UNDERSTANDING THE FLOWABILITY OF SPRAY DRIED MILK POWDERS USING THE FT4 POWDER RHEOMETER®

INTRODUCTION

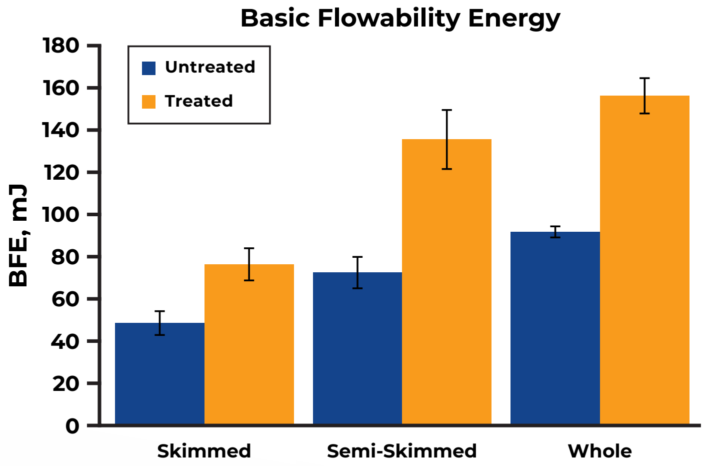
Milk powders produced by spray drying are used across the food industry to make products ranging from confectionery and baked goods to soups, sauces, and beverages; they are also supplied directly to consumers. The flow properties of these powders define their utility and by extension their value, notably for efficient and effective food processing. Powders that flow easily and reliably through the production chain maximise industrial throughput, eliminating the unplanned stoppages and inefficiencies that can degrade profitability. Understanding how to make milk powders with superior flow properties is therefore advantageous, with lipid content known to be highly influential though other factors such as moisture content and particle size also have a role to play in defining flow behaviour.

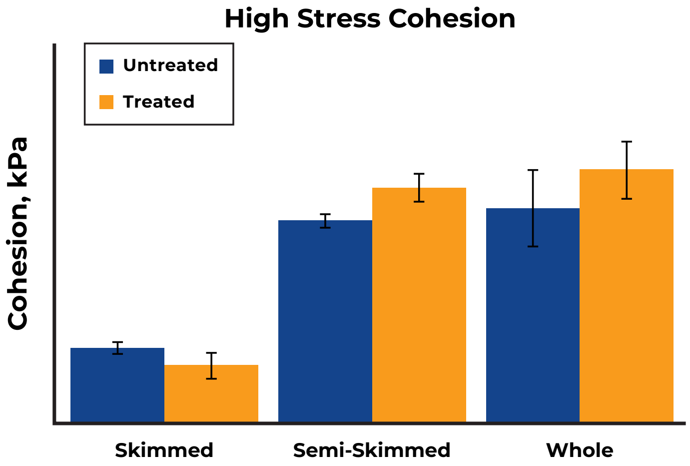
In this study by researchers at the Universite de Lorraine, Nancy, France, the flowability of spray-dried milk powders was investigated as a function of feed concentrate composition and an aeration pre-treatment [1]. Spray-dried powders of varying lipid content — 1.5%, 14% and 26% — were produced from skimmed, semi-skimmed and whole milk concentrates respectively, prepared by reconstituting skimmed and whole milk powders. These three samples were compared with aerated analogues, produced by whipping samples of each of the concentrates prior to spray-drying under strictly comparable conditions. Dynamic and shear flow properties were measured for all six spray-dried milk powders using the FT4 Powder Rheometer®. The results show valuable correlation between feed concentrate properties and process-relevant flow properties.

FLOWABILITY

Basic Flowability Energy (BFE) values quantify a powder's propensity to flow under confined or forcing conditions, when in a low to moderately stressed state. BFE values have been securely associated with, for example, blending performance and flow through the feedframe of a dosing system or tableting press making them relevant to food processing operations. Furthermore, they are highly differentiating, often able to detect even small differences in samples that other flow properties classify as identical or highly similar.

For these milk powders, BFE was found to increase with lipid content (skimmed 1.5%, semi-skimmed: 14%, whole: 26%) for untreated, and also for the samples prepared from treated/aerated concentrates. With these data, we can see that aeration has a strong influence on BFE, increasing resistance to flow.





Shear properties such as cohesion quantify the behaviour of consolidated powders under relatively high stress and are pertinent to hopper discharge performance. These results provide a different perspective on the samples indicating minimal differentiation between the semi-skimmed and whole milk powders but notably less cohesion in the skimmed sample. For all three samples aeration has only a marginal effect on sample behaviour.

Physicochemical properties measured for the milk powders provide insight into these observed trends. For example, semi-skimmed and whole milk powders were observed to have high and over-representative surface lipid content. Increased surface 'stickiness' as a result of lipid distribution therefore provides a rationale for the high cohesion and resistance to flow observed with the semi-skimmed and whole milk powders, relative to skimmed. The more marked effect observed under high stress conditions may be the result of free fat release at the powder surface under consolidating load.

Aeration results in more uniform lipid dispersion, but at the same time gives rise to narrower particle size distributions centred on a finer particle size. This latter trend potentially impacts particle packing, an important behaviour with respect to BFE values and may therefore help to explain the trends in flow behaviour observed under low stress conditions; high consolidation potentially masks the differences induced by pretreatment.

Crucially, however, the observed trends provide insight into how different milk powders will behave in process. Low lipid content is clearly conducive to low cohesion and good flowability in hoppers and silos, and indeed more generally while processors looking to aerate dairy concentrates to improve characteristics such as wettability and solubility should be wary of the possibility of simultaneously compromising flowability and, by extension processibility.

CONCLUSION

The results presented here illustrate the value of measuring dynamic and shear powder properties to gather process-relevant insight into different milk powders and the impact of concentrate pretreatment. This type of multivariate analysis provides a level of detail unobtainable via simple, single parameter powder testing methods and can be highly effective in supporting the development of optimal ingredients for food processing.

REFERENCES

[1] T. Fournaise, J. Burgain, C. Perroud, J. Scher, G. Gaiani, J. Petit ‘Impact of formulation on reconstitution and flowability of spray-dried milk powders’ Powder Technology 372 (2020) 107-116.

Freeman Technology Limited,
1 Miller Court, Severn Drive,
Tewkesbury, Gloucestershire,
GL20 8DN, UK

Tel: +44 (0) 1684 851 551
info@freemantech.co.uk
freemantech.co.uk

Micromeritics Instrument Corp.
4356 Communications Drive
Norcross, GA 30093

Tel.: +1 770 662-3636
info@micromeritics.com
micromeritics.com