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EFFECT OF *ACHILLEA MILLEFOLIUM* AND *MORINGA OLEIFERA* SUPPLEMENTATION ON PRODUCTIVE, IMMUNOLOGICAL AND PHYSIOLOGICAL RESPONSES OF WEANING V-LINE RABBITS

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ABSTRACT

This work aimed to investigate the effects of feeding yarrow and moringa on productive and physiological traits of weaned V-line rabbits. Forty-five male weaned V-line rabbits, at 35 days of age and distributed in a five treatment groups The 1st group was fed a complete pelleted diet and served as control, the 2nd and 3rd groups were fed a diet with 5 and 10g yarrow/ kg complete pelleted diet, respectively, the 4th and 5th groups were fed a complete pelleted diet with 5 and 10g moringa/ kg diet, respectively. The result showed that both yarrow and moringa improved the 5 or 10g/ kg diet significantly increased the body weight, body weight gain and performance index and improved feed conversion ratio of growing rabbits more than those of the control group. The least feed consumption was recorded due to feeding 5g/ kg diet of yarrow compared to all studied groups, while feeds supplemented with 10g/ kg diet of yarrow caused growing rabbits to consume the highest feed. Both yarrow and moringa supplements significantly increased RBCs, WBCs and PCV % compared to the control group. The highest albumin concentration was at moringa 10g/ kg diet level compared to the control. Moringa feed supplement at 5g/ kg diet significantly increased α-globulin concentration compared to the control group. Both control and moringa at 5g level indicated the least IgG and IgM compared to other treated groups. while yarrow supplement at 10g/ kg diet had the highest IgG. Yarrow feed supplement at 10g/ kg diet significantly induced the lowest total cost observed with control group. While, both yarrow and moringa supplements significantly increased net revenue and relative economic

efficiency compared to the control group. Moreover, moringa supplement at both 5g/ kg diet significantly increased economic efficiency percentage in comparison to the control group. The present results indicated that, supplementation of yarrow or moringa at 5g/ Kg to diet of weaned rabbits improved the productive performance, physiological, and immunity response and enhance net revenue.

Keywords: Yarrow, Moringa, Rabbits, Performance, Physiological Responses

INTRODUCTION

One of the many farm animal species that are suitable for raising meat is the rabbit. Rabbits are prolific, producing many young per kindling. They give meat with a high nutritional value, which makes rabbit production appealing. This meat can be a good, affordable source of animal protein for human use. The ability to use forages to produce high-quality meat and a decent development rate are a few noteworthy characteristics that encourage rabbit production **(Sharp *et al.*, 2007)**.

Rabbits could play a big role in addressing the issue of a lack of animal protein. Modern customers place a high value on nutritional factors in food, such as low-fat content and organic origin. Meat from rabbits has a high protein-to-calorie ratio, low cholesterol level, and is comparatively rich in important fatty acids **(Iraqi, 2003)**. The major methods to reduce the cost of animal feeding are thought to be the search for novel alternative feed supplies, complete exploitation of agricultural by-products, and growth promoters.

Yarrow (*Achillea millefolium* L.) is a flowering plant belonging to the family Asteraceae. The medicinal herb yarrow is used in traditional medicine to enhance the health of the gastrointestinal system, enhance feed nutrient digestion and assimilation, and enhance physiological health in both human and animal organisms. It is a growth promoter substitute with demonstrated antibacterial and antifungal properties **(Omidbaygi, 2004)**.

Yarrow is used to treat a variety of gastrointestinal issues and allergies. Numerous chemicals, including flavonoids, sesquiterpene lactones, and polyacetylenes, have been identified from Achillea species. For many years, different species of the genus have been used as traditional medicines to treat a wide range of illnesses **(Saeidnia *et al.*, 2005)**. According to reports, yarrow is used as a medication for conditions affecting the circulatory, pulmonary, digestive, hepatobiliary, urinary, and reproductive systems **(Blumenthal *et al.*, 1998)**. Extracts of yarrow have demonstrated antimicrobial activity against a wide variety of bacteria, such as *Streptococcus pneumoniae*, *Clostridium perfringens*, *Candida albicans*, *Mycobacterium smegmatis*, *Acinetobacter lwoffii*, and *Candida krusei*, have been shown to be susceptible to yarrow extracts' antibacterial and antioxidant properties **(Stojanovic *et al.*, 2005)**. There aren't many studies on this herb's impact on rabbit diets **(Bahabadi *et al.*, 2014)**.

One of the best natural sources for antioxidant and antibacterial activities is moringa (*Moringa oleifera*). According to research by **Jabeen *et al.*, (2008)**, the medical benefits of moringa include the treatment of high blood pressure, diarrhoea, colon inflammation, intestinal worms, skin antiseptics, and as a diuretic to help diabetic patients' blood glucose levels remain stable **(Chinwe and Isitua, 2010)**. Additionally, moringa was utilized to treat ulcers, enhance the intestinal health of broiler chicken (**Yang *et al.*, 2006)**, and strengthen the immune system against a variety of illnesses **(Jaiswal *et al*., 2009)**. *Moringa oleifera* had been documented to include~~s~~ nutritional qualities, being rich in vitamins especially beta-carotene and tocopherol **(Ayssiwede *et al.*, 2011)**, amino acids, energy, crude protein, low levels of antinutritional factors like tannins, trypsin and amylase inhibitors (**Ogbe and Affiku, 2012)** Despite the high crude protein content of moringa leaf meal, there is limited information on its application, particularly as a substitute protein supplement for the production of rabbits.

Therefore, the objective of this study was to determine the effect of yarrow and moringa on productive performance, physiological and immunological responses of weaned V-line rabbits.

MATERIALS AND METHODS

The present study was carried out at El-Bostan Poultry Farm, Faculty of Agriculture, Damanhour University during the period from February up to April 2021. Forty-five weaner male V-line rabbits were used to investigate the effect of feeding yarrow and moringa on productive performance, physiological traits as well as carcass characteristics of weaned V-line rabbits.

All treatments and birds care procedures were approved by the Institutional Animal Care and Use Committee in AU-IACUC, Damanhour University, Egypt. Authors declare that the procedures imposed on the birds were carried out to meet the Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals and birds used for scientific purposes.

Natural feed additives

Dried yarrow (*Achillea millefolium*) collected at the flowering stage, dried in the shade, and the leaves were separated from the stem and moringa (*Moringa oleifera*) were purchased from the local market. Each was ground in a grinder into fine powder using an electric blender. The powders were then stored in well-tied dry clean plastic food storage bags at the Fridge temperature (4-8°C) until used.

Experimental Design

A total number of forty-five male weaned V-line rabbit (purchase from Poultry Research Center, Alexandria University), at 35 days of age with an average initial weight 818.2±23.3g. Rabbits were randomly distributed among five equal treatment groups (nine rabbits each). Each treatment was divided into three equal replicates, each of three rabbits. The 1st group was fed a complete pelleted diet and served as control. The 2nd and 3rd groups were fed a diet with 5 and 10g yarrow/ kg complete pelleted diet, respectively. The 4th and 5th groups were fed a complete pelleted diet with 5 and 10g moringa/ kg diet, respectively.

Flock Management

The rabbits were housed in a naturally ventilated building (housed in an open), east-west oriented windowed rabbitry, with one level design cages having galvanized wire (40 × 50 × 35 cm) cages. Each cage was equipped with a metal feeder and water supply through nipple drinkers.

Table (1): Ingredient materials and determined analysis of the experimental diet

Ingredients	(kg/ton)	%	Determined composition (g/kg)	
Yellow corn	100.0	10	Dry matter	903.2
Barley	130.0	13	Organic matter	804.8
Molasses	30.0	3	Crude protein	172.4
Clover hay	395.0	39.5	Crude fiber	134.6
Wheat bran	150.0	15	Ether extract	28.00
Soybean meal	175.0	17.5	Nitrogen-free extract	569.8
Dicalcium phosphate	8.0	0.8	Ash	95.20
Limestone	5.0	0.5	digestible energy (kcal/kg)	2464
Sodium chloride	3.0	0.3		
Vitamin and minerals mixture*	3.0	0.3		
DL-methionine	1.0	0.1		
Total	**1000**	**100**		

* The premix provided the following each 3 kg/ton diet of rabbit premix contained: vitamin A 12,000,000 IU; vitamin D3 2,000,000 IU; vitamin E 10,000 mg; vitamin K3 2,000 mg; vitamin B1 1,000 mg; vitamin B2 5,000 mg; vitamin B6 1,500 mg; vitamin B12 10 mg; biotin 50 mg; choline chloride 250,000 mg; pantothenic acid 10,000 mg; nicotinic acid 30,000 mg; folic acid 1,000 mg; iron 30,000 mg; copper 10,000 mg; manganese 60,000 mg; iodine 1,000 mg; selenium 100 mg; cobalt 100 mg; zinc 50,000 mg and antioxidant, 1,000 mg to 3,000 g.
** According to NRC (1977).

Rabbits were kept under the same managerial and environmental conditions. Ventilation and temperature were natural, ranges of ambient temperature, relative humidity and day-light length during the experimental period were from 23 to 27°C, 60-65% and 14 hours, respectively. Feed and water were available all the time *ad libitum* during the experimental period. The commercial pellet diet contained (Table 1) 17.24% crude protein, 13.46% crude fiber, 2.80% fat and 2464 kcal/ kg diet were provided with all required vitamins and minerals as recommended by **(NRC, 1977)**. Clean fresh water was available for rabbits all the time.

Data collected for rabbit's performance:

The following traits were evaluated:

Individual live body weight: rabbits were individually weighed weekly in the morning before offering feed to the nearest 1gm.

Body weight gain (BWG): was calculated by subtracting the final live body weight from the initial live body weight/ No. of days.

Feed consumption (FC): was recorded weekly, during the whole experimental period, and recorded as (g/ rabbit/ week).

Feed conversion ratio (FCR): (g feed/ g gain) was calculated as follows: feed intake (g) during a certain period/ body weight gain (g) during the same period.

Performance index = (final live body weight (kg)/ feed conversion ratio) x 100 **(North, 1981)**

Survival rate: Dead rabbits were recorded during the whole experimental period for each treatment, and then the survival rate (SR) was calculated as the number of living rabbits at the end (70 days of age) of the experiment to the number of rabbits at the beginning of the study.

Blood Analysis

At the end of the experiment (at ten weeks of age), about 3 ml blood, six rabbits from each group were randomly taken at 08:00-09:00 AM from the marginal ear vein of rabbits under vacuum in clean tubes with and without heparin before slaughtering, coagulated blood samples were centrifuged at 4000 rpm for 15 minutes and the clear serum was separated and stored in a deep freezer at -20°C until biochemical analysis.

Noncoagulated blood was tested shortly after collection for estimating blood pictures.

Hematological criteria

Red blood cell counts (RBCs): Red blood cell counts were counted on bright line hemocytometer using light microscope at 400X magnification. RBCs were counted according to **Feldman *et al.* (2000)**.

Hemoglobin concentration (Hgb): Hemoglobin concentration (g/dl) was determined of fresh blood samples using hemoglobinometers according to **Whitehead *et al.* (2019)**.

Packed cell volume (PCV) as %: Blood was withdrawn by Wintrobe hematocrit tubes and centrifuged at 4000 rpm for 20 minutes. PCV (%) was recorded directly according to **Drew *et al*. (2004)**.

White blood cell counts (WBCs): White blood cell counts using a light microscope at 100X magnification according to **Feldman *et al*. (2000)**.

Differential leukocytes count: Blood film was prepared according to **Houwen (2002)**. A dry, unfixed smear was stained for one minute using ten drops of any Gunwale stain stack solution applied to an equivalent volume of distilled water. Decorating the dye was done without rinsing. After 20 minutes of counterstaining with diluted Gamesa's solution (10 drops of the dye to 10 ml distilled water), the film was rounded in the water current, and the absolute value for each type of cell was counted and calculated in relation to the total WBCs.

Determination of phagocytic activity (PA) and phagocytic index (PI):

Phagocytic activity was determined according to **Hustedt *et al.* (2021)**. One milliliter of citrated blood was mixed with 50 µg of the Candida albicans culture, shaken in a water bath at 23 to 25 degrees Celsius for three to five hours, and then stained with Giemsa solution. By calculating the percentage of macrophages with intracellular yeast cells among a random sample of 300 macrophages and expressing the result as a percentage of PA, the phagocytic index was calculated. In the phagocytic cells, the number of phagocytized organisms was counted and called PI.

PA =Percentage of phagocytic cells containing yeast cells.
PI = Number of yeast cells phagocytes/number of phagocytic cells.

Protein profile

To evaluate the changes in protein profile during the fattening period in rabbits, serum samples were analyzed for the concentrations of total protein and main protein fractions. Plasma total protein (g/dl) was measured using special kits delivered from Diamond diagnostics using a spectrophotometer according to guidelines of **(Doumas *et al.*, 1981)**. Serum albumin (g/dl) was determined using special kits delivered from Diamond diagnostics according to the method of **(Doumas *et al*., 1977)**. Serum globulin level (g/dl) was calculated by the difference between total protein and albumin, since the fibrinogen usually comprises a negligible fraction **(Sturkie, 1986)**.

The serum protein fractions were separated by zone electrophoresis on an agarose gel using an automated electrophoresis system and commercial diagnostic kits Diamond diagnostics according to the procedure described by the manufacturer. The following protein fractions were identified: Pre-albumin, albumin, α-, β-, and γ-globulins. The absolute concentrations (g/dl) of the fractions were quantified consequently from the total serum protein concentrations.

Economic efficiency of rabbits

The economic efficiency for all experimental groups were calculated as the difference between total income and total costs during the experimental period according to **Abdella *et al.*, (1988)**. The total costs included the feeding costs, rabbits purchased, and veterinary care costs. The total income included income value from final live body weight (rabbit). All these parameters were estimated in L.E. according to the price of the ingredients in the local market at the time of the experiment (2021). Economic efficiency was calculated from the following equation:

$$\textbf{Economic efficiency, \% =} \frac{\text{Net revenue}}{\text{Total cost}} \times 100.$$

$$\textbf{Relative Economic efficiency, \% =} \frac{\text{EE (treatment)}}{\text{EE (control)}} \times 100.$$

Where:

Net revenue = price of final live body weight (LE) - total cost (LE).

Price of final live body weight (LE) = average body weight (kg/ head) × price/ kg live body weight (LE).

Total cost (LE) = average cost (kg/ head) × price/ kg (LE).

Statistical analysis

Data were statistically analyzed using General Linear Model (GLM) procedure of the statistical analysis system of SAS Institute (SAS, 2002) using one-way analysis of variance according to the following formula: $Yij = \mu + Ti + eij$

Where: Yij= The observation of the statistical measured,

μ= The general overall mean,

Ti= The effect of treatment,

eij= The experimental random error.

Before analyses, arcsine transformation was done to normalize distribution of data. The least square mean (LSM) + standard errors were calculated and tested for significance using the “t” test **(Steel and Torrie, 1980)**.

RESULT AND DISCUSSION

Performance of weaned rabbits

The effect of yarrow and moringa feed supplements on productive performance of weaned and growing V-line rabbits is presented in Table 2. The body weight range of experimental rabbits at 5 weeks of age was (815.1-822.2gm). Adding both yarrow and moringa at the 5 or 10g/ kg diet significantly increased body weight of growing rabbits at 10 weeks of age more than those of the control group. However, no marked differences (P>0.05) were noticed between the 5th and the 10th rabbit groups of either yarrow or moringa supplemented once (Table 2).

The whole BWG (5-10 weeks) of weaned and growing rabbits followed the same pattern of the final body weight at 10 weeks of age of both yarrow and moringa supplemented feed at 5 and 10g/ kg diet (Table 2). Although no significant (P>0.05) differences were recorded between the supplemented 5th and 10th groups of either yarrow or moringa groups.

The most FC was recorded due to feeding 5g/ kg diet of yarrow (3442g) (P<0.05) compared to all studied groups under investigation during 5-10 weeks period, while feeds supplemented with 10g/ kg diet of yarrow caused growing rabbits to consume the lowest feed (3278g) (Table 2). Moreover, adding yarrow or moringa at 5 and 10g/ kg diet of each caused a fluctuant change in FC of rabbits shown in Table 2.

Yarrow and moringa feed supplements at the experimental levels under investigation significantly (P<0.05) decreased FCR (2.7-2.977g/g) in comparison to the control group (3.264g/g) during 5-10 weeks rabbit growing period. In addition, adding yarrow or moringa at 10g level significantly (P<0.05) improved FCR (2.7 and 2.838g/g) compared to the corresponding level at 5g (2.977 and 2.92g/g), respectively (Table 2).

Table (2): Effect of yarrow and moringa on productive performance of growing rabbits

Items	Control	Yarrow (g/kg diet)		Moringa (g/kg diet)		SEM	P value
		5	10	5	10		
Initial BW, g (5 Wk)	816.2	822.2	819.1	815.1	818.2	10.31	1.000
Final BW, g (10 Wk)	1820[b]	1979[a]	2035[a]	1957[a]	1990[a]	21.44	0.018
BWG at 5-10Wk, g	1003[b]	1157[a]	1216[a]	1142[a]	1142[a]	17.25	0.0001
FC at 5-10Wk, g	3260[b]	3442[a]	3278[b]	3334[b]	3315[b]	17.45	0.003
FCR at 5-10Wk, g/g	3.264[a]	2.977[b]	2.700[c]	2.920[b]	2.838[c]	0.04	0.0001
Performance Index, %	56.26[c]	67.03[b]	70.36[ab]	66.50[b]	75.53[a]	1.47	0.0001
survival rate, %	100	100	100	100	100	-	-

[a,b] Means in the same row having different letters are significantly different at ($p \leq 0.05$)
SEM = standard error of mean; BW= body weight; BWG= body weight gain; FC= feed consumption; FCR= feed conversion ratio.

Feeding either yarrow or moringa at 5 or 10g level improved the performance index of growing rabbits (66.53-75.53%) better than the control group (56.26%) (P<0.001). However, adding moringa at 10g/ kg diet level induced the maximum significant performance index (75.53%); while the 5g level induced the least performance index (66.5%) (Table 2). Moreover, the survival rate was 100% throughout the whole experimental period (5-10 weeks) for both treated and control groups.

The significant increase in body weight of growing rabbits at 10 weeks of age more than those of the control group due to feeding the feed supplements disagree with **Zanu *et al.* (2012)** who reported that significant decline in final BW with an increase in the dietary inclusion of moringa in broilers chicken diet, and **Atuahene *et al.* (2008)** who recorded that no significant effect of diets containing *Moringa oleifera* leaf meal at 0, 2.5, 5.0, and 7.5% levels on BW of broiler chickens. In the current study, BW increased linearly with an increase in moringa and yarrow levels. As expected, performance measures for birds on the negative control **(Nkukwana, 2012)**, were significantly (P<0.05) lower than those for their moringa supplemented counterparts.

The fore mentioned result agrees with the findings of **Nuhu (2010)** who reported significantly higher daily BWG in rabbits fed 5, 10 and 15% dietary moringa leaf meal than those on the control diet. However, the result of this study did not support the findings of **Kakengi *et al.*, (2007)** and **Olugbemi *et al.*, (2010)** who reported a reduction in performance of chicken fed moringa leaves meal, and **Adeyemi (2014)** who recorded a weight gain decrease with the increase in the level of *Moringa oleifera* leaf inclusion in the rabbit diet. The last author added that the average daily BWG was significantly higher for the rabbits on the control diet than those fed 7.5% moringa leaf meal.

It was concluded tentatively that dietary inclusion of yarrow may improve rabbit growth performance. Orthogonal contrasts between inclusion levels suggest that the dietary concentration of both feed additives has a greater effect on growth performance than the non-fed group. Both moringa and yarrow confer their finding was also achieved by beneficial effects on the whole growth rabbit period, as well as broiler growth performance **(Lewis, 2005)** by reducing pathogenic bacterial species and/or maintaining the beneficial species in order to maintain a stable and beneficial flora. **Nkukwana, (2012)** concluded that the antibiotic effect of both the synthetic and natural forms may be the only explanation behind the improved growth performance of birds that were supplemented with higher moringa leaf meal levels.

The current observation disagreed with the previously reported studies that have shown no significant differences ($P<0.05$) in FC caused by moringa feed additives, even when an improvement in FCR as a consequence of enhanced growth had been observed **(Windisch *et al.*, 2008 and Nkukwana, 2012)**. Similarly, as reported by **Bozkurt *et al.*, (2009)** plant additives fed in conjunction with mannan oligosaccharide can act as performance enhancers significantly improving broiler growth performance, in association with an increase in voluntary FC.

Although garlic and yarrow supplementation did not affect BWG or FC, chickens fed the higher rates of these two additives tended to have superior feed conversion efficiency throughout the experimental period (P=0.076), principally during the latter growth stage (P<0.05) **(Lewis, 2005)**. This may be attributable to the in vitro antimicrobial activity reported for garlic **(Arora and Kaur, 1999 and Harris *et al.*, 2001)** and yarrow **(Bishop and MacDonald, 1951 and Candan *et al.*, 2003)**.

In this study, it was observed that the survival rate was 100% due to the inclusion of moringa and yarrow in the diet. This reduction in rabbit mortality might be due to the presence of some phytochemicals such as chlorogenic acids and quercetin, among others in the moringa leaf that possess medicinal and therapeutic properties **(Adeyemi, 2014)**. **Ologhobo *et al.*, (2013)** reported that *Moringa oleifera* has antibiotic properties and may be used to replace conventional antibiotics. These antibiotic properties might have enhanced the ability of the rabbits on moringa diets to fight against diseases or infections.

The values obtained for feed conversion ratio in this study are lower than the values obtained by **Nuhu (2010)** (4.22 - 5.13), this is possibly linked to poor genetic constitution of the rabbits used in their experiment. In addition, **Olugbemi *et al.*, (2010)** observed that inclusion of leaf meals in broiler diets above 5-10% resulted in depressed performance.

Improvements in FCR seen in rabbits fed yarrow high treatment diets are consistent with the findings of **Cross *et al.,* (2002)** who fed yarrow to caged broilers up to 28 days of age. These authors hypothesized that the effects seen were a result of beneficial moderation of intestinal microflora. Orthogonal contrasts revealed that birds fed the yarrow high treatment diets had better FCR than those fed the yarrow low treatment diets because they ate less feed (P<0.05).

On an opposite, according to a review by **Wallace *et al.*, (2010)**, and **Nkukwana (2012)** experiment on broilers, FCR was not affected by the dietary inclusion of moringa extracts, although positive effects on BW, BWG, organ weight and/or energy utilization did exist.

Blood constituents

Hematological of blood

The effect of yarrow and moringa feed supplements on hematological parameters of growing rabbits is listed in Table 3. No significant changes (P>0.05) in Hgb level, basophils, and neutrophils percentages due to adding both the 2 feed additives to V-Line rabbits from 5-10 weeks of age compared to the control group at the same period. The Hgb level range was 8-8.646g/ dl; the basophils % range was 0.00-0.333%; and the neutrophils percentage range was 23.42-24.79%.

Table (3): Effect of Yarrow and Moringa on hematology of growing rabbits

Items	Control	Yarrow (g/kg diet)		Moringa (g/kg diet)		SEM	P value
		5	10	5	10		
RBCs, 10^6/mm^3	3.860^c	5.066^{ab}	4.666^{abc}	4.286^{bc}	5.316^a	0.16	0.015
Hemoglobin, g/dl	8.466	8.373	8.646	8.293	8.000	0.15	0.774
PCV, %	33.44^c	35.09^{ab}	34.29^{bc}	36.40^a	36.12^a	0.27	0.0001
WBCs, 10^3/mm^3	5.083^b	7.183^a	6.150^{ab}	5.750^{ab}	7.676^a	0.32	0.057
Lymphocyte, %	46.43^a	44.68^{ab}	46.80^a	44.75^{ab}	41.83^b	0.53	0.014
Monocyte, %	14.94^b	15.82^b	13.42^c	17.28^a	17.32^a	0.32	0.0001
Eosinophil, %	13.81^b	14.37^b	16.13^a	14.20^b	16.53^a	0.27	0.0001
Basophils, %	0.000	0.3333	0.000	0.3333	0.000	0.06	0.146
Neutrophils, %	24.79	24.78	23.64	23.42	24.30	0.25	0.292

^{a,b,c} Means in the same row having different letters are significantly different at ($p \leq 0.05$)
RBCs= Red blood cells; PCV= Packed cell volume; WBCs= White blood cells.

On the other hand, both yarrow and moringa supplements significantly increased RBCs, WBCs and PCV percentage at both 5 and 10g/ kg diet compared to the control group that had the least counts for RBCs (3.86×10^6), WBCs (5.083×10^3), and percentage for PCV (33.44%). In addition, yarrow and moringa at 10g/ kg diet supplement significantly increased the eosinophils percentage (16.13 and 16.53%) compared to those at 5g/ kg diet (14.37 and 14.2%) as well as control group (13.81%).

Moreover, moringa supplemented at both 5 and 10g/ kg diet significantly (P<0.05) increased monocytes percentage (17.2 and 17.32%) in comparison to the corresponding yarrow ones (15.82 and 13.42%) and control group (14.44%). On the other hand, no trend could be detected for lymphocyte percentage due to adding either yarrow or moringa at the studied levels. It was the highest (P<0.05) in yarrow at 10g/ kg diet (46.8%) and control group (46.43%); but no differences were detected for the 5g/ kg diet supplement of either yarrow (44.67%), or moringa (44.75%).

In this study, yarrow and moringa supplements significantly increased RBCs, WBCs and PCV percentage at both 5 and 10g/ kg diet compared to the control group, a finding that agrees with **Odetola *et al.*, (2012)** who recorded that an increase in leucocyte count in growing rabbits fed up to 15% dietary moringa, and **Ologhobo *et al.*, (2013)** who reported that higher erythrocyte count when broilers were fed 6g/ kg of moringa in their diet. However, it disagrees with **Adeyemi (2014)** who used *Moringa oleifera* leaf meal in rabbits' diet that significantly influenced the PCV, Hgb and erythrocytes during their growth as the control had the highest PCV (42.83%) and haemoglobin concentration (13.71g/100ml) with apparent decrease in the values as the *Moringa oleifera* leaf meal inclusion levels in the diets increased.

The values obtained for PCV (33.44-36.4%), WBCs (5.083-7.676×10^3), and erythrocytes (3.86-5.316 x10^6) in this study fall within the reported physiological ranges reported except Hgb (8-8.646 g/100ml) for normal rabbits by **Mitruka and Rawnsley (1981).** It can be interpreted that the dietary treatment induced nutritional anemia and provided inadequate nutrients needed by the rabbits. This is contradicted the efficient erythrocyte production in terms of the volume of RBCs, its pigmentation and concentration, a finding need further investigation. Moreover, the results of our study disprove the findings of **Ozovehe (2013)** and **Aderinola**

***et al.*, (2013)** that reported a decrease in PCV, erythrocytes and Hgb values in fishes and broilers fed diets containing varied levels of moringa respectively. In addition, the results of this work are not in agreement with the reports of **Nuhu (2010)** and **Ewuola *et al.*, (2012)** who reported from their findings that M. *oleifera* did not have any significant effect on haematological parameters of growing rabbits. Also, **Oyedemi (2011)** reported that crude extract of *Moringa oleifera* had no significant effect on the haematological parameters of lactating does.

Blood biochemical constituents

Protein profile

The results of feeding weaned V-Line rabbits on yarrow and moringa supplement at 5 and 10g/ kg diet on protein profile is listed in Table 4. Neither yarrow nor moringa at the 2 levels induced significant changes (P>0.05) in total protein (g/dl) and β-globulin (g/dl) compared to the control group. The total protein range was 5.3-5.446g/dl, for the treated and control groups. The β-globulin overall range was 0.733-0.933g/dl. As noted in listed results (Table 4), yarrow and moringa feed supplement significantly (P<0.05) induced reversed effect on albumin and globulin levels. The highest albumin concentration was at moringa 10g/ kg diet level (2.566g/dl) compared to the control that had the least (2.2g/dl). The same pattern, was also, noticed for α-globulin as moringa feed supplement at 5g/ kg diet significantly induced the highest concentration (1.7666g/dl) and the control group had the least (1.533g/dl) (Table 4).

It was, also, noted that treated rabbits with 10g/ kg diet moringa and 5g/ kg diet yarrow significantly (P<0.05) increased β-globulin to the maximum (0.9g/dl), compared to moringa at 5g/ kg diet group that had the least (0.733g/dl). On the opposite, the control group significantly recorded the highest globulin concentration (3.266g/dl) and rabbits fed moringa at 10g/ kg diet level showed the least (2.766g/dl). As for ɣ-globulin feedback response to yarrow and moringa feed supplements was almost the same as globulin. There was a marked significant (P<0.05) decrease of ɣ-globulin level was indicated by feeding moringa at 10g/ kg diet (0.2g/dl- the least), followed by yarrow at 5g/ kg diet (0.266g/dl), then moringa at 5g/ kg diet (0.366g/dl), while the control group showed the highest concentration (0.933g/dl).

Table (4): Effect of Yarrow and Moringa on protein profile of weaning rabbit

Items	Control	Yarrow (g/kg diet)		Moringa (g/kg diet)		SEM	P value
		5	10	5	10		
Total protein, g/dl	5.466	5.400	5.400	5.300	5.333	0.05	0.871
Albumin, g/dl	2.200[c]	2.566[a]	2.366[bc]	2.433[ab]	2.566[a]	0.04	0.001
Globulin, g/dl	3.266[a]	2.833[b]	3.033[ab]	2.866[b]	2.766[b]	0.05	0.013
α-globulin, g/dl	1.533[c]	1.633[bc]	1.666[ab]	1.766[a]	1.666[ab]	0.02	0.013
β-globulin, g/dl	0.800[ab]	0.933[a]	0.833[ab]	0.733[b]	0.900[a]	0.03	0.079
γ-globulin, g/dl	0.933[a]	0.266[c]	0.533[b]	0.366[bc]	0.200[c]	0.06	0.00٠1

[a,b,c] Means in the same row having different letters are significantly different at ($p \leq 0.05$)

These results are disagreement with **Onu and Aniebo (2011)** and **Ebenebe *et al.*, (2012)**, who reported that *Moringa oleifera* leaf meal at 2.5, 5 and 7.5% in broiler chickens diet improved total protein, however serum albumin and globulin showed no significant difference among the treatments. In addition, **Ewuola *et al.*, (2012)**, assessed that the serum total protein, albumin and globulin values of rabbits fed moringa-based diets were not significantly different from those fed the control diet. They concluded that feeding moringa up to 15% inclusion in rabbit diet would not have an adverse effect on the biochemical response of the growing rabbits. Similarly, our results were in agreement with **Odetola *et al.* (2012)**, who found that no significant difference among the serum proteins of growing rabbits fed graded levels of dried *Moringa oleifera* leaf meal at 0, 5,10, and 15 %.

On the other hand, **Toghyani *et al.,* (2011)** observed no significant effects on serum protein, albumin, globulin and albumin to globulin ratio of broiler chicks fed on diet supplemented with 5 and 10 g/kg yarrow compared with the control group. Also, **Eidrisha *et al.*, (2022)** indicated that dietary achillea plant had no significant (P≥0.05) effect on total protein, albumin, globulin and albumin/ globulin (A/G) ratio values compared with the control group. Furthermore, **Damaziak *et al.*, (2022)** observed that higher albumin and total protein were in the serum of turkeys receiving yarrow supplemented diet and it can be attributed to the high total phenol content in the extract.

Immune indices

The results of adding yarrow and moringa supplement to weaned and growing rabbit feeds on phagocytosis indices (PA% and PI%) and immunoglobulin indices (IgG and IgM) are presented in Table 5. Adding no feed supplement to rabbits significantly (P<0.05) decreased both PA% (18.98%) and PI% (1.561%) compared to all the treated groups. Moreover, moringa at 10g level improved (P<0.05) PA% (21.68%) in comparison to its corresponding level at 5g (19.32%) and yarrow at 10g/ kg diet (19.56%).

Table (5): Effect of Yarrow and Moringa on phagocytosis and immunoglobulins indices of weaning rabbit

Items	Control	Yarrow (g/kg diet)		Moringa (g/kg diet)		SEM	P value
		5	10	5	10		
Phagocytosis indices							
PA, %	18.98^{b}	20.42^{ab}	19.56^{b}	19.32^{b}	21.68^{a}	0.29	0.013
PI, %	1.561^{c}	2.787^{a}	1.722^{bc}	1.881^{b}	1.595^{bc}	0.09	0.0001
Immunoglobulin indices							
IgG, mg/ml	995.0^{b}	1007^{ab}	1011^{a}	995.0^{b}	998.0^{ab}	2.30	0.067
IgM, mg/ml	242.6^{b}	257.3^{a}	257.3^{a}	242.6^{b}	257.0^{a}	2.17	0.095

^{a,b,c} Means in the same row having different letters are significantly different at (p≤0.05)
PA= Phagocytic activity; AI= Phagocytic index

On the other hand, yarrow at 5g/ kg diet elevated PI% to the maximum (2.787%) (P<0.05), compared to the 10g (1.722%) level and moringa at 5g (1.881%) and 10g (1.595%) treated rabbit groups. As for the immunoglobulin indices, no specific trend could be driven due to the feed additives under investigation. Both control and moringa at 5g level indicated the least IgG (999 and 995mg/ml) and IgM (242.6 and 242.6mg/ml), respectively ($P<0.05$) compared to other treated groups (Table 5). while yarrow supplement at 10g/ kg diet had the highest IgG (1011mg/ml) ($P<0.05$) and both levels of yarrow at 5 and 10g, as well as moringa at 10g group, recorded 6% more IgM than the least mentioned control and moringa at 5g groups (Table 5).

Moringa leaves helped to positively modify immune response due to the presence of different proteins and various peptides (isothiocyanates, glycoside cyanides, etc.) in poultry diets **(Mahfuz and Piao, 2019)**. Moreover, **Abd El-Moez *et al.* (2014)** reported that rabbits fed diets supplemented with particular levels of moringa leaves showed significantly lower intestinal microbial counts and improved immunity levels. Similar to our results, **El-Gindy *et al.* (2017)** indicated that moringa leaf meal was an immunomodulatory substance. That stimulated IgG and IgM immune response of growing rabbits. Greater serum globulin level of the moringa fed rabbits supported the immune-stimulant effect of *M. oleifera* since globulins are mainly responsible for enhancing immunity **(Igbinaduwa and Ebhotemhem, 2016)**. In addition, **El-Gindy *et al.* (2017)** showed that stimulated IgG and IgM immune responses of growing rabbits were significantly reduced as the concentration of moringa administered increased. Furthermore, the presence of flavonoids in leaf extracts may be a factor contributing to immune boosting qualities **(Hosseinzade *et al.*, 2019)**. Moreover, **Pilotos *et al.* (2020)** concluded that the high vitamin A contents in moringa could improve the competence of the immune system.

On the other hand, **Candan *et al.* (2003)** observed that humoral immune parameters were expected to be elevated by feeding yarrow. It is likely that a higher dosage of yarrow herb may be needed to stimulate humoral immune response to Newcastle disease and avian influenza vaccines **(Stojanovic *et al.*, 2005)**. It has been stated that Achillea species may have the potential to develop new functionality and nutraceutical products due to their strong antioxidant and anticytotoxic effects **(Yilmaz *et al.*, 2018)**.

Economic efficiency

The results of feeding weaned V-Line rabbits on yarrow and moringa supplement at 5 and 10g/ kg diet on economic efficiency is listed in Table 6. The highest total body weight was at yarrow 10g/ kg diet level (2.035g) compared to the control that had the least (1.820g). The same pattern, was also, noticed for total revenue as yarrow feed supplement at 10g/ kg diet significantly induced the highest value (91.60LE) and the control group had the least (81.90LE) (Table 6). While no trend could be detected for total cost due to adding either yarrow or moringa at the studied levels. It was the highest ($P<0.05$) in yarrow at 10g/ kg diet (74.23LE) and the lowest total cost observed with control group (68.26LE).

On the other hand, both yarrow and moringa supplements significantly increased net revenue and relative economic efficiency at both 5 and 10g/ kg diet compared to the control group that had the least values for net revenue (13.64LE) and relative economic efficiency (100%). Moreover, moringa supplement at both 5g/ kg diet significantly ($P<0.05$) increased economic efficiency percentage (24.62%) in comparison to the control group (19.89%).

Table (6): Effect of Yarrow and Moringa on Economic Efficiency of weaning rabbit

Items	Control	Yarrow (g/kg diet)		Moringa (g/kg diet)		SEM	P value
		5	10	5	10		
TBW, g	1.820^{b}	1.979^{ab}	2.035^{a}	1.957^{ab}	1.990^{ab}	0.03	0.171
Total Revenue, LE	81.90^{b}	89.06^{ab}	91.60^{a}	88.06^{ab}	89.56^{ab}	1.31	0.169
Total Cost, LE	68.26^{d}	72.36^{b}	74.23^{a}	70.66^{c}	72.53^{b}	0.55	0.0001
Net revenue, LE	13.64^{b}	16.69^{a}	17.32^{a}	17.40^{a}	17.02^{a}	0.49	0.043
EE, %	19.89^{b}	23.06^{ab}	23.33^{ab}	24.62^{a}	23.45^{ab}	0.62	0.149
REE, %	100^{b}	115.8^{a}	117.2^{a}	123.7^{a}	117.8^{a}	2.84	0.063

^{a,b,c,d} Means in the same row having different letters are significantly different at ($p \leq 0.05$)

TBW=total body weight; EE=economic efficiency; REE=relative economic efficiency

One of the key elements influencing bird performance and, consequently, the economics of poultry farming is intestinal health. However, healthy animals are able to maintain a balanced microbial population, which is crucial for animal growth and health **(Nkukwana, 2012).**

These results are in agreement with **Ayssiwede *et al.,* (2011)** who found that 8% and 16% of *Moringa oleifera* leaf meal resulted in the lowest feed cost/kg carcass. The enhanced considerable weight gain and net benefit for the moringa group were demonstrated by **Owen *et al.*, (2013)**. According to **Sobhy *et al.*, (2016)**, replacing alfalfa hay with moringa petioles meal at levels of 25 and 50% in rabbit diets increased net revenue and subsequently improved economic efficiency compared to the control group. The relative economic efficiency was also improved, and the improvement in economic efficiency could be attributed to the improvement in feed conversion of rabbits fed these diets. Our findings, conflict with those of **El-Badawi *et al.* (2014)** reported that rabbits fed diets containing 0.30 or 0.45% *Moringa oleifera* leaves decreased the economic efficiency percentage. Furthermore, **El-Adawy *et al.*, (2020)** discovered that feeding Moringa diets to rabbits resulted in higher economic efficiency percentages and relative economic efficiency percentages than feeding controls, and the increases were correlated with the level of Moringa in the diet. Moreover, **Bakr *et al.*, (2019)** and **Omar *et al.*, (2020)** revealed that the economic efficiency and relative economic efficiency in the various dietary moringa treatments were nearly identical in terms of total feed cost/rabbit, total revenue/weight gain, net revenue/rabbit, and economic efficiency.

Additionally, **El-Kashef *et al.* (2017 a&b)** and **Hussain *et al.* (2021)** discovered that quail and broiler chicks fed with medicinal plants had greater overall income and economic efficiency compared to the control group. Similar to this, **Eidrisha *et al.*, (2022)** reported that quail chicks fed a meal enriched with 5 g/kg of achillea plant recorded 3.08, 1.44%, and 107.91 in terms of net income, economic efficiency, and relative economic efficiency.

CONCLUSION

The present results indicated that, supplementation of yarrow or moringa at 5g/ Kg to diet of weaned rabbit (during 35-70 days of age) improved the productive performance, physiological, immunity response and represented the highest EE and REE. Further investigation into the interactions between yarrow supplementation, feeding period and dietary saturation are needed in order to identify optimal situations for yarrow usage.

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الملخص العربي

تأثير إضافة القيصوم والمورينجا على الأداء الإنتاجي والمناعي والفسيولوجي لأرانب الفي لين المفطومة

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يهدف هذا العمل إلى دراسة تأثير القيصوم والمورينجا على الإنتاجية والاستجابة المناعية والفسيولوجية لأرانب الفى لاين المفطومة. تم استخدام ٤٥ ذكر من أرانب الفى لاين المفطومة، عمر ٣٥ يومًا ووزعت الأرانب عشوائياً إلى ٥ مجموعات تجريبية. المجموعة الأولى عبارة عن مجموعة الكنترول بدون اضافة. والمجموعتين الثانية والثالثة تغذت على علف يحتوي على ٥ و١٠ جم قيصوم/ كجم ، والمجموعتين الرابعة والخامسة تغذت على علف يحتوي على ٥ و١٠ جم مورينجا/ كجم على التوالي. أدت إضافة كل من القصوم والمورينجا بمعدل ٥ أو ١٠ جم/ كجم إلى زيادة وزن الجسم والزيادة الوزنية للجسم ومعدل الأداء وتحسين معدل التحويل الغذائي للأرانب النامية أكثر من مجموعة الكنترول. وكان أقل استهلاك للعلف باضافة ٥ جم/ كجم من القيصوم مقارنة بجميع المجموعات المدروسة الأخرى، في حين أن أعلى استهلاك للعلف كان باضافة ١٠ جم/ كجم من القيصوم. وأدت اضافة كل من القيصوم والمورينجا إلى زيادة كبيرة في عدد كرات الدم الحمراء، وكرات الدم البيضاء، وحجم كرات الدم الحمراء مقارنة بمجموعة الكنترول. وكان أعلى تركيز للألبومين باضافة المورينجا بمعدل ١٠ جم/ كجم مقارنة بالكنترول. وزاد تركيز الألفا جلوبيولين باضافة المورينجا بمعدل ٥ جم/ كجم مقارنة بالكنترول. أدت مجموعة الكنترول والمورينجا بمعدل ٥ جم إلى انخفاض مستوى IgG وIgM مقارنة بالمعاملات الأخرى. بينما كان أعلى تركيز للـ IgG باضافة القيصوم بمعدل ١٠ جم/ كجم. أدت اضافة القيصوم بمعدل ١٠ جم/ كجم إلى انخفاض التكلفة الإجمالية مقارنة بالكنترول. بينما زاد صافي الربح والكفاءة الاقتصادية النسبية باضافة القيصوم والمورينجا مقارنة بالكنترول. علاوة على ذلك، فإن اضافة المورينجا بمعدل ٥ جم/ كجم أدت إلى زيادة نسبة الكفاءة الاقتصادية مقارنة بالكنترول. وأوضحت النتائج الحالية أن إضافة القصوم أو المورينجا بمعدل ٥ جم/ كجم حسن الأداء الإنتاجي والاستجابة الفسيولوجية والمناعة وصافي الربح للأرانب النامية.

الكلمات الدالة: القيصوم – المورينجا – الأرانب – الإنتاجية – الفسيولوجي - الاستجابة