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Finding solutions through knowledge

MILK: MOTHER NATURE'S READY-TO-EAT MEAL (RTM)

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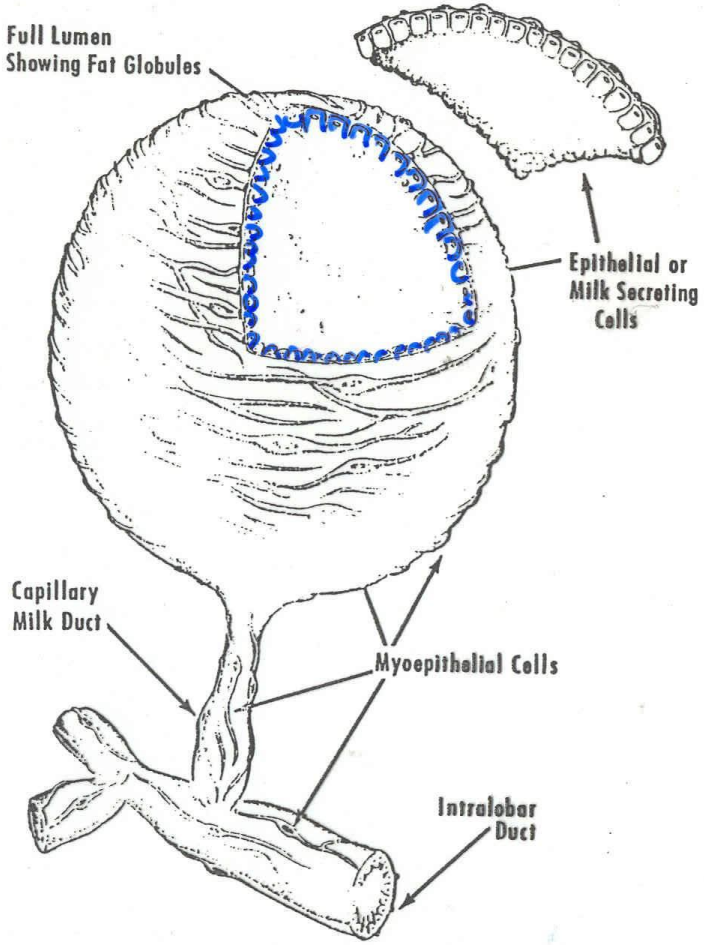
Outline of presentation

- Milk production and composition
- Colostrum
- Infant formula
- The Story

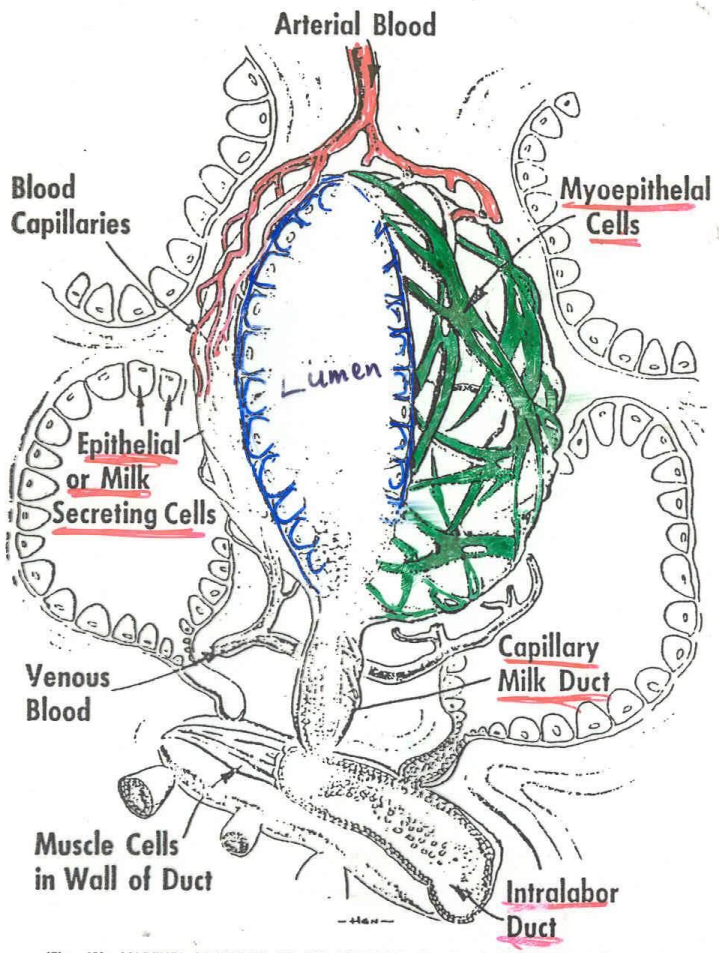
Milk is a complete diet

- Milk production - unifying feature of all mammals
- Neonate cannot collect, chew or digest solid food
- Milk provides:
  - Protein (EAA + NEAA)
  - Lipids (EFA + NEFA)
  - Minerals (macro + trace)
  - Vitamins
  - Water
  - Energy
    - 30-50% from fat
    - 40-60% from carbohydrtaes
    - 8-12% from protein
  - Immune factors
    - Colostrum!

Milk synthesis



(Fig. 11) THE ALVEOLUS where milk is made. Microscopic in size, there are literally millions of them in a cow's udder . . . each lined with thousands of epithelial, or milk secreting cells. However, getting anywhere near all of the milk these cells manufacture depends greatly on how well you manage your milking job in relation to the squeezing action of the little myoepithelial cells surrounding each alveolus. (See Fig. 1—Pages 2 and 3.)



(Fig. 41) ANOTHER DRAWING OF AN ALVEOLUS showing it lifted out of its connective membrane sheath and cut to show its inside lining of epithelial cells. On its right side are indicated the little (myoepithelial) muscle-like cells which squeeze it shut when activated by the hormone OXYTOCIN. On the left is the network of blood vessels which supply various hormones and the milk making constituents to each alveolus.

Species differences

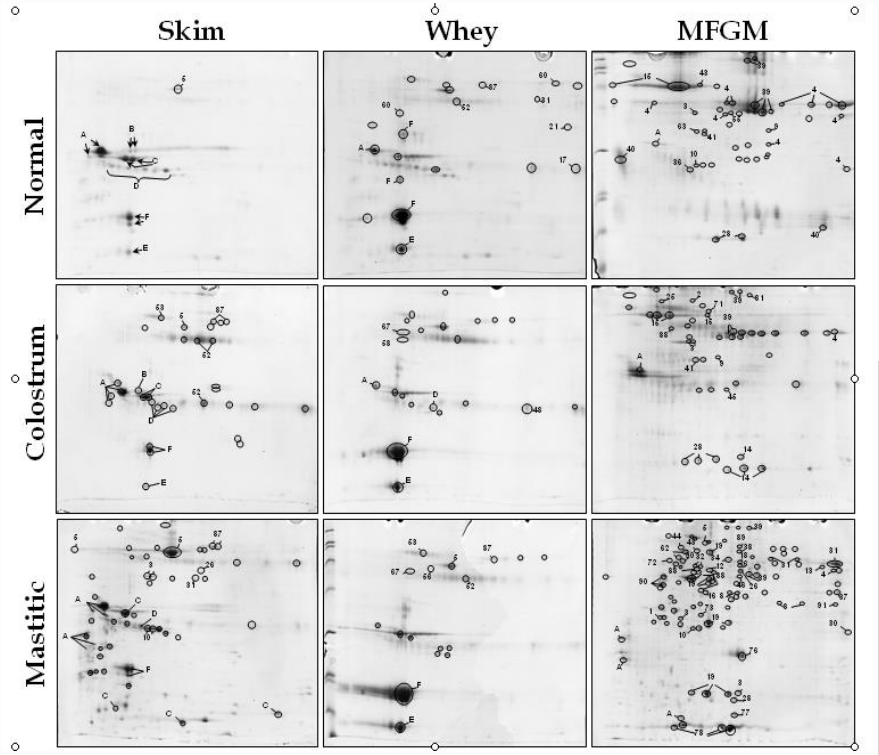
	Suckling Interval*	Fat (%)	Protein (%)	Lactose (%)	Energy (KJ/100 g)
Human	hours	4.5	0.9	7.1	17
Cow	hours	3.9	3.2	4.6	16
Rabbit	1 day	15.3	13.8	2.1	48
Tree Shrew	2 days	25.6	10.4	1.5	66
Fur seal	week	53.3	8.9	0.1	123

* Cross. 1977.

Jenness, 1986. J. Dairy Sci.

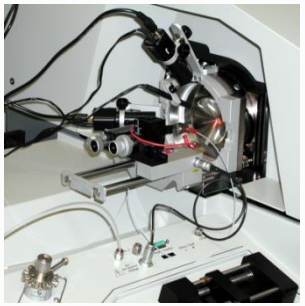
Proteomic analysis of bovine milk fractions

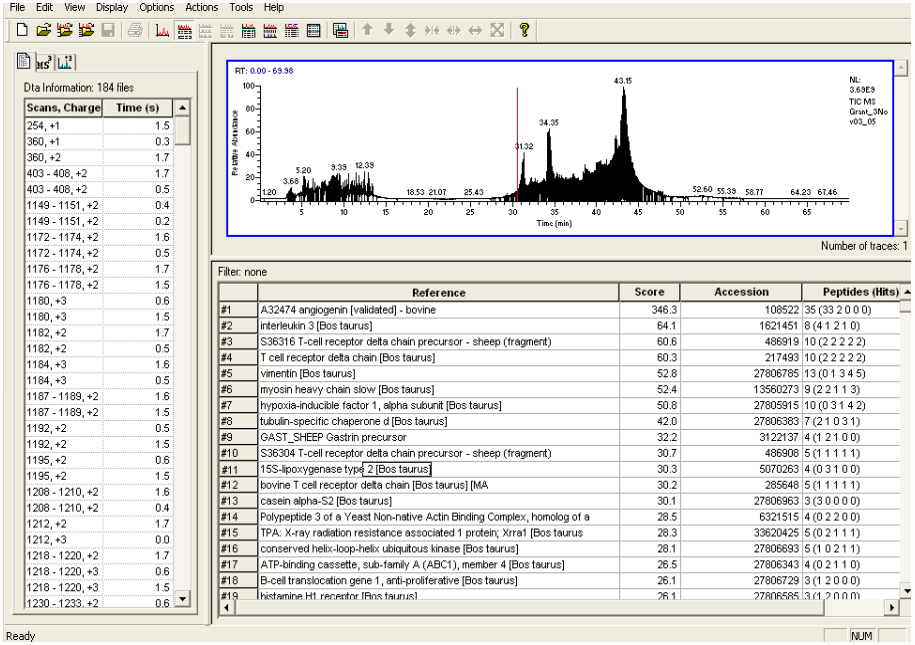
2-D gels



Smolenski et al. 2007. J. Proteome Res.

Mass spectrometry





Milk is a very complex fluid

- **Smolenski et al. 2007. Characterisation of host defence proteins in milk using a proteomics approach. *J. Proteom. Res*.**
  - **95 proteins → 15 involved in host defense (+ many with unknown function)**

- **Hettinga et al. 2011. The host defense proteome of human and bovine milk. *PlosOne***
  - **Bovine milk: 269 proteins → 51 involved in host defense**

Milk is a very complex fluid

- Further:
  - Fatty acids
  - Enzymes
  - Peptides
  - Amino acids
  - Vitamins
  - Minerals
  - Bacteria

- Blood *vs.* milk

- Milk is unique and no need for “©”

Milk

Value-add - bioactives

Definition:

- **A bioactive is *"any factor that elicits a biological response"***
- **Single component**
- **Fraction**
- **Special powders (caseinates, WPI, colostrum)**
- **Liquid colostrum**

Bioactive properties of milk

BIOACTIVE FUNCTION	BIOACTIVE COMPONENTS
Antibacterial	Lactoferrin, Lactoperoxidase, Lysozyme, defensin
Gut health	Casomorphin, CMP, α-lactalbumin, Opioids, Oligosaccharides
Cell growth & repair	Growth Factors, β-casein derived fragments, Lactoferrin
Hypertension-lowering	ACE inhibitors, Ca
Mineral utilization	Casein-derived phophopeptides
Bone synthesis	Ca, PTHrP, Whey proteins
Immune function	Immunoglobulins, Lactoferrin, RNases, Acutephase proteins, Oligosaccharides
Anticarcinogenic	CLA, Sphingolipids
Cardiovascular	CLA, Omega-3 fatty acids, Ca
Sports & performance	Whey proteins, Colostrum fractions

(Adapted from: Stelwagen. 2011. Encyclop. Dairy Sci. 2nd Ed, Vol. 3, pp 359-366)

bLF product examples in Japanese market

Product		Brand name	Company
Food	Infant formula	Hagukumi, Chilmil Ayumi, New-NA-20	Morinaga
	Supplements	Lactoferrin Plus, Lactoferrin Original, Type	Livewell
		Actio Lactoferrin	Asashi
	Yoghurt	Bifiene	Yakult
	Skim milk	Tetsu Lactoferrin Skim	Snow Brand
	Drinks	Lactoferrin Plus	Morinaga
	Pet food	Lactoferrin 200, Lactonin	Morinyu Sunworld
Cosmetics (skin care)	Lotions, creams, face washes	Milk Protein (DHC), Miss Yoko essential lotion / white cream / essence	Yoko
Oral care	Mouth wash, mouth gel, tooth paste, chewing gum	Biotene Oral Balance / mouthwash / tooth paste	Laclede
		Hamigaki Gum	Kanebo

Adapted from: Wakabayashi et al. 2006. Int. Dairy J.

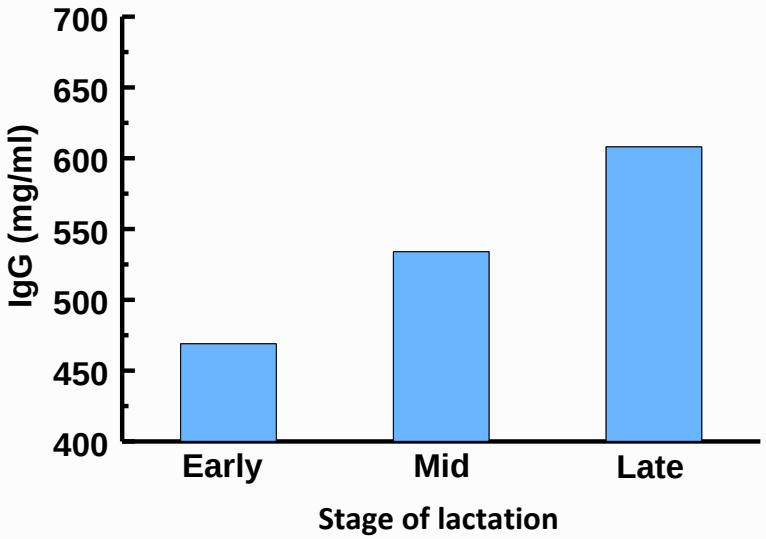
Bioactives and milk fractions

- A local product: IDP® (Quantec Ltd, Hamilton)

- Fraction vs single component
  - Extraction/separation
  - Health & Safety
  - Cost
  - Bioactivity!

On-farm

- Seasonal Calving
  - All cows at the same stage of lactation
  - Milk composition changes with advancing lactation
  - Economies of scale

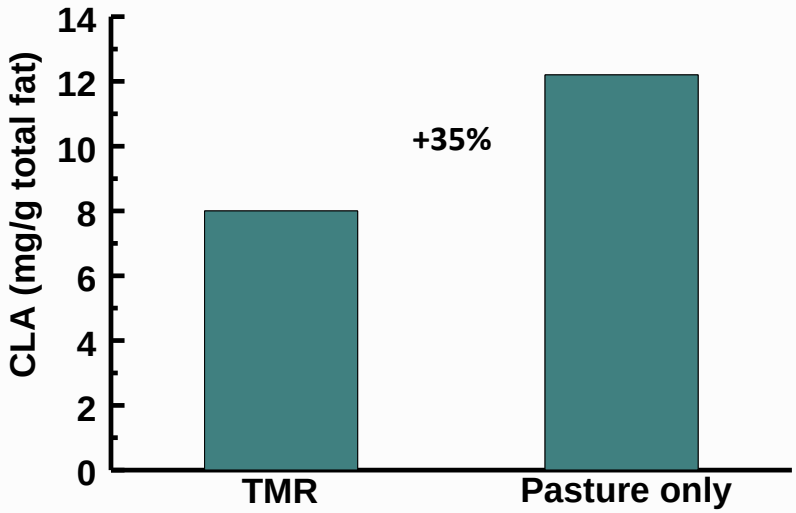


Auldist et al. 1998. J. Dairy Res..

On-farm

- Seasonal Calving
  - All cows at the same stage of lactation
  - Milk composition changes with advancing lactation
  - Economies of scale

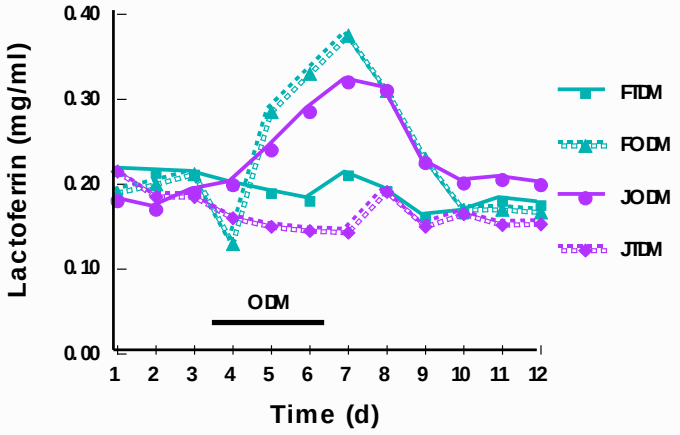
- **Pasture *vs.* supplement feeding**
  - **CLA content of milk**



Auldist et al. 2002 NZSAP

On-farm

- Seasonal Calving
  - All cows at the same stage of lactation
  - Milk composition changes with advancing lactation
  - Economies of scale
- Pasture *vs.* supplement feeding
  - CLA content of milk
- **Once-daily milking**
  - **Increase in immune factors**



Farr et al. 1998. NZ Soc. Anim. Prod.

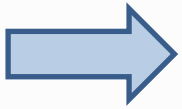
Processing

- Any heat treatment reduces bioactivity
  - Proteins are heat labile
  - Strict international rules
- Alternatives.
- High Pressure Preservation

From: www.hiperbaric.com

Milk and the elderly

- 20% of Asia is >50 years old now, rising to 40% by 2030
- Muscle mass and strength start to decrease after age 30
  - Whey high in leucine
- Also:
  - ↓ saliva production (mouth feel)
  - ↓ stomach acid production (whey does not require HCl)
  - ↑ anemia
  - ↑ Lactase deficiency (lactose-free dairy!)
  - ↓ Gut health



Huge market potential for milk!

Outline of presentation

- Milk production and composition
- **Colostrum**
- Infant formula
- The Story

Colostrum

- The first “milk” after calving
  - Brown colour
  - Thick (~20% DM)
- Nutrition for neonate
- Immune protection
  - Newborn
  - Udder

Species	In-utero transfer	Post-natal Transfer	Predominant Ig	
			Colostrum	Milk
Cow	None	Gut (24h)	IgG	IgG
Pig	None	Gut (24-36h)	IgG	IgA
Horse	None	Gut (24-36h)	IgG	IgA
Human	Placenta	None	IgA	IgA
Cuinea pig	Yolk sac	None	IgA	IgA

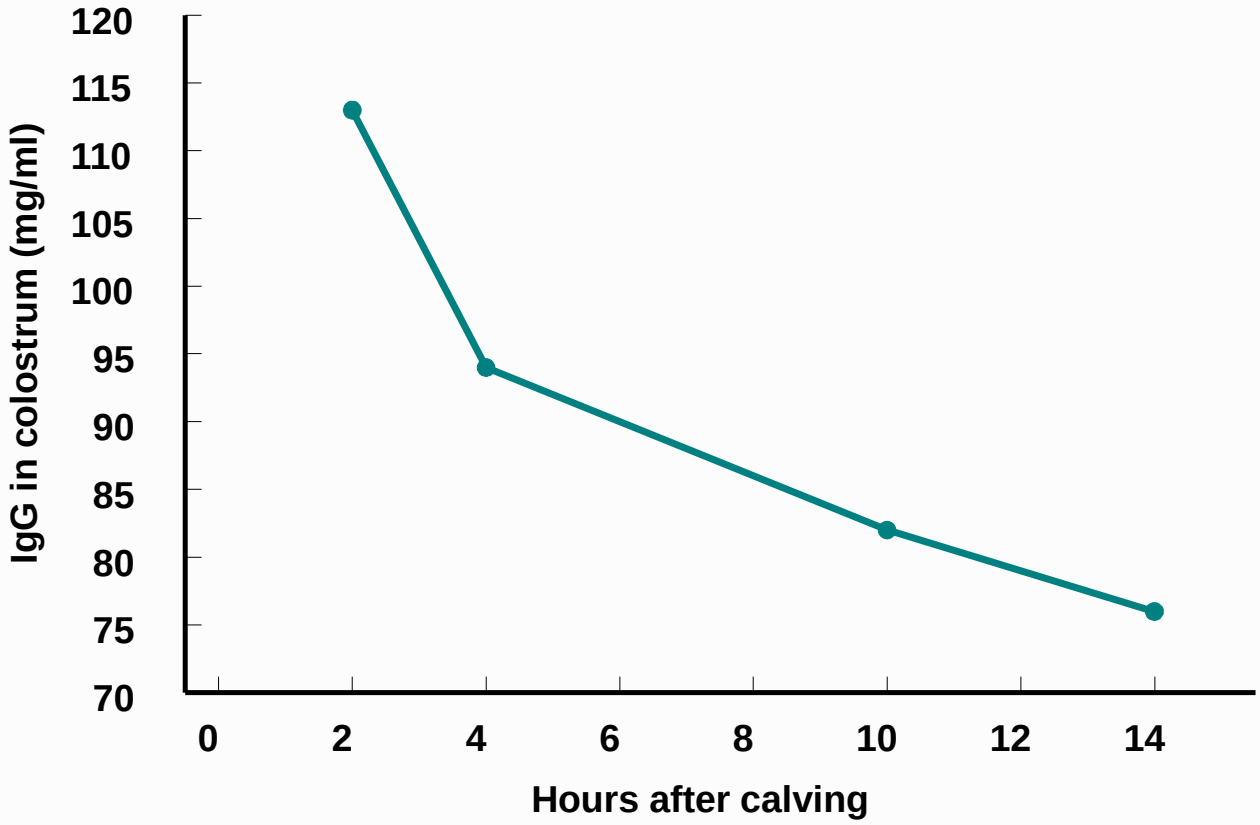
Larson et al. 1980. J. Dairy Sci.

Bovine and human colostrum are not the same

Species	Ig	Concentration (mg/ml)		% of total Ig	
		Colostrum	Milk	Colostrum	Milk
Bovine	IgG_1	47.60	0.59	81.0	73.0
	IgG_2	2.90	0.20	5.0	2.5
	IgA	3.90	0.14	7.0	18.0
	IgM	4.20	0.05	7.0	6.5
Human	Ig G	0.43	0.04	2.0	3.0
	IgA	17.35	1.00	90.0	87.0
	IgM	1.59	0.10	8.0	10.0

Larson et al. 1980. J. Dairy Sci

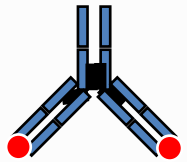
Colostrum – why only the first few milkings?

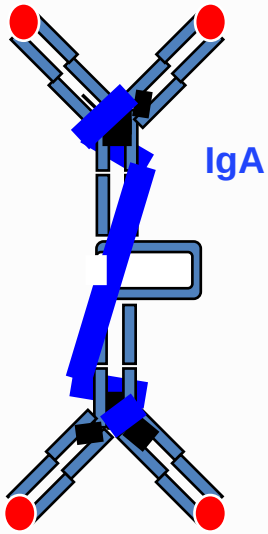


Moore et al. 2005. J. Am. Vet. Med. Assoc.

Colostrum bioactivity

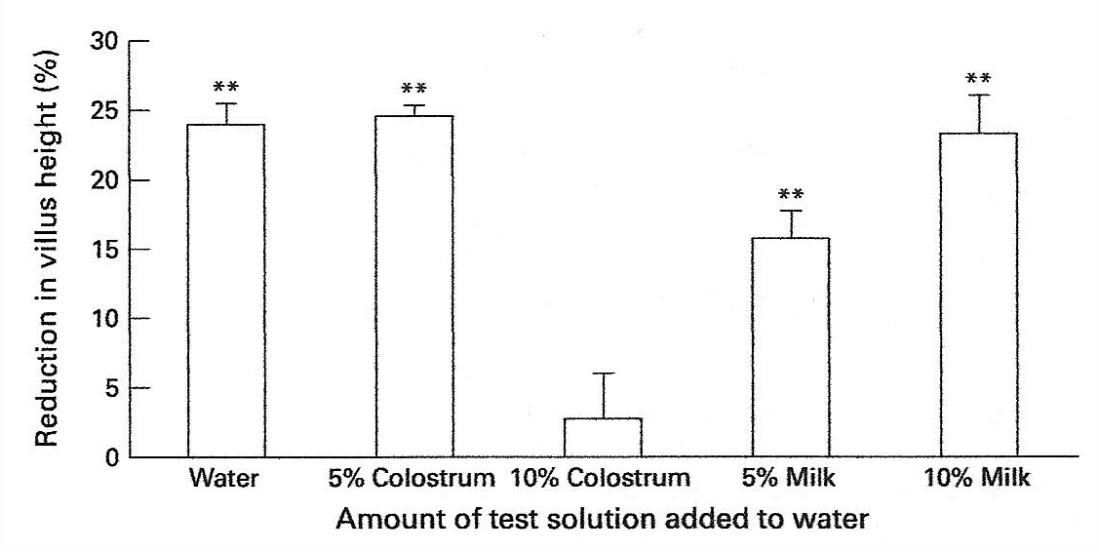
- Many bioactive molecules
- High concentration (compared to milk)
- Increasing body of scientific support
  - PUBMED (3 March 2013) – 7057 hits for “colostrum”
- Possible beneficial role in:
  - Diabetes Type 2
  - Increase in lean body mass
  - Sports performance
  - Immune function
  - Gut health





Colostrum – gut health: intestinal villus height

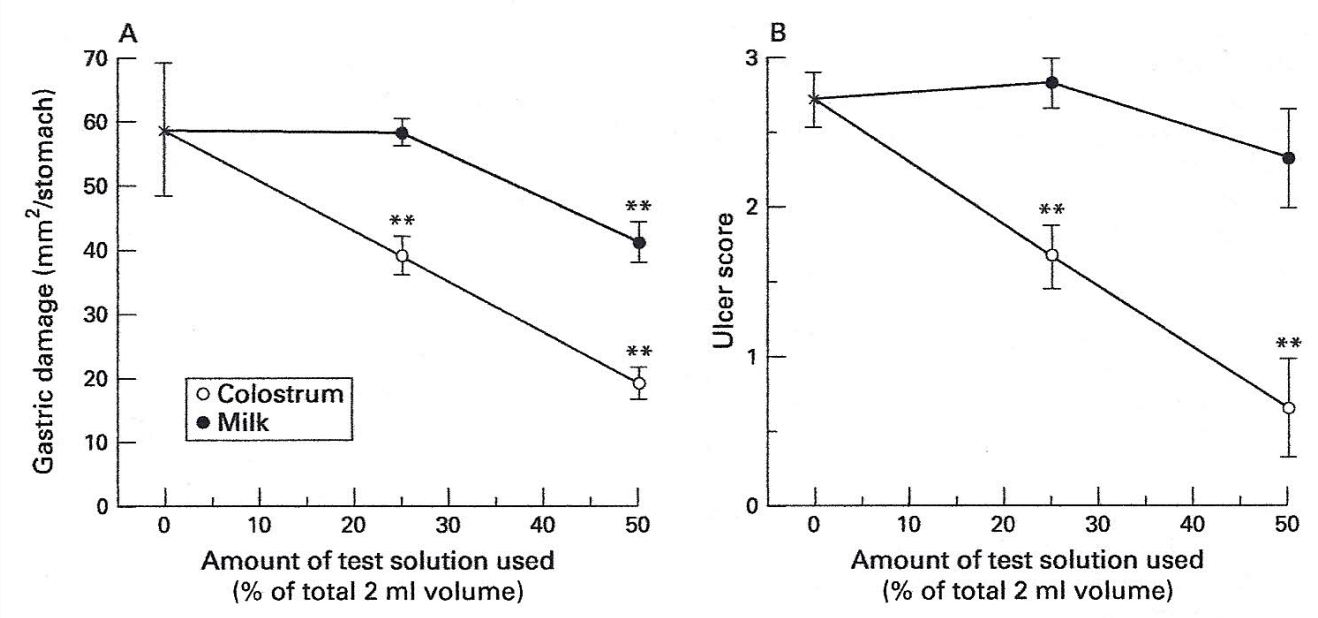
Indomethacin challenge



Playford et al. 1999. Gut

Colostrum – gut health: intestinal permeability

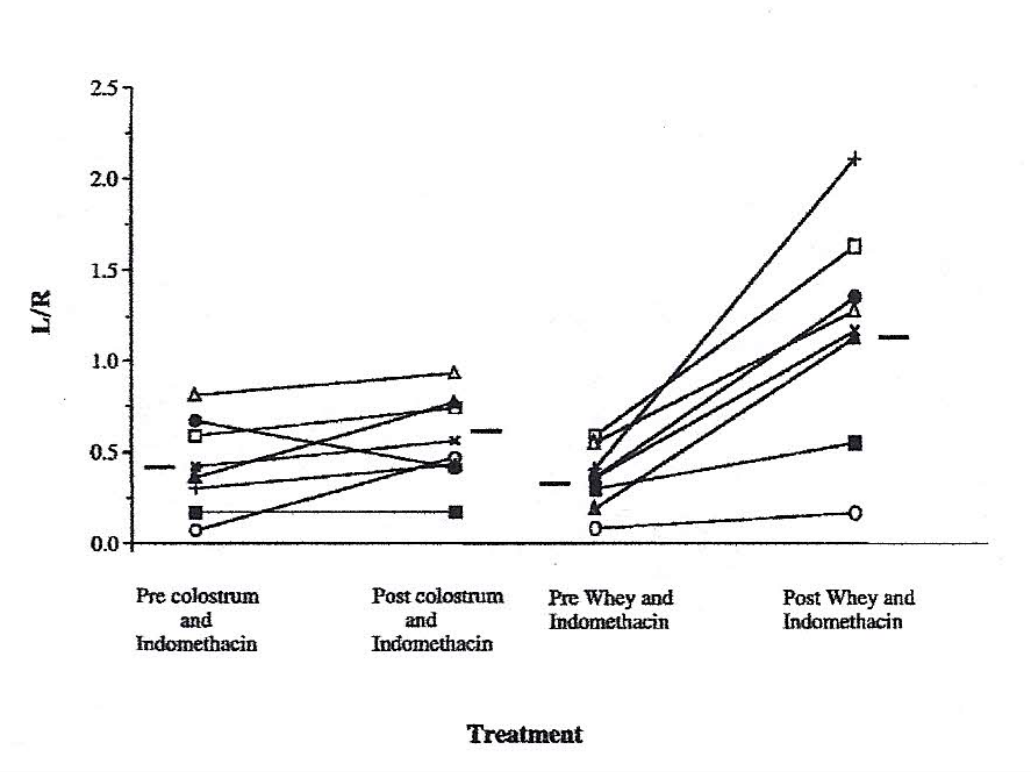
Indomethacin challenge



Playford et al. 1999. Gut

Colostrum – gut health: intestinal permeability

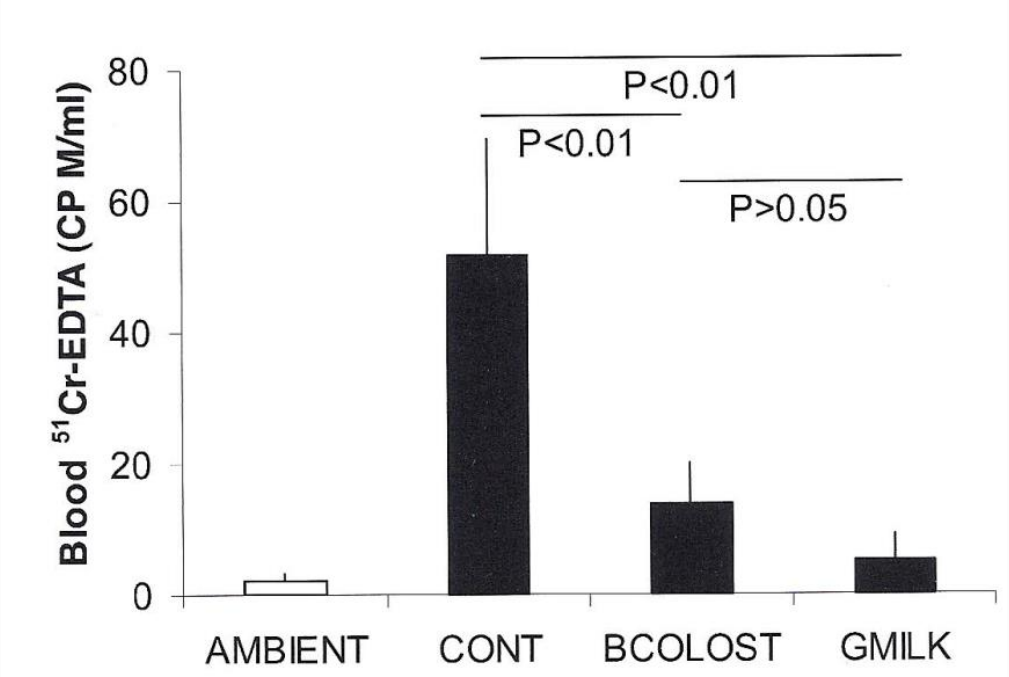
Indomethacin challenge in healthy humans volunteers



Playford et al. 2001. Clin. Sci.

Colostrum – gut health: effect of heat stress

Indomethacin challenge in rats



Prosser, Stelwagen et al 2004. J. Appl. Physiol.

Colostrum – gut health: Necrotizing enterocolitis (NEC)

- NZ study
- Bacteria isolated from babies with NEC
- Cultured with HT-29 cells
- Measured bacterial attachment

BACTERIA	UNTREATED	SKIM MILK	COLOSTRUM
Enterobacter cloacae	12.73	11.16	5.63
Escherichia coli	9.53	8.45	3.78
Klebsiella oxytoca	13.55	12.51	6.14
K. pneumoniae	14.88	13.26	5.33
Serrantia marcescens	11.76	11.00	4.00

Brooks et al. 2006. FEMS Immunol. Med. Microbiol.

Colostrum

- Significant value-add potential
- A lot of “hype”, not always supported by scientific evidence!
- Good underpinning science is crucial.
- Key areas are:
  - Gut health and function
  - Imune health
  - Elderly!

Outline of presentation

- Milk production and composition
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- **Infant formula**
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Infant formula

- **Mother milk is best. Without a doubt!**
- **Infant formula: match the composition as close as possible to that of mother milk.**
  - **Protein is key**
  - **Content AND amino acid profile**
- **Dairy-based formulas are the next best thing**
  - **Whey, α-lactalbumin, lactoferrin**

Bovine *vs.* Human – gross composition

COMPONENT	BOVINE MILK	HUMAN MILK
Water (%)	87.3	87.1
Fat (%)	3.9	4.5
Lactose (%)	4.6	7.1
Ash (%)	0.7	0.2
Protein (%)	3.3	0.9
- Casein (%)	2.65	0.25
- Whey (%)	0.65	0.63
- α-Lac (% of whey)	18	30
- Lactoferrin (% of whey)	trace	27
Whey : Casein		
- Start of Lactation	20 : 80	~80 : 20
- Mature milk	20 : 80	~60 : 40
- Late lactation	20 : 80	~50 : 50

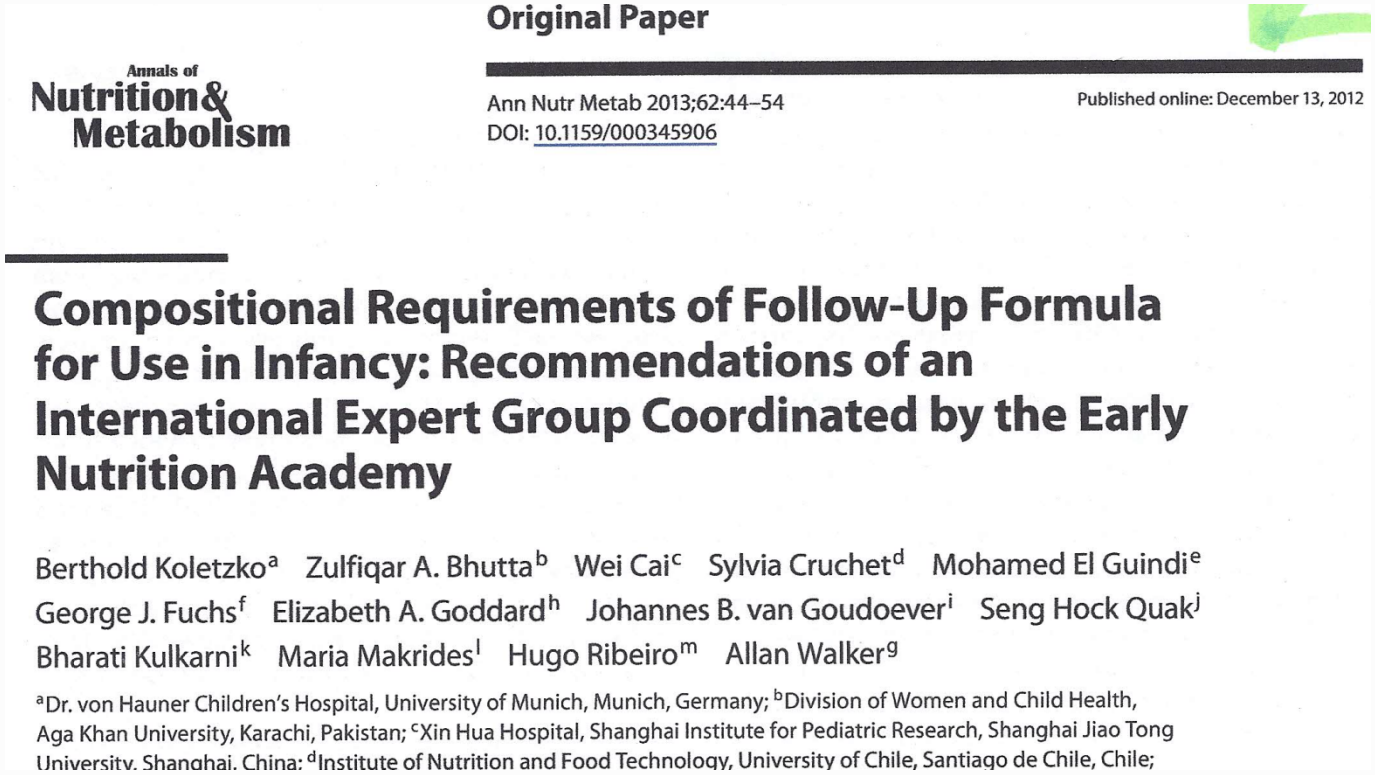
Source: various

Bovine *vs.* Human – other key differences

In human milk:

- **α-lactalbumin is the most abundant protein**
  - **Level of arginine in bovine α-Lac is only 25% of that in human α-lac**
- **Lactoferrin is second most abundant protein**
- **No β-lactoglobulin**
- **No α-Casein**
- **Contains high level of free AA (esp. glutamine, glutamate, taurine)**
- **Low total protein level (0.9%)**
  - **Formula often aim for 1.5%**

New Follow-On recommendations just published



Original Paper

Annals of Nutrition & Metabolism

Ann Nutr Metab 2013;62:44–54
DOI: 10.1159/000345906

Published online: December 13, 2012

Compositional Requirements of Follow-Up Formula for Use in Infancy: Recommendations of an International Expert Group Coordinated by the Early Nutrition Academy

Berthold Koletzko[a] Zulfiqar A. Bhutta[b] Wei Cai[c] Sylvia Cruchet[d] Mohamed El Guindi[e] George J. Fuchs[f] Elizabeth A. Goddard[h] Johannes B. van Goudoever[i] Seng Hock Quak[j] Bharati Kulkarni[k] Maria Makrides[l] Hugo Ribeiro[m] Allan Walker[g]

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New Zealand pushed for changes!

New Follow-On recommendations – key changes

INGREDIENT	CHANGE From: CODEX STAN 156-1987	MINIMUM	MAXIMUM
Cow's milk protein (g/100kJ)	↓ min, max	0.4	0.6
DHA (% of fat)	Now max	NS	1.0
Vitamin D3 (µg/100kJ)	↑ max	0.25	1.1
Ca (mg/100kJ)	↓min, now max	11	43
Mn (µg/100kJ)	Now max	NS	24
Choline (mg/100kJ)	↑ max	1.7	36
Total nucleotides (mg/100kJ)	↓ max	0	2.58

Koletzko et al. 2013. Ann. Nutr. Metab.

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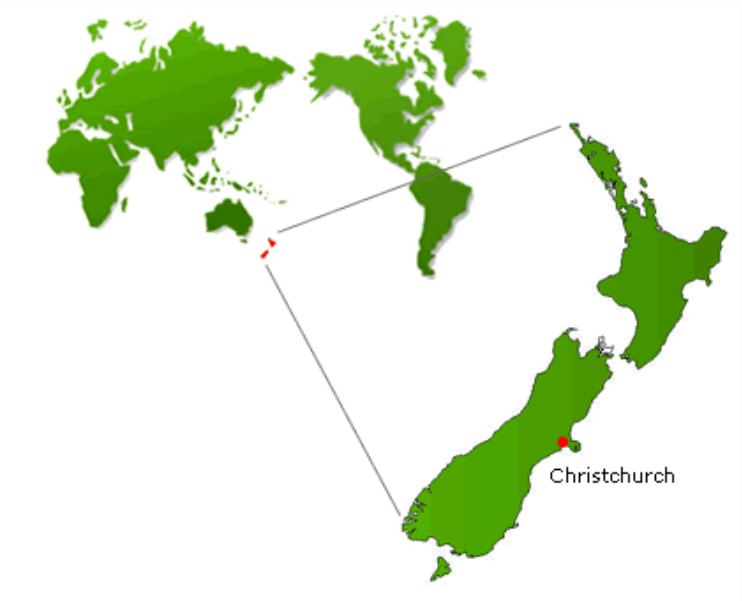
NZ's competitive advantage



- Land area
  - NZ 269,760 sq km
  - UK 244,820 sq km
- 4.4 M people
  - 4.5 M dairy cows
  - 32.4 M sheep
- Plenty of:
  - Clean air
  - Fresh water
  - Green grass

Building credibility with the CONSUMER

- Science:
  - Products need to be based on scientific underpinning
    - In vitro
    - In vivo
  - Science may already be there
  - Can be expensive, but necessary (e.g. DGC)
  - How does it compare with human milk?

Human milk and host-defense factors

- Waikato Hospital Neonatal Intensive Care Unit

- Milk collected from mothers:
  - Term at 37+ wk (n=10)
  - Premature at 32-36 wk (n=10)
  - Premature at 28-32 wk (n=10)
- Milk samples at wk 2 and wk 5 of lactation
- sIgA, IgG, Lf, SC, C3

Observations:

- Considerable variation between mothers
- All host-defense proteins expressed at every stage
- Levels decrease from 2 to 5 wk, except in 28-32 wk group

Broadhurst et al. 2012. NZ Med J

Building credibility with the CONSUMER (cont'd)

- Reputation:
  - MPI ("NZFSA")
  - NZ dairy experts to >140 countries
- Proactive – e.g DCD
  - Advanced technology
  - Trade-barriers
- Made in/from NZ
- Originality
  - Consumer wants to know where the product comes from
  - Guarantee the product comes from NZ
    - Oritain Global Ltd

"Discover which farmer supplied your milk"

“Companies will need to understand that their products are less important than their stories”

Rolf Jensen, Copenhagen Institute for Future Studies, author of The Dream Society

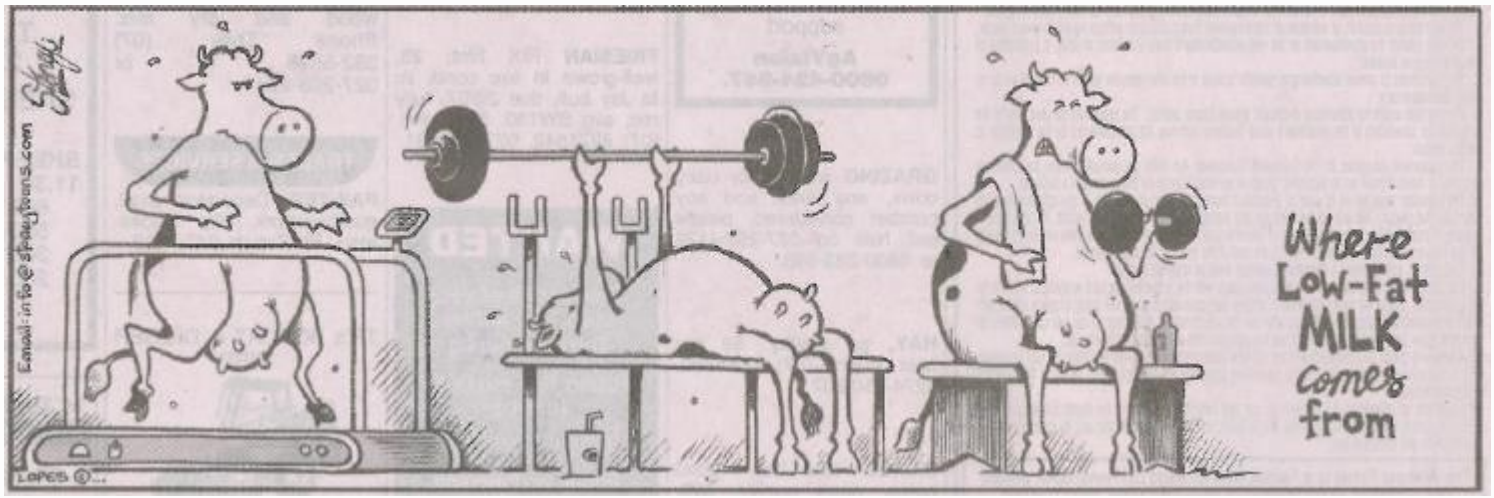
Summary

- Milk (incl. colostrum) is a natural product
- A very complex liquid
- Many bioactive components and fractions
- This + NZ image make for a good story – a NZ story!
- Growing market (esp. elderly)

Don't forget:

- Need scientific underpinning
- Guaranteed origin
- Credibility with the consumer

Thank you



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