Understanding the production and perception of chocolate through particle size analysis

PARTICLE SIZE

Introduction

Chocolate occupies a special place in the Western palate and one of its attractions is known to be due to its unique mouthfeel. The mouthfeel depends on the composition of the fat phase in the chocolate and also on the size of the cocoa, milk and sugar particles suspended in the fat. Extensive consumer research by chocolate manufacturers has determined that once a significant number of particles are above 30µm, the mouthfeel begins to deteriorate with consumers rating the chocolate as being of a lower quality.

The importance of particle size in chocolate

The particle size is a major factor in the texture of the final product and is controlled by grinding and conching, which are both milling steps [1]. Both are expensive in terms of time and energy, so if the particle size can be better controlled there is potential for large savings through process optimisation in addition to guaranteeing product quality. Laser diffraction instruments, such as the Mastersizer 3000, can be used either in a laboratory setting or beside product lines to measure the particle size at different stages in the manufacturing process.

The addition of milk was problematic in the early days because milk was a seasonal product and was out of season when the manufacturers wanted to make chocolate to sell at Christmas. Two solutions were found to this problem: the use of dried milk powder and the use of crumb. Crumb is made by drying milk, sugar and cocoa solids together, creating composite particles [1]. The dried crumb powder can then be stored for use throughout the year. The crumb process is more expensive and fresh milk is now available throughout the year. However crumb gives a different flavour profile from the powder process and it is still used to maintain the signature flavour of particular brands.

In this application note we will measure the particle size distributions of dark, milk and white chocolates and in a second experiment we will compare the particle size distributions of crumb and powder milk chocolates.

Materials and Methods

Dark, milk and white chocolates from a single range and brand of chocolate were selected for measurement to minimise variations in the chocolate manufacturing process and ingredient variation. The particulate ingredients of dark, milk and white chocolates are shown in table 1.

Table 1: The particulate ingredients in different types of chocolate.

	Cocoa solids	Sugar	Milk powder
Dark	Y	Y	
Milk	Y	Y	Y
White		Y	

The chocolate samples were pre-dispersed using ultrasound, and measurements made using a Mastersizer 3000 with Hydro MV dispersion unit.

Findings

There are clear differences in the shape of the particle size distribution between the three types of chocolate (figure 1). There are common features: a mode of large particles at approximately 30µm and a mode of smaller particles at approximately 5µm. Note that the 30µm mode is present as a slight shoulder in the dark chocolate. The proportion of these modes varies with the type of chocolate and may be related to the presence and proportion of the different ingredients. For example the large mode appears to correspond to the increasing sugar content from dark to milk to white chocolate. As there is a much smaller proportion of these large particles in the dark chocolate, it will be perceived by consumers as having a smoother, and more luxurious, texture than the others.

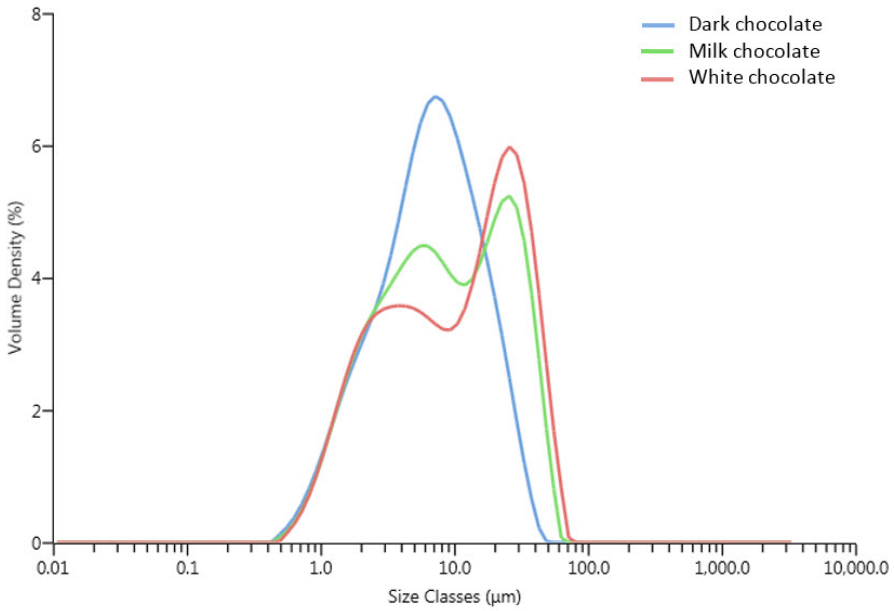

Figure 1: The particle size distributions of different types of chocolate made by one manufacturer.

The increase in particle size from dark to milk to white chocolate can be followed in Dv50 and Dv90, while Dv10 does not change significantly (table 2). As the main interest for chocolate manufacturers is detecting the presence of large particles, the critical parameter is often Dv95 or even Dv98, where we can detect significant differences between the chocolate types. Alternatively the proportion above 30µm can be obtained directly from the analysis.

Table 2: The percentiles and proportion of particles above 30µm for different types of chocolate.

	Dv10 (µm)	Dv50 (µm)	Dv90 (µm)	Dv95 (µm)	Dv98 (µm)	>30µm
Dark	1.74	6.62	19.5	24.5	30.3	2.13%
Milk	1.77	8.32	32.5	39.2	46.0	12.56%
White	1.77	10.8	37.0	44.4	52.2	17.32%

Particle size in powder and crumb milk chocolates

The particle size distributions from powder and crumb chocolates made by the same manufacturer are shown in figure 2 and the particle size statistics are shown in table 3.

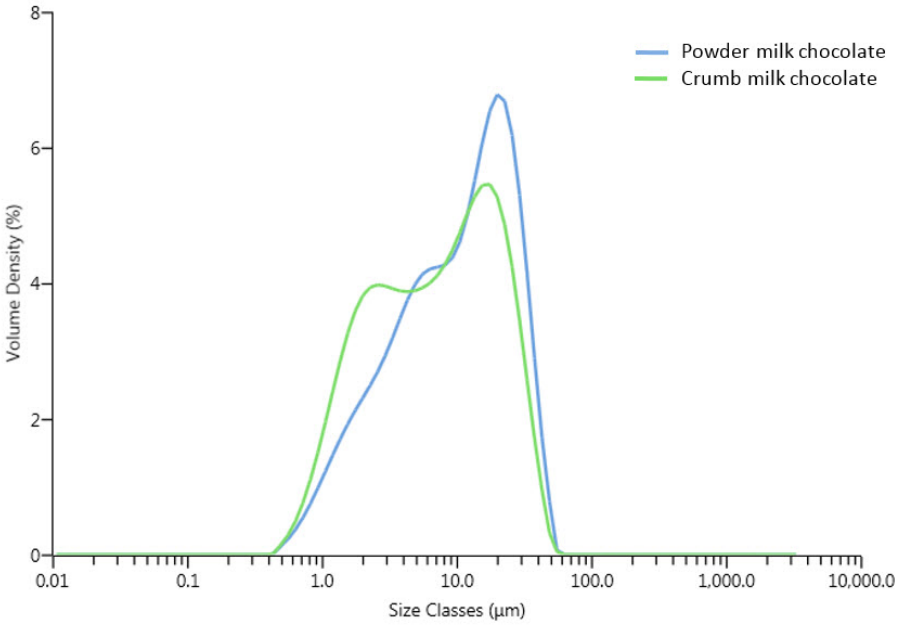

Figure 2: The particle size distributions of powder and crumb milk chocolates made by one manufacturer.

The mixed material nature of chocolate is again apparent with a multimodal particle size distribution. The two main modes are much closer together in powder chocolate than in the crumb chocolate. There is a tail of fines in the powder chocolate that isn't present in the crumb. These features give the crumb and powder chocolates each a distinctive profile in the particle size distribution and a distinctive texture. The source of these differences lies in the different recipe and processing routes. The crumb chocolate has a lower Dv90 than the powder chocolate and so will be perceived as being the finer chocolate by the consumer. This may be a true reflection of the quality of the chocolate, or it may be related to the flavour profiles and textures associated with each brand. In this case it is likely that the crumb chocolate had longer, and more expensive, grinding stages than the powder chocolate, as the composite particles in crumb enter the process with a larger particle size than milk powder.

Table 3: The percentiles and proportion of particles above for powder and crumb milk chocolates.

	Dv10 (µm)	Dv50 (µm)	Dv90 (µm)	Dv95 (µm)	Dv98 (µm)	>30µm
Powder	1.93	10.5	29.3	34.7	40.4	9.21%
Crumb	1.48	7.22	25.0	30.6	36.8	5.43%

Summary

The presence of particles above 30µm in size is a critical to quality parameter for chocolate. Laser diffraction is an ideal instrument for a quality control measurement for chocolate as it can detect changes in the presence of coarse particles relating to processing and product type. The proportion of particles above 30µm in size can be measured easily.

References

[1] Beckett, S. T. (2008). *The Science of Chocolate* (2nd ed.). York: Royal Society of Chemistry.

Malvern Instruments Limited

Grovewood Road, Malvern, Worcestershire, UK. WR14 1XZ

Tel: +44 1684 892456
Fax: +44 1684 892789
www.malvern.com