FOOD & BEVERAGES

Design of encapsulation of coagulants in W/O emulsions for tofu

INTRODUCTION

Tofu is a traditional soybean food originating in China 2000 years ago. The production is similar to that of cheese from milk, by coagulating soy milk and pressing it into bean curds. Various coagulants can be used however, $MgCl_2$ is preferred as it creates a more natural flavor and allows the original taste of the soybean to be retained. However, the magnesium ions do not quickly dissolve in soymilk and this often results in a rapid solidification of the gel and therefore it produces poor quality tofu.

This study is focused on designing water-in-oil (W/O) emulsions to encapsulate $MgCl_2$ and to control its release to slow down the gelation rate of tofu. This can be used to increase the yield and quality of the tofu.

KEY **BENEFITS**

VERSATILE

NO DILUTION

FAST AND ACCURATE

MATERIALS

The oil phase was prepared by mixing 0.6 or 1.0 g of the polyglycerol polyricinoleate (PGPR) emulsifier with 60 g soy oil. The aqueous phase that contained different concentrations of $MgCl_2$ varying from 0.4 to 2.6 M, was dispersed in the PGPR-soy oil blend and stirred for 15 minutes at 65 °C (Table 1).

Emulsion	PGPR % (w/w)	$MgCl_2$ (M)
A	0.6	0.4
B		1.2
C		2.0
D		2.5
E	1.0	0.4
F		1.2
G		2.0
H		2.5

Table 1: Compositions in emulsions A-H

EXPERIMENTAL RESULTS

1) TSI of W/O emulsions over 1 day at 65 °C

The global stability of samples is assessed automatically with the Turbiscan Stability Index (TSI). The index adds up all variations in signal due to size variation and phase separation detected in the sample. At a given ageing time, the higher is the TSI, the less stable is the sample.

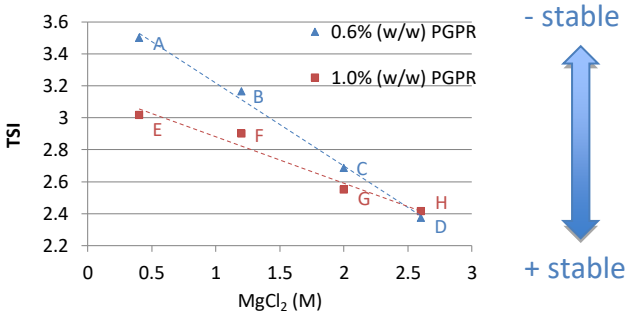

Figure 1: Stability versus PGPR and $MgCl_2$ concentrations at 65°C

Figure 1 shows that the TSI value decreases with the increase of the concentration of $MgCl_2$, indicating that adding magnesium salt improves the stability of W/O emulsions. As the concentration of surfactant PGPR increases from 0.6% to 1.0% (w/w), the TSI value tends to decrease, especially with low concentration of $MgCl_2$. A higher concentration of PGPR could rapidly coat and rigidify the interfacial film of a newly-formed emulsion and therefore prevent the coalescence. Thanks to the TSI, these conclusions could be made quickly after one day.

2) Stability of W/O emulsions over 14 days of storage at room temperature

To obtain a better comparison of the stability of these emulsions they were monitored over 14 days, the variations of the backscattering (ΔBS) profile were measured at 25°C. Figure 2 shows the results obtained for sample A.

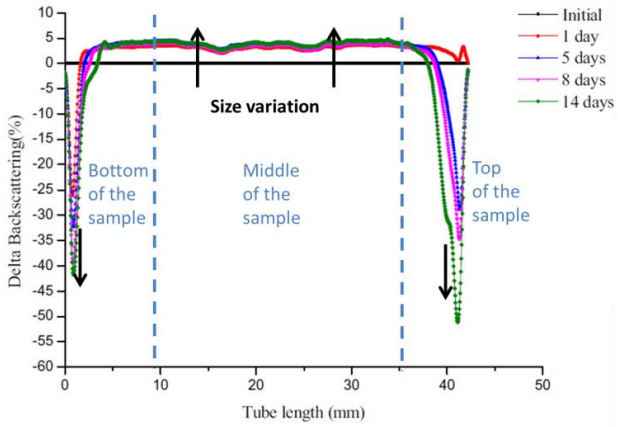

Figure 2: Evolutions of ΔBS signal for sample A over 14 days of storage

It is possible to identify different destabilization phenomena in different zones of the sample:

- **Bottom**: the intensity of ΔBS decreases corresponding to an increase of the concentration of water droplets. A separated aqueous phase appears.
- **Middle**: a variation of water droplet over time leads to a global increase of ΔBS. Water droplets tend to agglomerate into larger size.
- **Top**: a clear oil layer appears due to the creaming of oil phase, a decrease of ΔBS is observed.

These phenomena are observed in all samples but with different intensity in ΔBS, as summarized in Table 2. Adding more magnesium can delay phase separation and coalescence by influencing the osmotic pressure gradients. Moreover, the stability could also be improved by increasing the concentration of PGPR surfactant.

	PGPR % (w/w)	$MgCl_2$ (M)	BOTTOM	MIDDLE	TOP
A	*0.6*	*0.4*	++++	+	++++
D		*2.5*	+++	+	+++
E	*1.0*	*0.4*	++	++	++
H		*2.5*	+	+	+

Table 2: Phenomena observed in different zones (more "+" means higher ΔBS, and thus there are more instabilities in this zone)

The images in Figure 3 were taken after 14 days of storage at 25°C, the phase separation could only be seen visually in sample A. Turbiscan® is used to rank the stability of these samples effectively and with just 1 day of analysis, the one-click TSI tool makes it easy to quickly determine the global stability. Increasing the concentration of magnesium salt improves the stability of the emulsion with regards to phase separation and coalescence.

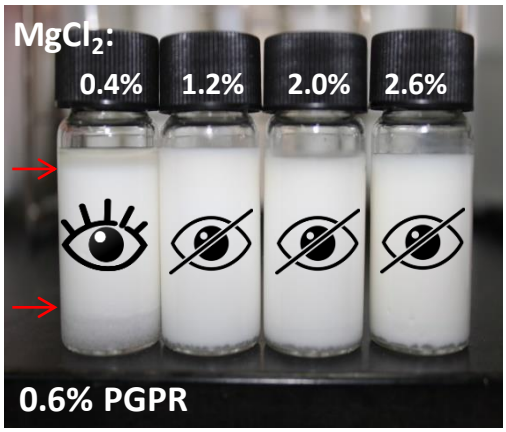

Figure 3: Picture of sample A, B, C and D over 14 days of storage

CONCLUSION

Using the Turbiscan is a simple method to study the stability of W/O emulsions containing the coagulant $MgCl_2$ that is carefully released into soymilk in tofu production.

Increasing the concentration of salt or surfactant stabilizes the emulsion. The formulation could be further optimized with other considerations such as yield, water-holding capacity, textural properties, cost of formulation, etc.

To satisfy different needs in rapidity or in precision, the Turbiscan allows samples to be compared in terms of stability in only one day by the 1-click TSI tool, or by comparing in detail backscattering evolution.

Reference:

Q. Zhu, F. Wu, M. Saito, E. Tatsumi et al. "Effect of magnesium salt concentration in water-in-oil emulsions on the physical properties and microstructure of tofu." Food chemistry 201 (2016): 197-204.