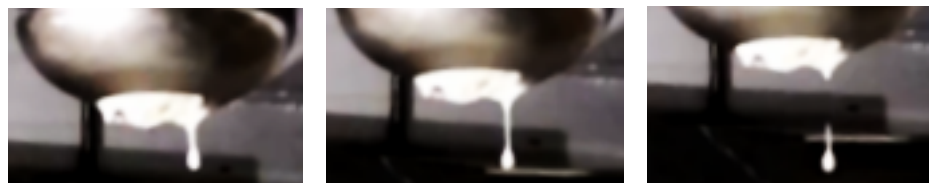


CORRELATION OF YOGHURT'S FLOW PROPERTIES TO FILLING ISSUES

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It is difficult to predict the flow behaviour of yoghurt during processing because it is a complex fluid that is problematic to characterise. This study correlated measurable flow properties to issues during automatic filling.

Yoghurt is currently the most popular fermented dairy product world wide. The complexity of yoghurt causes its viscosity, the property describing resistance to flow, to change with applied force and time. Currently, Tetra Pak uses a fluid model called 'Power Law', which is not sufficient for describing the complex behaviour of yoghurt. Because of this, Tetra Pak expressed an interest in investigating if the measurable flow properties of three different products could be correlated to common issues observed during automatic filling.

The aim of the study was to perform a multivariate statistical analysis using new measurable parameters and issues, and hopefully find correlations between them. This would reveal which parameters could possibly be used for anticipation of specific issues during automatic filling. If issues better can be anticipated and the filling process optimised to minimise these issues, this could lead to a decrease in cleaning time and an increase in plant efficiency and capacity.

The products chosen for studying were Skånemejerier Vaniljyoghurt, Skånemejerier Naturell Lättyoghurt and Arla Långfil. The first two products are yoghurts with slightly different compositions. The last product is a Scandinavian sour milk and contains a fermentation culture that results in exceptionally long polysaccharides, causing it to exhibit extensional properties such as very 'stringy' behaviour.

Several fluid models exist to describe liquid food products, and includes different parameters. The most common parameters are those that describe the products consistency and flow behaviour. The parameters included in this study describing the *consistency* in different ways are K , K_e and A . The parameters included in this study describing the *flow behaviour* in different ways are n , n_e and b . The parameters K and n come from the Power Law model. K_e and n_e also come from the Power Law model, but instead describe the product's

extensional properties. Similarly, the parameters A and b also describe the fluid behaviour as in Power Law but with the addition of a yield stress (σ_y), which is part of the 'Herschel-Bulkley' model. Yield stress describes a fluid's resistance to flow when exposed to very low forces. This behaviour is exemplified by toothpaste. When squeezed onto a plane surface, toothpaste will not move unless exposed to some minimum external force (the yield stress).

In addition to these seven parameters, two other parameters were also included in the study, both acting as boundary conditions of the product's viscosity. Zero-shear viscosity (η_0) describes the maximum viscosity of the products when exposed to very low forces, and viscosity at infinite shear rate (η_∞) describes the minimum viscosity of the products when exposed to extreme forces.

Filling issues were quantified according to their frequency for each product. The following were defined as common issues during automatic filling:

- **Droplets.** Small, round deposits of product outside of the designated fill volume.
- **Streaks.** Longer deposits of product located outside of the designated fill volume.
- **Drips.** The delayed formation of a droplet from product remaining on the fill nozzle after the end of the fill cycle that either falls outside of the designated fill volume.
- **Filaments.** A 'string' of product reaching from the fill nozzle into the package, formed following the closure of the filling nozzle. This is counted when the filament is still present after the end of the fill cycle.

Droplets and streaks were only observed in the yoghurts, mostly in Naturell Lättyoghurt and never in Långfil. Filaments were observed at the end of every fill cycle for both yoghurts, and never in Långfil. Drips were never observed in the yoghurts but frequently in Långfil.

Statistical analysis found there were correlations between some of the issues and parameters. b and n_e were positively correlated to all issues except drips. Conversely, K , A and K_e were

negatively correlated to all issues except drips. Finally, σ_y , n and η_0 appeared to be uncorrelated.

The strong, positive correlation of b and n_ε to all filling issues except drips is reasonable since they both describe the products' flow behaviours. This meant that products with high values for b and n_ε also had more occurrences of these issues per ten filling shots. Therefore, all issues except drips were considered to be related to the products' flow indices. Drips were instead considered to be related to the products' extensional behaviour, since this phenomenon only occurred in Långfil. With this in mind it would seem reasonable that K_ε and n_ε are strongly correlated to drips.

Together, A and b showed stronger correlations than K and n , to the observed issues, indicating that the Herschel-Bulkley

model is more suitable for anticipating filling issues than Power Law. While σ_y showed no correlation on its own, it is required to determine A and b .

Based on the results in this exploratory study, Herschel-Bulkley is recommended as a more suitable model than Power Law for anticipating issues during automatic filling. Its parameters can potentially be used for anticipating specific issues during automatic filling, and also be used for optimisation of the filling process. This will hopefully lead to an increase in yoghurt filling efficiency and production capacity, and thus contribute to an overall improvement to the process.