Small Ruminant Research 115 (2013) 21–28

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Grain excretion by goats fed whole or processed cereals with various roughages

B.A. McGregor[a,*], C.J. Whiting[b]

[a] Institute for Frontier Materials, Deakin University, Geelong, Victoria 3220, Australia
[b] Formerly Victorian College of Agricultural and Horticulture, Glenormiston Agricultural College, Glenormiston, Victoria 3265, Australia

ARTICLE INFO

Article history:
Received 15 November 2012
Received in revised form 2 August 2013
Accepted 19 August 2013
Available online 2 September 2013

Keywords:
Angora goats
Associative effects
Barley
Digestion
Oats
Ration composition
Roughage quality
Starch
Supplementary feeding

ABSTRACT

Despite cereal grains being grown on 5 continents where goats are kept, there is little information on the excretion of whole cereal grains when fed to goats. We determined the effects of various dietary treatments on whole grain and starch loss in the faeces of Angora goats. In Experiment 1 there were 4 replicates of the factorial design: (a) 2 grain types (barley, oats); (b) whole grain or processing (milled barley or rolled oats); (c) 2 roughage qualities (Persian clover hay, barley straw); and (d) 2 feeding levels (level 1, 150 g/d of grain, 250 g/d of roughage; level 2, 250 g/d of grain, *ad libitum* roughage). In Experiment 2, which immediately followed Experiment 1, and aimed to detect carry over effects of previous feeding of barley straw and grain processing, feed levels were either 650 g/d grain or 400 g/d grain with 550 g/d Persian clover hay. Data were analysed by ANOVA. In Experiment 1, processing had no effect on digestible dry matter intake. The number of whole grains lost per 100 g of fresh faeces and whole grains loss as the % of grain dry matter intake were affected by an interaction between processing and roughage quality. Whole grain fed with Persian clover hay had greater grain loss than all other diets. Whole grain loss was greater with whole grain than with processed grain. Level of feeding had no effects on grain loss. In Experiment 2, more whole grains were lost in fresh faeces when fed with Persian clover hay than when fed without hay, an effect of previous feeding with barley straw reduced whole grain excretion, and more barley grains were lost than oat grain. Faecal starch was affected, with higher levels when whole barley grain was fed, particularly with Persian clover hay, or when previously fed barley straw at a high level. Feeding grain at 650 g/d did not increase grain or starch excretion. Whole grains represented a small loss of grain dry matter intake in faeces, averaging 0.8% with a maximum recorded of 2.6%. Faecal concentration of the whole grains may be altered by grain size and the digestibility of the roughage component of the diet. In this study an additional cost of 3% for processing grains would not have provided economic benefits.

1. Introduction

For goat production, grains are used in processed rations in housed production systems, are fed strategically to overcome nutritional deficiencies during lactation, following weaning (Economides et al., 1989; Hadjipanayiotou, 1990; McGregor et al., 2010), when finishing goats for meat (McGregor, 1996) or in times of drought, after floods or when wildfires destroy pastures (McGregor, 1998, 2005, 2006). In Australia, grain supplements provided when forage is of low digestibility during the summer period moderate the expected 25–30% loss of live weight in grazing goats and sheep, which reduces their carcass weight,

* Corresponding author. Tel.: +61 3 9386 3102; fax: +61 3 52 272 539.
E-mail addresses: bruce.mcgregor@deakin.edu.au, bmcgregor@sub.net.au (B.A. McGregor).

0921-4488/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.smallrumres.2013.08.009

reproductive rate, mohair, cashmere and wool growth (McGregor, 2010; McGregor and Umar, 2000). Similar nutritional outcomes are expected in other harsh temperate and tropical environments where goats are kept.

Despite cereal grains being grown on a large scale on 5 continents where goats are kept, and that goats frequently graze cereal crop stubbles in these regions, there is little information on the loss of whole cereal grains when fed to goats (Iñiguez, 2004; McGregor, 2005). Many farmers, who have fed whole barley and oat grains to goats, have remarked to the authors about the apparent level of undigested whole grain excreted in faeces and questioned the need to process grain prior to feeding.

Processing grains in animal production systems is undertaken for a variety of reasons, including the need to mix components of a ration and to influence the extent and location of digestion of starch (Rowe et al., 1999). Grain processing is less important for sheep than for cattle because sheep masticate grains more completely. Neither the level of grain in the ration of sheep nor the methods of processing alter the digestibility of grain by sheep (Hale and Theurer, 1974; Orskov, 1976a). Orskov (1976b) concluded that whole grains appear in the faeces of sheep on occasions and more often when grains are a supplement to forage-based diets. Though faecal loss may convince farmers to process cereal grains, faecal loss is of no quantitative importance. However, the reported retention time of feeds in the gastro-intestinal tract of the goat is shorter than that of sheep and cattle so rate of passage is greater (Huston et al., 1986). Differences between goats and sheep in their rumination behaviour have been reported (Focant et al., 1986); this may be related to their mixed feeding behaviour compared with the grazing style behaviour of sheep (Hofmann, 1989; Pérez-Barbería et al., 2001).

Therefore, the issue of whether goat producers should process whole cereal grains prior to feeding them to goats in order to obtain high feed utilization remains unresolved. In the absence of literature on the extent of whole cereal grain loss in faeces of goats we studied the effects of: grain type, processing, roughage quality and feeding level, on faecal loss of whole barley and whole oat grain, as these factors may affect the rate of passage of digesta from the rumen. The present work used grain feeding at three different levels and used roughages of different digestibility to simulate lower digestibility senescent summer and autumn pastures typical of drought conditions, and contrasted this with higher digestibility roughage and the effects of carryover effects of previous feeding.

2. Materials and methods

2.1. Source and management of goats

Angora goats ($n = 32$), castrated at 6 weeks of age, were purchased at 4 months of age and grazed on annual temperate pastures. Goat were properly vaccinated against enterotoxaemia and tetanus as kids and every 6 months thereafter. At 3 years of age, the goats were shorn and dipped to eliminate external parasites. Goats were weighed 4 weeks later, to the nearest 0.5 kg, (mean ± s.d. live weight was 35.8 ± 4.41 kg). Two experiments were conducted in sequence, using the same materials but different dietary combinations and feed levels.

Table 1
Analysis of variance terms and degrees of freedom (d.f.) for measurements indicating the number of d.f. for the residual term.

Terms	d.f.
Replicate stratum	1
Time stratum	1
Rep. Animal stratum	
Grain type	1
Roughage quality	1
Feed level	1
Grain type. Roughage quality	1
Grain type. Feed level	1
Roughage quality. Feed level	1
Grain type. Roughage quality. Feed level	1
Residual	23
Replicate. Time stratum	1
Rep.Animal. Time stratum	
Processing	1
Processing. Grain type	1
Processing. Roughage quality	1
Processing. Feed level	1
Processing. Grain type. Roughage quality	1
Processing. Grain type. Feed level	1
Processing. Roughage quality. Feed level	1
Processing. Grain type. Roughage quality. Feed level	1
Residual	21 (1)
Total	63

2.2. Methods

2.2.1. Design of Experiment 1

The experiment had 2 replicates of the factorial design: 2 levels of grain type × 2 levels of grain processing × 2 levels of roughage quality × 2 feeding levels. The factors were:

Grain type: barley (*Hordeum vulgare* L.); oats (*Avena sativa* L.).
Grain processing: whole grain; processed.
Roughage quality: Persian clover hay (*Trifolium resupinatum* L.); barley straw.
Feeding level: Level 1; Level 2. Feeding level 1 was 150 g/d of grain with 250 g/d of roughage. Feeding level 2 was 250 g/d of grain with roughage available *ad libitum* (adjusted daily to minimize waste and selection).

There were 4 replicates of 1 goat per treatment. This was obtained by having 2 replicate goats in each of 2 time periods as follows. For Period 1, the 16 treatment combinations were allocated randomly to the 16 lightest goats (Rep 1, mean ± s.d. 32 ± 2.5 kg) and again to the 16 heaviest goats (Rep 2, mean ± s.d. 39 ± 2.5 kg). For Period 2, each goat received the same combination of grain type, roughage quality and feeding level, but if the goat had been fed processed grain, it received whole grain in Period 2 and *vice versa.* This provided 4 goats for each combination of treatments.

This design was chosen because the main effect of processing and all the interactions of processing with other effects are not confounded with the between animal variation nor with the time period effect as shown in Table 1.

2.2.2. Design of Experiment 2

This aimed to detect carry over effects of previous feeding of barley straw and grain processing, and to investigate higher feeding levels of grain. The experiment had 2 replicates of the factorial design: 2 levels of grain type × 1 level of roughage quality × 3 levels of previous feeding levels within straw (PFLINS) × 3 levels of previous processing treatment within straw (PROCINS) × 3 levels of processing within hay (PROCINH). Goats fed Persian clover hay at the low feeding level from Experiment 1 were excluded. The factors were:

Grain type and roughage quality: as in Experiment 1 except no treatment was fed barley straw.
PFLINS: Low, if low feeding level in previous periods; High, if high feeding level in previous periods; NA, if Persian clover hay fed in previous periods.