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Preface

Enzymes, direct-fed microbials and plant extracts in ruminant nutrition☆

Abstract

This preface outlines the reasons for the special issue, comments on the review process and provides a brief summary of the papers. Research on feed additives of 'natural' or biological origin was provided an impetus due to the European ban on growth-promoting antimicrobial feed additives. However, the potential of feed additive enzymes, direct-fed microbials and plant extracts as beneficial manipulators of ruminal fermentation extends beyond replacement of growth-promoting antimicrobial feed additives in ruminant livestock production to new functions and potential commercial roles.

Keywords: Rumen; Growth promotion

1. Introduction

Nutrition of ruminants is dominated by the microbial fermentation that occurs in the foregut. This fermentation enables ruminants to make maximal use of forages that cannot be used to feed pigs, poultry or humans. This fermentation could be improved in many ways, such as by improving fibre digestion, decreasing protein degradation, and/or inhibiting methane emissions which, if modified, might increase efficiency of ruminant livestock production and lessen impacts of animal production on the environment. Because ruminal digestion is entirely microbial in nature, it is subject to modification by selective antimicrobial agents, including antibiotics and ionophores. Ionophores, the best known of which is

Abbreviation: GPAFA, growth-promoting antimicrobial feed additives

☆ This paper is part of a special issue entitled "Enzymes, Direct Fed Microbials and Plant Extracts in Ruminant Nutrition" guest edited by R. J. Wallace, D. Colombatto and P. H. Robinson.

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monensin sodium, achieved some of the objectives identified by rumen microbiologists and ruminant nutritionists, at least to a limited extent, and the ban on their use in the European Union removed their benefits from ruminant livestock producers, prompting research on replacements. However, targets such as improving fibre digestion and suppressing the bacteriolytic activity of ciliate protozoa were never impacted substantively by ionophores. Thus, although the growth-promoting antimicrobial feed additives (GPAFA) ban has increased interest in feed additives such as probiotics (or more accurately in ruminants, direct-fed microbials), biological feed additives such as enzymes and plant extracts have the potential to address targets that differ from those affected by ionophores and/or have other beneficial impacts.

2. The review process for this issue

The papers were intended to cover feed additive enzymes, direct-fed microbials and plant extracts for ruminant production. Both the GPAFA ban and recent advances in these areas were considered by the Co Editors-in-Chief of Animal Feed Science and Technology to warrant coverage in a special issue. An open invitation was published in the journal and the Guest Editors also contacted many potential authors. Abstracts were received and, of the 60 reviewed, 46 were invited to submit full papers. Thirty-five papers were received and all were subjected to critical review, for which the Guest Editors would like to express their gratitude to all reviewers. Most papers were improved as a result of the reviewers' comments, indeed some were very extensively revised, and some were rejected. The result is a collection of 29 papers that, if not comprehensive in their coverage of the originally targeted topics, certainly cover a representative range across the topics.

3. Comments on the papers

Two papers, by Chaucheyras-Durand et al. and Benchaar et al. are reviews of the topics of yeasts and essential oils, respectively. Both are up-to-date and comprehensive, and they will be very useful to all researchers interested in these topics. Other papers deal with more specific investigations of the effects, or mode of action, of the additives. The papers grouped, unsurprisingly, into the three main types of additives, being direct-fed microbials, feed enzymes and plant extracts.

3.1. Direct-fed microbials

Direct-fed microbials, such as yeasts or *Aspergillus* spp., carry a connotation of being 'natural' and safe. After all, they are used in human foods. However why they should exert any beneficial influence on ruminal fermentation is not immediately obvious. Often, in the past, the mode of action in improving ruminal fermentation has tended to be rather vague or speculative. The review by Chaucheyras-Durand et al., while not being devoid of interesting speculation, interprets experimental evidence concerning yeast in a straightforward way that will be useful to all readers. The special issue contains disappointingly little information

on other direct-fed microbials, a group that now contains a number of strictly anaerobic bacteria.

3.2. Feed enzymes

A total of 12 papers on feed enzymes were submitted for consideration for this Special Issue, of which 10 were finally accepted. Whilst some papers within this group focused on effects of enzyme mixtures on beef and dairy production (see papers by Miller et al. or Hristov et al., for example), others concentrated on the relationship between enzymes and *in vitro* degradation of feeds (Eun and Beauchemin; Dean et al; Adesogan et al., to name a few). One interesting review on effects of supplementary amylases on ruminant production (*i.e.*, Tricarico et al.) should be of interest to many readers. Although several reviews on effects of feed enzymes on ruminant diets have been presented, the real potential and mode of action of these additives remains largely unknown as a result of the different methodologies used to evaluate enzymes, different substrates and the huge variability among experiments. This special issue contributes to the knowledge in this area by data that demonstrate relationships between enzymes not well characterized before, such as ferulic acid esterases, and *in vitro* degradation of fibrous forages (see data by Dean et al.; Krueger et al.).

3.3. Plant extracts

Ten of the papers in the special issue deal with plants rather than specific extracts. The targets are either general fermentation efficiency (Alexander et al.) or specifically protein metabolism (Hoffmann et al.) or methanogenesis (Bodas et al.), and the active compounds in these cases are only speculated upon. Other papers deal with specific types or groups of compounds. The range of bioactive compounds in plants is staggeringly large, so in a way it is inappropriate to group them together. However, the effects of tannins, saponins and essential oils all contribute to discussion of how these, and potentially other, plant extracts might be applied in ruminant nutrition. Here, there are more papers about essential oils than other groups, partly reflecting a resurgence in interest in these compounds and, no doubt, the relative ease of working with them rather than the chemically more difficult and diverse tannins, for example. The review by Benchaar et al. will prove to be valuable for many readers in this regard.

The perception that these extracts are ‘safe’ is of course a desirable one, but we must always be aware that many of the most poisonous chemicals known to man come from the plant kingdom. Indeed, the development of novel plant additives will be subject to rigorous safety and efficacy hurdles, making their transition from a research discovery to a product that is useful in ruminant production systems a lengthy and expensive process.

Essential oils are particularly attractive, because they have been used in many traditional remedies, or in human food flavouring, for a long time. Their antimicrobial properties were used extensively to control infections before the discovery of antibiotics. It is appropriate, therefore, that they should be again considered following the ban on GPAFA. Saponins appear to be useful in controlling the numbers of ciliate protozoa, thereby minimising bacterial protein turnover in the rumen, yet which of the many different types of saponin are most effective and persistent, and which protozoal species are affected most, remain

unanswered. Tannins appear to lack the specificity required to target specific functions such as methanogenesis, but again there is a void of knowledge about which of the many types of tannins might be more specific, and therefore potentially more useful, than others.

4. Final comments

We hope that this Special Issue of *Animal Feed Science and Technology* will prove useful to scientists from a range of disciplines, including ruminant production, ruminant nutrition and microbiology. The collection of papers provides a broad range of topics that will enable the interested reader to begin a search for more detail concerning enzymes, direct-fed microbials and plant extracts as feed additives in ruminant nutrition. While the potential of these additives is great, it is important that developments are built on a sound scientific basis.

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