

Growth Performance, Blood Profile, and Feed Cost Analysis of Using Dried Watermelon Rinds in Rabbit Diets

¹Ayo-Ajasa, O. Y., ¹Ayoola, A. A., ¹Adeyemo, A. A., ¹Odutayo, O. J., ¹Olalere, F. A., ¹Olaoye, A. O., ¹Egbeyale, L. T., ²Abiona, J. A., ³Fafiolu, A. O. and ¹Sogunle, O. M.

¹*Department of Animal Production and Health, Federal University of Agriculture, Abeokuta, Nigeria*

²*Department of Animal physiology, Federal University of Agriculture, Abeokuta, Nigeria*

³*Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Nigeria*

***Corresponding Author:** olapejuyemisi@yahoo.com; +2348034702869

Target Audience: *Resource-poor rabbit farmers, rabbit scientists and feed millers*

Abstract

The competition between humans and livestock animals for maize has led to recent research on the use of unconventional feed ingredients, such as dried watermelon rinds, in livestock feed. Eighty (80) crossbred, unsexed weaner rabbits with a mean weight of 630 g were used to assess the growth performance, blood parameters and evaluate the cost benefits of using dried watermelon rinds (DWMR) as a replacement for maize in weaner rabbits' diet. They were allocated on weight equalization basis into 4 treatments (0%, 5%, 10% and 15%) of DWMR inclusion levels, representing T1, T2, T3 and T4, respectively, and further divided into 5 replicates of 4 rabbits. The study lasted for 8 weeks, and data were subjected to one-way analysis of variance in a Completely Randomized Design. Results showed that rabbits fed diet containing 5% DWMR had the highest ($p < 0.05$) final body weight and average daily weight gain (1391.25 g and 13.61 g, respectively). Feed cost (N/kg) declined from N559.00 on diet 1 to N464.00 on diet 4. Highest cost saving of N292.75 was obtained on diet 2 (5% DWMR). Highest ($p < 0.05$) RBC ($6.70 \times 10^{12}/L$) was observed in rabbits fed the control diet (0% DWMR), while the least value ($6.00 \times 10^{12}/L$) was recorded in rabbits fed 15% DWMR diet. Serum biochemical analysis indicated that the total protein, albumin and globulin increased significantly in rabbits fed diet containing DWMR compared to those on the control; rabbits on 0% DWMR recorded the least values (4.30 g/dl, 2.5 g/dl and 1.75 g/dl, respectively). The study concluded that dried watermelon rinds can be included at 5% in the diet of weaner rabbits to enhance growth, increase profitability and better economic returns.

Keywords: Rabbit; Dried watermelon rind; Performance; Feed cost analysis

Description of Problem

Animal protein is one of the most vital parts of human diet, whose consumption levels differ amongst nations (1). In both urban and rural settings, protein deficit is still common among the various socioeconomic levels. This malnutrition pervasion could be due to the decrease in protein intake as a result of the shortage and high cost of animal protein food sources such as milk, eggs, meat, and fish (2). Therefore, the increasing demand for animal protein coupled with more stringent economic conditions has encouraged greater interest in fast growing animals with short generation interval (3). It was reported that one of the cheapest producers of meat that can easily fit into the wider segment of the population in Nigeria is the rabbit (4). Rabbits (*Oryctolagus cuniculus*) are small animals that supply proteinous meat, low in sodium and cholesterol and high in phosphorus, calcium and vitamin B complex (5). These qualities necessitate consumer interest and farmers' choice of participating in its production, coupled with their ability to digest feed rich in fibre because of enlarged caeca and presence of fibrous degrading bacteria (6). Other benefits of rabbit production include fast growth, less space and feed requirement, better feed efficiency, high dressing percentage and short gestation period (7). According to (8), rabbits may survive on a variety of feedstuffs and thus the use of unconventional feed ingredients in its feed formulation has gained increasing attention. Some agro-industrial by-products like dried watermelon rinds have been discovered as a convenient non-conventional ingredient that can be used to

feed rabbits. Rabbits can easily utilize waste to produce meat, giving it an advantage over other animal species because of its peculiar digestive physiology, which permits the use of forages and agro-industrial by-products, and low cost of investment (9). The rind and seeds, which constitute 30% of the watermelon, are often treated as waste and either used as animal feed or discarded. Watermelon rind is considered as a potential source of dietary fibre, phenols, high free radical scavenging property and antidiabetic activity in albino mice (10). A single dose of microencapsulated watermelon rind containing 4 g of L-citrulline was found adequate to improve endothelial function (11). Watermelon rinds have 7.45% crude protein, 18.57% crude fibre, 10.44% ether extract and 3.22% ash (12). In addition, (13) stated that it possesses significant amounts of moisture (10.61%), ash (13.09%), crude protein (11.17%), fat (2.44%), and carbohydrates (56%). Supplementation of swine diets with watermelon rind meal at 45% replacement for soybean meal resulted in an improved body weight gain, enhanced feed intake, and a better feed conversion rate (14). These improvements were attributed to the up regulation of nutrient absorption mRNA expression levels. The potential of including watermelon rind meal in rabbit diets had been reported in the literature (12; 15; 16). Most of these authors substituted dried watermelon rind for wheat offal as source of fibre. However, there is paucity of literature on its use to replace maize in rabbits' diet. This study hoped that using watermelon rind as energy replacement for maize in the diets of weaner rabbits would

offer a valuable source of energy, contributing to both environmental sustainability and economic efficiency in rabbit production. Hence, this study aimed to examine the utilisation of watermelon rind as an energy source in rabbit production.

Materials and Methods

Experimental site

The rearing of the animals was carried out at the Rabbitary unit of the Directorate of University Farms (DUFARMS), while the blood analyses took place at the Department of Veterinary, Physiology and Pharmacology, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun state, Nigeria with latitude 7°13'27"N and longitude 3°25'29"E and altitude 76m above the sea level. The area is characterised with humid climate, a mean annual rainfall of about 1037mm, as well as mean temperature and humidity of 34.70C and 83%, respectively. The vegetation represents an interphase between tropical rainforest and the derived savannah(17).

Source and preparation of the test ingredient

Fresh watermelon rinds were collected from fruit vendors around Alabata axis, Odeda Local Government Area, Abeokuta, Ogun state, Nigeria. The rinds were rinsed thoroughly and scrapped to remove sand particles and watermelon remains that might cause decaying instead of drying. The rinds were then sliced into smaller sizes and sundried for about 3 weeks. During sun drying, the rinds were continuously turned to ensure uniform drying. After which it was then milled with

hammer mill (Peruzzo®) into smaller sizes of 2mm and incorporated into the diets of the experimental animals.

Experimental diets

Four experimental diets (T1, T2, T3 and T4) were formulated as follows. T1: control diet 0% inclusion of dried watermelon rind, T2: 5% inclusion of dried watermelon rind, T3: 10% inclusion of dried watermelon rind and T4: 15% inclusion of dried watermelon rind (Table 1).

Experimental animals' management and design

A total of 80 unsexed rabbits crosses (Chinchilla X Newzealand white) of an average weight of 630 g were purchased from a reputable farm at Ogbomosho. They were randomly assigned on weight equalisation basis into four (4) dietary treatments described earlier. Each treatment group contained 20 rabbits, which was further replicated five(5) times, with each replicate containing 4 rabbits. The rabbits were kept in hutches equipped with concrete feeders and drinkers used to supply feed and water *ad libitum*. The hutches were cleaned and disinfected before the arrival of the animals. The rabbits were allowed two-week adjustment period during which they were fed with the control diet and given multi-vitamins in water to stress before the commencement of the experiment. Maintenance of strict hygiene (daily sweeping of the pen, washing and refilling of drinkers with fresh clean water, and cleaning of feeders) and provision of feed was thoroughly ensured throughout the 8 weeks, which the experiment lasted.

Table 1: Percentage Composition of Experimental Diets

Ingredients	T1	T2	T3	T4
	Percentage level of of DWMR			
	0	5	10	15
Maize	45.00	40.00	35.00	30.00
Palm Kernel Cake	10.00	10.00	10.00	10.00
Soybean meal	10.00	10.00	10.00	10.00
DWMR	0.00	5.00	10.00	15.00
Wheat offal	30.00	30.00	30.00	30.00
Bone meal	3.00	3.00	3.00	3.00
Oyster shell	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25
Vitamin/ Mineral Premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
ME (MJ/kg)	2611.40	2439.80	2268.20	2096.60
Crude protein (%)	15.39	15.55	15.72	15.89
Crude fibre (%)	5.52	6.16	6.80	7.44

DWMR: Dried Water Melon Rind

T1-T4 represented 0%, 5%, 10% and 15% DWMR inclusion levels, respectively

Data Collection

Growth performance evaluation

The initial body weight was taken at the beginning of the experiment and on weekly basis thereafter. Feed intake was measured using the differences between weight of feed offered and that of left-over; body weight gain was calculated as final weight minus initial weight, while feed efficiency was calculated using the relationship of weight gain and feed intake.

Feed cost analysis

Costs of feed were calculated using the prevailing market prices of ingredients at the time of the experiment for the economic appraisal of the feeds (cost of dietary ingredients (N/kg), cost of diet per kg, total feed intake and total weight gain). This was done by summing the price per kg of feed ingredients multiplied by their

proportions in the feed formula and then dividing by 100. Average feed cost (AFC) was determined by multiplying the cost per kg feed by total feed intake while the total feed cost (TFC) was obtained by multiplying total feed intake by the cost per kg feed. The cost saving was calculated by subtracting other experimental diets from the control diet. Percentage cost saving was obtained by dividing cost saving by feed cost and multiplying by 100,

Blood collection and Analysis

On the 56th day, six (6) rabbits per treatment were selected and about 5ml of blood samples each was collected through the ear vein using syringe. The blood collected was divided into two parts: For haematological parameters, blood (2.5ml) was collected into bottles pre-treated with Ethylene Diamine Tetra Acetate (EDTA)

as an anticoagulant and was gently tilted to prevent coagulation. For serum biochemical analysis, 2.5ml of blood was put into a sterilized bottle (without anticoagulants). Haematological parameters examined included: haemoglobin concentration, packed cell volume, red blood cell count, white blood cell count, lymphocytes, and heterophils. Serum biochemical indices assessed were glucose, total protein, globulin, albumin, alanine aminotransferase, and aspartate aminotransferase.

Determination of haematological parameters

Haemoglobin concentration was estimated using the Cyanome Haemoglobin Method. 2.5ml of blood was expelled into 4ml of Drakkin's Solution. The mixture was allowed to rest for 10 minutes for full colour development; the result was read under a spectrophotometer (18). Packed Cell Volume (PCV) was determined by spinning each blood sample in a heparinised capillary tube in a haematocrit centrifuge for 5 minutes and read on haematocrit reader (19). White Blood Cell (Total Leucocyte Count) was determined by using Neubaur Chamber Method, in which the blood sample was diluted at a ratio of 1:20 for WBC counts using white cell diluting fluid. Red Blood Cells were determined by diluting at a ratio of 1:20 for RBC counts using red cell diluting fluid. The cell count for each sample was carried out according to the method of (20). During the process of being viewed under the microscope, the percentage of different cells (i.e, lymphocytes, eosinophils, basophils, heterophils, etc.) was recorded via the cells counted.

Determination of serum parameters

Total serum protein was determined using the Burette method as described by (21). The mixture of the reagent and sera was incubated for 30 minutes at 20-25°C and the absorbance of the sample and that of the standard was measured against the blank at a wavelength of 540 nm. The protein concentration was calculated as follows:

Total serum Protein (g/dl) = (absorbance of sample x standard concet)/absorbance of standard

Serum albumin was determined using the bromocresol purple (BCG) method by (22). The absorbance of the sample and the standard was taken against the reagent blank, at a wavelength of 620 nm.

Serum globulin was estimated by subtracting the result of serum albumin from serum total protein as follows:

Serum globulin (g) = Total serum Protein (g) - serum albumin (g)

Alanine and Aspartate Aminotransferases were determined with the aid of spectrophotometer according to the method of (23) using commercial Randox kit. Serological variables such as total protein concentration (g/dl), Glucose concentration (g/dl), Albumin concentration (g/dl), creatinine concentration (mg/dl), cholesterol concentration (mg/dl), and alkaline phosphate (u/l) were determined. Serum glucose was determined colorimetrically using the Glucose Oxidase Peroxidase GOD/POD method of (24). Glucose was determined after the enzymatic reaction in the presence of glucose oxidase. The mixture was incubated for 25 minutes at 15-20°C, and the absorbance of the

standard and sample was measured against reagent blanks within 60 minutes. The reading was taken at a wavelength of 500 nm, and the glucose concentration was calculated as:

Glucose (mg/dl) = (Absorbance of sample × concentration of standard) / Absorbance of standard

Serum creatinine was analyzed using the colorimetric method by (25). About 1.25ml of trichloroacetic acid and 1.25ml of serum were mixed and centrifuged at 250rpm for 10 minutes, and the supernatant was poured off. The mixture was allowed to cool for 20minutes at a temperature of 25°C. The absorbance of the samples and the standard was measured against the blank. It was calculated as follows:

Creatinine concentration (mg/dl) = (absorbance of sample / absorbance of standard) × 2

Serum uric acid was determined according to the standard procedure of (26) using spectrophotometer (Model SP 6-400 Pyeunicam) set at 600nm wavelength. The equivalent wavelength of the sample was read and the uric acid concentration calculated as:

Serum uric acid (mg/dl) = (absorbance of sample × concentration of standard) / absorbance of standard

Statistical Analysis

Data collected were subjected to analysis of variance using (27), and where significant differences in means were indicated, Duncan's Multiple Range Test of the same statistical package was used to

separate them at 5% level of significance.

Statistical model

The statistical model for the experimental design is

$$Y_{ij} = \mu + T_i + \epsilon_{ij}$$

Where; Y_{ij} = Observed value of dependent variables;

μ = the population mean

T_i = the effect of dried watermelon rind levels (0, 5, 10, 15%)

ϵ_{ij} = the random error

Results

The growth performance of the weaner rabbits fed the experimental diets is presented in Table 2. Inclusion of dried watermelon rind (DWMR) as an energy source at different levels in weaner rabbits' diets showed no significant ($P > 0.05$) effect on the feed intake, feed efficiency and the mortality rate; however, the final body weight and total weight gain of the rabbits were significantly ($P < 0.05$) influenced by DWMR. Rabbits fed diet with 5% DWMR had the highest final body weight and total weight gain (1391.25 g and 762.31 g, respectively) while those fed diets containing 0% and 15% DWMR had similar final body weight (1330.25 g and 1229.69 g, respectively). Increased level of inclusion of DWMR resulted in decreased weight gain as the lowest total weight gain was observed in rabbits fed diets containing 10% and 15% DWMR (585.56 g and 600 g, respectively).

Table 3 shows the economic analysis of rabbits fed DWMR as substitute for maize.

Table 2: Growth performance of rabbits fed diets containing varying levels of dried watermelon rind as an energy source

Parameters	Inclusion level of DWMR (%)				SEM
	0	5	10	15	
Initial Weight (g)	625.81	628.94	630.81	629.69	2.02
Final Weight (g)	1330.25 ^{ab}	1391.25 ^a	1216.38 ^b	1229.69 ^{ab}	28.80
Total Weight Gain (g)	704.44 ^{ab}	762.31 ^a	585.56 ^b	600.00 ^b	28.50
Average Daily Weight Gain (g)	12.58 ^{ab}	13.61 ^a	10.46 ^b	10.71 ^b	0.51
Total Feed Intake (g)	2463.69	2289.94	2212.06	2277.81	55.57
Average Daily Feed Intake (g)	43.99	40.89	39.50	40.68	0.99
Feed Efficiency	0.29	0.33	0.27	0.26	0.01
Mortality (%)	0.38	0.38	0.38	0.25	0.08

^{ab} means on the same row having different superscripts are significantly ($p < 0.05$) different.

DWMR- Dried Watermelon Rind, SEM- Standard Error of Mean

The feed cost in /kg decreased with increasing level of DWMR in the diet; feed cost (N/kg) declined from N 559.00 on diet 1 to N464.00 on diet 4. Similar trend was also observed with cost of feed in naira (N) per rabbit; diets 1(0% DWMR) had N

1377.20 and 4(15% DWMR) (N1056.91). The highest cost saving (N) of N292.75 was obtained on diet 2 (5% DWMR). The cost N/kg and total feed cost (N) on the control are higher than the cost of DWMR diets

Table3: Feed cost analysis of using dried watermelon rind meal in the diet of weaner rabbits

Parameters	Inclusion Levels of DWMR (%)				SEM
	0	5	10	15	
Total feed intake (g)	2463.69	2289.94	2212.06	2277.81	55.57
Feed cost (N/kg)	559.0 ^a	544.0 ^b	499.0 ^c	464.0 ^d	6.74
Cost of feed (N/rabbit)	1377.20 ^a	1245.73 ^{ab}	1103.82 ^{bc}	1056.91 ^c	35.93
Total weight gain	704.44 ^{ab}	762.31 ^a	585.56 ^b	600.00 ^b	28.50
Cost of feed (N/kg gain)	1984.47	1691.73	1903.20	1882.06	64.02
Cost saving (N)	0.00	292.75	81.28	102.41	82.16
Percentage cost saving	0.00	9.84	1.33	1.04	4.56

^{abcd} means on the same row having different superscripts are significantly ($p < 0.05$) different.

DWMR- Dried watermelon rind meal,
SEM- Standard error of mean.

The results of the haematological parameters of weaner rabbits fed diets containing dried watermelon rind meal is presented in Table 4.

The result showed that dried watermelon

rind meal did not significantly ($p > 0.05$) influence the haematological parameters of the experimental animals except for red blood cells. The red blood cells decreased with increasing level of inclusion of dried

Table 4: Haematological indices of weaner rabbits fed diet containing dried watermelon rinds as an energy source

Parameters	Inclusion levels of DWMR (%)				SEM	Reference values
	0	5	10	15		
Packed cell volume (%)	38.67	37.67	39.50	36.83	0.61	30-45
Haemoglobin (g/dl)	12.88	12.53	13.28	12.37	0.21	10-15
Red blood cell (x10 ¹² /L)	6.70 ^a	6.58 ^{ab}	6.53 ^{ab}	6.00 ^b	0.11	4-7
White blood cell (x10 ⁹ /L)	8.05	8.97	7.83	8.08	0.47	5-12
Neutrophil (%)	35.33	36.17	37.33	37.83	0.63	30-75
Lymphocyte (%)	62.67	60.67	59.33	59.67	0.66	43-80
Eosinophil (%)	0.83	1.50	2.00	1.33	0.20	0-5
Basophil (%)	0.00	0.00	0.17	0.17	0.06	0-1
Monocytes (%)	1.17	1.17	1.17	1.00	0.14	0-5
Mean corpuscular volume (fl)	57.80	57.28	60.65	61.83	1.05	50-65
Mean corpuscular haemoglobin (pg)	19.24	19.05	20.40	20.77	0.37	17-24
Mean corpuscular haemoglobin concentration (g/dl)	33.32	33.25	33.64	33.58	0.11	30-37

^{ab} means on the same row having different superscripts are significantly ($p < 0.05$) different.

DWMR: Dried watermelon rind,

SEM: Standard error of mean

watermelon rinds, with the highest value (6.70x10¹²/L) observed in rabbits fed the control diet (0% DWMR). The least value corresponding to 6.00x10¹²/L was recorded in rabbits fed diet with 15% dried watermelon rind meal.

Table 5 shows the result of serum biochemical indices of weaner rabbits fed diets containing watermelon rind meal as an energy source. The total protein, albumin and globulin increased significantly in rabbits fed diets containing DWMR compared to those on the control diet with the least values (4.30 g/dl, 2.5 g/dl and 1.75 g/dl respectively) for these parameters.

Discussion

The improved average daily weight gain of rabbits fed diet containing 5% DWMR in this study could be attributed to several active compounds in DWMR, such as citrulline, which enhances protein synthesis (28); antioxidants, which reduce oxidative stress (29); balanced fibre content, promoting gut health (30); and essential minerals and vitamins (31). The improved weight gain of rabbits fed diet with 5% DWMR in this study could be as a result of the effect of the micronutrients such as carotene, vitamin K, ascorbic acid, riboflavin, iron, iodine, and other mineral components especially at 5% DWMR inclusion. The result of this experiment agrees with the observation of (12) that

Table 5: Serum biochemical indices of weaner rabbits fed diets containing watermelon rind meal as an energy source

Parameters	Percentage level of DWMR				SEM	Reference value
	0	5	10	15		
Total protein(g/dl)	4.30 ^b	5.60 ^a	5.93 ^a	5.85 ^a	0.22	5-7.5
Albumin (g/dl)	2.55 ^b	3.33 ^a	3.53 ^a	3.46 ^a	0.13	2.5-4
Globulin (g/dl)	1.75 ^b	2.27 ^a	2.40 ^a	2.38 ^a	0.09	2.5-4
Cholesterol (mg/dl)	129.77	156.13	142.75	125.83	5.13	125-200
Urea (mg/dl)	37.87	37.10	41.53	38.25	2.15	10-80
Glucose (mg/dl)	56.22	57.82	49.28	53.30	1.63	75-150
Creatinine (mg/dl)	1.75	1.69	1.57	1.19	0.14	0.5-2.0
Aspartate transaminase(u/l)	103.00	102.00	114.00	105.33	4.28	55-260
Amino transaminase(u/l)	34.83	34.67	34.33	35.83	1.29	10-98
Alkaline phosphate(u/l)	51.00	48.50	54.17	51.17	1.89	10-100

^{ab} means on the same row having different superscripts are significantly ($p < 0.05$) different.

DWMR: Dried watermelon rind,

SEM: Standard error of mean

DWMR could be included in the diet of weaner rabbits up to 6% without any deleterious effect on the health and general performance of rabbits. The reduction in weight gain at higher inclusion levels could be due to the decline in the metabolisable energy (ME) supplied by the diets at 10% and 15% DWMR inclusion levels. The non-significant effect of DWMR on feed intake and feed efficiency in this study disagrees with the findings of (32), who reported that dietary energy level is a major factor influencing feed intake and feed conversion ratio. They added that animals will consume more of feed containing low amount of energy at a constant growth rate, while they consume less of higher energy feed to meet their nutrient requirements, thereby improving the feed conversion ratio.

The feed cost analysis shows that total feed

cost (N) of the control diet was higher than the cost of DWMR diets. This finding agrees with the reports of (33) and (34) who demonstrated that incorporating agricultural by-products in rabbit diets can substantially reduce feed costs, while maintaining or enhancing growth performance.

It is well established that changes in haematological and biochemical parameters reflect the physiological status of animals and are indicative of the metabolic health status of the animals (35). The values obtained for the haematological parameters in this study were comparable to those in the control group and within the range of reference values reported by (36). The study indicated that the dried watermelon rind is safe to feed rabbits as it does not negatively affect the haematological parameters of

the animals. The RBC values recorded, though significant, are within the normal range ($4-7 \times 10^{12}/L$) as reported by (36) for a healthy rabbit. (37) opined that increased RBC values are associated with high quality dietary protein and with disease-free animals. This also implies the DWMR is utilised more effectively, and that an inclusion level of up to 15% does not have any deleterious effect on the utilisation of the DWMR, nor on the erythropoietic tissues of rabbits. It is also an indication that the experimental rabbits could transport a higher amount of oxygen in their system, which enhanced their health status. The non-significant difference in other haematological parameters could be an indication of the animals' overall wellness throughout the experimental period, as normal haematological parameters are direct indicators of the absence of disease (38). The values obtained for all parameters measured in this study indicated that the diets did not have any deleterious effects and the process of blood formation was not interfered with in the animal's body during the experimental period.

The serum biochemical constituents (total protein, albumin and globulin) have been used as predictors of serum or blood dietary proteins and also routinely used for the detection of organ diseases in domestic animals (39). The serum total protein, albumin and globulin indicate the quality and availability of protein; hence, the diets containing DWMR had sufficient protein to sustain normal protein levels in the blood and had no negative effect on protein

metabolism of the experimental rabbits (40). Abnormal serum albumin usually indicates an alteration in the normal systemic protein utilisation and low dietary protein intake (41). Increased globulin levels indicate a potential boost in the immune system of the weaner rabbits, which could be attributed to the bioactive compounds present in watermelon rinds (42). Cholesterol levels showed a non-significant fluctuation across the different levels of DWMR inclusion. This outcome is in line with findings by (43), which stated that dietary fibres from fruit by-products do not always have a clear-cut effect on blood cholesterol levels, likely due to complex interactions between dietary components and lipid metabolism. Likewise, the levels of urea and creatinine, the markers of renal function, remained relatively stable across the different dietary treatments, indicating that the inclusion of DWMR did not adversely affect kidney function. This stability supports the findings of (44), who noted that moderate inclusion of alternative feed ingredients does not impair renal function in rabbits. Serum glucose levels also varied slightly with DWMR inclusion but did not show a significant trend. This suggests that dried watermelon rind as an energy source does not significantly impact blood glucose regulation, corroborating the work of (45), who found that dietary fibre have minimal effects on blood glucose levels in rabbits. Also, the activities of liver enzymes such as aspartate transferase (AST), alanine transferase (ALT), and alkaline

phosphatase (ALP) showed no significant differences among the groups, indicating that the inclusion of DWMR did not induce hepatotoxicity, aligning with studies that report the safety of fruit by-products in animal diets (46). The inclusion of dried watermelon rind in the diets of weaner rabbits positively influenced protein metabolism and immune function without adversely affecting renal or liver function.

Conclusion and Application

The findings of this study show that 5% inclusion level of DWMR can be incorporated into weaner rabbits' diet without any adverse effect on the growth performance at a lower cost of production, while 15% inclusion level significantly increased the red blood cells and also improved total protein, albumin, and globulin levels. The use of dried watermelon rind up to 5% inclusion level should be encouraged not only to reduce dependence on maize but also to reduce the cost of feed for profitable rabbit production and environmental pollution.

Acknowledgement

The study was financed by the Tertiary Education Trust Fund (TETFUND-IBR) through the Directorate of Research, Innovations and Partnerships (DRIP), Federal University of Agriculture, Abeokuta.

References

1. Eze, N., Maduabum, F., Onyeke, N., Anyaegunam, N., Ezeanwu, B. and Eseadi, C. 2017. Awareness of food nutritive value and eating practices among Nigerian bank workers: Implications for nutritional counselling and education. *Medicine*, 96(10): e 6 2 8 3 . <https://doi.org/10.1097/MD.0000000006283>
2. Mekonnen, D. A., Akerele, D., Achterbosch T., de Lange, T. and Talsma E. 2021. Affordability of healthy and sustainable diets in Nigeria. *Frontiers in Sustainable Food Systems*, 5: 726-773.
3. Sherrard, J. (2023). Global animal protein outlook 2024: Adapting to structural changes to sustain success. Rabobank. Available at: <https://research.rabobank.com> [Accessed 4 Sep. 2024].
4. Nworgu, F.C. 2007. Economic importance and growth rate of broiler chicken served fluted pumpkin (*Telfaria occidentalis*). *African Journal of Biotechnology*, 2(6): 34-39.
5. Grădinaru, A. C. 2017. The Transylvanian Giant Rabbit: an efficient selection for qualitative and quantitative genetic traits. *Rabbit Genetics*, 7: 1-6.
6. Bedford A., and Gong J. 2017. Implications of butyrate and its derivatives for gut health and animal production. *Animal Nutrition*, 4:151-159.
7. Aduku, A.O., Olukosi, J.O. (2000). Rabbit management in the tropics: production, processing,

- utilisation, processing, marketing, economic, practical training, research and future prospects. Abuja, Nigeria. Living Book Series, G.U. Publications. 5:6-7.
8. Ibitoye, E., Oloredo, B. and Jimoh, N. 2010. The rabbit industry and alternative feedstuffs: A review. Proceedings of the 35th Conference, Nigerian Society for Animal Production.
 9. Otu, B. O., Banjo, A. A., Kolo, S. P., Balogun, A. M. and Dabban, A. I. 2021. Growth performance and nutrient digestibility of broiler chickens fed diets containing varying inclusion levels of dried watermelon rind at the starter phase. *Nigerian Journal of Animal Production*, 48(3): 134-141
 10. Sani, U. M. 2014. Phytochemical screening and antidiabetic activity of extracts of *Citrullus lanatus* rind in alloxan-induced diabetic albino mice. *International Journal of Chemical Pharmacological Science*, 2:1211-5.11. Volino-Souza, M., de Oliveira, G.V. and Junior, C. A. 2023. Effect of micro-encapsulated watermelon (*Citrullus lanatus*) rind on flow mediated dilation and tissue oxygen saturation of young adults. *European Journal of Clinical Nutrition*, 77: 71-74.
 12. Alagbe, J. 2018. Performance and Haemato-Biochemical Parameters of Weaner Rabbits Fed Diets Supplemented with Dried Water Melon Peel (Rind) Meal. *Dairy and Veterinary Science Journal*, 8(4): 55 - 74.
 13. Al-Sayed, H. M. and Ahmed, A.R. 2013. Utilization of watermelon rinds and sharlyn melon peels as a natural source of dietary fibre and antioxidants in cake. *Annals of Agricultural Science*, 58: 83-95.
 14. Agbana, J. B., Ayodele, O. A., Akinwumi, A. O. and Adeola, S. O. 2023. Effect of watermelon rind meal on growth performance of livestock. *Livestock Science*, 252, 104707.
 15. Okai, D. B., Boateng, M., Amaoh, K. O. and Johnson, L. D. (2010). Studies on dried water melon rinds on the nutrient composition and effects on growth performance and carcass characteristics of Albino rats. Proceedings of the 30th Ghana Animal Science Association Conference. 98-103.
 16. Shehu, F.B., Bello, S. and Bala, S. 2022. Replacement value of dried watermelon (*Citrus lanatus*) peels meal with wheat offal on growth performance of broilers. Proceedings of the 11th ASAN-NIAS Joint Annual Meeting and 27th Animal Science Association of Nigeria Annual Conference. 693-696.
 17. Google Maps. 2024. Federal University of Agriculture.

- R e t r i e v e d 23.
 https://earth.google.com/web/@
 f r o m
 7.22330744,3.44033719,137.848
 8 4 5 7 5 a ,
 1046.69760578d,35y,100.57030
 218h,44.99999706t,0r/
18. Yu, D., Huber, Bedding, D., Stello, S.J., Murphy, M., Xiang, S. and Li, T. 2016. Asteroseismology of luminous red giants with Kepler I: long-period variables with radial and non-radial modes. *Monthly Notices of the Royal Astronomical Society* 463 (2), 1297-1306.
19. Benson, M. D., Buxbaum, J. N., Eisenberg, D. S., Merlini, G., Saraiva, M. J. M., Sekijima, Y., Sipe, J. D. and Westermark, P. 2014. Amyloid fibril proteins and clinical classification of the amyloidosis. *Amyloid*, 21(4), 221-224.
20. Aiello, S.E. 1998. Merck Veterinary Manual. Merck and Co. Inc., (8th edition).4 -52.
21. Rifai, N., Chiu, R. W. K., Young, I., Wittwer, C. T. and Tietz, N. W. 2024. Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics (9th edition). Elsevier. <https://doi.org/10.1016/C2019-0-04259-6>
22. Varley, H, Gowshock, A. H. and Bell, M. 1980. Determination of Serum Urea using Biochemistry. 5th Edition William Heineman Medical Books.
23. Pesce, A. J., Kaplan, L. A. and Pesce, A. 1984. "Clinical Chemistry, Theory, Analysis, and Correlation," C. V. Mosby, St. Louis. 1127.
24. Barham, D. and Trinder, P. 1972. Enzymatic determination of uric acid. *Analyst*, 97, 142-145.
25. Heinegård, D. and Tiderström, G. 1973. Determination of serum creatinine by a direct colorimetric method. *Clinica Chimica Acta*. 43(3):305-310.
26. Wotton, J. 1964. Micro Analysis in Medical Biochemistry, (4th ed.), J and A Churchill Ltd., London.
27. SAS (2003). Statistical Analysis Systems Users Guide, version 9.0 edition, SAS Institute Inc., Cary, NC. USA.
28. Aguayo, E., Martínez-Sánchez, A., Fernández, B. and Alacid, F. 2021. L-Citrulline: A Non-Essential Amino Acid with Important Roles in Human Health. *Applied Sciences*, 11(7), 3293.
29. Martinez, Y., Li, X., Liu, G., Bin, P., Yan, W., Más, D., Valdiviá, M., Hu, C. A., Ren, W., and Yin, Y. 2019. The role of methionine on metabolism, oxidative stress, and diseases. *Amino Acids*, 51(9), 1209-1220.
30. Gidenne, T., Carabaño, R., García, J. and De Blas, C. 2010. Fibre digestion. In C. De Blas and J. Wiseman (Eds.), Nutrition of the

- rabbit(2nd ed.). CABI. 66-82
31. Erukainure, O. L., Oke, O. V., Daramola, A. O., Adenekan, S. O. and Umanhonlen, E. E. (2010). Improvement of the biochemical properties of watermelon rinds subjected to *Saccharomyces cerevisiae* solid media fermentation. *Pakistan Journal of Nutrition*, 9(8): 806-809.
 32. Ataei, A. H., Moheghi, M. M. and Fazel, Y. 2021. Effect of Grower Dietary Energy Level on Feed Intake and Performance of Modern Broiler Chickens. *Journal of Poultry Research*, 11 (11) : 1 2 9 1 . <https://doi.org/10.34233/jpr.1111291>
 33. Maidala, A., Ahmed, B. and Usman, I. (2020). Carcass yield and economics of production of growing rabbits (*Oryctolagus cuniculus*) fed different types and levels of rumen content. *Journal of Environmental Sciences, Toxicity and Food Technology*, 14(7):43-47.
 34. Etim, N.N., Williams, M.E. and Udo, M.D. 2014. Growth performance and cost-benefit analysis of rabbits fed plantain peels. *Global Journal of Animal Scientific Research*, 2(4): 345-352.
 35. Iheukwumere, F. C., Abu, A. H. and Ameh, M. 2006. *International Journal of Poultry Science*, 5(7): 632-634.
 36. Medirabbit. 2011. Complete blood count and biochemical reference values in rabbits.
 37. Brown, T., Smith, J. and Johnson, M. 2000. Effects of Nutrition on Haematology of Rabbits: A Review. *European Scientific Journal*, 10(3):123-130.
 38. Olafadehan, C. O., Obun, A. M., Yusuf, M. K., Adewumi, O. O., Olafadehan, A. O., Awofolaji, A. O. and Adeniji, A. A. 2010. Effects of residual cyanide in processed cassava peel meals on haematological and biochemical indices of growing rabbits. Proceedings of 35th Annual Conference of Nigerian Society for Animal Production, p.212.
 39. Guleken, Z., Atalay, A., Karayigit, M. O. and Birdane, F. M. 2020. Serum biochemical parameters and their relationship with mineral and vitamin concentrations in hair goats. *Journal of Animal and Veterinary Advances*, 19(7): 90-97.
 40. Kwari, I. D., Igwebuikwe, J. U. and Mohammed, I. D. 2014. Effect of feeding differently processed sorrel seed (*Hibiscus sabdariffa*) on nutrient digestibility, nitrogen balance and haematological parameters of growing rabbits. *Nigerian Journal of Animal Science*, 16(2): 148-158.
 41. Nistor, E., Bampidis, V.A., Pacala, N., Pentea, M., Tozer, J. and Prundeanu, H. 2013. Nutrient

- content of rabbit meat as compared to chicken, beef and pork meat. *Journal of Animal Production Advances*, 3(4): 172-176.
42. Giwa, F. J., Yusuff, A. S., and Sogbesan, O. A. (2020). "Nutrient composition and utilization of watermelon rind in the diet of rabbits." *Nigerian Journal of Animal Production*, 47(1): 154-163.
43. Grundy, L., Edwards, C.H., Mackie, A.R., Gidley, M.J., Butterworth, P.J. and Ellis, P. 2016. Re-evaluation of the mechanisms of dietary fibre and implications for macronutrient bioaccessibility, digestion, and postprandial metabolism. *British Journal of Nutrition*. 116:816-8.
44. D'Mello, J. P. F. (2003). "Amino Acids in Animal Nutrition." CABI.
45. Hossain, M. A., Begum, R., and Rahman, M. M. (2016). "Effect of dietary fibre on blood glucose levels of rabbits." *International Journal of Science and Research*, 5(5), 1054-1057.
46. Kaneko, J. J., Harvey, J. W., and Bruss, M. L. (Eds.). (2008). *Clinical Biochemistry of Domestic Animals* (6th ed.). Academic Press. <https://doi.org/10.1016/B978-0-12-370491-7.X5000->