

## Effect of shear and additive on crystallization of cocoa butter under the tempering process

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Cocoa butter is the major ingredients in chocolate. Six different polymorphic forms (form I - VI) are well known in cocoa butter. For chocolate production, controlling the crystallization to form V is critically important for optimal melting and textural properties. To obtain the form V, tempering and shear stress are applied on cocoa butter. In general, chocolate contains particles, such as cacao and sugar, and they affect significantly on the shear stress under the tempering process. Therefore, many researchers have been studied on the effect of shear stress and solid particles separately. However, the effect of shear stress and solid particles under tempering is still obscure. Elucidation of crystallization behavior of CB in the manufacturing process of chocolate, not only leads to the elucidation of the crystallization mechanism to form V but also brings significant information to chocolate makers. In this study, we observed the crystallization behavior of chocolate under shear and tempering in the system near the actual chocolate manufacture by using synchrotron radiation X-ray diffraction. We performed two different experiments, focusing on the effect of shear and particles as follows; tempering 1 and tempering 2. Shear rate was fixed at  $400\text{s}^{-1}$  during all experiments.

Tempering 1: CB (cocoa butter 100%) was applied to the temperature of cooling –heating-cooling program ( $50^{\circ}\text{C}$  for 15 min→ $15^{\circ}\text{C}$  for 10 min→ $27.5^{\circ}\text{C}$  for 5 min→ $15^{\circ}\text{C}$  for 5 min) under shear or without shear. CB was crystallized form II or III in first cooling process, then form V was observed after heating to  $27.5^{\circ}\text{C}$  with the shear. On the other hand, without shear CB was crystallized form II or III.

Tempering 2 : CB, with cocoa and/or sugar particles were applied to the tempering process of cooling-heating-cooling program (  $50^{\circ}\text{C}$  for 15 min→ $17.5^{\circ}\text{C}$  for 5 min→ $27.5^{\circ}\text{C}$  for 5 min→ $17.5^{\circ}\text{C}$  for 10 min) with or without shear. CB with solid particles was crystallized form V under shear. In contrast, CB without solid particles did not form any crystals. The form V was not obtained without shear.

These results indicate that shear stress promotes polymorphic transition to form V of CB. Additionally, not only cocoa particles but sugar promotes crystallization of form V.