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The effect of supplementing different levels of chicory and yeast to growing dairy goats fed on *Rhodes grass* basal diet on feed intake and weight gain

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Abstract
This study explored the impact of supplementing Chicory and yeast in varying proportions to the diets of weaned dairy goats primarily fed a *Rhodes grass* basal diet. The study was conducted at Egerton University's Tatton Agricultural Park (TAP), Njoro. The feeds were formulated into eight diets and offered to 24 crossbred (Saanen × Toggenburg) weaned dairy goats (14±0.5 Kg) using a CRD with a (4x2) factorial design. The diets were *Rhodes grass* hay and chicory supplementation at (T_1: 0, T_2: 10, T_3: 20, and T_4: 30%) as the main effects and yeast, with (+) and without yeast (-) as interaction levels. The findings suggest that including yeast and Chicory has a significant effect ($p<0.05$) on ADG and Voluntary feed intake. Average daily gain (ADG) was notably higher in supplemented goats, with the highest observed in diets containing 30% Chicory and yeast. The findings suggest a synergistic impact of Chicory and yeast on feed intake, and nutrient digestibility, contributing to improved growth performance in growing goats. Non-supplemented diet *Rhodes grass* (T_1-) recorded a negative ADG at -7.14 g/day. Yeast addition to the basal diet (T_1+) boosted the ADG to 28.21 g/day. However, there were variations in treatment T_2+ and T_3+, which were not significantly different. The addition of yeast at this level might not have influenced the weight gain. The study recommends the incorporation of Chicory at a 30% inclusion level and yeast supplements at 10 g/day in growing goat diets for optimal feed utilization and robust growth, offering a promising avenue for sustainable and efficient goat farming practices.

Keywords: Inulin, yeast, synbiotic probiotics, prebiotics, weight gain

1. Introduction
Effective management of dairy goats' nutrition is essential in the ever-changing realm of livestock production as it ensures the well-being of the animals and the development of high-quality dairy products (Silva *et al*., 2022) [22]. In addition to having a higher concentration of medium-chain fatty acids, goat milk is safer for individuals with lacto-albumin allergies. Despite these advantages, the production of dairy goats is constrained by many challenges ranging from inadequate management, nutritional deficiencies, inferior genotypes, and a scarcity of quality replacement stock and breeding opportunities. In particular, the scarcity of high-quality fodder is a significant impediment to the expansion of the dairy goat industry.
Rhodes grass (*Chloris gayana*) is regarded as an important ruminant basal feed because of its appealing taste and rich nutritional content (Van Soest, 1994) [21]. *Rhodes grass* is a commonly utilized primary feed in Kenya but is inadequate for optimal growth development, and production due to its low protein content. To enhance its utilization by ruminants, it should be supplemented with protein sources such as herbaceous legumes, multipurpose trees, oil seed cakes, and Chicory. In recent years, Chicory has become a widely recognized substitute for legumes and is also increasingly popular because of its therapeutic, gastronomic, and nutritional attributes. The crude protein content of this forage is more than 19%, and therefore being 1.6-2.4 times greater than that found in conventional cereal grains such as wheat, rice, corn, and barley (Vandeputte *et al*., 2017) [22]. Chicory also contains a high amount of phytochemicals, such as inulin, which is a type of soluble dietary fibre. Inulin acts as a prebiotic, enhancing animal nutrition by promoting good health.

Inulin is associated with immune system activation, decreased levels of pathogenic microorganisms, alleviation of constipation, decreased susceptibility to osteoporosis, and reduced likelihood of developing atherosclerosis (Vandeputte *et al*., 2017) [22]. Chicory is cultivated in Kenya, specifically on fertile and well-drained soils ideal for cool temperature zones.

The nutritional and therapeutic characteristics of this forage also enhance the reproductive capacity of goats. Yeast (*Saccharomyces cerevisiae*) is a probiotic substance that is extensively utilized in animal feeds to improve rumen fermentation, promote health, increase milk production, and aid in adapting to heat stress (Henderson *et al*., 2015) [6]. The yeast is cost-effective and can enhance animal productivity without incurring significant extra expenses. Yeast is also advantageous for dairy goat nutrition as it enhances their rumen fermentation parameters and improves their nutritional value (Chaucheyras-Durand & Durand, 2010) [2]. Yeast and Chicory (*Cichorium intybus*) are two potential options that contain distinct bioactive compounds capable of influencing the delicate equilibrium between the ruminant digestive system and metabolic processes. Further research is needed to understand how probiotics like yeast and prebiotics like chicory-inulin affect animal health and performance. Therefore, the objective of this study was to determine the effect of supplementing different levels of Chicory with (+) and without (-) yeast to growing dairy goats fed on *Rhodes grass* basal diet on voluntary feed intake and weight gain.

2 Materials and Methods

2.1 Study Site

The study was conducted at Egerton University's Tatton Agricultural Park (TAP), Njoro. The farm is situated in Kenya in Njoro Sub-County, Nakuru County in the Rift Valley of East Africa, on the eastern slopes of the Mau Escarpment. Its latitude and longitude are 0º 23'S, longitude 35º57'E, respectively and an altitude of 2,200 to 2,280 meters above sea level. The region experiences a bimodal rainfall pattern with long rains coming from March to May and short rains from September to November.

2.2 Experimental Animals

The experimental animals for this study consisted of twenty-four (24) crossbreed (Saanen and Toggenburg) weaned dairy goats with initial weights of 14±0.5 Kg and ages between 3-4 months. Each goat's initial weight was determined by averaging it over three days.

2.3 Experimental Diets

The basal diet comprised *Rhodes grass* (*Chloris gayana*) hay, with chicory leaves and yeast serving as supplements. The hay was obtained from the Njoro area. A tractor-driven forage shredder was used to shred the well-cured *Rhodes grass* hay into 2 cm size and then stored in gunny sacks. Chicory was grown at the Egerton University farm and harvested, then dried. It was then cut into 2 cm size using an electric power fodder chopper and kept in gunny bags. Two weeks before the start of the trial, the feeds were transported to the experimental site. The feeds were kept in a clean, dry store at room temperature with plenty of ventilation throughout the experiment. Each feed sample was hammer-milled to pass through a 1-2 mm screen before being placed in sampling bottles for later chemical analyses. The experimental diets consisted of (T_1) as the control comprising of *Rhodes grass* hay and basal plus chicory included at three levels T_2 (10%), T_3 (20%) and T_4 (30%), and with all four dietary treatments being with (+) at a rate of 10g/goat. Day and without (-) yeast (Table 3.2). The higher DMI figure recorded for goats was used to compute dry matter intake, which was 5% of the live weight of each goat. The supplement diets were fed at 10, 20, and 30% of the expected daily DM intake, whereas the base diet was provided *ad libitum*. The amount fed was modified at the start of each week to account for changes in body weight. It was fed to them before their *ad libitum* to the base diet to guarantee that the goats eat the entire supplement.

Table 1: Dietary treatments consisting of basal hay with different levels of chicory and with (+) and without (-) yeast

	Basal *Rhodes grass* hay	Chicory	Yeast	
T_1 (Control)	100%	0	-	+
T_2	90%	10%	-	+
T_3	80%	20%	-	+
T_4	70%	30%	-	+

2.4 Experimental Design

The experimental design was a completely randomized design (CRD) in a (4x2) factorial arrangement replicated thrice with eight dietary treatments. The dietary treatments were as shown in Table 3.2 with four levels of Chicory at 0, 10, 20 and 30% with and without yeast. The animals were confined in individual, slatted-floor, well-ventilated pens. Every fortnight the experimental animals were drenched with 10% Albendazole (anti-helminthic) to prevent internal parasites, while the acaricide was used to control external parasites. Data collection was done for four weeks after a 14-day adaptation period. The eight dietary treatments were allocated to the animals in a randomized manner. The animals were fed the experimental diets twice daily, in the morning at 08:00 hr and 14:00 hr. In the morning diet, supplements were prioritized in feeding, followed by the basal diet. In the afternoon diet (14:00 hr), the basal diet was offered to the experimental animals concerning the 08:00 hr basal diet intake. Each animal's basal and supplement diet intake was recorded daily. The refusals from the previous day's feed were collected, weighed, and recorded. At the end of every week, the weights of the experimental animals were taken before morning diets, and all weights were recorded.

2.5 Feed Intake and Weight Gain

Voluntary feed intake was determined by summing up the animal's voluntary intake concerning the basal and supplemental diets, less refusal, all in DM.

Total dry matter intake (TDMI) = DMI of the basal diet (g) + DMI of the supplemental diets (g).

To establish the weight gain, the initial weight of each goat before the commencement of the feeding process was deducted from the weekly recordings of weights during the feeding experiment.

Weekly weight gain (WG) = Weekly weight recorded (WWR) - Initial weight recorded (IWR).

2.6 Statistical analysis

The values of the measured parameters (DMI, ADG, crude fibre, minerals, IVOMD, ME) were determined by analysis of variance (ANOVA) using the general linear model (GLM) procedure of statistical analysis system (SAS, 2002). Significant differences in means were separated using the least significance difference (LSD) at (p<0.05).

Statistical model

Yijk = μ + Ai +Bj + (BR) ij + eijk
Where,
Yijk = (Intake, digestibility, and Weight gain)
μ = Overall population mean
Ai = Effect of level of factor A (Main effects): Chicory levels, {i= 1, 2, 3 & 4}
Bj = Effect of level of factor B, (Yeast levels) j = {1, 2}
(BR) ij = Effect of interaction between Factor A and B.
eijk = Random error associated with Yijk

3. Results

3.1 1 Voluntary feed intake, average daily gain

The experimental diets' values for dry matter intake (DMI), weight gain, and average daily gain are shown in Table 2. The dry matter intake (DMI) of the basal diet exhibited a significant increase ($p<0.05$) as a result of supplementation and yeast addition. T_4 + had the highest intake of 591.70 g/day, whereas T_1 - (*Rhodes grass*) showed the lowest DMI at 359.21/day. The increased DMI with supplementation from 10-30% was due to the improved level of CP as a result of supplementation as well as the fermentation effect of yeast.

In terms of weight change, there were significant ($p<0.05$) differences in average daily gain (ADG) across the treatments (Figure 4.3). Supplemented goats showed higher ADG compared to non-supplemented. Basal diets that were supplemented with the highest level of supplementation (30%) showed a higher ADG. These were *Rhodes grass* +30% chicory + yeast (T_4+), *Rhodes grass* +30% chicory, without yeast (T_4-), and *Rhodes grass* +20% chicory + yeast, which had ADG of 154.64.8 g/d, 125.12.0 g/d and 110.83 g/d respectively. Non-supplemented diet *Rhodes grass* (T_1-) recorded a negative ADG at -7.14 g/day. Yeast addition to the basal diet (T_1+) boosted the ADG to 28.21 g/day. However, there were variations in treatment T_2+ and T_3+, which were not significantly different. The addition of yeast at this level might not have influenced the weight gain.

Table 2: Dry intake (DMI) and ADG of goats fed *Rhodes grass* hay, supplemented with different levels of chicory and yeast

	Dietary Treatments								
	T_1		T_2		T_3		T_4		
Parameter	**(-)**	**(+)**	**(-)**	**(+)**	**(-)**	**(+)**	**(-)**	**(+)**	**P-Value**
DMI (g/day)	359.21^{f}	424.40^{e}	451.20^{de}	476.51^{dc}	488.57^{dc}	503.82^{bc}	533.39^{b}	591.70^{a}	<.0001
INWT (Kg)	14.23^{a}	14.07^{a}	13.87^{a}	13.73^{a}	14.33^{a}	14.13^{a}	14.17^{a}	14.13^{a}	0.2262
FWT (Kg)	14.03^{f}	14.86^{ef}	15.44^{de}	15.74^{de}	16.44^{dc}	17.24^{bc}	17.67^{ab}	18.46^{a}	<.0001
WTG (Kg)	-0.20^{e}	0.60^{de}	0.63^{cd}	1.48^{cd}	1.77^{c}	3.10^{b}	3.63^{ab}	4.17^{a}	<.0001
ADG (g/day)	-7.14^{e}	28.21^{d}	56.07^{dc}	71.55^{c}	75.48^{c}	110.83^{b}	125.12^{b}	154.64^{a}	<.0001

$^{a, b, c, d, e,f}$ means in the same row with different superscripts are significantly different at $p<0.05$), Chicory (C), Diet with yeast (+), a diet without yeast (-); T_1=(*Rhodes grass*), T_1+(0%+ yeast), T_2-(10%C), T_2+(10%C+Yeast), T_3-(20%C), T_3+(20%C+Yeast), T_4-(30% C), T_4+(30% C+ Yeast), DMI= Dry Matter Intake, INWT=Initial Weight, FWT=Final Weight, WTG=Weight Gain, ADG=Average Daily Gain.

4. Discussion

4.1 Voluntary Feed Intake

The present study showed that there was a significant increase in DM intake when weaned dairy goats were fed with Chicory and yeast. Goats whose primary diet consisted of only a basal diet of *Rhodes grass* hay without yeast (T_1-) recorded the lowest feed intake, 359.21 g/day, while T_4+ goats recorded the maximum intake, 591.7 g/day. These results corroborate the findings by Murney *et al*. (2019) [9] who also reported a significant increase in DMI when housed goats were supplemented with yeast and Chicory. According to their findings, adding yeast to the diet stimulates rumen microorganisms, leading to enhanced fibre digestion and as a result greater feed DM intake. Elghandour *et al*. (2022) [5] demonstrated that goat kids not given yeast supplementation exhibited a reduced average daily gain compared to those given 2.5 and 5 g/day of yeast. In addition, Salem *et al*. (2023) [18] noted that incorporating a yeast culture with monensin (a common prebiotic and probiotic combination) into the diet of lambs resulted in enhanced body weight gain.

The incorporation of probiotics into animal diets appeared to enhance the growth of lambs, resulting in increased live weight gain and improved feed conversion ratio (Soliman *et al*., 2016) [20]. The increased intake may have been due to the additional provision of rumen-degradable nitrogen supplied by the addition of Chicory. This enhances the activity of the bacteria in the rumen, thus enhancing the digestibility of organic matter and, consequently promoting higher feed dry matter intake (Soliman *et al*., 2016) [20]. The increased feed intake by the goats may be attributed to the palatability of Chicory in diets containing it, as opposed to diets lacking Chicory like in T_1- in this study. This is in agreement with the findings by Perović *et al*. (2021) [15], which also noted that Chicory has a diverse range of nutrients, such as fibre, vitamins, and minerals. Chicory's high nutritional content is likely to fulfil the nutritional needs of growing goats. Chicory's other nutritional beneficial components, like inulin, may positively impact on rumen microbial activity and gut health, which could enhance digestion and the nutritive value of the diet Perović *et al*. (2021) [15]. Chicory contains both soluble and insoluble fibres, which are within the required levels of ruminants (291 g kg^{-1} DM). Sufficient dietary fibre promotes rumination and increased saliva flow and is crucial for preserving the well-being of the rumen and for optimal digestion in ruminant animals.

The high NDF content (732 gkg^{-1}) of *Rhodes grass* hay is a factor that led to decreased feed intake in the non-supplemented goats compared to the supplemented animals whose diets had low NDF levels. This is because the level of NDF in an animal ration typically affects their feed consumption as it brings about a faster rumen fill. It also implies that the supplemental diets had a higher feeding value than *Rhodes grass* hay as the higher proportion of cell contents is a good index of the nutritional value of a feed. Additionally, Niderkorn *et al*. (2019) [11] found that the digestibility of Chicory has a significant role in determining its effect on feed consumption. Enhanced nutrient absorption and increased animal performance can result from high digestibility and intake of feed. Nwafor *et al*. (2017) [13] opine that because of its relatively high digestibility, Chicory can enhance the efficient utilization of nutrients by developing goats, hence positively impacting their growth and development.

The combination of Chicory and yeast may synergistically impact the amount of feed consumed by goats. From this study, non-supplemented goats recorded the lowest intake (359.21 g/day) while supplemented ones, particularly in the diet with yeast addition (T_2+, T_3+, and T_4+), improved intake at 476.51 g/day, 503.82 g/day and 591.70 respectively. These results are also in agreement with those of who reported that probiotic supplementation has a beneficial impact on feed intake after weaning. This effect may be attributed to an increase in the quantity and proportion of cellulolytic bacteria in the rumen, as well as an improvement in ruminal pH. These improvements are likely to result in better fiber digestion and therefore enhanced feed intake.

Similarly, Ogbuewu & Mbajiorgu (2022) [14] found that the DM intake of Saanen goats increased when they were given 0.2 g/head. Day of *Saccharomyces. cerevisiae* (CNCMI-1077) over 12 weeks. The enhanced digestive process may result in a higher feed consumption since goats can more nutrients from the combined chicory and yeast diet. The use of Chicory and yeast may also enhance nutrient absorption in goats. The process of yeast fermentation can increase the accessibility of nutrients in the rumen. At the same time, the nutritional composition of Chicory has the potential to contribute to a well-balanced diet. The improvement in DM intake has also been reported before. In contrast, there has also been a report of yeast culture not having any beneficial impact on the dry matter intake and live weight gain in finishing lambs.

4.2 Average Daily Gain

The average daily gains (ADG) of non-supplemented animals (-7.14 g/day) were consistent with findings by Kenana (2022) [8], who noted that goats fed with basal *Rhodes grass* alone recorded weight gain of -20 g/day. The ADG of supplemented goats was greater than that of non-supplemented goats. The basal diets that received the highest supplementation of Chicory (30%) exhibited a greater average daily gain (ADG). T_4+ (*Rhodes grass* + 30% chicory + yeast) and T_4- (*Rhodes grass* + 30% chicory no yeast) had ADGs of 154.64 g/day and 125.12 g/day, respectively. The enhanced growth relative to non-supplemented diets may have been caused by higher protein (CP) and energy levels from supplementation, which may have contributed to the higher ADG observed in supplemented diets.

The basal diet without yeast T_1- had a negative ADG (-7.14g/day) compared to one with yeast T_1+, which recorded positive results (28.21 g/day). These results are consistent with the findings of Sawsan *et al*. (2012) [19] who reported that the fibre-degrading properties of specific yeast isolates may increase the digestibility of fibre in *Rhodes grass* when yeast supplementation is used. This may result in enhanced utilization of nutrients by the goats. Furthermore, Conte *et al*. (2018) [3] reported that growth performance was improved as noted by the higher final body weight and average daily gain. Moreover, according to Alugongo *et al*. (2017) [1], yeast has been linked to enhanced immune activity in livestock. This may enhance the health well-being and development of a growing goat as a whole.

The current study found that enhanced nutrient intake can increase weight gain efficiency in growing goats as indicated by high DMI (591.70 g/day) resulting in high ADG (154.64 g/day). These results are also in agreement with those reported by Pradhan *et al*. (2018) [16], who reported that supplementing sure goat kids with active dried yeast (*S. cerevisiae* CNCM I-1077) at a rate of 2% of dry matter intake resulted in enhancement of growth, feed conversion efficiency, and a reduction in feeding cost. The potential contribution of Chicory to gut health, combined with the excellent influence of yeast on digestion, may improve overall growth performance, as shown by the results of this study. The synergistic impact of Chicory and yeast on feed intake, nutrient digestibility, and gut health can enhance growth and overall performance in growing goats, is also supported by findings by Gangadoo *et al*. (2018). Moreover, opine that yeast and Chicory may exert synergistic effects on the health of the digestive tract. Chicory's prebiotic characteristics and the yeast's probiotic impacts can synergistically establish a harmonious and salubrious microbial environment within the goat's gastrointestinal tract. This can lead to better nutrient utilization and stimulate development in growing goats. The potential efficacy of Chicory's ant-parasitic properties may result in a diminished parasite burden within the gastrointestinal tract of goats, thereby providing additional support for their growth and general well-being.

5. Conclusion

The optimal concentration of Chicory for promoting the growth of dairy goats is 30% when supplemented with 10 g/goat. Day of yeast. To achieve feed efficiency and strong development, farmers may add Chicory and yeast to the diets of growing goats to improve productivity. Further investigation is needed to explore the possible long-term effects and economic feasibility of adding Chicory and yeast to the diet of lactating dairy goats.

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7. Conflict of Interest

Not available

8. Financial Support

Not available

9. References

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