Analyzing chocolate with the Morphologi G3 automated image analysis system

PARTICLE SHAPE

PARTICLE SIZE

Introduction

Particle size measurement is already established as a useful tool for testing the final product quality of chocolate. In particular particle size measurements made using a laser diffraction technique can be correlated with subjective tasting panel observations such as 'mouth feel'.[1]

The Malvern Morphologi® G3 Automated Particle Characterization System equipped with the wet cell accessory can be used to further characterize chocolate in terms of the shape of the particles. Additionally, the intensity of the grey scale images recorded during the analysis provides further information.

Analyzing chocolate Methodology

Three different samples of milk chocolate from different manufacturers, a leading brand (#1), a supermarket brand (#2) and a luxury brand (#3), were selected for analysis. The samples were dispersed in sunflower oil by immersion in an ultrasonic bath for 10 minutes, such that a suspension of the non fat-soluble solid components was produced. The samples were then diluted to a concentration suitable for the analysis and 2ml of the suspension was injected into the Morphologi G3's wet cell accessory (Figure 1). The wet cell has two glass windows separated by a 250 mm gasket spacer and held together by a magnetic clamping assembly. It is designed to take a fixed volume of a liquid suspension.

Figure 1: the Morphologi G3 wet cell

Analysis of the samples was carried out according to a standard operating procedure (SOP) that defined all the software and hardware variables. The SOP required the 5X objective and the system to scan in a set area of the wet cell until 30,000 particles had been measured.

Results and discussions

An overlay of the particle size distributions measured by the Morphologi G3, expressed in volume weighted Circle Equivalent (CE) diameter, together with representative particle images of each chocolate sample are shown in figure 2. The three samples have very similar median particle sizes, seen in the D[v, 0.5] values shown in Table 1. However, there are significant differences in the size distributions for the three samples. This is particularly evident in the D[v, 0.9] values which show that Brand #3 has a significantly smaller proportion of very large particles than the other two brands. This result is consistent with the fact that Brand #3 is marketed as a luxury brand, and therefore the consumer would expect that the chocolate feels 'smoother' in the mouth.

Table 1: Particle size statistics of 3 different chocolate samples.

	D[v, 0.1] (mm)	D[v, 0.5] (mm)	D[v, 0.9] (mm)
Brand # 1	8.747	21.68	46.77
Brand # 2	8.230	23.69	39,76
Brand # 3	9.835	22.23	33.75

As well as particle size, the Morphologi G3 also calculates various shape factors for each and every particle measured. One such shape parameter is High Sensitivity (HS) Circularity, which is essentially a measure of how close the 2D projection of the particle image is to a perfect circle. Figure 3 shows the HS circularity distributions for the three different chocolate samples. Interestingly, Brand #1 shows a different particle morphology from the two other brands, the particles being more 'rounded' with higher HS Circularity values than the other two brands. This could be due to using ingredients of a different origin, or perhaps due to different pre-processing of the dry ingredients.

A more spherical particle morphology might also be expected to lead to an improved 'mouth feel' with less 'sharp edged' particles than the other brands.

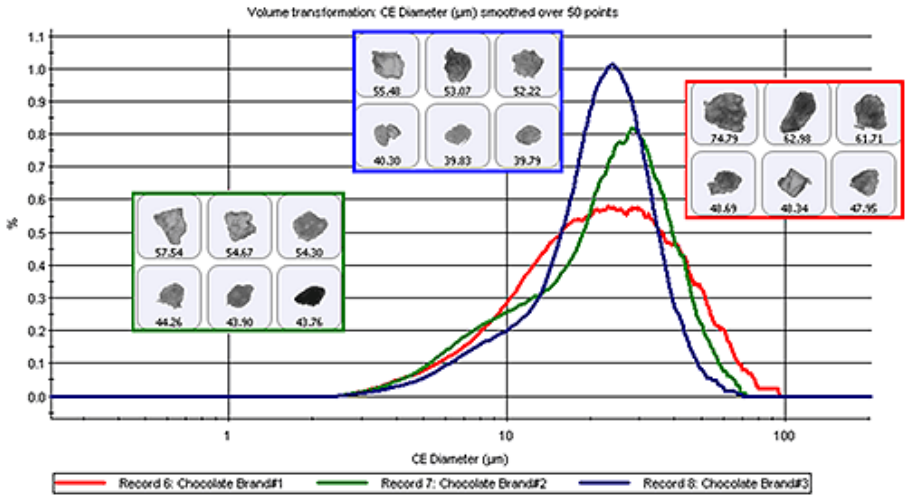


Figure 2: Volume weighted particle size distributions for the 3 chocolate samples along with example particle images

A similar trend is also seen in the Elongation distributions for the three samples as shown in Figure 4. Brand #1 has a lower Elongation than the two other brands, which again indicates either ingredients of a different origin, or different processing such as milling for example.

A qualitative view of the particle images for all three samples, shown in figure 5 appears to agree with the overall trend that the particles in Brand #1 particles have a different morphology than the particles in Brand #2 and Brand #3. In the Morphologi G3 experiment, images of all particles are stored (in this case 30,000 per measurement) and can be compared in terms of size and shape parameters across the measured samples.

It is possible to filter the results post analysis in order to concentrate only on particles meeting certain criteria. In this case a further post-analysis filter was applied to remove particles images with a CE Diameter of less than 20 µm from the results. Interesting, trends were found in the Mean Intensity of the particles which are not apparent when all of the particle images are included. Generally the leading brand's particles are darker than the others and the standard deviation of the Mean Intensity is higher. The luxury brand shows the lowest standard deviation of mean intensity perhaps, reflecting more homogeneous ingredients. The supermarket brand has the lightest particles overall - probably due to a higher sugar content.

Differences are also observed in the convexity distributions for the larger than 20 µm fractions of the samples, which were not apparent when including all particles (figure 7). The leading brand appears to have particles with different convexity (edge roughness) than the two other brands. This might again be related to different processing.

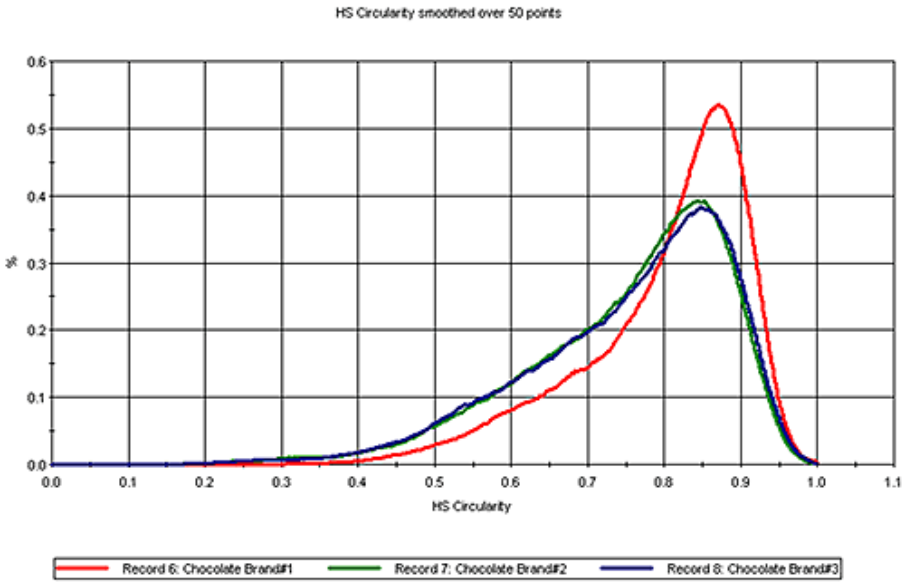


Figure 3: HS Circularity distributions for the three chocolate samples.

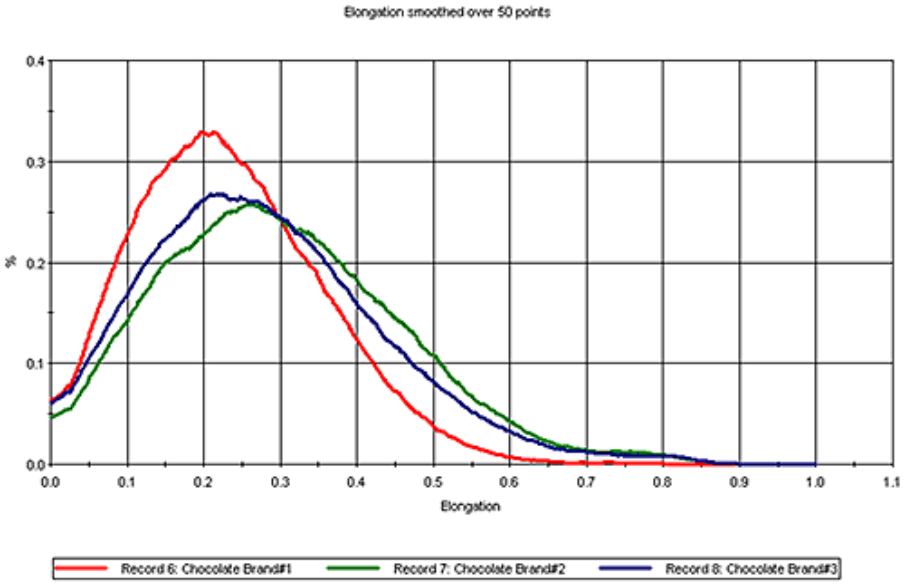
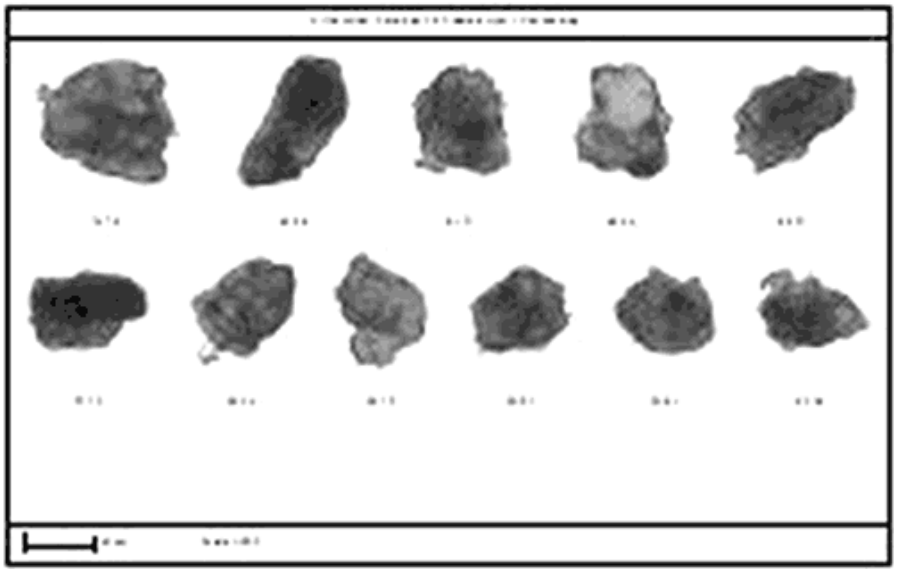
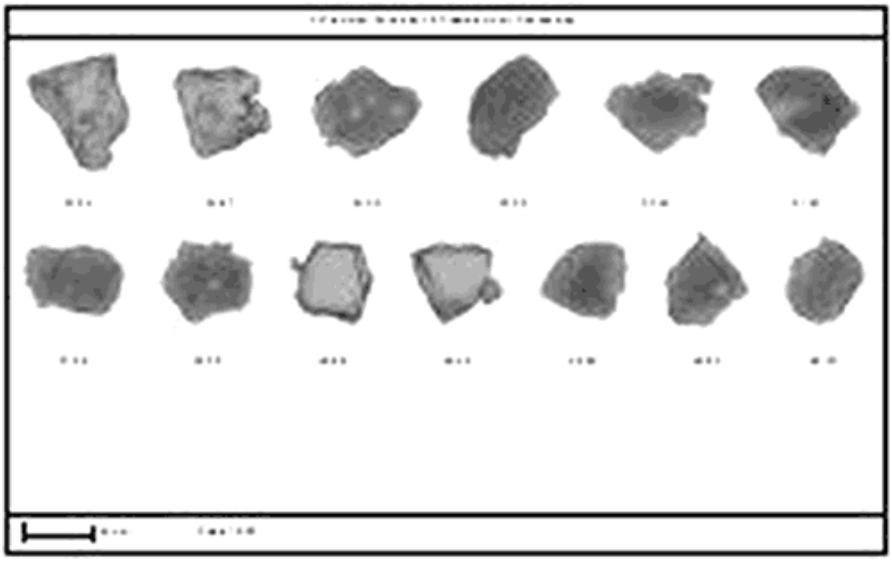


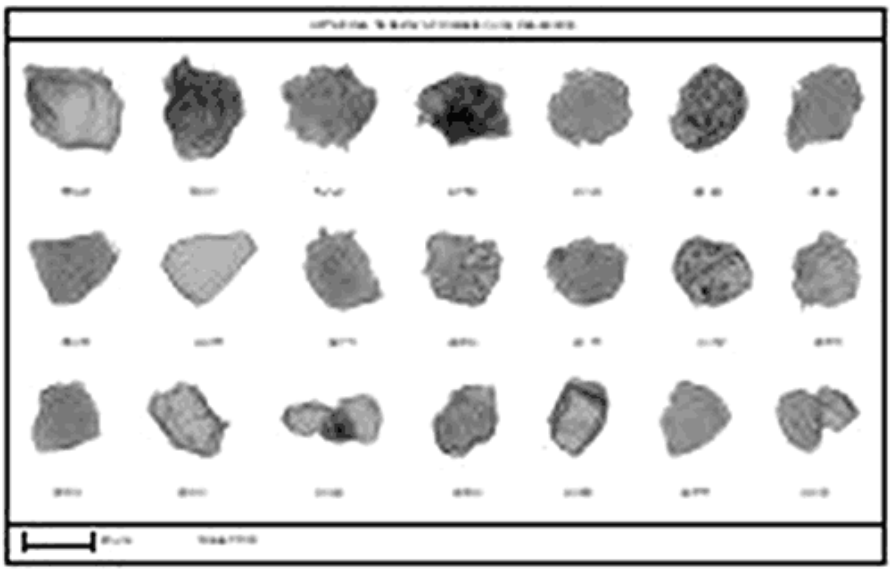
Figure 4: Elongation distributions for the three chocolate samples.



a) Brand # 1



b) Brand # 2



c) Brand # 3

Figure 5: Images of the largest particles analyzed in each of the three chocolate samples.

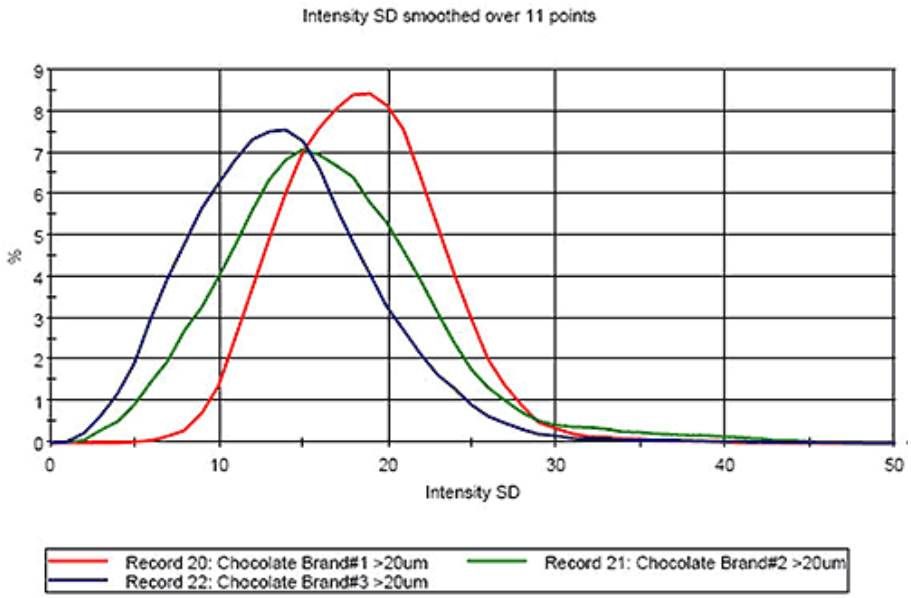


Figure 6: Intensity Mean distributions for the three chocolate samples.

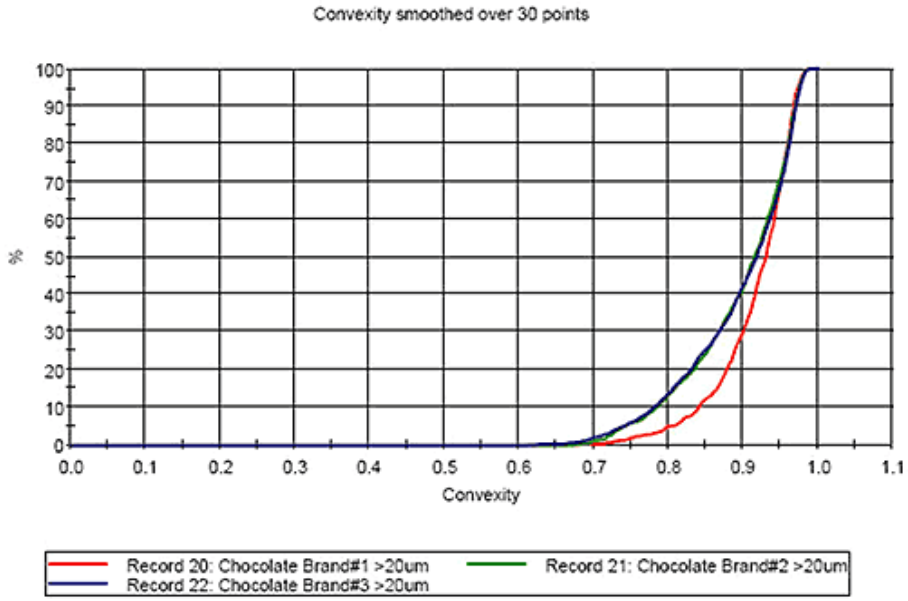


Figure 7: Convexity undersize distributions for the three chocolate samples.

Conclusions

The Morphologi G3 equipped with the wet cell accessory can successfully be used to measure size and shape and of particles in different samples of chocolate as well as the intensity of the particle images. Differences in terms of size, shape and intensity could be seen between these three samples, which with sufficient information could be correlated with subjective quality tests such as 'mouth feel'.

References

[1]Chocolate characterisation using the Mastersizer

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