Continuous Seed Precrystallisation of Chocolates by the SeedMaster System

Selective Precrystallisation: „A Revolutionary Process“

With its process for the selective precrystallisation of chocolate and fat masses, Buhler-Bindler is offering users new processing options and a potential for raising quality. The new process may legitimately be characterised as revolutionary.

The seed crystallization process was developed at the Swiss Federal Institute of Technology in Zurich (ETH) in a close research cooperation venture together with renowned Swiss chocolate producers and under the direction of Professor Erich Windhab (1). The practical application of the knowledge gained in the venture and the provision of the process engineering expertise by Buhler-Bindler allowed the process to be implemented on a commercial scale. Today, Buhler-Bindler is offering the chocolate production community a system based on the new precrystallisation process: The SeedMaster.

CLASSICAL TEMPERING MAY BE TRICKY

The molten chocolate mass is a concentrated suspension made up of sugar, cocoa and milk solids as the dispersed phase, and cocoa butter, milk fat plus other vegetable fats and oils as the continuous phase. Cocoa butter is polymorphous. It can be crystallised in various crystal modifications. The crystal modifications differ in their crystal structures, their melting temperature ranges and their stability. The goal of precrystallisation is to generate sufficient amounts of stable cocoa butter crystal nuclei, usually β_V/β_{VI} modifications.

Conventional precrystallisation processes (tempering process) involve different temperature stages (normally three) before the chocolate mass leaves the tempering machine with an operating temperature of 31 °C (dark chocolate). Even minor temperature fluctuations will have an appreciable impact on the tempering degree and therefore on the achievement of a uniform crystallisation quality. At a lower discharge temperature, the chocolate mass will be overtempered, and at a higher temperature undertempered. The associated viscosity fluctuations make further processing of the precrystallised chocolate mass – moulding, forming, final cooling – more difficult.

For recipe-related reasons, operation of conventional tempering machines involves higher requirements for the precrystallisation of milk chocolate and filling masses containing hazelnut and almond oils. The milk fat, the nut oils and other vegetable fats retard crystallisation of the cocoa butter. With a conventional tempering machine, it often proves impossible to precrystallise filling masses adequately. This results in a considerable quality degradation of the filled chocolate products owing to the creation of fat bloom during storage. For these reasons, a new precrystallisation process was developed at the Swiss Federal Institute of Technology in Zurich (ETH) in close cooperation with Swiss chocolate producers, in which chocolate or chocolate-like masses are precrystallised by seeding using a Cocoa Butter Crystal Suspension (CBCS).

THE SEED PRE-CRYSTALLISATION PROCESS

The process basically consists of two stages. In the first stage, the goal is to produce the cocoa butter crystal suspension. In the second stage, the chocolate mass to be precrystallised must be cooled without crystallisation and be mixed with the necessary amount of cocoa butter crystal suspension (1, 2, 3).

A seed precrystallisation system is therefore made up of a central crystallisation unit for production of cocoa butter crystal suspension, a unit for crystal-free cooling of the chocolate mass to be seeded and one or more seeding units for blending and mixing chocolate masses with CBCS (Fig. 1).

PRODUCTION OF CBCS

The crystallisation unit consists of a conversion tank with agitator, a pump and a shear crystalliser (see Fig. 1).
The cocoa butter melted in the tank (initial temperature: 40 - 50 °C) is conveyed by a pump to the shear crystalliser and shear-crystallised at a cooling water temperature of 5 - 15 °C. The shear-crystallised cocoa butter is returned to the tank and mixed by agitation with the remainder of the cocoa butter in the tank. In order to avoid remelting of the crystals (β_V/β_{VI} modifications) in the tank formed by the shear crystalliser (3, 5), the tank is initially cooled for about 100 minutes at a cooling water temperature of 24 - 28 °C. The cooling action produces additional crystals inside the tank. This is accompanied by a crystal conversion from β_V/modification to β_{VI} modification.

After about 100 minutes, the CBCS inside the tank has reached a crystal content of about 16 %. The water temperature of the tank is increased to about 32 °C and the shear crystalliser is stopped and heated to about 50 °C. The CBCS is then transferred to the loop (temperature controlled at about 32 °C) and then circulates between the loop and the tank.
During a circulation time of about 30 minutes, conversion to bVI continues, and a thermodynamic equilibrium of the CBCS is obtained. After this, the CBCS remains constant in terms of crystal modification (β_{VI}), crystal content (about 12 %) and flow characteristics. This makes it fit for the seed precrystallisation of chocolate.

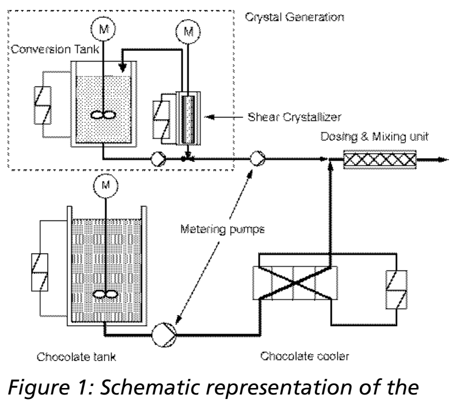


Figure 1: Schematic representation of the seed precrystallisation process.

Figure 2 shows the DSC melting curve of a bVI CBCS in thermodynamic equilibrium (sample 2). As a comparison, a DSC melting curve of a β_V crystal suspension (sample 1) is shown.

Sample 1 was drawn at the start of the process from the outlet of the shear crystalliser. Sample 2 was drawn 2 hours after the start of the process from the conversion tank. As a result of thermal and mechanical treatment, more and more stable bVI crystals are gradually generated. The melting range of the β_{VI} seed crystals now is between 33.6 and 37.5 °C. Under consistent process conditions, the characteristics of the β_{VI} CBCS remain constant for several days. This ensures a consistent product quality.

SEED PRECRYSTALLISATION

In seed precrystallisation, the chocolate mass is first cooled. To achieve crystal-free cooling of the chocolate, static or dynamic heat exchangers are applied, which allow efficient cooling at elevated water temperatures. The chocolate thus cooled is then mixed in the blending and mixing unit with the cocoa butter crystal suspension. Mixing is done in a static mixer, which ensures gentle and efficient mixing action (see Figure 1 and Photographs 1, 2).

Thanks to the centralized provision of the crystal suspension, it is possible to supply several blending and mixing units with CBCS through a loop. This enables simultaneous and individual precrystallisation of several different chocolate masses (e.g. shell, filling 1, filling 2, lid).

INFLUENCING FACTORS: SEEDING CONCENTRATION AND SEEDING TEMPERATURE

A dark chocolate mass was seed-precrystallised at different seeding temperatures (31 - 34°C) with bVI CBCS. The tempering degree of the seed-precrystallised mass was analysed using a Tempermeter. With a given seeding concentration (1.0 %), the tempering degree remains virtually constant at seeding temperatures between 31 and 34 °C (see Fig. 3), i.e. the tempering degree of the dark chocolate mass seed-precrystallised with β_{VI} CBCS will remain stable and withstand temperature fluctuations between 31 and 34 °C (4).

In the conventional precrystallisation process, the tempering degree depends to a large extent on the mass discharge temperature at the outlet of the tempering machine. At temperatures > 32 °C, no sufficiently effective crystal nuclei can be formed.
One significant innovation is the fact that seed precrystallisation using β_{VI} CBCS increases the processing temperature of chocolate masses by 3 - 4 °C compared with conventionally tempered masses.

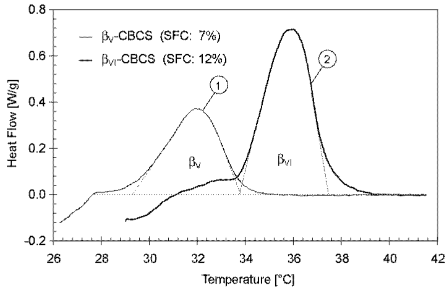
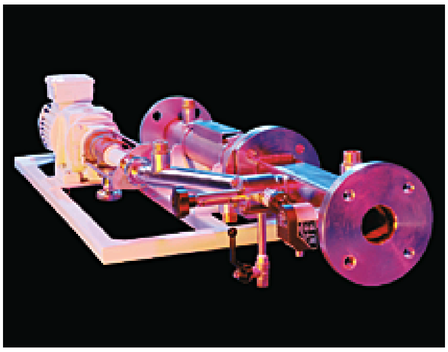


Figure 2: DSC melting curves of a β_{VI} CBCS and a β_V CBCS (heating rate 4 °C/min, DSC Gold Plus, RheometricScientific).

Photograph 1: SeedMaster cryst crystallisation unit for the production of the cocoa butter crystal suspension.



Photograph 2: SeedMaster mix blending and mixing unit for continuous seeding of the chocolate mass with CBCS.

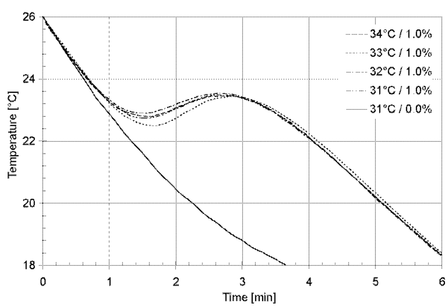


Figure 3: Tempering curves of seed-precrystallised dark chocolate. Constant seeding concentration of CBCS (34 °C), variable seeding temperature (measurement temperature 8 °C, Tempermeter Exotherm 7000, Systech Analytics).

Higher processing temperatures allow lower processing viscosities. The mass therefore becomes less viscous and is easier to process. The product quality remains constant across an extended temperature range.
The viscosity-reducing effect on the one hand offers a potential to save cocoa butter, and on the other hand improves the processibility of high-viscosity masses.

The β_{VI} modification cocoa butter crystals have the same crystal lattice structure (triclinic crystal lattice) as the bV modification crystals. Although the chocolate mass with β_{VI} crystal nuclei has undergone precrystallisation, it crystallises during end cooling fully into the β_V modification. The melting characteristics of chocolate seed-precrystallised with β_{VI} CBCS are found to be identical after final cooling to the chocolate precrystallised in conventional tempering machines. This is demonstrated by appropriate comparative DSC measurements (see Fig. 4). Only a small melting peak in the DSC melting temperature range of 34.5 to 37°C proves the presence of the seeded bVI seed crystals.

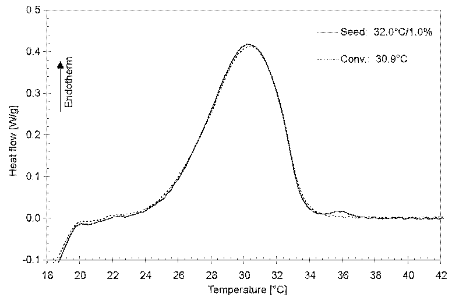


Figure 4: DSC melting curve of the differently precrystallised dark chocolate after final cooling.

The DSC measurement result is consistent with the fact that the seed-precrystallised chocolate produces the same sensory perception as conventionally tempered chocolate. A waxy feel in the mouth, as we know it from chocolate with a high β_{VI} cocoa butter crystal content (as a result of prolonged storage) is not possible with seed-precrystallised chocolate.

PRODUCT QUALITY AND STORAGE STABILITY

Chocolate products seed-precrystallised with β_{VI} CBCS show a markedly better gloss and stronger structure after final cooling. This applies especially to filled chocolate products with filling masses containing extraneous vegetable fats or oils.
In comparison, seed-precrystallised, filled products show higher strength after cooling and therefore have a denser and more compact structure.
Figure 5 shows the result of penetration force measurements. For this purpose, products filled in industrial-scale tests (hazelnut and

almond oils as well as cocoa butter) were subjected to both conventional tempering and to seed precrystallisation. Their strength was measured immediately after discharge from the cooling tunnel. As can be seen, the seed-precrystallised specimen shows a perceptibly higher resistance to penetration than the conventionally tempered specimen. The higher strength indicates a denser and therefore more compact structure of the seed-precrystallised specimen.

Migration of the liquid fats and oils is retarded by the more compact structure of the seed-precrystallised product.
Seed-precrystallised products therefore exhibit markedly better resistance to fat bloom than conventionally tempered ones.

Photographs 3a and 3b show a filled chocolate product with a filling mass containing hazelnut and almond oil besides cocoa butter. After a storage period of seven months, the product precrystallised with β_{VI} CBCS shows a perfect quality (see Photograph 3a), whereas strong fat bloom has appeared on the surface of the conventionally tempered chocolates (see Photograph 3b).
Photograph 4 shows a filled chocolate article. The filling mass contains lauric-acid-containing CBR besides nut oil. The resistance to fat bloom of this product was also improved by seed precrystallisation. The products are made by different producers, which are already applying the seed precrystallisation process today.

Figure 6 shows the development of fat bloom for a filled product. The filling consists of hazelnut and almond mass and of cocoa butter. The products are from normal commercial production of a Swiss chocolate producer. Several production batches were involved, both conventionally tempered and seed-precrystallised.

The products were stored at the producer's site at 18 - 20 °C and visually assessed for fat bloom after different periods of time.

It is apparent that the conventionally tempered specimens form fat bloom at an appreciably earlier point of time than the seed-precrystallised specimens. This means fat bloom stability was increased perceptibly thanks to seed precrystallisation.

Based on these commercial-scale results, we can conclude that the new seed precrystallisation process enables fat bloom stability to be significantly improved, offering chocolate producers a process opening new possibilities in product and process development.

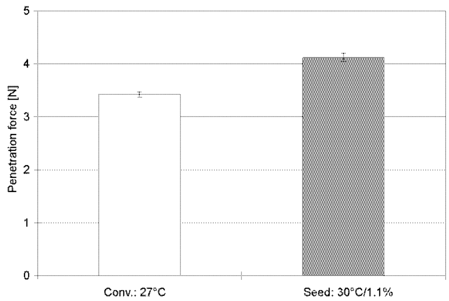
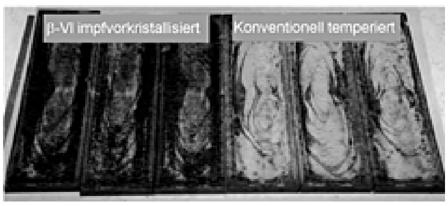


Figure 5: Strength (penetration force with penetration depth of 3 mm) of the filling mass after final cooling in the cooling tunnel.

Photograph 3a: Seed-crystallised product with nut-containing filling after six-month storage period at 18 - 20 °C.

Photograph 3b: Conventionally made product with nut-containing filling after six-month storage period at 18 - 20 °C.



Photograph 4: Filled chocolate product after a storage period of five months (left: seed-precrystallised with β_{VI} CBCS; right: conventionally tempered).

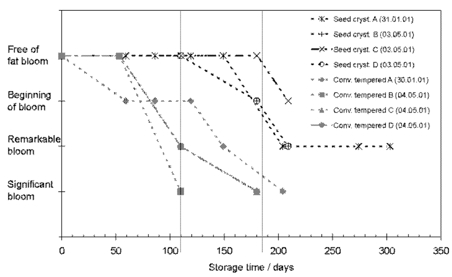


Figure 6: Comparison of eight commercially made product batches. Products with nut-oil-containing filling, stored at 18 - 20 °C. The change was visually assessed.

ABSTRACT

In the new seed precrystallisation process, chocolate mass is precrystallised by seeding with cocoa butter crystal suspension. The cocoa butter crystal suspension is continuously added at rates of 0.2 to 2 % to the precooled and fat-crystal-free chocolate mass. A static mixer ensures gentle and homogeneous mixing of the two sub-streams, which are capable of flowing.
As the chocolate mass is seeded directly with cocoa butter crystals of the stable β_{VI} modification (2), the possible processing temperature is 3 - 4 °C higher than that of conventionally tempered masses.

In the new seed precrystallisation process, the chocolate mass is seeded with a large number of very fine crystal nuclei. The articles thus produced not only have an appreciably better gloss, but also a denser structure and higher strength, which significantly retards fat migration and thereby perceptibly increases storage stability.

Seed precrystallisation offers special advantages in the production of chocolate-like masses with continuous fat phases containing other fats or oils (e.g. hazelnut or almond oil, hardened lauric-acid-containing vegetable fats, etc.) besides cocoa butter. As seeding is done using crystal nuclei obtained from pure butter, the objectionable crystallisation-retarding action of these fats or oils is eliminated during the seeding process. Although the chocolate mass is precrystallised with β_{VI} seed crystals, the cocoa butter crystallises during final cooling in the cooling tunnel in the same way as conventionally tempered β_V modification mass.

This ensures a smooth and unchanged sensation in the mouth compared with conventionally tempered products (no waxiness).

LITERATURE

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Keywords: Seed Precrystallisation – SeedMaster – Chocolate