat products in the currently growing light cheese products segment. The prospects are also good for using the MF-method in the diverse field of cheese products for further processing. The advantage for this sector lies in producing the desired chemical composition and sensorial properties of the cheese raw material in a targeted and low cost way. Applications in the area of fresh cheese varieties such as for example the manufacture of mozzarella or cottage cheese are possible. However, suitable technologies still have to be further developed in specific trials.

Fig. 3: Will it be possible to enjoy more cheeses with whey proteins?

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