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What can we learn from infant nutrition?

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Milk is the ideal food for newborn mammals

Nutrient Composition of Milks from Different Species*

Nutrient	Species				
	Cow	Human	Buffalo	Goat	Sheep
Water, g	87.99	87.50	83.39	87.03	80.70
Food energy, kcal	61.44	69.56	96.62	68.81	107.81
kJ	257.00	291.00	404.00	288.00	451.00
Protein (N x 6.38), g	3.29	1.03	3.75	3.56	5.98
Fat, g	3.34	4.38	6.89	4.14	7.00
Carbohydrate, total, g	4.66	6.89	5.18	4.45	5.36
Fiber, g	0	0	0	0	0
Ash, g	0.72	0.20	0.79	0.82	0.96
Minerals					
Calcium	119.40	32.20	169.00	133.50	193.40
Iron, mg	0.05	0.03	0.12	0.05	0.10
Magnesium, mg	13.44	3.40	31.12	13.97	18.36
Phosphorus, mg	93.40	13.70	117.40	110.70	158.00
Potassium, mg	151.50	51.20	177.70	204.40	136.50
Sodium, mg	49.00	16.90	52.20	49.80	44.10
Zinc, mg	0.38	0.17	0.22	0.30	0.54
Vitamins					
Ascorbic Acid, mg	0.94	5.00	2.25	1.29	4.16
Thiamin, mg	0.038	0.014	0.052	0.048	0.065
Riboflavin, mg	0.162	0.036	0.135	0.138	0.355
Niacin, mg	0.084	0.177	0.091	0.277	0.417
Pantothenic Acid, mg	0.314	0.223	0.192	0.310	0.407
Vitamin B_6, mg	0.042	0.011	0.023	0.046	0.060
Folate, mcg	5.000	5.200	5.600	0.600	7.000
Vitamin B_{12}, mcg	0.357	0.045	0.363	0.065	0.711
Vitamin A, RE	31.00	64.00	53.00	56.00	42.00
IU	126.00	241.00	178.00	185.00	147.00
Cholesterol, mg	14.00	14.00	19.00	11.00	27.00

* Amount in 100 Grams Edible Portion

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Human milk: the „designer“ food for human infants

- Human milk is the ideal nutrition for the infant concerning the composition and its optimal digestibility.
- During the first 4 to 6 months it is exclusively the only source for the supply with food and water.
- Human milk can never be overdosed!
- It is:

„A Gold-Standard of nutrition“

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Human milk is a functional food

The „health claims“ of human milk:

- Feeding human milk will provide the infant:
- A higher IQ-score (Lucas et al., 1992)
- A better neurological development (Lanting et al., 1994)
- The longer the feeding period the lower the risk of becoming obese in school age (in Bavaria) (von Kries et al., 1999).
- For these „health effects“ there are a lot of **functional components** in human milk: some we know, most we do not!

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Human milk: composition
vs. cows milk

	Human milk	Cows milk
Volume (ml/day)	800	~ 19 000
Lactose (g/l)	69	47
Oligosaccharides (g/l)	11	0.1
Proteins, total (g/l)	10.5	33
Alpha-Lactalbumin (g/l)	2.8	1.5
IgA (g/l)	1.2	0.03
Fat, total (g/l)	38	36
Minerals (g/l)	1.6	6.1
Sodium (g/l)	0.16	0.62
Potassium (g/l)	0.52	1.5

Human milk: protein
vs. cows milk

Protein type	Human milk (g/100ml)	Cows milk (g/100ml)
Total protein	1.05	3.3
Casein	0.31	2.6
Whey protein	0.72	0.64
Alpha-lactalbumin	0.28	0.15
Beta-lactoglobulin	-	0.30
Lactoferrin	0.15	traces
Lysozyme	0.05	traces
IgA	0.12	0.003

Human milk proteins: antimicrobial functions

AGENTS	PRIMARY FUNCTIONS
Proteins	
Lactoferrin	Iron chelation
Lysozyme	Peptidoglycan degradation
Fibronectin	Opsonins
Secretory IgA	Antigen binding

Human milk: cytokines

TABLE 8. Concentrations (Mean Values) and Potential Functions of Cytokines in Human Milk

CYTOKINES	POSSIBLE FUNCTIONS	CONCENTRATION (pg/mL, approximate)
Interleukin-1-beta	Activates T cells	1,130
Interleukin 6	Enhances IgA production	151
TNF-alpha*	Enhances secretory component secretion	620
TGF-beta**	Enhances isotype switching to IgA+ B cells	?

** TNF = tumor necrosis factor*
*** TGF = transforming growth factor*
From Goldman, AS. The immune system of human milk: antimicrobial, antiinflammatory and immunomodulating properties. Pediatr Infect Dis J. *1993;12:664–671.*

Human milk: bioactive peptides

Bioactive peptide	Protein precursor	Bioactivity
Casomorphins	α-, β-Casein	Opioid agonist
α-Lactorphin	α-Lactalbumin	Opioid agonist
β-Lactorphin	β-Lactoglobulin	Opioid agonist
Lactoferroxins	Lactoferrin	Opioid antagonist
Casoxins	κ-Casein	Opioid antagonist
Casokinins	α- β-Casein	ACE-inhibitory
Lactokinins	α-Lactalbumin, β-Lactoglobulin, Serum albumin	ACE-inhibitory
Immunopeptides	α- β-Casein	Immunomodulatory
Lactoferricin	Lactoferrin	Antimicrobial
Casocidin	α_{S2}-Casein	Antimicrobial
Isracidin	α_{S1}-Casein	Antimicrobial
Casoplatelins	κ-Casein	Antithrombotic
Phosphopeptides	α-, β-Casein	Mineral binding

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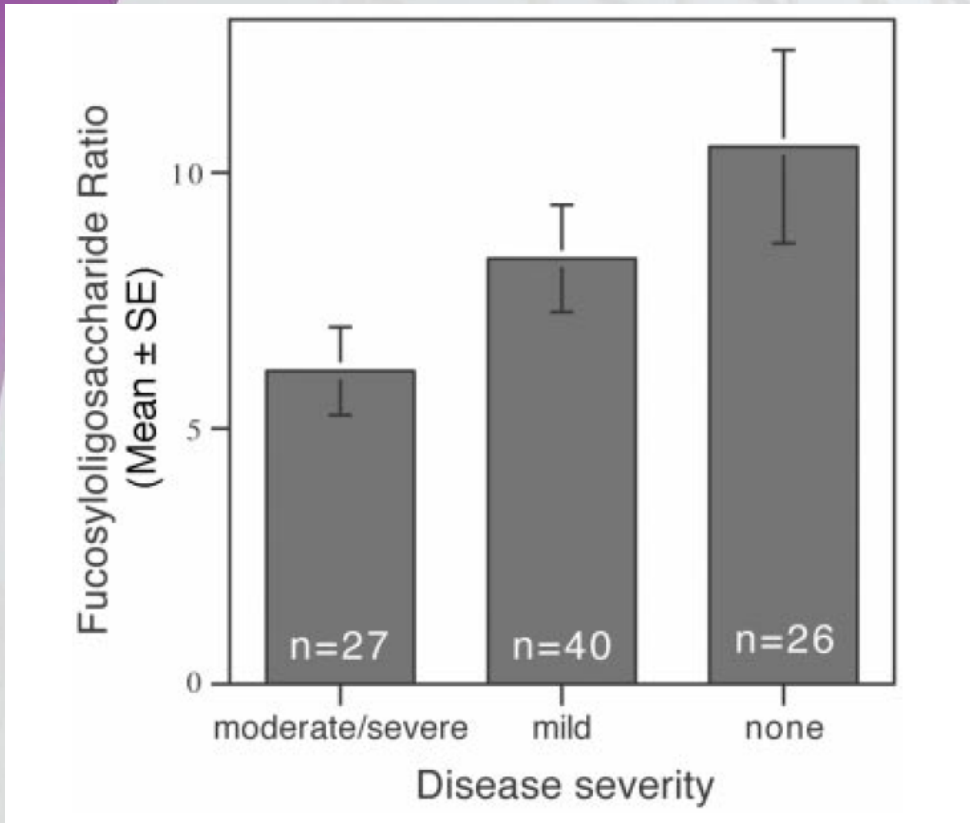
Human milk: carbohydrates

- All milks of mammals contain **lactose**
- In human milk about **10% of the lactose are oligosaccharides**; these are composed of lactose, amino sugars, fucose and sialic acid
- Up to now more than 130 structural different oligosaccharides are known

Human milk: oligosaccharides

L0/1-0 2'-FL	2'-Fucosyllactose	Fuc α1-2 Gal β1-4 Glc
L0/1-0 3-FL	3-Fucosyllactose	Gal β1-4 Glc 3 | Fuc α1
L0/2-0 DFL	Difucosyllactose	Fuc α1-2 Gal β1-4 Glc 3 | Fuc α1
L1/0-0 LNT	Lacto-N-tetraose	Gal β1-3 GlcNAc β1-3 Gal β1-4 Glc
L1/0-0 LNnT	Lacto-N-neotetraose	Gal β1-4 GlcNAc β1-3 Gal β1-4 Glc

Human milk: oligosaccharides



- 3 mother-infant groups:
  - è With different levels of fucosylated oligo-saccharides;
  - è Were folllowed prospectively for clinical symptoms of diarrhea
  - è The 26 **infants with the highest level of fucosyloligosaccharides never experienced diarrhea**

Human milk: fat

Human milk contains LCPUFA (long chain polyunsaturated fatty acids) their level is depending on the food (e.g. fish for DHA)

TABLE 1
Polyunsaturated Fatty Acids in Samples of Mature Human Milk from Different Countries (wt% of total, mean, or median values)[a]

	China Chulei *et al.*, 1995 (23)	U.K. Sanders *et al.*, 1978 (25)	Canada Chen *et al.*, 1995 (43)	Hungary Sas *et al.*, 1986 (44)	Sweden Jansson *et al.*, 1981 (45)	Japan Idota *et al.*, 1991 (46)
Number of women	39	4	198	13	24	351
LA	20.6	6.9	10.5	11.0	12.9	13.3
AA	0.9	0.5	0.4	0.5	0.4	0.4
ALA	3.0	0.8	1.2	1.2	<1.4	1.4
DHA	0.9	0.6	0.1	0.1	0.3	1.0
LA/ALA ratio	6.9	8.6	9.0	9.2	>9.2	9.3

	Spain de Lucchi *et al.*, 1988 (47)	Germany Koletzko *et al.*, 1988 (48)	Gambia Prentice *et al.*, 1988 (49)	United States Putnam *et al.*, 1982 (24)	South Africa van der Westhuizen *et al.*, 1988 (20)
Number of women	28	15	23	9	12
LA	14.7	10.8	13.0	15.8	16.2
AA	0.8	0.4	0.3	0.6	0.6
ALA	1.3	0.8	0.8	0.8	0.4
DHA	0.4	0.2	0.4	0.1	0.2
LA/ALA ratio	11.3	13.3	15.5	18.8	40.5

[a]Abbreviations: LA, linoleic acid; AA, arachidonic acid; ALA, α-linolenic acid; DHA, docosahexenoic acid.

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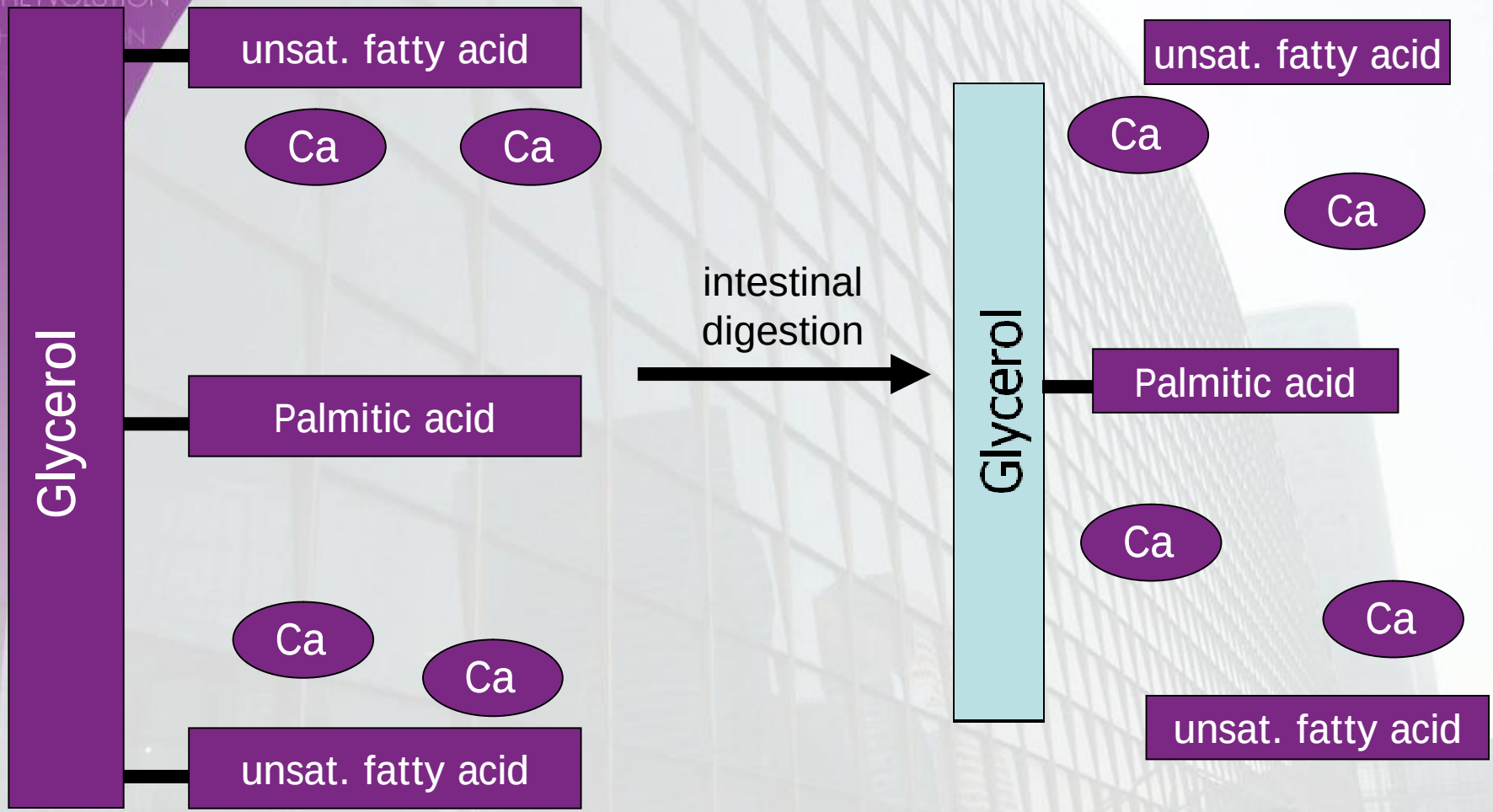
Human milk: fat structured lipids



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Human milk: an undiscovered source of ideas for functional food

How to learn from human milk:

- Understand the basic physiological functions of the milk
- Carefully change the food by following the principle of „metabolic fidelity“
- Look for factors which favor a healthy metabolism and prevent the silent start of diseases
- Search for metabolic markers and physiological functions which can be measured easily
- Start well planned clinical studies which will support the functional claims
- „Nature is always better than you!“

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Human milk our model for functional food

Thank you!