The Growth Components of Milk

Dairy Nutrition: An engine for Economic Growth
Boise Idaho May 2017

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Child undernutrition < 5y

- 165 mill stunted
- 33 mill moderately wasted - MAM
- 19 mill severely wasted - SAM
- 3.1 mill deaths due to undernutrition

Milk has an important role in treatment

Ethiopia 1985
Effect of scale up on deaths - children < 5 y

Lancet series 2013 - Bhutta et al: Interventions

500,000 deaths can be saved each year if management of SAM and MAM and complementary feeding is optimal
What are the growth components in milk?

- **Protein** – DSM and Whey
- **Lactose**
- **Minerals** – Permeate
- Bioactive peptides
- Less antinutrients
Protein energy percentage from milk in foods for MAM and SAM

- Therapeutic formula (F-100) 100%
- RUTF or LNS - typically 40-50%
- CSB++ (Super cereal plus) 20%
• Improves weight gain, linear growth, and recovery from malnutrition
• Improves the protein quality, measured as PDCAAS/DIAAS
• With improved protein quality it is possible to reduce the total amount of protein in the blend, which could have potential metabolic advantages.
• Allows for a reduced content of soy and cereal and thereby a reduction of potential anti-nutritional effects
• Improves flavor; SMP more so than WPC
• Increases the price considerably – limiting factor in food aid
• Adds lactose which potentially have positive effects
Using whey (WPC34%) compared with SMP

- Slightly better protein quality measured as PDCAAS, but not likely to be important.
- Potential beneficial effects on the immune system and muscle synthesis have been suggested, but convincing evidence still lacking.
- Not as widely available as SMP
- Price lower than SMP?

Modified from Hoppe et al.
J Nutr 2008
Whey and muscle mass
Whey and muscle synthesis

- Increase in muscle mass beneficial in malnutrition
- Aminoacid pattern (espec. BCAAs) of whey protein is similar to skeletal muscle
- Whey seems to stimulate insulin and thus protein synthesis
- Most data from sport nutrition show convincing positive effect of intake of whey
  - but only immediately after endurance training
- Whey contains arginine and lysine which stimulates growth hormone, an anabolic hormone - speculative
- Effects of encouraging physical activity during whey supplementation?

Skimmed milk powder might have comparable effects on muscle mass?
Cow’s milk and growth

Cow’s milk
Protein (whey-casein)
Peptides/bioactive factors
Minerals - Lactose

Mainly whey?
Mainly casein?

Insulin
IGF-I

Growth Hormone
Programming effect?

Linear Growth
Lean mass accretion

Positive effect
Negative effect

Hoppe et al
EJCN 2005
What are the growth components in milk?

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- Less antinutrients
Is lactose a problem in undernourished children?
Focus on MAM and SAM < 3 y

Food Nutr Bull 2016

Undernourished Children and Milk Lactose

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Denmark 2017

Ethiopia 1985
Effects of lactose

• Potential negative effects
  – Lactose intolerance

• Potential positive effects
  – Prebiotic effects
  – Increased mineral absorption
  – Improved growth? (pig studies)
  – Energy density, palatability and dental effects
### Definitions

<table>
<thead>
<tr>
<th>Lactose intolerance</th>
<th>GI symptoms: abdominal pain, diarrhea, nausea, flatulence after ingestion of lactose. Depends on the amount of lactose ingested and residual lactase activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactose malabsorption</td>
<td>Occurs when the capacity of the small intestine to hydrolyze the ingested amount of lactose is exceeded</td>
</tr>
<tr>
<td><strong>Primary lactase “deficiency”</strong></td>
<td>Genetically programmed reduction of lactase activity after weaning</td>
</tr>
<tr>
<td><strong>Secondary lactase deficiency</strong></td>
<td>Temporary lactase deficiency as a consequence of small bowel injury, e.g., acute gastroenteritis, persistent diarrhea, enteropathies</td>
</tr>
</tbody>
</table>

**Balance**

**Preterm infants and breastfeeding**

**No symptoms before 3-4 years**
Primary lactase deficiency
– no symptoms before 3-4 y

Figure 1 Interpolated map of Old World LP phenotype frequencies. Dots represent collection locations. Colours and colour key show the frequencies of the LP phenotype estimated by surface interpolation.
Lactose malabsorption causes prebiotic effects

- Non digested lactose continues to the large intestine
- Lactose is hydrolyzed and fermented to SCFAs and gas ($CO_2$, $H_2$, $CH_4$)
- Reduces pH
- Preterm infants - 50-70% lactose passes into the large intestine
- Term infants – some lactose passes to the large intestine?

Klein J Nutr 2002

After He et al 2008
Prebiotic effects of lactose

• Buturate (SCFA) is an important fuel for colonocytes

• Lactose passing to the colon seems to stimulate a beneficial flora with more bifidobacteria and lactobacillla and less E.coli and bacteroides

• In maldigestion lactose content should be balanced between beneficial probiotic effects and osmotic diarrhea
Lactose stimulate weight gain in studies of weanling piglets

• Whey used to feed piglets for decades - very effective in stimulating weight gain
• Discussed if the effect is due to whey protein or lactose
• Several studies suggest that the lactose fraction has an important effect and some suggest that the lactose effect is stronger than the protein effect
• Growth effect stronger in younger piglets
Lactose to piglets during weaning

- 1320 crossbred pigs were studied at 3 sites
- Pigs were weaned at 15 – 20 days
  - Phase 1: 20% lactose (week 1 after weaning)
  - Phase 2: 15% lactose (week 2 after weaning)
  - Phase 3: Randomized to 0, 2.5%, 5%, 7.5%, 10% lactose (w 3 + 4 after weaning)
  - Corn substituted by equal amounts of permeate
Lactose to piglets during weaning

Average daily weight gain and average daily feed intake increased linearly (p<0.05) with increasing levels of lactose in phase 3.

Highest lactose content
- 350 g of additional body weight
- 420 g additional feed intake

Does lactose have a positive effect on growth in undernourished children?
<table>
<thead>
<tr>
<th>Type</th>
<th>Percent of Energy from Lactose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human milk</td>
<td>≈40 E%</td>
</tr>
<tr>
<td>Cows milk</td>
<td>≈25 E%</td>
</tr>
<tr>
<td>F-100</td>
<td>16 E%</td>
</tr>
<tr>
<td>RUTF</td>
<td>up to 11 E%</td>
</tr>
<tr>
<td>F-75</td>
<td>6 E%</td>
</tr>
<tr>
<td>CSB++</td>
<td>4 E%</td>
</tr>
</tbody>
</table>
## Sources of lactose for food aid

### Lactose in SMP and Whey

<table>
<thead>
<tr>
<th>w/w%</th>
<th>SMP</th>
<th>WPC34</th>
<th>WPC80</th>
<th>WPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactose</td>
<td>50</td>
<td>50</td>
<td>10</td>
<td>≈1</td>
</tr>
</tbody>
</table>

### Permeate

**Crystalline lactose**
Conclusions on lactose

- Lactose intolerance can be a problem during initial treatment of children with SAM with GI problems
- Lactose content in breastmilk is high (≈40 E%); Infants and young children with MAM and SAM tolerate breastmilk well
- Lactose in foods to infants and young children is likely to have beneficial effects:
  - Modify microbiota – prebiotic effect
  - Increase mineral absorption
  - Improve energy density and taste
  - Improve dental health
  - Might increase growth? (piglets)
Conclusions on lactose

• Lactose content in foods for MAM and SAM can be increased by choosing protein sources with high content (WPC34 and SMP) or permeate
• Optimal amount of lactose need to be determined
• Guestimate:
  – 5 E%?
  – 15 E% as in F-100?
  – Higher and closer to breastmilk (40 E%)?
What are the growth components in milk?

- **Protein** – DSM and Whey
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Characteristics of nutritional deficiency

Type I nutrients

• Late or no growth response
• Tissue level variable
• Characteristic physical signs
• Stored in body
  – Selenium
  – Iron
  – Copper
  – Calcium
  – Retinol
  – Tocopherol
  – +others

Type II nutrients

• Immediate growth response
• Tissue level fixed
• No characteristic signs
• No body store
  – Nitrogen
  – Sulphur
  – Essential amino acids
  – Potassium
  – Sodium
  – Magnesium
  – Zinc
  – Phosphorus
Minerals for growth (type II)

High content of bioavailable minerals in cow’s milk

- Potassium
- Phosphorus
- Zinc

SMP contains twice the amount of minerals compared to WPC34%

Low S-phosphate predicts death in malnourished children

Evaluation of whey permeate in the treatment of moderate malnutrition
Department of Human Nutrition

Prepared by Benedikte Grenov, Anne-Louise Hother Nielsen, Christian Mølgaard and Kim Fleischer Michelsen for Arla Foods Ingredients Group P/S

http://www.arlafoodsingredients.com
Permeate contains 85% lactose and minerals important for growth (type II)

<table>
<thead>
<tr>
<th>Mg per 100 g powder</th>
<th>Permeate</th>
<th>Permeat content relative to SMP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>1715</td>
<td>107</td>
</tr>
<tr>
<td>Magnesium</td>
<td>121</td>
<td>110</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>636</td>
<td>67</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.1</td>
<td>2</td>
</tr>
<tr>
<td>Calcium</td>
<td>554</td>
<td>45</td>
</tr>
<tr>
<td>Sodium</td>
<td>575</td>
<td>132</td>
</tr>
</tbody>
</table>
Minerals in whey permeate and SMP

- Milk products contain important growth minerals including phosphate, magnesium and potassium
- High bioavailability
- Bioavailability might be increased through interaction with lactose
- Content should be adjusted to recommended levels in foods for MAM and SAM
- Relative high sodium content is a limitation in whey permeate – up to 20% w/w whey permeate in FBF seems to be OK
Cow’s milk and..
Linear growth and stunting
Adult stature
Cow’s Milk and Linear Growth in Industrialized and Developing Countries


• The strongest evidence that cow’s milk stimulates linear growth comes from observational and intervention studies in low-income countries
• Many observational studies from well-nourished populations also show an association between milk intake and linear growth
• These results suggest that milk has a growth-stimulating effect even in situations where the nutrient intake is adequate.

Strong evidence that cows milk stimulate linear growth
Height and serum IGF-I levels according to milk intake in 2.5 y old healthy children

95 % confidence intervals, controlled for sex and body weight

Hoppe et al, AJCN 2004
Continuing positive Secular Growth Change in The Netherlands 1955-1997
Fredriks et al, Ped Res 2000;47:316-23

Suggests that the explanation for the Dutch population being the tallest in the world could be a high consumption of dairy products, one of the highest in the world
245 ml milk daily results in an increase of 0.4 cm/y
Conscript height (cm)

NL: 320L
DK: 295L
S: 355L
P: 222L
F: 260L
I: 256L
ES: 177L
N: 261L

L/capita/year

ChartsBin.com

Bernhard Watzl

Schmidt et al
Annals Human Biology 1995
# A century of trends in adult human height

**NCD Risk Factor Collaboration (NCD-RisC)**

1472 population-based studies, with more than 18.6 million participants born between 1896 and 1996 in 200 countries.

## Tallest men
1. Netherlands – 182.5 cm
2. Belgium
3. Estonia
4. Latvia
5. Denmark

## Tallest women
1. Latvia – 170.0 cm
2. Netherlands
3. Estonia
4. Czech Republic
5. Serbia

## Shortest
- East Timor – 160 cm
- Guatemala – 149 cm
Authors: 800+  – 9 pages
Decreasing trend in adult stature in some African countries since the 60’ies
Major correlates of male height: A study of 105 countries

P. Grasgruber*, M. Sebera, E. Hrazdíra, J. Cacek, T. Kalina

Faculty of Sports Studies, Masaryk University, Kamenice 5, 625 00 Brno, Czech Republic

Economics and Human Biology 2016

Three “fundamental” types of diet

Dairy and animal protein
Europe and the US

Wheat
North Africa and Near East

Rice
Tropical Asia

Causality?
Key Collaborators

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