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## GOAT MILK: AN ALTERNATIVE INFANT FEED

**Infant formulas made with cows' milk have usually been the first choice when breastfeeding is not possible, or where there is insufficient breast milk. Now, the suitability and safety of goat milk as an alternative infant formula has recently been approved.**

Until recently, the majority of conclusive studies in human infants published in the international literature have been limited to the evaluation of cows' milk or soy protein-based infant formulae. Proteins from the milk of animals other than cows, or from various plant sources, have now been considered potentially suitable for use in infant formulae.<sup>5,6</sup> The suitability and safety of goat milk, however, has only recently been approved.

Goat milk has a history of use for human nutrition in many cultures.<sup>7-9</sup> Goat milk infant formulas have always been in demand, with reports of homemade goat formula and raw goat milk being used.<sup>10-13</sup> The Dietetic Products, Nutrition and Allergies of European Food Safety Authority (EFSA) panel<sup>14</sup> concluded that protein from goat milk is suitable as a protein source for infant and follow-on formulae. The final products must comply with the compositional criteria as per the EU Directive 2006/141/EC. This ruling occurred on March 2014 and goat milk infant formula is now available throughout the EU.

Milk is produced in the mammary glands by forming minute droplets. These contain proteins, lactose, vitamins and minerals. Two different processes secrete these called merocrine and apocrine

secretion. In goat milk, the apocrine process has a greater role compared to that of cows' milk.<sup>19</sup> It is similar to human milk, as it contains numerous cytoplasmic particles that are broken off from the cell during apocrine secretion.<sup>15</sup> It is during this secretory process that it is thought to naturally endow goat and human milk with the cellular components, free amino acids and nucleotides.

### MEDIUM CHAIN FATTY ACIDS

Goat milk has a higher content of medium chain fatty acids (MCFA) compared to cows' milk.<sup>16</sup> Infant formula with goat milk fat contains 10-20% MCFA.<sup>17</sup> This compares to human milk, which, depending on maternal diet, can contain up to 15% MCFA.<sup>18</sup>

### COMPOSITIONAL PROPERTIES

#### Nucleotides

Nucleotides are important constituents of RNA and DNA. During infancy, when rapid growth occurs, this can increase the need for nucleotides. It has already been well referenced that nucleotide supplementation increases weight gain and head growth in infants who are formula-fed. Therefore, in some formula-fed populations, nucleotides may be conditionally essential for optimal growth in infants.<sup>24</sup>

Table 1: Goat milk compared to cows' milk

Secreted by an apocrine process, similar to that of breast milk. <sup>19</sup>
Lower level of alpha s1-casein and greater proportion of beta-casein compared to cows' milk and is more similar to human milk. <sup>20</sup>
More medium chain fatty acids than cows' milk. <sup>22</sup>
Higher levels of bio active components such as nucleotides than cows' milk, similar to human milk. <sup>23</sup>
Does not need to be whey-adjusted to be suitable for infant feeding. <sup>20</sup>

Cow's milk infant formulas are now routinely supplemented with nucleotides. However, goat milk formula already contains an array of nucleotides and so requires no supplementation.<sup>23</sup>

### Protein and Amino Acids

When expressed on a per-energy basis, goat milk infant formula has amino acids in amounts similar to human milk reference values.<sup>25</sup>

Historically, protein content of infant formula has always been set higher compared to human milk. The reasoning was due to concerns regarding the quality of the protein and insufficient amounts of some amino acids. However, there is now evidence that the protein content has been set too high. This can result in excess weight gain and place stress on a young infant's immature kidneys.<sup>26,27</sup>

With this 'growth acceleration hypothesis, suggesting that early and rapid growth during infancy programs the infant metabolic profile to be susceptible to obesity and the other components of metabolic syndrome, it is essential that infant formulas are brought in line with human milk reference values. It has also been demonstrated that in infants fed goat formula, blood urea levels are closer to those fed on human milk and, when compared to those fed cows' milk formula, were actually 11% lower.<sup>20</sup> This confirmed an adequate supply of amino acids from goat formula and less excess amino acids compared to a cow's milk formula, with added whey proteins.

### Whey proteins

Whey proteins are often added to infant milk formulas to improve the quality of protein available as essential and semi-essential amino acids.<sup>28,29</sup> However, goat milk infant formulas have been shown to have sufficient quantities of all essential and semi-essential amino acids, without the need to add whey proteins. They, therefore, have an amino acid profile compatible with international standards for infant formula.<sup>25</sup> In an animal model, the amino acid digestibility and absorption properties of goat milk formula made with whole goat milk are similar to those of a cows' milk infant formula with added whey.<sup>30</sup>

It has also been demonstrated that in goat milk formula made from whole goat milk, the amount and bioavailability of the amino acids provides less excess amino acids but still maintains



adequate growth of the infant.<sup>20</sup> Therefore, there is no evidence supporting any advantage in adding extra whey proteins to goat milk infant formulas.

Adding whey also reduces the casein proteins in formula whilst increasing beta lactoglobulin. This results in higher levels of proteins in whey enhanced formulas, which are not found in human milk.<sup>31</sup> The lower levels of alpha s1 casein and the absence of added whey proteins in goat whole milk (80:20) formula means that the levels of non-human proteins are lower than when compared to either whey enhanced or casein dominated cows' milk formula. These two proteins, alpha s1 casein and beta lactoglobulin, are known to induce allergic reactions in people sensitised to milk<sup>32</sup> and so this maybe an important factor for goat milk formula.

### NUTRITIONAL ADEQUACY

Infant formulas containing new sources of protein must be established for suitability and nutritional adequacy, as well as meeting international compositional standards.<sup>33,34</sup>

There has only been one previous randomised controlled trial using a goat milk infant formula fed to infants.<sup>35</sup> It demonstrated that the growth of 30 infants fed a goat milk formula was similar to that of 32 infants fed a whey-based cows' milk formula. However, the study was criticised for lack of blood biochemical data and numbers.<sup>36</sup> Since then, a study has been published demonstrating that in infants, growth and nutritional outcomes provided by the goat milk formula did not differ from those provided by a standard whey-based cows' milk formula. This study provided the evidence leading to the change that allowed goat milk as a base in infant formula.<sup>37</sup>

When comparing formula-fed infants with a breastfed group, Zhou et al<sup>37</sup> also found some interesting differences in weight and weight for

length z-scores. Their findings were consistent with other studies when comparing the growth of formula and breastfed infants.<sup>38-40</sup> Whilst the differences in weight or weight for length z-scores continued at 12 months between the breastfed infants and cows' milk formula-fed infants, there were no differences between the goat milk formula-fed infants and the breastfed infants. They used the same formula with a lower protein content for goat and cows' milk formulas (2.0g/100kcal and 2.1g/100kcal for goat and cows' milk formulas respectively) until 12 months, rather than changing to a follow-on formula at six months, which contains a higher protein content, as had been done in the other three studies. This might help to partly explain the difference observed between the findings of Zhou et al and the other three formula studies. It had been demonstrated that weight for length z-score at 24 months in infants fed a low protein formula did not differ to that of breastfed infants. However, infants fed a high protein formula (2.9g/100kcal) had higher z-scores.

An earlier study by Zhou et al<sup>20</sup> measured how many times an infant was offered an alternative formula or non-formula foods before the age of four months, as a measure of compliance. In the group randomised to receive the cows' milk formula, almost 40% of the infants were offered either another formula or a non-formula food for more than 12 days before the age of four months. The rates in the infants fed the goat milk formula were far less and more similar to the breast milk fed infants.

When parents change their baby's formula, or when complementary foods are introduced earlier than the recommendation, it is often said that it is done because the baby is not satisfied. Although this needs to be investigated further, it could possibly suggest that they were more satisfied on the goat milk formula.

A more recent study<sup>48</sup> has also compared the growth and nutritional status of infants fed goat milk-based formula (GMF) and cows' milk-based formula (CMF). A total of 79 infants aged 0-3 months old were recruited and randomised in GMF or CMF group. The infants were fed the allocated formula to six months of age. GMF-provided growth and nutritional outcomes did not differ from those provided by CMF.

## INTESTINAL HEALTH

In the immature infant gut, development and maintenance of the protective gut barrier is important as allergic symptoms are often associated with increased intestinal permeability between the ages of six to 12 months of age.<sup>41</sup> It has been demonstrated that goat milk prevents the loss of intestinal barrier function following heat stress in animals.<sup>42</sup> This indicates the presence of factors helping to maintain intestinal health.

## COWS' MILK PROTEIN ALLERGY

It is estimated that 1.9% to 4.9% of children suffer from cows' milk protein allergy<sup>43</sup> Suggestions have previously been made that goat milk could be used as a possible nutritional alternative to cows' milk for these infants. However, clinical studies have demonstrated a risk of cross-reactivity between the proteins in cows' milk and in goat milk.<sup>44,45</sup> Infants with confirmed IgE-mediated cows' milk allergy developing anaphylaxis after the ingestion of goat milk have also been reported.<sup>46</sup>

In 2012, EFSA concluded that 'there is insufficient data on the allergenicity of goat milk protein, with no convincing data to support the conclusion that the incidence of allergic reactions is lower when feeding goat milk-based infant formula when compared with cows' milk-based infant formula'.<sup>47</sup> They also concluded that 'substituting goat milk protein for cows' milk protein in infant formula intended for cows' milk allergic infants cannot be considered safe, unless proven to be so in clinical and in vitro studies'.

## SUMMARY

There is now published evidence that goat milk infant formula is a safe and suitable alternative to cows' milk and soy-based formulas. This has been confirmed by its approval for use. Goat milk has several properties that give it a greater similarity to human breast milk than cows' milk. Also, there is no evidence to suggest that there is any advantage to including extra whey proteins in goat infant formula. Government advice at present is that 'goat milk infant formula and follow-on formula is not suitable for infants with a cows' milk protein allergy unless directed by a suitably qualified healthcare professional'.