INTRODUCTION

When it comes to chocolate processing the manufacturer is mostly concerned with the viscosity of the molten, tempered and solidifying state. Processing involves activities as diverse as pumping, moulding (depositing), and covering containing items (enrobing). Typical values for flow properties of chocolate employed in different processes are given in Table 1. These can be taken as personal preferences since Seguiné [2] suggests quite different figures. However, they do show the wide range of values according to process.

The rheological behavior of chocolate is influenced by several factors, including non-fat solids particle size, emulsifier type and amount, moisture content and fat level [3]. When chocolate is tempered, small amounts of fat are crystallised in the form of seed crystals, ranging from around 2% up to as much as 15% (as a percentage of the fat phase). This small amount of solid fat changes the flow properties of the molten chocolate (Table 2).

OBJECTIVE

To obtain information on the effect on flow characteristics (Casson parameters) of non-fat solid and the solid fat formed at temper.

APPROACH

Three series of experiments were performed.

Groundnut oil chocolate coatings. In the first series, a light chocolate coating was prepared using groundnut oil in place of cocoa butter with a fat level of 28%. This was split into 6 batches of which further groundnut oil was added to bring the total fat level to 30, 32.5 and 35% respectively (see Table 3 for recipe of 32.5% chocolate).

Groundnut oil with S3 TAG chocolate coatings. In the second series, a similar recipe was prepared and split into six batches. To each batch was added a mixture of groundnut oil and trisaturated triacylglycerols (S3 TAG, from Dynason®) such that each batch had a final total fat level of 32.5% and that of the S3 TAG across the series ranged from 0% to 10%. It was anticipated that most of this would be solid at temperatures below 70°C.

CBE chocolate coatings. The third series, was composed of milk chocolate coatings made using two cocoa butter equivalents (CBE) (see Table 4.). The two CBEs differ in that they were based on different palm oil fractions that had either low or high trisaturated triacylglycerols. Thus, the CBEs contained 1.7% and 3.7% S3 TAG respectively. Blends of these two were used to obtain samples with intermediate S3 TAG.

Viscosity measurement. A Haake™ Rotovisco™ RV20 was utilised to perform controlled shear rate experiments in which the shear stresses were recorded. The supplied proprietary software was used to calculate the Casson yield value (\(\tau_0\)) and plastic viscosity (\(\eta_0\)). For the first two series, viscosity were measured at temperatures of 70°C, 60°C, 50°C and 28°C.

The CBE coatings were tempered using a batch method in which they were cooled from 50°C to 28°C, seeded with powdered ‘refiners paste’ and the state of temper monitored by the Greer method. When the coating was well tempered, the viscosity was determined. It was also measured at 50°C, when fully molten, and again following rapid cooling to 28°C, during which time it was anticipated that no crystallisation would take place. Additionally, the solid fat content was determined using a Bruker PC20 Minispec and the indirect method.

RESULTS

Groundnut oil chocolate coatings. The plastic viscosity and yield values are plotted in Fig. 1, where surface smoothing has been applied. With fat level, there is a strong variation in both yield value and plastic viscosity. As might be anticipated, the rate of increase per unit of fat increases as the level of fat decreases. At fat levels of around 30% the yield value and viscosity change by around 2 Pa/s and 6 Pas/°C solid phase volume. Here, it appears to increase slightly as the temperature falls. This may be due to the manner in which the Casson parameters are calculated (extrapolation of viscosity at zero shear rate).

Table 1. Typical viscosity and yield value requirements for chocolate process

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<th>Process</th>
<th>Moulding</th>
<th>Hollow moulding</th>
<th>Smoothing</th>
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<td>4.6 – 7.5</td>
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Groundnut oil with 3 TAG chocolate coatings. The plastic viscosity and yield values are plotted in Fig. 2, where surface smoothing has been applied. As the solid fat content of the fat phase increases towards 10%, the yield value quadruples and the plastic viscosity increase by a factor of about 6. The same temperature dependence is seen as for the coatings without S3. At the higher levels of S3 addition, the increase in yield value is around 4.5 Pa/s extra solid phase volume. This is greater than seen for non-fat solids, seen in the previous series (2 Pa/s), which suggests that fat solids have a stronger effect than non-fat solids, such as sugar and cocoa powder.

CBE chocolate coatings. The only difference between the coatings in this series was the CBE composition, particularly the S3 TAG. Thus, the yield values and plastic viscosity at 50°C (when fully molten) were similar, being 15.4±1.3 Pa and 1.36±0.18 Pa respectively. The corresponding values after rapid cooling to 28°C (still fully molten) were 19.1±3.2 Pa and 5.40±0.60 Pas.

Once tempered, the impact of the difference in S3 TAG is evident in that the amount of solid fat present at temper increases dramatically with S3 TAG (Fig. 3). For every 1% increase in S3 TAG, there is an increase of about 3.5% solid at temper. Although a straight line is shown, it is expected that the amount of solid at temper when there is zero S3 TAG would still be measurable, and not negative, as implied by the intercept of the line.

Towards the highest level of S3 TAG in the CBE, the yield values increases at about 12 Pa/s extra solid phase volume (Fig. 3). This is twice that seen for S3 TAG added to groundnut oil chocolate coatings. This must be due to the size and shape of the additional solid fat particles, which in the case of CBEs must incorporate TAG other than S3, such as the symmetric monounsaturated S3 TAG (SODS).

CONCLUSIONS

A wide range of flow effects are achievable in chocolate coatings using fat level and solid fat content. In particular, there appears to be a stronger dependence on solid fat content rather than non-fat solid content (bay a factor of around 3). Thus, subtle adjustments of the fat phase composition, and hence the solid fat at temper, can enable the engineering of abroad spread of flow properties and allow tailoring of the properties to the desired end use.

REFERENCES