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In vitro rumen fermentation characteristics of substrate mixtures with soybean meal partially replaced by microbially fermented yellow wine lees

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ABSTRACT

This study was conducted to evaluate the effects of replacing soybean meal (SBM) with unfermented and microbially fermented yellow wine lees (YWL) mix on the *in vitro* rumen fermentation characteristics of substrate mixtures. Both types consisting of YWL at 400 g/kg were included in the mixtures at different ratios (1:0, 1:1, 1:2, 1:5 and 0:1, w/w) to replace SBM. Microbial fermentation of YWL did not have a negative impact on gas value ($p > .05$), increased microbial protein (MCP, $p < .01$) and *in vitro* crude protein (CP) digestibility ($p < .01$), and improved the efficiency of nitrogen utilisation ($p < .01$). The ratio of YWL replacing SBM had linear and quadratic effects on gas production (GP, $p < .01$), the rate of GP ($p < .01$), MCP ($p < .01$), total volatile fatty acids (VFAs, $p < .01$), *in vitro* CP digestibility and efficiency of nitrogen utilisation ($p < .01$), with the optimal ratio at 1:1. The *in vitro* digestibilities of dry matter and organic were slightly ($p < .01$) reduced with the increasing ratio of YWL. Besides, positive associative effects were observed on GP parameters, VFA and MCP at some replacement ratios. Considering the *in vitro* rumen characteristics and their associative effects, the optimal ratio at which to replace SBM with microbially fermented YWL was indicated to be 1:1.

HIGHLIGHTS

- The *in vitro* rumen fermentation characteristics performed better with microbially fermented than unfermented yellow wine lees (YWL) replacing soybean meal (SBM).
- The positive associative effects were observed on gas production parameters, volatile fatty acid and microbial protein at replacing ratio of 1:1.
- The optimal ratio at which to replace SBM with microbially fermented YWL was 1:1.

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Introduction

Soybean meal (SBM) is the most important plant protein source in animal industry (Boguhn et al. 2008). In recent years, alternative protein feeds have attracted much interest all over the world, with growing consumer demand for dairy products because of the insufficient supply and high price of SBM. Many studies have been conducted on the utilisation of unconventional feed resources, such as palm meal, distiller's grains and sesame cake, in dairy production (Boguhn et al. 2008). In China, million tons of distiller's grains, by-products of the wine industry, are not well treated, but still contain quite a lot of unused protein, starch, fat and other ingredients which may have feeding value (Schingoethe et al. 2009).

Yellow wine is a traditional Chinese alcoholic beverage made from rice, sorghum or wheat (Hu et al. 2014). The yield of yellow rice wine amounted to 16 billion litres in 2015, generating nearly 1 million tons of yellow wine lees (YWL) as a co-product (Wang 2016). They contain a high content of crude protein (CP, 315–413 g/kg of DM) and the price is one third of that of SBM (Hu et al. 2014). However, YWL has an unbalanced amino acid (AA) profile and is hard to preserve because of its high moisture content (Cheng and Qian 2007). A previous study showed that through microbial pre-treatment, the CP and peptide contents, AA profile and the *in vitro* rumen digestibility of YWL was also improved (Yao et al. 2018), indicating that fermented YWL has potential as protein feed in ruminant rations.

Dairy rations with microbially fermented feed change the rumen fermentation, including increasing rumen microorganisms, enhancing nutrient flow and

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improving the digestibility of feeds (Piamphon et al. 2017). In addition, microbially fermented feed can greatly improve the health and production performance of goats and beef cattle (Syngai et al. 2016). The inclusion of microbially fermented feed in a concentrate mixture at a level of 50% significantly improved the nutrient digestibility of feed and the average daily gain of goats and enhanced their disease resistance (Zhang 2017). A diet with yeast cultures could improve milk production and digestibility of CP and DM in lactating cows (Meller et al. 2019). *Bacillus subtilis* probiotics can increase the degradation rate of feed by *in vitro* fermentation, promote the growth of rumen microorganisms and increase the production of microbial protein (MCP) and volatile fatty acids (VFAs) in the

statistical analyses, the model included substrates, ratio and their interaction as fixed effects. The linear and quadratic effects of the ratio were analysed using orthogonal polynomial contrasts. The cubic effects of the ratio were not examined for inexplicability in biology. Probability values of $p < .05$ were used to define statistical significance, and values of $p \leq .10$ and $p \geq .05$ were regarded as statistical trends.

Results and discussion

Gas production parameters

The cumulative GP was similar between the UM and FM, but differed among the ratios of UM or FM replacing SBM (Table 2). The GP data of both substrates showed a similar quadratic pattern, i.e. initial increase and then decline with decreasing SBM ratio ($p < .01$). No differences were observed between the two substrates in the rapid degradation fraction of the GP ($p >$

2018), contributing to the higher ruminal ammonia-N level in FM than in UM at each replacement. The MCP concentration was higher in the FM than in the UM ($p < .01$). A linear decline in MCP values was observed with increasing levels of UM or FM ($p < .01$), and quadratic effects of the replacement ratio were observed in both substrates ($p < .01$). Ruminal MCP provides 40–80% of the protein needs for ruminants (Uyeno et al.

Table 5.

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Associative effects on in vitro *rumen fermentation characteristics*

The associative effects of YWL mix and SBM on *in vitro* rumen fermentation variables are shown in Table 5. A positive associative effect on GP was found at 1:1 of SBM to FM ($p < .05$) and a tendency for a positive associative effect was at 1:2 (SBM to UM, $p < .10$). A positive associative effect on the rate of GP was observed for all UM and FM replacement ratios ($p < .01$). Positive associative effects were found in MCP, VFA and ENU at a replacement ratio of 1:1 ($p < .01$). However, no associative effect was observed on the *in vitro* digestibility at all replacement ratios for both substrates ($p > .10$), except for a slightly positive associative effect on IVCPD at the ratio of 1:1 (SBM to FM) ($p < .10$).

The positive associative effects of the YWL mix and SBM on the rate of GP, VFA and MCP at some replacement ratios, indicated their positive effects on improving rumen fermentation and protein synthesis. Positive associative effects exist among corn, distiller's grains and SBM (Lin 2009). In this study, corn and distiller's grain were considered to provide NFC, while the SBM provided N. The proper ratio of NFC to N may promote rumen fermentation and improve N utilisation and feed efficiency. Additionally, the increased AA and CP in microbially fermented YWL may have a positive effect on rumen fermentation, as Ismail et al. (2018) reported that with microbially fermented feather replacing SBM, the *in vitro* rumen fermentation characteristics of dairy rations were improved because of higher contents of CP and AA. An *in vivo* animal study may be needed to confirm these associative effects.

Conclusions

Compared with unfermented YWL mix consisting of 400 g/kg YWL, replacing SBM with microbially fermented YWL mix increased the rate of GP, improved the MCP and VFA synthesis and enhanced the digestibility of the rations. The replacement ratio had linear and quadratic effects on rumen fermentation characteristics and *in vitro* digestibility. Replacement of SBM with microbially fermented YWL mix at 1:1 had optimal *in vitro* characteristics and a positive associative effect among all the treatments. The results of the present study indicated that microbially fermented YWL could partially replace SBM in dairy rations and performed better than unfermented YWL. *In vivo* studies are needed to evaluate the optimised utilisation of the fermented YWL mix.

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Disclosure statement

No potential conflicts of interest were reported by the authors.

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