







Kinetics of heat-induced denaturation of whey proteins and characterization of protein aggregates in model infant formulas

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Infant milk formulas (IMFs)

Way of feeding of world infants 0-5 months of age in 2018

Benefits of breastfeeding



Goal for the IMF formulation:

to mimic the human milk composition, in particular the protein profile



Milk proteins



The CN:WP ratio and the WP composition have to be modified for the IMF formulation



Heat treatments of IMFs



Adapted from Human Milk Biochemistry and Infant Formula Manufacturing Technology, 2014

Lack of knowledge of the heat treatment impact on the IMF proteins



Objectives and strategy

Heat treatment impact on the protein fraction of IMFs mimicking

the human milk protein profile



Prediction of the **WP denaturation rate and the protein structure** in heated IMFs, based on their WP composition and the heat treatment parameters



Part 1: Kinetics of heat-induced denaturation of WP





Part 1: Kinetics of heat-induced denaturation of WP Strategy





Part 1: Kinetics of heat-induced denaturation of WP

Kinetics of thermal denaturation of WP in IMFs at 75°C



Part 2: Characterization of heat-induced protein aggregates





Part 2: Characterization of heat-induced protein aggregates











Part 2: Characterization of heat-induced protein aggregates Protein aggregate morphology of the IMFs heated at 80°C by transmission electron microscopy



Variation of the nature and morphology of protein aggregates according to the IMF and the heat treatment parameters









Objectives

Study of the heat treatment impact on the protein fraction of IMFs mimicking the human milk protein profile

Strategy

- Kinetics of heat-induced denaturation of WP
- Characterization of heat-induced protein aggregates

Results

- Kinetics of heat-induced denaturation of WP
 - No modification of the heat denaturation rate of LF by the presence of the other WP
 - Decrease of the heat denaturation rate of α -LA with the β -LG content reduction
 - Increase of the heat denaturation rate of β -LG in the presence of LF
- Characterization of heat-induced protein aggregates
 - Composition and morphology of protein aggregates depend on the WP composition of IMFs and the heat treatment parameters



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Thank you for your attention

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Supplemented data



Part 1: Kinetics of heat-induced denaturation of WP

Fraction of residual native WP in IMFs after pasteurization treatments



High pasteurization treatment: *M* native WP for IMFs without β-LG











Part 2: Characterization of heat-induced protein aggregates Contents of residual native WP in IMFs at 65% of WP denaturation rate



Variation of the residual native WP contents according to the IMF and the heat treatment parameters











💋 α-LA

β-LG

LF

Part 2: Characterization of heat-induced protein aggregates AF_4 – MALLS data for the CN micelle population of the unheated and heated IMFs at 67.5°C and 80°C

		Elution range (min)	$\overline{M_w}$ (10 ⁸ g.mol ⁻¹)	$\overline{R_g}$ (nm)	R _g /R _h ratio	df _{app}
Control	Unheated	20-28	6.4	140	1.1	3.0
	67.5°C	22-28	5.8	116	1.1	2.9
	80°C	22-28	6.8	123	1.2	2.9
LF ⁺	Unheated	20-28	4.7	142	1.1	3.1
	67.5°C	20-28	6.0	138	1.2	3.3
	80°C	20-28	7.3	167	1.5	2.6
LF ⁺ α-LA ⁺	Unheated	20-28	4.7	148	1.1	2.7
	67.5°C	20-28	6.0	152	1.1	2.9
	80°C	20-28	6.2	124	1.1	2.6

