B-5642
[1-8]

RESEARCH ARTICLE Indian Journal of Animal Research

Effect of Different Levels of Probiotic Supplementation on the Carcass Characteristics and Meat Quality in Soviet Chinchilla Rabbits

A. Vanathi[1], K. Thilak Pon Jawahar[2], A. Shanmuga Sundaram[3], C. Vennila[2], T. Muthuramalingam[2], B. Rajesh Kumar[2], K. Jeeva[4], M. Manobhavan[5]

10.18805/IJAR.B-5642

ABSTRACT

Background: This study investigated the impact of feeding different levels of probiotic supplementation on the carcass characteristics, offal percentages, carcass measurements, cut-up parts percentages and meat quality of grower Soviet Chinchilla rabbits.

Methods: Twenty-four rabbits were divided equally into four groups: T_1 (Paragrass + concentrate), T_2 (Paragrass + concentrate + 0.05% probiotics), T_3 (Paragrass + concentrate + 0.1% probiotics) and T_4 (Paragrass + concentrate + 0.2% probiotics). The rabbits had an average body weight of 850±50 g at 60 days of age and study was conducted during the year 2023-2024.

Result: Significant differences were observed in live weight (2.25±0.12 Kg to 3.36±0.28 Kg), slaughter weight (2.08±0.13 to 3.22±0.12), carcass weight (1.23±0.73 to 2.07±0.07) and specific organ weights (such as heart, liver and kidney) among treatment groups ($P<0.05$). Hot carcass weight was highest in the T_4 group (2.07±0.07 kg), indicating enhanced carcass yield with higher probiotic levels. Significant increase ($P<0.01$ and $P<0.05$) in carcass length, thorax circumference and hind leg length was found in T_3 and T_4 group when compared with T_1 and T_2. Weights of edible offals were found higher in T_3 and T_4 dietary group with no statistically significant differences ($P>0.05$) in weight of inedible offals. Significantly higher increase ($P<0.01$) in weight of thorax (381.33±14.89), shoulder (313.12±9.21 gm), loin (365.80±14.5 gm), abdominal flap (143.43±6.65 gm) and rump (158.98±6.21 gm) was noticed in T_4 except for hind leg when compare with T_1, T_2 and T_3 dietary group with their consistent yield of cut up parts. No significant differences ($P>0.05$) were noticed in proximate composition of all the treatment group but with significantly reduced fat content in T_3 (6.46±0.26 to 4.59±0.39) when compare with other treatment group. Cooking loss and pH values were consistent ($P>0.05$), across different dietary groups. The above experiment showed that supplementation of probiotics @ 0.2% with paragrass and concentrate had beneficial effect in terms of carcass quality (*i.e.* live weight, hot carcass weight, carcass measurements, cut-up parts and specific organ weights *etc.*) and meat quality (*i.e.* ether extract, moisture, protein, ash content *etc.*) of growing Soviet Chinchilla rabbits.

Key words: Carcass characteristics, Cut-up parts percentage, Meat quality, Offals percentage, Paragrass, Probiotic supplementation, Soviet chinchilla rabbit.

INTRODUCTION

Global demand for rabbit meat continues to escalate, as it is an alternative to broiler chicken rearing. Interestingly, worldwide rabbit population exceeds 1 billion, with China, Italy and Spain leading as major producers (FAO, 2023) of rabbit. As per the FAOSTAT (2014), in 2012, global rabbit meat production increased to 1.83 million tons. Rabbit meat is considered as lean due to very low level of intramuscular fat and as an alternative to broiler chicken due to its higher protein (20-21%) and low fat content (10-11%), when compared with meat from other species.

Usage of antibiotic growth promoters in livestock nutrition (Windisch *et al.,* 2008) for the improvement production performance was completely prohibited, as they might result in resistance to antibiotics and the antibiotic residues could be present in products of animal origin intended for human consumption. Due to this ban, presently, the livestock owners are using probiotics in feed to its role in reducing early mortality rates, improving feed conversion efficiency (Elmasry *et al.,* 2021) and enhancing the activity of digestive enzymes while maintaining microbial balance in the digestive tract (Soomro *et al.,* 2019).

[1]Livestock Farm Complex, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Theni-625 534, Tamil Nadu, India.
[2]Livestock Farm Complex, Madhavaram Milk Colony, TANUVAS, Chennai-600 051, Tamil Nadu, India.
[3]Department of Wildlife Science, Madras Veterinary College, Chennai-600 007, Tamil Nadu, India.
[4]Department of Veterinary Parasitology, Veterinary College and Research Institute, TANUVAS, Theni-625 534, Tamil Nadu, India.
[5]Department of Animal Nutrition, Madras Veterinary College, TANUVAS, Chennai-600 007, Tamil Nadu, India.

Corresponding Author: A. Vanathi, Livestock Farm Complex, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Theni-625 534, Tamil Nadu, India. Email: vanathivet07@gmail.com
ORCID: https://orcid.org/0000-0002-5261-4894

How to cite this article: Vanathi, A., Jawahar, K.T.P., Sundaram, A.S., Vennila, C., Muthuramalingam, T., Kumar, B.R., Jeeva, K. and Manobhavan, M. (2025). Effect of Different Levels of Probiotic Supplementation on the Carcass Characteristics and Meat Quality in Soviet Chinchilla Rabbits. *Indian Journal of Animal Research*. 1-8. doi: 10.18805/IJAR.B-5642.

Submitted: 05-06-2025 **Accepted:** 07-10-2025 **Online:** 25-10-2025

In Tamil Nadu, rabbit farming is widely based on locally available feed resources including natural grasses, legume leaves, wild vegetables and agro industrial byproducts which have a very important role for rabbit production. The diet for rabbits usually contain high proportion of fiber and low protein content. Paragrass, also called buffalo grass, is a perennial fodder crop that spreads through stolons and is found in tropical countries like India, Africa and Australia, mostly in wet and swampy areas near rivers, lakes and dams and it is valued as a natural fodder rich in dietary fibre. However, using solely para grass in the diets could reduce the growth rate of rabbits due to its higher dietary fiber content and similar negative growth rate was also observed in our pilot study of treatment groups fed with paragrass alone. The soluble fiber fraction serves as a prebiotic and may have synergistic effects with probiotics (Wong *et al.,* 2006) and thus, offer improvement in nutrient digestibility and stimulate growth of rabbits. Different levels of probiotic inclusion can influence carcass traits such as dressing percentage, muscle deposition and fat content, while also enhancing meat quality attributes like tenderness, juiciness and nutrient composition. (Abdel-Wareth and Lohakare, 2014; Al-Saef, 2017)

Moreover, the synergetic effects of probiotics and paragrass in rabbits have not been reported consistently in previous studies and also not been focused to improve animal health, particularly improving the carcass characteristics and meat quality of rabbits. The study was, thus, conducted to evaluate the efficacy of different level of probiotic supplementation on the carcass characteristics and meat quality in Soviet Chinchilla rabbits under cage system of housing.

MATERIALS AND METHODS

Location of study

The present study was conducted at the Rabbit Section, Livestock Farm Complex, Madhavaram Milk Colony, Chennai-600 051, which is located at 13.15°N latitude and 80.24°E longitude, with an elevation of approximately 8 m above mean sea level. In this region the maximum temperature is about 38°C, while the minimum is around 21°C and an average relative humidity of about 71%. The area receives an annual rainfall of around 1,336 mm.

Details of experimental animals and duration of study

A total number of twenty four (comprising of both the sex) growing soviet chinchilla rabbits with an average body weight of 850±50 gm, 60 days of age, were randomly assigned to four dietary treatment groups (n=6 irrespective of sex). This study was conducted during the year 2023-2024.

Animal management

Experimental rabbits were reared individually in cages of galvanized wire net (width × length × height: 60 cm × 60 cm × 40 cm) equipped with automatic drinker and a manual feeder. Ambient temperature was maintained at 22°C with a 12 h light/dark cycle. The rabbits were housed under the similar managerial, hygienic and environmental conditions. Every rabbit, was provided with sufficient fresh drinking water. The details of green fodder, concentrate feed, different levels of probiotic supplementation for the experimental rabbits were mentioned in Table 1.

Details of experimental groups

The first group was fed with paragrass and concentrate (T_1), paragrass and concentrate mixed with probiotics at 0.05% (T_2), paragrass and concentrate mixed with probiotics at 0.1% (T_3) and paragrass and concentrate mixed with probiotics at 0.2% (T_4) respectively for three months. The probiotics levels were selected based on company recommendations (Healthy gutTM probiotics for rabbit, Equa Holistics manucature, Athens) and contains a unique and balanced mix of lactic acid bacteria culture, (*P. freudenreichii, P. shermani, E. thermophilus, L. lactis, L. casei, B. longum, P. acidilacti, P. pentosaceus, B. bifidum, B. animalis, L. brevis, L. fermentum, L. acidophilus, L. plantarum, S. cerevisiae*) fermentation extract of freeze dried probiotic organism, in a high concentration that adds to the count and assist in maintaining a healthy microflora which helps maximize feed digestion and utilization and prevent digestive upsets as well as contains a unique balanced combination of the was used for study. Probiotics at different level were mixed separately in 1 kg of the concentrate and were added to the required feed amount for the prescribed experimental period. Throughout the whole experimental period (three months), rabbit diets were formulated to meet the standard nutritional requirements for growing meet type rabbit. The ingredients used and chemical composition of green fodder and concentrate feed provided for the experimental diets are mentioned in Table 1 and 2. Six rabbits from each group were slaughtered at five months of age. The carcass characteristics, edible and inedible offals (%), Intestinal villus morphology, carcass measurements, Cut-up parts (%) and meat quality characteristics were recorded and evaluated as per the standard procedure.

Carcass characteristics, offals yield, carcass measurements and cutup parts yield

At the end of three months of experimental feeding, all the rabbits were slaughtered after starving them for 12 hours by Halal method (Ramayyan *et al.,* 1980). The carcass was split into different cuts-two shoulder, thorax, loin, abdominal flap, rump and hind leg. The two legs were separated by sharply cutting across the carcass immediately in front of hip joint. The loin was separated from the chest at the last rib. Two shoulders were removed from the thorax by separating muscles between scapula and ribs**.** The weight of primal cuts was expressed as percentage of hot carcass weight. The cut up parts were measured for its length and circumference and expressed in centimeter. The weight of blood, different parts (head, skin, feet and carcass), edible (liver, heart and kidney) and inedible offal's (stomach and gastrointestinal tract) were

recorded soon after slaughter and expressed as percentage of slaughter weight. Carcass yield was calculated as per the following formula.

$$\text{Carcass yield (\%)} = \frac{\text{Hot carcass weight, g}}{\text{Slaughter weight, g}} \times 100$$

Intestinal histomorphometry

The small intestine of one randomly chosen animal per replicate from the four groups was taken for histomorphometry examination. The ilium samples approximately 4-5 cm from the pylorus were carefully dissected (2 cm of tissue samples) during the slaughter time and were first rinsed with saline (0.85% NaCl) and preserved in 10% formalin solution. The routine histological methods were applied to the specimen and were trimmed and transverse sections of 4-5 micron were stained with hematoxylin and eosin. The slides were examined under × 10 magnification and micrographs were taken with trinocular light microscope (Labomed, L × 400. Labo America, Inc. USA) supplied with a computerized digital camera (IVU 3000). Images were analyzed to measure the crypt depth and villi height using stereological image software which its scale was calibrated to the micrometer unit (µm) using a micrometric ruler. The villus height was measured (3-5 villi per sample) from the villus tip to villus-crypt junction. Measurements for crypt depth were taken from the base of the villus to the submucosa were followed as per the procedure Helal *et al.,* 2021.

Meat proximate composition

Meat samples were collected from the breast portion of carcasses per treatment, wrapped individually in polythene bags and immediately placed in a refrigerator (+4°C) until used for chemical analysis. Collected meat samples were analyzed for moisture, fat, protein and ash content (AOAC, 2016).

Statistical analysis

Data generated from the trials were compiled and were analysed by one way analysis of variance (ANOVA) using SPSS software for window (Version 17.0, SPSS, Inc., Chicago, IL).

RESULTS AND DISCUSSION

Carcass characteristics

Effect of feeding paragrass and probiotics combination on the carcass characteristics of grower Soviet Chinchilla rabbits is presented in Table 3. Highly significant increases ($P<0.01$) were noticed in live weight (3.11±0.09 and 3.36±0.28 kg), slaughter weight (2.85±0.12 and 3.22±0.12 kg), after bleeding weight (2.64±0.12 and 2.87±0.16 kg), carcass with giblet weight (2.09±0.08 and 2.31±0.14 kg) and hot carcass weight (1.80±0.06 and 2.07±0.07 kg) of T_3 and T_4 groups respectively compare with T1 and T2. The hot carcass weight of the T_4 (2.07±0.07 kg) group was the highest, suggesting that a higher level of probiotics may further enhance carcass yield. Also, the weight of the head was found significantly higher in T_3 and T_4 group with no significant difference in yield among different groups. However, no significant difference was noticed in the dressing percentage of rabbit fed with different feeding regime. But relatively the yield of feet % was found higher in T_1 and T_2 when compare with T_3 and T_4.

However, improved live weight, slaughter weight, after bleeding weight, carcass with giblet weight and hot carcass weight, highlights the growth-promoting effects of probiotics in rabbits (García-Ruiz *et al.,* 2019; Riad *et al.,*

Table 1: Details of feeds, fodders and feeding of different experimental rabbit groups.

Ingredients	Experimental diet (g/ day/animal)			
	T_1 (Paragrass + concentrate)	T_2 (Paragrass + concentrate + 0.05% probiotics)	T_3 (Paragrass + concentrate + 0.1% probiotics)	T_4 (Paragrass + concentrate + 0.2% probiotics)
Green fodder				
Paragrass	200	200	200	200
Concentrate feed (g/Kg)	200	200	200	200
Maize	510.0	510.0	510.0	510.0
De oiled rice bran	100.0	100.0	100.0	100.0
Wheat bran	100.0	100.0	100.0	100.0
Soyabean meal	200.0	200.0	200.0	200.0
Sunflower oil cake	50.0	50.0	50.0	50.0
Common salt	5.0	5.0	5.0	5.0
Dicalcium phosphate	15.0	15.0	15.0	15.0
Calcite powder	8.0	8.0	8.0	8.0
DL-methionine	2.0	2.0	2.0	2.0
Trace mineral and vitamin	2.50	2.50	2.50	2.50
Additives	7.50	7.50	7.50	7.50
Probiotics	0	5	10.0	20.0

2017) and improved carcass characteristics in rabbits fed with probiotics in T_4 group (Probiotics at 0.2%) when compared with T_1, T_2 and T_3. This might be due to increased nutrient utilization and improvement in gut health in rabbits, attributed to probiotics, likely contributing to these results (Bovera *et al.,* 2010). Rabbit in all dietary groups had similar dressing yield (Ranges from 59.67 to 64.40%), which corroborate with earlier findings of Marounek *et al.,* 2007; Rotolo *et al.* 2014 on effect of live yeast (*Saccharomyces cerevisiae* var. *boulardii*); diet supplemented with conjugated linoleic acid on the productive performance and meat quality of rabbit. Kouadio *et al.,* 2023 reported that slaughter traits of rabbit were not affected by Sun-Dried Stylo hay as a dietary fiber source in rabbit.

Edible and inedible offals %

Effect of feeding para grass and probiotics combination on the offals % of grower Soviet Chinchilla rabbits were presented in Table 4. Heart (7.31±0.60 and 7.36±0.48 gm), liver weight (62.58±3.74 and 66.30±5.53 gm) and kidney weight (16.10±0.58 and 17.48±0.45) had a significant increase ($P<0.05$ and $P<0.01$) in T_3 and T_4 groups respectively compare with T_1 and T_2 groups. However, in the yield of kidney was significantly lower in the T_2 and T_3 groups compared to T_1, but not in T_4. However, the heart and liver percentage did not show significant variation across treatments. The present result was consistent with the findings of Abdel-Azeem *et al.* 2018 and Hou *et al.,* 2020 observed that addition of anaerobic probiotic on the diet of rabbit increased ($P<0.05$) the percentage of liver, with no significant effect on percentage of heart and kidney compare to control diet.

Inedible offals, including stomach and whole intestine weights, as well as total inedible offals weight did not show significant differences ($P>0.05$) across the dietary treatments. It indicates that combined effect of paragrass and concentrate feed mixed with probiotics at 0.1 and 0.2% level did not substantially affect the nonedible organs of rabbit. Chandra *et al.* (2015) also reported similar non significant findings in the weight of inedible offals in rabbit ration supplemented with probiotics Kemzyme HF @ 0.05 % (Saccharomyces boulardi 50 % and Pediococcus acidilactii 50%) and enzymes (cellulose, xylanase, pectinase, β-glucanase, amylase, protease and lipase).

Carcass measurements

Effect of feeding paragrass and probiotics combination on carcass measurements of grower Soviet chinchilla rabbits were presented in Table 5. Significant increase ($P<0.01$ and $P<0.05$) were noticed in carcass length (39.16±0.70 and 40.18±0.79 cm), thorax circumference (24.63±0.33 and

Table 2: Chemical composition of paragrass and concentrate feed used for experimental rabbit.

Parameters	Para grass	Concentrate feed
Moisture %	71.88	11.14
Protein %	12.51	22.66
Crude fiber %	26.49	5.96
Fat %	2.05	3.75
Total ash %	11.04	6.64
Nitrogen free extract %	47.92	60.99

Table 3: Carcass characteristics of experimental rabbits under different feeding regimen.

Parameters	Experimental diets				F value
	T_1 (Paragrass + concentrate)	T_2 (Paragrass + concentrate + 0.05% probiotics)	T_3 (Paragrass + concentrate + 0.1% probiotics)	T_4 (Paragrass + concentrate + 0.2% probiotics)	
Carcass characteristics					
Live weight (kg)	2.25±0.12^{A}	2.63±0.11^{B}	3.11±0.09^{C}	3.36±0.28^{C}	18.98
Slaughter weight (kg)	2.08±0.13^{A}	2.41±0.10^{A}	2.85±0.12^{B}	3.22±0.12^{C}	16.68
After bleeding weight (kg)	1.82±0.13^{A}	2.11±0.12^{A}	2.64±0.12^{B}	2.87±0.16^{B}	12.49
Blood weight (gm)	0.15±0.017	0.18±0.017	0.17±0.036	0.19±0.025	0.44
Blood %	7.35±0.93	7.73±0.75	6.12±1.23	6.18±1.04	0.66
Skin weight (gm)	0.18±0.017	0.19±0.010	0.23±0.024	0.23±0.02	2.07
Skin %	8.69±0.51	8.12±0.61	8.09±0.70	7.29±0.57	0.91
Carcass with giblet weight (kg)	1.42±0.07^{A}	1.66±0.09^{B}	2.09±0.08^{B}	2.31±0.14^{B}	14.71
Head weight (gm)	0.18±0.008^{A}	0.20±0.01^{A}	0.25±0.009^{B}	0.26±0.008^{B}	13.86
Head %	8.95±0.37	8.50±0.61	8.97±0.64	8.10±0.40	0.62
Hot carcass weight (kg)	1.23±0.73^{A}	1.48±0.05^{B}	1.80±0.06^{C}	2.07±0.07^{D}	28.14
Dressing percentage %	59.67±2.18	61.80±1.28	63.25±1.15	64.40±0.64	2.03
Feet weight (gm)	0.05±0.002	0.05±0.002	0.05±0.003	0.05±0.004	2.03
Feet %	2.42±0.13^{b}	2.09±0.13^{ab}	2.05±0.1^{a}	1.79±0.09^{a}	4.61

Alphabets a, b, c, d are used for significant at 5% level ($P<0.05$) and A, B, C,D for significant at 1% level ($P<0.01$).
Different alphabets in different columns differed significantly.

26.63±0.82 cm), thorax length (16.85±0.69 and 17.10±0.62 cm), hind leg length (20.11±0.84 and 20.56±0.99 cm), fore leg circumference (10.11±0.44 and 11.21±0.47 cm) and non-significant increase (P>0.05) was noticed in for leg length, loin length and lumbosacral length, of rabbit fed with probiotics (T_3 and T_4) compared to group receiving only paragrass and concentrate (T_1). This enhancement in carcass length can be attributed to the synergistic effects of paragrass and higher level of probiotics supplementation especially at 0.2% (T_4), which may promote better nutrient

Table 4: Offal characteristics of experimental rabbits under different feeding regimen.

Parameters	Experimental diets				F value
	T_1 (Paragrass + concentrate)	T_2 (Paragrass + concentrate + 0.05% probiotics)	T_3 (Paragrass + concentrate + 0.1% probiotics)	T_4 (Paragrass + concentrate + 0.2% probiotics)	
Edible offals characteristics					
Heart weight (gm)	5.60±0.28^{a}	6.36±0.24^{ab}	7.31±0.60^{b}	7.36±0.48^{b}	3.85
Heart %	0.25±0.006	0.24±0.008	0.23±0.021	0.22±0.015	0.79
Liver weight (gm)	49.85±4.20^{a}	53.16±1.68^{ab}	62.58±3.74^{bc}	66.30±5.53^{c}	3.67
Liver %	2.26±0.25	2.04±0.14	2.00±0.10	1.98±0.19	0.49
Kidney weight (gm)	15.18±0.53^{a}	15.35±0.86^{a}	16.10±0.58^{ab}	17.48±0.45^{b}	2.75
Kidney %	0.68±0.03^{B}	0.58±0.02^{A}	0.51±0.02^{A}	0.52±0.01^{B}	7.78
Edible offals weight (gm)	70.66±3.70^{A}	74.88±2.08^{AB}	85.96±3.88^{BC}	91.16±5.35^{C}	5.86
Edible offal %	3.20±0.26	2.87±0.15	2.76±0.11	2.72±0.19	1.25
Inedible offals characteristics					
Stomach (gm)	97.21±4.68	102.38±6.71	94.85±3.21	97.80±5.14	0.38
Whole intestine weight (gm)	306.68±5.79	311.93±8.41	293.58±11.01	302.11±5.03	0.96
Inedible offals weight	403.90±5.60	414.31±5.63	388.43±10.23	399.91±8.76	1.86

Alphabets a, b, c, d are used for significant at 5% level (P<0.05) and A, B, C, D for significant at 1% level (P<0.01).
Different alphabets in different columns differed significantly.

Table 5: Carcass measurements (cm) and cut-up parts (gm) of experimental rabbits under different feeding regimen.

Parameters	Experimental diets				F value
	T_1 (Paragrass + concentrate)	T_2 (Paragrass + concentrate + 0.05% probiotics)	T_3 (Paragrass + concentrate + 0.1% probiotics)	T_4 (Paragrass + concentrate + 0.2% probiotics)	
Carcass measurements (cm)					
Carcass length	33.8±0.66^{A}	36.15±0.63^{B}	39.16±0.70^{C}	40.18±0.79^{C}	17.13
Fore leg length	15.55±0.52	16.20±0.72	17.71±0.99	17.35±0.51	1.97
Thorax circumference	20.13±0.67^{A}	22.13±0.92^{A}	24.63±0.33^{B}	26.63±0.82^{B}	15.34
Thorax length	12.30±1.17^{a}	13.33±1.63^{a}	16.85±0.69^{b}	17.10±0.62^{b}	4.83
Loin length	11.66±1.10^{a}	13.78±0.87^{a}	14.25±1.24^{ab}	17.16±0.83^{b}	0.32
Hind leg length	19.16±0.83^{a}	19.88±1.34^{a}	20.11±0.84^{b}	20.56±0.99^{b}	4.84
Lumbosacral length	6.65±1.11	7.46±1.15	7.30±1.65	6.71±1.65	0.12
Fore leg circumference	8.30±0.67^{a}	9.26±0.82^{a}	10.11±0.44^{ab}	11.21±0.47^{b}	3.91
Hind leg circumference	9.33±0.71^{A}	11.53±0.93^{AB}	12.58±0.82^{B}	13.70±082^{B}	5.03
Cut-up parts (gm)					
Thorax weight	222.46±13.92^{A}	267.20±11.35^{B}	330.08±13.21^{C}	381.33±14.89^{D}	27.08
Shoulder weight	181.35±11.49^{A}	219±9.13^{B}	269.66±11.22^{C}	313.12±9.21^{D}	27.08
Loin weight	212.05±13.6^{A}	256.38±10.06^{B}	314.40±13.48^{C}	365.80±14.5^{D}	26.51
Abdominal flap weight	87.96±5.89^{A}	104.78±4.62^{B}	125.91±4.89^{C}	143.43±6.65^{D}	18.87
Rump weight	93.83±6.29^{A}	113.68±4.90^{B}	138.31±5.48^{C}	158.98±6.21^{D}	24.23
Hind leg weight	439.67±29.30^{A}	525.76±23.49^{B}	625.22±24.78^{C}	714.80±26.74^{D}	20.82

Alphabets a,b,c,d are used for significant at 5% level (P<0.05) and A, B, C,D for significant at 1% level (P<0.01).
Different alphabets in different columns differed significantly.

absorption and muscle growth. These findings corroborated with previous research studies, that demonstrated the positive impact of probiotics on growth performance and carcass characteristics of rabbits (Bovera *et al.,* 2010).

Cut-up parts

Effect of feeding paragrass and probiotics combination on the cut-up parts % of grower Soviet Chinchilla rabbits were presented in Table 5. Significant increases (P<0.05) in Thorax (381.33±14.89 gm), Shoulder (313.12±9.21 gm), Loin weight (365.80±14.5 gm), abdominal flap (143.43±6.65 gm) and Rump (158.98±6.21 gm) were highest in T_4 group (combination of paragrass and concentrate feed mixed with probiotics at 0.2%) followed by T_3, T_2 and T_1. Similar findings on carcass characteristics were reported by Memon *et al.* 2024 and Öztürk and Yıldırım (2005) respectively in rabbit fed with dietary prebiotic, probiotic and symbiotics.

Intestinal villus morphology

Effect of feeding para grass and probiotics combination on the intestinal villus morphology of grower Soviet chinchilla rabbits were presented in Table 6. Combined effect of feeding paragrass and concentrate feed mixed with probiotics at 0.05, 0.1 and 0.2% showed significant variation and had a positive effect (P<0.01 and P<0.05) on the height and width of the villi in all three segments of small intestine such as duodenum (8492.33±296.99 and 730.83±24.37 µm), jejunum (6112.33±267.03 and 625.00±25.61 µm) and ileum (4846.33±84.10 and 584.50±36.33 µm) respectively in T_4 groups as compare with T_1, T_2 and T_3 groups. This description was also stated by William and Linda (2000). Villus height and the ratio of villus height to crypt depth are indicators of gastrointestinal tract morphology (Shamoto and Yamauchi 2000) and intestinal histomorphology are one of the important indications of gut health in different animal species. The surface area of the intestinal villi plays an important role in the absorption of nutrients by small intestine. Moreover, the improvement of available nutrients in intestine would, result in increasing weights of visceral organs and improving growth performance of animal.

Meat quality characteristics

Effect of feeding a combination of paragrass and probiotics on the meat quality of grower Soviet Chinchilla rabbits was assessed, as presented in Table 7. No significant differences (P>0.05) were noticed in moisture, protein, crude fiber, total

Table 6: Intestinal villus measurements (µm) of experimental rabbits under different feeding regimen.

Parameters	Experimental diets				F value
	T_1 (Paragrass + concentrate)	T_2 (Paragrass + concentrate + 0.05% probiotics)	T_3 (Paragrass + concentrate + 0.1% probiotics)	T_4 (Paragrass + concentrate + 0.2% probiotics)	
Villus height (µm)					
Duodenum	6662.33±542.55^{A}	6331.50±54.92^{A}	7560.66±543.78^{AB}	8492.33±296.99^{B}	3.86
Jejunum	5163.00±269.18^{A}	4794.33±209.83^{A}	5454.50±162.55^{AB}	6112.33±267.03^{B}	5.80
Ileum	4047.83±222.7^{a}	4282.0±161.95^{a}	4734.83±57.82^{b}	4846.33±84.10^{b}	6.40
Villus width (µm)					
Duodenum	544.16±40.15^{A}	581.66±25.70^{AB}	665.00±33.52^{BC}	730.83±24.37^{C}	7.04
Jejunum	534.33±26.45^{ab}	509.83±12.60^{a}	610.00±38.45^{bc}	625.00±25.61^{c}	4.23
Ileum	456.33±32.25^{a}	457.00±39.79^{a}	517.66±18.08^{ab}	584.50±36.33^{b}	3.48

Alphabets a, b, c are used for significant at 5% level (P<0.05) and A, B, C for significant at 1% level (P<0.01).
Different alphabets in different columns differed significantly.

Table 7: Meat quality characteristics of experimental rabbits under different feeding regimen.

Parameters	Experimental diets				F value
	T_1 (Paragrass + concentrate)	T_2 (Paragrass + concentrate + 0.05% probiotics)	T_3 (Paragrass + concentrate + 0.1% probiotics)	T_4 (Paragrass + concentrate + 0.2% probiotics)	
Moisture %	72.37±0.57	71.46±0.73	74.13±0.68	72.66±0.80	2.46
Protein %	17.30±0.56	18.25±0.74	16.58±0.55	16.70±0.96	1.10
Crude fiber %	0.00	0.00	0.00	0.00	
Fat %	6.46±0.26^{b}	5.82±0.47^{ab}	4.59±0.39^{a}	5.78±0.47^{ab}	3.58
Total ash %	1.67±0.15	1.71±0.30	1.54±0.15	19.4±0.33	0.44
Nitrogen free extract %	2.19±0.39	2.74±0.48	3.14±0.29	2.90±0.5	0.88

Different alphabets in different columns differed significantly at 5% level (P<0.05).

ash, nitrogen free extract except fat %. Similar findings was also reported by Chandra *et al* 2015, on dietary supplementation of probiotics and enzymes on meat composition of broiler rabbits. This research study shows that probiotics had significant effect on fat content, while other meat quality parameters, including moisture, crude protein, total ash and nitrogen-free extract.

CONCLUSION

It was concluded from the above experiment that supplementation of probiotics @ 0.2% with paragrass and concentrate had beneficial effect in terms of carcass quality (*i.e.* live weight, hot carcass weight, carcass measurements, cut-up parts and specific organ weights *etc.*) and meat quality (*i.e.* ether extract, moisture, protein, ash content *etc.*) of growing Soviet Chinchilla rabbits.

ACKNOWLEDGEMENT

The authors are thankful to the Livestock Farm Complex, Madhavaram Milk Colony, Chennai-600 051 for providing necessary funds, laboratory facilities and manpower to conduct the research work.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

REFERENCES

Abdel-Azeem, A.S., Hassan, A.A., Basyony, M.M. and Abu Hafsa, S.H. (2018). Rabbit growth, carcass characteristic, digestion, caecal fermentation, microflora and some blood biochemical components affected by oral administration of anaerobic probiotic (ZAD®). *Egyptian Journal of Nutrition and Feeds*. **21(3):** 693-710.

Abdel-Wareth, A.A.A. and Lohakare, J. (2014). Effect of dietary supplementation of probiotic and prebiotic on growth performance, carcass characteristics and meat quality of rabbits. *Animal Nutrition and Feed Technology*. **14(2):** 271-289.

Al-Saef, A.M. (2017). Influence of probiotics supplementation on carcass traits and meat quality of growing rabbits. *Egyptian Poultry Science Journal*. **37(4):** 1109-1122.

AOAC. (2016). Official methods of analysis, 20th edn. Association of Official Analytical Chemists, Washington, DC.

Bovera, F., Lestingi, A., Marono, S., Iannaccone, F., Nizza, S. and Lanza, A. (2010). Effect of dietary inclusion of a probiotic on growth performance, nutrient digestibility and carcass and meat traits of rabbits. *Animal.* **4(3):** 442-448.

Chandra, A.S., Mahender, M. and Harikrishna, C. (2015). Dietary supplementation of probiotics and enzymes on slaughter traits and meat composition in broiler rabbits. *Indian Journal of Animal Production and Management.* **31(1-2):** 73-78.

Elmasry, A.M.A., Miranda, L.A., Mendoza, G. and Plata, F.X. (2021). Effect of yeast type and dose on growth performance and nutrient digestibility of growing rabbits fed maize or Barley. *Indian Journal of Animal Research*. doi: 10. 18805/ IJAR.B-1331.

Food and Agriculture Organization of the United Nations (FAO). (2014). FAOSTAT statistical database: Livestock primary [Data set].

Food and Agriculture Organization of the United Nations (2023). FAOSTAT Database: Livestock Primary [Data set]. FAO

García-Ruiz, A.I., García-García, R.M., Rodríguez-Calleja, J.M. and Santos, J.A. (2019). Growth performance and carcass traits of fattening rabbits under intensive management conditions: Effect of dietary crude protein and slaughter weight. *Livestock Science*. **229:** 1-6.

Helal, F., El-Badawi, A., El-Naggar, S., Shourrap, M., Aboelazab, O. and Abu Hafsa, S. (2021). Probiotics role of Saccharomyces cerevisiae and Bacillus subtilis in improving the health status of rabbits' gastrointestinal tract. *Bulletin of the National Research Centre*. **45(1):** 66.

Hou, Q.R., Zhang, J., Chen, T., Zhao, W.G. and Li, L. (2020). Effects of dietary supplement of mulberry leaf (Morus alba) on growth and meat quality in rabbits. *Indian Journal of Animal Research*. **54(3):** 317-321. doi: 10.18805/ijar.B-1006.

Kouadio, K.S., Yapi, Y.M., Kimse, M., Alla, K.J.B., Gidenne, T. and Wandan, E.N. (2023). Sun-dried Stylo Hay (Stylosanthes guianensis CIAT 184) as Dietary Fibre Source in Rabbits. *Indian Journal of Animal Research*. **57(11):** 1512-1516. doi: 10.18805/IJAR.BF-1501.

Marounek, M., Skrivanova, V., Dokoupilova, A., Czauderna, M., Berladyn, A. (2007). Meat quality and tissue fatty acid profiles in rabbits fed diets supplemented with conjugated linoleic acid. *Veterinary Medicine*. **52:** 552-561.

Memon, S., Kachiwal, A.B., Malhi, M.C. and Mughal, G.A. (2024). Effects of dietary prebiotics, probiotics and symbiotics on growth performance, carcass characteristics, body condition score and nutrients digestibility of rabbits. *Jammu Kashmir Journal of Agriculture*. **4(1):** 1-13.

Öztürk, E. and Yıldırım, A. (2005). Prebiotics supplementation to the diets broiler on performance and intestinal microbiological characteristics. III. *National Animal Nutrition Congress.* pp: 69-75.

Ramayyan, G.N, Ramamurthi, R., Venkatesan, G.S and Govindarajan, C.V. (1980). Dressing percentage and proportion of certain edible and inedible offals in relation to slaughter weight at rabbit. *Cherion*. **9:** 319-324.

Riad, F., Farghly, M.F.A., Mohamed, E.A.H. and Abd El-Motaal, M.E. (2017). Effect of dietary supplementation of mannan-oligosaccharides on productive performance, immunity parameters and carcass characteristics of growing rabbits. *World Rabbit Science*. **25(1):** 45-56.

Rotolo, L., Gai, F., Peiretti, P.G., Ortoffi, M., Zoccarato, I., Gasco, L. (2014). Live yeast (*Saccharomyces cerevisiae* var. boulardii) supplementation in fattening rabbit diet: Effect on productive performance and meat quality. *Livestock Science*. **162:** 178-184.

Shamoto, K. and Yamauchi, K. (2000). Recovery responses of chick intestinal villus morphology to different refeeding procedures. *Poultry Science*. **79(5):** 718-723.

Soomro, R.N., Abd El Hack, M.E., Shah, S.S., Taha, A.E., Alagawany, M., Swelum, A.A., Hussein, E.O., Ba Aawdh, H.A., Saadeldin, I., El Edel, M.A. and Tufarelli, V. (2019). Impact of restricting feed and probiotic supplementation on growth performance, mortality and carcass traits of meat type quails. *Animal Science Journal*. **90(10):** 1388-1395.

William, J.B. and Linda, M.B. (2000). Color Atlas of Veterinary Histology, 2nd edn. Lippincott Williams and Wilkins, Hoboken.

Windisch, W., František, J.M.M.W. and Kroismayr, A. (2008). Use of phytogenic products as feed additives for swine and poultry: A review. *Journal of Animal Science*. **86(14):** 140-148.

Wong, J.M.., De Souza, R., Kendall, C.W., Emam, A. and Jenkins, D.J. (2006). Colonic health: fermentation and short chain fatty acids. *Journal of Clinical Gastroenterology*. **40(3):** 235-243.