Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 12(X), 202X:
http://dx.doi.org/10.7770/safer-V12N1-art2405

Influence of *Moringa oleifera* and *Senna occidentalis* leaf meal composite mixture as alternative to antibiotics on the growth, nutrient digestibility, costs and returns of broiler chickens.

Influencia de la mezcla compuesta de harina de hojas de Moringa oleifera y Senna occidentalis como alternativa a los antibióticos en el crecimiento, digestibilidad de nutrientes, costos y retornos de pollos de engorde.

S.O. Omoikhoje, R.O. Akindele, J.U. Hadome and F.Z. Mutana

Department of Animal Science, Ambrose Alli University, P.M.B 14, Ekpoma, Edo State, Nigeria. soomoikhojeaau@yahoo.com and stanleyoomoikhoje@aauekpoma.edu.ng

ABSTRACT

This study was conducted to assess the effect of *Moringa oleifera* leaf meal (MOLM) and *Senna occidentalis* leaf meal (SOLM) composite mixture on the growth performance, nutrient digestibility, costs and returns of broiler chickens. One hundred and fifty (150) day-old Cobb broiler chicks were randomly allotted to five (5) treatment groups (T_1, T_2, T_3 ,T_4 and T_5) in a completely randomized design (CRD). Each treatment group contained three (3) replicates with ten (10) birds per replicate and the feeding trial lasted for 8 weeks (56days). The experimental treatment included the control (maize – soya bean meal basal diet with oxytetracyline administered to the birds through drinking water) as $T_{1,}$ T_2 (same basal diet was mixed with 0.5% MOLM + 2.0% SOLM), T_3 (same basal diet was added with 1.0% MOLM + 1.5% SOLM), T_4 (same basal diet was added with 1.5% MOLM + 1.0% SOLM) and T_5 (same basal diet was mixed with 2.0% MOLM + 0.5% SOLM). There was no effect of treatments on the live weight, daily weight gain and feed intake, feed conversion ratio (FCR) and protein efficiency ratio (PER) of broiler chickens at the starter phase. At the finisher phase, live weight, daily weight gain and feed intake, feed conversion ratio (FCR) and protein efficiency ratio (PER) were better in broiler chickens that had 1.5% MOLM + 1.0% SOLM (T4) compared to other treatments. Apparent digestible dry matter, crude protein, crude fibre, ash, ether extract and nitrogen free extract (NFE) of broiler chickens were better in MOLM and SOLM

mixture than those on the control. The cost incurred per kilogramme weight gain, total cost of production, income and net profit were lower in birds on MOLM and SOLM blend compared to those on the control group. Conclusively, the combination of *Moringa oleifera* and *Senna occidentalis* leaf meal was beneficial in improving the growth performance, nutrient utilization and economic value of broiler chickens.
Key words: economic value, growth promoters, oxytetracycline, phytobiotics

RESUMEN

Este estudio se realizó para evaluar el efecto de la mezcla compuesta de harina de hojas de Moringa oleifera (MOLM) y harina de hojas de Senna occidentalis (SOLM) sobre el rendimiento del crecimiento, la digestibilidad de nutrientes, los costos y la rentabilidad de los pollos de engorde. Se asignaron al azar ciento cincuenta (150) pollos de engorde Cobb a cinco (5) grupos de tratamiento (T1, T2, T3, T4 y T5) en un diseño completamente aleatorizado (CRD). Cada grupo de tratamiento contenía tres (3) repeticiones con diez (10) aves por repetición y la prueba de alimentación duró 8 semanas (56 días). El tratamiento experimental incluyó el control (dieta basal de maíz - harina de soja con oxitetraciclina administrada a las aves a través del agua de bebida) como T1, T2 (se mezcló la misma dieta basal con 0.5% MOLM + 2.0% SOLM), T3 (misma dieta basal fue agregado con 1.0% MOLM + 1.5% SOLM), T4 (la misma dieta basal se agregó con 1.5% MOLM + 1.0% SOLM) y T5 (la misma dieta basal se mezcló con 2.0% MOLM + 0.5% SOLM). No hubo efecto de los tratamientos sobre el peso vivo, el aumento de peso diario y la ingesta de alimento, el índice de conversión alimenticia (FCR) y el índice de eficiencia proteica (PER) de los pollos de engorde en la fase inicial. En la fase de finalización, el peso vivo, el aumento de peso diario y la ingesta de alimento, el índice de conversión alimenticia (FCR) y el índice de eficiencia proteica (PER) fueron mejores en pollos de engorde que tenían 1.5% MOLM + 1.0% SOLM (T4) en comparación con otros tratamientos. La materia seca digestible aparente, la proteína cruda, la fibra cruda, la ceniza, el extracto de éter y el extracto libre de nitrógeno (NFE) de pollos de engorde fueron mejores en la mezcla de MOLM y SOLM que los del control. El costo incurrido por kilogramo de aumento de peso, el costo total de producción, los ingresos y la ganancia neta fueron menores en las aves con la mezcla MOLM y SOLM en comparación con las del grupo de control. En conclusión, la combinación de harina de hojas de Moringa oleifera y Senna occidentalis fue beneficiosa para mejorar el rendimiento del crecimiento, la utilización de nutrientes y el valor económico de los pollos de engorde.
Palabras clave: valor económico, promotores del crecimiento, oxitetraciclina, fitobióticos.

Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 12(X), 202X: http://dx.doi.org/10.7770/safer-V12N1-art2405

INTRODUCTION

Multiple forms of malnutrition which are evident in many countries of the world, due to poor access to healthy foods or balanced diets contribute immensely to under nutrition (FAO 2018) which increases the low birth weight, childhood stunting and anaemia in women of reproductive age. Besides, the high cost of nutritious food, which lead to maternal and infant/child food deprivation can result in foetal and early childhood metabolic immunity which increases the risk of obesity and diet-related non-communicable diseases later in life. Against this backdrop, the role of poultry production particularly broiler chickens in increasing the quality and quantity of animal protein intake in Nigeria because of the short generation interval and prolificacy cannot be overemphasized. In broiler production, good health accompanied with fast growth is necessary if maximum productivity is to be achieved. In the real sense, high quality and adequate quantity of feed may be provided, the amount of feed digested, nutrient absorbed and utilized is of paramount importance which is why the need to formulate diets that enhance gut health and function has become imperative. Consequently, feed additives such as antibiotics have been included in broiler rations to control the outbreak of diseases and to promote growth of broiler chickens. However, birds raised with these feed additives such as antibiotics achieve good performance but the potential side effects such as host and cross drug resistance poses a public health concern globally (Al-Harthi, 2006) and this has led to the ban of these products by many countries of the world (Kehinde et al 2011). The emergence of antibiotic resistant pathogens has necessitated the search for economically viable alternatives to antibiotics such as plant and plant extracts from herbs and spices which have been shown to have medicinal properties and improve feed efficiency. This is because they are known to contain bioactive compounds like tannins, saponins, alkaloids etc that have inhibitory activities against pathogens. Plant-derived natural products such as leaf meals represent an attractive source of antimicrobial agent since they are natural, have manageable side effects and are readily available at cheaper prices. The use of leaf meals particularly those of the leguminous plants as alternative to in-feed antibiotics in poultry production are fast gaining popularity globally. This perhaps can be adduced to the relatively high crude protein content and the presence of some bioactive ingredients or chemicals which help to improve the growth, health status and physiological conditions of the birds. Phenols for instance have been reported to promote the immune organ development as well as stimulate the immune system of chicks (Kamboh et al 2015). In line with this, Onyimonyi and Ernest (2009) opined that dietary inclusion of 2% papaya leaf meal in finisher diets improved carcass and organoleptic traits of broiler meat. Dietary inclusion of papaya leaf meal had also been reported (Ebrahimi et al 2015) to reduce lipid peroxidation and increased antioxidant activity of broiler breast meat. Moreover, feeding of *Sauropus androgynous* leaf meal reduced fat deposition in abdomen, liver and carcass of broiler chickens (Santoso and Sartini 2001). In terms of fat deposition, the phenolic compounds in leaf meal may serve as a lipid-lowering agent by inhibiting the synthesis of lipids and thereby reducing fat deposition in the body of broilers (Santoso and Sartini, 2001; Starcevic et al 2015). However, it should be noted that different types of leaf meals may exert different impacts on broiler meat traits due to a vast variety of types and levels of phenolic compounds across the plant leaves. Recently, Prakoso et al (2018) incorporated 5% of *Sauropus androgynus* leaf meal in broiler diets and observed that the treatment increased the final body weight of broilers contaminated with aflatoxin. This may be due to the fact that phenolic compounds inhibited the activity of the toxin and thereby alleviating the negative effect of aflatoxin in broiler chickens. Aside the antitoxin activity of green leaves, they may also be used as therapeutic agents for bacterial infections in broiler chickens. For example, Suryani et al (2014) and Sharma et al (2016) used *Morinda citrifolia* leaf extract and neem leaf extract respectively to reduce the prevalence of colibacillosis in broiler chickens. The antibacterial properties and immunomodulatory effects of the bioactive compounds in green leaves seem to be attributable to the therapeutic effects of the leaves (Sharma et al 2016). Mustafa (2019) reported that dietary incorporation of 1% *Eucalyptus camaldulensis* leaf meal improved the sensory evaluation such as flavour and juiciness of thigh and breast meats of broilers as well as the reduction of hardness and thiobarbituric acid reactive substances in the thigh and breast meats of the birds compared to control. Generally, medicinal plants are cheap and renewable sources of pharmacologically-active substances and are known to produce certain chemicals that are naturally toxic to bacteria (Basile et al 1999).

Moringa oleifera is one of the most researched trees that have attracted prominence owing to its vast range of nutritional contents (Mune et al 2016) and medicinal properties such as antibacterial , antiviral, antifungal, antiprotozoan, anticancer, antioxidant, anti-inflammatory (Al-husnan and Alkahtani, 2016; Liaqat et al 2016; Khan et al 2017). Similarly, the antimicrobial, antiallergic, antidiabetic,antipueretic, anti-inflammatory, antioxidant, hepatoprotective and analgesic properties of *Senna occidentalis* had been stressed (Sreejith et al 2010). The present study is to investigate the effect of *Moringa oleifera* and *Senna occidentalis* leaf meal mixture on growth performance, nutrient digestibility and economics of producing broiler chickens.

MATERIALS AND METHODS

Experimental location and climate: The experiment was carried out at the Poultry Unit of the Livestock Section, Teaching and Research Farm, Ambrose Alli University, Ekpoma , for a period of eight (8) weeks. The farm lies between lat 6.44^0N and long 6.8^0E in Esan West Local Government Area of Edo State, Nigeria. Ekpoma is within the south-geo-political zone of Nigeria and experiencing tropical climate with a mean annual rainfall of about 1556mm. The mean ambient temperature ranges from 26^0C in December to 34^0C in February, relative humidity ranges from 61% in January to 92% in August with yearly average of about 82%. The vegetation in this area represents an interface between the tropical rain forest and the derived savanna.

Sources of ingredients, fresh *Moringa oleifera* and *Senna occidentalis* leaves: The ingredients for the broiler starter and finisher diets were purchased from a reputable feed dealer in Benin City, Edo State, Nigeria. Fresh *Moringa oleifera* and coffee weed (*Senna occidentalis*) leaves were harvested within the University community.

Processing of *Moringa oleifera* and *Senna occidentalis* leaves: The fresh leaves of *Moringa oleifera* and *Senna occidentalis* were thoroughly rinsed and sparsely spread on jute mat at room temperature for 6-7 days until they became crispy. The leaves were turned regularly to avoid uneven drying and decay to ensure that the greenish colour of the leaves was maintained. Afterwards, the dried crispy leaves were hammer milled through a 2mm sieve and stored in airtight plastic containers to avoid moisture absorption till they were required for laboratory analyses and preparation of the experimental treatments and diets. The *Moringa oleifera* leaf meal and *Senna occidentalis* leaf meal were designated as MOLM and SOLM respectively.

Feeding and experimental treatments: The birds were fed commercial diets for one (1) week acclimatization period. Thereafter, they were fed with formulated basal starter and finisher diets as shown in Table 1 for the remaining three (3) weeks starter phase (brooding) and four (4) weeks finisher phase. The treatment groups included: the control (maize-soya bean meal basal diet but the birds took the antibiotic (Oxytetracycline) in drinking water) as T_1, T_2 (same basal diet was mixed with 0.5% MOLM + 2.0% SOLM), T_3 (basal diet was added with 1.0% MOLM + 1.5% SOLM), T4 (basal diet was added with 1.5% MOLM + 1.0% SOLM) and T_5 (basal diet was mixed with 2.0% MOLM + 0.5% SOLM). The antibiotic (oxytetracycline) was administered to the birds at weekly intervals following the manufacturer's prescription as a positive control (T_1). The basal diets (starter and finisher) were prepared and formulated to meet the nutrient requirements of broiler chickens (NRC 1994).

Experimental birds, design and management: A total of 150 Cobb strain of broiler chicks were used for the experiment. Thirty (30) chicks were randomly selected and allocated to each of the five (5) treatment groups (T_1, T_2, T_3, T_4 and T_5) in a completely randomized design (CRD). Each treatment group contained three (3) replicates with ten (10) birds per replicate. The chicks were brooded for four (4) weeks and during this period; they were fed a commercial starter diet without the experimental treatment for one (1) week acclimatization period. Thereafter, the birds were allowed free access to the dietary treatments *ad libitum* throughout the duration of the study. All routine management practices were carried out including vaccination.

Performance study: During the feeding trial, the broiler chicks were weighed at the beginning of the experiment and subsequently on a weekly basis. Weight changes and feed consumption were recorded weekly, while weight gain, feed intake, feed conversion ratio (FCR), protein efficiency ratio (PER) were estimated to assess the growth performance of the birds. Weight gain was calculated at the end of the week as final weight minus initial weight, while feed conversion ratio (FCR) and protein efficiency ratio (PER) were calculated using the formulae below:

$$\text{Feed conversion ratio} = \frac{\text{Feed intake (g)}}{\text{Weight gain (g)}}$$

Protein efficiency ratio = Weekly weight gain (g) / Protein intake

Digestibility Study: On the last week of both the starter and finisher phases, four birds were randomly selected per replicate to make a total of twelve birds per treatment group. The birds were placed in individual battery cage for faecal collection and were allowed two days acclimatizing period. Thereafter, measured quantities of the treatment diets were supplied to the birds every morning and left over weighed the next morning to obtain daily feed intake for each bird. Faeces were collected every morning for 5 consecutive days. Faeces or excreta collected were pooled together and oven dried at 80^{0}C for 12hours, homogenized and used for proximate analysis. The result of proximate analysis of the faecal samples and treatment diets were used to calculate the apparent nutrient digestibility using the formula proposed by Vogtman et al (1975) as expressed below:

$$\text{Apparent nutrient digestibility} = \frac{\text{Nutrient in feed} - \text{Nutrient in faeces}}{\text{Nutrient in feed}} \times \frac{100}{1}$$

Table 1: Nutrient composition of maize soybean basal starter and finisher diets

Nutrients (%)	Starter	Finisher
Maize	55.00	56.00
Soyabean meal	33.00	28.00
Fish meal	1.50	1.50
Palm kernel cake	3.00	5.00
Wheat offal	2.80	4.80
Bone meal	1.50	1.50
Limestone	2.50	2.50
Premix	0.25	0.25
Lysine	0.10	0.10
Methionine	0.10	0.10
Salt	0.25	0.25
Total	100.00	100.00
Calculated Analyses		
Crude protein (%)	21.49	20.02
Metabolizable energy (M.E Kcal/kg)	2832	2946

Cost and Return Analysis: The prevailing market prices of feed ingredients, day old chicks, market value of broiler chickens as at the time of the experiment (June to August, 2019) were used to estimate cost of feed consumed, cost of feed per kg weight gain, income and net profit. Cost of feed per kilogram weight gain of birds was estimated using the formula:

$$\text{Feed cost/kg gain} = \frac{\text{Feed consumed (kg) x cost of feed/kg}}{\text{Weight gain (kg)}}$$

Statistical Analysis: Data generated were subjected to a one way analysis of variance (ANOVA) and treatment means that significantly differed were compared using the Duncan's Multiple Range Test (DMRT) as outlined by Steel and Torrie (1990) using the SPSS (2014) IBM version 20.

RESULTS AND DISCUSSION

Data on the performance of broiler chickens as influenced by *Moringa oleifera and Senna occidentalis* leaf meal mixture revealed that there were no ($p > 0.05$) variation in live weight, daily weight gain, daily feed intake, feed conversion ratio and protein efficiency ratio at the starter phase (Table 2) while at the finisher phase, live weight, daily weight gain, protein efficiency ratio and feed conversion ratio were ($p < 0.05$) affected (Table 3). The non-significant variation in the live weight and daily weight gain of broiler chickens at the starter phase may be due to the fact that the inclusion of MOLM and SOLM in the diets did not in any way affect the growth performance of the birds negatively. According to Ladeji et al (1995) and Nworgu et al (2007) plant extracts such as *Senna occidentalis* and *Telfera occidentalis* leaf extracts contain low levels of saponins, tannic acid, phytate, and oxalate which are anti -nutrient substances that depress animal growth. However, in the present study, the inclusion of MOLM and SOLM did not exert any negative influence on the growth of the birds at the starter phase indicating that the concentrations of these inherent anti-nutrient substances in the leaf meal mixture were not toxic to the birds. The better final live weight and daily weight gain of birds on treatments 3, 4 and 5 suggests that these treatments may have stimulated a higher digestive activity on the nutrients consumed by the birds thereby promoting greater efficiency in the utilization of feed resulting in enhanced growth that culminated into the highest final live weight. This observation gives credence to the report of Zhang et al (2009) that plant extracts possess digestion stimulating properties and further strengthened the findings of Machebe et al (2010), Nworgu et al (2015) and Omoikhkoje et al (2018) that broiler chickens tolerated lower levels of *Gongronema latifolia, Telfera occidentalis* and *Senna occidentalis* leaf extracts respectively. However, daily feed intake was not ($p>0.05$) affected by the administration of the various treatments to the birds, this perhaps may point to the fact that the composite mixtures (MOLM + SOLM) were within the tolerable limits of the birds and as such did not hamper their growth. At the finisher phase, feed intake was numerically higher in birds that had the control compared to those on the test treatments. This alluded to the opinion of Ashong and Brown (2011) and Alabi et al (2017) that feed intake was higher in the control group compared to the treatment groups when *Moringa oleifera* leaf meal and *Moringa oleifera* leaf aqueous extract were administered to white leghorn and broiler chickens respectively. The decrease in the feed intake of broiler chickens placed on the treatment groups could be ascribed to the improvement in digestion and metabolic activities of *Moringa oleifera* and *Senna occidentalis* leaf meal mixture, thereby meeting the nutrients requirements of the birds at lower feed intake (Ghazalah and Ali, 2008). The comparable daily weight gain and feed intake of birds across the different combinations of MOLM and SOLM at the starter phase could be an indication that the concentration was within the adequate limits of the birds and as such did not suppress their growth.

Table 2: Performance indices of broiler chickens as affected by the treatments at the starter phase

Indices	Composite Mixture (MOLM + SOLM)					SEM±	Probability
	Control	0.5% + 2.0%	1.0% + 1.5%	1.5% + 1.0%	2.0% + 0.5%		
	Treatments (T)						
	1	2	3	4	5		
Llive weight (g/bird)	856	890	930	872	901	29.8	.873
Daily weight gain (g/bird)	36.6	37.3	39.6	37.4	37.9	0.91	.738
Daily feed intake (g/bird)	65.23	61.73	63.23	63.17	60.89	4.88	.997
Feed conversion ratio	1.77	1.65	1.62	1.68	1.60	0.10	.958
Protein efficiency ratio	1.70	1.73	1.81	1.74	1.76	0.42	.869
Mortality (%)	0.40	0.33	1.00	0.00	1.33	0.45	.743

SEM± : Standard error of mean

This observation is in line with the report of Tarimbuka et al (2017) who observed similarities in the weight gain and feed intake of weaner rabbits fed toasted *Senna ocidentalis* seed meal. The lowest and best feed conversion ratio recorded among the broiler chickens that had 2.0% MOLM + 0.5% SOLM at the starter phase and 1.5% MOLM + 1.0% SOLM at the finisher phase maybe attributed to the improvement in the energy and protein consumption of birds resulting from the enhanced nutrient availability due to MOLM and SOLM blend. This implies that the inclusion of 1.5% MOLM and 1.0% SOLM improved the conversion ability of the birds. This could be adduced to the fact that both leaf meals are not only concentrated in nutrients, but also help to reduce the activity of pathogenic bacteria and molds, thus improved the digestibility of other nutrients thereby helping the birds to express their natural genetic potentials (Gaia, 2005).

Mixtures of MOLM and SOLM (p<0.05) influenced the apparent dry matter, crude protein, crude fibre, ether extract, ash and NFE digestibility of broiler chickens at both starter and finisher phases except for crude protein that was not (p<0.05) affected at the finisher phase (Tables 4 and 5). The apparent digestible crude protein showed (p<0.05) variation among birds placed on the various combinations of *Moringa oleifera* leaf meal (MOLM) and *Senna occidentalis* leaf meal (SOLM) with the highest value recorded among birds on T_4. Though, there were no ($p>0.05$) differences in the digestible crude protein values of broiler chickens across the treatments at the finisher phase but the highest numerical value was also recorded in birds on T_4 which implies that 1.5MOLM + 1.0 SOLM mixture (T_4) improved the protein quality of the birds than the other dietary treatments at both phases.

Table 3: Performance indices of broiler chickens as affected by the treatments at the finisher phase

Indices	Composite Mixture (MOLM + SOLM)					SEM±	Probability
	Control	0.5% + 2.0%	1.0% + 1.5%	1.5% + 1.0%	2.0% + 0.5%		
	Treatments (T)						
	1	2	3	4	5		
Live weight (Kg/bird)	2.40^{a}	1.52^{b}	2.05^{a}	2.50^{a}	2.45^{a}	0.09	.005
Daily weight gain (g/bird)	47.0^{b}	55.0^{b}	67.0^{a}	67.3^{a}	65.0^{a}	1.71	.003
Daily feed intake (g/bird)	104	97.3	103	91.0	101	2.97	.429
Feed conversion ratio	2.14^{a}	1.78^{b}	1.66^{bc}	1.37^{c}	1.58^{bc}	0.06	.007
Protein efficiency ratio	2.35^{b}	2.75^{b}	3.16^{a}	3.36^{a}	3.23^{a}	0.07	.001
Mortality (%)	0.00	0.00	1.00	0.33	0.66	0.19	.226
Mortality (%)	0.00	0.00	1.00	0.33	0.66	0.19	.226

abc: Means in the same row with varying superscripts differ ($p<0.05$)

This could be adduced to the high protein content of the test ingredient as apparent crude protein digestibility had been reported to depend on the source and concentration of the protein in the feed stuff (McDonald et al 1994). This observation is in tandem with the report of Mustafa (2019) who observed significant differences in the crude protein content of broiler chickens placed on varying dosages of dried vegetable residue. Apparent crude fibre digestibility was ($p<0.05$) influenced by the various treatments with the highest value recorded in birds maintained on T_3 (1.0 MOLM + 1.5 SOLM) and lowest in those placed on the control at both phases. The higher apparent digestible crude fibre recorded in birds on the test treatments compared to the control could be due to the mixture of MOLM and SOLM as both are known to contain high fibre which facilitate the enhancement of the gastroduodenal refluxes that facilitates the contact between nutrients and digestive enzymes (Svihus et al 2004) which hitherto improved the nutrient digestibility (Amerah et al 2009) and growth performance of the birds (Gonzalez-Alvarado et al 2010). The apparent digestible ash, ether extract and NFE were (p<0.05) better in broiler chickens that had the MOLM and SOLM blend compared to those maintained on the control. This improvement in the digestibility of nutrients was triggered by an increase in the activities of digestive enzymes in the gastrointestinal tract of the birds (Lee et al 2004; Hernandez et al 2004). This can be ascribed to the fact plant extracts, leaves, herbs and spices contain different phytochemicals that have intrinsic bio-activities on animal physiology and metabolism. In fact, the incorporation of leaf meals have been found to increase production and activities of digestive enzymes as well as improve the intestinal morphology of broiler chickens resulting in improved nutrient digestibility and utilization (Mariana et al 2018; Mustafa, 2019).

The observed improvements in the apparent digestibility of dry matter, crude protein, crude fibre, ash, ether extract and NFE of broiler chickens at both phases corroborated the reports of Gakuya et al (2014) and Sebola et al (2019). The study revealed that MOLM and SOLM mixture improved the digestibility of nutrients in the diets of broiler chickens and therefore can be used as alternative to synthetic antibiotics.

The economics of producing broiler chickens using MOLM and SOLM composite mixture as alternative to antibiotics is reflected in Table 6. Total cost of feed consumed, cost of feed per kg weight gain, total cost of production, income and net profit were better in birds on the MOLM and SOLM blend compared to those on the control group. Highest income and net profit were generated from birds maintained on 1.5% MOLM + 1.0% SOLM based diet compared to those on other treatment groups. The result in the study showed that feeding broilers on 1.5% MOLM + 1.0% SOLM based diet led to better improvement in body weight which translated to the highest profit per bird. Thus, it could be inferred that it was more economically viable to feed broilers with 1.5% MOLM + 1.0% SOLM mixture for profit maximization.

Table 4: Apparent nutrient digestibility of broiler chickens as influenced by the treatments at the starter phase

	Composite Mixture (MOLM + SOLM)					SEM±	Probability
		0.5%	1.0%	1.5%	2.0%		
	Control	+ 2.0%	+ 1.5%	+ 1.0%	+ 0.5%		

Nutrients (%)	Treatments (T)						
	1	2	3	4	5		
Dry matter	53.80^{c}	54.65^{b}	54.85^{a}	53.71^{c}	53.84^{c}	0.05	.000
Crude protein	69.26^{d}	70.37^{c}	72.36^{b}	75.47^{a}	68.45^{e}	0.09	.000
Crude fibre	49.32^{d}	49.40^{d}	64.40^{a}	61.38^{b}	58.66^{c}	0.08	.000
Ether extract	64.73^{b}	73.54^{a}	62.63^{b}	63.45^{b}	62.63^{b}	2.62	.065
Ash	64.52^{c}	69.49^{a}	60.73^{d}	58.54^{e}	65.54^{b}	0.12	.000
Nitrogen free extract (NFE)	57.39^{e}	64.59^{c}	65.36^{b}	62.77^{d}	67.66^{a}	0.13	.000

abcde: Means in the same row with varying superscripts differ (*p*<0.05)

Table 5:Apparent nutrient digestibility of broiler chickens as influenced by the treatments at the finisher phase

	Composite Mixture (MOLM + SOLM)					SEM±	Probability
	Control	0.5% + 2.0%	1.0% + 1.5%	1.5% + 1.0%	2.0% + 0.5%		
Nutrients (%)	Treatments (T)						
	1	2	3	4	5		
Dry matter	53.39^{b}	52.66^{a}	51.32^{c}	50.00^{d}	50.00^{d}	0.07	.000
Crude protein	68.81	75.39	75.09	76.72	74.69	2.39	.236
Crude fibre	42.91^{d}	53.90^{c}	73.23^{a}	57.32^{bc}	66.73^{ab}	3.22	.001
Ether extract	53.90^{b}	66.74^{a}	50.25^{c}	53.90^{b}	66.77^{a}	0.08	.000
Ash	46.28^{c}	50.28^{b}	55.56^{a}	55.56^{a}	50.25^{b}	0.24	.000
Nitrogen free extract (NFE)	52.62^{d}	66.59^{a}	65.87^{b}	66.64^{a}	63.76^{c}	0.07	.000

abcd: Means in the same row with varying superscripts differ (*p*<0.05)

Table 6: Cost and returns analysis of broiler chickens as affected by the treatment.

	Composite Mixture (MOLM + SOLM)				
	Control	0.5% + 2.0%	1.0% + 1.5%	1.5% + 1.0%	2.0% + 0.5%

	Treatments (T)				
Parameters	1	2	3	4	5
Cost of feed /kg (₦)	108.11	108.11	108.11	108.11	108.11
Total cost of feed consumed (₦/bird)	521.54	490.16	510.73	475.51	493.92
Cost of feed/kg weight gain (₦)	239.00	191.38	166.59	146.19	169.89
Total cost of production (₦/bird)	1,081.54	1,050.16	1,070.73	1,035.51	1,053.92
Income (₦/bird)	2,584.00	3,485.00	4,080.00	4,250.00	4,165.00
Net Profit (₦/bird)	1,502.46	2,434.84	3,009.27	3,214.49	3,111.08

In conclusion, the supplementation of broiler chicken diets with *Moringa oleifera* leaf meal and *Senna occidentalis* leaf meal mixture generally improved the growth performance, nutrient digestibility and ultimately, better economic value of the birds. This therefore revealed the potentials of *Moringa oleifera* and *Senna occidentalis* leaf meal blend as probiotic additive in broiler chicken production. It can therefore be inferred that 1.5% MOLM + 1.0% SOLM can be included into the diets of broiler chickens as supplement to improve the performance of broiler chickens.

REFERENCES

Alabi O.J., Malik A.D., Ng'ambi J.W., Obaje P. and Ojo B.K. 2017 Effect of Aqueous *Moringa oleifera* (Lam) leaf extracts on growth performance and carcass characteristics of Hubbard Broiler Chicken. Brazillian Journal of Poultry Science. 19(2): 273-280.

Al-Harthi M A 2006 Efficiency of vegetable diet with antibiotics and different types of species or their mixture on the economic efficiency and carcass traits of broilers. Journal of Agricultural Science. 27: 3531-3545

Al-husna L A and Alkahtani M D F 2016 Impact of *Moringa* aqueous extract on pathogenic bacteria and fungi *in vitro.* Annals of Agricultural Science. 61: 247-250.

Amerah A, Ravindran M and Lentle R G 2009 Influence of insoluble fibre and whole wheat inclusion on the performance, digestive tract development and ileal microbiota profile of broiler chickens. British Poultry Science. 50:366–375.

Ashong J O and Brown D L 2011 Safety and efficiency of *Moringa oleifera* powder of growing poultry. Journal of Animal Science. 89(84): 273 – 278

Basile A, Giordano S, Lopez-Saez J A and Cobianchi R C 1999 Antibacterial activity of pure flavonoids isolated from mosses. Phytochemistry. 52: 1479-1482.

Ebrahimi M, Maroufyan E, Shakeri M, Oskoueian E, Soleimani A F and Goh Y M 2015 Papaya leaf in broiler chicken feed can reduce lipid peroxidation of meat. International Conference on Animal and Veterinary Medicine, April 20-21, 2015, Boston, USA.

F A O - Food and Agricultural Organization 2018. *Moringa*: Traditional Crop of the Month. Available online: http://www.fao.org/traditional-crops/moringa/en/2014

Gaia S 2005 Wonder tree 100 facts moringa fact 04 exceptional animal feed moringa as livestock feed & pet food. Moringa Mission Trust. http://gaiathelivingplanet.blogspot.com/2005/06/wondertree-100-facts-moringa-fact-04.html.

Gakuya D W, Mbugua P N, Kavoi B and Kiama S G 2014 Effect of supplementation of *Moringa oleifera* leaf meal in broiler chicken feed. International Journal of Poultry Science. 13: 208-213.

Ghazalah A A and Ali A M 2008 Rosemary leaves as dietary supplement for growth in broilers. International Journal of Poultry Sciences. 7(3): 234 – 239.

González-Alvarado J M, Jiménez-MorenoE, Lázaro R, Mateos G G 2010 Effects of type of cereal, heat processing of the cereal, and inclusion of fiber in the diet on productive performance and digestive traits of broilers. Poulttry Science. 86:1705–1715

Kamboh A A, Hang S Q, Khan M A and Zhu W Y 2016 *In vivo* immunomodulatory effects of plant flavonoids in lipopolysaccharide-challenged broilers. Animal. 10: 1619-1625.

Kehinde A S, Obun C O, Inuwa M and Bobado O 2011 Growth performance, haematological and some serum biochemical indices of cockerel chicks feed Ginger (*Zingiber officinate*) additives diets production. 36th Conference Nigeria society for Animal Production 13th-16th March, 2011 at University of Abuja, Nigeria .pp 185-189.

Khan N, Ajmal M, Nicklin J, Aslam S and Ali M 2007 Nutritional value of *Pleurotus (flabellatus)* DJAMOR(R-22) cultivated on saw dusts of different woods. Pakistan Journal of Botany. 45(3): 1105 – 1108.

Ladeji O, Okoye Z S C and Ojebe T 1995 Chemical evaluation of the nutritive value of leaf of fluted pumpkin (*Telfaria occidentalis*). Food Chemistry. 53: 353-355

Lee K W, Kappert H J and Frehner M 2004 Effects of dietary essential oil components on growth performance, digestive enzymes and lipid metabolism in female broiler chickens. British Poultry Science. 44: 450-457.

Liaqat S, Mahmood S, Ahmad S, Kamran Z and Koutoulis K C 2016 Replacement of canola meal with *Moringa oleifera* leaf powder affects performance and immune response in broilers. Journal of Applied Poultry Research. 25: 352-358.

Machebe N S, Agbo C U and Onuaguluchi C C 2010 Performance of finisher broilers served *Gongronema latifolia* Benth. Leaf extracts as supplementary source of vitamins and minerals. Proceedings of the 15th Annual Conference of Animal Science Association of Nigeria. Pp 20 -24

Mariana R A, Cecilia J P, Carlos J W, Jesús R G, Alejandro Á E and David S C 2018 Inclusion of the *Moringa oleifera* leaf on immunological constants in broiler chickens. Abanico Veterinario. 8: 68-74.

McDonald P, Edward R A and Greenhalgh (1994). Evaluation of food in Animal nutrition (4th Edn) Longman Scientific and technical. England Pp 260-283.

Mune M A M, Nyobe E C, Bassogog C B and Minka S R 2016 A comparison on the nutritional quality of proteins from *Moringa oleifera* leaves and seeds. Cogent Food and Agriculture, 2, 1213618.

Mustafa M A G 2019 Effect of *Eucalyptus* leaf and its supplementation with diet on broiler performance, microbial and physiological statues to alleviate cold stress. Iraqi Journal of Agricultural Science, 50, 953-963.

NRC-National Research Council 1994 Nutrient requirements of poultry (9th Revised Edition). NRC Academy Press, Washington DC. Volume 2, pp 26 – 34.

Nworgu F C, Alikwe P C N, Egbunike G N and Ohimain E I 2015 Economic importance and growth rate of broiler chickens fed with water leaf (*Talinum triangulae*) meal supplements. Asian Journal of Agricultural Extension, Economics Sociology. 4(1): 49-57

Omoikhoje S O, Obasoyo D O, Okosun S E, Uwaya J I, Adamu I and Idahor E 2018 Impact of coffee weed (*Senna occidentalis*) leaf aqueous extract as probiotic on the performance of broiler chickens in humid tropical environment. Microbiology Research Journal International 23(6): 1-10.

Onyimonyi A E and Ernest O 2009 An assessment of pawpaw leaf meal as protein ingredient for finishing broiler. International Journal of Poultry Science. 8: 995-998.

Prakoso Y A, Puspitasari Rini C S, Aliviameita A, Salasia S I O, Kurniasih Ikram A F D, Walalangi B, Utama K P, Al Huda M F and Su'udiyah N A 2018 The role of *Sauropus androgynus* (L.) Merr. leaf powder in the broiler chickens fed a diet naturally contaminated with aflatoxin. Journal of Toxicology,

Santoso U and Sartini R 2001 Reduction of fat accumulation in broiler chickens by *Sauropus Androgynus* (Katuk) leaf meal supplementation. Asian-Australasian Journal of Animal Science 14: 346-350. https://doi.org/10.5713/ajas.2001.346

Sebola N A, Mlambo V and Mokoboki H K 2019 Chemical characterization of *Moringa oleifera* (MO) leaf and the apparent digestibility of MO leaf meal-based diets offered to three chicken strains. Agroforestry Systems 93: 149-160.

Sharma V, Jakhar K K and Dahiya S 2016 Immuno-pathological studies on broiler chicken experimentally infected with *Escherichia coli* and supplemented with neem (*Azadirachta indica*) leaf extract. Veterinary World 9: 735-741.

S P S S 2014 Statistical Package for Social Sciences.Version 2.0 model of IBMSS.

Sreejith G, Latha P G, Shine V J, Anuja G I, Suja S R, Sini S, Shyama S, Predeep S, Shikha P and Rasasekharan S 2010 Anti-allegic, anti-inflammatory and anti-lipid peroxidant effects of *Cassia occidentalis* (L). India Journal of Experimental Biology. 5(48): 495 – 498.

Starcevic K, Krstulovic L, Brozić D, Mauric M, Stojevic Z, Mikulec Z, Bajic, M and Masek T 2015 Production performance, meat composition and oxidative susceptibility in broiler chicken fed with different phenolic compounds. Journal of the Science of Food and Agriculture 95: 1172-1178.

Steel R G D and Torrie J H 1990 Principle and procedure of statistics. A Biometrical Approach 3rd Edition. MacGraw Hill Book Co. New York.

Svihus B, Juvik I, Hetland H, Krogdahl A 2004 Causes for improvement in nutritive value of broiler chicken diets with whole wheat instead of ground wheat. British Poultry Science. 45:55–60.

Suryani A E, Karimy M F, Istiqomah L, Sofyan, A, Herdian H and Wibowo M H 2014 Colibacillosis prevalence in broiler chicken infected by *Escherichia coli* with administration of bioadditive, probiotic, and antibiotic. Widyariset 17: 233-244

Tarimbuka L I, Yusuf H B and Wafar R J 2017 Response of weaner rabbits fed toasted sickle pod (*Senns occidentalis*) seed meal. Asian Journal of Advances in Agricultural Research. 1: 1-8

Vogtman H, Pfirter P and Prabucki A L 1975 A new method of determining metabolizable energy and digestibility of fatty acids in broiler diets. British Poultry Science. 16: 531-534.

Zhang G F, Yang Z B, Wang Y, Yang W R, Jiang S Z and Gai G S 2009 Effects of ginger root (*Zingiber officinale*) processed to different particle size on growth performance, antioxidant status, and serum metabolites of broiler chickens. Poultry Science. 88: 2159-2166.

Received: 20th January 2021; Accepted: 15th March 2021; First distribution: 16th March 2022.