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Patulin-producing molds in corn silage and high moisture corn and effects of patulin on fermentation by ruminal microbes in continuous culture

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Abstract

The objectives were to investigate the presence of patulin-producing *Penicillium* sp. in corn silage and high moisture corn as well as adverse effects of patulin on microbial fermentation in continuous culture fermenters. Eighty-three samples of corn silage or high moisture corn were cultured to determine the presence of molds. *Penicillium* sp. were isolated from 0.82 of samples. Of these *Penicillium* sp. isolates, 0.03 produced patulin on yeast extract sucrose and potato dextrose agar. The patulin-producing isolates belonged to the *P. viridicatum* group. The other molds identified were: *Mucor* sp. (0.45), *Aspergillus* sp. (0.41), and *Fusarium* sp. (0.25). Eight single-flow continuous culture fermenters were used to study effects of patulin on fermentation by ruminal microbes. Two 1-l fermenters were supplemented with 0, 10, 20 or 40 mg of patulin every 12 h for three consecutive days. Increasing patulin reduced neutral detergent and acid detergent fiber digestibility at a decreasing rate

Abbreviations: APDA, acid potato dextrose agar; cfu/g, colony forming units per gram; CYA, Czapeck yeast autolysate; PDA, potato dextrose agar; YES, yeast extract sucrose; DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; TNC, total non-structural carbohydrates; VFA, volatile fatty acid; NH_3-N, ammonia nitrogen; NAN, non-ammonia nitrogen; EMPS, efficiency of microbial protein synthesis; BCVFA, branched-chain VFA; ENU, efficiency of N utilization

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(linear, $P < 0.01$; quadratic, $P < 0.05$). True digestion of organic matter and total non-structural carbohydrates decreased linearly ($P < 0.05$) as patulin concentration increased. Crude protein digestion and bacterial N flows decreased linearly ($P < 0.05$). Conversely, there was a linear increase ($P < 0.05$) in ammonia nitrogen with increased patulin. Total, ammonia and non-ammonia N flows were not affected by patulin. Efficiency of microbial protein synthesis was not affected by patulin but there was a linear decreased ($P < 0.05$) in the efficiency of N utilization. Increasing patulin levels caused a linear decrease ($P < 0.001$) of total volatile fatty acid concentration and a quadratic decrease of acetate and propionate molar proportions ($P < 0.05$). Ten and 20 mg/l of patulin produced a decrease in acetate proportion and an increase in propionate proportion. Lactate concentration (mmol/l) increase from 0.0 to 216.5 mmol/l (linear, $P < 0.05$) with increasing patulin concentration. *Penicillium* sp. molds are common contaminants of corn silage and high moisture corn and they produce patulin that can adversely affect fermentation by ruminal microbes. Alterations in microbial digestion of dry matter, and production of microbial end products, impact the production and/or health of ruminants.

Keywords: Patulin; Fermented feeds; Ruminal fermentation; Continuous culture

1. Introduction

Corn silage and high moisture corn are fermented feeds frequently used in beef and dairy rations in the USA. A multitude of factors, including molds, may adversely affect the quality of fermented feeds. Molds identified in fermented feeds include *Aspergillus* sp., *Cladiosporum* sp., *Fusarium* sp., *Mucor* sp., *Penicillium* sp., and adverse effects of molds may occur either through their deleterious effects on nutrient quality and/or their production of mycotoxins.

Penicillium sp. are commonly found in fermented feeds and are known to produce several mycotoxins including citrinin, ochratoxin, roquefortine, PR toxin, penicillic acid and patulin (Pelhate, 1977; Seglar, 1999). Patulin contamination of silage has been associated with hemorrhagic disorders in cattle in England (Syret, 1977). Other patulin-related diseases have been reported in Japan, France, and Germany when cattle ingested moldy fermented feeds (Hori et al., 1954; Moreau and Moreau, 1960; Jacquet et al., 1963; Schultz et al., 1968).

Patulin (4-hydroxy-4H furo (3,2C)pyran- 2(6HO)-one) is toxic to a wide range of organisms including microbes, plants, and animals (Singh, 1967; Stott and Bullerman, 1975; McKinley and Carlton, 1991). Patulin has an antimicrobial effect on aerobic Gram-positive and Gram-negative bacteria and also affects anaerobic bacteria (Singh, 1967). Acetic acid production was reduced in a batch culture exposed to 100 μg/ml of patulin (Escuola, 1992). In vitro dry matter (DM) and organic matter (OM) digestibilities were reduced in wheat straw to which 10 nmol of patulin had been added (Abdelhamid et al., 1992), we found that high doses of patulin adversely affect fermentation by ruminal microbes maintained in continuous culture fermenters (Tapia et al., 2002).

In this study, we tested the hypotheses that patulin-producing *Penicillium* sp. molds occur naturally in Upper Midwest (USA) corn silage and high moisture corn and that low doses of patulin adversely affect ruminal fermentation.