Improving the Dispersibility & Emulsifying Properties of Micellar Casein to Replace Sodium Caseinate

How JOHA® Emulsifying Salts Improve the Functionality of MicC

1. Aim

The aim of this study was to improve the dispersibility and emulsifying properties of micellar casein (MicC) to replace sodium caseinate (NaCa).

For this purpose, JOHA® emulsifying salts were tested in combination with micellar casein. These salts can change the pH and open the micelle by calcium sequestration and electrostatic interaction with the protein constituting the micelle.

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2. Introduction

Milk proteins have functional properties that provide desirable attributes to final food products.

The dairy industry produces a wide range of milk protein products like milk protein concentrates/isolates, whey protein concentrates/isolates, casein and caseinates. Their use can affect the texture, structure, and stability of food systems (Berghofer, et al. 2016). One of the most effective dairy ingredients is NaCa, which is produced through casein precipitation (Mounsey, O'Kennedy and Kelly 2005a). Caseinates are amphiphilic, which means they contain hydrophilic and lipophilic sites. Therefore, they provide very good emulsion properties and are highly soluble in water (Damodaran 2005). Caseinates are used widely in industrial food applications such as dairy and nondairy creamers, sauces, analog cream, seasoning, meat preparations and pastries. NaCa can also be used in other nonfood applications, such as pharmaceutical, cosmetic, and the replacement of plastic polymers.

Over the past 10 years, the market has experienced a reduced availability of caseinates and increased prices which has led many customers to search for alternatives. MicC offers the potential to function as a substitute for NaCa. This micellar casein is produced out of raw and skimmed milk through microfiltration followed by spray drying. Internal analyses at ICL Food Specialties highlighted that the low solubility properties of MicC means that protein particles partially settle in a solution after a certain time. Low solubility properties might also lead to poor functional properties of the product (Morr, et al. 1971). In order to improve this low solubility and poor functional properties of MicC, the addition of phosphates, such as in the form of JOHA SE, could be helpful.

3. Materials & Methods

The following tables list the substances (Table 1) and instruments (Table 2) used in the present paper.

Substance	Manufacturer
Micellar Casein (MicC)	Lactalis Ingredients
Sodium Caseinate (NaCa)	Armor Proteins
Sunflower Oil	aro
JOHA SE1	ICL

TABLE 1: List of chemicals used.

Instrument
Balance (d=0,001 g)
Conductivity Meter
Magnetic Stirrer with Temperature Control
Microscope
pH-meter
Ultra Turrax: Rotor Stator (S18N – 19G)

TABLE 2: List of instruments used.

One kg of a 1% (w/w) MicC/NaCa solution was prepared and stirred at 300 rpm for 60 min on a magnetic stirrer at 60°C. After the powder was dissolved, the pH value was measured. 0.05% of JOHA SE was added only to the MicC solution and stirred again at 300 rpm for 10 min without heating. NaCa solution and MicC solution were included as a reference without JOHA SE. Eight g of the MicC/NaCa solution were weighed into a 150 ml plastic beaker and 9 g sunflower oil were added. The beaker was placed in the Ultra Turrax appliance, and the rotor-stator unit was posi-tioned in the middle of the beaker. The Ultra Turrax was started for 2 min at 14.000 rpm. After the first minute, the rotor-stator was placed 1 cm below the surface of the liquid. The conductivity meter was placed in the water/oil emulsion right after the Ultra Turrax stopped and the conductivi-ty value was noted manually. The total volume for the water phase plus the oil phase had to be constant at 17 ml for every water/oil ratio. Five different volume combinations above the inver-sion point were measured to present a graph.

4. Results & Discussion

4.1 Dispersibility Improvement

Before determining the emulsion capacity, the dispersibility of the MicC in water was examined with and without additional phosphate.

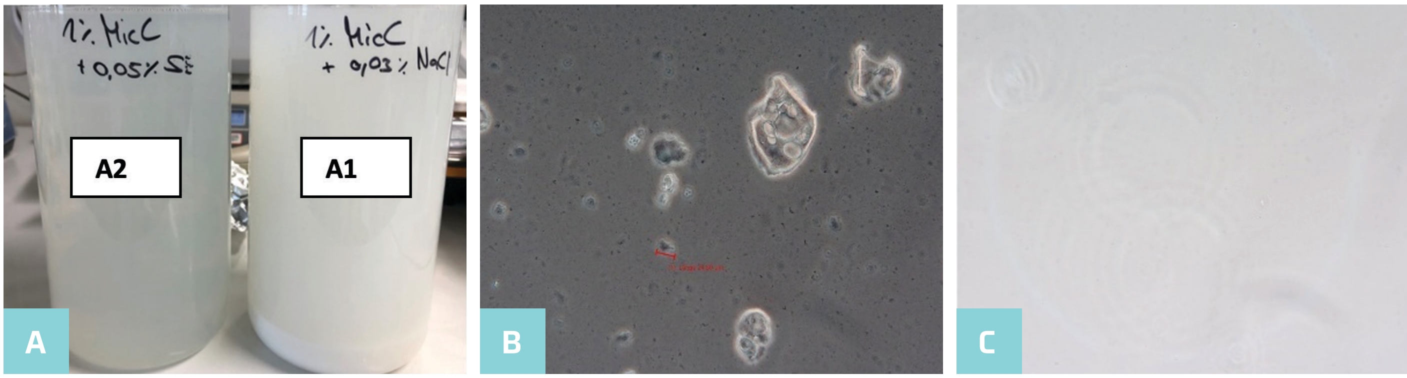

FIGURE 1: (A) Images of MicC dispersions without (right) and with JOHA SE (left). (B) Microscopy image of MicC dispersion in absence (B) and in presence of JOHA SE (C). White bars represent 50µm.

In Figure 1, A1, 1% MicC solution without JOHA SE (right beaker), is mixed with 0.03% of Sodium Chloride (NaCl) to have the same ionic strength. It shows significant turbidity and sedimentation.

In Figure 1 A2, 0.05% JOHA SE was added and the dispersion becomes more translucent. Light microscopy images of the protein dispersions explain this observation. While the image of the MicC solution in Figure B shows particles from 24 to 250 µm diameter, a homogeneous structure can be seen in Figure C with JOHA SE.

It is known that phosphate molecules can enter the micelle through gaps between κ-casein to change the configuration of the protein (Dalgleish 1998). The resulting dissolution of calcium leads to an increase of negative charges on the protein which promotes intermolecular repulsion and thus an increase of the solubility (Mu, Tan und Xue 2009).

4. Results & Discussion

4.2 Emulsion Improvement

After the 1% MicC/NaCa solutions were prepared, they were mixed with sunflower oil in a mixing ratio of 1:1 and dispersed in the Ultra Turrax to form an emulsion.

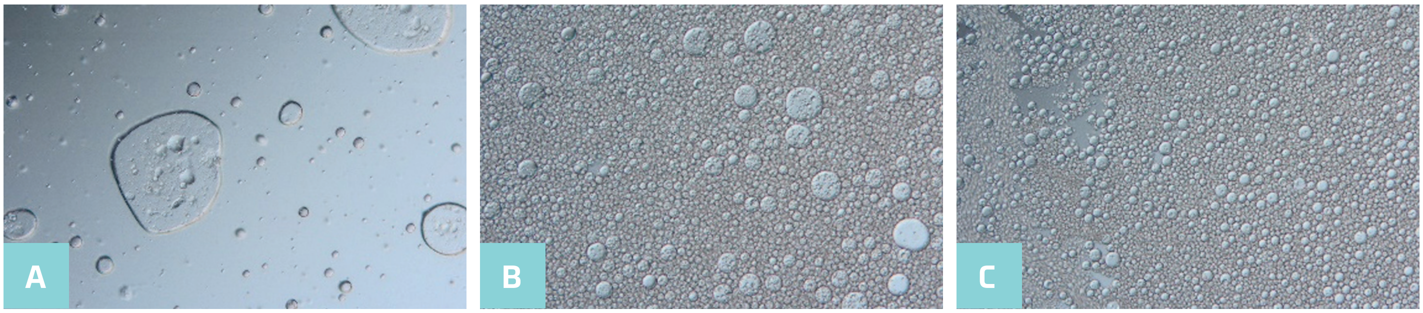

FIGURE 2: Microscopy images of emulsions prepared with MicC (A), MicC + JOHA SE (B), and NaCa (C). White bars represent 50µm.

Figure 2 shows the microscopic images of the emulsions. Comparing Figure 2B with 2C and 2A shows that in the emulsion with only micellar casein the oil droplets are strongly coalesced. With the presence of 0.05% JOHA SE, a similar oil droplet distribution to sodium caseinate could be achieved. It can therefore be assumed that the better dispersibility of MicC with JOHA SE also has a positive influence on emulsion quality, as demonstrated by Mohanty et. al. (1988). To quantify the effect of JOHA SE on MicC, particle sizes of emulsions were analyzed via laser diffraction and the emulsion capacity was determined using the method described in chapter 3.

	MicC	MicC + JOHA®SE	NaCa
D [4;3] [µm]	No stable emulsions	12.9	14.1
Emulsion capacity [g(oil)/g(MicC/NaCa)]	317	389	492
Protein content of ingredient [w/w]	0,80	0,80	0,88

TABLE 3: Average particle diameter and Emulsion capacity of emulsions with MicC, MicC + JOHA SE and NaCa.

Table 3 shows that no particle size could be determined with micellar casein alone because it was not possible to generate a stable emulsion. In the presence of 0.05% JOHA SE, a stable emulsion was generated. The average particle size of 12.9 µm was comparable with that of the emulsion containing NaCa (14.1 µm). According to Table 3 the emulsion capacity of a MicC dispersion was increased from 317 to 389g oil/g MicC/NaCa by the addition JOHA SE, which represents an increase of 22.71%. The NaCa dispersion emulsified 492g oil/g MicC/NaCa, which means an 55.20% higher emulsion capacity than with MicC without JOHA SE.

5. Conclusion

In summary, JOHA SE phosphate salt increases the water dispersibility and emulsifying properties of micellar casein with a minimum dosage of 0.05% JOHA SE by gram of MicC in solution. The upgraded emulsion capacity of micellar casein came closer to the emulsion capacity of sodium caseinate permitting its substitution. It is also Interesting to highlight that the taste of MicC + JOHA SE was much more favorable than the Sodium Caseinate solution, as the taste is neutral with dairy notes.

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