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Feeding of cabbage leaves as a roughage source and its impact on growth performance and blood biochemical parameters in growing rabbits

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Abstract
An experiment was conducted in growing rabbits with an aim to study the effect of feeding of cabbage leaves as a roughage source on growth performance and blood biochemical parameters. A total of 12 rabbits (56-60 d old) with an average body weight of 755.41±40.63g were randomly distributed into two groups consisting of six animals in each group. Group-I animals were fed *ad libidtum* of Lucerne plus 100 g of concentrate daily and Group- II animals were fed *ad libidtum* of cabbage leaves plus 100 g of concentrate daily. The experiment was conducted for 60 days. No significant difference was observed in average daily gain, feed intake, dry matter intake and feed conversion ratio among the two experimental groups. All the serum biochemical constituents were within the normal range and no significant difference was observed among the two groups with the exception of creatinine content. Based on the results it can be concluded that cabbage leaves can be fed to the growing rabbits as roughage source without any adverse effects on growth performance and blood biochemical parameters.

Keywords: Cabbage, body weight, lucerne, rabbit

Introduction
With constantly growing human population there arises a need to be able to produce sufficient source of animal protein for human consumption. This could be achieved through intensive rearing of rabbit and its use as a source of animal protein for human consumption is gaining momentum. In intensive rabbit production systems, the cost of feed constitutes a significant portion, ranging from 60 to 70% of the total production cost. Currently, the production costs for meat rabbits are 20-30% higher than those for pigs and nearly double the costs for poultry (Maertens, 2009) [11]. In order to remain competitive with these animal productions, it is crucial to reduce the expenses associated with feeding. Additionally, there is a shortage of green fodders like Berseem and Alfalfa, the main fodder crops used in rabbit feeding owing to the climate change and shrinkage of fodder producing lands causing the non-availability of these fodders around the year. Insufficient fodder supply increases reliance on costly feed ingredients, further driving up production costs. Therefore, alternative feeds such as vegetable and fruit wastes are needed. The use of fruit and vegetable wastes as animal feed is of great interest due to its environmental and public benefits, as well as its potential to reduce the cost of animal production (Westerndorf, 2000) [20]. Moreover, the rabbit's digestive system is well-suited for diets that are low in grains and high in fibre (Abdel-Aziz *et al.*, 2015) [1].
The global quantity of food losses and waste for fruits and vegetables is estimated to be approximately 40-50% per year (FAO, 2017). According to recent statistics from the FAO (2021), India is the second-largest producer of cabbage, with an annual production of 8.75 million tonnes. It has been observed that cabbages and cauliflowers generate a waste material of about 30-50%, consisting of stems, stalks, and leaves, which are not utilized (Monika *et al.*, 2022) [12]. Cabbage leaves are rich in crude protein (CP) and mineral content. On a dry matter (DM) basis, cabbage leaves contain more CP (17.0 to 17.2%) than stems but less than heads (Rosa and Heaney, 1996) [16]. Additionally, the concentrations of calcium (Ca), sulphur (S), and manganese (Mn) are higher in leaves compared to stems and heads. Considering the nutritional content, cabbage leaves have great potential as a roughage source in rabbit feed. With this perspective in mind, the present study aims to investigate the impact of feeding of cabbage leaves as an alternative to Lucerne on the growth performance and blood biochemical profile in rabbits.

Materials and Methods

Place of study: The present study was carried out at Rabbit Research Centre, Department of Animal Genetics and Breeding, College of Veterinary Science, Rajendranagar, and Hyderabad. The study was aimed at investigating the impact of feeding cabbage leaves (CL) and its impact on body weight gain.

Experimental animals and feeding management: A total of 12 rabbits (56-60 days old: body weight; 755.41± 40.63) were randomly allocated into two groups consisting of 6 rabbits in each group. Group-I was fed 100 gm of concentrate and Lucerne was offered *ad libitum* daily. Similarly, the Group-II rabbits were fed with 100 gm concentrate and offered *ad libitum* of CL daily. The duration of the trial period is 60 days. Fresh cabbage leaves were obtained from college farm and washed thoroughly with water before feeding. Concentrate mixture was formulated to contain 18% CP. The ingredient composition of concentrate mixture is mentioned in Table 1. Before start of the experiment the animals were fed with respective diets for a period of 14 days. Feeds were offered twice daily at 9:00 AM and 3:00 PM. During trial period, the rabbits were reared under uniform environmental conditions at Rabbit Research Centre. The left-over feed and fodder (Lucerne & Cabbage) were weighed and recorded daily to estimate feed intake. Fresh water was made available at all the times. Body weight of each individual rabbits was recorded at weekly interval. The feed and fodder samples were analysed for proximate principles as per AOAC (1990) [4].

At the end of the trial period, blood samples (1.00 ml) were collected from each rabbit aseptically from ear vein. Blood biochemical constituents were analysed using commercially available kits.

Table 1: Ingredient composition of concentrate mixture used in the experiment

Name of the ingredient	Kg /100 kg
Maize	50
Groundnut cake	24
Wheat bran	24
Mineral mixture	2

Statistical Test: The data generated under different parameters were subjected to statistical analysis using SPSS version 16.

Results and Discussion

Chemical composition of experimental diets: The proximate composition of experimental diets is shown in Table 2. On Dry matter basis (DMB), the cabbage leaves contained 21.02% crude protein (CP), 2.04% ether extract (EE), 10.97% crude fibre (CF) and 16.69% of total ash (TA). Lucerne contained 24.13% CP, 5.24% EE, 18.0% CF and 14.88% TA. Concentrate mixture contained 19.38% CP, 2.36% EE, 4.91% CF and 7.30% TA.CP content of the cabbage leaves is lower than the Lucerne. The CP and ash content of CL is in agreement with the findings of Hang *et al.* (2011) [9] and Arias *et al.* (2003) [5] who also reported similar values for CL. Proximate composition of CL was within the range of values reported by Mustafa and Baurhoo (2017) [14] for dried cabbage leaf residues.

Table 2: Proximate Analysis of feeds (% dry matter basis) used in experiment

S. N.	Sample	Dry Matter (%)	Crude Protein (%)	Ether Extract (%)	Crude Fibre (%)	Total Ash (%)	NFE (%)
1.	Concentrate Feed	90.26	19.38	2.36	4.91	7.30	66.05
2.	Cabbage Leaves	9.64	21.02	2.04	10.97	16.69	49.28
3.	Lucerne	16.18	24.13	5.24	18.0	14.88	37.75

Each value is the average of duplicate analysis

Growth performance of rabbits

Weekly body weights

The average weekly bodyweights of rabbits reared under group-I and II are presented in Table 3. The average body weights among rabbits under group-I at start of trial and at the end of trial were 733.33 and 2013.33 gm, respectively. Whereas the same among rabbits under group-II were observed to be 777.50 and 1986.67 gm, respectively. Statistical analysis revealed that there was no significant difference (p>0.05) in the body weights among the two experimental groups which indicates that the inclusion of cabbage leaves did not show any negative impact on growth performance in rabbits. Similarly, Hang *et al.* (2011) [9] observed no significant difference in body weights of rabbits fed cabbage leaves with or without supplementation of paddy rice or sweet potato tuber. Okereke *et al.* (2012) [15] observed no difference in body weights of rabbits when fed with Hausa potato tubers meal at different levels of inclusion.

Table 3: Average weekly bodyweights (g) of rabbits fed lucerne and cabbage leaves as a roughage source.

Treatments	Start	1st Wk	2nd Wk	3rd Wk	4th Wk	5th Wk	6th Wk	7th Wk	8th Wk	9th Wk
Group I	733.33 ± 21.85	889.17 ± 33.94	1035.00 ± 42.62	1181.67 ± 52.57	1331.67 ± 69.69	1545.00 ± 70.80	1668.33 ± 68.97	1740.00 ± 81.32	1850.83 ± 72.87	2013.33 ± 76.15
Group II	777.50 ± 85.16	931.67 ± 80.00	1071.67 ± 82.06	1211.67 ± 90.42	1365.00 ± 85.67	1520.83 ± 89.68	1615.83 ± 104.31	1761.67 ± 104.39	1867.50 ± 143.35	1986.67 ± 148.32
S.Em	42.44	41.93	44.43	50.07	52.89	54.60	60.14	63.17	76.71	79.59

Each value is an average of six observations
Group –I- Rabbits fed lucerne+ concentrate
Group –II- Rabbits fed cabbage leaves + concentrate

Average daily gain (ADG)

The average daily gain (ADG) in rabbits fed Lucerne and cabbage leaves is presented in Table 4. From 1st to 9thwk, there was no significant difference (p>0.05) in ADG among the two groups. Overall ADG in group I and II is 20.32 g and 19.19 g, respectively and the values were comparable (p>0.05) among the two groups. The growth performance of rabbits in studies reported from tropical countries is generally

in the range of 10-20g per day, in contrast to 35- 40g per day commonly observed in temperate regions (Cheeke, 2003) [8]. This data shows that feeding of cabbage leaves to the rabbits did not show any adverse effect on growth performance. Similar ADG values were reported by Dairo (2008) [6] in weaner rabbits with inclusion of 10-15% of loofah gourd seed meal. Hang *et al.* (2011) [9] reported comparable body weights in rabbits fed cabbage leaves with or without supplementation of carbohydrate sources. Alabi *et al.* (2018) [7] observed no effect on ADG value with inclusion of okra meal in growing rabbits.

Table 4: Weekly Average Daily Gain (g) in rabbits fed lucerne and cabbage leaves as a roughage source.

Average Daily Gain (g)										
Treatments	**1stWk**	**2ndWk**	**3rdWk**	**4thWk**	**5thWk**	**6thWk**	**7thWk**	**8thWk**	**9thWk**	**Mean**
Group I	22.26 ± 2.16	20.83 ± 1.28	20.95 ± 1.79	21.43 ±3.87	30.48 ± 2.38	17.62 ± 2.35	10.24 ± 5.36	15.83 ± 5.23	23.21± 2.97	20.32±2.27
Group II	22.02 ± 2.38	20.00 ± 2.16	20.00 ± 2.31	21.90 ± 0.89	22.26 ± 1.50	13.57 ± 6.59	20.83 ± 1.18	15.12 ± 10.84	17.02± 1.90	19.19±1.30
SEM	1.54	1.21	1.40	1.90	1.83	3.39	3.07	5.74	1.93	1.04

Each value is an average of six observations
Group –I- Rabbits fed lucerne+ concentrate
Group –II- Rabbits fed cabbage leaves + concentrate

Feed intake and dry matter intake

The average weekly feed intake (FI)and dry matter intake (DMI) of rabbits fed experimental diets is mentioned in Table 5 and Table 6. The overall average daily FI (gm/d) and DMI (gm/d) of group-I and group II was observed to be 125.90and68.99; 124.62 and 62.37, respectively. From 1stwk to 9thwk there was no significance difference in FI between two experimental groups. Similarly the total dry matter intake (DMI) was comparable(p>0.05) among the two groups indicating that the cabbage leaves are equally palatable as lucerne and its feeding did not show any adverse effect on feed intake. Similar DMI (66g/day) was reported by Nakkitset *et al.* (2008) [19] in growing rabbits fed water spinach. The results are in agreement with the findings of Ilaboya *et al.* (2021) [10] who also found no significant difference in DMI between weaned pigs fed with cabbage waste and those fed control diet. Mustafa and Baurhoo (2017) [14] reported that the inclusion of dried cabbage leaf residue in broiler diet did not show any negative effect on feed intake.

Table 5: Average weekly feed intake (g) in rabbits fed lucerne and cabbage leaves as a roughage source

Treatments	**1stWk**	**2ndWk**	**3rdWk**	**4thWk**	**5thWk**	**6thWk**	**7thWk**	**8thWk**	**9thWk**	**Mean**
Group I	96.50 ± 1.42	99.19 ± 1.47	97.17± 2.82	107.52 ±0.83	115.43 ±1.49	149.29 ± 4.43	154.83 ± 4.12	155.26 ± 1.88	157.93 ± 1.23	125.90±9.22
Group II	99.88 ± 1.13	96.06 ± 2.87	102.74 ± 2.69	108.02. ± 2.56	112.50 ± 2.06	143.76 ± 3.11	144.90 ± 4.01	152.10 ± 3.32	159.40 ± 1.39	124.62±8.30
SEM	0.92	1.22	1.20	0.65	1.27	2.01	2.38	1.90	0.92	6.02

Each value is an average of six observations
Group –I- Rabbits fed lucerne+ concentrate
Group –II- Rabbits fed cabbage leaves + concentrate

Table 6: Average weekly Dry matter intake (g) in rabbits fed lucerne and cabbage leaves as a roughage source

Treatments	**1stWk**	**2ndWk**	**3rdWk**	**4thWk**	**5thWk**	**6thWk**	**7thWk**	**8thWk**	**9thWk**	**Mean**
Group I	51.49± 1.31	53.53± 1.31	52.67± 1.65	61.76±0.73	68.77±1.35	83.15± 1.51	81.93± 2.16	82.45± 1.70	85.17± 1.12	68.99±4.82
Group II	50.02± 1.03	48.32± 1.77	52.42± 1.34	57.25± 0.90	61.23± 1.86	72.31± 2.26	67.33± 3.15	73.02± 2.98	79.38± 1.25	62.37±3.73
SEM	0.83	1.13	1.06	0.63	1.21	1.47	2.06	1.78	0.89	3.06

Each value is an average of six observations
Group –I- Rabbits fed lucerne+ concentrate
Group –II- Rabbits fed cabbage leaves + concentrate

Feed conversion ratio (DMI g/ gain g)

Table 7 represents the feed conversion ratio (FCR) of rabbits fed various experimental diets. Average FCR was 2.89 and 2.94 for G-I and G-II, respectively. From 1stwk to 9th wk the values were comparable except on the 5th wk. On the 5th wk highest FCR was recorded in the group II. However, overall FCR was differed non significantly (p>0.05) among the two groups. Ilaboya *et al.* (2021) [10] reported that inclusion of 20% of cabbage waste to the weaned piglet diets did not show any significant effect on FCR. The FCR values obtained in this study were similar to the values reported by Adeyemi *et al.* (2011) [2] for growing rabbits. Similar observations were made by Nisar *et al.* (2022) [13] in poultry with feeding of vegetable waste.

Table 7: Average feed conversion ratio (DMI g/gain g) in rabbits fed lucerne and cabbage leaves as a roughage source

Treatments	**1stWk**	**2ndWk**	**3rdWk**	**4thWk**	**5thWk**	**6thWk**	**7thWk**	**8thWk**	**9thWk**	**Mean**
Group I	2.33± 0.31	2.62± 0.18	2.64± 0.31	3.40±0.58	2.31^{b}±0.15	5.43±1.19	3.81± 2.08	-0.18± 5.98	3.63± 0.43	2.89±0.50
Group II	2.46±0.36	2.46± 0.09	2.83± 0.40	2.63. ± 0.12	2.82^{a}±0.25	2.60± 1.24	3.30± 0.38	2.37± 0.73	4.95± 0.52	2.94±0.27
S.Em	0.23	0.10	0.24	0.30	0.16	0.92	1.01	2.90	0.38	0.39

Each value is an average of six observations
Mean with different superscripts differ significantly (p≤0.05)
Group –I- Rabbits fed lucerne+ concentrate
Group –II- Rabbits fed cabbage leaves + concentrate

Biochemical parameters

The various biochemical parameters estimated from blood sample collected from rabbits reared under group I&II on the last day of the trial is presented in Table 8. In the current study, all the blood biochemical constituents were within the normal range as described by Alessandro (2007) [3], and the values were comparable (p>0.05) among the two groups with the exception of creatinine. Among the parameters estimated the mean creatinine content among group-I rabbits was significantly (p<0.05) higher compared to group-II rabbits. However, the values of creatinine in both groups were within the normal range. Higher creatinine level in group I may be due to higher level of protein intake through Lucerne as dietary protein consumption increases serum creatinine level through protein catabolism rather than decreased clearance (Juraschek *et al.*, 2013) [18]. The results of the present study indicated that inclusion of cabbage leaves had no deleterious effect on serum biochemical constituents.

Table 8: Serum Biochemical parameters in rabbits fed lucerne and cabbage leaves as a roughage source

Parameter	Group I	Group II
Glucose (mg/dl)	99.33 ± 12.94	109.67 ± 5.16
BUN (mg/dl)	15.13 ± 0.26	15.12 ± 1.03
Creatinine (mg/dl)	0.94^{a} ± 0.02	0.88^{b} ± 0.04
Calcium(mg/dl)	13.22 ± 0.36	11.68 ± 0.36
Phosphorus(mg/dl)	3.70 ± 0.13	3.45 ± 0.11
Cholesterol (mg/dl)	107.00 ± 6.64	113.83 ± 13.48
Total Bilirubin(mg/dl)	0.12 ± 0.02	0.14 ± 0.03
Total Protein (gm/dl)	6.02 ± 0.12	5.93 ± 0.14
Albumin (gm/dl)	4.4 ± 0.09	4.55 ± 0.03

Each value is an average of six observations
Mean with different superscripts differ significantly (p≤0.05)
Group –I- Rabbits fed lucerne+ concentrate
Group –II- Rabbits fed cabbage leaves + concentrate

Conclusion

The results of the current study showed that the feeding of cabbage leaves to the rabbit did not show any adverse effect on growth performance and serum biochemical constituents. Hence, cabbage leaves can be fed to the growing rabbits as a roughage source for economically profitable production.

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