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**NUTRITIVE VALUE OF CHICORY
(Cichorium intybus) AS A SPECIAL PURPOSE
FORAGE FOR DEER PRODUCTION**

**A Thesis Presented in Partial Fulfilment of
the Requirements for the Degree of Doctoral of
Philosophy in Animal Science at Massey University**

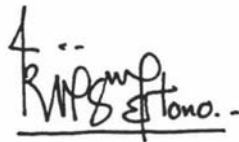
KUSMARTONO

1996

DECLARATION

The studies presented in this thesis were completed by the author whilst a postgraduate student in the Department of Animal Science, Massey University, Palmerston North, New Zealand. This is all my own work and the views presented are mine alone. Any assistance received is acknowledged in the thesis. All references cited are included in the bibliography.

I certify that the substance of the thesis has not been already submitted for any degree and is not being currently submitted for any other degree. I certify that to the best of my knowledge any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.



Kusmartono

PhD candidate



Professor T.N. Barry

Chief Supervisor



Associate Professor P.R. Wilson

Co-supervisor



Dr K.J. Stafford

Co-supervisor



Dr P.D. Kemp

Co-supervisor

March 1996

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KUS

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ABSTRACT

(Kusmartono, Department of Animal Science, Massey University, Palmerston North, NEW ZEALAND. *Nutritive value of chicory (Cichorium intybus) as a special purpose forage for deer production*)

A series of grazing and indoor experiments were conducted at Massey University Deer Research Unit and Nutrition Laboratory, Palmerston North, New Zealand, to study the effects of grazing chicory (*Cichorium intybus*) and perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) upon the growth, voluntary feed intake (VFI) and venison production of red and hybrid deer, and to study rumen digestion in deer fed either diet, to define factors responsible for the difference in feeding value (FV) between the two forages. Half of the animals in each experiment (Chapter 2) were grazed on either chicory or perennial ryegrass using a rotational grazing system, whilst for the indoor experiments (Chapter 3 & 4), rumen fistulated red deer individually kept in metabolism crates were fed fresh chicory or perennial ryegrass using automatic feeders at hourly intervals. In the last grazing Experiment (Chapter 5), to investigate the effect of condensed tannin (CT) in chicory and perennial ryegrass upon protein degradation, half of the animals were supplemented with polyethylene glycol (PEG; MW 3350) to inactivate CT and effects of CT were defined by comparing unsupplemented deer (CT acting) with PEG supplemented deer (CT inactivated).

1. The effects of grazing chicory or perennial ryegrass/white clover pasture upon growth and VFI of red and hybrid calves were compared both during lactation in summer of 1993 (Experiment 1; Chapter 1) and during post-weaning growth in autumn, winter and spring of 1993 (Experiment 2; Chapter 2). Relative to pasture, chicory had a higher ratio of readily fermentable:structural carbohydrate in all seasons and had higher organic matter digestibility (OMD) in summer and autumn but not in spring. Deer grazing chicory had higher VFI, bite weight, liveweight gain (LWG), and greatly reduced ruminating time than deer grazing pasture. Carcass dressing percentage and carcass weight of deer grazing chicory were higher than those grazing pasture. Hybrid deer grew better than red deer

and there were forage x genotype interactions in Experiment 2, with LWG and carcass weight of hybrid deer (especially stags) being much greater when grazed on chicory. Carcass weight for red deer and hybrid stags was 64.9 and 73.0 kg when grazed on chicory and 56.6 and 57.0 kg when grazed on pasture. Grazing chicory advanced the date of first cut velvet antler by 28 days and increased the weight of total harvestable (first cut+regrowth) velvet antler. It was concluded that grazing chicory increased carcass weight, especially in hybrid stags with increased growth potential, and increased velvet antler production. This was achieved by increased VFI in all seasons and increased OMD of chicory in summer and autumn relative to deer grazing pasture.

2. Intra-ruminal particle size reduction in rumen fistulated castrate red deer (*Cervus elaphus*) fed fresh chicory was compared with that in deer fed fresh perennial ryegrass in a two-period each of 12 days indoor experiment, with each period being 15 days long. Measurements included the efficiency of particle breakdown during the time allowed for rumination (<C.PART>) to below the critical size required to leave the rumen (passage through a 1mm sieve) and jaw activities (ie. eating and ruminating). Total eating time and the number of eating bouts were similar for deer fed each forage, but deer fed chicory had a greater chewing rate during eating (97.4 v. 81.0 chews/min), and a higher number of chews/g DM eaten (36.2 v. 31.5). Deer fed chicory had lower total ruminating time (30 v. 257 min/22.5h), lower number of boli ruminated (38 v. 440/22.5h), lower number of rumination bouts (5.4 v. 16.2/22.5h) and less chews per minute ruminating (16.5 v. 44.3) than those fed perennial ryegrass. Of the ten deer used to measure (<C.PART>), only four ruminated when fed chicory compared with nine when fed perennial ryegrass. Deer fed chicory had a higher efficiency of particle breakdown (<C.PART>; 0.64 v. 0.42), higher fractional degradation of particles >1mm to <1mm (9.2 v. 5.1%/h) and faster fractional disappearance of total DM from the rumen (10.2 v. 5.3%/h). All three measurements for chicory were similar in deer that did or did not ruminate, but with perennial ryegrass all values were considerably reduced in the deer that did not ruminate. It was concluded that chicory can be broken down faster in the rumen, with less

rumination being required than perennial ryegrass, and that some deer (60%) could break down swallowed chicory to below the critical particle size without ruminating at all. The faster clearance of DM from the rumen explains the high VFI of deer grazing chicory.

3. The effects of feeding chicory and perennial ryegrass indoors on apparent digestibility, rumen fractional disappearance rate (FDPR), rumen fractional degradation rate (FDR), rumen fractional outflow rate (FOR) and mean retention time (MRT; 1/FOR) were measured in deer fed at hourly intervals. The ratio of readily fermentable carbohydrate to structural carbohydrate was *c.* three times higher in chicory than in perennial ryegrass. Apparent digestibility of DM was higher in deer fed chicory than in deer fed perennial ryegrass (0.785 *v.* 0.727), whilst apparent digestibility of neutral detergent fibre (NDF) was lower in deer fed chicory (0.679 *v.* 0.755), due only to reduced hemicellulose digestibility (0.667 *v.* 0.783). Relative to deer fed perennial ryegrass, those fed chicory had higher rumen FDPR values for DM (14.5 *v.* 8.6%/h), soluble carbohydrate (69.9 *v.* 54.7%/h), cellulose (15.5 *v.* 9.8%/h) and lignin (6.8 *v.* 3.8%/h). Rumen FDR in deer fed chicory was higher than those fed perennial ryegrass for cellulose (11.4 *v.* 7.0%/h) and lignin (2.7 *v.* 1.0%/h), but tended to be lower for hemicellulose. Rumen FOR was higher and MRT was lower for both liquid and particulate matter in deer fed chicory compared to deer fed perennial ryegrass. It was concluded that rumen FDPR and apparent digestibility were much higher in deer fed chicory than in deer fed perennial ryegrass, due to faster degradation rates of most constituents in the rumen and faster outflow rates from the rumen. An exception was hemicellulose, where reduced rumen degradation rates and shorter rumen particulate MRT contributed to reduced apparent digestibility. Faster clearance from the rumen, due to both faster degradation and outflow rates may be used to explain the greater VFI, as well as faster growth rate in deer grazing chicory compared to those grazing perennial ryegrass. Faster rates of lignin solubility (as in the rumen (as measured by FDR) probably contributed to the more rapid breakdown of chicory in the rumen.

4. A laboratory and a grazing experiment were conducted to study the effects of CT in chicory and perennial ryegrass upon protein solubility and protein degradation. Nitrogen (N) solubility was measured *in vitro* in mineral buffer, using freeze dried samples of forages cut at the vegetative stage. Rumen ammonia concentration in rumen fistulated castrate red deer stags grazing either on perennial ryegrass or chicory was used as an index of protein degradation. Samples of rumen fluid were taken every 4 h for 24 h for ammonia concentration and pH. In both experiments, the effects of CT were deduced from responses to supplementation with PEG which binds and activates CT. PEG was given three times daily (total 20 g/day) in the grazing experiment. Small concentrations of CT were measured in both forages (0.3-2.5 g/kg DM), with chicory containing slightly higher total CT concentration than perennial ryegrass. Protein solubility was lower for chicory than for perennial ryegrass but was not affected by PEG addition for either forage. Rumen ammonia concentration was consistently higher for PEG-supplemented than for unsupplemented deer grazing each forage, suggesting that the low CT concentration in both forages was slowing protein degradation to ammonia without affecting protein solubility. Rumen pH tended to be slightly higher in PEG supplemented animals than in unsupplemented animals grazing either forage and mean rumen pH over all sampling times was much lower for deer grazing chicory, either with (5.81 v. 6.62) or without PEG supplementation (5.63 v. 6.44). It was concluded that action of CT contained in perennial ryegrass and chicory reduced protein breakdown in the rumen of deer grazing both forages, and that the low rumen pH found in deer grazing chicory may explain the low fibre digestibility of this forage.

5. Overall it was concluded that chicory was of very high FV and had excellent nutritional attributes for increasing deer production. However, its adoption as a forage by the NZ deer industry is likely to depend upon agronomic aspects, in particular devising grazing systems and breeding new chicory cultivars that have increased persistency and less tendency to go into a lignified reproductive state during summer. Chicory should be either sown alone or in a mixture with a legume such as white clover and should not be grazed in winter. Chicory should

not be grazed using accepted practices for perennial ryegrass/white clover pastures (ie including a grass component and grazing it in winter); rather special grazing systems as used in this thesis should be used to prolong the life of chicory stands to 5 or 6 years.

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LIST OF ABBREVIATIONS

ADF	acid detergent fibre
cm	centimetre
Cr-EDTA	chromium ethylenediamintetra acetic acid
CT	condensed tannin
D	digestibility
DM	dry matter
DMI	dry matter intake
DOMI	digestible organic matter intake
EAA	essential amoni acids
FDR	fractional degradation rate
FDPR	fractional disappearance rate
FO	faecal output
FOR	fractional outflow rate
FV	feeding value
GR	a measurement of total soft tissue depth over the 12th rib at a point 11 cm from the carcass line
GI	gastro intestinal
GIB	game industry board
GT	grazing time
h	hours
ha	hectare
k_f	efficiency of utilization of ME for fattening
k_g	efficiency of utilization of ME for growth
k_l	efficiency of utilization of ME for lactation
k_m	efficiency of utilization of ME for maintenance
kg	kilograms
l	litres
Ltd	limited

LWG	liveweight gain
ME	metabolisable energy
min	minute
MJ	megajoule
N	nitrogen
NAN	non-ammonia nitrogen
NaOH	sodium hydroxide
ND	not determined
NDF	neutral detergent fibre
NEAA	non-essential amino acids
NH ₃	ammonia
NV	nutritive value
NZ	New Zealand
OM	organic matter
OMD	organic matter digestibility
OMI	organic matter intake
PEG	polyethylene glycol
rpm	revolutions per minute
SC	structural carbohydrate
SD	standard deviation
SE	standard error
t	tonne
µg	microgram
USA	United States of America
VFA	volatile fatty acid
VFI	voluntary feed intake
v/v	volume by volume
WSC	water soluble carbohydrate