Investigating the rehydration characteristics of dairy and infant formula powders using electrical resistance tomography (ERT) and focused beam reflectance measurement (FBRM)

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Introduction

Background:

Determining the rehydration quality of dairy powders e.g. skim milk and infant formula (IF) powder (SMP), remains a challenge in dairy processing and research. By using process analytical technologies (PAT) for process monitoring, process managers can ensure high quality and consistent final powders. Electrical resistance tomography (ERT) and focused beam reflectance measurement (FBRM) are potential high-value PAT tools for monitoring powder rehydration characteristics.

objectives:

The objective of this study was to investigate the rehydration characteristics of dairy and infant formula powders namely SMP, stage 1 IF and plant based IF powders using ERT and FBRM (Fig.1).

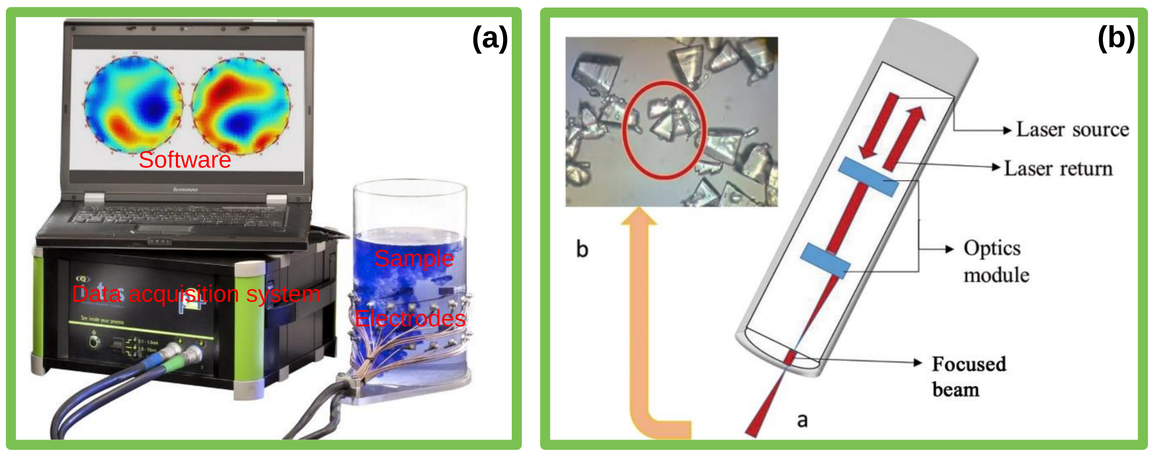

Figure 1 (a). P2+ ERT system manufactured by Industrial Tomography Systems (ITS) Inc. (Sharifi and Young, 2013a); (b). Working principle of focused beam reflectance measurement (FBRM). a - FBRM probe schematic, b - detection of particles by probe using a laser moving at a constant velocity (Pandalaneni and Amamcharla, 2016).

Material and methods

Table 1. Composition of powder samples.

Composition (w/w)	SMP	IF1	IF2	IFsoy
Fat	0.60%	22.20%	27.00%	26.30%
Lactose	49.80%	45.70%	51.60%	50.10%
Protein	34.90%	8.50%	10.00%	11.80%
Minerals	1.30%	1.70%	0.60%	0.90%

Samples:

- SMP: Skim milk powder
- IF1: Infant formula from Ireland
- IF2: Infant formula from United States
- IFsoy: Plant based protein (soy) infant formula

Rehydration tests:

- Two batches of each powder were rehydrated at 38 °C for 30 min. using a stirring speed: 200 rpm.
- PAT tools and monitor system (as given in Figure 2).

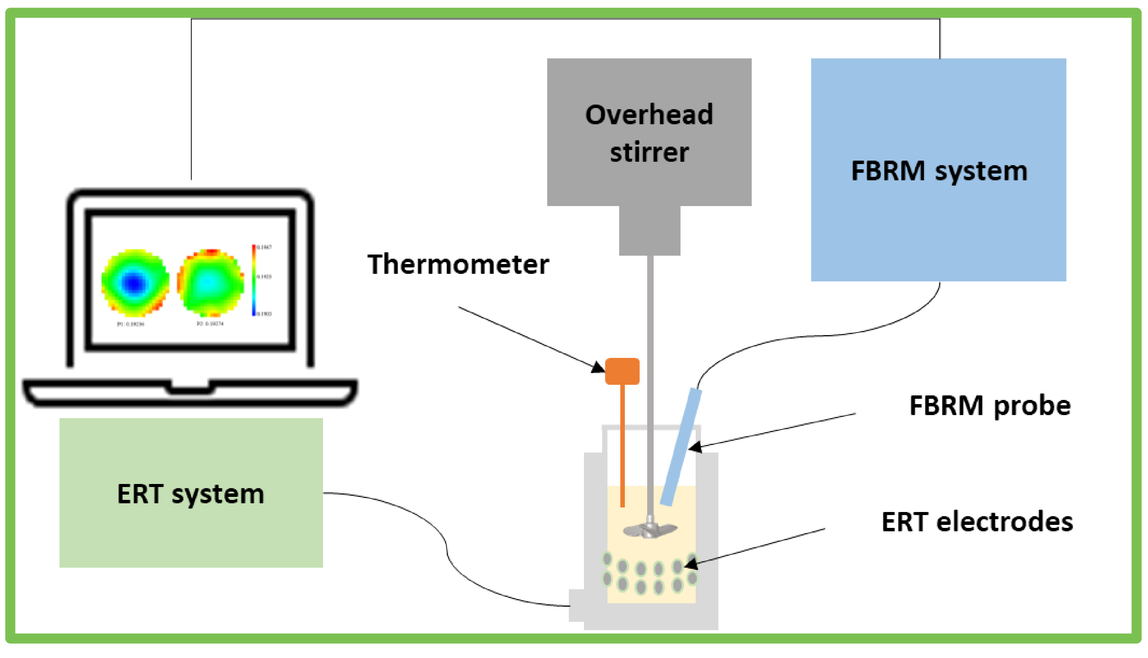

Figure 2. Schematic of the powder rehydration monitoring system

Results

- Conductivity was increasing due to powder dispersion: as the test progressed, tomograms showed more of a light green colour with blue in the centre of the graph (Figure 3).
- No difference observed among the three IF powders nor between batches.
- Major differences between SMP and IFs was the fat and protein content (Table 1).

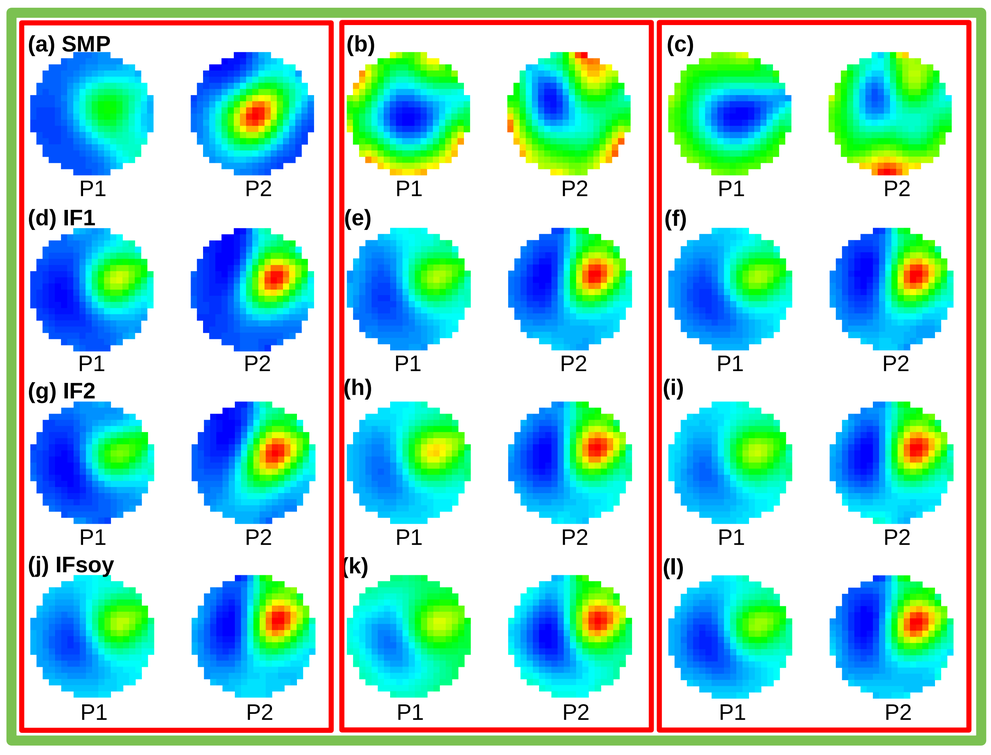

Figure 3. Tomograph (ERT data) of powder rehydration captured at the start (a, d, g, j), the time where conductivity equilibrated (b, e, h, k), and the end (c, f, I, l) (P1 – upper position electrodes, P2 – lower position electrodes; warm colours – red at a higher conductivity, and cold colours – blue at a lower conductivity).

- SMP had the highest fines count peak value of 178,922 compared to IF1 (140,178) > IF2 (109,364) > IFsoy (83,445) (Figure 4).

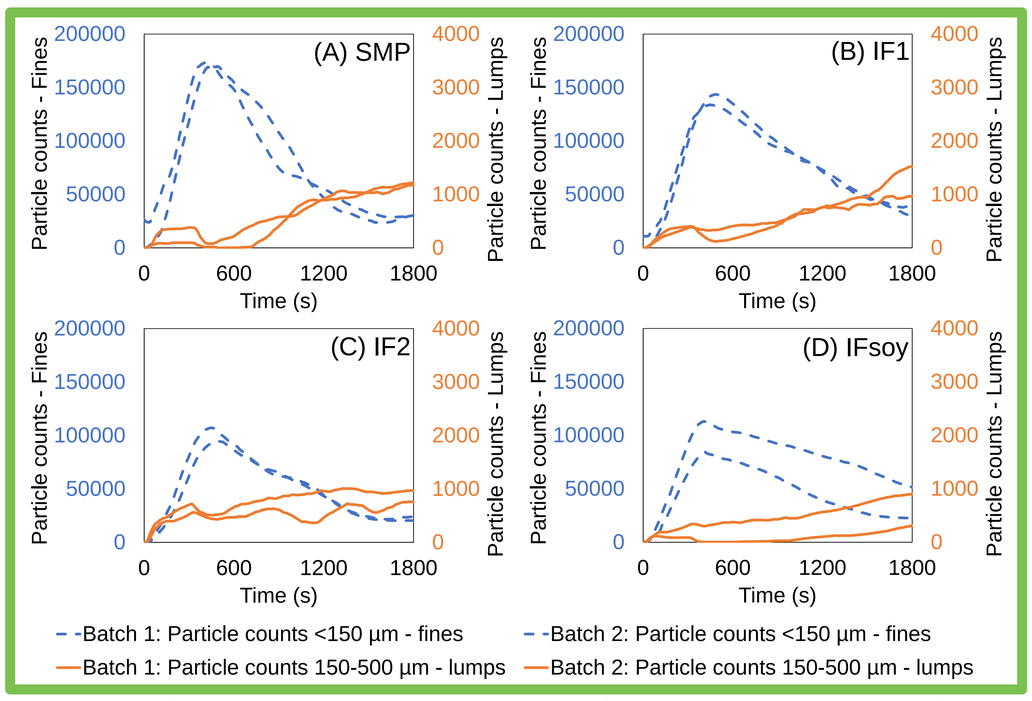

Figure 4. Changes in particle counts of powder samples during rehydration tests.

Conclusion

- PAT tools can differentiate rehydration kinetics among SMP and IF powders.
- In particular, conductivity values generated from the ERT, are more sensitive to formulations that have a higher protein content, and are more suitable in describing the sinking/ wetting properties of powders.

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