Gelling hydrocolloids in low fat spread: A rheological characterisation

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ABSTRACT

Vegetable hydrocolloids with gelling properties can be used for stabilising low fat spread. The gelling and melting properties of hydrocolloids in the water phases of low fat spread affect the quality of the final product in terms of physical stability, texture, mouthfeel, droplet size distribution and microbiological stability.

INTRODUCTION

Low fat spreads should have similar eating properties to full fat margarines with regard to flavour release and mouthfeel. To achieve this, protein is usually added to the water phase, providing a looser emulsion with improved taste and flavour release. However, as protein favours an oil-in-water emulsion, its addition can cause instability in low fat spread.

Traditionally, low fat spreads containing protein have been stabilised with the aid of gelatine or a high level of sodium caseinate. Due to the origin of gelatine and the cost of using sodium caseinate, alternative stabili- ser systems based on vegetable raw mate- rials are becoming increasingly popular.

MATERIALS AND METHODS

A standard 40% fat spread recipe with 1.0 % skimmed milk powder was used to produce a low fat spread on a 2-tube lab-perfector. (see recipe and processing conditions in Table 1). Various hydrocolloid compositions were tested in the spread recipe at a dosage of 2%.

The water phase composition of the standard 40% fat spread was used for comparing the gelling and melting behaviour of the hydrocolloid compositions. 3.3% hydrocolloid was added, corresponding to 2.0% hydrocolloid in total spread. Dynamic rheological analysis were used to investigate the gelling and melting profile of the water phase of the low-fat spread.

The quality of the low fat spread was evaluated visually and organoleptically by a trained panel. Stability upon spreading with a knife on cardboard was evaluated, using a stability index. Furthermore the texture was evaluated on a TA-XT2 Texture Analyser. (see Table 1 for more detailed description).

The influence of the gelling profile on the droplet size distribution in the final low fat spread was investigated using Nuclear Magnetic Resonance (NMR) and microscopy.

To demonstrate the importance of a specific gelling and melting profile of the low fat spread's water phase, the following three hydrocolloid compositions have been selected:

- Hydrocolloid 1: A low ester amidated pectin with high gelling temperature
- Hydrocolloid 2: A sodium alginate
- Hydrocolloid 3: A blend of low ester amidated pectin and sodium alginate.

Dynamic rheological analysis

The measurements were performed on a Bohlin VOR Rheometer (a controlled strain instrument) with a constant strain level of 0.004 and frequency 1 Hz, which is in the linear viscoelastic region.

The low-fat spread water phase was added to the C25 measuring system at 70 °C and covered with silicone oil to prevent evaporation. The complex modulus G* and phase angle δ were measured during the following temperature sweep:

- Cooling from 70 °C to 10 °C at a cooling rate of 1 °C/min.
- Heating from 10 °C to 70 °C at a heating rate of 1 °C/min.

NMR droplet size analysis

The droplet size analysis was performed on a NMS100 Minispec NMR Analyzer, equipped with a Pulsed Gradient Unit GU200.

The low-fat spread was placed in a glass tube and tempered to 5° C prior to measurement. The mean droplet size (volume distribution d50,3) and 95 % confidence interval were calculated.

RESULTS

On the gelling profile curves the following characteristic points are defined:

- Gel onset (δ=45 °)
- Strong gel build-up (δ=20 °)

On the melting profile curves, the following characteristic point is defined:

- Gel softening (reduction of G* to 20 % of original value)

Inferior gelling and melting profile

The gelling and melting profile of hydrocolloid 1 is shown in Fig. 1 and 2. The water phase has a gel onset of around 54°C and a strong gel build-up at 37°C.

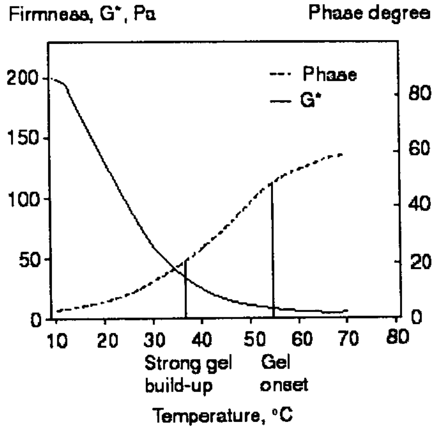

Figure 1. Gelling profile, hydrocolloid 1.

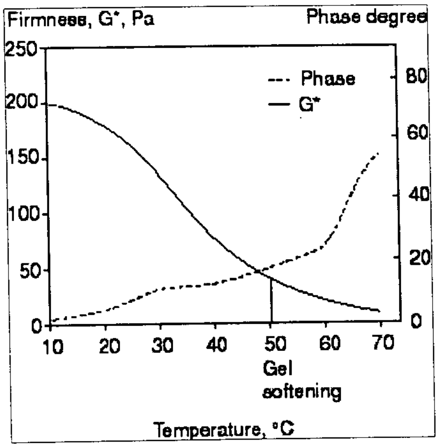

Figure 2. Melting profile, hydrocolloid 1.

The quality of the low fat spread obtained with hydrocolloid 1 is shown in Table 1. The low fat spread is very soft, paste-like, grainy and not stable enough for spreading. Organoleptically the melt-down properties are registered as average.

The processing of the low fat spread is very difficult due to the total gelling of the water phase before emulsification. The emulsion is grainy in appearance.

Optimal gelling and inferior melting profile

The water phase with hydrocolloid 2 has a gel onset of around 25 °C (Fig. 3) and is not melted or softened upon heating (Fig. 4). The low fat spread obtained with hydrocolloid 2 is smooth, firmer and more brittle. Total spreading stability is obtained. Organoleptically, the low fat spread is characterised by a slow melt-down and rather sticky mouthfeel (see Table 1).

During processing, the water phase of the low fat spread is pumpable at 40 °C and the emulsion smooth in appearance.

Optimal gelling and melting profile

Hydrocolloid 3 has a gel onset of approximately 22 °C and a strong gel build-up at 10 °C (Fig. 5). When the water phase is heated, gel softening is obtained at approx. 37 °C (Fig. 6).

The low fat spread produced with hydrocolloid 3 is smooth and resembles the spread containing hydrocolloid 2.

Organoleptically the melt-down and flavour release properties are better than those obtained with hydrocolloid 2 (Table 1). During processing, the water phase is pumpable at 40° C and the emulsion obtained smooth in appearance.

Water droplet size distribution

The water droplet size distribution for the three low-fat spreads containing hydrocolloid 1, 2 and 3 is shown in Table 2. It is clear that a water phase with a very high gelling temperature results in a bigger droplet size and much broader distribution. Microscopic evaluations have confirmed the differences in droplet size. The big droplets were found to be very irregular and long in shape, creating areas in the low-fat spread which can be looked upon as O/W emulsions as well as W/O emulsions.

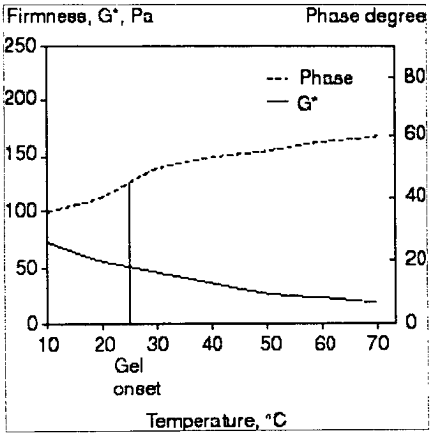

Figure 3. Gelling profile, hydrocolloid 2.

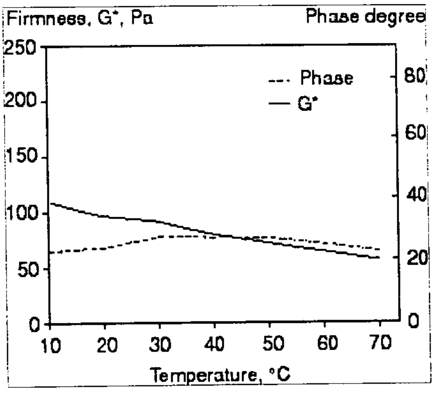

Figure 4. Melting profile, hydrocolloid 2.

This mixture of an oil continuous phase and a water continuous phase should in theory influence the texture of the low-fat spread. The texture measurements on the TA-XT2 Texture Analyzer confirm that a softer and more paste-like texture is obtained.

CONCLUSION

The gelling and melting properties of hydrocolloids in milk-containing low fat spreads have a pronounced effect on the properties of the low fat spread produced.

The gelling profile influences the stability, appearance and texture of low fat spread as well as ease of processing. The gel onset temperature should preferably be low, e.g. 25 °C.

The melting profile of the water phase influences the melt-down and mouthfeel properties of the low fat spread along with flavour release.

The experiments performed have been extended to other gelling hydrocolloid blends. The results all confirmed that a certain gelling and melting profile is needed to obtain an optimum low fat spread quality. However some variations in low fat spread stability were observed which could not be explained by the rheological measurements.

In conclusion further work is needed to obtain a complete picture of the mechanisms involved in the stabilisation of low fat spreads.

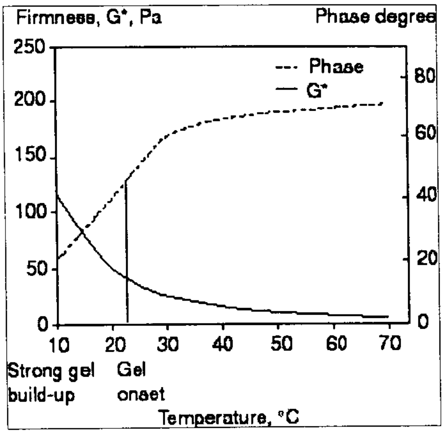

Figure 5. Gelling profile, hydrocolloid 3.

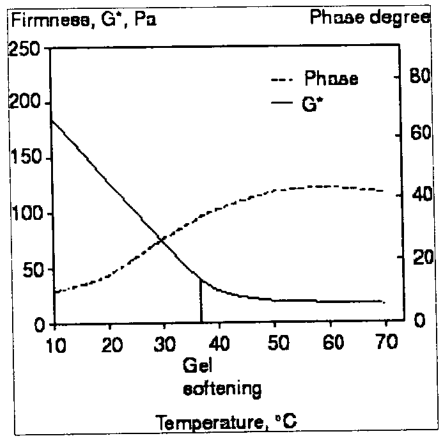

Figure 6. Melting profile, hydrocolloid 3.

Table 1. Quality evaluation of low-fat spread.

Product	Dosage [1]	Spread firmness (5°C)[2]	Stability towards spreading[3]	Organoleptic evaluation Appearance	Melt-down	Flavour release
Hydrocolloid 1	2.0%	160 g	8	grainy, dull	average	average
Hydrocolloid 2	2.0%	347 g	10	smooth	slow	slow
Hydrocolloid 3	2.0%	265 g	10	smooth	fast	fast

1) Of the weight of the emulsion tested in:

Water phase: 1.0% skimmed milk powder
1.5% salt
0.1% K-sorbate
up to 60.0% water

Fat phase: 0.5% DIMODAN® OT Distilled monoglyceride
4 ppm ß-carotene
39.5% fat blend: 25 parts soya 41°C
75 parts soya oil

Flavourings:
0.01 GRINDSTED™ Butter Flavouring 2701 to fat phase
0.01 GRINDSTED™ Butter Flavouring 2807 to water phase

Processing:
2-tube lab perfector, emulsion temperature 40°C, ammonia -15°C, through-put 20 Kg/h, rotor speed 950 rpm, outlet temperature of spread approx. 11°

2) TA-XT2 Texture Analyser, probe AO5 7172"), compression 15 mm, speed 0.5 mm/sec., after min. 2 days storage.

3) Stability upon spreading with a knife on cardboard, using the following index:

10 - Highly stable, very smooth
9 -
8 - Stable, but separates when worked intensively
7 -
6 - Separates when worked
5 -
4 - Separates when worked a little
3 -
2 - Separates
1 -
0 - Separates in tube chiller or is an O/W product

Table 2. Low fat spread droplet size measurement (volume distribution).

Hydrocolloid no.	2,5 % < µm	50,0 % < µm	97,5 % < µm
1	0.0	13.4	2520.0
2	1.1	8.6	71.3
3	1.4	6.4	28.8