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In vitro screening of plant extracts to enhance the efficiency of utilization of energy and nitrogen in ruminant diets☆

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Abstract

This study was completed to identify plant extracts that modulate partitioning of degraded organic matter (OM) towards microbial protein synthesis, at the expense of gas production, and decrease protein degradation in the rumen. In the preliminary study, effects of aqueous extracts of *Picrorhiza kurroa* root, *Plumbago zeylanica* root, *Terminalia bellerica* fruit and *Zingiber officinale* rhizome and aqueous methanol extract of *Moringa oleifera* seed on rumen fermentation end products were examined *in vitro* at 2.0 mg/ml of incubation medium using white clover hay (*Trifolium repens*) as substrate. Another study was conducted to evaluate the ability of two promising extracts, selected based on their ability to decrease ammonia N concentration, on *in vitro* degradable crude protein (IVDCP) and protozoal populations using the same substrate at a lower dose (1 mg/ml). Finally, the extract which did not affect IVDCP, but decreased ammonia concentration, was further investigated to assess its effect on substrate degradability, microbial mass and a partitioning factor (PF; ratio of substrate truly degraded to gas volume produced at 24 h of incubation) at two different doses (0.75 and 1.0 mg/ml) using a mixed diet (700 g local grass hay and 300 g concentrate mixture/kg) as substrate.

Abbreviations: ADF, acid detergent fibre; A:P, acetate propionate; DM, dry matter; CP, crude protein; EE, ether extract; EMPS, efficiency of microbial crude protein synthesis; IVDCP, *in vitro* degradable CP; lignin(sa), acid detergent lignin; OM, organic matter; NDF, neutral detergent fibre; NDFom, NDF expressed exclusive of residual ash; PF, partitioning factor; PSM, plant secondary metabolites; VFA, volatile fatty acids

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In the preliminary study, *M. oleifera* aqueous methanol extract decreased total gas, total volatile fatty acids (VFA) production, acetate propionate ratio and ammonia concentration and increased microbial purines (44%) and efficiency of microbial CP synthesis (EMPS). *P. kurroa* aqueous extract decreased total gas production and ammonia concentration (35%) and increased propionate production but did not affect total VFA production, microbial purines and EMPS. The decrease of ammonia in the presence of *P. kurroa* extract was mainly mediated through a decrease in *in vitro* CP degradability (28%). *M. oleifera* extract had activity against rumen protozoa, but did not influence CP degradability. Even at a lower concentration (*i.e.*, 0.75 mg/ml) with a forage based mixed diet as substrate, *M. oleifera* extract decreased gas production, without affecting true organic matter or neutral detergent fibre degradability, and increased microbial purines and PF. Results suggest that aqueous methanol extract of *M. oleifera* seed and aqueous extract of *P. kurroa* root may have potential as feed additives to increase the efficiency of utilization of energy and N in ruminant diets.

Keywords: Plant extracts; Rumen fermentation; Microbial protein synthesis; Partitioning factor; Protein degradation

1. Introduction

Ruminants possess the unique ability to transform low quality fibre and non-protein N into high quality protein sources for human consumption. There are several possibilities to make energy and N utilization in the rumen more efficient. Increasing fibre digestion, propionate production, yield and efficiency of microbial crude protein (CP) synthesis (EMPS) and decreasing methanogenesis, extensive dietary CP degradation and predation of bacteria by protozoa are some of the recognized ways to improve nutrient utilization and ruminant productivity (Nagaraja et al., 1997; Eugène et al., 2004). Physical, chemical, biological and biotechnological methods have been tried in the past to achieve one or more of these objectives, but all have had a limited impact in practice.

Volatile fatty acids (VFA), gases and microbial cells are the main end products of fermentation of feed organic matter (OM) in the rumen. The VFA and microbial cells supply a major part of the energy and protein to the host, while gases, especially methane, accounts for loss of substantial amounts of feed energy and contributes to global warming. However, VFA, microbial cells and gases produced per unit of substrate degraded are not constant. Microbial yield relative to VFA produced (*i.e.*, microbial growth efficiency) in the rumen is variable (Leng, 1993). Methods based on *in vitro* gas production techniques have been employed to assess partitioning of degraded nutrients between microbial cells, VFA and gases. The amount of substrate truly degraded to gas volume produced in an *in vitro* gas system has been defined as partitioning factors (PF). A higher PF (defined at the $t_{1/2}$ for gas production) indicates a higher proportion of degraded substrate being partitioned towards microbial cells (Blümmel et al., 1997).

Recent studies have shown that many plant secondary metabolites (PSM) have potential to modify rumen fermentation favourably, at relatively low concentrations. At appropriate doses, saponins, or saponin containing plants, have suppressed protozoal populations, increased bacterial and fungal populations, propionate production, microbial yield and EMPS, and decreased methanogenesis to improve growth in ruminants (Diaz et al., 1993;