



Effect of Different Combinations of Methanolic Extract of *Moringa oleifera* and *Thymus vulgaris* on Production Performance, Gut Morphology, Hematology and Nutrient Digestibility in Broilers

Majid Ali^{1*}, Naila Chand¹, Sarzamin Khan¹, Shakoor Ahmad² and Muhammad Tahir³

¹Department of Poultry Science, Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture, Peshawar, Pakistan

²College of Veterinary Sciences, Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture, Peshawar, Pakistan

³Department of Animal Nutrition, Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture, Peshawar, Pakistan

ABSTRACT

The present study was designed to find the effect of methanolic extract of *Moringa oleifera* and *Thymus vulgaris* on the performance, hematology, digestibility and gut health in broiler chickens. A day-old 270 broiler chicks (Ross-308) were randomly assigned to 6 treatment groups with 3 replicates and 15 birds per replicate. CON (Control) group; M100 (*M. oleifera* 200mg/L); T100 (*T. vulgaris* 300mg/L); M50T50 (*M. oleifera* 100mg/L and *T. vulgaris* 150mg/L); M75T25 (*M. oleifera* 150mg/L and *T. vulgaris* 75mg/L); and M25T75 group (*M. oleifera* 50mg/L and *T. vulgaris* 225mg/L). Methanolic extract of both *M. oleifera* and *T. vulgaris* were supplemented in drinking water. The duration of the experiment was 42 days. The results showed significantly higher feed intake, body weight gain, feed conversion ratio, broiler performance efficiency factor, and broiler farm economy index in the M50T50 diet group. Digestibility of ash, dry matter, ether extract, crude fiber, and nitrogen-free extract were not affected except for crude protein which was significantly higher in the M50T50 diet group. Similarly, hematological parameters were not affected, while villus height, width, and crypt depth were significantly improved in the M50T50 diet group. These findings demonstrate that the supplementation of methanolic extract of *M. oleifera* and *T. vulgaris* in drinking water either alone or in combination improves the production performance, nutrient digestibility and gut health in broilers.

Article Information

Received 18 December 2022

Revised 20 February 2023

Accepted 10 March 2023

Available online 05 May 2023

(early access)

Published 10 May 2024

Authors' Contribution

MA study design, Animal trial, laboratory experiment, statistical analysis, and writing. NC study design, feed formulation, data evaluation, manuscript review. SK, SA and MT data analysis, data evaluation, manuscript review.

Key words

Moringa oleifera, *Thymus vulgaris*, Gut health, Digestibility, Production performance

INTRODUCTION

The poultry industry is the second largest sector of Pakistan and for the last several decades performed an emerging role in the country's economic sector contributing 5.77% to the agriculture sector, 26.7% to total meat in the form of superior protein, and 1.3% to national GDP (PPA, 2018-2019). More than 1.5 million people in

the country are involved in the poultry industry in the form of employment. In the last few decades, different synthetic and chemical antibiotics were used as growth promoters that harm the natural physiology of the bird microflora and also induced drug resistance in humans and bacteria. There is an intense need to decrease the application of synthetic drugs such as antibiotics in poultry production because of antimicrobial resistance (Borazjanizadeh *et al.*, 2011). This is possible through the inclusion and use of phyto-genic plants which replace antibiotics and work as growth promoters in poultry production. Therefore, poultry scientists are involved to investigate and use unconventional plants and plant by-products to decline the heavy economic damage in the form of different microbial diseases and improve poultry health and production. To date incorporation of phyto-genic extract generated an essential role in the improvement of the poultry industry in the form of health and performance. *Moringa oleifera* is a drought, a resistant

* Corresponding author: majidaup1@gmail.com
0030-9923/2024/0003-1477 \$ 9.00/0



Copyright 2024 by the authors. Licensee Zoological Society of Pakistan.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

and fast-growing tree grown in sub-Himalayan zones of northern Pakistan, Afghanistan, India, and Bangladesh. It is growing worldwide now in the subtropics and tropics zone (Fahey *et al.*, 2001). Siddhuraju and Becker (2003) reported that *M. oleifera* contains active ingredients such as crude protein 27.51%, ether extract 22.3%, crude fiber 19.25%, ash 7.13%, and dry matter 76.53%. It has also been reported to contain caffeic acid and chlorogenic acid also which are known for antioxidant effects. *M. oleifera* reduces and inhibits the degradation of amino acids and positively improves the growth performance of birds (Alagawany *et al.*, 2017). Ebenebe *et al.* (2012) have reported that *M. oleifera* supplementation improves the feed conversion ratio of meat-type birds. Supplementation of *M. oleifera* in the feed of broiler and layer birds suppresses the gut microbial count such as *C. perfringens*, coliforms, and *E. coli*, and also has a gut integrity role (Arif *et al.*, 2019). *Thymus vulgaris* known for cosmetic, medical, and culinary purposes. It has strong growth stimulant properties mostly used as an alternative for synthetic and chemical materials in the poultry industry. *T. vulgaris* have some important functions such as antioxidant, antiseptic, antispasmodic, and expectorant (Hertrampf, 2001; Adu-Darwish *et al.*, 2009). *T. vulgaris* contains thymol which is the fundamental active ingredient and also contains 21-56% volatile oils, carvacrol (5-isopropyl-2-methyl phenol), and phenolic compound (5-methyl-1-2-isopropyl phenol) with well-known antimicrobial activity (Rahimi *et al.*, 2011). Thyme contains intrinsic bioactivities and also has appetite and digestion-stimulating properties (Herendez *et al.*, 2004). This appetizing property increases feed utilization and growth performance (Bolukbasi *et al.*, 2006; Al-Mashadani *et al.*, 2011). Plant extract protects the absorptive surface and villi of the gut and intestine against toxins produced by pathogens mostly viruses and bacteria (Rolfe *et al.*, 2000). Thyme in combination with other phytochemicals significantly improves gut integrity by enhancing the villus height and width (Demir *et al.*, 2003). To date, very less studies reported on the extract of *M. oleifera* and *T. vulgaris* but no such study reported on the combined use of *M. oleifera* and *T. vulgaris* extract on poultry health and performance. Therefore; the current study was designed to determine the effect of different combinations of methanolic extract of *M. oleifera* and *T. vulgaris* on overall performance, gut morphology, hematology, and nutrient digestibility in broilers.

MATERIALS AND METHODS

Preparation of methanolic extract of *Moringa oleifera* and *Thymus vulgaris*

M. oleifera and *T. vulgaris* fresh leaves were harvested and collected from local areas of Peshawar, Khyber

Pakhtunkhwa Pakistan, and were separately air and shade dried because directly expose to extreme sun light effect the active ingredient of the plant leaves. For inhibiting the fungal growth, leaves were turned over at constant intervals for at least one week. After complete drying, the leaves were ground and sieved with a 0.15-mm sieve and made a fine powder. About 100 ml of absolute methanol and 200 gm powder of both *M. oleifera* and *T. vulgaris* leaves dissolved separately in soxhlet apparatus overnight. After 24 h about 50 ml extract was dissolved in dimethyl sulfoxide and kept for 72 h. After 72 h a cohesive mass was obtained which contained 10 mg/ml of methanolic extract of *M. oleifera* and *T. vulgaris* approximately. Experimental diets are presented in Table I.

Table I. Composition of feed during the starter and finisher phase of experimental birds.

Ingredients (%)	Starter phase	Finisher phase
Corn gluten meal	1.98	7.14
Corn	54.1	60.2
Corn oil	2.18	2.70
Soyabean meal	37.6	24.0
Limestone	0.81	0.67
Dicalcium phosphate	2.35	2.10
VM mix ^a	0.50	0.50
Salt	0.50	0.55
Lysine HCL	0.21	0.40
DL-Methionine	0.22	0.12
Cholin chloride	0.06	0.06
Threonine	0.12	0.10
Chemical composition		
Crude protein (%)	23.0	21.0
ME (Kcal/kg)	3000	3150
Methionine (%)	0.54	0.44
Sulphur amino acid (%)	0.94	0.78
Lysine (%)	1.40	1.22
Calcium (%)	1.06	0.90
Phosphorus (%)	0.50	0.46
Threonine (%)	0.95	0.88

^aVitamin-mineral premix contains the following ingredient per kg of feed: vitamin A, (2,400,000 IU); vitamin E, (16,000 IU); vitamin K, 800 mg; vitamin D, 1,000,000 IU; vitamin B12, 6 mg; vitamin B6, 1000 mg; vitamin B2, 1600 mg; vitamin B1, 600 mg; folic acid, 400 mg; biotin 40 mg; niacin, 8000 mg; pantothenic acid, 3000 mg; antioxidant, 3000 mg; copper, 2000 mg; selenium, 60 mg; cobalt, manganese, 18,000 mg; 80 mg; iron, 1200 mg; iodine, 400; zinc and 14,000 mg.

Experimental design and bird's husbandry

A total of 270 days old chicks (Ross-308) were

randomly assigned to six different treatment groups in a completely randomized design (CRD). Each treatment group was further divided into 3 replicates with 15 birds per replicate. The same basal diet was fed to birds of all experimental groups. Control group with (no supplementation); M100 (Supplemented with *Moringa* 200mg/L); T100 (supplemented with *Thyme* 300mg/L); M50T50 (supplemented with *M. oleifera* 100mg/L and *Thymus vulgaris* 150mg/L); M75T25 (supplemented with *Moringa oleifera* 150mg/L and *T. vulgaris* 75mg/L); M25T75 (supplemented with *M. oleifera* 50mg/L and *T. vulgaris* 225mg/L). All the supplementation was given in the drinking water. The optimum number of the drinker, feeder, and other requirements were provided to the birds in such a way that the bird's genetics show the best potential results of all the experimental parameters. The experiment was extended for 42 days including 7 days of adaptation.

Performance parameters

Feed was offered to the broiler chicks *ad libitum* and daily feed intake was measured by subtracting the refused feed from the feed offered while weight gain was calculated by subtracting the initial body weight from the final body weight. The feed conversion ratio was calculated by dividing feed intake by weight gain x 100. Mortality was recorded throughout the experiment. The percent livability was calculated at the end of the experiment by the formula:

$$\text{Livability (\%)} = \frac{\text{Birds sold} \div \text{number of birds present at the beginning} \times 100}{}$$

The broiler performance efficiency factor (BPEF) was computed by the formula;

$$\text{BPEF} = \frac{\text{Bird live body weight in Kg} \div \text{feed conversion ratio} \times 100}{}$$

while the broiler performance efficiency index was calculated by the formula:

$$\text{BPEI} = \frac{\text{live weight in kg} \times \% \text{ livability} \div \text{feed conversion ratio} \times \text{growing period in days}}{}$$

Hematology and gut morphometry

Blood parameters were determined on the last day of the experiment and 3 to 5 ml of blood was collected from the wing vein of 03 birds of each replicate. Hemocytometer was used for the manual calculation of total white blood cells (WBCs) and total red blood cells (RBCs) (Campbell, 1995). The packed cell volume (PCV) was measured by a standard manual technique using microhematocrit capillary tubes and blood was centrifuged at 2500 rpm for 5 min. The cyanmethemoglobin methodology was implemented for the estimation of hemoglobin (HB) concentration in the blood. For gut morphometry, the procedure used by Shuaib *et al.* (2022) was followed.

Nutrient digestibility

Nutrient digestibility was calculated by using the indigestible and insoluble marker Cr_2O_3 on day 35. From each replicate, 5 birds were randomly shifted to metabolic cages on day 35 of the experiment for total excreta collection. The birds remained for 4 days in these metabolic cages provided with a ration containing 0.2% Cr_2O_3 as an indigestible marker. Fresh fecal samples were collected twice a day in a plastic bag and stored at -20°C . Excreta samples, ileal digesta, and ground feed were properly dried, ground, and sieved through a 0.5-01 mm sieve and kept at -20°C . Proximate analyses of feed and excreta samples were done as defined by (Adejumo *et al.*, 2005). The concentrations of chromium were determined with the help of a UV absorption spectrophotometer (Shimadzu, Kyoto, Japan Shimadzu, UV-1201) as described by Williams *et al.* (1962). The nutrient digestibility was determined according to the procedure used by (Stefanello *et al.*, 2020).

Statistical analysis

Complete randomized design (CRD) was used for the analysis and computing of the collected data. For significance, the difference means were reviewed by least significant difference (LSD) (Guide, 2010).

RESULTS

Results regarding feed intake, weight gain, feed conversion ratio, production traits, and gut health are shown in Table II. During the starter phase higher ($P < 0.05$) feed intake was recorded in the M50T50 diet group but at the finisher phase in the M100, M50T50, and M75T25 diet groups. Overall, significantly higher feed intake was recorded in the M50T50 and M75T25 diet groups. Weight gain during the starter and finisher phases as well as overall was calculated higher ($P < 0.05$) in the M50T50 diet group. At the starter, and finisher phases and an overall significantly better FCR was recorded in the M50T50 and M75T25 diet groups. The highest significant BPEF was noted for M50T50, M25T75, and M75T25 diet groups, and the highest broiler farm economy index was noted for the M50T50 group. Mortality was recorded as non-significant among the groups. The villus height and villus width were recorded higher ($P < 0.05$) in the M50T50 diet group while the crypt depth had a higher ($P < 0.05$) value in the control group. Results regarding nutrient digestibility and hematology are presented in Table III. Digestibility of dry matter, ash, crude fiber, ether extract, and the nitrogen-free extract was not affected but crude protein had a significantly higher digestibility in the M100, M50T50, and M75T25 diet groups than the all-other groups. Blood parameters were not affected ($P < 0.05$) among the groups.

Table II. Effect of methonolic extract of *Moringa oleifera* and *Thymus vulgaris* alone or in different combinations on feed intake, weight gain, FCR, production traits and gut health of broiler birds.

Parameters	Groups						P value
	Control	M100	T100	M50T50	M75T25	M25T75	
Feed intake (g)							
Starter phase	982.3±7.35 ^c	1009±7.26 ^b	976.6±2.33 ^c	1048.3±3.28 ^a	1014.2±5.02 ^b	982±9.50 ^c	0.001
Finisher phase	2442.7±5.81 ^c	2745.3±11.7 ^a	2641.7±1.45 ^b	2780.7±3.93 ^a	2781.3±3.92 ^a	2668±23.3 ^b	0.003
Overall (day1-42)	3425±3.51 ^d	3754.7±5.36 ^b	3618.3±1.45 ^c	3829±38.6 ^a	3795.5±8.65 ^{ab}	3650±15.8 ^c	0.002
Weight gain (g)							
Starter phase	601.8±4.37 ^d	633.5±8.25 ^c	602.2±3.05 ^d	678.5±5.81 ^a	649.8±1.33 ^b	608.8±3.45 ^d	0.001
Finisher phase	1017±29.1 ^d	1399.3±12.3 ^c	1355.3±37.9 ^c	1650.7±10.7 ^a	1564.7±10.4 ^b	1342.3±8.25 ^c	0.002
Overall (day1-42)	1618.9±26.9 ^c	2032.9±18.6 ^c	1957.5±38.5 ^d	2329.2±9.07 ^a	2214.5±11.4 ^b	1951.2±11.7 ^d	0.003
FCR							
Starter phase	1.63±0.01 ^a	1.59±0.01 ^b	1.62±4.60 ^{ab}	1.54±9.30 ^c	1.56±7.30 ^c	1.61±8.50 ^{ab}	0.004
Finisher phase	2.40±0.06 ^a	1.96±0.02 ^b	1.94±0.05 ^b	1.68±0.02 ^c	1.77±0.01 ^c	1.98±0.02 ^b	0.001
Overall (day1-42)	2.11±0.04 ^a	1.84±0.01 ^b	1.84±0.03 ^b	1.64±0.01 ^c	1.71±0.01 ^c	1.87±0.01 ^b	0.002
Livability (%)	93.7±2.22	100.0±0.00	100.0±0.00	100.0±0.00	100.0±0.00	97.7±2.22	0.366
BPEF (%)	82.3± 4.08 ^d	109.3± 1.21 ^b	95.2± 2.66 ^c	121.4±1.31 ^a	116.4±0.41 ^a	118.3±1.50 ^a	0.003
BFEI	1.95± 0.30 ^c	2.63± 0.32 ^b	1.96 ±0.17 ^c	3.32± 0.11 ^a	2.67± 0.22 ^b	2.72± 0.33 ^b	0.000
Mortality (%)	1.00±0.57	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.33±0.33	0.366
Gut health							
Villus height(µm)	610± 4.08 ^c	824± 1.21 ^b	755± 2.66 ^{bc}	862±1.31 ^a	803±0.41 ^b	788±1.50 ^{bc}	0.003
Villus width (µm)	54± 0.30 ^c	68± 0.32 ^b	57±0.17 ^{bc}	74± 0.11 ^a	64± 0.22 ^b	59± 0.33 ^b	0.045
Crypt depth (µm)	68±1.23 ^a	59±0.53 ^b	56±2.78 ^b	47±2.22 ^d	56±2.78 ^b	53±2.22 ^c	0.003

Means with different superscripts in the same row to each treatment are significantly different at $\alpha=0.05$. Control, untreated; M100, supplemented with 100% *Moringa oleifera*; T100, supplemented with 100% *Thymus vulgaris*; M50T50, supplemented with 50% *M. oleifera* and 50% *T. vulgaris*; M75T25, supplemented with 75% *M. oleifera* and 25% *T. vulgaris*; M25T75, supplemented with 25% *M. oleifera* and 75% *T. vulgaris*; BFEI, broiler farm economy index; BPEF, broiler performance efficiency factor (%).

Table III. Effect of methonolic extract of *Moringa oleifera* and *Thymus vulgaris* alone or in different combinations on nutrient digestibility and hematology of broilers.

Parameters	Groups						P. value
	Control	M100	T100	M50T50	M75T25	M25T75	
DM (%)	66.3±0.76	70.2±0.47	68.5±0.38	71.7±0.37	70.6±0.34	69.1±0.60	0.140
Ash (%)	41.5±3.53	45.6±2.44	43.8±0.11	47.7±0.53	44.9±1.00	44.7±0.40	0.348
CP (%)	70.3±0.25 ^c	72.2±0.13 ^{ab}	70.7±0.22 ^c	73.0±0.16 ^a	71.9±0.04 ^{ab}	71.2±0.80 ^{bc}	0.002
EE (%)	77.9±2.83	81.3±1.23	78.6±2.29	85.0±1.21	81.7±1.26	80.1±0.68	0.128
CF (%)	79.8±1.33	83.5±0.92	81.6±0.74	83.9±0.01	83.6±0.33	81.2±0.28	0.299
NFE (%)	80.4±0.95	83.5±1.39	80.8±1.15	85.5±0.93	84.7±0.46	80.4±2.31	0.053
RBC (10 ¹² /L)	1.98±0.03	2.30±0.06	2.14±0.05	2.50±0.07	2.38±0.30	2.08±5.35	0.122
WBC (10 ⁹ /L)	10.5±0.85	7.97±1.19	8.85±2.38	6.98±0.03	6.32±0.57	6.97±0.05	0.188
PCV (%)	28.2±2.43	30.4±1.00	30.6±1.00	32.5±1.70	31.0±0.86	30.0±2.08	0.632
HB (g/dl)	10.2±1.00	10.9±0.60	10.8±0.20	12.6±0.40	12.0±0.87	11.2±1.08	0.357

Means with different superscripts in the same row to each treatment are significantly different at $\alpha=0.05$. DM, Dry matter; CP, Crude protein; EE, Ether extract; CF, Crude fiber; NFE, Nitrogen free extract; RBC, Red blood cells; WBC, White blood cells; PCV, Packed cell volume; HB, Hemoglobin.

DISCUSSION

In the current study, the M50T50 diet group exhibit the highest performance in the form of feed intake, body weight, and improved FCR while all the performance parameter were observed better in the phytogetic (*M. oleifera* and *T. vulgaris*) combination group than in the control group. Our results are similar to the findings of Feizi *et al.* (2013) who reported that thyme extracts contain thymol which activates broiler's digestive system by secreting endogen a digestive enzyme that speeds up the absorption rate of the intestine and subsequently improved the utilization and absorption of feed. Our results are also in line with the results of Mikhail *et al.* (2020) who stated that kaempferol and quercetin flavoring glycosides are abundant in the *M. oleifera* leaf. Provision of M50T50 significantly increased the bird's final body weight gain which might be due to synergetic effect of both *M. oleifera* and *T. vulgaris*. *M. oleifera* contains flavonoids having antimicrobial activity and the thymus contains thymol and carvacrol principle active molecules which increased the palatability of feed and also help to boost the nutrient absorption of broilers which ultimately leads to increased weight gain. Similarly, Alabi *et al.* (2017) reported that the phenolic compounds containing flavonoid content present in *M. oleifera* seeds had an encouraging effect on broiler growth rate. Alagawany *et al.* (2017) reported that *M. oleifera* could decrease and inhibit the degradation of amino acids and hence positively improve growth performance. Similarly, Feizi *et al.* (2013) supplemented the birds with *T. vulgaris* (200cc/1000 liter) and reported higher body weight gain, and Saki *et al.* (2014) mixed 0.2 ml/liter extract of *T. vulgaris* in drinking water and reported higher weight gain. Similarly, the best FCR was recorded in the M50T50 diet group which might be due to the synergetic effect of both *M. oleifera* and *T. vulgaris*. Similar results were also reported by Kout *et al.* (2015), who fed MOLM to birds with 0.2% concentration in the feed. Ebenebe *et al.* (2012) also found better FCR by supplementation of *M. oleifera*. Our results are also in line with Ocak *et al.* (2008) by the inclusion of 2% thyme. Cross *et al.* (2003), Dahal and Farran (2011) also favor our results. Supplementation of the methanolic extract significantly improved the broiler performance and economical parameters which are similar to the findings of Zanu *et al.* (2012) who reported improved feed cost in meat-type birds by supplementation of *M. oleifera* mix with fish meal. Abbas *et al.* (2012) also concluded that 10% *Moringa* leaf meal is cost-effective in broilers. Supplementation of methanolic extract of *M. oleifera* and *T. vulgaris* significantly ($P < 0.05$) affected the crude protein which is in line with the results of El-Badawi *et al.* (2014) who fed 0.15 or 0.30% *M. oleifera* dry leaves powder to the rabbits in the ration. Supplementation

of methanolic extract of *M. oleifera* and *T. vulgaris* significantly ($P < 0.05$) increased the height and width of the ilium portion of villi in all supplemented groups which is due to the synergetic effect of both phytogetic methanolic extract and this synergetic effect increases the surface area which directly increases the absorptive capacity and ultimately leads to increased digestibility and nutrient utilization. Generally, crypt depth decreased by increasing villus height and width and similarly, our findings also exhibited a higher decrease in crypt depth in group M50T50. Similarly, Saeed *et al.* (2018) found that broilers fed with herbs significantly stimulate the jejunum histology which enhanced the absorption of nutrients and growth performance.

CONCLUSION

The administration of methanolic extract of *M. oleifera* and *T. vulgaris* enhanced the utilization of feed efficiency, and body performance and also potentially modulate and improve gut health which beneficially improves the crude protein digestibility. Hence supplementation of methanolic extract of *M. oleifera* and *T. vulgaris* alone and in combination form enhanced the broilers' performance but the most effective improvement was exhibited by the M50T50 group in drinking water on the production performance, nutrient digestibility, and gut health in broilers.

ACKNOWLEDGMENT

We acknowledge the staff of the Department of Poultry Science and Faculty of Animal Husbandry and Veterinary Sciences (FAHVS), The University of Agriculture Peshawar, Pakistan who provided technical and laboratory facilities.

Funding

No funding was provided /received for this study.

IRB approval

The experimental work was approved by the Advanced Studies and Research Board (ASRB) (No.712/ASRB-56/UAP), The University of Agriculture, Peshawar, KP, Pakistan.

Ethical statement

This study was approved by the animal welfare and care committee of the Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture, Peshawar, Pakistan, and all the measures and tools was considered to minimize the pain and discomfort of birds during the conduction of this experiment.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

- Abbas, T.E., 2013. The use of *Moringa oleifera* in poultry diets. *Turk. J. Vet. Anim. Sci.*, **37**: 492-496. <https://doi.org/10.3906/vet-1211-40>
- Abbas, K.A., Saleh, A.M., Lasekan, O. and Sahar, K., 2010. A review on factors affecting drying process of pistachio and their impact on product's quality. *J. Agric. Sci.*, **2**. <http://psasir.upm.edu.my/id/eprint/13271/>
- Abu-Darwish, M.S., Abu-Dieyeh, Z.H., Batarseh, M., Al-Tawaha, A.R.M. and Al-Dalian, S.Y.A., 2009. Trace element contents and essential oil yields from wild thyme plant (*Thymus serpyllum*) growth at different natural variable environments. *Jordan J. Fd. Agric. Environ.*, **7**: 920-924. <https://pubag.nal.usda.gov/catalog/774817>
- Adejumo, T.O. and Awosanya, O.B., 2005. Proximate and mineral composition of four edible mushroom species from South Western Nigeria. *Afr. J. Biotechnol.*, **4**: <https://www.ajol.info/index.php/ajb/article/view/71255>
- Adejumo, T.O. and Awosanya, O.B., 2005. Proximate and mineral composition of four edible mushroom species from south western Nigerian mushrooms: Underutilized non-wood forest resources. *Afr. J. Biotechnol.*, **4**: 1084-1088. <https://doi.org/10.4236/nr.2021.122005>
- 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. *Braz. J. Poult. Sci.*, **19**: 273-280. <https://doi.org/10.1590/1806-9061-2016-0373>
- Alagawany, M., Abd El-Hack, M.E., Arain, M.A. and Arif, M., 2017. Effect of some phyto-genic additives as dietary supplements on performance, egg quality, serum biochemical parameters and oxidative status in laying hens. *Indian J. Anim. Sci.*, **87**: 103-110. <https://doi.org/10.3390/ani12172278>
- Al-Mashhadani, E.A., Farah, K.A., Farhan, Y.M. and Al-Mashhadani, H.E., 2011. Effect of anise, thyme essential oils and their mixture on broiler performance and some on physiological traits. *Egypt. J. Poult. Sci.*, **31**:481-489.<http://dx.doi.org/10.13140/RG.2.2.24998.01607>
- Arif, M., Hayat, Z., Abd El-Hack, M.E., Saeed, M., Imran, H.M., Alowaimer, A.N. and Swelum, A.A., 2019. Impacts of supplementing broiler diets with a powder mixture of black cumin, *Moringa* and chicory seeds. *S. Afr. J. Anim. Sci.*, **49**: 564-572. <https://doi.org/10.4314/sajas.v49i3.17>
- Attia, Y.A., Bakhashwain, A.A. and Bertu, N.K., 2017. Thyme oil (*Thyme vulgaris* L.) as a natural growth promoter for broiler chickens reared under hot climate. *Ital. J. Anim. Sci.*, **16**: 275-282. <https://doi.org/10.1080/1828051X.2016.1245594>
- Bolukbasi, S.C. and Erhan, M.K., 2007. Effect of dietary thyme (*Thymus vulgaris*) on laying hens performance and *Escherichia coli* (*E. coli*) concentration in feces. *Int. J. Nat. Engin. Sci.*, **1**: <https://doi.org/10.1002%2Fvms3.736>
- Borazjanizadeh, M., Eslami, M., Bojarpour, M., Chaji, M. and Fayazi, J., 2011. The effect of clove and oregano on economic value of broiler chickens diet under hot weather of Khuzesta. *J. Anim. Vet. Adv.*, **10**: 169-173. <https://doi.org/10.3923/javaa.2011.169.173>
- Campbell, R.P., Ristaino, J.B. and Larkin, C.L., 1995. Detection and quantification of *Phytophthora capsici* in soil. *Phytopathology*, **85**: 1057-1063. <https://doi.org/10.1094/Phyto-85-1057>
- Choi, J.H., So, B.S., Ryu, K.S. and Kang, S.L., 1986. Effects of pelleted or crumbled diets on the performance and the development of the digestive organs of broilers. *Poult. Sci.*, **65**: 594-597. <https://doi.org/10.3382/ps.0650594>
- Cross, D.E., Svoboda, K., Mcdedvitt, R.M. and Acomovit, 2003. The performance of chicken fed diet with and without thym oil and enzyme. *Br. Poult. Sci.*, **44** (suppl. 1): 18-19. <https://doi.org/10.1080/713655293>
- Dahal, I.M. and Farran, M.T., 2011. Effect of dried medicinal crops on the performance and carcass flavour of broilers. *Int. J. Poult. Sci.*, **10**: 152-156. <https://agris.fao.org/agris-search/search.do?recordID=DJ2012062783>, <https://doi.org/10.3923/ijps.2011.152.156>
- Demir, E., Sarica, Ş., Özcan, M.A. and Suiçmez, M., 2003. The use of natural feed additives as alternative for an antibiotic growth promoter in broiler diets. *Br. Poult. Sci.*, **45**(Suppl. 1): 44. <https://doi.org/10.1080/713655288>
- Ebenebe, C.L., Umegechi, C.A. and Nweze, B.O., 2012. Comparison of haematological parameters and weight changes of broiler chicks fed different levels of *Moringa oleifera* diet. *Inter. J. Agric. Bio Sci.*, **1**: 23-25.
- El-Badawi, A.Y., Omer, H.A.A., Abedo, A.A. and Yacout, M.H.M., 2014. Response of growing New Zealand white rabbits to rations supplemented with different levels of *Moringa oleifera* dry leaves. *Glob. Vet.*, **12**: 573-582. <https://www.cabdirect.org/>

- [cabdirect/abstract/20143162776](https://doi.org/10.1016/S0031-9422(00)00316-2)
- Fahey, J.W., Zackmann, A.T. and Talalay, P., 2001. The chemical diversity and distribution of glucosinolates and isothiocyanates among plants. *Corgendum Phytochem.*, **59**: 200-237. [https://doi.org/10.1016/S0031-9422\(00\)00316-2](https://doi.org/10.1016/S0031-9422(00)00316-2)
- Feizi, A., Bijanzad, P., and Kaboli, K., 2013. Effects of thyme volatile oils on performance of broiler chickens. *Eur. J. exp. Biol.*, **3**: 250-254. <https://www.researchgate.net/publication/235694304>
- Guide, S.U., 2010. *Statistic* (Version 9.3). SAS Institute. Inc, Cary, NC, USA.
- Hernandez F., Madrid J., Garcia V., Orengo J. and Megias M.D., 2004. Influence of two plant extracts on broilers performance, digestibility, and digestive organ size. *Poult. Sci.*, **83**: 169–174 <https://doi.org/10.1093/ps/83.2.169>
- Hertrampf, J.W., 2001. Alternative antibacterial, performance promoters. *Poult. Int.*, **42**: 50-52.
- Jang, I.S., Ko, Y.H., Kang, S.Y. and Lee, C.Y., 2007. Effect of a commercial essential oil on growth performance, digestive enzyme activity and intestinal microflora population in broiler chickens. *Anim. Feed Sci. Technol.*, **34**: 304–315. <https://doi.org/10.1016/j.anifeedsci.2006.06.009>
- Kout, E., El, M., Riry, M., Shata, F.H., Hanan, M.A.M., Alghonimy, A.H. and Youssef, S.F., 2015. Effect of using *Moringa oleifera* leaf meal on performance of Japanese quail. *Egypt. Poult. Sci.*, **35**: 1095-1108. <https://www.researchgate.net/publication/286418868>
- Mikhail, W.Z., Abd El-Samee, M.O., El-Affif, T.M. and Mohammed, A.R., 2020. Effect of feeding *Moringa oleifera* leaf meal with or without enzyme on the performance and carcass characteristics of broiler chicks. *Pl. Arch.*, **20**: 3381–3388. <https://arcejournals.com/journal/asian-journal-of-dairy-and-food-research/DR-1612>
- Ocak, N., Erener, G., Burak Ak, F., Sungu, M., Altop, A. and Ozmen, A., 2008. Performance of broilers fed diets supplemented with dry peppermint (*Mentha piperita* L.) or thyme (*Thymus vulgaris* L.) leaves as growth promoter source. *Czech J. Anim. Sci.*, **53**: 169. <https://www.agriculturejournals.cz/publicFiles/01131.pdf>, <https://doi.org/10.17221/373-CJAS>
- Ochi, E.B., Elbushra, M.E., Fatur, M., Abubakr, O., and Ismail, H.A., 2015. Effect of *Moringa oleifera* (Lam) seeds on the performance and carcass characteristics of broiler chickens. *J. natl. Sci. Res.*, **5**: 66-73. <https://www.researchgate.net/publication/324543462>
- PPA (Pakistan Poultry Association), 2018-19. <https://pakistanpoultryassociation.com.pk/#:~:text=Pakistan%20Poultry%20Association%20%E2%80%93%20PPA>
- Rahimi, S., Zadeh, Z.T., Torshizi, M.A.K., Omidbaigi, R. and Rokni, H., 2011. Effect of the three herbal extracts on growth performance, immune system, blood factors and intestinal selected bacterial population in broiler chickens. *J. Agric. Sci. Technol.*, **13**: 527-539. [https://www.scirp.org/\(S\(czeh2tfqw2orz553k1w0r45\)\)/reference/referencespapers.aspx?referenceid=2670162](https://www.scirp.org/(S(czeh2tfqw2orz553k1w0r45))/reference/referencespapers.aspx?referenceid=2670162)
- Rolfe, R.D., 2000. The role of probiotic cultures in the control of gastrointestinal health. *J. Nutr.*, **130**(2S Suppl.): 396S–402S. <https://doi.org/10.1093/jn/130.2.396S>
- Saeed, M., Arain, M.A., Naveed, M., Alagawany, M., El-Hack, A., Ezzat, M. and Chao, S., 2018. *Yucca schidigera* can mitigate ammonia emissions from manure and promote poultry health and production. *Environ. Sci. Pollut. Res.*, **25**: 35027-35033. <https://doi.org/10.1017/S0043933918000235>
- Saki, K., Bahmani, M. and Rafieian-Kopaei, M., 2014. The effect of most important medicinal plants on two important psychiatric disorders (anxiety and depression)-a review. *Asian Pacif. J. trop. Med.*, **7**: S34-S42. [https://doi.org/10.1016/S1995-7645\(14\)60201-7](https://doi.org/10.1016/S1995-7645(14)60201-7)
- Shuaib, M., Hafeez, A., Kim, W.K., Khan, A., and Sufyan, A., 2022. Effect of dietary inclusion of soybean hulls in basal diet on digesta viscosity, fecal consistency, hematology, serum biochemistry, and intestinal morphometric parameters in the laying hens during peak egg production stages. *Pakistan J. Zool.*, pages 1-9. <https://doi.org/10.17582/journal.pjz/20220424140433>
- Siddhuraju, P. and Becker, K., 2003. Antioxidant properties of various solvent extracts of total phenolic constituents for three different agro climatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. *J. Agric. Fd. Chem.*, **51**: 2144-2155. <https://doi.org/10.1021/jf020444>
- Stefanello, C., Rosa, D.P., Dalmoro, Y.K., Segatto, A.L., Vieira, M.S., Moraes, M.L. and Santin, E., 2020. Protected blend of organic acids and essential oils improves growth performance, nutrient digestibility, and intestinal health of broiler chickens undergoing an intestinal challenge. *Front. Vet. Sci.*, **6**: 491. <https://doi.org/10.3389/fvets.2019.00491>
- Tesfaye, E., Anmut, G., Urge, M. and Dessie, T., 2012. Effect of replacing *Moringa oleifera* leaf meal for

- soybean meal in broiler ration. *Glob. J. Sci. Front. Res. Agric. Biol.*, **12**: <https://www.researchgate.net/publication/269953735>, <https://doi.org/10.3923/ijps.2013.289.297>
- Thompson, L.U., 1993. *Potential health benefits and problems associated with antinutrients*. [https://doi.org/10.1016/0963-9969\(93\)90069-U](https://doi.org/10.1016/0963-9969(93)90069-U)
- Wang, M.Q., Xu, Z.R., Sun, J.Y. and Kim, B.G., 2008. Effects of enzyme supplementation on growth, intestinal content viscosity, and digestive enzyme activities in growing pigs fed rough rice-based diet. *Asian Aust. J. Anim. Sci.*, **21**: 270-276. <http://www.ajas.info/Editor/manuscript/upload/21-39.pdf>
- Williams, C.H., David, D.J. and Iismaa, O., 1962. The determination of chromic oxide in faeces samples by atomic absorption spectrophotometry. *J. agric. Sci.*, **59**: 381-385. <https://doi.org/10.1017/S002185960001546X>
- Zanu, H.K., Asiedu, P., Tampuori, M., Abada, M. and Asante, I., 2012. Possibilities of using Moringa (*Moringa oleifera*) leaf meal as a partial substitute for fishmeal in broiler chicken's diets. *Online J. Anim. Feed Res.*, **2**: 70-75. <https://www.cabdirect.org/cabdirect/abstract/20123130680>