Between Ewe and Me

Composition and health benefits of sheep’s milk

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AgResearch Grasslands
Objectives

• A comprehensive review of the available scientific literature regarding the composition and nutritional value of sheep milk, and what distinguishes it from cow and goat milk.

• Jointly funded by Blue River Nutrition and AgResearch

![Cow vs. Sheep vs. Goat](image)
Overview

Literature search
• Databases and search strategy used
• Search results

Review to date

Composition
• Basic composition
• Amino acids
• Lipids and fatty acids

Nutritional value / health benefits
• Digestibility
• Allergy
• Bioactive compounds
Literature search strategy

CAB Abstracts, Biosis Previews, Food Science & Technology Abstracts, Medline, Scopus

Initial search strategy

• Keyword, title & abstract searches using combinations of the following
  • (ovine and bovine and caprine and milk) or (sheep and goat and cow and milk) or (sheep's and goat's and cow's and milk);
  • (composition or component/s or comparison or comparative);
  • (health benefit/s or nutritional quality or human nutrition or human health or nutritional study or nutritional value or health effect/s).

• Search strategy subsequently refined as follows:

  COMPOSITION
  NUTRITIONAL VALUE / HEALTH EFFECTS
  TOTAL MILK SOLIDS
  DIGESTIBILITY
Literature search results

>500 references found to date

• Composition
  • 235 English language
  • 98 not English language

• Health benefit
  • 71 English language
  • 14 not English language

• Specific to sheep (no comparison with cow or goat)
  • 139

• Allergy
  • 58
Composition

- Basic composition
- Amino acids
- Lipids and fatty acids
## Basic milk composition

<table>
<thead>
<tr>
<th>Component</th>
<th>Cow (g/L)</th>
<th>Goat (g/L)</th>
<th>Sheep (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solids</td>
<td>120</td>
<td>140</td>
<td>190</td>
</tr>
<tr>
<td>Protein</td>
<td>35</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Fat</td>
<td>40</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Lactose</td>
<td>50</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>Energy</td>
<td>2,800</td>
<td>2,800</td>
<td>4,200</td>
</tr>
<tr>
<td>Calcium</td>
<td>120</td>
<td>130</td>
<td>200</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>120</td>
<td>120</td>
<td>140</td>
</tr>
</tbody>
</table>

References:
Amino acid composition

<table>
<thead>
<tr>
<th>Amino acid (mg/100 g milk)</th>
<th>Cow</th>
<th>Goat</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alanine</td>
<td>100</td>
<td>118</td>
<td>269</td>
</tr>
<tr>
<td>Arginine</td>
<td>110</td>
<td>118</td>
<td>198</td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>260</td>
<td>210</td>
<td>328</td>
</tr>
<tr>
<td>Cysteine</td>
<td>20</td>
<td>46</td>
<td>35</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>770</td>
<td>626</td>
<td>1019</td>
</tr>
<tr>
<td>Glycine</td>
<td>60</td>
<td>50</td>
<td>41</td>
</tr>
<tr>
<td>Histidine*</td>
<td>100</td>
<td>98</td>
<td>167</td>
</tr>
<tr>
<td>Isoleucine*</td>
<td>140</td>
<td>207</td>
<td>338</td>
</tr>
<tr>
<td>Leucine*</td>
<td>290</td>
<td>314</td>
<td>587</td>
</tr>
<tr>
<td>Lysine*</td>
<td>270</td>
<td>290</td>
<td>513</td>
</tr>
<tr>
<td>Methionine*</td>
<td>60</td>
<td>80</td>
<td>155</td>
</tr>
<tr>
<td>Phenylalanine*</td>
<td>160</td>
<td>155</td>
<td>284</td>
</tr>
<tr>
<td>Proline</td>
<td>320</td>
<td>368</td>
<td>580</td>
</tr>
<tr>
<td>Serine</td>
<td>160</td>
<td>181</td>
<td>492</td>
</tr>
<tr>
<td>Threonine*</td>
<td>150</td>
<td>240</td>
<td>268</td>
</tr>
<tr>
<td>Tryptophan*</td>
<td>50</td>
<td>44</td>
<td>84</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>150</td>
<td>179</td>
<td>281</td>
</tr>
<tr>
<td>Valine*</td>
<td>160</td>
<td>240</td>
<td>448</td>
</tr>
</tbody>
</table>

# Lipids and fatty acids

<table>
<thead>
<tr>
<th>Component</th>
<th>Cow</th>
<th>Goat</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fat (g/L)</td>
<td>40</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Saturated fatty acids (% of total fatty acids)</td>
<td>56-73</td>
<td>60-74</td>
<td>58-75</td>
</tr>
<tr>
<td>Monounsaturated fatty acids (% of total fatty acids)</td>
<td>23-30</td>
<td>23-40</td>
<td>22-36</td>
</tr>
<tr>
<td>Polyunsaturated acids (% of total fatty acids)</td>
<td>2.4-6.3</td>
<td>2.5-7.3</td>
<td>2.4-5.6</td>
</tr>
<tr>
<td>Linoleic acid ($C_{18:2}$) (% of total fatty acids)</td>
<td>1.2-3.0</td>
<td>1.9-4.3</td>
<td>1.6-3.6</td>
</tr>
<tr>
<td>Linolenic acid ($C_{18:3}$) (% of total fatty acids)</td>
<td>0.2-1.8</td>
<td>0.2-1.2</td>
<td><strong>0.5-2.3</strong></td>
</tr>
<tr>
<td>Conjugated linoleic acids (% of total fatty acids)</td>
<td>0.2-2.4</td>
<td>0.3-1.2</td>
<td>0.6-1.1</td>
</tr>
<tr>
<td>$n$-6:$n$-3 ratio</td>
<td>2.9</td>
<td>4.0</td>
<td><strong>2.4</strong></td>
</tr>
<tr>
<td>Cholesterol (mg/100 mL milk)</td>
<td>22</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Fat globule diameter ($\mu$m)</td>
<td>3.7</td>
<td>3.1</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Nutritional value / Health benefits

Digestibility

Allergy

Bioactive compounds
Health benefits - digestibility

Several factors influence the digestibility of milk, including:

- Curd formation in the stomach
- Differences in total protein composition
  - Casein content
  - Casein/whey protein ratio
- Micelle structure
  - Size
  - Casein distribution
  - Mineralization
- Differences in digestibility of individual proteins from different species
- Size of the milk fat globule

Health benefits - digestibility

Some differences are well established

• Goat and sheep β-lactoglobulin are more easily digestible than bovine
• Sheep and goat milk have smaller fat globules than bovine milk
• Bovine milk produces a firm and dense coagulum, while other species produce soft curds in the stomach, more like human milk, e.g.
  • Goat
  • Donkey
  • Camel

Still much that is not known about digestibility of sheep’s milk
• Opportunity?
Health benefits - allergy

• ~60 references relating to allergy

• Wide range of opinion expressed
  • “The milk of goat and sheep harbor an allergic potential and is not suitable for the nutrition of milk-allergic patients.”
  • “Goat's milk has a guaranteed space in the market, due of it is high biological value and low allergenicity.”

• In cases of severe cow’s milk allergy (CMA), very unlikely that sheep’s (or any other) milk would be suitable
  • High degree of cross-reactivity between different ruminant milks

• There are clearly cases of low-level CMA where goat’s or sheep’s milk can be tolerated
  • The cause of intolerance is a factor, e.g., sensitization due to childhood exposure

• Digestion may play a role – how different milks are digested influences how allergens are presented
Health benefits - allergy

• Caution must be exercised when making any claims around allergy, because it can have serious consequences

• MORE RESEARCH IS NEEDED
  • The level of data currently available is not sufficient
  • This may represent an opportunity for differentiation of sheep’s milk
Health benefits - bioactives

• 12 references relating to bioactive compounds

• Example: lactadherin
  • A major protein of the milk fat globule membrane
  • May act as a potent anti-viral agent in rotavirus-induced gastroenteritis
  • Lactadherin structure is species dependent
  • Potential functional differences in the biological function of lactadherin due to different isoforms

• Example: lactoferrin
  • Lactoferrin is a non-immunoglobulin defence protein found in milk
  • Peptides derived from lactoferrin have antibacterial properties
  • Lactoferrin level in sheep milk 4-fold higher than goat, 8-fold higher than cow
Health benefits - bioactives

• Example: Angiotensin converting enzyme (ACE) inhibitory peptides
  • ACE regulates several systems that affect blood pressure
  • ACE inhibitory peptides are of potential benefit for treating hypertension
  • Most research has been in bovine milk, but sheep (and goat) milk proteins are recognised as a potential source of ACE inhibitory peptides

• Example: Antithrombotic peptides
  • Cardiovascular diseases (e.g., thrombosis, or clotting) are important causes of adult mortality
  • Peptides derived from κ-casein have antithrombotic properties
  • Some evidence that ovine-derived peptide have a stronger effect than those from other species

Summary

Composition

• Appear to be clear differences in composition of sheep’s milk (total solids, amino acids, lipid profile) compared with other milk
• Many factors influence this, so a better picture of NZ sheep milk composition is needed to capitalize on these differences

Nutritional value / health benefits

• Early research suggests that sheep milk has many potential benefits (e.g., digestibility, allergy, bioactives)
• MORE RESEARCH IS NEEDED & WARRANTED
Acknowledgements

- Blue River Nutrition
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