Histopathological effects of alternative feedstuffs (sesame hulls and Prosopis juliflora) on ruminal walls in black goat kids in Jordan

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ABSTRACT
This study evaluated the histopathological effects of alternative feedstuffs on ruminal walls and, subsequently, the impact on growth performance of black goat kids in Jordan. Male goat kids (n = 62, BW = 17.1 ± 2.0 kg, age = 120 ± 5 days) housed in individual pens were randomly assigned to one of seven diets for 84 days. Treatment diets were prepared by partially replacing barley in the control diet (CTL; n = 9) with different levels (10%, 15%, or 20%) of Prosopis juliflora pods (JP; n = 26) or partially replacing barley and soybean meal in the control diet with different levels of P. juliflora pods (10%, 15%, or 20%) plus sesame hulls (20%, 15%, or 10%; PJS; n = 27). All kids were slaughtered and sections from ruminal walls were examined for vacuolar degeneration, dysplasia, hyperplasia, hyperkeratosis, stunting, submucosal inflammation, submucosal oedema, erosions, lymphangiectasia, and ulcers. Dietary treatments had no effects on all studied histopathological changes. The growth rate of kids was negatively correlated (P ≤ .05) with submucosal oedema and inflammation. However, the severity of submucosal oedema and inflammation was not affected by dietary treatments. Alternative feedstuffs had no detrimental histopathological effects on ruminal walls of goat kids.

1. Introduction
Non-conventional (alternative) feedstuffs have been successfully used (Awawdeh 2011) in feeding small ruminants (i.e. sheep and goats). Utilizing alternative feedstuffs has been an important, cost-saving, and appealing practice in many areas with limited grass and grain resources. Olive cake, Prosopis juliflora pods, poultry litter, sesame meal/hulls, and yellow grease are common alternative feedstuffs in Mediterranean countries (Awawdeh 2011).

Many previous studies, cited by Awawdeh (2011), evaluated the effects of alternative feedstuffs on growth (i.e. nutrient intake and digestibility, growth rate, and carcass weight/composition) and lactation (i.e. milk composition and yield) performance of small ruminants. Several studies have evaluated the effects of dietary inclusion of alternative feedstuffs on the ruminal ecosystem and fermentation. In his review, Awawdeh (2011) concluded that with appropriate inclusion proportions, alternative feedstuffs can be used in feeding small ruminants without negative effects on quantity and quality of products (meat or milk). Research has shown that diet can affect the morphology and histology of ruminal papillae (Nockels et al. 1966; Nocek et al. 1984; Di Giancamillo et al. 2003). However, very few studies have evaluated the effects of diet on rumen histology (Álvarez-Rodríguez et al. 2012; Sun et al. 2013). To the best of our knowledge, the impact of dietary inclusion of alternative feedstuffs on rumen histopathology in small ruminants has not been previously described.

Rumen health (morphology and histopathology) can impact nutrient absorption and metabolism and, subsequently, animal performance. However, the relationship between histopathological changes in the rumen and growth rate of small ruminants has not been investigated. Understanding this relationship can help explain the depression in animal performance in some studies cited by Awawdeh (2011) in response to dietary inclusion of certain alternative feedstuffs.

We hypothesized that moderate (<50%) dietary inclusion of alternative feedstuffs would not negatively impact rumen histopathology and that the growth rate of goat kids may be correlated with ruminal wall lesions. The objective of this study was to evaluate the effects of dietary inclusion of alternative feedstuffs on histopathological changes of the ruminal wall and, subsequently, the impact (correlation) of ruminal lesions on the growth rate of black goat kids. Black goat (Baladi) is the major goat breed (>80% of the total goat population) in Jordan (Titi et al. 2000) and other Mediterranean countries.

2. Materials and methods
The study was conducted at the Agricultural Research and Training Unit (semi-arid area, 32°30′N, 35°57′E, and 510 m above sea level) at Jordan University of Science and Technology (JUST). The Institutional Animal Care and Use Committee at JUST approved all procedures used in this study.
Introduction

Sixty-two sexually intact male goat kids (BW = 17.1 ± 2.0 kg, age = 120 ± 5 days) housed in individual pens were randomly assigned to one of seven diets (Table 1) for 84 days. All diets were isonitrogenous and formulated to meet the nutrient requirements of goat kids (NRC 1981). Diets (total-mixed ration) were offered twice daily ad libitum and kids had free access to clean water. Kids were part of feeding trials (Abdullah et al. 2011 and unpublished data).

Treatment diets were prepared by partially replacing barley in the control diet (CTL; n = 9) with different levels (10%, 15%, or 20%) of P. juliflora (Mesquite) pods (PJ; n = 26) or partially replacing barley and soybean meal in the control diet with different levels of P. juliflora pods (PJ1, PJ2, and PJ3) were pooled together plus sesame (Sesamum) hulls (20%, 15%, or 10%; PJSH; n = 27). Sesame hulls and P. juliflora pods were selected because they are commonly available and relatively inexpensive in Jordan. At the beginning and weekly throughout the study kids were weighed before the morning feeding. At the conclusion of our study, all kids were slaughtered, as described by Abdullah et al. (2011).

2.1. Animals and experimental design

At slaughter, sections (5 x 5 cm) from the ruminal wall (ventral sac) of all kids were harvested, fixed in 100 g/kg buffered formalin solution and processed, as described by Mepham (1991). The processed tissues were sectioned (4–5 µm) and stained with haematoxylin and eosin stain. Tissues were examined and histopathological changes were recorded by a pathologist blinded to the respective dietary treatments. The quantitative changes (vacuolar degeneration, dysplasia, hyperplasia, hyperkeratosis, stunting, submucosal inflammation, and submucosal oedema) were assessed and scored as 0 (no lesion), 1 (mild), 2 (moderate), or 3 (severe). Qualitative changes (presence of erosions, lymphangiectasia, and ulcers) were assessed and scored as 0 (not present) or 1 (present).

2.3. Statistical analysis

All data were statistically analysed using the SAS System for Windows Release 8.1 (SAS Inst. Inc., 2002). For statistical analysis, the data for diets that contained different levels (10%, 15%, and 20%) of P. juliflora pods (PJ1, PJ2, and PJ3) were pooled together (PJ) and those that contained different levels (10%, 15%, and 20%) of P. juliflora pods plus sesame hulls (PJSH). Please refer to text for details.

Table 1. Growth performance of local black goat kids fed diets containing different levels of P. juliflora pods and sesame hulls.

| Dietary treatmenta | PJ1 | PJ2 | PJ3 | PSH1 | PSH2 | PSH3 |
|--------------------|-----|-----|-----|------|------|------|
| Item               |     |     |     |      |      |      |
| Barley             | 59  | 49  | 44  | 39   | 36   | 34   |
| Soybean meal       | 13  | 13  | 13  | 13   | 6    | 8    |
| P. juliflora pods  | 0   | 10  | 15  | 20   | 10   | 15   |
| Sesame hulls       | 0   | 0   | 0   | 0    | 20   | 15   |
| Wheat bran         | 15  | 15  | 15  | 15   | 15   | 15   |
| Wheat hay          | 10  | 10  | 10  | 10   | 10   | 10   |
| Salt               | 1.5 | 1.5 | 1.5 | 1.5   | 1.5  | 1.5   |
| Limestone          | 1.4 | 1.4 | 1.4 | 1.4   | 1.4  | 1.4   |
| Vitamins/minerals  | 0.1 | 0.1 | 0.1 | 0.1   | 0.1  | 0.1   |
| Nutrient, %        |     |     |     |      |      |      |
| Dry matter         | 93.9| 92.8| 94.1| 94.3  | 94.3 | 94.5 |
| Organic matter     | 88.6| 90.6| 89.6| 90.5  | 87.9 | 88.0 |
| Crude protein       | 17.4| 17.0| 17.5| 17.4  | 17.2 | 16.8 |
| Ether extract       | 2.8 | 3.1 | 2.8 | 6.6   | 9.9  | 9.4   |
| Neutral detergent fibre | 31.4 | 35.1 | 32.6 | 33.6 | 32.6 | 31.9 |
| Acid detergent fibre | 10.7 | 14.0 | 13.2 | 13.6 | 13.9 | 14.4 |
| Metabolizable energyb | 2.77 | 2.78 | 2.78 | 2.77 | 2.94 | 2.91 |

| Item               |    |    |    |      |      |      |
|--------------------|----|----|----|------|------|------|
| Item               |    |    |    |      |      |      |
| Initial BW, kg     | 16.4| 17.1| 16.5| 0.50  | .46  |      |
| Final BW, kg       | 24.8| 24.4| 22.8| 1.17  | .55  |      |
| Total gain, kg     | 7.7 | 6.3 | 5.7 | 1.17  | .55  |      |
| Average daily gain, g/d | 78.8 | 64.7 | 57.8 | 11.95 | .55  |      |

Table 2. Percentage of histopathological changes in the ruminal wall of black goat kids fed diets containing different levels of P. juliflora pods and sesame hulls.

| Dietary treatmenta | PJ1 | PJ2 | PJ3 | PSH1 | PSH2 | PSH3 |
|--------------------|-----|-----|-----|------|------|------|
| Item               |     |     |     |      |      |      |
| Number of kids     | 9   | 26  | 27  | 15   | 15   | 15   |
| Dysplasia          | 11  | 12  | 11  | 11   | 11   | 11   |
| Hyperplasia        | 56  | 58  | 63  | 63   | 63   | 63   |
| Hyperkeratosis     | 100 | 100 | 96  | 96   | 96   | 96   |
| Stunting           | 67  | 69  | 74  | 74   | 74   | 74   |
| Submucosal oedema  | 56  | 50  | 56  | 56   | 56   | 56   |
| Submucosal inflammation | 56 | 50  | 52  | 52   | 52   | 52   |
| Vacular degeneration | 100 | 96  | 96  | 96   | 96   | 96   |
| Erosions           | 10  | 11  | 15  | 15   | 15   | 15   |
| Lymphangiectasia   | 44  | 31  | 37  | 37   | 37   | 37   |
| Ulcers             | 0   | 15  | 4   | 4    |      |      |

| Item               |    |    |    |      |      |      |
|--------------------|----|----|----|------|------|------|
| Item               |    |    |    |      |      |      |
| Item               |    |    |    |      |      |      |

aDiets contained: 0% P. juliflora pods and sesame hulls (CTL); different levels of P. juliflora pods (PJ); different levels of P. juliflora pods plus sesame hulls (PJSH). Please refer to text for details.

bMcal/kg.
Results and discussion

All kids within the study were clinically normal. No evidence of infectious or non-infectious diseases was present throughout the study. Growth performance (initial BW, final BW, total gain, and growth rate) of kids was not significantly affected by dietary inclusion of sesame hulls and/or P. juliflora pods at different levels (Table 2).

Percentages of histopathological changes in the ruminal wall of goat kids fed diets containing different levels of P. juliflora pods and sesame hulls are presented in Table 3. It is clear that dietary inclusion of sesame hulls and/or P. juliflora at these levels had no effects on the prevalence of all of the studied histopathological changes. Additionally, severity of quantitative histopathological changes was not affected by diets (Table 4).

Changes in ruminal mucosa in response to diet are mainly determined by changes in ruminal fermentation (i.e. volatile fatty acids amount and type) and/or amount of dietary fibre (Neiva et al. 2006). Although P. juliflora pods contain more neutral and acid detergent fibre (40% and 32%, respectively) than barley (20% and 7%, respectively), their dietary inclusion of up to 20% did not impact ruminal mucosa, probably because it did not drastically affect fermentation products (NRC 1981; Mahgoub et al. 2005). Additionally, submucosal oedema of the ruminal wall was associated with high-concentrate (75–84% of DM) diets (Černík et al. 2011). Our treatment diets contained lower amounts (average <50%) of concentrate than the control diets. Thus, increases in submucosal oedema are not expected in response to treatment diets.

Correlations among histopathological changes in the ruminal wall and growth rate of kids are presented in Table 5. Of all studied parameters, the growth rate of kids was negatively correlated (P ≤ 0.05) with the presence of submucosal oedema and inflammation (r = –0.25 and –0.30, respectively). However, the severity (score) of submucosal oedema and inflammation was not affected by dietary treatments (Table 4). Additionally, there was no association between kid growth rate and presence of erosions (P = .20), lymphangiecstasia (P = .07), or ulcers (P = .14).

Infectious causes (zygomycosis, aspergellois, fusobacteriosis, and candidiasis) could induce submucosal oedema and inflammation in the ruminal wall (Zachary & McGavin 2012). These microorganisms are commonly identified within ruminal wall lesions. However, none of the aforementioned microorganisms were observed in the examined rumen wall sections. In addition, these organisms induce their changes not only as inflammation and submucosal oedema, but also as more severe effects in other tissues, which were not detected in our study. The definitive cause that induced those changes (submucosal oedema and inflammation) could not be determined in this study. More research is needed to elucidate the mechanism and aetiology behind such changes and how these changes could be nutritionally prevented to improve growth performance of kids.

Conclusion

Dietary inclusion of sesame hulls and/or P. juliflora pods had no detrimental histopathological effects on ruminal walls of black goat kids. The growth rate of kids was negatively correlated with submucosal oedema and inflammation in the ruminal wall, which deserves further investigation. Severity of submucosal oedema and inflammation was not affected by dietary inclusion of alternative feedstuffs. Similar studies on the feeding of other alternative feedstuffs in small ruminants are required.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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