SHORT COMMUNICATION

ABSORPTION OF AMINO ACIDS FROM AN AMINO ACID MIXTURE SIMULATING CASEIN AND A TRYPDIC HYDROLYSATE OF CASEIN IN MAN

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SUMMARY

1. A double-lumen perfusion technique has been used in man to study jejunal absorption of individual amino acids from an amino acid mixture simulating casein, and a tryptic hydrolysate of casein consisting of oligopeptides and amino acids.

2. Total absorption was greater from the tryptic hydrolysate than from the amino acid mixture. There was wide variation in the extent to which individual amino acids were absorbed from the amino acid mixture. This was decreased when the tryptic hydrolysate was perfused. Amino acids which were particularly poorly absorbed from the amino acid mixture were absorbed to a substantially greater extent from the tryptic hydrolysate.

3. The results suggest that the characteristics of absorption of amino acid mixtures do not represent those of absorption of the physiological products of intraluminal digestion, oligopeptides and amino acids.

Key words: amino acid absorption, peptide absorption, intestinal perfusion, casein hydrolysate.

It is well known that in man (Adibi, Gray & Menden, 1967) and animals (Delhumeau, Pratt & Gitler, 1962) the rates at which individual amino acids are absorbed from a mixture are very unequal. This is partly due to the fact that some amino acids, such as glutamic acid and aspartic acid, are relatively slowly absorbed when present alone, and partly to competitive phenomena. Investigations of intestinal transport of individual oligopeptides and the equivalent amino acid mixtures have shown (1) that amino acids which are particularly slowly absorbed...
on their own may be much more rapidly absorbed from peptides (Matthews, 1972; Burston, Addison & Matthews, 1972) and (2) that competition for transport between free amino acids is avoided when peptides are absorbed (Matthews, Lis, Cheng & Crampton, 1969; Adibi, 1971; Matthews, 1972).

It has been shown that pancreatic hydrolysates of proteins are absorbed faster than equivalent amino acid mixtures in the rat (Crampton, Gangolli, Simson & Matthews, 1971). In the present study, a perfusion technique has been used in man to investigate the extent to which individual amino acids are absorbed from a pancreatic hydrolysate of casein, and an amino acid mixture simulating casein.

MATERIALS AND METHODS

Normal adult volunteers, who gave their informed consent, were intubated with a double-lumen perfusion tube incorporating a proximal occlusive balloon (Sladen & Dawson, 1970; Silk, Perrett & Clark, 1973). The tube was allowed to pass until the 30 cm perfusion segment was positioned in the upper jejunum and the final position was checked radiologically. The perfusion solutions, which were infused at 15 ml/min, contained either (1) a tryptic hydrolysate of casein made up of approximately 66% small peptides of 2–3 amino acid residues and 34% free amino acids (Crampton et al., 1971), or (2) an equivalent amino acid mixture simulating the composition of casein (Ling, Kon & Porter, 1961). Both solutions containing α-amino-nitrogen (40 mmol/l) were made iso-osmotic by adding sodium chloride and contained polyethylene glycol (PEG), labelled with 1 μCi of [14C]PEG/l (New England Nuclear Corp., Boston, U.S.A.), at a concentration of 2.5 g/l.

In order to quantitate absorption of individual free plus peptide-bound amino acids from the tryptic hydrolysate of casein, the perfusion solutions and intestinal aspirates were hydrolysed in sealed glass tubes at 110°C for 24 h with HCl (6 mol/l). Acid hydrolysis causes appreciable losses of some amino acids which might influence the values for their absorption, so in order that absorption from the tryptic hydrolysate and amino acid mixture could be compared, the perfusion solutions and intestinal aspirates containing the amino acid mixture were also submitted to the hydrolytic procedure.

Amino acids were estimated by ion-exchange chromatography on a Locarte automatic-loading amino acid analyser. 14C radioactivity was measured using a scintillation counter (Wingate, Sandberg & Phillips, 1972). Absorption was calculated as previously described (Holdsworth & Dawson, 1964) and expressed on a percentage basis. The significance of differences between means was assessed by the paired t-test.

RESULTS AND DISCUSSION

The results (Fig. 1) show that the extent to which amino acids were absorbed from the amino acid mixture varied considerably, the proportion absorbed ranging from 73% (Met) to only 26% (Asp). The variation in the extent to which the amino acids were absorbed from the tryptic hydrolysate was less, ranging from 73% (Phe) to 47% (Gly). There was a tendency for the amino acids which were poorly absorbed from the amino acid mixture to be absorbed more extensively from the tryptic hydrolysate, and this was significant for Phe, Lys, Glu, Ala, His and Asp ($P = 0.05$ or less). Although there seemed to be a tendency for amino acids which were well
Absorption of tryptic hydrolysate of casein

Fig. 1. Absorption of individual amino acids from an amino acid mixture simulating casein and a tryptic hydrolysate of casein. The total height of each column represents the mean value (n = 6), and one standard error is shown by a transverse line across the column. The significance of the difference between absorption of individual amino acids from the amino acid mixture and the tryptic hydrolysate is given below each pair of columns. Open columns, amino acid mixture; shaded columns, tryptic hydrolysate. n.s., not significant.

absorbed from the mixture to be absorbed less extensively from the hydrolysate, in no case was the difference significant at the 5% level. Total absorption of all amino acids was greater from the tryptic hydrolysate (62.4 ± SEM 6.4%) than from the amino acid mixture (53.4 ± SEM 5.7%, P < 0.01).

The results support previous work suggesting that the characteristics of absorption of amino acid mixtures are not representative of those of absorption of protein digestion products (Nasset, 1965; Nixon & Mawer, 1970a, b).

Standard tables giving the amino acid composition of casein, e.g. Ling et al. (1961), quote only values for 'glutamic acid' and 'aspartic acid', and the amino acid mixture was formulated on this basis, though it is known that casein contains both glutamine and asparagine (the amides are converted into the corresponding amino acids on acid hydrolysis). A recent analysis suggests that casein contains 50–60% of the material estimated as glutamic acid as glutamine, and about 50% of that estimated as aspartic acid as asparagine (Mercier, Grosslande & Dumas, 1972). Thus there was a second way in which the tryptic hydrolysate differed from the amino acid mixture, apart from its content of peptides. If the dicarboxylic amino acids and mixtures of these amino acids and their amides were absorbed at different rates, this could influence the results. To investigate this possibility six further subjects were perfused with solutions con-
taining (1) the standard amino acid mixture containing only glutamic acid and aspartic acid, and (2) a similar mixture in which glutamic acid was replaced by equal proportions (by weight) of glutamic acid and glutamine, and aspartic acid by equal proportions of aspartic acid and asparagine. Absorption of 'glutamic acid' from solution (1) was 51.7 ± SEM 6.1% and from solution (2) 65.4 ± SEM 5.1%. Absorption of 'aspartic acid' from solution (1) was 37.4 ± 9.9% and from solution (2) 55.3 ± 7.4%. These results were quite similar to those obtained when the amino acid mixture simulating casein and the tryptic hydrolysate of casein were perfused (Fig. 1). This makes the results obtained with the amino acid mixture and tryptic hydrolysate more difficult to interpret. If, on the one hand, the dicarboxylic acids and their amides are taken up by the intestinal mucosa as peptides, the rates of absorption of the free forms of the dicarboxylic acids and the corresponding amides are irrelevant. If, on the other hand, these amino acids and their amides are completely liberated in the free state within the lumen of the small intestine, then the enhanced absorption of 'glutamic acid' and 'aspartic acid' from the tryptic hydrolysate could be due to its content of the amides. Previous evidence suggests that the dicarboxylic amino acids, at least, are taken up as peptides (Nixon & Mawer, 1970b; Burston et al., 1972).

Despite the fact that there is now good evidence that, in man as in animals, a number of amino acids may be absorbed more rapidly when presented as small peptides than in the free form (Craft, Geddes, Hyde, Wise & Matthews, 1968; Adibi, 1971; Silk, Perrett, Webb & Clark, 1973) and that mucosal transport of dipeptides is independent of that of free amino acids (see Matthews, 1972), there is still a tendency to assume that amino acid mixtures are the ‘most readily assimilable’ form in which protein digestion products can be given by mouth. The present results suggest that, if maximally effective absorption is aimed at, as when the absorptive capacity of the intestine is decreased, the oral administration of mixtures of free amino acids might be less satisfactory than that of enzymic hydrolysates of protein containing oligopeptides as well as amino acids.

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REFERENCES


