

Flow Processing and Gel Formation – a Promising Combination for the Design of the Shape of Gelatin Drops

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INTRODUCTION

Manufacturing processes are often designed to create special structures in food products. Among others the morphology of particles in a dispersion is a key factor for its rheological behaviour.

This investigation is a model study with the aim to evaluate the possibilities to create different drop shapes by a combination of flow processing and temperature induced gel formation of a cold set biopolymer. Basically, the flow forces deform the drops and the gelation preserves the shapes.

The work has been published in detail elsewhere (Walther et al.¹) and is part of an EU-project.

MATERIALS AND METHODS

Gelatin was chosen as a cold set biopolymer. In aqueous solutions, gelatin forms homogeneous, transparent gels simply by lowering the temperature to roughly below 30°C. The gelation kinetic depends on several factors. For instance, the lower the solution temperature the faster the gelation kinetics, furthermore, the higher the gelatin concentration the higher the temperature for the onset of gelation.

The flow field was created in a 4-Roll mill (4RM) with a high viscous silicon oil of 5°C as the continuous phase. Drops of a 60°C gelatin solution (diameter 1.5-2.8 mm) were subjected to the flow from two different start positions (see Fig. 1).

Thereby, the drops followed two different streamlines and were deformed in accordance with the flow patterns, i.e. by pure elongation from start position 1 and a mixture of shear and elongation forces from start position 2. Figure 1 shows a schematic illustration of the 4RM, the start positions, the streamlines and the camera frame for observation.

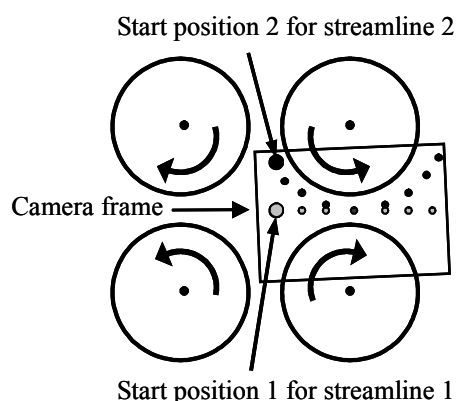


Figure 1. Schematic illustration of the 4RM, start positions, streamlines and the camera frame for observation.

RESULTS

With the method, different drop shapes from elongated to more complex forms were reproducibly created under controlled process conditions.

A gel strength strong enough to resist further deformation was achieved at different positions in the 4RM, denoted as fixation zones which depended on the process parameters of flow type, flow rate,

drop size and gelatin concentration. The shape created was directly related to the fixation zone. Fig. 2a gives a summary of achieved drop shapes in relation to fixation zones and Fig. 2b an experimentally derived and a numerically calculated velocity profile (finite volume technique) for a drop following streamline 1.

Though figure 2 represents fixed shapes, it is possible to recognise the development of a shape by having a look at the preceding fixation zones. There was a broad freedom to combine different parameter values to fix a drop in a certain fixation zone. This is a promising result regarding the adaptation to future industrial processes.

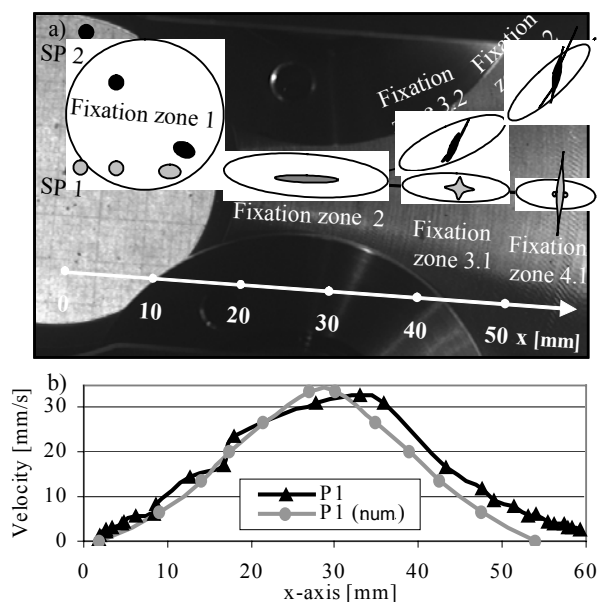


Figure 2. a) Illustration of final drop shapes and related fixation zones in the 4RM. b) Experimental (P1) and numerically calc. (P1(num)) velocity profile in the 4RM for a drop following streamline 1 (Walther et al.¹).

DISCUSSION

Around $x = 30$ mm, when the drops pass the narrowest gap between the rollers, they have the highest velocity. The interaction of acceleration (positive velocity gradients), deceleration (negative velocity gradients)

and gel formation is the key factor for drop shaping and fixation.

Elongation under positive velocity gradients is the major contribution to the shaping mechanism in the case of elongated drops (fixation zone 1 and 2). The ratio of length to width varies depending on the variable set up.

The complex shapes (fixation zone 3 and 4) are explained by elongation followed by relaxation and pinching due to negative velocity gradients. A gelled skin layer around the drop is assumed to be present after the narrowest gap. Pinching means that the faster moving end part of the drop is pushed towards the already slow moving front, thereby, the liquid middle part of the drop is squeezed out into two new arms. For fixation zone 3 the drops get fixed after the pinching ($x=35-45$ mm) while for fixation zone 4 the drops are still susceptible to the flow forces. The shear impact along streamline 2 was responsible for slightly more elongated drops, the not orthogonal protruded arms and their stretching.

This investigation studied drops on the mm scale in a discontinuous process. Ongoing work focuses on a continuous process for drops in the micrometer range.

ACKNOWLEDGMENTS

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REFERENCES

1. Walther, B., Walkenström, P., Hermansson, A.-M., Fischer, P., Windhab, E.W. (2002), "Flow Processing and Gel Formation – a Promising Combination for the Design of the Shape of Gelatin Drops", *Food Hydrocolloids*, in press.