

Forage Chicory (*Cichorium intybus* L.) - Pretability in Crops and Effects in Ruminants Feeding

REVIEW

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Abstract

During the last years an increasing attention has been focused on chicory (*Cichorium intybus* L.) use in ruminant's nutrition. Chicory is a perennial plant that is suited to well-drained or moderately drained soils, with medium to high fertility levels and a pH of 5.5 or upper. Chicory has a comparable nutritional value to alfalfa, containing similar proportions of proteins, lipids, minerals and other nutrients. It has a relatively deep taproot, which provides tolerance to drought conditions. Furthermore, due to the drought resistance it is suitable for cultivation in areas with deficit of moisture. The aim of the current study was focused on the chemical composition and nutritive value of chicory, as well as the possibility of using it in different plants mixture in cattle feeding, as an alternative source of feed.

Keywords: *Cichorium intybus* L., forage, nutritive value, ruminants

1. Introduction

Chicory (*Cichorium intybus*) is perhaps the most known for the extract of its roots, used as main ingredient in "coffee substitute"[1]. There are many evidences that chicory yield could be efficiently as a beneficial source of highly palatable and nutritious feed for grazing livestock. [2] Chicory was re-assessed as a potential forage crop in the mid-1970' in New Zealand. After ten years of breeding the world's first forage variety of chicory became commercially available in 1985. Several different chicory varieties are now used worldwide.

Even nowadays the researchers continue to develop and release different chicory varieties, the most surveys, regarding herbage production and animal performance, were conducted on the Puna variety.[2] Since the release of Puna chicory, researchers from many parts of the world have

tried various combinations of perennial grasses and legumes with chicory.[3]

In properly managed conditions, the chicory leafy yield could be increased reaching the similar nutritive value as alfalfa, [4] with higher content of copper and zinc [5].

Due of its deep root system, chicory is able to establish and grow well under dry conditions in summer. [6] Nowadays, the studies conducted on chicory bioactive compounds, such as tannins or lactones, proved a positive effect in respect to reducing nematodes and helminths infections in animals. [7-9] In addition to grazing, chicory could be used in ensilaged mixtures to improve their quality. [10]

2. Chicory economic and nutritional importance

The chicory economically and nutritionally importance ensues from the following features:

- long life (5-7 years), as similar species of grass (orchard grass) or alfalfa;

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- resistance to weather conditions: in acidic soil (pH = 5.5), clay or sandy soils compacted to or less salty drained;
- well developed root system gives a better adaptation to moisture deficit, during periods of drought, being stronger than alfalfa;
- it can be cultivated as pure culture and in association with other perennial species (orchard grass, perennial ryegrass, fescue, clover, white clover and lucerne) through setting up lawns sown in long-term, which provide high yields and less fluctuating in subsequent crops compared with conventional mixtures of grasses and legumes;
- very fast recovery after grazing or mowing that lead to shortening of production cycle (28-30 days), as well as performing more production cycles or grazing (4-6 / year), compared to other perennial species;
- high expendability in all species of ruminants (cattle, sheep, goats), due to the nutritional value of the feed;
- the chicory pure culture production varies according to the natural and technological conditions (30-60 t / ha green mass, 7-15 t / ha of dry matter), with a daily production rate during the growing season of 150 - 400 kg / day / ha of green mass. [10-14]

3. Chemical composition

A. Minerals

Chicory contains high concentrations of minerals, [6] as has been also reported for plantain (Table1). Generally, chicory have higher minerals content than alfalfa or cool-season grasses.[15] Minerals in chicory meet or exceed the recommended dietary mineral requirements of lactating dairy cows.[16] Compared to perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) pasture, chicory contains higher concentrations of most minerals. [17-19] The concentration of silicon is lower than in either perennial ryegrass (*Lolium perenne*) or white clover (*Trifolium repens*). [20] Studies conducted by Clark (1990) and Barry (2002) on liver copper status of lambs and deer, has been shown an increase content after grazing chicory compared with perennial ryegrass / white clover pasture [19-22]

B Crude protein

The crude protein concentration in chicory ranges

from 12 to 18 % [17, 23, 24] and is lower compared with that of Perennial ryegrass (*Lolium perenne*) which ranges from 18 to 19 % and red clover (*Trifolium pratense*) which ranges from 27 to 29 %. [22] Wang and Cui (2011) show that crude protein (CP) content in chicory is more valuable than in alfalfa. In growth stage, the chicory rosette leaves contains higher crude protein than alfalfa, e.g. cv. Puna at 24.77%, cv. Yifen at 22.90% and cv. Qikeli at 22.87%; [10]. Whereas the average CP from whole growth stage of Puna chicory is about 20.33% higher than the average CP of 10 alfalfa varieties at 17.85% of the shoots and leaves in bloom stage (Table 2). The chicory protein has high biological quality containing 17 kinds of amino-acids, including 9 essential amino-acids for animal and human health; chicory lysine content (1.2%) is similar to alfalfa (1.05-1.38%) [25, 10]

Table 1. The mineral content of the chicory, as compared with other feed [13]

g/kg DM	Chicory	Alfalfa	White clover	Orchard grass
P	4.7	3.3	3.3	3.4
K	36	25.1	24.4	29.1
Ca	18	15	14.5	2.7
Mg	4.8	2.1	4.7	1.1
Mn	170	47	123	157
Cu	32	11.4	9.4	19
B	33	-	-	-
Zn	45	37	17	40

C. Soluble and structural carbohydrates

In contrast to crude protein, the concentrations of soluble sugars and pectin are higher in chicory than in perennial ryegrass (*Lolium perenne*). On the other hand, the concentrations of cellulose and "hemicellulose" in chicory determined using the detergent analysis system are lower than those in perennial ryegrass (*Lolium perenne*) and are similar to those of red clover (*Trifolium pratense*).[22]

The ratio of readily-fermentable carbohydrate (water-soluble sugars and pectin) to structural carbohydrate ("hemicelluloses" and cellulose) in chicory is higher by up to approximately three times than that in perennials ryegrass (*Lolium perenne*) [26] and is even higher than that in red clover (*Trifolium pratense*). [1] The metabolisable energy (ME) concentration is higher in vegetative chicory than in perennial ryegrass (*Lolium perenne*). These contribute to the higher nutritive value of chicory [22].

Table 2. The nutritional components of chicory varieties and 10 alfalfa varieties

Forage chicories, phenological stage	Puna chicory*					Qikeli*		Yifen*	Alfalfa*
	Rosette leaves	Elongation stage	Start in bloom	Blooming stage	Average of all stages	Rosette leaves	Start in bloom	Rosette leaves	Average of 10 varieties
CP (%)	24.77	21.56	18.25	16.75	20.33±3.58	22.87	14.73	22.90	18.11±1.53
CL (%)	3.15	3.52	4.01	4.43	3.78±0.56	4.46	2.10	5.01	2.94±0.55
CF (%)	26.83	32.61	35.98	38.97	33.60±5.21	12.90	36.81	13.14	28.89±1.52
NFE (%)	21.25	24.35	26.89	28.82	25.33±3.28	30.34	24.92	30.02	43.10±1.70
Ca (%)	1.49	1.12	1.08	1.01	1.18±0.21	1.50	1.18	1.50	-
P (%)	0.55	0.37	0.31	0.25	0.37±0.13	0.42	0.24	0.24	-

Note: CP: crude protein; CL: crude lipid; CF: crude fibre; NFE: nitrogen free extract

D. Secondary compounds

The lignin content of chicory is about 20 g/kg [1] lower compared with alfalfa (75 g/kg), young orchard grass (43 g/kg). [27]

The concentration of condensed tannins in chicory is low, only 4.2 g/kg DM and is lower than the minimum concentration (5 g/kg DM) required to prevent bloat in cattle and to increase wool growth in sheep.[16] The sesquiterpene lactones, cichoriin and cichoric acid occur in chicory in low concentrations and are present at the highest levels in the most actively growing tissue. [28] They are part of the natural plant's defense against insect attack, [28] tainting cow's milk. [1] These components have been implicated in the reduction of gastrointestinal (GI) parasitism in young ruminants grazing chicory. [8, 22]

4. Feeding value

Factors affecting feeding value

In the grazing animal production system, feeding value has been defined as the animal production obtained from grazing forage under unrestricted conditions. It is a function of voluntary feed intake (VFI) and nutritive value per unit dry matter eaten. VFI contributes more than nutritive value *per se* to feeding value. [29]

Voluntary feed intake

The chicory has a higher VFI in ruminants compared to perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*). Kusmartono et al. (1996) found a higher VFI for chicory in deer compared to perennial ryegrass (*Lolium*

perenne) and white clover (*Trifolium repens*) pasture during autumn, and similar VFI in spring. For red deer castrated male reared indoors, the wilting chicory increase voluntary DM intake from 49 to 57 g DM / kg BW/ day without significant changes in the apparent digestibility of DM, organic matter (OM), hemicellulose and cellulose.[30] Previous studies conducted on different species (deer and sheep) highlights that chicory is highly palatable. [6, 30, 22]

Nutritive value

Nutritive value is given by the following: the chemical composition of the forage, the availability (digestibility and absorption) of nutrients, the efficiency of use of absorbed nutrients and the effect of chemical composition on VFI. (Table 3) [32, 22]

Efficiency use of absorbed nutrients

Energy metabolism

There have been no studies to directly determine the energy utilisation of digested nutrients from chicory. However, the efficiency of energy utilization varies inversely with the ratio of acetic acid to propionic acid in the rumen. [33] Hoskin et al. (1995) found that the acetate/propionate ratio in the rumen of chicory-fed deer was higher than that in perennial ryegrass-fed deer, suggesting that the energy released from chicory may not be better utilised than energy from perennial ryegrass- based pasture. [20]

Table 3. The nutritive value of different types of chicory [13]

Variety	Crude protein (%)	Digestibility in vitro (%)	NDF(%)
Forage Feast	19.5	80.7	45.5
Puna	18.1	82.1	43.5
Lacerta	17.0	73.6	46.2
Lancelot	17.3	71.3	50.2
Tonic	17.9	72.4	47.6

5. The productive performance of animals using chicory in feed

A. Voluntary feed intake

Deer (*Cervus elaphus*) have a higher VFI when grazing chicory rather than perennial ryegrass-white clover pasture. [34] Kusmartono (1996) found that VFI of deer grazing chicory was higher compared to deer grazing perennial ryegrass-based pasture by 56 % during summer, 26% during autumn and 15% during spring. Further research showed that the fractional degradation of large particles to small particles and the fractional disappearance of DM from the rumen were both approximate twice as fast for deer fed chicory than for those fed perennial ryegrass [6]. The faster clearance of DM from the rumen provides an opportunity for increased VFI as this has long been recognized as a major process determining intake and nutritive value of forage. [6]

B. Liveweight gain

Sheep, deer, and cattle grazed on Puna chicory have all exhibited greater liveweight gains in comparison to perennial ryegrass/white clover pasture. The liveweight gain was approximately 240 g/day up to 290 g/day per head for lambs grazed on chicory, which was similar to lambs grazed on legumes such as alfalfa and white clover and higher than in lambs grazed on grasses, especially in late spring and summer when conventional pastures often have lower feed quality. Holst *et al* (1998) concluded that both chicory and alfalfa pastures produced sufficient DM of quality forage to finish lambs over summer. In three of five lamb groups, growth rate on chicory pastures was significantly greater than on alfalfa. Calves grazed on chicory gained 900 g day when offered chicory *ad lib*. [35, 3]

Kusmartono *et al* (1996) compared relative feeding values of chicory, red clover and perennial ryegrass/white clover pastures for grazing red deer (*Cervus elaphus*) and found that the feeding value of chicory and red clover were superior to that of perennial ryegrass/ white clover pasture in autumn, spring, and summer. The feeding value of chicory for deer was higher than that of red clover in autumn (157 / 126), similar in spring (115 / 114) and lower in summer (114 / 124), when all data for deer were expressed relative to liveweight gain on perennial ryegrass/white clover pasture being 100. [6]

C. Milk production

Dairy cows in Pennsylvania grazing on Puna chicory had increased milk production compared to those grazing a mixture of cool-season grasses and white clover. [16] compared crops of Puna chicory and Barkant turnips fed as supplements to dairy cows grazing pasture at Hamilton, New Zealand. Cows had similar milk-solids (MS) responses on chicory and turnips (40-41 g MS kg DM) when offered 4 kg DM / cow /day of crop and 25 kg DM / cow /day of pasture. However, the milk from dairy cows fed sole chicory diet has been found to have a bitter taint and for this reason chicory feeding to dairy cows has been limited to 2 hours per day, generally following the morning milking, to restrict chicory intake to about 25 % of the total daily DM intake.[1] Degradation products of the sesquiterpene lactones, namely dihydrolactucin, tetrahydrolactin and hydroxyphenylacetic acid have been identified as the taint compounds in the milk of chicory-fed cow. Forage chicory with lower levels of the sesquiterpene lactones are most unlikely to cause a taint or bitter aftertaste in the milk. [16, 1, 3]

6. Conclusions

In conclusion, most of the aspects considered in this report suggest that the use of chicory, either in different types of mixtures with other legumes or grasses or in pure culture in animal feed is justified as a viable alternative both in terms of the nutritional value as well as economically.

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