Technical information sheet

Dairy Goat Co-operative

Milk Fat Components in Goat Formulas

Background

Goat milk formula manufactured by Dairy Goat Co-operative (DGC) uses fresh whole goat milk as the key and characterising ingredient. This ensures that the natural components present in the goat milk, including the goat milk fat, are retained in the final formula and available for utilisation by the infant. This is a key point of difference to most other infant and follow-on formula products, which are produced without milk fat by using a combination of skim milk and whey or whey protein concentrate, with a blend of vegetable oils as the source of fatty acids.

The following summarises the information currently available about the main components of milk fat, their functions and potential advantages to infants and young children.

Fatty acids

Breast milk contains a different profile of fatty acids than either goat or cow milk. For instance, breast milk contains less saturated and medium chain fatty acids (MCFA), but more concentrations of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) (Harzer et al, (1983); Pugo-Gunsam et al, 1999; Haenlein, 2004). To compensate for this, the fatty acid composition of goat infant and follow-on formula is adjusted by the addition of selected vegetable oils to match the profile of breast milk as much as possible. The main requirement is to enhance the levels of polyunsaturated fatty acids linoleic acid (LA) and α-linolenic acid (ALA) (LSRO, 1998), but the ratios of saturated and monounsaturated fats are also altered to be more similar to those in breast milk.

Several fatty acids in goat milk have potential functional benefits for the infant. For instance, caproic, caprylic and capric acid have anti-bacterial (Sun et al, 2002) and anti-viral activity (German & Dillard, 2004) when released as free fatty acids following digestion. These fatty acids are characteristic of goat milk fat, but are absent or only present at very low levels in vegetable oils. Milk from pasture-fed goats also contains conjugated linolenic acid (CLA), which is a potent anti-oxidant and has been implicated in cancer prevention (Parodi, 1999).

Goat milk fat contains several fatty acids which have distinctive flavours and odours characteristic of certain types of cheeses for example. However, these fatty acids only become an issue for milk if it is poorly handled. For instance, excessive agitation can disrupt the milk fat globule allowing release of the free fatty acids into the skim milk fraction. Use of high quality manufacturing practices ensures that the goat formula produced by DGC has a clean, fresh flavour and odour.

Milk fat globule membrane

The fat in milk is enveloped by a membrane as it is being secreted from the mammary secretory cell. This membrane, termed the milk fat globule membrane, contains a variety of components that may have functional benefits (Spitsberg, 2005). Some of these are discussed below.

Phospholipids

Phospholipids represent the main component of the milk fat globule membrane. The levels in milk are listed in table 1.

TABLE 1 phospholipid profile of human, cow and goat milk

Phospholipid (% total phospholipids)	**Human milk[1]**	**Cow milk[1]**	**Goat milk[2]**
Phosphatidylcholine	27.5	33.8	25.7
Phosphatidylethanolamine	19.9	36.3	33.2
Phosphatidylserine	8.4	3.9	6.7
Phosphatidylinositol	5.3	5.2	5.6
Sphingmyelin	38.9	20.8	29.9
Total (% of total lipid)	1.3	0.8	0.8

[1] data from Jensen et al (1990)
[2] data from Jeness (1980)

Consumption of sphingomyelin in young animals accelerates enzymatic and morphological maturation of their intestine (Motouri et al, 2003). In other animal studies, the digestion of phospholipids in the gut leads to release of compounds that inhibit growth of bacteria such as Listeria, E coli, Campylobacter or Clostridium (Sprong, Hulstein & Van der Meer, 2001).

Glycoproteins

The milk fat globule membrane contains several glycoproteins of which mucin is the most well known (Patton, 1995; Patton, 1999). Mucins are very high molecular weight glycoproteins attached to the outer membrane of epithelial cells lining the gut and mammary cells (Patton et al, 1995). Mucin resists digestion in the newborn's stomach and prevents gastrointestinal infection by binding bacteria or viruses (Yolken et al, 1992, Patton, 1999).

Gangliosides

Gangliosides are glycosphingolipids containing sialic acid. They are present on the membrane of most cells, including the mammary secretory cell and are secreted into milk as part of the milk fat globule membrane. There are four main gangliosides in human milk GM1, GM2, GM3 and GD3, with GM3 (28%) and GD3 (32%) being the most abundant (Pan & Isumi, 2000). Goat milk contains seven different gangliosides, with GM3 (15%)and GD3 (54%) and G5 (12%), being the most abundant at 60 days of lactation (Puente et al, 1994).

Gangliosides are particularly abundant in the nervous system and play an important role in cell signaling. Gangliosides in human milk have been proposed to provide protective activities against bacterial derived toxins (Newburg, 1994). The functional properties of gangliosides in goat milk or milk powders are still to be determined.

Milk fat globule size

The fat globules in fresh goat milk are 27% smaller than cow milk (Attaie and Richter, 2000). This has lead to the suggestion that goat milk fat is easier to digest than cow milk fat. However, the process of homogenisation of milk, which is used during production of infant formula, reduces the size of fat globules (Lee & Sherbon, 2002). Homogenisation dictates the size and uniformity of the fat globules in infant formula products, overriding differences in the size and distribution of the fat globules in the milk.

Nutritional implications

A clinical trial shows growth of newborn infants fed a goat milk infant formula containing a mixture of goat milk fat and vegetable oils was equivalent to a cow milk infant formula containing only vegetable oils, thus proving the nutritional quality of the goat milk infant formula (Grant et al, 2005). Animal studies have also shown that the digestive utilisation of goat milk fat is better than cow milk fat and similar to olive oil (Alferez et al, 2001).

Summary

Increasing knowledge concerning the composition of breast milk and the nutritional and developmental requirements of infants indicate the importance of bioactive components. These components, although present at low concentrations, have a profound impact on the development of metabolic, immunoglogic and physiologic processes of the infant. Milk fat is one source of these components. The use of whole goat milk for production of goat infant and follow-on formula manufactured by DGC, means that components naturally present in milk fat and the benefits and synergies that these provide, are retained in these formulae.

References

Alferez MJ, Barrionuevo M, Lopez-Aliaga I, Sanz-Sampelayo MR, Lisbona F, Robles JC, Campos MS. (2001) Digestive utilization of goat and cow milk fat in malabsorption syndrome. J Dairy Res 68:451-461

Attaie R & Richter RL (2000) Size distribution of fat globules in goat milk. J Dairy Sci 83:940-944

German JB & Dillard CJ (2004) Saturated fats: what dietary intake? Am J Clin Nutr 80: 550-559.

Grant C, Rotherham B, Sharpe S, Scragg R, Thompson J, Andrews J, Wall C, Murphy J & Lowry D (2005) Randomized, double-blind comparison of growth in infants receiving goat milk infant formula versus cow milk infant formula. *J Paediatr Child Health* **41**, 564-568.

Haenlein GFW (2004). Goat milk in human nutrition. *Small Ruminant Research*, 51:155-163.

Harzer G et al (1983). Changing patterns of human milk lipids in the course of the lactation and during the day. *American Journal of Clinical Nutrition*, 37:612-621.

Jenness R (1980) Composition and characteristics of goat milk *Journal Dairy Science,* 63: 1605-1630.

Jensen RG, Ferris AM, Lammi-Keefe CJ & Henderson RA (1990) Lipids of bovine and human milk: A Comparison. *Journal Dairy Science* 73: 223-240.

Jensen RG (1999). Lipids in human milk. *Lipids*, 34:1243-1271.

Lee SJ & Sherbon JW (2002) Chemical changes in bovine milk fat globule membrane caused by heat treatment and homogenization of whole milk. J Dairy Sci 69: 555-567.

Life Sciences Research Office (LSRO) (1998). Assessment of nutrient requirements for infant formulas. Raiten DJ et al editors, *Journal of Nutrition*, 128:2059S - 2294S.

Motouri M, Matsuyama K, Yamamura J, Tanaka M, Aoe S, Iwanaga T & Kawakami H (2003) Milk sphingomyelin accelerates enzymatic and morphological maturation of the intestine in artificially reared rats Pediatr Gastroenterol Nutr. 36: 241-7.

New Zealand Institute for Crop & Food Research Limited (1995). Fats and Fatty Acids in New Zealand Foods, 1st edition, Palmerston North, New Zealand.

Newburg DS (1996) Oligosaccharides and glycoconjugates in human milk: their role in host defense. *Journal Mammary Gland Biology and Neoplasia* 1: 271-283.

Pan XL & Izumi T (2000) Variation of the ganglioside compositions of human milk, cow's milk and infant formula. *Early Human Development* 57: 25-31.

Parodi PW (1999) Conjugated linolenic acid and other anticarcinogenic agents of bovine milk fat. Journal of Dairy Science 82: 1339-1349.

Patton S, Gendler SJ and Spicer AP (1995) The epithelial mucin, MUC1, of milk, mammary gland and other tissues. Biochim Biophys Acta 1241: 407-424.

Patton S (1999) Some practical implications of the milk mucins *Journal of Dairy Science* 82: 1115-1117.

Puente R, Garcia-Pardo LA, Rueda R, Gil A & Hueso P (1994) Changes in ganglioside and sialic acid contents of goat milk during lactation. *Journal of Dairy Science* 77: 34-44

Pugo-Gunsam P et al (1999). Fatty acid composition of white adipose tissue and breast milk of Mauritian and French mothers and erythrocyte phospholipids of their full-term breast-fed infants. British Journal of Nutrition, 82:263-271.

Spitsberg VL (2005) Bovine milk fat globule membrane as a potential nutraceutical. J Dairy Sci 88:2289-2294.

Sprong RC, Hulstein MF & Van der Meer R (2001) Bactericidal activities of milk lipids. *Antimicrobial Agents & Chemotherapy* 45: 1298-1301.

Sun CQ, O'Connor CJ, Robertson AM (2002) The antimicrobial properties of milkfat after partial hydrolysis by calf pregastric lipase Chem Biol Interact 140:185-198

Yolken, RH, Peterson, JA, Vonderfecht SL, Fouts ET, Midthun K and Newburg DS (1992) Human milk mucin inhibits rotavirus replication and experimental gastroenteritis. *Journal of Clinical Investigation*. 90: 1984-1991.

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