The role of fibres in digesta passage behaviour in monogastrics

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By altering the gastrointestinal environment, digesta transit behaviour, and the site of nutrient digestion, physicochemical properties of fibres such as particle size of insoluble fibres or gelling of soluble fibres are likely to influence the absorption kinetics of nutrients and their metabolic use.

In chickens, the role of fibres, particularly insoluble fibres, on gizzard development and function has been extensively studied. Dietary structure, typically provided by insoluble dietary fibre sources, is known to stimulate grinding activity and relative weight of the gizzard as a result of more intense muscular contractions, but the influence of specific fibre physicochemical properties, such as hardness, particle size, gelling- and hydration properties, and fermentability remains uncertain.

Sugar beet pulp – having a high water binding capacity and soluble fibre content - increased gizzard weight and tended to accelerate prececal, but more importantly, cecal retention time of digesta. In contrast, the addition of arabinoxylans - viscous soluble fibres - reduced gizzard weight and prolonged retention time of solid and liquid digesta throughout the gastrointestinal tract.

When studying digesta passage behaviour in chickens, selective retention of various fractions throughout the gastrointestinal tract should be anticipated. Coarse fibre particles may be retained longer in the proventriculus and gizzard compared with fine particles or liquids, although this was not observed in laying hens where coarse oat hulls were retained longer than fine solids in the crop but not in the proventriculus and gizzard. After passing the ileocecal junction, digesta passes through the colon to the cloaca, where coarse particles are assumed to be directly voided, resulting in typical total tract mean retention times of ~3-8 h when estimated based on solid digesta. Reflux from the cloaca through the colon selectively delivers fluids, including urine, and small particles to the ceca. In this way, solubilized materials and fine particles can enter the ceca and be subjected to fermentation by the microbiota residing in the ceca. Estimated mean retention times in the ceca for liquid digesta range from 500-1500 min, implying that total tract mean retention times of digesta that enter the ceca may reach ~14-31 h. However, our provisional estimates indicate that only ~30% of the liquid digesta fraction entered the ceca.

In pigs, beyond commonly described effects of fibres on digesta transit in the large intestine, fibres can affect gastric emptying, thereby modulating delivery of nutrients into the small intestine, but also affecting intragastric mixing and acidification kinetics. Gastric emptying is a heterogenous process, where liquids are rapidly emptied (MRT ~ 20 min to 90 min) whereas solids, particularly fibrous particles are selectively retained (MRT ~ 1 to > 10h). Compared with coarse insoluble fibres, fine insoluble fibre sources accelerated gastric emptying and reduced gastric sieving, thereby diminishing the intragastric pH gradient. Addition of pectins accelerated emptying of (fine) solids and reduced gastric sieving.

These insights can be useful to better predict the nutritional values of fibre-rich diets but also to develop nutritional solutions to support gastrointestinal function and health.