

Is Chicory a Viable Feedstuff for Cattle?

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Abstract

The aim of the current study was to test the viability of including chicory in cows' diet. A total of 2250 data were recorded from 150 Romanian Spotted cows related to 6 forage structures: alfalfa ($\alpha\alpha$), chicory (C), mixed alfalfa and chicory (αC), mixed gramineous (G), mixed gramineous and alfalfa ($G\alpha$), mixed gramineous and chicory (GC). Data aimed total daily duration of forage consumption (TDD), daily round frequency (DRF) and average consumption round (ACR) according to forage structures. The effects of chicory were assessed based on ANOVA protocol with categorical factor "chicory". Chicory significantly influenced ($p \leq 0.05$) TDD and ACR. No significant influence ($p > 0.05$) was recorded related to DRF. Chicory significantly increased TDD and DRF compared to G (294 vs. 190.8 min./day, 12.1 vs. 9.37 rounds/day, $p \leq 0.001$), being superior compared to $\alpha\alpha$ (264 min./day, 11.3 rounds/day, $p \leq 0.05$). Also, chicory improved the forage consumption in mixed GC compared to $G\alpha$ (243.6 vs. 224.4 min./day, 10.1 vs. 9.8 rounds/day, $p \leq 0.01$). In mixed αC , chicory increased TDD and DRF compared to $\alpha\alpha$ (283.8 vs. 264 min./day, 12.6 vs. 11.3 rounds/day, $p \leq 0.05$). In conclusion, the use of chicory in cows' diet could improve the feeding behavioural traits with economically benefits.

Keywords: chicory, feeding behaviour, Romanian Spotted

1. Introduction

Chicory has been known, studied, and used on a global scale for a long time, with evidence of its use dating back to the Bronze Age [1,2]. Despite its Mediterranean origins, it has a high adaptation potential and may now be found on all continents. Chicory was first mentioned as a forage plant early in 1915 by Leonard Cockayne and Ebenezer Teichelmann (1915) in New Zealand, after which it remained understudied for a long time until 1978, when Lancashire J.A. (1978) defined chicory as an

excellent ruminant feed [3,4]. Drought-resistant, especially improved cultivars, among which the Puna variety stands out, have been licensed for commercialization in 1985. The research primarily focused on the agricultural techniques required for crops, their management and the chemical composition compared to other grasses, and to a lesser extent on the effects exerted on cow's production performances. Chicory is a perennial plant with an excellent harvest index [5,6], increased feed quality [7-10] and great results in animals fed with this fodder crop.

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Chicory has long been an integral part of natural pastures in many parts of the world, but it only recently became a forage plant cultivated solely for this purpose. Numerous varieties have been created due to the implementation of genetic improvement programs for these species [11,12]. The average daily gain (ADG) of calves fed pure chicory crops in New Zealand was higher (900 g/day) [13] than the rate achieved in a conventional crop of perennial ryegrass (*Lolium perenne* L.), or white clover (*Trifolium repens* L.) and were similar to those obtained on some leguminous pastures such as alfalfa (*Medicago sativa* L.) [14].

Chicory for livestock forage has significantly expanded worldwide during the last decades [15]. There is a lack of knowledge in the literature related to nutritional aspects of chicory as well as the effects on the cow's feeding behaviour. An important aspect seems to be chicory's ability to mobilize soil resources and maintain higher levels of protein and dry matter in simple or complex mixtures. In terms of nutrition, chicory has a higher mineral content (with the exception of Ca) compared to other leguminous and gramineous plants. Reduced lignin content (15-20 g/kg DM) compared to alfalfa (70-75 g/kg DM) provides chicory a higher digestibility (70-85%) than alfalfa (50-70%). The high prevalence of lactones and chicory acid contributes to significant anthelmintic potential. However, the taste and smell associated with lactones could decrease palatability of chicory. According to Foster *et al.* (2006), a 0.58% lactone content is associated with Puna chicory variant compared to other floristic species with higher values ranging from 0.79% to 1.52 %, [16]. In light of these findings, Foster *et al.* (2002) highlights the anthelmintic activity of lactones in his research [17].

The use of chicory in cows' nutrition recorded positive results in terms of milk production. In this respect, an increased milk yield by 10-12% was observed compared to an alfalfa-based diet. Also, use of chicory in cows' diet led to a different shape of the lactation curve, resulting in an early upward trend even from the beginning of lactation. Cows

with an alfalfa diet have shown a constant milk yield. Compared to alfalfa, chicory has higher palatability (91-94% vs. 87-92) [18]. The protein content of chicory is closely correlated with agrotechnical and environmental factors, varying in relatively wide limits 10-18% according to Crush J.R. and Evans J.P.M. (1990) or 25% according to Wang Q. and Chiu J. (2010) [19,20]. An important aspect is the quality of the available protein which proves to be superior to other plants, due to the 17 amino acids of which 9 are essential for animals and humans [21]. The increased consumption of chicory in animal feed also comes from a lower lignin content (20 g / kg DM) compared to alfalfa (75 g / kg DM) with beneficial effects on digestibility (86% vs. 55%) [22]. However, the effects on growth vary according to the morpho-productive type of cattle. In this respect, beef cattle recorded a higher weight gain (1-1.1 kg/day), compared to Holstein cattle, which reach growth thresholds between 0.4-0.7 kg/day [23,24]. Unrestricted administration of chicory has led to an increase in voluntary consumption from 1.7 to 3.6 kg / DM / hour. The structure of the chicory and especially its availability as fodder, can influence the feeding behaviour of the animals, with implications on the daily activity budget and implicitly on the productive performances. Unrestricted administration of chicory did not show an increase in the frequency of seizures, only in the quantity of forage associated with them, with the immediate effect of increasing the intake of dry matter and protein [25].

Plant diversity is progressively dwindling, due to the extended collapse of the processing industries. Each species plays a role in sustaining a productive ecosystem, supporting the increase of soil fertility and biomass production, according to several previous studies regarding plant biodiversity. The use of relatively new plants introduced into animal feed without being well known from a scientific point of view generates a certain reluctance from farmers. In general, chicory, viewed through the prism of different levels of knowledge (agrotechnical, nutritional, chemical,

morphological) still remains an unknown plant with tremendous potential, being a real alternative to the particularly conditions of soil, climate and agricultural techniques as well as the nutritional needs of cattle.

2. Materials and methods

This research was observational and non-invasive. Ethical considerations of this study were evaluated according to the European Union's Directive for animal experimentation (Directive 2010/63/EU) and the study was approved by the Scientific Council at the Research and Development Station for Bovine Arad through the Decision no. 51 issued on November 11, 2015.

Location: The study was carried out at the Research and Development Station for Bovine Arad, Romania (location: 46° 10' 36" N, 21° 18' 4" E, 107 m altitude, 582 mm annual average rainfall, 21°C / -1°C average temperature corresponding to summer / winter seasons).

The data recording was performed in August 2021. Cows that were included in the research herd were managed under a loose system with zero grazing and were between 2nd and 5th lactation, with age and parity balanced within the herd.

Cows were kept on deep straw bedding, with a space allowance of 9 m² in the resting area and free access to forage, water and outside paddocks. All cows were included in the Official Performance and Recording Scheme.

Cows were milked twice per day (starting at 5:00 and 17:00) in a "herringbone" milking parlour (2 by 14 units). The milking parlour was equipped with AfiMilk 3.076 A-DU software (Afikim, Israel). Furthermore, all cows were fitted with AfiTag pedometers (Afikim, Israel) for production traits, oestrous and specific diseases detection. Data related to production and reproduction were collected from the results of the official performance recordings, according to the standardized International Committee for Animal Recording (ICAR) guidelines (2012), and also with the proprietary recording system AfiMilk 3.076 A-DU software (Afikim, Israel).

The behavioural patterns were recorded with 4 cameras (Sony HDR-CX240E) and were analysed

by The Observer XT specialized software. The cow's feeding behaviour was continuously recorded for 24 hours in days 1, 7, 14 and 21, after all forage structures were included in diet, data being expressed as average.

Cows received daily feed rations made of 55 kg green fodder (one of the studied forage structures), 8 kg corn silage, 5 kg of alfalfa hay and 4 kg of concentrates starting from spring until late autumn, and a ration made of 15 kg alfalfa, 25 kg of corn silage, 6 kg of alfalfa hay and 5 kg of concentrates during winter.

Cows were fed 3 times per day, at 7.00, 13.00 and 19.00 o'clock so that the cows benefit from green fodder 24 hours per day. Cows had a feeding space allowance of 75 cm / individual.

A data set for 150 cows was analysed for estimation of the effects of the forage structure on total daily duration of forage consumption (TDD), daily round frequency (DRF) and average consumption round (ACR) in Romanian Spotted breed.

The effects of studied parameter were assessed using a factorial ANOVA protocol. Differences were tested using Tukey's test. The analysed data were expressed as least square means and standard errors of the mean.

All the statistical inferences were carried out using the software package Statistica (StatSoft Inc., Tulsa, OK USA) [26].

Decisions about the acceptance or rejection of statistical hypothesis were made at the 0.05 level of significance. To determine the effects of influence of included factor on behavioural patterns, the trait of interest was set up as the dependent variable and the behaviour related traits as independent variables in the model.

The aim of the current research was to determine the influence of forage structure on total daily duration of forage consumption (TDD), daily round frequency (DRF) and average consumption round (ACR) in the Romanian Spotted breed.

3. Results and discussion

The stockholders have as main goal increasing forage consumption based on a strongly linked between it and increasing cattle production [27] and implicitly increasing the farm's efficiency.

There are numerous previous studies aimed these goals. Various methods were studied, started with researches regarding availability of forage amount, forage structures and forage quality based on different nutrients contained. Founding, testing and assessment of the new cultivars constitutes in an actual goal. Not at least, feeding intake proved to be significantly influenced by the externally influential factors as environment or crop technology and influential factors depending by animals as health, welfare condition, social interactions and hierarchy or feeding behaviour patterns [28]. Delivery in three daily portions ensures a fresh, constant and controlled availability of forage for cattle. The delivered forage, as opposed to grazing, prevents premature crops destruction and eliminates crops mismanagement. An important consideration is the harvesting technique, which is highly dependent on the cutting height of the plant and can result in losses of up to 30%, depending on plant density. A study conducted by Clark et al. (1990) that found a higher

loss in cutting chicory at ground level compared to cutting at 10 cm height is suggestive in this respect. Grazing has been found to be extremely preferential. Before grazing, chicory was 48 percent stem and 27 percent leaf, according to Clark et al (1990) [29]. The preference of cattle for the leaf was evident when an analysis performed after grazing revealed that only 19% of the leaf remained compared to 50% of the stem. In the current study, chopped green forage (solely or mixture) permanently available for cattle allowed a higher rate of consumption while avoiding these kind of waste [29]. The daily meal rank seems to have a significant influence on TDD, DRF and ACR. In this respect, the first two meals of the day were found to be superior to the evening third meal. These results are in accordance to those founded by Erina et al. (2014) [30]. The least square means, significance, and multiple comparison test results for TDD, DRF and ACR according to forage structure are presented in Table 1.

Table 1. Least-squares means (LSM) ± standard errors (St. Err.) and multiple comparison test results for TDD, DRF and ACR according to the forage structure

Parameters	Forage structure					
	<i>aa</i>	<i>C</i>	<i>aC</i>	<i>G</i>	<i>Ga</i>	<i>GC</i>
TDD (min.)	264±11.3 ^a	294.12±21.56 ^b	283.8±17.6 ^b	190.8±11.6 ^c	224.4±13 ^c	243.6±27.4 ^d
DRF (no)	11.3±1.07 ^a	12.1±1.24 ^a	12.3±1.56 ^b	9.37±2.04 ^c	9.8±1.17 ^c	10.1±2.2 ^c
ACR (min.)	23.3±1.57 ^a	24.29±2.14 ^b	22.52±3.42 ^a	20.36±1.6 ^c	22.89±0.89 ^a	24.11±3.12 ^b

Different superscripts in the same row significantly differ at $P \leq 0.05$

Table 2. Least-squares means (LSM) ± standard errors (St. Err.) and multiple comparison test results for TDD, DRF and ACR according to the forage structure and feeding round rank

Parameters		Forage structure					
		<i>aa</i>	<i>C</i>	<i>aC</i>	<i>G</i>	<i>Ga</i>	<i>GC</i>
7.00 h	TDD (min.)	100.2±6.8 ^a	115.8±4.12 ^b	102.6±3.09 ^a	80.4±2.11 ^c	91.2±3.09 ^d	94.8±4.14 ^c
	DRF (no.)	4.29±0.37 ^a	4.78±0.93 ^b	4.57±1.1 ^a	3.94±0.96 ^c	3.91±1.11 ^c	4.12±2.63 ^d
	ACR (min.)	23.33±2.6 ^a	24.23±1.89 ^b	22.43±2.16 ^a	20.38±3.44 ^c	23.03±4.81 ^c	24.13±3.56 ^d
13.00 h	TDD (min.)	68.4±3.56 ^a	100.2±5.12 ^b	85.2±3.54 ^c	64.2±2.46 ^a	79.2±3.29 ^d	87.6±5.17 ^c
	DRF (no.)	2.94±0.16 ^a	4.14±0.47 ^b	3.75±0.66 ^c	3.15±0.9 ^a	3.45±1.21 ^d	3.65±2.68 ^c
	ACR (min.)	23.28±3.1 ^a	24.21±2.55 ^b	22.69±1.89 ^c	20.36±2.1 ^d	22.95±3.33 ^c	24.01±5.23 ^b
19.00 h	TDD (min.)	95.4±5.88 ^a	78±4.57 ^b	96±2.64 ^a	46.2±3.47 ^c	54.2±4.56 ^d	61.2±3.61 ^c
	DRF (no.)	4.07±0.01 ^a	3.18±0.6 ^b	4.27±1 ^c	2.27±1.25 ^d	2.39±2.16 ^d	2.52±3.55 ^c
	ACR (min.)	23.45±2.76 ^a	24.25±1.87 ^b	22.48±1.12 ^c	20.33±1.22 ^d	22.68±1.82 ^c	24.26±2.74 ^b

Different superscripts in the same row significantly differ at $P \leq 0.05$

Related to TDD, previously studies founded that cows spent 4-6 h/day feeding, divided in 9-14 feeding rounds [31,32] which is in accordance to

our current results that recording a TDD range between 3.18-4.4 h/day divided in 9.37-12.6 feeding rounds/day. When comparing C to *aa*, G

or their mixtures, the data in Table 1 reveals a strong preference of cows for C. The maximum TDD value was determined for C, while the lowest value was calculated for G. The addition of C in forage mixtures results in a greater TDD, which is clearly noticeable in GC as compared to G. Furthermore, C has been proven to be responsible for the improvement of TDD in GC mixtures if compared to G mixtures.

DRF proved to be strongly linked to the forage structure. The highest DRF was recorded for αC mixture, which proved to be comparable to that associated with C and significantly higher than that associated with $\alpha\alpha$. The presence of G as solely feed or in mixtures leads to a decrease of DRF, even if the presence of C in mixtures maintains DRF at a high value compared to $G\alpha$ or G solely. Increased DRF in C constitutes a solid statement of the feasibility of including it in the cows' daily diet. Based on a high and positive correlation ($R = 0.42$), the influence of the forage structure was found to be significant for ACR. Related to DRF, the correlation was slightly lower ($R = 0.26$). When compared to the $\alpha\alpha$ or αC mixture, the cows spend significantly more time-ingesting for C. The lowest ACR was found for G. The presence of C in G mixtures increases the ACR to comparable levels to those calculated for pure C and significantly higher than those calculated for G, $\alpha\alpha$, or αC , indicating higher preference of cows for C.

The data presented in Table 2 highlights the dynamics of cows feeding behaviour patterns according to the forage structure during experimental days. In this respect, the time that cows spent consuming the feed ration was related to the daily meal rank. The correlation between the DRF, ACR and the forage structure was the starting point of this study, which aimed to assess the degree of preference of cows for chicory. In the first two meals of the day, the cows allocated the longest period for chicory consumption. Related to ACR, it could be extended by overcrowding, reducing feeding space or providing a limited amount of forage. The current study did not encounter such a problem, thus the differences in ACR were solely due to the managed forage structure [33].

The increased frequency of forage delivery increases the availability of fresh food and its

palatability. Cows enjoy eating it, which resulted in an increase in ACR. De Vries (2005) performing a study regarding correlation between frequency of forage delivery and ACR, founded an increased TDD by 10-14 min./day [27]. Also, Mantysaari et al (2006) reported an increased TDD by 1.4% in 5 times /day compared to 1 time/day forage delivery. TDD and ACR proved to be significantly influenced by the cow's access method to the feeding area [34]. Headlock barrier reduced the TDD and ACR compared to free access, based on an increased comfort for cows. No significant differences were recorded by Endres et al (2005) conversely to those founded by Huzzey et al (2006) [35,36]. Also, significant differences were recorded by Batchelder (2000) based on the increased intake of dry matter for cows with no headlock system [37]. The forage delivery in multiple portions significantly influences the DRF and implicitly the ruminal pH also feeding behaviour patterns. The permanent availability of fresh forage positively influences the rate of consumption and the DRF, which is strongly correlated with the frequency of delivery. These were significantly higher than those associated with $\alpha\alpha$ consumption, as well as to those associated with αC mixture. Furthermore, significant differences in consumption durations related to G and GC or $G\alpha$ mixtures were calculated. The presence of C in G mixtures has led to an increased duration of consumption compared to solely G or $G\alpha$ mixture.

When compared to solely $\alpha\alpha$, αC mixture increased forage consumption. In the presence of chicory, the DRF has also increased. The highest DRF was associated with C compared to $\alpha\alpha$, G and $G\alpha$ or GC mixtures. The presence of C in the GC mixture was strongly preferred rather than the G or αG mixture. A very similar situation was recorded related to DRF. The presence of C in the forage structure resulted in a higher ACR being assigned. Compared to solely $\alpha\alpha$, G, or mixtures thereof, the ACR of C or C mixtures was greater. The third meal of the day was evaluated against the background of the establishment of a state of satiety, which has been supported by previous consumption during the study day. The results of this

analysis reveal that solely $\alpha\alpha$ has a larger mass than C, G or their mixtures. The presence of C in α C mixture improved the DRF. The associated ACR analysis reveals the cows' preference for C. Chicory or mixtures with C allow for the establishment of an upward trend in terms of ACR comparisons to $\alpha\alpha$, G or mixtures thereof.

4. Conclusions

The dynamics of the daily feeding behavioural patterns highlighted the increased interest of cows for solely C or C mixtures, which supports its implementation and unrestrained large-scale use in cows feeding.

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