Children and milk

The old adage that 'breast is best' has received further support from a study conducted in CSIRO's Division of Food Processing. The work has also shed some light on the problem of hyperactive children.

Conducted by Mr Reg Adams, Dr Keith Murray, and Mr Kevin Shaw, all of CSIRO, and Dr John Earl of the Royal Alexandra Hospital for Children in Sydney, the study forms part of a project designed to investigate the interactions between food and the micro-organisms that inhabit our large intestines.

The main functions of a gut are simply to break down food and then absorb the simpler constituents (see *Ecos* 51 for more details). Most absorption takes place in the small intestine, or ileum, where micro-organisms are quite rare. Anything that has not been absorbed then moves on to the colon, or large intestine. Water passes out across the wall of the colon, and what's left is compacted into faeces.

Bacteria live and proliferate in the colon and generally cause no trouble. Indeed, they are positively advantageous: they help prevent colonisation of that area by other, possibly harmful, bacteria; they supply us with Vitamin B12; and, as recent research has shown, they actually do some digesting of dietary fibre for us. (Our own digestive enzymes cannot do this, as was also explained in *Ecos* 51.)

Contrary to what scientists used to think, we are now finding out that almost completely undigested bits of perfectly usable food can pass into the colon — as well as the fibre, indigestible to us, that normally ends up there. The microflora of the colon will start metabolising these food residues, and the resulting products may have unwelcome effects.

For example, the sort of milk given to infants will affect the quantity and type of a class of compounds called amines that the intestinal microbes produce. The scientists showed this in a preliminary study, which involved identifying and measuring amines in the faeces of infants aged from 1 to 23 months, and correlating the results with information on the babies' diets.

How is a useful food molecule like an amino acid finding its way down into the colon?

Those babies fed on cow's milk had far higher concentrations of the amine tyramine in their faeces than did their breast-fed fellows. Tyramine comes mainly from the action of microbial enzymes on the amino acid tyrosine. (Other studies have shown that the gut's own enzymes produce but little tyramine.)

This raises an important question: how is a useful food molecule like an amino acid — from which proteins are made — finding its way down into the colon rather than being absorbed in the ileum as conventional wisdom suggests it should be? Mr Adams and his colleagues put forward two ideas.

Firstly, the baby is getting too much of this particular food constituent; the absorptive region of the gut becomes saturated, with the result that some of the protein continues on into the colon, where the bacteria metabolise the tyrosine in it. Relevant to this is the fact that cow's milk contains much more tyrosine than human milk, so drinking unmodified cow's milk may well lead to a tyrosine overload for the human infant.

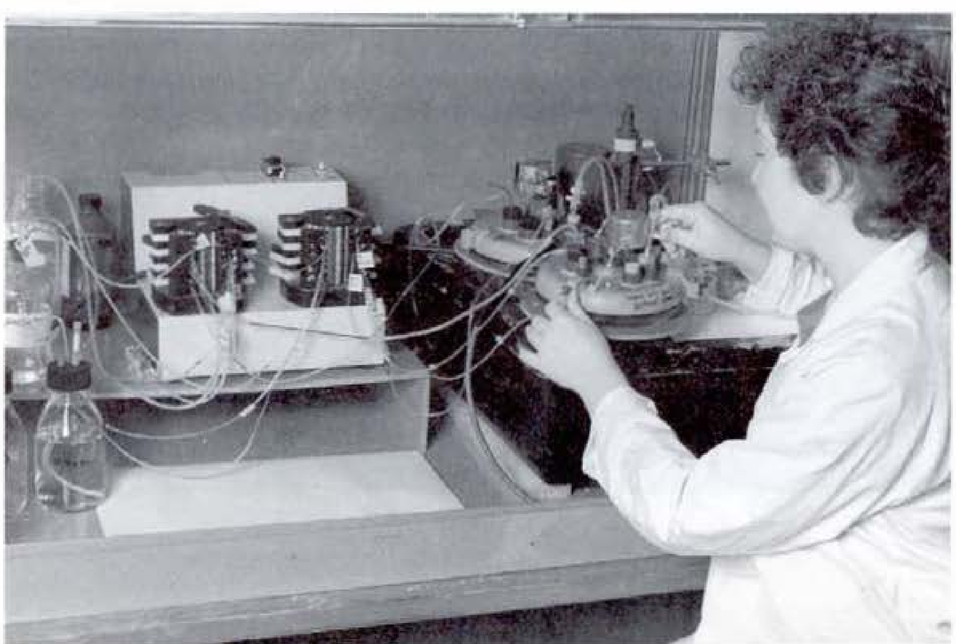
Secondly, cow's milk protein — which is less easily digestible than human milk protein — may not be fully broken down and absorbed during its time in the ileum. (In young and very old people, cow's milk can coagulate in the gut to form a tough curd — made of the milk protein casein — which in extreme cases can even block a baby's intestine. Such undigested curd in the colon would be a source of tyrosine-rich protein for the bacteria.)

As you might expect, infants fed on a special formulation based on cow's milk or soybeans produced less tyramine in their faeces than those consuming unmodified cow's milk, but still significantly more than those who were receiving human milk (see the chart).

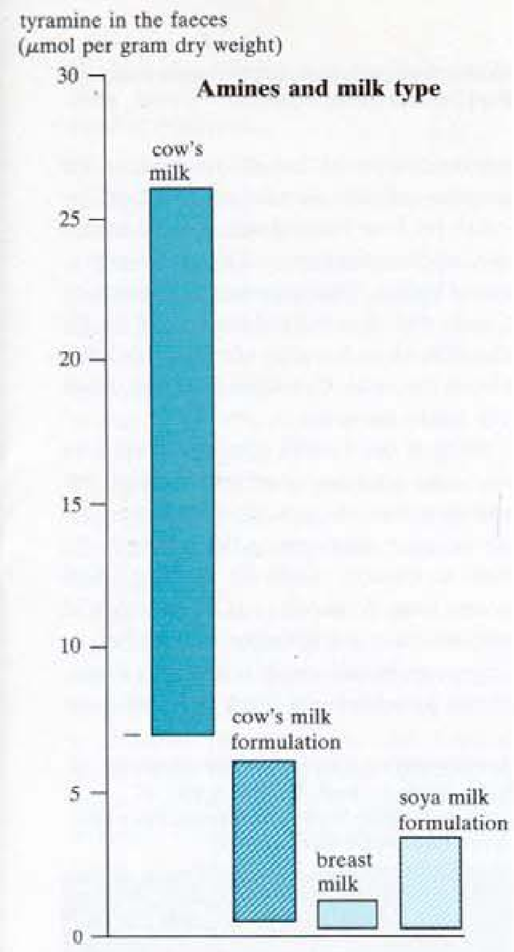
The team also examined amines in the faeces of infants with diarrhoea caused by an infection. The results showed that, as a group, the sick babies had significantly more tyramine and another amine called phenylethylamine in their faeces than did their healthy peers. (Within the sick group, those individuals on mother's milk had less faecal amines than those on cow's milk, as with the healthy children.)

One possible reason for the higher amine levels among the diarrhoetic infants is the fact that diarrhoea reduces the time that material spends in the gut, so the colon has less time to absorb the amines produced by bacteria, which therefore appear in greater abundance in the faeces.

Another reason is that any malfunction of the system may reduce digestion and so allow more protein tyrosine to reach the colon bacteria. Of course, the finding does not necessarily imply that these amines are causing the diarrhoea — their appearance in greater amounts in the faeces is most probably just a consequence of the infection. It is possible, however, that they may



An artificial colon: two vats of human faecal bacteria (right of picture) are kept at 37°C in a controlled medium corresponding to gut secretions. Periodically, the scientists 'feed' the system with nutrients (via the tubes), and can take samples to assess the products of bacterial metabolism. The volume in the vats increases as the bacteria grow, and so a waste output — akin to loss of bacteria in the faeces — is provided. Here, technical assistant Ms Patricia Clements checks the health of the system.



Infants who drank cows' milk had much more tyramine in their faeces than those fed breast milk.

actually be exacerbating the diarrhoea by having an effect on the wall of the intestine, such as increasing its movement. At the moment, we don't know.

Now why is all this important? A disturbing fact is that many amines, including tyramine, are toxic above a certain concentration, and may have other effects at lower levels. Amines in the colon could either exert a direct effect on the cells that make up its wall or, possibly, pass into the blood-stream and affect the whole body. Dr David Topping of CSIRO's Division of Human Nutrition in Adelaide has data from human adults showing that amines and phenols made in the colon can indeed enter the blood-stream.

Hyperactive children

An important substance derived from tyramine is the phenol *para*-cresol. As phenols are known to act on the nervous system, the question arose whether *para*-cresol could have a part to play in the puzzling phenomenon of the hyperactive child. Other studies have suggested a link between diet and this distressing problem of unmanageable children.

The team therefore measured the quantities of *para*-cresol in the faeces of nine children who were in hospital for observation, either because of a condition diagnosed as hyperactivity or because of persistently poor performance and uncontrollable behaviour at school or at home. Eleven 'normal' children made up a control group. The 20 subjects ranged in age from 3 to 11 years.

Using a type of chromatography, the scientists separated out the phenols from the faecal samples, and then confirmed the identity and quantity of the different types of phenol by a technique called field desorption mass spectrometry.

The content of *para*-cresol averaged a huge 243 μg per g of faeces in the hyperactive children, compared with only 58 μg per g in the control group — a very significant difference. (Of course, the 'normal' children had some *para*-cresol in their faeces, derived either from small amounts of tyrosine contained in a normal diet or from tyrosine present in broken-down intestinal cells or micro-organisms. A little of this would inevitably be metabolised by the intestinal bacteria into *para*-cresol and other phenols.)

Now the finding of greater amounts of faecal *para*-cresol in the hyperactive children certainly does not prove that this chemical causes the problem. But it does suggest an interesting connection: phenols, albeit in larger single quantities than occurred in this study, are toxic to the nervous system of rodents, and scientists know that small amounts of *para*-cresol, constantly applied over long periods, may also affect the nervous system. (Research has also implicated phenols as co-factors in the origin of certain types of cancer.)

But what is the difference that enables the colonic bacteria in hyperactive children to make more *para*-cresol? The scientists think that these children are probably consuming greater amounts of the amino acid tyrosine, from which the *para*-cresol is formed, than are their normal counterparts. Also, they may perhaps be less able to absorb tyrosine in the small intestine — but this has not yet been tested. The astute reader will leap to one possible conclusion: which common item in a child's diet contains a lot of tyrosine-rich protein? If you didn't say milk, go back to the beginning of the article and read it through again.

Mr Adams and his colleagues therefore suggest the following pattern: certain children consume a lot of dairy products, which give them a tyrosine overload and may also lead to the formation of a casein curd that escapes proper digestion and passes through to the colon; furthermore, some individuals may be less able to absorb tyrosine in the small intestine, allowing more of it than usual to pass through to the colon; the micro-organisms there metabolise the tyrosine to *para*-cresol and other phenols that are absorbed into the blood-stream, where they may act upon the nervous system — possibly being one of the causes of, or at least an aggravating factor in, the problem of hyperactivity.

These connections, although strongly suggested by the evidence so far, are by no means proved. However, supporting evidence has come from elsewhere. In the United States, scientists have observed a high intake of cow's milk in groups of juvenile delinquents with behavioural problems. Certainly, milk and dairy products are the sources of dietary tyrosine most readily available to children.

Of course, the scientists are not saying that children should not drink milk. It is an important source of calcium and protein — so much so, in fact, that we should really consider it a food, not a drink.

Using milk to quench your thirst, however, may mean that you are taking in too much protein all at once, as well as possibly an excess of animal fats, which are bad for the cardiovascular system. It is possible to have too much of a good thing! A long drink of milk need not give you too much protein for the whole day, but it may give a temporary overload of a type of protein that is particularly tyrosine-rich, and this may cause problems for some children who don't digest milk efficiently. Incidentally, plant proteins — with the exception of soybean — are generally lower in tyrosine.

One way of combating overloads is by means of dietary fibre. Fibre can act to fill you and reduce the density of various nutrients by diluting them. Mr Adams is now collaborating with Dr David Oakenfull, Dr Tony Evans, and Dr Charn Sidhu, all of the Division of Food Processing, to form a group to study how fibre can modify the high-density Western diet, and how this may affect the compounds produced by the activity of gut microbes. Preliminary results are most interesting — but that's another story!

Roger Beckmann

More about the topic

Studies of the free faecal amines of infants with gastroenteritis and of healthy infants. K.E. Murray, R.F. Adams, J.W. Earl, and K.J. Shaw. *Gut,* 1986, **27**, 1173–80.

High levels of faecal *p*-cresol in a group of hyperactive children. R.F. Adams, K.E. Murray, and J.W. Earl. *The Lancet*, 1985, 1313.