THE EFFECT OF PHYTOBIOTICS ON PERFORMANCE AND GUT FUNCTION IN MONOGASTRICS

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Phytobiotics may be explained as plant derived products added to the feed in order to improve performance of agricultural livestock. This definition addresses mainly the purpose of use in terms of a feed additive to healthy animals under common practical conditions of production of food of animal origin rather than the veterinary use for prophylaxis and therapy of diagnosed health problems. According to this definition, phytobiotics comprise are very wide range of substances with respect to biological origin, formulation, chemical description and purity. Within this variety, some subgroups may be classified, such as herbs (product from flowering, non-woody and non-persistent plants), botanicals (entire or processed parts of a plant, e.g. root, leaves, bark), essential oils (hydro distilled extracts of volatile plant compounds), and oleoresins (extracts based on non-aqueous solvents). The active compounds of phytobiotics are secondary plant constituents. Their primary mode of action is often not known sufficiently to explain the final effects in vivo, especially since phytobiotics usually contain mixtures of compounds with beneficial and potentially adverse effects, depending on the nature and the dose of the respective substances. Nevertheless, common knowledge from folk medicine and recent experiences from feeding studies give significant rise to accept the principal potential of phytobiotics to significantly improve zootechnical performance in agricultural livestock. The following paper describes shortly some major effects addressed to phytobiotics used as feed additive to monogastric agricultural livestock in an exemplified way without addressing the wide variety of classes of substances.

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Stimulation of feed intake

Phytobiotics, especially those from the group of essential oils are often claimed to improve flavour and palatability of feed and hence to raise performance of monogastrics agricultural livestock through stimulation of feed intake. Indeed, there are numerous reports on positive effects, but also on depression of feed intake especially at rising dietary additions of these substances (e.g. Rodehutscord and Kluth 2002). Besides the problem to identify the optimum dietary concentration within the vast variety of potentially active substances, the varying contents of concomitant compounds with potentially adverse impact on palatability may additionally modify the total effect on feed intake (e.g. Straub et al. 2005). The latter seems to be the case especially when using intact parts of herbs compared to plant extracts providing a more standardized composition. In total, the mode of action to stimulate feed intake remains unclear, since in contrast e.g. to sweeteners, rising additions of phytobiotics often reduce palatability. In some cases it may be hypothesized that higher feed intake might results indirectly of e.g. from a higher saliva production rather than a better taste of feed *per se*.

Some phytobiotics act also as antioxidant (e.g. rosemary oil) and may thus indirectly stabilize the nutritional and sensorial feed quality. This effect could be of relevance to feed rich in fat (oil), like for pet feed. But it remains unclear whether dietary additions necessary to induce protective effects comparable to common antioxidants (e.g. tocopherols, BHA, BHT) are compatible with sufficient palatability of the feed.

Stimulation of digestive secretions

Stimulation of digestive secretions such as saliva, digestive enzymes, bile, and mucus is often considered to be a core mode of action of phytobiotics. Experimental evidence for this hypothesis, however, is very small with respect to practical feeding conditions (e.g. Lee et al. 2003). Nevertheless, conclusion by analogy from commonplace knowledge of using spices in human nutrition seems to justify this hypothesis in general. But in context with highly productive agricultural livestock it has to be mentioned that stimulation of digestive secretion is not a beneficial action *per se*. It is often a concomitant phenomenon of an irritating action being accompanied by shortening of intestinal villi length (resulting from higher tissue turnover) and a higher passage rate of digesta. Nevertheless, such effects may have a beneficial action at low hygiene as they counteract the attack of potential pathogens to the intestinal tissue.

Antimicrobial action

There is a vast variety of *in vitro* studies on antimicrobial actions of phytobiotics (e.g. Sivropoulou et al. 1996; Hammer et al. 1999; Chami et al. 2005), while until now there is only little experimental experience when using such products as feed additives to healthy animals under common practical conditions. Nevertheless, the antimicrobial property may be considered as mode of action being most relevant to agricultural livestock, especially to young animals. Like e.g. antibiotic feed additives and organic acids, phytobiotics have to be considered as potential candidates contributing to stabilize eubiosis of intestinal microbiota. The overall benefit to animals supplied with such types of feed additives originates from the complex interaction between the direct antimicrobial action in the gastrointestinal tract, the resulting relief of the host animal from microbial degradation of nutrients prior to absorption and exposure to undesired microbial products (e.g. toxins), and the reaction of the organism on higher influx of nutrients from the intestinal tract and lower immune defence stress. An example demonstrating this interaction is given by a recent model study with weanling piglets (Kroismayr et al. 2006a, b, Stoni et al. 2006). In this study, animals were fed 3 diets differing only in content of feed additives: (1) no additive (control); (2) addition of a phytobiotic feed additive; (3) addition of an antibiotic feed additive. A commercial product (Biomin® P.E.P1000) served as model to phytobiotics. It contained essential oils derived from oregano, anis, and citrus peels (40 mg essential oils per kg of feed). Avilamycin (Tetracycline) was used as model for antibiotic feed additives (Maxus 100, Elanco Animal Health LTD; 40 mg Avilamycin per kg of feed). After 3 weeks of feeding, 12 representative animals were sacrificed per treatment in order to derive samples of gut contents and gut tissues for analysis of indicators of gut functionality.

Both feed additives (antibiotic and phytobiotic) decreased microbial activity at the end of the ileum, caecum and colon. This could be concluded from reduced bacterial colony counts in the chymus, and from reduced contents of volatile fatty acids, as well as of biogenic amines. Relief from microbial activity and related by-products is of high relevance especially in the small intestine, as e.g. volatile fatty acids produced by microbial fermentation counteract stabilization of intestinal pH close to 7, which is prerequisite to maintain of full activity of digestive enzymes. Furthermore, formation of biogenic amines by microbiota is undesired not only because of toxicity, but also due to the fact that biogenic amines are produced mainly by decarboxylation of limiting essential amino acids (e.g. cadaverine from lysine, scatol from tryptophan). Consequently, relief from microbial fermentation in the small intestine may improve supply status of essential and limiting nutrients. This sparing effect has been demonstrated e.g. for combined additions of lysine and organic acids (Roth et al. 1998)

Histology revealed smaller surface of lymph cells in Peyers´ Patches due to essential oils and Avilamycin, indicating less immune defence activities in the small intestine. No changes were observed regarding morphology of mucosa in jejunum, ileum and colon (villi length, crypt depth), demonstrating that both feed additives did not affect tissue functionality *per se*.

Improved digestive capacity in the small intestine is an overall effect of feed additives with antimicrobial actions (antibiotics, organic acids, and phytobiotics). It results from the relief of the host animal from microbial activity and their undesired products, and the lower immune defences activities. Indeed, such an effect is very difficult to demonstrate in quantitative terms. But indirect evidence can be derived from (apparent) digestibility of protein and dietary dry matter. These parameters reflect the extent of postileal microbial growth and excretion via feces, which in turn depend on the influx of fermentable carbohydrates into the hind gut. An improved digestive capacity in the small intestine reduces the influx of fermentable carbohydrates into the hind gut, lowers postileal microbial growth and hence raises apparent digestibility of protein and dry matter. This effect has been demonstrated for antibiotics, organic acids (e.g. Roth et al. 1998) and also in the phytobiotics (Cho et al. 2006, Stoni et al. 2006).

Other phytobiotic actions at the level of the digestive tract

A wide range of phytobiotics are known from folk medicine to exert pharmacological actions within the digestive tract, such as laxative and spasmolytic effects as well as prevention from flatulence (mainly due to easement of gas transport from liquid hind gut chymus towards the blood through inhibition of formation of foam). Representatives are for example aniseed oils, which are discussed also to pronounce precaecal absorption of glucose via direct stimulation of Na/K-ATPase (Kreydiyyeh et al. 2003).

Another field of phytobiotic actions comprises astringent and denaturizing properties. Tannins are well known examples, proven and tested by folk medicine and regular veterinary use for treatment e.g. of diarrhoea. When applied to healthy animals as feed additives on a long term basis, however, the astringent and denaturizing property of tannins may reduce intestinal villi length and impair function of other protein based feed additives (e.g. phytase, NSP degrading enzymes). This ambivalence in efficacy for veterinary vs. feed additive purposes may restrict the broad use of such phytobiotics in agricultural livestock under common conditions of production.

In some cases, the effects advertised in context with phytobiotics are unclear with respect to the site of primary mode of action. Especially significant improvements in feed efficacy indicate at least in part a redistribution of nutrient flow from fat deposition towards protein synthesis (e.g. Rodehutscord and Kluth 2002). The same applies to reports on increased meat to fat ratio e.g. in fattening pigs. Such effects are somewhat likely to originate also from metabolic and/or (phyto)hormonal effects rather than from gastrointestinal actions only.

Conclusions

There are numerous reports on phytobiotic formulations being clearly efficacious in monogastric agricultural livestock in terms of improving zootechnical performance by enhancing gastrointestinal functions. The latter seems to be based mainly on antimicrobial actions and its consequences (improved supply of nutrients, less exposure to undesired microbial products, relief from immune defence activities). Other gastrointestinal modes of action are also discussed to improve performance (e.g. stimulation of digestive secretions), but their quantitative relevance is still unclear as well as possible undesired side effects especially at rising dietary doses. In total, there is still necessity to systematically investigate the complex interaction of favourable and undesired constituents in entire plant material as well as the most relevant active compounds with respect optimum dose and method of preparation and extraction, respectively. Finally, it has to be accepted that phytobiotics are not able to care specific illness and gastrointestinal disorders or to compensate for adverse environmental conditions. But they can contribute to stabilize gut health and functionality and thus to enable the animal to carry out its genetic potential for zootechnical performance.

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