



**Institute**  
for dairy nutrition and health

# Protein glycation in infant formula

For use by healthcare professionals only. Not for public display.





### Contact

The FrieslandCampina Institute provides nutrition and health professionals with extensive information about dairy, nutrition and health following the most recent scientific developments. This information is solely meant for professionals and not for consumers, clients or patients. Are you a nutrition or health professional who wants to know all about dairy, nutrition and health? Please contact the FrieslandCampina Institute.

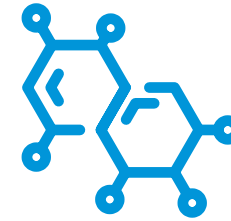
[www.frieslandcampinainstitute.com](http://www.frieslandcampinainstitute.com) • [institute@frieslandcampina.com](mailto:institute@frieslandcampina.com)

Follow us on social media:

**Twitter:** @FCInstitute\_Int • **Facebook:** /FrieslandCampinaInstitute

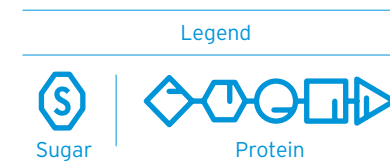
### Important note

Breastfeeding is the best nutrition for healthy growth and development of babies. Exclusive breastfeeding for six months is the optimal way of feeding infants. Thereafter infants should receive complementary foods with continued breastfeeding up to two years or beyond. Mothers should receive guidance on proper maternal nutrition in order to help sustain an adequate supply and quality of breast milk. Unnecessary introduction of bottle-feeding, partially or fully, or of other complementary foods and drinks may have a negative impact on breastfeeding, which may be irreversible. Mothers should consult their doctor and consider the social and financial implications before deciding to use breast milk substitutes or if they have difficulty breastfeeding. Usage, preparation and storage instructions of breast milk substitutes or of other complementary foods and drinks should be followed carefully as improper or unnecessary use may pose a health hazard.



Protein is an important nutrient in the diet of children, as protein helps in tissue building and growth.

Protein glycation is a reaction that happens during heat processing of infant formula in the factory. Due to glycation, the structure of proteins changes, which has implications on the digestibility and nutritional value of infant formula.



Poor digestibility of protein in infant formula



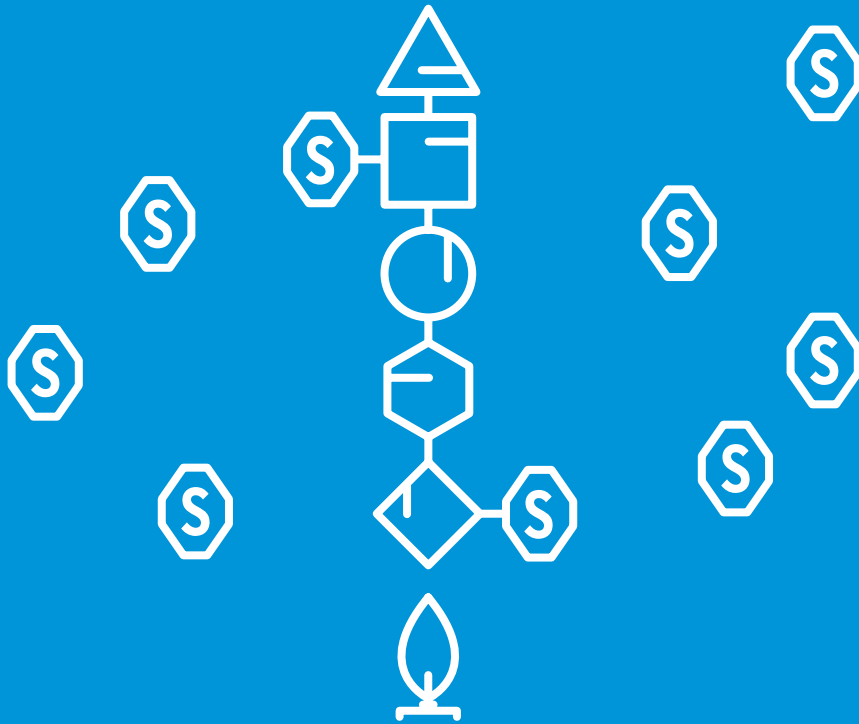
Milk contains **high-quality proteins**.  
When the structure of these proteins is  
modified, its **digestibility may be affected**.

Good digestibility of protein in infant formula



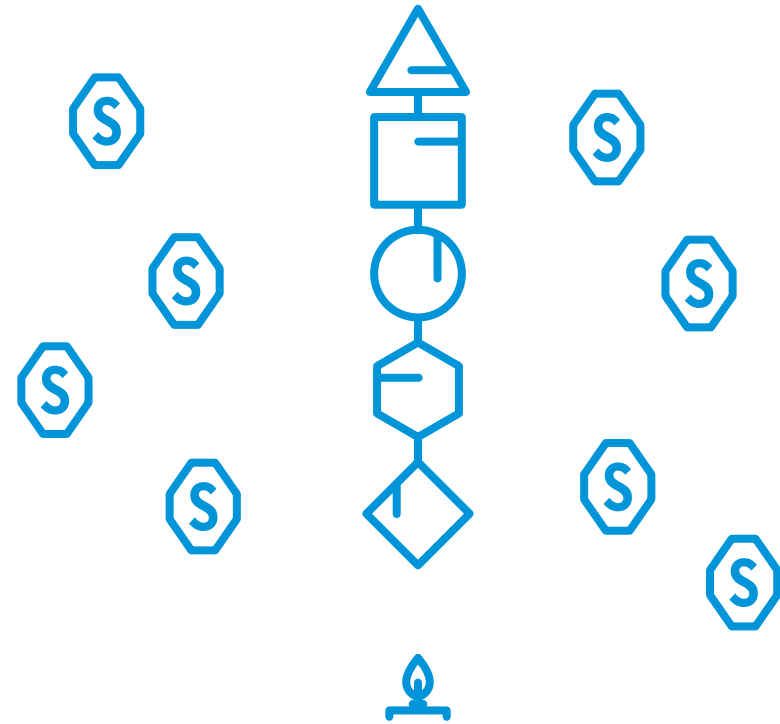
High-quality milk protein in  
natural structure can **easily**  
be **digested** by babies.

Poor digestibility of protein in infant formula



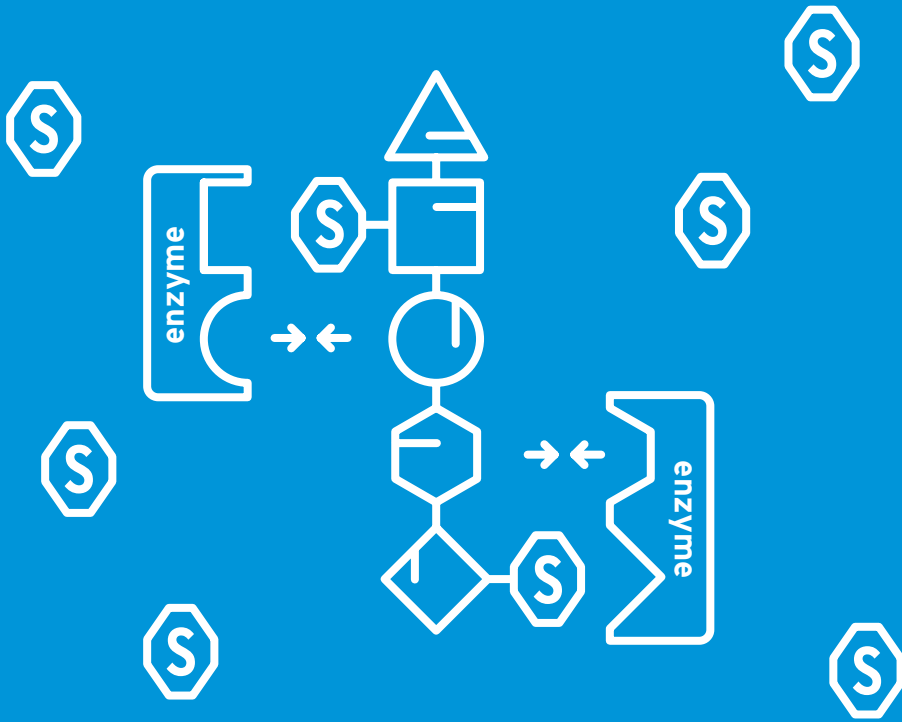
During **intensive heat treatment** of infant formula, a part of the milk proteins will react with a reducing sugar and form **glycated proteins**.

Good digestibility of protein in infant formula



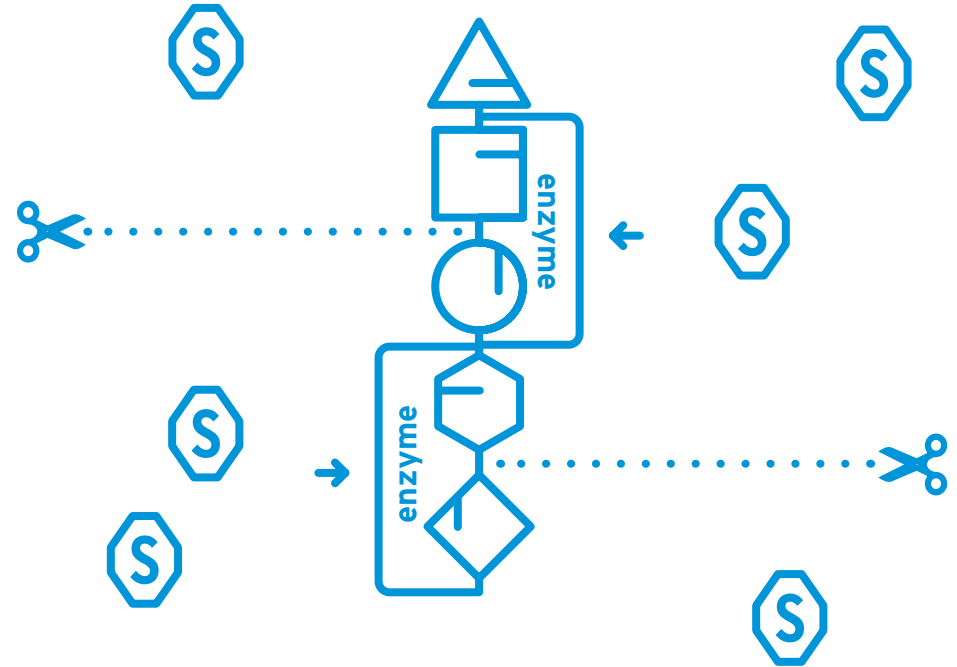
During **mild heat treatment**, less glycation will occur. Non-glycated milk proteins remain in their **natural structure**.

Poor digestibility of protein in infant formula



Due to **glycation**, some of the enzyme cleaving sites are either blocked or hidden, which **prevents digestive enzymes from cleaving** to these sites.

Good digestibility of protein in infant formula



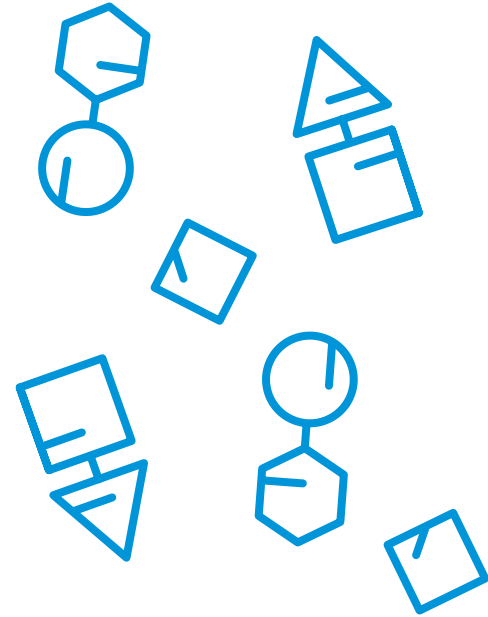
When **no glycation** occurs, enzyme cleaving sites are accessible to digestive enzymes **to cleave the protein**.

Poor digestibility of protein in infant formula



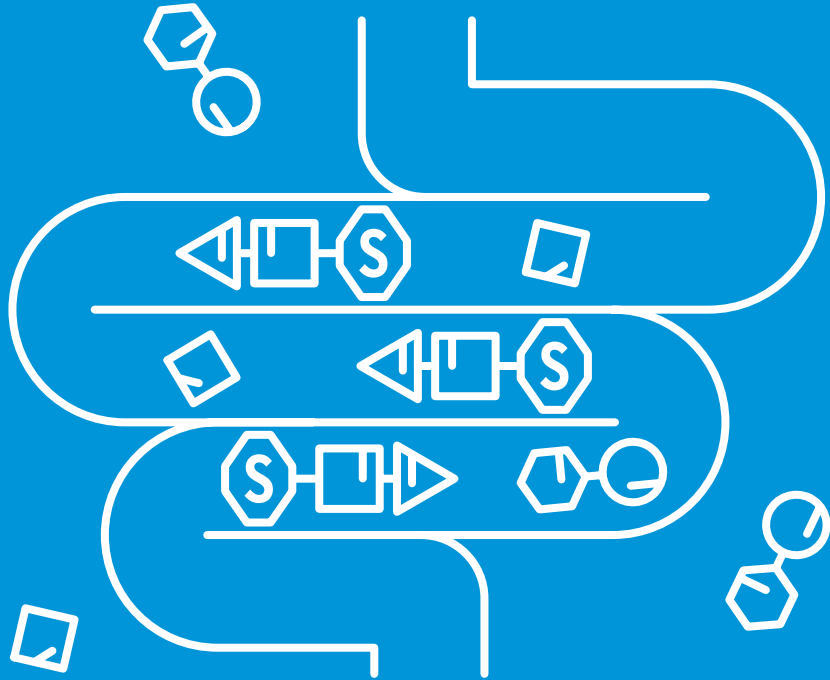
Glycated proteins are **not fully cleaved** to smaller structures and therefore larger structures remain intact, making them **less digestible**.

Good digestibility of protein in infant formula



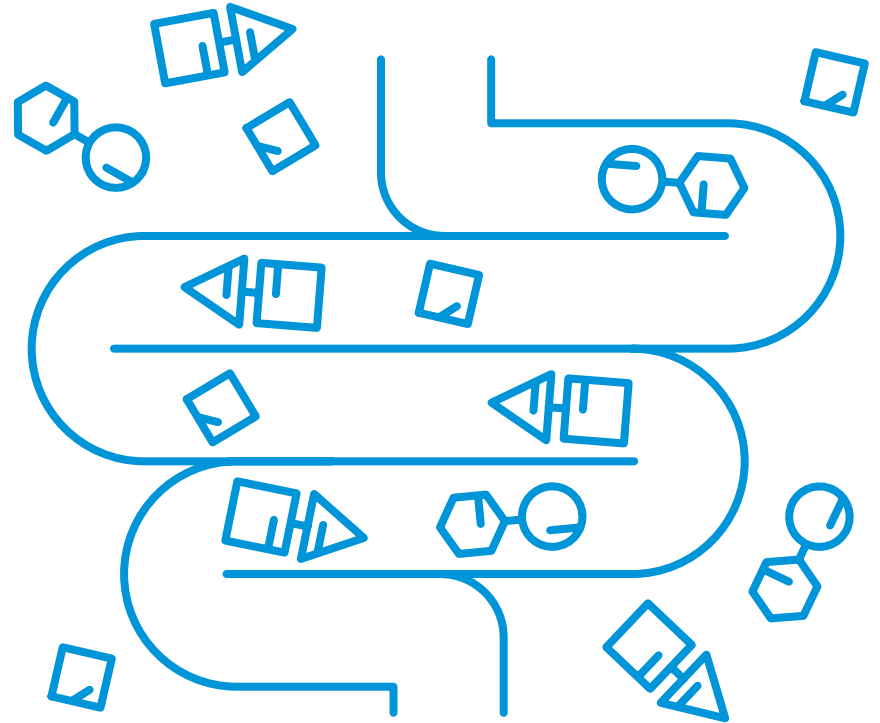
Non-glycated proteins are cleaved to smaller structures and are therefore **easy to digest**.

Poor digestibility of protein in infant formula



Glycation of the essential amino acid **lysine** makes it less available for the human body, and impairs the **nutritional value** of milk protein.

Good digestibility of protein in infant formula



When lysine is not glycosylated, it is **absorbed** by the digestive tract and available to the **human body**.

Poor digestibility of protein in infant formula



Infant formulas with **high levels** of glycation are **harder to digest** by babies and have a decreased amount of available lysine, providing a **lower quality protein**.

Good digestibility of protein in infant formula



Infant formulas with **low levels** of glycation are **easily digested** by babies and have a high amount of available lysine, providing **high quality protein**.



## References

1. Birlouez-Aragon, I., Pischetsrieder, M., Leclere, J., Morales, F. J., Hasenkopf, K., Kientsch-Engel, R., ... & Rutledge, D. (2004). Assessment of protein glycation markers in infant formulas. *Food Chemistry*, 87(2), 253-259.
2. Deng, Y., Wierenga, P. A., Schols, H. A., Sforza, S., & Gruppen, H. (2017). Effect of Maillard induced glycation on protein hydrolysis by lysine/arginine and non-lysine/arginine specific proteases. *Food hydrocolloids*, 69, 210-219.
3. Pinto, M. S., Léonil, J., Henry, G., Cauty, C., Carvalho, A. F., & Bouhallab, S. (2014). Heating and glycation of  $\beta$ -lactoglobulin and  $\beta$ -casein: Aggregation and in vitro digestion. *Food research international*, 55, 70-76.
4. Rérat, A., Calmes, R., Vaissade, P., & Finot, P. A. (2002). Nutritional and metabolic consequences of the early Maillard reaction of heat treated milk in the pig. *European journal of nutrition*, 41(1), 1-11.
5. Moughan, P. J., Gall, M. P., & Rutherford, S. M. (1996). Absorption of lysine and deoxyketosyllysine in an early-Maillard browned casein by the growing pig. *Journal of agricultural and food chemistry*, 44(6), 1520-1525.
6. Rutherford, S. M., & Moughan, P. J. (2008). Effect of elevated temperature storage on the digestible reactive lysine content of unhydrolyzed-and hydrolyzed-lactose milk-based products. *Journal of dairy science*, 91(2), 477-482.
7. Corzo-Martínez, M., Soria, A. C., Belloque, J., Villamiel, M., & Moreno, F. J. (2010). Effect of glycation on the gastrointestinal digestibility and immunoreactivity of bovine  $\beta$ -lactoglobulin. *International Dairy Journal*, 20(11), 742-752.
8. Seiquer, I., Díaz-Alguacil, J., Delgado-Andrade, C., López-Frías, M., Muñoz Hoyos, A., Galdó, G., & Navarro, M. P. (2006). Diets rich in Maillard reaction products affect protein digestibility in adolescent males aged 11-14 y. *The American journal of clinical nutrition*, 83(5), 1082-1088.

## Disclaimer

© FrieslandCampina 2019. Although FrieslandCampina has taken the greatest possible care in preparing this document, the information provided and/or displayed in this document may be incomplete or incorrect. The FrieslandCampina Institute assumes no responsibility with respect to any printing, spelling, typographical or other similar errors of any kind in materials published by it.