Methionine transport: more complicated than travelling in rush hour

As feed additives contribute a significant cost to diets, the need to minimise wastage throughout all steps of handling and usage is important. This is not only true for feed mills and farms, but also within the animal itself.

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Of the commercially available supplemental methionine products, pure methionine powders (both DL- and L-methionine) are highly digestible and rapidly taken up in the lumen, while liquid Methyl Hydroxy Analogue-Fatty Acid (MHA-FA) loses its efficacy through microbial degradation and faecal excretion.

This contributes to the approximate 65% comparative efficacy of MHA-FA to DL- and L-methionine on a product comparison basis. Understanding the uptake of these products in the intestine is important to ensure dietary efficiency, but are there any synergies or antagonisms from using different methionine sources?

Intestinal activity

Methionine transport is not straightforward as there are several transporters on both the luminal (facing the lumen) and serosal (interacting with circulatory and lymph systems) sides of intestinal cells that accept both D- and L-methionine isomers. Some of these transporters are sodium or chlorine dependent.

Methionine can even be used by transporters to help shuttle amino acids through the intestinal cell into the blood. It is also utilised for the intestinal cell's own metabolic needs, even being brought back into the intestinal cell from the blood to sustain it between meals.

The active component of MHA-FA, 2-hydroxy-4-(methylthio) butanoate (HMTBa), is not an amino acid and therefore is not absorbed through amino acid transporters. HMTBa is absorbed through monocarboxylate transporters which are designed for transport of short chain fatty acids such as butyrate and lactate.

Comparatively to methionine transporters, monocarboxylate transporters are not dependent on sodium or chlorine, but hydrogen. As energy-dependent systems are required to maintain the balance of sodium, chlorine and hydrogen in the cell, both methionine and HMTBa transport systems are indirectly energy dependent.

Evonik conducted an experiment in collaboration with the Free University of Berlin in Germany to investigate whether feeding piglets diets supplemented with DL-methionine, L-methionine or MHA-FA would affect their ability to transport D-methionine, L-methionine or HMTBa through the intestine.

Trial set up

The study investigated how the dietary methionine source (DL-methionine, L-methionine or MHA-FA) affected the flux rate of either D-methionine, L-methionine or HMTBa across different areas of the intestinal section (duodenum, jejunum or ileum). 27 barrow grower piglets (DanBred x Pietrain), with a mean initial weight of 25kg were assigned to three treatments with nine piglets per treatment.

The three dietary treatments contained supplemental methionine sources at the following product inclusion rate; 0.21% DL-methionine, 0.21% L-methionine and 0.31% MHA-FA to account for the approximate 65% product bioefficacy of MHA-FA compared to methionine.

Piglets were offered experimental diets ad libitum for 10 days to adapt to the methionine source treatments. After this

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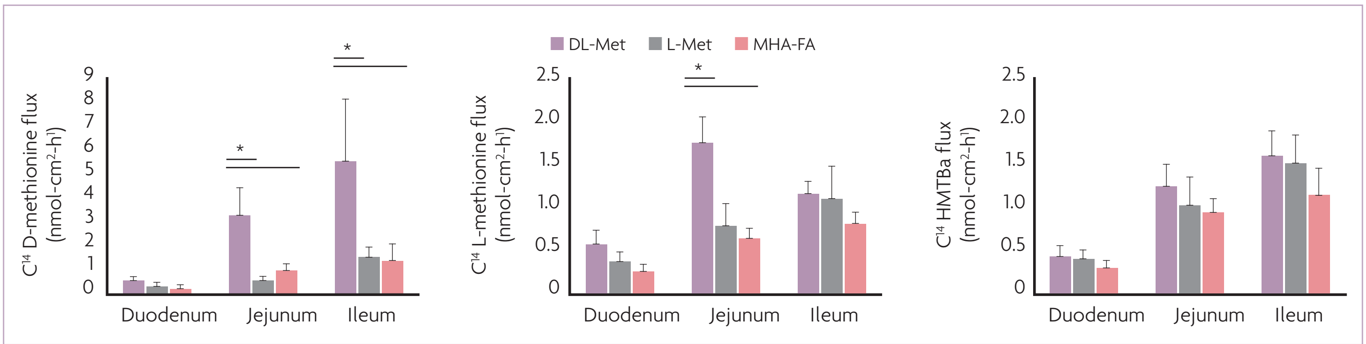
Fig. 1. Flux rate of C^{14} labelled D-methionine, L-methionine and HMTBa across different intestinal tissue.



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period piglets were euthanised and tissue from mid-jejunum, ileum and duodenum were extracted for evaluation of methionine transport capacity via Ussing chambers.

In the Ussing chamber, a segment of tissue is stretched across a chamber while still physiologically active.

Radio labelled (C^{14}) D-methionine, L-methionine and DL-HMTBa (50:50 mix D- and L-HMTBa) were applied to the buffer on the luminal side of the extracted intestinal tissue. Over an hour, the amount of nutrients transported were measured on the serosal side of the tissue using the C^{14}-label. This was repeated for the duodenum, jejunum and ileum to measure the rate of the methionine sources transported through the different intestinal tissues.

Results

The intestinal section affected the flux rate of methionine sources as it was higher in the jejunum and ileum than in the duodenum. This may be due to the concentration of nutrients being higher in the duodenum than jejunum or ileum, where the tissue must become more efficient to capture the last of the available nutrients. L-methionine was the substrate absorbed fastest compared to D-methionine or DL-HMTBa, which were absorbed at comparable rates.

However, DL-methionine fed piglets had increased flux rates of both D-methionine and L-methionine in the jejunum and ileum compared to L-methionine fed piglets. In this respect the total methionine flux rate in D-methionine fed pigs was higher than in L-methionine fed pigs (Fig. 1).

There was no effect of dietary methionine source on the absorption of DL-HMTBa, even in pigs fed MHA-FA.

What does it mean?

This study showed that feeding diets supplemented with DL-methionine increased the flux rate of both D- and L-methionine in the jejunum and ileum of growing pigs compared to L-methionine or MHA-FA supplemented diets.

Feeding MHA-FA was not shown to improve absorption of HMTBa, nor that of L-methionine, so this source had no inherent benefit on absorption of supplemented HMTBa nor of the L-methionine which would be found naturally in the feed ingredients.

Conversely, this study suggests the presence of D-methionine in the diet induces specific amino acid transporters that can improve the uptake of both D-methionine and L-methionine, an effect not seen when L-methionine alone was supplemented.

Additionally, this affect was only observed if sodium was present in the media, which may already indicate which of the possible transporters was involved.

As none of the amino acid transporters potentially induced are specific to only methionine, future research should investigate whether feeding DL-methionine may also improve transport of other amino acids in pigs.

Between the three commercially available methionine sources, it is not uncommon for different products to be used at various growth stages, or in combination with each other to ensure sufficient levels of methionine in the diet.

Due to their significant contribution to diet costs and the need to meet the animal's amino acid requirements, considerable care is taken to feed quality and form to ensure efficient uptake of these nutrients.

This research shows that feeding DL-methionine for even 10 days leads to improved uptake of both and D and L-methionine from the intestinal lumen.

This suggests that a consistent supplementation with DL-methionine throughout the growth cycle will ensure the most efficient uptake of supplemental feed-ingredient derived methionine. ■

References are available from the authors on request