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The Effect of Seasonal Variations and Diet on the Growth and Production Performance of Angora Rabbits Under Captivity

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ABSTRACT

An attempt has been made to evaluate the effect of different diets and seasonal variations on Angora rabbits (Oryctolagus cuniculus) in the subtropical climate of Mardan, Pakistan. A total of 10 pairs of adult Angora rabbits were reared for one year (2022-2023). Daily meteorological data, including minimum and maximum temperatures, relative humidity, and rainfall, were recorded during the winter (October-March), summer (April-June), and rainy seasons (July-September). The body weight of angora rabbits decreases in the summer season. While a gear change was observed in the winter months. Wool yield varied significantly ($p<0.05$) between summer and winter. Wool quality attributes showed that winter was the best season. The reproduction performance also shows significant differences indicating winter as the best season for breeding. The survival rate also increases in winter while summer shows low conception and survival rate. Both diets resulted in increased body weight gain, wool yield, and wool characteristics in adult rabbits. The findings revealed that the subtropical weather of Mardan is not suitable due to its major impact on quality. Rice bran is thought to improve digestive efficiency and growth in Angora rabbits, whereas groundnut cake can be replaced with rice bran up to 5% in adult Angora rabbits. Subtropical regions are unsuitable for angora rabbit rearing. A cost-effective diet replacing 5% rice bran with groundnut improves productivity without adverse effects. Ongoing research and operational studies are essential to enhance productivity and sustainability in angora farming, particularly in Mardan, fostering advancements in economic viability and agricultural development.

INTRODUCTION

Oryctolagus cuniculus commonly known as Angora rabbit is a breed of rabbits that was introduced in Pakistan from Germany (Motamedi *et al*., 2014). This species has gained popularity for its commercial fiber production. The wool obtained from Angora rabbits has become the primary component in the high-end fabric business (Ning *et al*., 2022). This wool is silky and luxuriant and offers an insulation potential of up to five times quicker than ordinary cotton (Hunter, 2020). The wool is used in manufacture of many comfortable apparels such as warm shawls, thermal pants and hats (Motamedi *et al*., 2014).

Climate, nutrition, and management all have a significant influence on the amount of wool produced by Angora rabbits, when raised using conventional techniques. Even in controlled circumstances, rabbit reproduction is strongly influenced by seasonal variation. The growth performance of Angora rabbits, together with the quantity and quality of their wool, can be adversely affected by even a small fluctuation in temperatures. For instance, in hot climates, fertility is impacted by heat stress, hence reducing the litter size to only 4 – 5 per year. The ideal temperature ranges for Angora rabbit care range from 15 to 25°C (Bhatt *et al*., 2009). Likewise, the length of gestation, the time between kindling's, and the weight of the litter as well as the production of wool also varies with season (Rochambeau *et al*., 2010). In rabbits, winter is associated with greater birth weight, litter numbers, and adult body weight (Rahim, *et al*., 2022). In temperate and tropical regions, summer season is not ideal for rabbit breeding (Garcia *et al*., 2000; Ponce *et al*., 2000). The sustainability and viability of angora wool production systems face significant risks due to climate change in several parts of the world (Gaughan *et al*., 2010).

The quality and quantity of feed is one of the primary limiting factors in the production success of rabbits. High nutrient absorption efficiency during the fattening phase of rabbit feeding results in a high accumulation of muscle mass. Due to the peculiarities of their digestive physiology, rabbits may consume large volumes of fibrous feedstuffs, which may lead to the introduction of certain by-products from the agro-industrial sector (Guermah *et al*., 2016). The substitution of conventional protein with cost efficient protein sources like maize and soybean meal can not only lower the feed costs but can also have positive impacts by increasing the productivity (Bhatt *et al*., 2005). In addition, the nutritional protein demand of angora rabbit is high as compared to the other breeds reared for meat production. For the high-quality wool production, the rabbit needs high protein demand in their diet, however the expensive protein sources can be substituted for the larval protein to lower feed costs.

The cost of fish meal, soya meal and groundnut cake as a source of protein in the animal feed is higher. Feeding expenses may be reduced by switching from protein sources like groundnut cake to less expensive sources such as rice bran. The by-products of milling grains are said to create nutritious rabbit fodder. Among these, rice bran is a staple of rabbit diet and is easily obtainable in tropical climates (Bhatt *et al*., 2009).

The current study was conducted to examine the influence of season and nutrition on the growth, development, wool quality and productive performance of Angora rabbit at District Mardan, Khyber Pakhtunkhwa (KPK), Pakistan. Our findings highlight the importance of the diet plan used throughout the study and its potential to improve local rabbit farming practices.

MATERIALS AND METHODS

Study area

The experiment used ten pairs of mature adult Angora rabbits to examine the effects of temperature, seasonal variations, and nutritional changes on rabbit development and production in terms of wool quality, quantity and reproduction rate over a period of one year from October 2022 to September 2023. The study trials were carried out in the animal house at Sar Anjaam Khan Wildlife Park at Abdul Wali Khan University Mardan.

Assessment of seasonal growth

The 12 months' study period was divided into three seasons such that October-March was designated as winters, April to June was Summer, and July to September as Rainy season. The weekly average values of Temperature (ºC), humidity (%), and rainfall (mm) were measured to analyze the impact of change in weather patterns throughout the three designated seasons.

The weight of rabbits at the beginning and end of each month was taken using a digital balance (SF 400). The growth rate was calculated as percentage body weight gain over the three seasons using the following formula.

$$\% W_G = W_F - W_I \times 100$$

Where

W_G = Weight gain

W_F = Final weight

W_I = initial weight

Assessment of Quality and Quantity of Wool

To analyze the wool quality and quantity, the rabbits were trimmed using a trimmer to remove their hair at the end of each season. After collecting, the wool was properly cleaned with regular tap water to eliminate any dirt or grime. The acquired sample was first weighed using a digital balance (SF 400) to determine the weight of wool produced by rabbits at the end of each season. Afterwards the wool was transferred to Umar Wool Mill Industry Peshawar, for a thorough study of the wool quality. The wool quality was evaluated based on a variety of parameters, including staple length, (the length of each individual fiber) fiber diameter (thickness of the fibers) and medullation percentage (the percentage of the medulla or central core within the fibers).

Pregnancy Assessment

Likewise, the influence of seasonal variation was investigated on the reproductive efficiency of Angora rabbits in terms of gestation rate, litter response, and offspring survival.

Dietary Experiment

For dietary experiments, the rabbits were divided into two groups and maintained separately in normal wire mesh cages (5′ ×3′ ×2′) in a stable setting. Each group of rabbits were fed with one of the two types of professionally developed diets (Table 1), at the rate of 150g per day. In addition, mixed grazed grasses, grass hay and mulberry leaves (Azadirachta leaves) were offered as a supplementary dietary item, as they form an essential component of their diet.

Table 1

A detailed breakdown of the diet administered during dietary trials for Angora rabbits.

Diet	D1(%)	D2(%)
Maize	20	20
Rice Bran	15	20
Barley	20	20
Sunflower Cake	6	6
Groundnut Cake	20	15
Soya Flakes	6	6
Fish Meal	4	4
Molasses	5	5
Mineral Mixture	1	1
Salt	1	1

Every fortnight, the total DMI (dry matter intake) was recorded. The fiber components in feed and feces were analyzed using the method provided by Goering and Van Soest (1984). The digestible energy (DE) was calculated using Fekete and Gipperts, (1986) equation, which considered the ash and crude fiber contents.

A 5-days study was carried out on four adult rabbits from each group, to evaluate their digestibility coefficient by monitoring their intake of concentrate and roughage, as well as their feces.
Digestibility Formula = Intake – Excreted/Intake×100

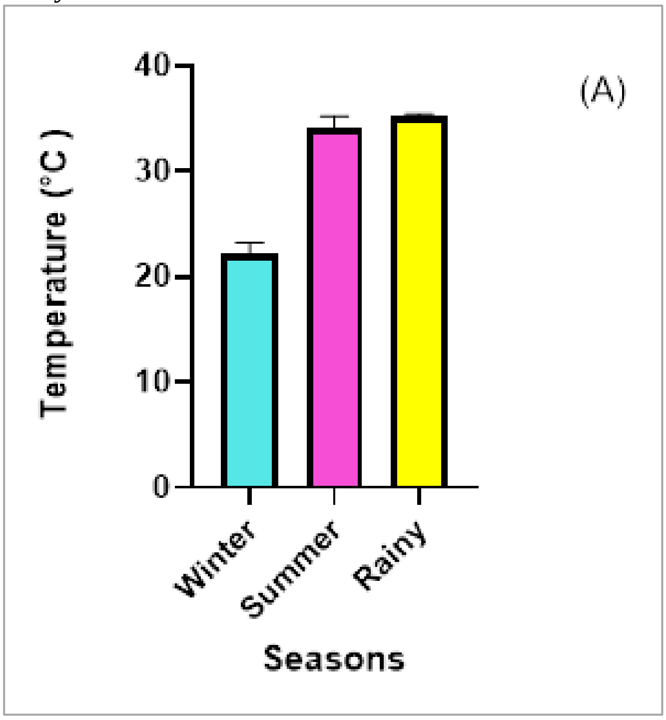
Statistical Analysis
The data was statistically analyzed using one-way ANOVA approach standard error (Snedecor and Cohran, 1994).

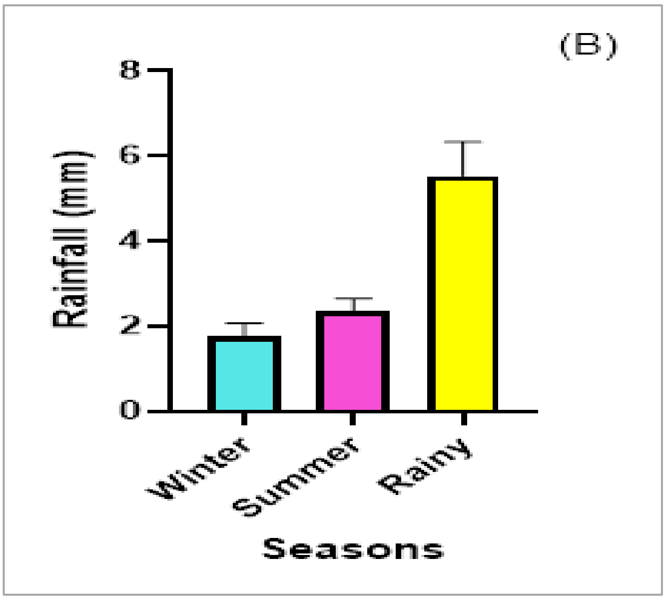
RESULTS

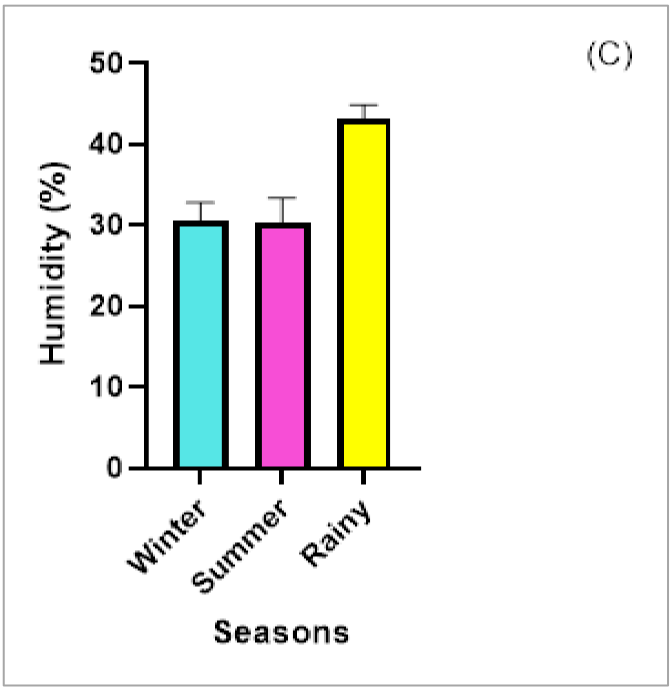
Seasonal evaluation

During the experiment, monthly average temperatures varied from 15.00 to 32.90°C in the winter, 27.80 to 39.80°C in the summer, and 33.50 to 37.90°C in the rainy season (Figure 1). Temperatures averaged 22.23 ±1.0 in winter, 34.04 ±1.2 in summer, and 35.15 ±0.3 in the rainy season. The average relative humidity for the winter, summer, and rainy seasons was 36.61±2.2%, 30.25±3.1%, and 43.211.7%, respectively. The average rainfall for winter, summer, and rainy seasons was 1.77±0.3mm, 2.36±0.3mm, and 5.53±0.8mm, respectively (Figure1).

Figure 1
The Figure (A) illustrates the temperature variations across three seasons: Winter, Summer, and Rainy. (B) illustrates the rainfall variations across three seasons: Winter, Summer and Rainy. (C) illustrates humidity variations across three seasons: Winter, Summer and Rainy.





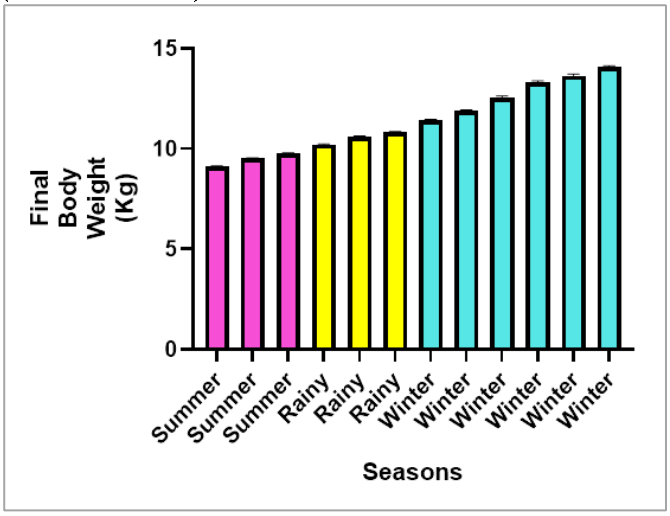


Biological Functionality
The graphs (Figure 2) present the body weights of Angora rabbits in various seasons and months. With mean values ranging from 2.29±0.02 kg to 2.15±0.03 kg, the data shows a progressive decline in body weight from the summer months of April, May, and June. During the rainy season, body weight somewhat increases in July 2.20±0.03 kg, August 2.24±0.03 kg and September 2.27±0.03 kg. October 2.33±0.03 kg to March 3.07±0.01 kg, the winter months, show a steady increase in body weight. The final body weight data for Angora rabbits shows distinct growth patterns throughout the seasons. The mean body weight gradually decreases in the summer months of April, May, and June, indicating possibly unfavorable conditions for growth. On the other hand, the mean body weight increases slightly from July to September in the Rainy season. The biggest growth happens in the Winter months, from October

through March, indicating consistent and substantial increases in the mean body weight. January, February, and March in particular stand out with the highest mean weights, indicating Winter as the best season for Angora rabbit growth based on the data provided.

Figure 2

Represents the final body weight (in kilograms) of subjects across three different seasons: Summer (April, May, June), Rainy (July, August, September) and Winter (October-March).

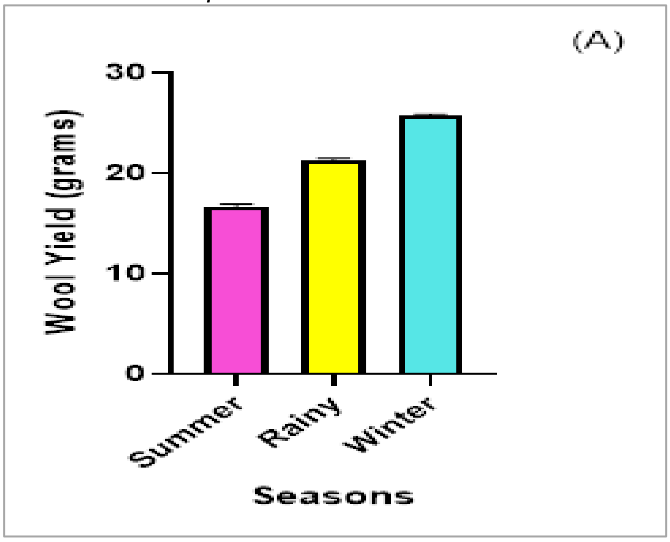


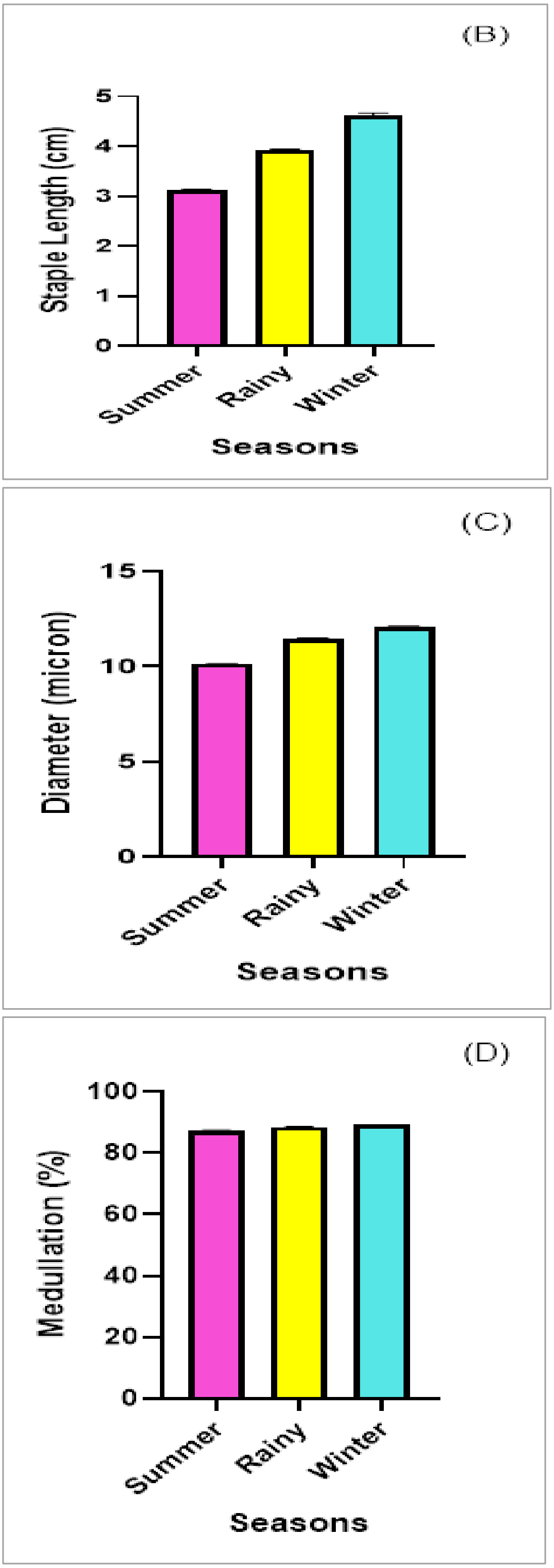
Wool Yield

The average yield of sheared wool (Figure 3) throughout the summer is 16.70±0.17grams. The average wool yield increases to 21.29±0.19 grams as the rainy season starts. The rise in mean values shows that in comparison to rainy season the summertime shows drops in wool yield. While the winter season stands out the most during three seasons with average wool yield of 25.77±0.0 grams.

Figure 3

The figure (A) illustrates wool yield across three seasons: Winter, Summer and Rainy. (B) illustrates the staple length of wool across three seasons. (C) illustrates the diameter of wool across three seasons. (D) illustrates the medullation of wool across three seasons.





Staple Length

In summer season the mean average length of angora hair was 3.13 ±0.01cm as the season changes to rainy the value changes to 3.93±0.01cm showing a little increase in length as shown in Figure 3. As winter approaches an acceleration in mean values occurs. In winter mean staple length reaches up to 4.62±0.05cm showing that winter produces great quality wool.

Diameter

During summer the average diameter of wool is 10.15±0.01µ. In rainy season the diameter increases up to 11.48±0.04µ while it increases furthermore in winter and sticks out the most 12.12±0.01µ (Figure 3).

Medullation

In summer season the medullation reaches to 87.3±0.03% while in rainy season it shows slight increase up to 88.55±0.05% indicating rainy being good in comparison to summer season. While as for other attributes the winter stands out the most with 89.30±0.03% of medullation (Figure 3).

Pregnancy and Survival Rate of Newborns

Positive pregnancy incidences and subsequent litters are noticeably absent throughout the summer months (April to June). Newborn survival rates at these times are routinely reported as zero, indicating unfavorable circumstances for both successful reproduction and the survival of progeny. This pattern is consistent with many animals' normal reproductive cycles, which show that breeding activity often decreases in the warmer months because of physiological reactions or environmental influences.

From July to September, which is the rainy season, there is a noticeable change in the dynamics of Angora rabbit reproduction and young survival. There were no pregnancies in July so obviously there was no litter produced and no neonatal survival occurs. As august approaches positive pregnancies were recorded. As a result, there were six litters born, with a modest two neonatal survivals were recorded. As September comes the positive pregnancies were noted, producing 6 litter with survival rate of zero showing the environmental effect on reproduction of Angora rabbits. As winter sets in an increase in positive pregnancies has been recorded. A total of 169 bunnies were produced with newborn survival of 159 showing good survival rate at that period of year indicating winter as the nest season for rabbits' reproduction.

Dietary Experiment

The rabbits' diet consists of a variety of items, which are shown in Table 1. These include fish meal, molasses, rice bran, sunflower cake, mustard cake, groundnut cake, soy flakes, fish meal and salt. The percentage of each dietary component that is present in the rabbits' feed is shown by the values in Table 1.

Chemical Composition of Feed

Table 2 provides an in-depth analysis of the chemical makeup of several feed components that were fed to angora rabbits as part of dietary research, such as roughage, rice bran, and groundnut cake. The table shows that D1 had a lower amount of crude fiber i.e. 8.8% and a higher percentage of ether extract (3.6%) and crude protein (16.4%) in comparison to D2. As D1 had lower amounts of rice bran than D2 the calcium level (1.8%) and total ash (8.7%) was low in comparison to D2. Because rice bran has greater quantities of fiber than other materials, the fiber fractions (NDF, ADF, lignin, cellulose, and hemicellulose) rose somewhat in D2 when rice bran was substituted.

Table 2

The detailed chemical composition of the various dietary ingredients utilized in the trials.

Chemical Composition	D1 (%)	D2 (%)	Groundnut cake (%)	Rice Bran (%)	Roughage (%)
Dry Matter	92	89.9	92.4	90.9	34
Organic Matter	92.3	91	93.9	89.9	90.1
Crude Protein	16.4	15.6	42.8	12.5	13.1
Crude Fiber	8.8	8.9	8.8	19	21.5
Ether Extract	3.6	2.9	6.3	4.6	3.1
Total Ash	8.7	9.4	6.4	11	10.6
Nitrogen Free Extract	64.4	64.6	37.1	54.9	54.6
Calcium	1.8	1.9	0.24	1.6	3.2
Phosphorous	1.3	1.3	0.72	2.5	2.6
Neutral Detergent Fiber	40.9	41.7	20.01	42	48.8
Acid Detergent Fiber	18.8	19.1	11.7	22.2	28.9
Hemicellulose	22.3	22.6	8.3	19.9	20.1
Lignin	3.1	2.8	2.03	8.7	4.5
Cellulose	15.9	16.1	6.8	13.9	24.7
Acid Insoluble Ash	2.5	2.6	2.4	2.3	2.2
Digestible energy (MJ DE/kg DM)	10.9	10.3			
Digestible protein to DE (g/MJ)	9.8	9.1			

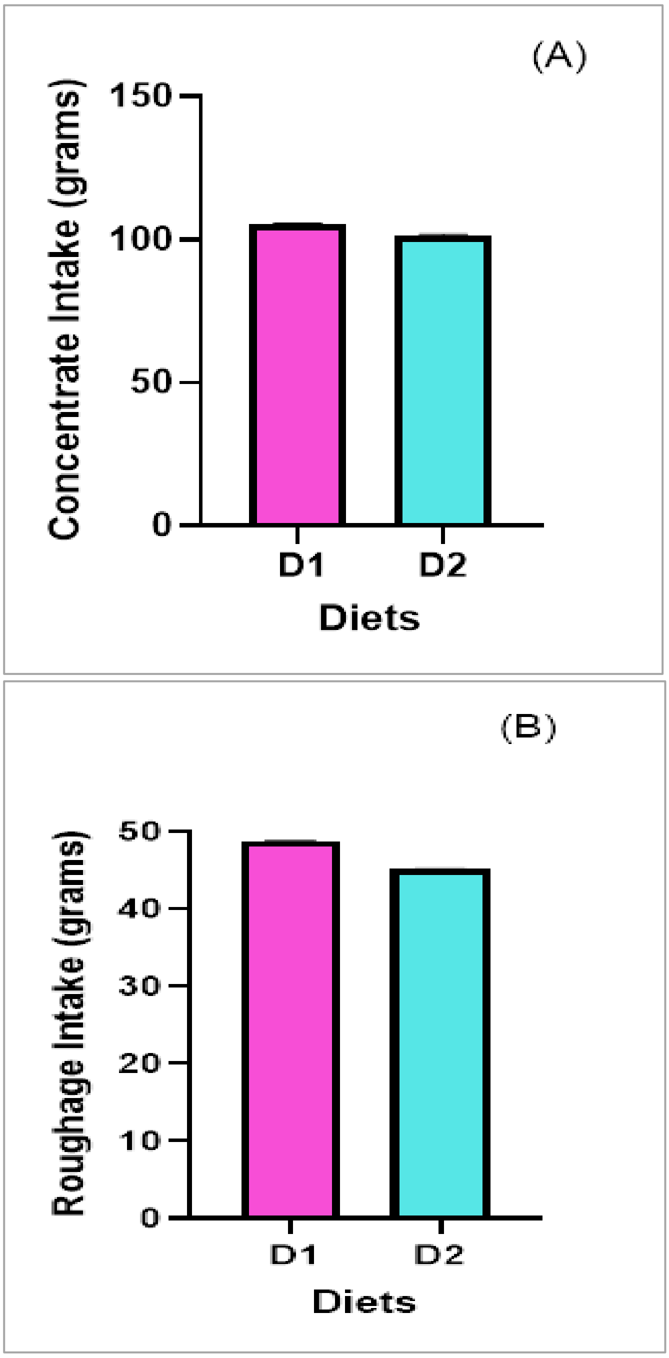
Because rice bran has a lower energy value than groundnut cake, replacing groundnut cake with it resulted in a drop in the diet's DE from 10.9 MJ/kg DM to 10.3 concentrate. As the amount of rice bran increased, the digestible protein (DP) to Digestible energy (DE) ratio for concentrate dropped from 9.8 to 9.1 g DP/MJ DE. The little difference has no appreciable impact on the general health of angora rabbits. After examination, it becomes clear that D1, which is groundnut cake, and D2, which is rice bran, show similar results on several measures. Similar patterns in concentrate and roughage consumption, and wool properties such as staple length and diameter are shown in both groups. Although D1 often has somewhat higher parameter values, overall similarity indicates that rice bran might replace groundnut cake and produce results that are equivalent in terms of animal performance and wool quality.

Effect on Food Intake

Diet 1 (5%) more groundnut cake shows more concentrate (105.6±0.1) and roughage (48.7±0.7) in take while diet 2 (5%) more rice bran, shows a slight decrease in concentrate (101.6±0.2) and roughage (45.1±01) intake. The data shown in Figure 4 indicates that both groups show more or less similar food intake patterns.

Figure 4

The figure (A) represents the concentrate intake of angora rabbits under both diets: Diet 1 and 2. (B) represents the roughage intake of angora rabbits under both diets: Diet 1 and 2. Diet 1 consist of groundnut cake than diet 2 while 5% less rice bran than diet 2.

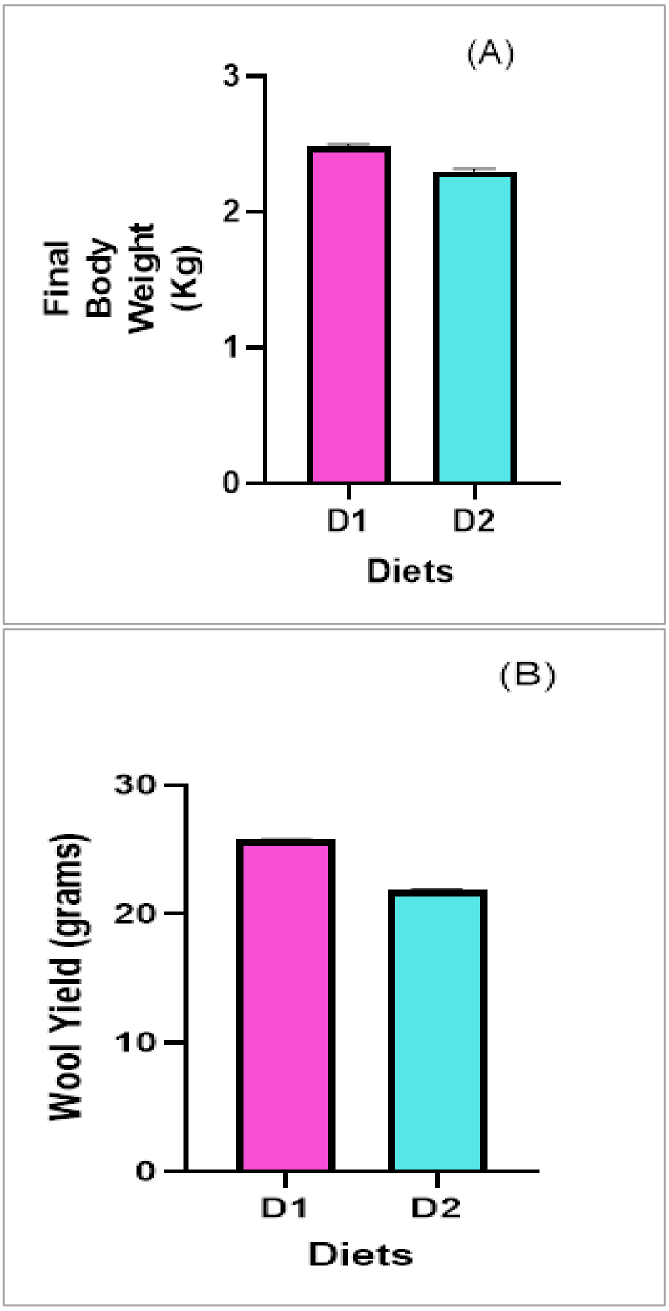


Effect on Body Weight

The resultant body weights of Angora rabbits in D1 demonstrated increase (2.48±0.02) as per shown in the Figure 5, in which the diet constituted 5% more groundnut cake and 5% less rice barn as compared to rabbits in D2, where the rabbits presented similar proclivity in increase in body weight (2.30±0.02), but with a rather slower rate than D1. In D2, the diet comprised of 5% more rice barn and 5% less groundnut cake. Indicating growth on both D1 and D2.

Figure 5

The figure (A) shows the final body weight of angora rabbits under the influence of both diets: Diet 1 and Diet 2. (B) shows the wool yield of angora rabbits under the influence of both diets. Diet 1 and 2. Diet 1 consists of 5% more groundnut cake than diet 2 while 5% less rice bran than diet 2.



Effect on Wool Shearing

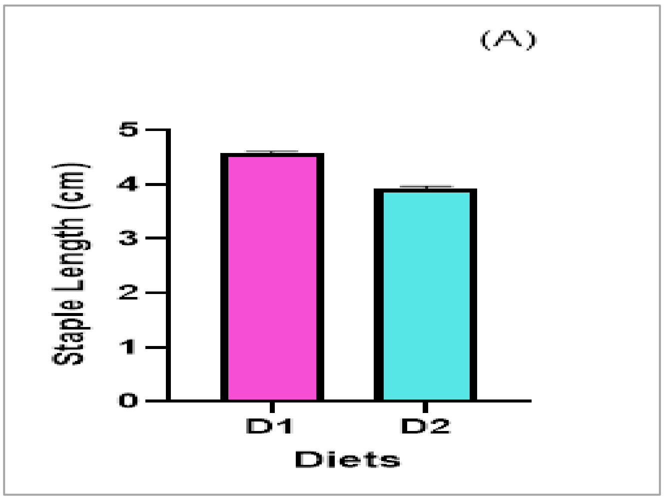
The average wool output of Angora rabbits was marginally greater in D1(25.7±0.07) (the diet comprises 5% more groundnut cake and 5% less rice bran) than in D2 (21.80±0.1). Furthermore, D1's standard deviation is marginally larger than D2's, indicating a somewhat higher degree of variability in the wool output of D1's rabbits (Figure 5).

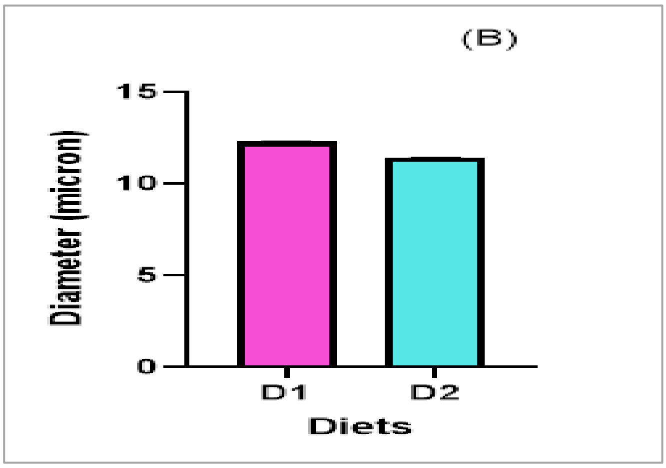
Staple Length, Diameter and Medullation

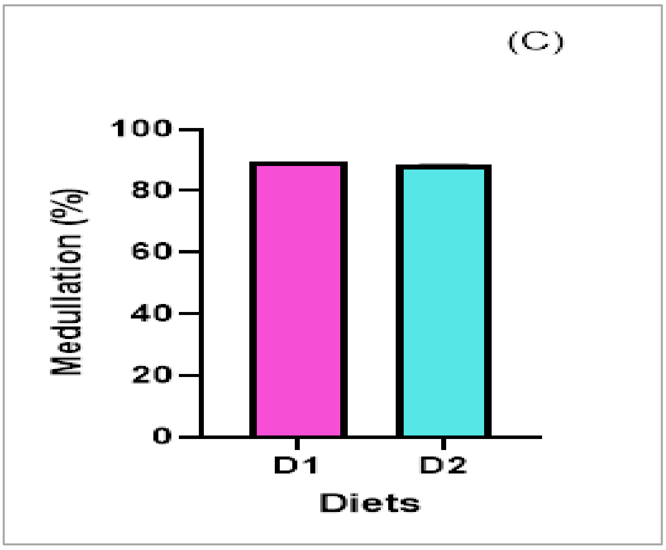
Figure 6 presents a comparison of some Angora wool properties between the two circumstances, D1 and D2. The staple length in D1 is 4.57±0.04, which is somewhat longer than the 3.93±0.04 seen in D2. Moreover, D1 displays a diameter of 12.27±0.04, which is somewhat thicker than D2's 11.42±0.03. On the other hand, D1 has a greater medullation level (89.34±0.03) than D2 (88.51±0.04). These modest variations imply that D1 would provide wool with a slightly longer staple length and more medullation, whereas D2 might yield wool with a somewhat finer diameter.

Figure 6

The figure (A) represents staple length of angora rabbit's wool on both diets: Diet 1 and 2. (B) represents diameter of angora rabbit's wool on both diets. (C) represents medullation of angora rabbit's wool on both diets. Diet 1 consists of 5% more groundnut cake than diet 2 while 5% less rice bran than diet 2.





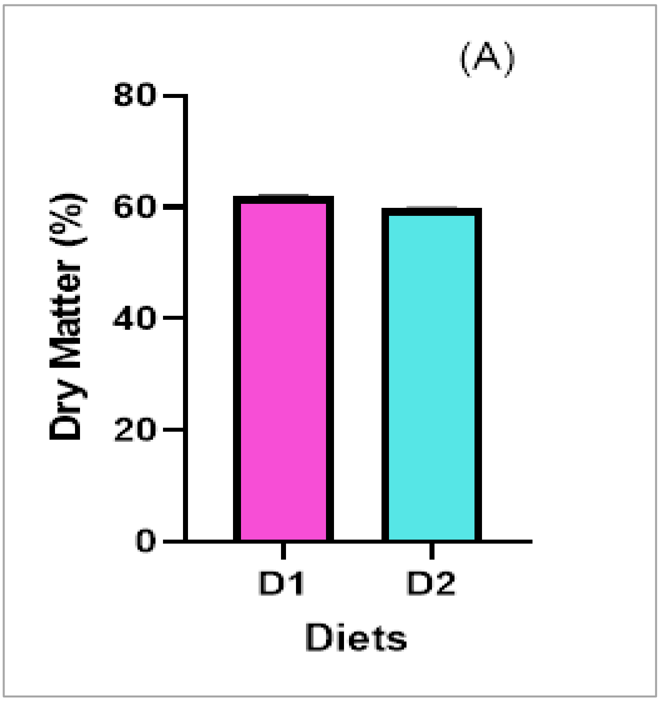


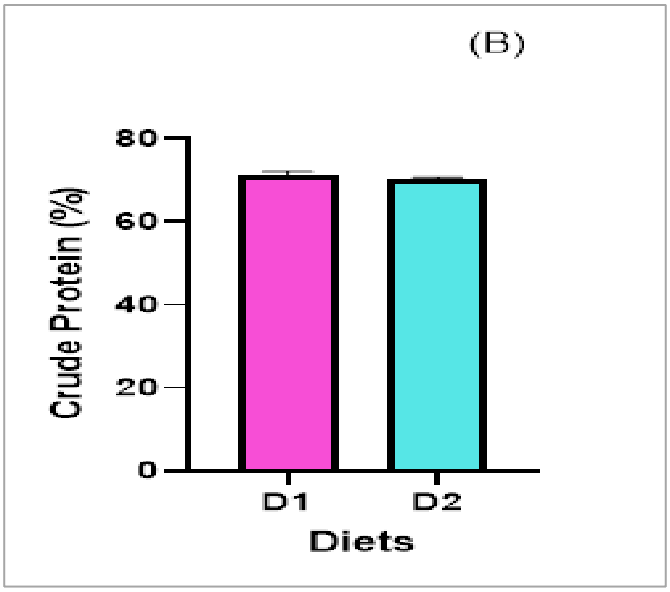
Digestibility Coefficients of Experimental Diet

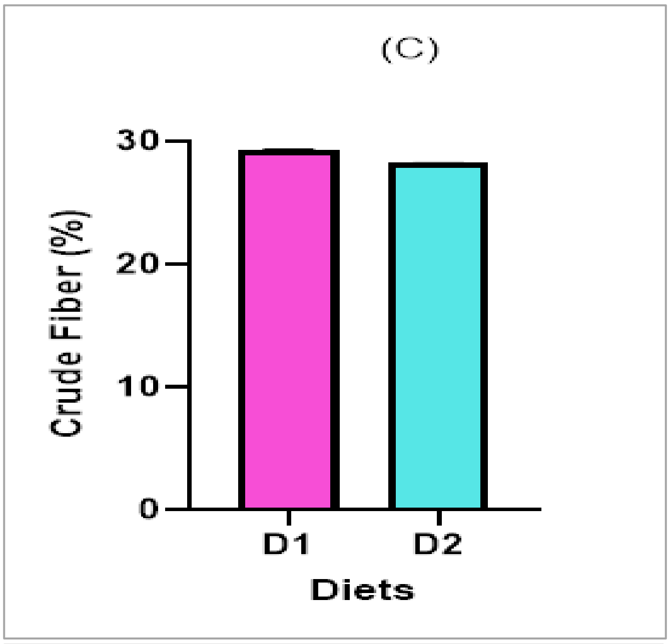
The findings (Figure 7) exhibit that there is no evident change in the digestibility coefficients between the two groups, illustrating that Angora rabbits' digestion is not unfavorably affected by swapping bran rice with groundnut cake. Simply, the results show that no matter if the rabbits were fed rice or groundnut cake, both groups were able to digest their food as effectively. After the analysis of these nutritional components, it became clearer that the mean values of the diets used are somehow identical.

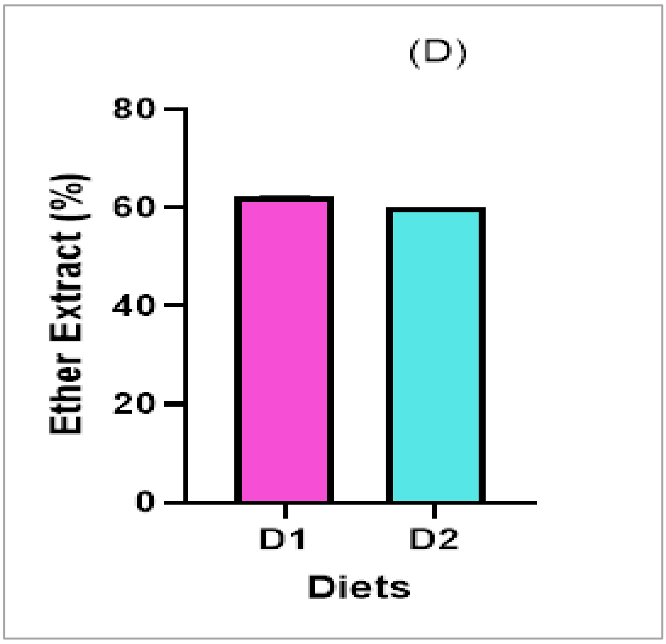
Figure 7

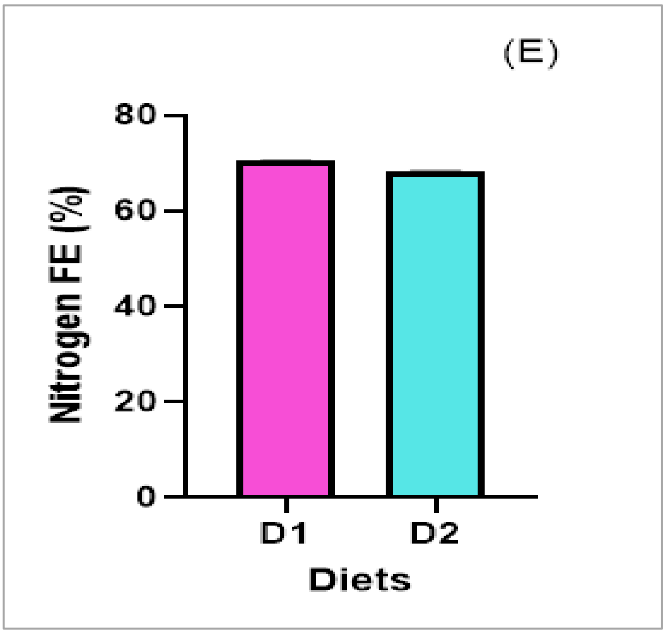
Shows the digestibility coefficient under the influence of both diets. (A) shows dry matter percentage. (B) shows crude protein percentage. (C) shows crude fiber percentage. (D) shows ether extract percentage. (E) shows percentage of nitrogen free extract percentage. Diet 1 consists of 5% more groundnut cake than diet 2 while 5% less rice bran than diet 2.











In terms of dry matter, diet 2 has a mean value of 59.70±0.2, while on the contrary, diet 1 has a mean value of 61.88±0.3. In a similar vein, diet 1 records 71.32±0.08 for crude protein, whilst diet 2 measures 70.27±0.05. All other components, including ether extract, nitrogen-free extract, and crude fiber, follow this same pattern. The graph shows that D1 ether extract digestibility coefficients was 62.33±0.1 while D2 shows 60.16±0.02. In terms of Nitrogen free extract, diet 2 has a mean value of 68.26±0.07, while on the contrary, diet 1 has a mean value of 70.37±0.1. The crude firer also shows similar results while D1 has a mean value of 29.30±0.1 while D2 has a mean value of 28.26±0.03. Comparable results could be obtained by replacing ground nut cake with rice bran, as indicated by the similarity in mean values between the two diets for these essential components. Because it allows greater flexibility in component selection without sacrificing nutritional benefits, this discovery is especially important for dietary planning or formulation.

DISCUSSION

The body weight of angora rabbits during different seasons shows significant differences. The body weight declines in the summer, climbs somewhat during the rainy season, and grows dramatically in the winter, indicating that winter is the best time of year for angora growth. Summertime (April, May, June) rabbits' final body weights vary from 2.15±0.03 to 2.29±0.02, demonstrating rather stable weights. From October to March, or Winter, there is a notable increase in final body weights, which vary from 2.33±0.3 to 3.07±0.01. All angora body weights showed a substantial seasonal fluctuation. When rabbits reached reproductive age, they gained weight, which was significantly higher in winter compared to summer and wet seasons. It's possible that they consume less in the summer to keep their bodies warm, resulting in weight loss to live. According to study by (Khan *et al*., 2020), winter is the ideal season since it has a significant impact on body weight. In a comparable investigation, Stephen (1980) showed less gain at higher (30°C) ambient temperatures compared to lower (5°C) temperatures. In contrast, R. S. Bhatt and S. R. Sharma's (2009) observations show that body weight increases during the rainy season rather than in the winter. This might be due to the older research having different temperatures than the subsequent ones, which could be attributed to localized climate changes. Prassana *et al*. (2006) also discovered that environmental stress causes rabbits to lower their meal consumption at high temperatures (35 °C).

Shearing rabbit wool production exhibited substantial seasonal fluctuations. Winter produced significantly more wool than the rainy, summer, and fall seasons combined. The average wool output was highest in winter (25.77±0.9) and lowest in summer (16.70±0.17). Wool output increased significantly in winter and spring compared to summer and autumn (Bai *et al*., 2016). According to R. S. Bhatt and S. R. Sharma's (2009) study, wool yield increased throughout the winter. In another study, (Bhatt *et al*., 2005) found low wool yield while shearing during the warmer season. In terms of wool quality, the staple length was 4.62±0.5 longer in winter and 3.13±0.1 shorter in summer. The average staple length during the wet season was 3.93±0.1. Wool characteristics vary significantly. Doppler *et al*. (1984) discovered that Angora rabbits generated less wool at higher ambient temperatures. This was attributed to the fact that colder locations had longer fibers and higher fiber density than warmer ones. Rochambeau and Thebault (1990) found that winter cutting produces longer bristles and dawn than summer trimming. Allain and Thebault (1988) found seasonal differences, noting thick, extended coats in the autumn and winter, and thin, flat coats in the summer. Another study by (Hermann *et al*., 1996) also found that environmental conditions influence angora fiber yield and quality.

In the present study the Angora rabbit breeding and neonatal survival rates vary depending on the season. In April and May, no positive pregnancy cases occur, resulting in three litters and one neonatal survival. From July to September, the wet season brings a shift in dynamics, with six litter and a modest two percent survival rate. However, neonatal survival rates drop to zero in September, indicating a challenge in preserving offspring viability. Positive pregnancy rates are high from October to March, giving in a significant litter output. December and February are particularly successful, producing 30 and 52 litter, respectively. Infant survival rates are typically high, illustrating the adaptability and endurance of Angora rabbits over the winter. Another study by (Marai *et al*., 2001) also discovered that extreme heat stress in mature female rabbits had a deleterious influence on their growth and reproduction. Another study by the same author (Marai *et al*., 2002) found that heat stress in female rabbits lowers conception rate, embryonic development, litter size, litter weight, and milk production. It also raises the age of puberty and pre- and post-weaning mortality.

The chemical composition of the experimental meals in the current investigation found that D1 included less crude fiber (8.8%), but more ether extract (3.6%) and crude protein (16.4) than D2. This difference was induced by proportional increases and decreases in groundnut cake against rice bran. Calcium (1.8%) and total ash (8.7%) levels increased somewhat since D2 included more rice bran than D1. Rice bran has more fiber than other materials, hence the fiber fractions (NDF, ADF, lignin, cellulose, and hemicellulose) in D2 increases somewhat when rice bran was replaced. Because rice bran contains less energy than groundnut cake, replacing it reduced the diet's DE from 10.9 MJ/kg DM to 10.3. As the percentage of rice bran increased, the digestible protein (DP) to DE ratio in concentrate reduced from 9.8 to 9.1 g DP/MJ DE. The little modification has no substantial impact on the overall health of angora rabbits.

Diet 2 has a mean dry matter value of 59.70±0.2%, compared to diet 1's mean value of 61.88±0.3%. Similarly, diet 1 has 71.32±0.08% crude protein, whereas diet 2 has 70.27±0.05%. All other components, such as ether extract, nitrogen-free extract, and crude fiber, follow the same pattern. The crude fiber yields comparable findings, with D1 having a mean value of 29.30±0.1% and D2 having a mean value of 28.26±0.03%. Diet 2 has a mean nitrogen-free extract value of 68.26±0.07%, whereas diet 1 has a mean value of 70.37±0.1.

Following inspection, it is obvious that D1, which is groundnut cake, and D2, which is rice bran, provide identical outcomes on a variety of metrics. Both groups exhibit similar trends in concentrate and roughage consumption, as well as wool qualities including staple length and diameter. Although D1 frequently has somewhat higher parameter values, overall similarity suggests that rice bran might substitute groundnut cake and achieve outcomes comparable in terms of animal performance and wool quality.

Diet 1 (5%) has greater concentrate (105.6±0.1) and roughage (48.7±0.7), whereas diet 2 (5%) contains less concentrate (101.6±0.2) and roughage (45.1±01). The statistics suggest that both groups had identical food intake patterns. Angora rabbits in D1 showed a 2.48±0.02 increase in body weight due to a diet containing 5% more groundnut cake and 5% less rice barn. In D2, rabbits showed a similar increase in body weight (2.30±0.02) but at a slower rate than in D1. D2's diet consisted of 5% more rice barn and 5% less groundnut cake. D1 and D2 both show an increase.

The average wool output of Angora rabbits was somewhat higher in D1 (25.7±0.07) compared to D2 (21.80±0.1) due to a 5% increase in groundnut cake and a decrease in rice bran. Furthermore, D1's standard deviation is somewhat bigger than D2's, indicating that D1's rabbits produce more variety in their wool output. The graphs in Fig.7 compare various Angora wool qualities between two instances, D1 and D2. The staple length in D1 is 4.57±0.04, somewhat longer than the 3.93±0.04 found in D2. D1 has a diameter of 12.27±0.04, somewhat thicker than D2's 11.42±0.03. D1 has higher medullation levels (89.34±0.03) than D2 (88.51±0.04). These minor differences suggest that D1 would produce wool with a slightly longer staple length and greater medullation, whereas D2 may produce wool with a slightly finer diameter. According to the results, both diets produced wool with equal qualities.

The digestibility coefficients for D1 ether extract were 62.33±0.1%, whereas D2 showed 60.16±0.02%. The closeness in mean values between the two diets for these key components suggests that substituting rice bran for ground nut cake might yield comparable benefits. This discovery is particularly relevant for dietary planning or formulation since it provides for greater flexibility in component selection while maintaining nutritional advantages.

Following investigation, D1, which is groundnut cake, and D2, which is rice bran, produce identical results across a range of metrics. Both groups show comparable patterns in concentration and roughage intake, as well as wool characteristics including staple length and diameter. Although D1 typically has somewhat higher parameter values, the overall comparability shows that rice bran might replace groundnut cake and produce equivalent results in terms of animal growth performance and wool quality. This research emphasizes how dietary flexibility might enhance rabbit nutrition while maintaining desired outcomes. A prior study (Bhatt *et al* 2005) discovered that substituting protein sources with energy sources by 5-10% had no negative effects on the health of adult angora rabbits. Furthermore, rice bran can be used instead of ground nut cake to reduce the cost of rabbit cultivation.

CONCLUSIONS

On the grounds of the research findings, subtropical regions are considered not suitable for angora rabbits rearing. Moreover, applying an improved diet plan that includes ground nut instead of rice brain can be a very economical technique which can be 5% substitution without influencing the productivity of adult angora rabbits during the growth. Moving ahead, continuous activities and Operation Research are needed to discover new chances for advancement in productiveness and sustainability within the angora farming sector in the Mardan region.

Abbreviations

DM (Dry matter), CP (Crude Protein), CF (Crude Fiber), EE (Ether Extract), NFE (Nitrogen Free Extract), NDF (Neutral Detergent Fiber), ADF (Acid Detergent Fiber), DE (Digestible Energy), DP (Digestible Protein).

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REFRENCES

1. Allain, D. D. (1988, October). Effects of various melatonin treatments on summer wool production in Angora rabbits. In *4. Congres International Cunicole*. WRSA. https://hal.science/hal-02782139/
2. Bhatt, R. S., & Sharma, S. R. (2009). Seasonal production performance of angora rabbits under sub-temperate himalayan conditions. *Asian-Australasian Journal of Animal Sciences*, *22*(3), 416-420. https://doi.org/10.5713/ajas.2009.80326
3. Bhatt, R. S., & Sharma, S. R. (2009). Seasonal production performance of angora rabbits under sub-temperate himalayan conditions. *Asian-Australasian Journal of Animal Sciences*, *22*(3), 416-420. https://doi.org/10.5713/ajas.2009.80326
4. Bhatt R. S., Sharma S. R., Singh U., Kumar D., & Risam K. S. (2010). Effect of substituting groundnut cake for different levels of rice bran on growth and wool production of German angora rabbits. *World Rabbit Science*, *13*(3). https://doi.org/10.4995/wrs.2005.519
5. Fekete, S., & Gippert, T. (1986). Digestibility and nutritive value of nineteen important feedstuffs for rabbits. *Journal of Applied Rabbit Research 9*, 103-108. https://www.cabidigitallibrary.org/doi/full/10.5555/19871494195

6. García, M. L., Lavara, R., Viudes de Castro, M. P., & Vicente, J. S. (2000, July). Litter size components from two selected lines of rabbits. In *Proc.: 7th World Rabbit Congress, Valencia* (pp. 133-137). http://world-rabbit-science.com/WRSA-Proceedings/Congress-2000-Valencia/Papers/Reproduction/R08-Garcia.pdf

7. Gaughan, J. B., Mader, T. L., Holt, S. M., Sullivan, M. L., & Hahn, G. L. (2009). Assessing the heat tolerance of 17 beef cattle genotypes. *International Journal of Biometeorology*, *54*(6), 617-627. https://doi.org/10.1007/s00484-009-0233-4

8. Goering, H. K., & Van Soest, P. J. (1970). Forage fiber analysis. Agricultural handbook no. 379. *US Department of Agriculture, Washington, DC*, 1-20.

9. Guermah, H., Maertens, L., & Berchiche, M. (2016). Nutritive value of brewers' grain and maize silage for fattening rabbits. *World Rabbit Science*, *24*(3), 183. https://doi.org/10.4995/wrs.2016.4353

10. Herrmann, S., Wortmann, G., & Wortmann, F. J. (1996). Characteristics of Angora rabbit fibre 1-the influence of fibre origin on fibre and medulla diameter in angora wool. *World Rabbit Science*, *4*(3), 149-153. https://doi.org/10.4995/wrs.1996.287

11. Hunter, L. (2020). Mohair, cashmere and other animal hair fibres. In *Handbook of natural fibres* (pp. 279-383). Woodhead Publishing. https://doi.org/10.1016/B978-0-12-818398-4.00012-8

12. Khan, N. N., Rather, M. A., Hamadani, A., Ayaz, A., & Dar, E. A. (2020). Performance evaluation of body weight traits of exotic rabbit breeds in an organized farm of Kashmir.

13. Marai, I. F. M., Ayyat, M. S., & Abd El-Monem, U. M. (2001). Growth performance and reproductive traits at first parity of New Zealand White female rabbits as affected by heat stress and its alleviation under Egyptian conditions. *Tropical animal health and production*, *33*, 451-462. https://doi.org/10.1023/A:1012772311177

14. Marai, I., Habeeb, A., & Gad, A. (2002). Rabbits' productive, reproductive and physiological performance traits as affected by heat stress: A review. *Livestock Production Science*, *78*(2), 71-90. https://doi.org/10.1016/s0301-6226(02)00091-x

15. Eslampanah, M., Paykari, H., Moharami, M., Motamedi, G., & Omraninava, A. (2014). A survey on the gastrointestinal parasites of rabbit and guinea pig in a laboratory animal house. *Archives of Razi Institute*, *69*(1), 77-81. https://doi.org/10.7508/ari.2014.01.011

16. Ning, C., Xie, K., Huang, J., Di, Y., Wang, Y., Yang, A., Hu, J., Zhang, Q., Wang, D., & Fan, X. (2022). Marker density and statistical model designs to increase accuracy of genomic selection for wool traits in angora rabbits. *Frontiers in Genetics*, *13*. https://doi.org/10.3389/fgene.2022.968712

17. PONCE, D. L. R., Guzmán, G., Quesada, M. A. E., Mora, M., & Feblas, M. (2000). Reproductive performance of four rabbit breeds with concentrate: forage diets in the subtropics. In *7th World Rabbit Congress, 2000 July, Valencia, Spain*. http://world-rabbit-science.com/WRSA-Proceedings/Congress-2000-Valencia/Papers/Genetics/G24-PoncedeLeon.pdf

18. Prasanna, S. B., Chhabra, A. K., Pankaj Kumar, P. K., & Ravindra Kumar, R. K. (2006). Rabbit production under enriched environment. https://www.cabidigitallibrary.org/doi/pdf/10.5555/20063221942

19. Rahim, A., Rajaravindra, K. S., Chaturvedi, O. H., Chaudhary, R., & Sharma, S. R. (2022). Genetic studies on growth and production traits in German Angora Rabbits under sub-temperate climatic conditions. *Indian Journal of Animal Sciences*, *92*(11), 1307-1313. https://epubs.icar.org.in/index.php/IJAnS/article/download/124611/48544/340441

20. De Rochambeau, H., Thébault, R. G., & Grun, J. (1991). Angora rabbit wool production: Non-genetic factors affecting quantity and quality of wool. *Animal Science*, *52*(2), 383-393. https://doi.org/10.1017/s0003356100012927

21. Rochambeau, H. D., & Thebault, R. G. (1990). Genetics of the rabbit for wool production. *Animal Breeding Abstract 58*, 1-15. https://www.cabidigitallibrary.org/doi/full/10.5555/19900182614

22. Snedecor, G. W. & Cochran. W. G. (1994). Statistical methods (6th Ed). Oxford and IBH publishing Co. Calcutta.

23. Stephan, E. (1980). The influence of environmental temperatures on meat rabbits of different breeds. In *Proceedings of 2nd World Rabbit Congress, Barcelona, Spain, 1980* (Vol. 2, pp. 399-409). https://cir.nii.ac.jp/crid/1572543025774868096