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Review

The feeding value of forage brassica plants for grazing ruminant livestock

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ABSTRACT

Forage brassicas fed to ruminants include swedes, turnips, kale and forage rape. All have high dry matter (DM) digestibility (0.81–0.89) and metabolisable energy (ME) (12.1–14.1 MJ/kg DM), which are higher than most grass based pastures or legumes. All brassicas contain the secondary S-containing compounds S-methyl-cysteine sulphoxide (SMCO) and glucosinolates. The SMCO is fermented in the rumen to dimethyl disulphide, which causes haemolytic anaemia and depressed voluntary feed intake (VFI). Glucosinolates are decomposed to iso-thiocyanate and nitriles, with the latter having the potential to depress VFI. When grazed by young ruminants as the sole diet, their growth was considerably less than would have been expected with high ME forages, and was variable. Nevertheless, growth of young sheep was higher on forage rape (225 g/d) and turnips (173 g/d) than on swedes (95 g/d) and kale (120 g/d), with swedes and kale having the highest concentrations of SMCO where initial growth was very low. However grazing lambs fed low SMCO kale, induced by low S fertiliser treatment, eliminated the initial 6-wk period of low lamb growth. Nitrate N concentrations in turnip leaves and kale were variable, with some in the range associated with reduced VFI. End products of kale digestion are low in absorbed amino acids in relation to ME, perhaps explaining responses to protein supplementation in sheep fed forage brassicas. In contrast, where brassicas have been fed as a supplement to supply 0.2–0.3 of DM eaten, notably to grazing dairy cows during dry summer conditions, there have been responses in milk yield equal to those with supplementation of chicory and barley grain. Low growth in sheep and cattle fed sole diets of brassicas may be due to combinations of degradation products from secondary compounds, low amino acid absorption in relation to ME, induced trace element deficiency in long term studies and perhaps high nitrate N concentrations in some crops. SMCO and glucosinolate concentration in kale, the highest yielding forage brassica, have heritabilities of 0.24 and 0.48. Low glucosinolate lines have been produced and should be evaluated as the sole diet of ruminants. It has not proven possible to breed low SMCO kales to date, but single trait selection is suggested for future research. Low S and N fertiliser treatments can reduce SMCO and nitrate N concentrations in kale. Protein supplementation should be evaluated in young ruminants fed sole diets of all brassicas and careful adaption to sole diets of forage brassicas over 5 wks is recommended.

Abbreviations: CHO, carbohydrate; CP, crude protein; DM, dry matter; FV, feeding value; ITC, iso-thiocyanate; LW, liveweight; LWG, LW gain; ME, metabolisable energy; NZ, New Zealand; OM, organic matter; SMCO, S-methyl-cysteine sulphoxide; SOD, superoxide dismutase; UK, United Kingdom; VFI, voluntary feed intake.

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Contents

1. Introduction

Brassica plants are annuals which have traditionally been used to fill periods of feed deficits in temperate ruminant grazing systems. In New Zealand (NZ) this has traditionally been winter in the colder far south of the country, especially for wintering sheep fed mainly on swedes, and in more northerly areas as livestock feed during dry late summer/autumn periods, notably for finishing lambs. More recently brassicas have been evaluated in NZ as a summer supplement for lactating dairy cows and are now being researched as a potentially major component of very high DM production dairy systems. In traditional systems of brassica use in NZ, high levels of sheep and cattle growth were not sought, but that view has changed to one of the requiring high productivity of growing and lactating animals grazing brassicas, which makes a review of brassica feeding value timely.

There are four main types of brassica used in grazing systems: swedes (*Brassica napus* spp. *napobrassica*), kale (*Brassica oleracea* spp. *acephala*), forage rape (*Brassica napus* spp. *biennis*) and turnips (*Brassica rapa* spp. *rapa*), and all are covered in this review. The feeding value of brassica forages in NZ was last reviewed by Nicol and Barry (1980), and their conclusions have been retained in this review as a benchmark, while developments since then have been summarised using data from a range of countries where relevant information could be found, notably NZ, USA, UK and Australia. Because brassicas have been used as a temporary "fill-in" crop, research on forage brassicas has been sporadic and not as plentiful as for grasses, legumes and herbs. Hence some older references on animal performance have been retained in this review but these have been re-interpreted in light of developments in modern forage analysis techniques, notably in the area of secondary compound analysis.

Forage feeding value (FV) is defined as the animal production response to grazing forage under conditions where availability of the forage does not restrict animal performance. It is generally expressed as liveweight gain (LWG) in growing animals or milk yield in lactating animals, often when they are grazing diets of only one forage. Many brassica grazing experiments with sheep fit this criterion. Components of FV are voluntary feed intake (VFI), apparent digestibility and efficiency of utilisation of digested nutrients. Of these, the most information for brassicas is for apparent digestibility with information on VFI available in only some experiments. When comparing FV among forages, it is generally accepted that a high ratio of readily fermentable carbohydrate (CHO) to structural CHO will lead to more rapid degradation in the rumen, faster rumen clearance and higher VFI and FV. This is true where there are no negative influences from plant secondary compounds, which is not the case with forage brassicas. Fig. 1 shows the secondary compounds which occur in forage brassicas, their degradation/metabolism in the ruminant digestive system and the absorbed products which can cause negative effects in grazing animals. The extent of conversion from plant precurser to active toxin may differ among brassica forages and, in most cases, this is unknown, which makes effects upon FV hard to estimate. Different secondary compounds may cause problems with some brassica forages, but a likely effect from the action of products from brassica secondary compounds is depressed VFI (Fig. 1).

2. Plant chemical composition

2.1. Carbohydrates and secondary compounds

As a group, brassica plants have a much higher ratio of readily fermentable CHO (*i.e.*, water soluble sugars and pectins) to structural CHO (*i.e.*, cellulose and hemicellulose) than grass based pastures (Table 1), whilst crude protein (CP) content is similar. Another feature of brassica plants is their high concentration of S compared with other forage plants (Tables 1 and 2),

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