Qualitative Aspects of Protein in Human Milk and Formula: Amino Acid Pattern

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HISTORY OF COW’S MILK PROTEIN ADAPTATION TO HUMAN MILK

Since analytical data on the different composition of human milk and cow’s milk became available at the beginning of this century, human milk has always been the gold standard for creation of infant formulas. When it became evident that cow’s milk contains three times the protein concentration of human milk, the first steps of protein adaptation consisted in dilution of cow’s milk at a 1:1 ratio with water and supplementation with sucrose and starch to compensate for dilution-related energy losses.

As methods for the determination of amino acid concentrations became more reliable, the considerable differences in almost all amino acid patterns in human milk and cow’s milk proteins were recognized. Because of the comparatively low concentration in cow’s milk of cystine, which was thought to be an essential amino acid in infancy, it was then recommended that cow’s milk should be diluted with water in a ratio of 2:1 for the preparation of infant formulas in order to meet the infant’s cystine requirements. These formulas, which contained 2.3% protein, were generally in use up to the 1950s. They contained the majority of all amino acids in abundance and represented a large excretory load in the form of urea and ammonia. At that time, attention was focused on the amino acid composition of the various fractions of human milk and cow’s milk protein. The whey protein fraction of cow’s milk was found to be rich in the essential amino acids deficient in whole cow’s milk protein and the idea of whey protein supplementation of cow’s milk came into being. The admixture of whey protein to cow’s milk at ratios of 60:40 or 50:50 rendered it possible to adapt the amino acid pattern of cow’s milk more closely to the amino acid composition of human milk protein and to avoid an excessive supply of aromatic amino acids and methionine, as well as avoiding cystine and tryptophan deficiency. The surplus of threonine, due to the whey protein admixture, was considered to be unimportant.

Whey protein-enriched formulas are one of the most important innovations in infant nutrition of modern times. Formulas adapted in this manner enabled a reduction of
the protein concentration to 1.8% and even to 1.5%. This seemed to be quite similar to the protein quantity of human milk when calculated by nitrogen content. However, human milk contains a substantial amount of non-protein nitrogen and its true protein concentration is apparently not higher than 0.9% (1). This means that whey protein adapted formulas still provide infants with an excess of most amino acids of up to 200%. Moreover, the various fractions of cow's milk protein differ substantially in quantity and quality compared with human milk (Fig. 1). In this context it is remarkable that β-lactoglobulin, which represents the main fraction of cow's milk whey protein, is completely absent in human milk. This may explain the relatively high prevalence of β-lactoglobulin-related allergies in formula-fed infants.

**POTENTIAL HAZARDS RELATED TO HIGH OR LOW PROTEIN INTAKES IN EARLY LIFE**

The potential consequences of feeding formulas rich in protein are not known in detail. High protein intakes may result in high protein accretion, leading to a completely different body composition from that found with human milk feeding. In this connection the question arises as to whether this is harmless in the long term or hazardous for certain at-risk groups, such as very low birthweight infants—and if so, whether we should continue the search for formulas more closely adapted to human milk than our adapted formulas are at present. Pediatric nutritionists would certainly approve the latter aim. The food industry, however, will always want a demonstration of the shortcomings of the current generation of infant formulas and of the advantages of intended improvements.

Lately, increasing evidence has emerged that the mode of infant, especially preterm
infant, nutrition may have consequences for the neuropsychological outcome of in-
fants in later periods of life (2). We are not certain whether this has anything to do
with disturbances caused by excess or deficiency of amino acids or whether it may
be related to a deficiency of long-chain polyunsaturated fatty acids, sialic acid, or
other essential components of human milk. The neurological consequences of some
inborn errors of amino acid metabolism such as phenylketonuria are well established.
However, disturbances of plasma amino acid concentrations that place a newborn
infant at risk are ill defined and probably vary from infant to infant.

Deviations in the amino acid pattern of infant formulas from the amino acid compo-
sition of human milk are reflected in the plasma amino acid levels of infants. In 1968,
Snyderman and co-workers (3) studied the plasma amino acid alterations caused by
protein intakes of between 1.1 and 9.0 g/kg/d in 15 normal infants 1–6 months old.
The feeds were prepared from cow's milk which was either diluted or enriched with
demineralized casein and was made isocaloric with dextrimaltose and corn oil. In
comparison with a control group receiving 3–3.5 g protein/kg/d, protein intakes rang-
ing between 1.1 and 1.5 g/kg/d were accompanied by a depression of the plasma
concentrations of the branched-chain amino acids leucine, isoleucine, and valine and
of lysine and tyrosine, whereas glycine and serine concentrations were found to be
increased. The plasma concentrations of threonine, phenylalanine, ornithine, cystine,
and proline were less strikingly decreased. The extremely high intake of 9 g protein/
kg/d, corresponding to 32% of the total energy intake, resulted in a rise in the levels
of most of the amino acids, with excessive elevations of methionine, valine, leucine,
iso leucine, and proline while the level of glycine was depressed.

Low birthweight infants have been shown to be especially susceptible to such
amino acid imbalances (4,5). The conversion of methionine to cysteine is apparently
reduced in very low birthweight infants (6).

Cow's-milk-based formulas may induce prolonged elevations of valine, phenylala-
nine, and methionine in neonates or preterm infants (7). Whey protein predominant
formulas have been shown to cause hyperthreoninemia in preterm infants (8). Feeding
formulas that contain whey protein/casein mixtures in a 60:40 ratio may also cause
elevations in the plasma concentrations of valine, phenylalanine, methionine, lysine,
leucine, and isoleucine (9–11). Furthermore, in comparison with human milk feeding,
plasma urea concentration is also increased on such feeds, indicating that these amino
acids are administered in excess and are partially catabolized (Table 1). If the protein
concentration of whey protein-enriched formulas is lowered into the range of human
milk values to correct the excessive amino acid concentrations, this results in low
plasma tryptophan and taurine concentrations and does not necessarily correct the
plasma amino acid imbalances (12). Tryptophan is the precursor of the neurotransmit-
ter serotonin. Deficiencies of tryptophan could conceivably influence conscious be-
vavior and sleep patterns. In healthy infants tryptophan has been shown to promote
the onset of serotonin-induced sleep while unmodified formula feedings have the
opposite effect (13). Low plasma taurine concentrations suggest cysteine deficiencies.

While the protein tolerance of term infants, as reflected in their plasma amino acid
patterns, is considered to be relatively high, low birthweight infants are apparently
TABLE 1. Changes in the plasma amino acid pattern of neonates and preterm infants fed on cow's-milk-based formulas compared to breast feeding

<table>
<thead>
<tr>
<th>Bovine milk formula</th>
<th>Whey protein-enriched formula</th>
<th>Low protein whey protein-enriched formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valine ↑</td>
<td>Valine ↑</td>
<td>Valine ↑</td>
</tr>
<tr>
<td>Phenylalanine ↑</td>
<td>Phenylalanine ↑</td>
<td>Phenylalanine ↑</td>
</tr>
<tr>
<td>Methionine ↑</td>
<td>Methionine ↑</td>
<td>Methionine ↑</td>
</tr>
<tr>
<td>Urea ↑</td>
<td>Threonine ↑</td>
<td>Threonine ↑</td>
</tr>
<tr>
<td></td>
<td>Lysine ↑</td>
<td>Lysine ↑</td>
</tr>
<tr>
<td></td>
<td>Leucine ↑</td>
<td>Leucine ↑</td>
</tr>
<tr>
<td></td>
<td>Isoleucine ↑</td>
<td>Isoleucine ↑</td>
</tr>
<tr>
<td></td>
<td>Urea ↑</td>
<td>Tryptophan ↓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taurine ↓</td>
</tr>
</tbody>
</table>

Data from refs. 9 to 12.

Put at risk by amino acid imbalances. In a follow-up study on 62 prematurely born infants, a significantly lower performance IQ was found in children who had had high plasma tyrosine levels in the neonatal period (4). However, the differences were true only of low birthweight infants weighing 2000 g or more; no adverse effects of high tyrosine levels were observed in a group of smaller preterm infants. Goldman and co-workers (14) conducted psychometric evaluations in 304 children aged 3 and 5–7 years of age who were born prematurely and randomly assigned to either a 2% or a 4% cow's milk protein-based diet in the premature nursery. The incidence of low IQ scores was significantly increased in the group of infants of birthweight below 1300 g, who had had high protein intakes. Comprehensive psychometric tests in 15 children who as full-term neonates had experienced transient neonatal tyrosinemia due to high protein milk formula feeding (5.7 g/kg/d) resulted in specific learning disabilities compared to a control group that had not received a high protein milk formula in early infancy (15).

It can be concluded from these studies that high protein intakes in the neonatal period in preterm infants and newborns at risk may induce neuropsychological disturbances in later life. It is currently not known whether this is due only to metabolic perturbations of aromatic amino acids, which are present in excess in casein predominant formulas that are high in protein. Deleterious effects may also originate from imbalances of other amino acids accumulating in the extracellular and intracellular space as a result of high intakes, disturbances of assimilation, different needs, low degradation rates, and impaired renal excretion. The introduction of whey protein-enriched formulas containing lower protein concentrations may have contributed to a reduced prevalence of amino acid imbalances in the neonatal period. However, preterm infant formulas still contain protein concentrations of between 2.1 and 2.3%, although such high requirements for protein are restricted to the period between the 28th and 34th week of gestational age if the fetal accretion rate is taken as a standard (16).
PROCESSING OF INFANT FORMULAS WITH IMPROVED BIOLOGICAL VALUE: α-LACTALBUMIN AS A KEY PROTEIN

The problems arising from deviations between the amino acid pattern of cow’s milk protein and human milk protein cannot be solved by choosing other ratios of whey protein/casein mixtures. Further adaptation of the protein pattern of infant formulas to make it more like human milk protein composition would either require fortification with tryptophan, cystine, and other essential amino acids or a protein which is extremely high in these essential amino acids. Among all the fractions of cow’s milk protein, α-lactalbumin is the only one that could fulfill these requirements (Table 1) (17,18). Most of the protein mixtures in bovine milk-based formulas are low in tryptophan and cysteine (19). α-Lactalbumin has an exceptionally high concentration in tryptophan and cystine and a low methionine concentration (Table 2) and is thus an ideal supplement to compensate for the deviations in the amino acid pattern of infant formula protein mixtures currently in use.

Fortification of low protein formulas with free amino acids seems to be an effective method to correct imbalances of protein amino acid patterns (20), although the absorption kinetics and the utilization rates might be different from those of protein-bound amino acids (21). Potential side effects of free amino acids and the high costs related to the fortification of infant formulas are other aspects that make the realization of this procedure difficult in practice. Considering the disadvantages of free amino acids, α-lactalbumin-enriched fractions of cow’s milk whey protein seem to be a more suitable source of material for upgrading infant formula proteins. Whey protein fractions rich in α-lactalbumin are now being produced on a large scale and are offered by the food industry at reasonable prices.

One of the main problems in the adjustment of protein amino acid patterns in infant formulas to human milk protein values is related to the fact that we do not have reliable data on the amino acid composition of human milk protein. Comparing the

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Whole bovine milk protein</th>
<th>Whey protein</th>
<th>α-Lactalbumin</th>
<th>Human milk protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tryptophan</td>
<td>1.3</td>
<td>1.9</td>
<td>5.9</td>
<td>1.9 (2.3)*</td>
</tr>
<tr>
<td>Threonine</td>
<td>4.6</td>
<td>7.3</td>
<td>5.0</td>
<td>6.6</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>4.7</td>
<td>3.5</td>
<td>4.0</td>
<td>6.2</td>
</tr>
<tr>
<td>Leucine</td>
<td>9.5</td>
<td>10.1</td>
<td>10.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>5.8</td>
<td>6.2</td>
<td>6.1</td>
<td>5.8</td>
</tr>
<tr>
<td>Methionine</td>
<td>2.5</td>
<td>2.2</td>
<td>0.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Lysine</td>
<td>7.6</td>
<td>9.0</td>
<td>10.3</td>
<td>6.2</td>
</tr>
<tr>
<td>Valine</td>
<td>6.2</td>
<td>6.2</td>
<td>4.3</td>
<td>6.0</td>
</tr>
<tr>
<td>Cystine</td>
<td>0.8</td>
<td>2.2</td>
<td>5.3</td>
<td>1.7</td>
</tr>
</tbody>
</table>

* The tryptophan value in human milk protein is apparently higher (2.3%) than assumed originally.
values in published reports (22–25) shows substantial differences for the individual amino acids (Fig. 2). These differences are presumably due to the methods used for the determination of the amino acids and may also reflect a relatively broad range of amino acid concentrations in human milk protein. It is a matter of fact that there are considerable variations of single fractions, such as immunoglobulins, in human milk samples, related to individual particularities and to the lactation period. It is of special importance that the reference value for tryptophan in human milk is apparently considerably higher than originally assumed (Table 2). For practical purposes, it is sufficient to equalize the differences in the amino acid values of human milk protein, as published by different authors, by using mean values, which can serve as reference values for the creation of protein mixtures mimicking human milk protein. Such formulas make a reduction of the protein concentration in infant formulas to human milk protein values possible. Whether imbalances in the plasma amino acid patterns found in infants fed conventional low protein infant formulas can be avoided by such α-lactalbumin-enriched formulas has yet to be proven.

The experiences with tryptophan-supplemented low protein infant formulas have shown that these formulas produce plasma amino acid patterns in infants which do not differ from those found with human milk feeding (20). Since the consequences of amino acid imbalances in preterm infants and neonates at risk are currently not well known, we should continue the effort to formulate cow’s milk protein mixtures with amino acid patterns closely resembling human milk. “Humanized” milk produced by transgenic cows is at present only a dream. Whether this dream will become true in the near future will depend on overcoming the numerous ethical, technical, and commercial problems connected with this new development.
CONCLUSIONS

1. Moderate deviations in the plasma amino acid levels from those found with human milk feeding are common in healthy infants fed on adapted formulas.

2. Preterm infants and neonates with limited functional capacity of the liver, the kidneys, and other organs are at risk of clinically relevant perturbations of the amino acid homeostasis.

3. The clinical significance of transient neonatal amino acid disorders is not well defined. Further studies are required to clarify potential side effects of neonatal amino acid imbalances on brain development and intellectual behavior.

4. Further adaptation of the amino acid pattern of infant formulas to that of human milk protein should become possible by admixtures of bovine α-lactalbumin to casein and whey protein.

5. Infant formulas fully adapted to human milk protein make a reduction of the total protein concentration below the currently recommended lowest limit possible. They could increase the protein efficiency rate, reduce the renal load, and thus provide more safety for infants at risk for transient neonatal disorders of amino acid metabolism.

REFERENCES


**DISCUSSION FOLLOWING THE PRESENTATION OF DR. HEINE**

*Dr. Lönnerdal:* I should like to return the question of the true protein level of infant formulas. Those studies that have found significantly lower tryptophan levels in the plasma of formula-fed infants all used low protein formulas with high non-protein nitrogen values. This means that the level of protein was lower than expected and I should call these very low protein formulas. When we did a study of a formula containing 15 g per liter of true protein, which I consider to be a low protein formula, we did not see any significant differences in tryptophan. Therefore, I am not especially concerned about the tryptophan level as long as we are talking about true protein levels.

*Dr. Rassin:* There is a paper looking at tryptophan supplementation (1). It is interesting that plasma tryptophan is about 5 μmol/dl without supplementation and at three different levels of supplementation it goes up by about 20%, although the rise does not correlate with the level of supplementation. However, some definite physiological and behavioral changes were found in association with the increase. This is one of the few papers I have seen that used the fluorometric technology to measure tryptophan. It is a very nice experimental design because the authors looked at the same formula with and without tryptophan supplementation.

*Dr. Lönnerdal:* In a study which we published (2,3), we suggested that bovine α-lactalbumin could be added to whey-predominant formula to change the plasma amino acid pattern. I think it is important to note that even if the α-lactalbumin in cow’s milk is similar to that in human milk, they are not identical. There are significant differences in their amino acid composition, for example the antibodies do not cross-react with each other, and they are quite different with regard to composition, digestibility, and immunological reactivity. Our conclusions were that while tryptophan levels could be improved, the pattern of the other amino acids might well become less favorable.
Dr. Heine: The admixture of α-lactalbumin to casein/whey protein mixtures may compensate for low concentrations of cystine and aspartic acid and may reduce the surplus of threonine and methionine. The amino acid pattern obtained in this way are practically identical with the human milk pattern. The search for an improved amino acid composition in the protein of infant formulas is really only of importance for preterm infants and neonates at risk.

Dr. Raihā: I think this is a little bit too modest! I really believe that this could be an improvement for all newborn infants. Do we really need to wait for long-term effects to show up before we work to improve formulas? Taurine is a typical example of this. We say that exclusive breast feeding for the first 4, 5, maybe even 6 months should be the norm or the gold standard. If we agree on that, we should be trying to make formula as close as possible to breast milk, particularly as far as the infant’s plasma amino acid pattern is concerned. There is enough evidence at present to make changes justified. We supplemented formulas with taurine long before we had any evidence that there are long-term effects of taurine deficiency. I don’t think we should wait to find long-term pathology. Potential problems are very difficult to assess and as we know from the story of taurine, we often have to wait for highly sophisticated methods before we can identify pathological conditions for certain. They may well be there but we can’t measure them. So I think this could be of benefit for all infants, not only the preterm and at-risk infants.

Dr. Heine: You may be right. We cannot be certain at the moment what the effects of individual deficiencies or abundance of particular amino acids may be. I appreciated Alan Lucas’s paper very much (4) since it focused on the point that nutrition in early infancy may have consequences for the outcome of the infant. And if what Alan Lucas has published is indeed true, that the intelligence quotient is lower in preterm infants who are fed formulas as opposed to human milk, we must look seriously at the differences between the types of feeding. Niels Raihā has already mentioned that in Sweden all preterm infants are fed on human milk and we did the same in the eastern part of Germany. Pediatric nutritionists should think hard about improvements to formulas and have a close look not only at long-chain polyunsaturated fatty acids but also at the amino acid patterns, at the supply of sialic acid and other essential carbohydrates, and at the many factors that are present in human milk but absent in formula.

Dr. Raihā: I think your idea of modifying cow’s milk protein even further than it is at present is an intriguing possibility. I really think this should be the next step before we start using transgenic proteins on a large scale. There may even be other advantages than just a better amino acid profile; for example, there is the possibility of decreasing cow’s milk allergy by replacing β-lactoglobulins with α-lactalbumin. Do you have any comment on that?

Dr. Heine: I have some doubts on whether this is possible. The amount of β-lactoglobulin is not a very critical factor; allergies can be originated by very low concentrations of these antigenic proteins. Also the preparations now available are whey protein fractions, provided by the industry, which contain enriched concentrations of α-lactalbumin, not the pure protein. So I do not believe that we can solve all the problems connected with the allergy by these means.

Dr. Guesry: Not only is β-lactoglobulin allergenic in cow’s milk but so is bovine serum albumin and also casein, which is as allergenic as β-lactoglobulin. So even if we replace part of the β-lactoglobulin by α-lactalbumin, we shall not change the allergenicity of the cow’s milk.

Dr. Lönnerdal: Dr. Heine raised the question of the variation in amino acid content in human milk. Some of this may be methodological, but part could be due to the diet of the
mother. I should also like to emphasize that there is substantial variation in plasma amino acid pattern standards among different laboratories, probably due to natural variation both in amino acid composition and in plasma amino acid patterns.

**Dr. Heine:** I was surprised to see how much difference there is in the amino acid concentrations reported by different authors. This makes it really difficult to formulate a gold standard for human milk.

**Dr. Cooper:** Are there any data, particularly from developing parts of the world where diets would be different, on individual amino acid compositions of human milk?

**Dr. Lönnberdal:** I should like to answer this question. Several people have looked at this, including us. It is a very complicated issue because the amino acids will reflect the maternal proteins. We did a study recently in the Gambia and looked at parity and its effect on breast milk composition. We found effects on the casein/whey ratio and therefore on the amino acid composition. So in developing countries, not only does the food supply affect the amino acid and protein composition to some extent, but so do other factors, such as parity.

**Dr. Uauy:** Should we not be looking at the tissue amino acid composition? Plasma will vary tremendously, but tissue will probably vary less.

**Dr. Heine:** That is a crucial question. Tissue amino acid values may differ considerably from the plasma values. However, plasma is readily available and I see some difficulties in determining tissue values in normal infants.

**Dr. Uauy:** In the field of adult nutrition, people are now suggesting that we should be looking at the amino acid composition of muscle as a representation of tissue protein. It would be interesting to see how the amino acid pattern of human milk reflects that of muscle. You mentioned that there were clinically relevant conditions in neonates relating to changes in dietary protein supply. To what were you referring specifically?

**Dr. Heine:** Menkes and co-workers (5) were the first to show lower IQ performances in school-age children who were prematurely born and who had high plasma tyrosine concentrations in their neonatal period. There have been two further publications in 1974 and 1976 by Goldman (6) and Mamunes (7) suggesting that there are differences in the neuropsychological development and behavior in children who were fed on high protein diets after birth. It is well known from phenylketonuria that such correlations exist, but the values quoted by these investigators are of course well below the critical values seen in phenylketonuria. I had the feeling, when I read these articles, that the conditions under which the studies were done were not sufficiently well defined. We need further randomized studies to clarify the situation and discover for certain whether there is a correlation between raised plasma amino acids, both essential and non-essential, in neonates and preterm infants and later outcome. The problem is that it may not only be amino acids that might be dangerous for the infant. We have seen that other components, sialic acid and so on, may also play a role, so it is very difficult to prove these correlations.

**Dr. Bremer:** I find it astonishing that nutritionists often neglect the results obtained by people working with metabolic diseases; for instance, in tyrosinosis very high levels of tyrosine occur over a long period of life and nothing occurs in the brain. There are results available for histidine and for other amino acids. I think it is important that these matters be discussed with people who have experience with high amino acid levels over long periods while treating children with metabolic diseases. I am not convinced that the concentration differences that are seen as a result of feeding different amounts and types of protein are likely to be of any relevance.

**Dr. Rassin:** One should nevertheless bear in mind some of the results of the maternal PKU collaborative studies, which suggest that the amounts of phenylalanine that can be toxic
are much lower than we ever considered in true PKU. In fact, we keep lowering the cutoff point for what we consider toxic levels of phenylalanine. I appreciate that in utero exposure is a different model from ex utero exposure. It is important to remember that certain amino acids can become altered in the central nervous system without any particular indication of this from the plasma aminogram. Although the idea that muscle composition should form the amino acid standard is an interesting one, in terms of cognitive outcome the brain is where my money is.

I would like to support what Dr. Raiha said about the term infant. We have all been discussing Alan Lucas’s study in the UK in relation to the outcome in preterm infants, but there were several earlier studies which showed that there are long-term cognitive benefits of breast feeding term infants. While not perfect studies, these have shown that there is a definite advantage to being breast-fed. When you look at all these studies together, there has never been one that has shown an advantage to being formula-fed. So, although the methodology is often weak, there has been a great deal of consistency about the findings. I think there is quite a lot to be done to improve full-term preparations as well as preterm preparations.

Dr. Raiha: You said that the brain is where your money is, but there are other organs we should look at in this context. There is certainly evidence that a high protein intake or amino acid intake may have effects on insulin secretion and I think there is evidence that breast-fed infants are less prone than formula-fed infants to developing type I diabetes in later life. There may also be long-term effects on renal function. Thus there may be many other organs that could be affected by either an excessive or a deficient supply of protein and amino acids.

Dr. Lönnerdal: I agree that there are long-term benefits of breast feeding, but I really don’t think that the small deviations that we see in plasma amino acid patterns are responsible. Coming back to what I said earlier, I don’t think that additional α-lactalbumin in formulas for the normal term infant would be likely to make any significant contribution. It is perfectly possible to reduce the protein level and produce a plasma amino acid pattern very close to the breast-fed one.

But the point I really want to pursue is the one of cost that was raised by our colleagues in South Africa and India. Even in the USA, and within the state of California, the price issue is a relevant one. We have a significant population of poor people in the state, and as soon as the price of the formula is raised they will go to evaporated cow’s milk or whole cow’s milk instead because it is much cheaper. This is something we don’t want to see happening. There is no way that you can add a highly enriched α-lactalbumin fraction to regular term formula without increasing the price. For special groups, yes; preterm infants, yes; but not for the regular population.

Dr. Pettifor: One area we haven’t discussed much is the effect of changing the protein constituents of cow’s milk on mineral absorption. How important are metalloproteins, and do they have a role in the absorption of any of the minerals?

Dr. Heine: α-Lactalbumin is known to bind calcium and zinc and other metals, but its capacity to do so is pretty low, so it does not play a significant role in this field.

Dr. Lönnerdal: I don’t have much to add. α-Lactalbumin is not really a significant contributor to calcium or zinc nutrition. Overall, when it comes to mineral absorption, the whey-predominant product is advantageous because it is more easily digestible. With casein you always have the problem of incomplete digestion and the possibility of forming aggregates which may make trace elements and to some extent calcium less available.

Dr. Guesry: This is not really a problem. Absorption of minerals is always quite good and when it is not good enough with a cow’s milk formula, we can improve it either by increasing the quantity of the mineral or by adding other nutrients, for example vitamin C, which will
improve iron absorption. With soya formulas there is more of a problem because there are some factors, such as phytate, which block the absorption of zinc and iron and perhaps calcium.

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