



Lactose hydrolysis and protein fortification pose an increased risk for the formation of Maillard reaction products in UHT treated milk products

Aytül Hamzalıođlu¹, Işıl Gürsul Aktađ², Vural Gökmen¹

¹Food Quality and Safety (FoQuS) Research Group, Department of Food Engineering, Hacettepe University, Beytepe, Ankara, Türkiye

²Department of Gastronomy and Culinary Arts, Munzur University, Aktuluk, Tunceli, Türkiye



HACETTEPE UNIVERSITY

Food Quality and Safety (FoQuS)

Research Group

Background

Milk;

- ✓ Most important food for daily diet; balanced protein, carbohydrate, lipid and mineral content
- ✓ Dairy consumption during years changing

○ whole milks



- semi-skimmed milks
- skimmed milks
- flavored milks
- low-lactose milks
- lactose-free milks
- protein fortified milks
- follow-on milks



Background

UHT processing-Maillard reaction

✓ increase the shelf-life; **UHT processing (130-150°C)**



inactivation of bacteria
and enzymes, > 6 months



chemical changes
(Maillard reaction)

- color & taste
- nutritional loss
- formation of possible harmful compounds



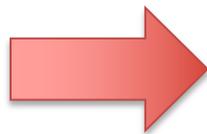


Background

Maillard Reaction

- reducing sugar
- lactose
 - glucose
 - galactose

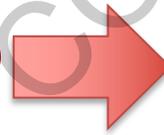
lysine



heating

indication of lysine blockage

**Amadori product
(lactulosyllysine)**



**highly reactive compounds
react with DNA and tissue
proteins in the body**

- α -dicarbonyl compounds**
- galactosone
 - glucosone
 - 3-deoxyglucosone
 - methylglyoxal
 - glyoxal



- AGEs**
- carboxyethyllysine, CEL
 - carboxymethyllysine, CML

**related with various chronic-
degenerative diseases in humans
diabetes-mellitus, Alzheimer's
disease and atherosclerosis in
humans**

7th INTERNATIONAL CONGRESS ON FOOD SAFETY

Objective

- Lactose hydrolysis (yields 2 fold reactive reducing sugar)
- Protein fortification
- Follow-on milks (higher sugar content, fortification with honey or syrups)



does compositional differences affect the MR products in UHT milks

- aiming to see in different UHT milks
- content of dicarbonyl compounds
 - content of AGEs
 - lysine blockage

Experimental

different UHT milks
collected from local market

freeze drying



Analysis by Triple Quadrupole LC-MS/MS

Results

Dicarbonyl compounds

- ✓ 3-DG and 3-Dgal; the dominant dicarbonyl compounds in all milks
- ✓ Lactose-hydrolyzed milks; highest amounts of α -dicarbonyl compounds
- ✓ infant follow-on milks; great variation in 3-DG (3-DG content of sugar syrup or honey)

dicarbonyl compounds (mg/L)	UHT milk		Lactose-hydrolyzed UHT milk		Protein fortified UHT milk		Lactose-hydrolyzed protein fortified UHT milk		Infant UHT milk (follow-on)	
	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
3-Deoxyglucosone	0.22-0.40	0.36	3.12-12.67	9.06	0.45-1.61	1.03	13.45-21.98	17.29	4.59-40.38	7.42
3-Deoxygalactosone	0.17-0.43	0.36	4.00-17.51	13.66	0.26-1.84	1.05	12.22-22.71	17.58	0.45-2.69	0.55
1- Deoxyglucosone	0.10-0.82	0.37	0.06-1.78	0.95	0.30-0.47	0.39	0.01-0.97	0.26	n.d.-0.31	0.01
Glucosone	0.01-0.03	0.01	0.83-2.02	1.76	0.11-0.12	0.11	0.97-4.12	3.13	n.d.-6.66	6.16
Galactosone	0.01-0.04	0.02	0.94-2.52	2.52	0.08-0.18	0.13	0.85-7.65	3.37	n.d.-0.13	0.06
Diacetyl	0.01-0.06	0.04	0.03-0.05	0.05	0.07-0.18	0.12	0.03-0.12	0.08	n.d.-0.25	0.06
Methylglyoxal	n.d.-0.07	0.02	0.10-0.16	0.11	n.d.	0.00	0.03-0.95	0.20	n.d.-1.20	0.61
Glyoxal	0.30-0.85	0.50	0.60-0.89	0.63	0.61-0.78	0.69	0.72-5.38	1.65	0.88-1.90	1.42

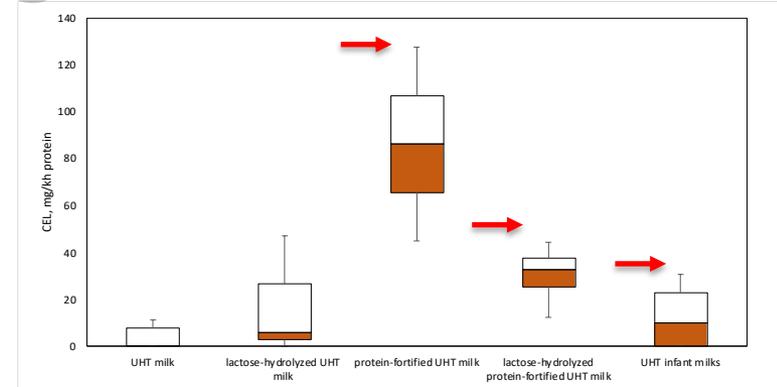
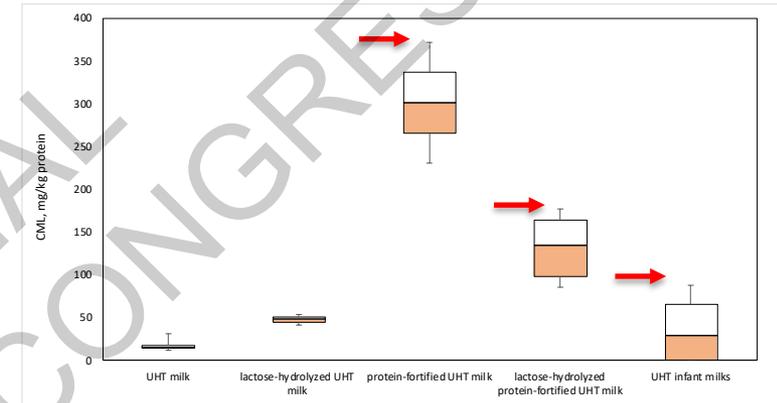
○ *n.d.: not detectable

Results

AGEs

	CML, mg/kg protein				
	UHT milk	lactose-hydrolyzed UHT milk	protein-fortified UHT milk	lactose-hydrolyzed protein-fortified UHT milk	infant UHT (follow-on) milks
min	11,80	41,40	230,60	86,00	0,00
median	15,24	48,10	301,40	134,50	29,15
max	31,06	53,80	372,20	177,20	88,20

	CEL, mg/kg protein				
	UHT milk	lactose-hydrolyzed UHT milk	protein-fortified UHT milk	lactose-hydrolyzed protein-fortified UHT milk	infant UHT (follow-on) milks
min	0,00	0,00	45,00	12,40	0,00
median	0,00	5,90	86,25	32,55	10,10
max	11,30	47,30	127,50	44,40	30,70



CML and CEL formation;

✓ higher in the milks other than whole UHT milk

✓ **max in protein fortified milk samples**

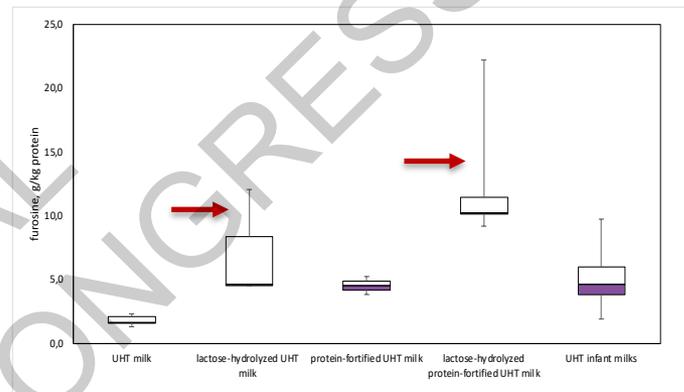
protein fortified milks > lactose hydrolyzed protein fortified milks > infant follow-on milks

Results

Furosine & Lysine loss

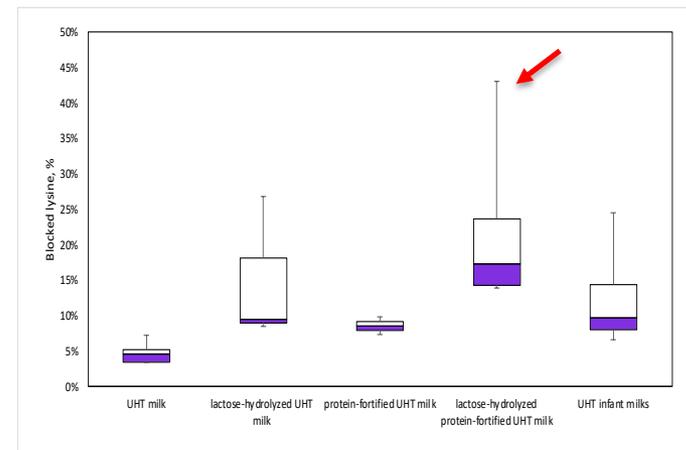
	FUR g/kg protein				
	UHT milk	lactose-hydrolyzed UHT milk	protein-fortified UHT milk	lactose-hydrolyzed protein-fortified UHT milk	infant UHT (follow-on) milks
min	1,32	4,47	3,85	9,20	1,92
median	1,61	4,66	4,55	10,26	4,63
max	2,34	12,08	5,25	22,20	9,74

✓ furosine levels; higher in lactose-hydrolyzed milks



- double reducing sugar conc
- galactose, glucose more reactive than lactose
- more lysine provided for MR by protein enrichment

	blocked lysine, %				
	UHT milk	lactose-hydrolyzed UHT milk	protein-fortified UHT milk	lactose-hydrolyzed protein-fortified UHT milk	infant UHT (follow-on) milks
min	3,4%	8,5%	7,4%	13,9%	6,6%
median	4,6%	9,6%	8,6%	17,3%	9,8%
max	7,2%	26,8%	9,8%	43,0%	24,5%



lysine loss is as high as 43.0% for lactose-hydrolyzed protein-fortified milks
 hydrolysis of lactose and protein fortification; higher loss of lysine

to conclude...

❑ Formation of intermediates, early and advanced Maillard reaction products in UHT affected by the fortification of different ingredients.

- Fortification of infant follow-on milks with syrup or honey; higher amounts of dicarbonyl compounds
- Protein fortification and lactose hydrolysis; higher levels of Maillard reaction products
- Fortification of milks with proteins; loss of available lysine

❑ Limit the loss of available lysine

❑ Mitigation of MR in these products

- ✓ proper ingredient selection
- ✓ gentle techniques other than UHT
- ✓ lactose removal instead of lactose hydrolysis





Thank you for your attention

aytulhamzalioglu@hacettepe.edu.tr

Journal of Food Composition and Analysis 84 (2019) 103308



ELSEVIER

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Journal of Food Composition and Analysis

journal homepage: www.elsevier.com/locate/jfca



Original Research Article

Lactose hydrolysis and protein fortification pose an increased risk for the formation of Maillard reaction products in UHT treated milk products

Işıl Gürsul Aktaş^{a,b}, Aytül Hamzalıoğlu^a, Vural Gökmen^{a,*}

