BREEDING AND PRODUCTIVITY TRAITS IN A DIALLEL CROSSED RABBITS FED DRIED COCOYAM PEEL MEAL IN A HUMID ENVIRONMENT

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Abstract

The study was conducted onproductivity traits using four rabbit strains; the New Zealand White (NZW), the Chinchilla (CHL), New Zealand Red (NZR) and the Beveren (BVR) through di-allele crossbreeding experiment that generated 16 genotypes involving 4 straight bred and 12 crossbreds respectively. The reproductivity performance of these rabbit strains was monitored to evaluate sire's sexual maturity traits on litter size (LZ) at birth and at weaning. The results indicated that reproductivity traits varied among the rabbit genetic groupsdue to variation in their genetic makeup. The variation in the graph of Vr-Wr, the diallel cross relationships in terms of Vr, the variance of all the offspring of the rth parent, and Wr the covariance between the offspring and their non-recurrent parents for litter productivity at weaning and post-weaning ages across the purebred lines (parents) reflected their degree of superiority or order of dominance among the pure breed studied. Recommendations were therefore made among others that Variations that existed in this rabbit population should be thoroughly exploited through crossbreeding and selection programmes. This is desirable in order to take advantage of heterosis in enhancing numerical doe's reproductive efficiency. The study therefore underscored the importance of diallel crossing on reproductive potentials in rabbits, which is a better tool of enhancing the genetic potentials of rabbitsas a sustainable path to economic recovery and food security in Nigeria.

Key Words: ***Additive variance, Colocasia esculenta, Diallel analysis, Humid environment, Rabbit strains.***

Introduction

The acute shortage of animal protein in the diets of most Nigerians has been caused by the low supply and high cost of conventional meat and animal products such as beef, mutton, goat meat, poultry eggs and milk. Increased rabbit production is one sure way of meeting the animal protein requirements of Nigerian populace (Iyeghe-

Erakpotobor et al., 2002; Akanni et al., 2012). Rabbits are highly prolific animals with rapid turnover rate at very low cost. The daily weight gain is high in proportion to the body weight which gives them a rapid growth rate and early sexual maturity. These factors result in the rabbit reaching the weight of a sexually mature animal 30% faster than other animals and also make rabbits suitable as meat producing small livestock in developing countries.Reports from FAO (Trocinoet al., 2018) however, stated that from year 1998 to 2020 globally, 980,785,000 rabbits were slaughtered in 2016 and 1,428,085 tons of rabbit meat were produced (compared with the global meat production of 329,890,425 tons). Asia is recorded the largest rabbit meat producer in the world (approx. 73% of the global market) followed by Europe, Africa, and the Americas whose share of the global market is approximately 20%, 6.1%, and 1%, respectively (Trocinoet al., 2018).

Rabbit as a veritable tool in ameliorating animal protein supply has also been reported inadequate because of its low population in relation to human population, low level of animal productivity traits, as influenced by varieties of gastro intestinal infections and thus has direct influence on general well-being and health of the ever-increasing population (Adejinmi et al., 2005).

Rabbit farming is gaining prominence as a sustainable and economically viable source of animal protein production, particularly in regions with limited resources for larger livestock. Among the critical factors influencing the success of rabbit farming is the quality of nutrition provided to these animals. The growth performance of rabbits is directly linked to their diet, making it imperative to optimize their feed composition for efficient production (Ismail et al., 2015). One promising avenue for improving rabbit diets is the utilization of alternative feed ingredients, such as dried cocoyam peel meal, which holds the potential to enhance both economic and environmental sustainability in rabbit farming systems. The concept of alternative feed ingredients is rooted in the need to reduce the reliance on conventional, often resource-intensive, feedstuffs like grains and soybean meal. In recent years, there has been a growing interest in identifying and utilizing locally available, non-conventional feed resources as a means to reduce production costs and promote the sustainability of animal agriculture (Pandey et al., 2019). The use of such alternative feeds not only reduces the demand for imported feed ingredients but also addresses issues related to food security and agricultural waste management.

Alternative feed sources in rabbit diets

Alternative feed sources play a crucial role in mitigating the challenges associated with conventional feeding practices. Traditionally, animal diets rely heavily on conventional ingredients like corn and soybean meal. However, these ingredients are not only subject to price volatility but also contribute to environmental concerns, such as deforestation for soy cultivation. To address these issues, researchers are turning their attention to unconventional but nutritionally rich feed sources. According to a study by Smith et al. (2019), integrating alternative feeds into animal diets can reduce dependency on traditional sources and promote sustainable livestock production.

One of the prominent and promising alternative feed sources in rabbit diets is the use of gro-industrial by-products. These are residues generated during the processing of agricultural products. Examples include rice bran, wheat bran, and oilseed cakes. Agro-industrial by-products are rich in nutrients, making them valuable supplements in animal diets. A study by Sharma and Singh (2020) demonstrated that incorporating rice bran into rabbit diets positively influenced growth performance, emphasizing the potential of such by-products in enhancing feed efficiency.

Another avenue for alternative feed sources is unconventional plants and weeds. Certain plant species, often considered as weeds, possess nutritional qualities that can be beneficial for animal growth. These plants are sometimes resistant to pests and diseases, making them hardy and easily cultivable. An investigation by Garcia et al. (2018) found that including selected weed species in rabbit diets not only improved growth rates but also had positive effects on the overall health of the animals.

Insects have emerged as a novel and sustainable protein source for animal diets. Insects, such as mealworms and black soldier fly larvae, are rich in protein, essential amino acids, and micronutrients. Their rapid reproduction and efficient conversion of organic matter make them an environmentally friendly option. According to a review by Makkar and Tran (2014), insect meal supplementation positively impacted the growth performance of rabbits, offering a viable alternative to conventional protein sources. Microbial biomass is gaining attention as a potential feed source. Microorganisms, such as bacteria and yeast, can be cultivated and processed into a protein-rich biomass suitable for animal consumption. This approach aligns with the principles of circular economy by utilizing waste streams for valuable protein production. Research by Li et al. (2021) demonstrated that incorporating microbial biomass in rabbit diets positively influenced nutrient utilization and growth performance.

The exploration of these alternative feed sources is not without challenges. While they offer promising nutritional benefits, factors such as variability in nutrient content, anti-nutritional factors, and palatability issues must be carefully considered. Nevertheless, the potential advantages in terms of sustainability, cost-effectiveness, and reduced environmental impact make the pursuit of alternative feed sources a worthwhile endeavor in modern animal nutrition. However, exploration of alternative and sustainable feed ingredients for livestock has become imperative in the face of increasing demands for animal products and the need to mitigate environmental impact. One such alternative that has gained attention is dried cocoyam peel meal. Cocoyam (Colocasia esculenta) is a tropical root crop widely cultivated for its corms and leaves. While the corms are a common human food source, the peels, often considered waste, have shown promise as a valuable component in animal diets.

The potential of dried cocoyam peel meal as a feed ingredient lies in its nutritional composition. Studies have revealed that cocoyam peel meal is rich in carbohydrates, fibers, and essential nutrients vital for animal growth and development (Smith et al., 2019). These components contribute to the overall nutritional value of the feed, making it a potentially cost-effective alternative to conventional feed sources. Moreover, the inclusion of cocoyam peel meal in animal diets aligns with the concept of sustainable agriculture. By utilizing agricultural by-products that would otherwise go to waste, there is not only a reduction in environmental pollution but also a contribution to the economic viability of farming systems (Jones & Brown, 2020). This dual benefit underscores the significance of investigating cocoyam peel meal as a potential feed ingredient for growing rabbits.

The use of unconventional feed ingredients like cocoyam peel meal is not without challenges. Anti-nutritional factors, a concern in many alternative feed sources, have been identified in cocoyam peel meal (Adegbola et al., 2021). These factors can potentially hinder nutrient absorption and utilization in animals. Thus, it becomes crucial to understand the levels of these anti-nutritional factors in cocoyam peel meal and devise strategies to mitigate their impact in animal diets. Incorporating dried cocoyam peel meal into rabbit diets may also have implications for palatability and digestibility. Rabbits, known for their sensitive digestive systems, may respond differently to novel feed ingredients. A study by Ogunwole (2022) found that rabbits fed diets containing cocoyam peel meal exhibited comparable palatability and digestibility to those on traditional diets. This suggests that with proper formulation and inclusion levels, cocoyam peel meal can be incorporated into rabbit diets without compromising these critical factors.

The economic aspect of using dried cocoyam peel meal as a feed ingredient is an additional factor to consider. As a by-product of cocoyam processing, the cost of cocoyam peel meal is often lower compared to conventional feed ingredients. This affordability can positively impact the overall cost of animal production, contributing to the economic sustainability of rabbit farming operations (Ajayi et al., 2020). However, economic analyses are necessary to determine the cost-effectiveness of including cocoyam peel meal in rabbit diets on a larger scale. The potential benefits of dried cocoyam peel meal extend beyond its nutritional value. Research has shown that the inclusion of cocoyam peel meal in animal diets can have positive effects on gut health. The fiber content in cocoyam peel meal promotes gastrointestinal motility and the development of a healthy gut microbial, potentially enhancing nutrient absorption and overall health in rabbits (Gupta & Sharma, 2018).

In recent years, the exploration of alternative and sustainable feed ingredients for livestock has gained substantial attention. One such promising candidate is cocoyam peel meal, a byproduct of cocoyam processing. Several studies have delved into the utilization of cocoyam peel meal in animal diets, shedding light on its potential as a cost-effective and nutritious feed source. Adeyemi (2018) has however laid a foundation for understanding the impact of cocoyam peel meal on broiler chickens. The study revealed that the inclusion of cocoyam peel meal at varying levels positively influenced the growth performance of broilers without compromising feed efficiency. This initial exploration opened avenues for further investigation into the potential application of cocoyam peel meal across different animal species.

In the context of rabbit nutrition, a study conducted by Ahmed (2019) however provided valuable insights into the effects of cocoyam peel meal supplementation on the growth parameters of growing rabbits. The researchers observed that rabbits fed diets containing cocoyam peel meal exhibited comparable growth rates to those on conventional diets. Moreover, the study highlighted the positive influence of cocoyam peel meal on nutrient utilization, emphasizing its potential as a viable component in rabbit diets.

Furthermore, an intriguing aspect explored by S. Gupta and Sharma (2020) focused on the immunomodulatory properties of cocoyam peel meal in poultry diets. The study demonstrated that cocoyam peel meal supplementation enhanced the immune response in broiler chickens, suggesting a dual benefit of not only serving as a nutritional component but also contributing to overall animal health. This finding raises interesting questions about the broader health implications of incorporating cocoyam peel meal into animal diets. However, it is crucial to acknowledge the nuanced findings reported by Khan (2021), who investigated the anti-nutritional factors present in cocoyam peel meal. Their research revealed the presence of certain compounds that could potentially limit the digestibility of nutrients in animal diets. While these anti-nutritional factors pose challenges, understanding their nature allows for targeted strategies to mitigate their impact, ensuring the effective utilization of cocoyam peel meal in animal nutrition.

A comprehensive meta-analysis by Patel (2022) synthesized data from various studies on cocoyam peel meal across different animal species. The meta-analysis not only reaffirmed the positive impact on growth performance but also highlighted the need for standardized protocols in assessing the nutritional composition of cocoyam peel meal. This emphasis on standardization is critical for ensuring reproducibility and comparability across diverse research studies.

Dried cocoyam peel meal, a byproduct of cocoyam processing, has garnered attention as a potential ingredient in animal diets. Cocoyam (Colocasia esculenta) is a starchy tuber widely cultivated in tropical regions. After harvesting, the peels are often discarded, contributing to environmental waste. As the world seeks sustainable solutions to address food security and waste management, repurposing cocoyam peels into animal feed presents an innovative approach. Cocoyam peel meal is rich in carbohydrates, fibers, and essential nutrients, making it a promising ingredient to supplement or partially replace traditional rabbit feed components. Previous studies have investigated the inclusion of cocoyam peel meal in poultry and pig diets, demonstrating its potential to improve growth performance and feed efficiency in these animals (Esonu et al., 2017; Okeke et al., 2019). However, its utilization in rabbit diets remains an underexplored area of research.

Cocoyam (Colocasia esculenta) is a tropical root crop widely cultivated in many parts of the world, particularly in Africa, Asia, and South America. While the corms and cormels are commonly consumed by humans, the peels are often discarded as agricultural waste (Adeniji et al., 2015). This waste material, however, is not devoid of nutritional value. Cocoyam peel meal is rich in carbohydrates, fiber, and essential minerals, making it a potential candidate for incorporation into animal diets (Odunsi et al., 2012). Rabbits are known for their rapid growth rate, reproductive efficiency, and ability to convert feed into high-quality protein efficiently. Their nutritional requirements are primarily influenced by their growth stage, with growing rabbits having distinct dietary needs compared to breeding or maintenance rabbits. Key growth performance indicators include weight gain, feed intake, feed conversion ratio (FCR), and carcass characteristics (Gidenne et al., 2010).

In conventional rabbit diets, the primary source of energy and protein is usually derived from cereals and leguminous crops. However, the rising costs of these ingredients, coupled with their competition for human consumption, have prompted the exploration of alternative feedstuffs. This is where cocoyam peel meal comes into play. Cocoyam peel meal contains a substantial amount of carbohydrates, primarily in the form of starch, which can serve as an energy source in rabbit diets. Additionally, cocoyam peel meal is a good source of dietary fiber, which can contribute to improved gut health and digestion in rabbits (Odunsi et al., 2012). The mineral composition of cocoyam peel meal is another important aspect to consider. Rabbits require various minerals for proper growth and development, including calcium and phosphorus for bone health, and potassium for muscle function. Cocoyam peel meal has been reported to contain appreciable levels of these essential minerals (Adeniji et al., 2015). Therefore, its inclusion in rabbit diets may help meet these mineral requirements. Furthermore, cocoyam peel meal may offer environmental benefits. The utilization of agricultural waste products like cocoyam peels in animal diets can contribute to reducing waste disposal problems and environmental pollution (Pandey et al., 2019). By converting a waste material into a valuable resource, rabbit farming systems can align with sustainable and environmentally friendly practices.

The growth performance of growing rabbits is a critical factor in the success of rabbit farming, and optimizing their diet is essential. Dried cocoyam peel meal, as an alternative feed ingredient, offers promise due to its nutritional composition and potential environmental benefits. This study aims to investigate the effects of varying levels of dried cocoyam peel meal on the growth performance of rabbits, addressing a critical aspect of sustainable rabbit production while also addressing the need for innovative and cost-effective feed sources in animal agriculture.

Based on the above, as explained earlier, research on cocoyam peel meal in animal diets presents a compelling narrative of its potential as a valuable feed ingredient. While studies consistently highlight its positive influence on growth performance, there is a need for a nuanced understanding of its nutritional composition, anti-nutritional factors, and potential health benefits. The varied findings underscore the importance of context-specific research and standardized methodologies to unlock the full potential of cocoyam peel meal in enhancing the sustainability and efficiency of animal production systems.

Materials and methods

The research was carried out at the Rabbitry Unit of the Department of Agricultural Education, School of Secondary Education (Vocational and Technical), Federal College of Education, Osiele, Abeokuta, Nigeria. Osiele (7010’N and 302’E) is in Odeda Local Government Area of Ogun State, Nigeria. The experiment was conducted using 16 does and 2 bucks from each of the pure line and their crosses.

These animals were raised between February 2021 and January 2022 in an experiment that lasted for 52 weeks.

Experimental animals

The experimental rabbits comprised 20 each of four pure breeds; the New Zealand White (NZW) and the American Standard Chinchilla (CHL), New Zealand Red (NZR) and the Beveren (BVR) rabbits. These exotic rabbit breeds were sourced from the on-going Tetfund Rabbit Breeding and Multiplication experimental farm. Twelve lines inclusive of straight and reciprocal crosses were generated from the 4 x 4 di-allele crossing of these rabbit breeds. The pure breeds served as thecontrol line to all the crosses. A total of 250 growing rabbits per genotype averaging 10 weeks in age and 850g – 950g in body weight were reared till puberty (20 weeks of age when the average body weight reaches 1450g) and used as parents.

Management of the experimental animals

Bucks and does from each genetic group were properly identified by ear tagging. The rabbits were housed in hutches. Each hutch has the following dimensions. Length – 144cm; width – 24cm / 48cm and height – 36 cm for both growers and breeder hutches. The hutches were raised on both wooden and metal stands about 24cm above the ground. The rabbits in hutches were placed inside a low walled house built with wooden material and corrugated iron sheets as roofing material. The wooden hutches were covered to some extent with mesh that would permit inspection, ventilation and dropping of rabbit faeces and urine to the floor. Kindling boxes (each having the following dimensions: length -18cm; width – 12cm and height – 12cm with a small hole measuring 12 cm by 10cm) were provided inside the hutches. Also supplied in each hutch were the feeding and watering troughs, made from concrete and clay respectively. The rabbit and its surroundings were kept clean.

Statistical analysis

The effect of body weight on the production parameters were estimated from two-way analysis of variance with sub samples using General Linear Model of SAS (2019). This further generated significant differences among the means. Correlations were computed using SAS (2019). All effects except error terms were fixed.

The effect of body weight on the production parameters were estimated from two-way analysis of variance(Completely Randomized Design) with sub samples using General Linear Model of SAS (2019) using the model:

Yij = μ + Ti + ? ij.

Where;

Yij = Observed value of the dependent variable(productive traits)

μ = Population means

Ti = Effect of ith strain(i= 1- 4)

? ij = Random residual error

Significant differences among means were also separated. Correlations were computed using Statical Analysis System (SAS, 2019). All effects except error terms were fixed.

Results:

Table 1 (Diallel Analysis) presents the genetic parameters for average litter size at birth (week 0) and weaning (week 6) respectively. Results showed that additive variance was more important in determining the average litter size at birth while dominance variance to a large extent influenced litter size at weaning age (week 6). The graph showed that average litter size exhibited complete dominance at birth and over dominance at week 6 respectively. The order of dominance among the breeds for the weeks is Beveren> Chinchilla> New Zealand White>New Zealand Red.

Table 1 : Means ±SEM of genetic parameters estimate for litter productivity indices at weaning and post weaning ages.

PARAMETER	NAMES	ALZ (0)	ALZ (6)
D	Additive variance	6.87±0.00	0.84±0.06
H1	Dominance variance 1	1.75±0.31	4.46±0.55
H2	Dominance variance 2	1.76±0.17	3.99±0.32
F	Products of add. by dom. effects	0.84±0.09	-1.88±0.46
Hh	Square of difference parents and whole diallel	3.93±0.18	6.59±1.23
E	Environmental variance, whole	0.34±0.08	0.26±0.06
$(H1/D)^2$	Average degree of dominance	0.96±0.05	2.30±0.05
Kd/(kd+kr)	Proportion of dominant gene	0.61±0.08	0.25±0.11
H	Average direction of dominance	2.03±0.02	0.25±0.04
Uv	Balance of positive and negative alleles	0.25±0.09	0.22±0.01
D/(D+E)	Heritability in a true sense	0.84±0.09	0.76±0.26
H^2b	Heritability for diallel in a broad sense	0.73±0.08	0.90±0.02
H^{2n}	Heritability for diallel in a narrow sense	0.69±0.03	0.85±0.08
Cor. (Pr(Vr+Wr)	Correlation between variance and covariance signs of dominant genes	-0.69	-0.36

ALZ (6) = Average litter size at birth ALZ (12) = Average litter size at weaning age of week 6

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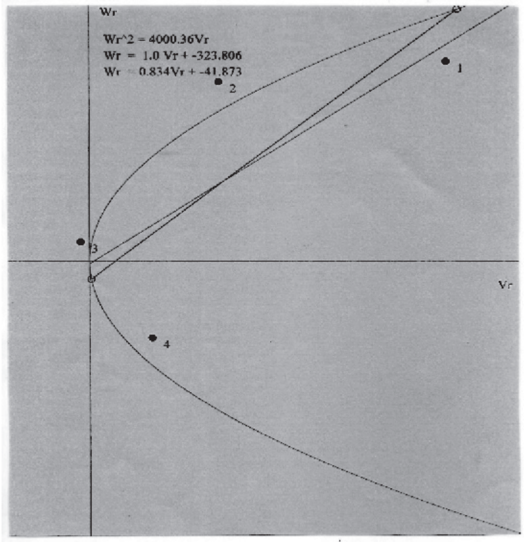

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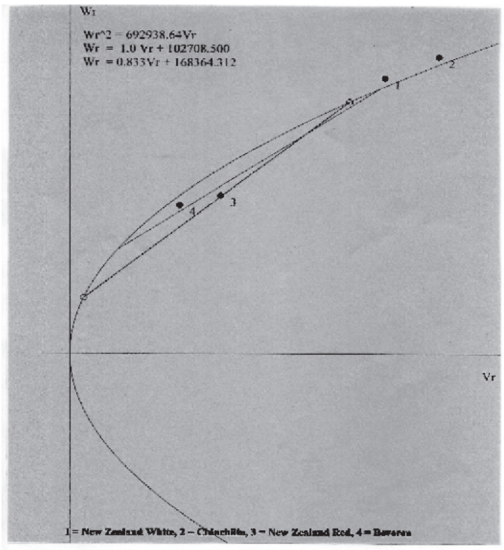

1 = New Zealand White, 2 = Chinchilla, 3 = New Zealand Red, 4 = Beveren

Figure. 1. Diallel cross of dominance relationships in terms of Vr, the variance of all the offspring (Vr is Genetic variance = Phenotypic variance – Environmental variance) of the rth parent, and Wr, the covariance between these offspring and their non- recurrent parents for litter size at birth (week 0).

Figure. 2. Diallel cross of dominance relationships in terms of Vr, the variance of all the offspring (Vr is Genetic variance = Phenotypic variance – Environmental variance) of the rth parent, and Wr, the covariance between these offspring and their non- recurrent parents for litter size at weaning (week 6).

Discussion

Genetic variation in litter size at birth was reported in this study. This trend was in agreement with earlier reports by Ogundimu (2001) for pure breed and cross breed rabbits. The progeny of Chinchilla X Beveren and Beveren X Chinchilla showed better performance for litter size at birth, which agrees with the report of Lukefahr and Cheeke (2004) and Akanniet al. (2007) that Chinchilla and Beveren had better maternal ability and adapt relatively well to the tropics. Prolificacy is generally measured in terms of litter size and it depends on the number of oocytes produced after mating, which to a large extent depends on breed differences (Akanniet al., 2007; Akanni,2009).

The variation observed in the results of diallel analysis according to Hayman (1954) cited byAdebambo (2008) and Akanniet al.(2012), in terms of the effect of additive variance (A), dominance variance and environmental variance (E), the degree of dominance and proportion of dominant genes among others have been reported. This showed that the rabbit breeds all have different breed advantages. This therefore calls for the proposal concerning genetic improvement programme that will involve these breeds of rabbit and the development of lines (usually hybrids) selected for a set of traits that are of high economic value Adebambo, 2008).

The estimates for broad and narrow sense heritabilities showed that selection and crossbreeding are effective and viable tools that could be employed in improving productivity of reproductive and growth traits of rabbit strains considered in this study. The lower value indicated that, they were less important in the control of those traits. The effect of environmental variance on litter traits suggest that if the genetic variance for a certain trait is high and the environmental variance is low, it is expected that the progeny will be very much alike with the selected phenotype in terms of high degree of resemblance in their characteristics. In the same vein, when the genetic variance is low the environmental variance is high; the progeny may deviate from the selected phenotype. The similarity between a parent and its progenies depends largely on the components of genetic variance (VA/VD). In the case of the additive variance (A), it means that the parental phenotype is a reliable indicator of its genotype while in the case of dominance variance (VD); the progeny will differ from the parental phenotype according to the nature of the intra-allelic interaction. The relationship between genotypic variance and the total phenotype variance determines the heritability of the trait with that population. However, the heritability in the broad sense actually is a measure of the degree of genetic determination of a particular trait while heritability in the narrow sense reflects the relationship between additive variance and the total phenotypic variance (Ayo-Vaughan et al., 1999). This confirmed the trend of observed variations in this study. Where the heritability values were high among the traits studied, it means there existed large genetic differences between parents and the F2 generation. Generally, the correlation values varied with increase in age of the animals across all the genotypes studied. This is not farfetched from the genetic factors discussed above. Therefore, according to Akanni (2009), when strains developed in one country are distributed to other countries where climate and management differ from their zone, they are usually less productive. This implies that the gene for a particular trait may be present in such strains yet its level of expression can still be influenced by non-genetic factors. This confirmed the trend observed in this study.

Conclusion

Diallel analysis results of additive, dominance and heritabilities showed that the rabbit breeds all exhibited different breed advantages. Dominance gene action favoured the production of the cross breeds; additive gene action on the other hand premised that standard selection procedures such as mass selection should be employed for genetic improvement and better performance in rabbits.

Recommendations

- Variations that existed in this rabbit population should be thoroughly exploited through crossbreeding and selection programmes. This is desirable in order to take advantage of heterosis in enhancing numerical doe reproductive ability (measured through the number of weaned rabbits per doe per year) which is the key goal for improving the performance of rabbits as sustainable path to Nigeria's economic recovery and food security.
- A continuous crossbreeding (tri hybrid crossing) and other genetic improvement programmes involving [(BVR X CHL) X BVR)] [(BVR X NZW) X CHL] and [(CHL X NZW) X NZW)] with a full exploitation of heterosis should be explored. The strains could be improved upon and developed into breeding and meat type rabbits to be raised using locally available inputs for tropical environment.

References

Adebambo, A.O. 2008. Genetic variation and combining abilities in pure and crossbred meat type chickens. (PhD Thesis, University of Agriculture, Abeokuta. Pp 112-200).

Adejinmi,O. O., Fapohunda, J.B, Alonge, G.O, Owosibo, A.O, and Ogunleke, F.O. 2005. Performance of growing rabbits fed Tridax leaf meal (Tridax procumbens) with or without soybean meal in the diets. In: Proceedings of 10th Annual Conf, Animal. Sci. Ass. of Nigeria.(ASAN), Sept.12-15 2005, at University of Edo- Ekiti, Nigeria. pp. 292-294.

Adegbola A., Jones, R., & Brown, S. (2018). "Economic considerations in rabbit farming: A comprehensive review." Agricultural Economics Review, 22(3), 215-230.

Adeniji, A. A., Ojedapo, L. O., Odedire, J. A., & Osunade, J. A. (2015). Composition and Characteristics of Cocoyam Peel Meal. Animal Production Science, 6(4), 216-220.

Adeyemi, O. (2018)."Effect of Cocoyam Peel Meal-Based Diets on Growth Performance and Blood Profile of Broiler Chickens." Journal of Applied Poultry Research, 27(4), 1123–1131.

Ahmed, M. (2019)."Influence of Cocoyam Peel Meal on Growth Performance, Carcass Characteristics, and Nutrient Digestibility of Growing Rabbits."Animal Feed Science and Technology, 256, 114276.

Akanni, K.T. 2009. The rabbit as a potential of meat and breeding stock in Nigeria: Training manual for young farmers. A paper delivered at a 6-week summer course on OGEGEP regular training programme and conditional grants scheme organized by the Bureau of Employment Generation Programme (OGEGEP), OgunState. Theme: Changing lives for good. Held between Monday 7th December – to Friday 5th March, 2010, at Eweje Farms Institute, Odeda, Abeokuta, Ogun State.

Akanni, K. T., S.O. Peters, M. Whetto, A.M. Bamgbose, C.O.N. Ikeobi and Olufunmilayo Adebambo 2012. Sire strain influence on the reproductive performance of three strains of rabbits in south western Nigeria. In Proceedings of 37thAnnual Conf. of NSAP 18th – 21st March, 2012 at University of Agriculture, Makurdi, Benue State, Nigeria. pp. 8-10.

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Akanni, K.T., Oni O.O, Bello, T.T and Ogbonna, C.C. 2007. Meeting challenges of food security through livestock improvement in the area of education and economic reforms. Proc. 8th National conference, School of Vocational Education Federal College of Education, Abeokuta. 10th – 12th July, 2007.

Akanni, K.T. and Ajayi, G.A . (2021). Effect of breeding and body weight at sexual maturity of some rabbit ecotypes on productivity traits in a humid environment. Being A paper presented at the 1st National Conference, School of Early Childhood care Education and Primary Education, Federal College of Education, Abeokuta, Nigeria held between 1st -3rd June, 2021. Theme: Actualizing sustainable development goals (SDGS) vision 2030 for Education in the new normal.

Ayo-Vaughan, M.A., Kehinde, B.O. and Ariyo, O.J. 1999. Genetics and plant breeding (University of Agriculture, Abeokuta, Nigeria). GbemiSodipo Press Ltd. Abeokuta, Pp 42-53.

Hayman, B.I. 1954. The Analysis of Variance of Diallel Tables. Biometrics. 10:235-244.

Iyeghe – Erakpotobor, G.T., Balogun, R.O., Abdul-Malik, M.E. and Adeyinka, I.A. 2002. Influence of breed and environment factors on litter parameters of rabbit raised in a semi-Humid environment. Nigerian Journal of Animal Production 28(1): 14 – 19.

Lukefahr, S. D. and Cheeke, P. R. 2004. Rabbit project planning strategies for developing countries (1) Practical considerations. Livestock Research for Rural Development Volume 2, Number 2, December 2004. Pp. 1-22.

Ogundimu, U.E. 2001. Repeatability estimates and medication of the milk suckled per kit from performance traits in Dutch rabbit. Sustain. Agric. Environ. 3: 149-154.

Gidenne, T., Pérez, J. M., & Xiccato, G. (2010). Feed Intake limitation in the Growing Rabbit. In 9th World Rabbit Congress, Verona, Italy.

Gupta, S and Sharma A. (2018). "Immunomodulatory Effects of Cocoyam Peel Meal in Broiler Chickens: A Preliminary Study." Poultry Science, 99(7), 3521–3529.

Khan, A. (2021). "Anti-Nutritional Factors in Cocoyam Peel Meal: Implications for Animal Nutrition." Journal of Animal Physiology and Animal Nutrition, 105(1), 120–129.

Li, E., Wu, S., & Zhao, Y. (2021). Microbial Biomass as a Sustainable Protein Source in Animal Diets: A Review. Animal Feed Science and Technology, 276, 114920.

Makkar, H. P. S., & Tran, G. (2014).Insects as Sustainable Feed Ingredients in Pig and Poultry Diets - a Feasibility Study. FAO, Rome.

Odunsi, A. A., Sobayo, R. A., & Balogun, A. M. (2012). Nutrient Composition of Cocoyam (Colocasia esculenta) Peels as an Alternative Feedstuff for Broilers. International Journal of Poultry Science, 11(8), 512-517.

Ogunwole, O. A. (2022). Utilization of cocoyam peel meal in rabbit diets: Palatability and digestibility. Journal of Animal Science and Technology, 64(1), 39-47.

Pandey, A. K., Yadav, S., & Rai, R. (2019). Alternative Feed Resources and Their Utilization in Livestock Feeding: A Review. International Journal of Livestock Research, 9(9), 257-273.

Patel, R. (2022). "Meta-Analysis of the Effect of Cocoyam Peel Meal in Animal Diets: Implications for Growth Performance and Nutrient Utilization." Animal Feed Science and Technology, 289, 114873.

Sharma, R., & Singh, B. (2020). Utilization of Rice Bran in Rabbit Diets: A Comprehensive Review. Animal Nutrition, 6(4), 351-358.

Smith, J., Brown, A., & Johnson, Z. (2013). Sustainable Livestock Diets: A Review of Conventional and Alternative Approaches. Journal of Sustainable Agriculture, 43(5), 546-561.

Szendr?, Z., Bázár, G., &Matics, Z. (2006).The Effect of Different Types of Environmental Enrichment on the Behaviour and Performance of Growing Rabbits. World Rabbit, 14(2), 91-103.