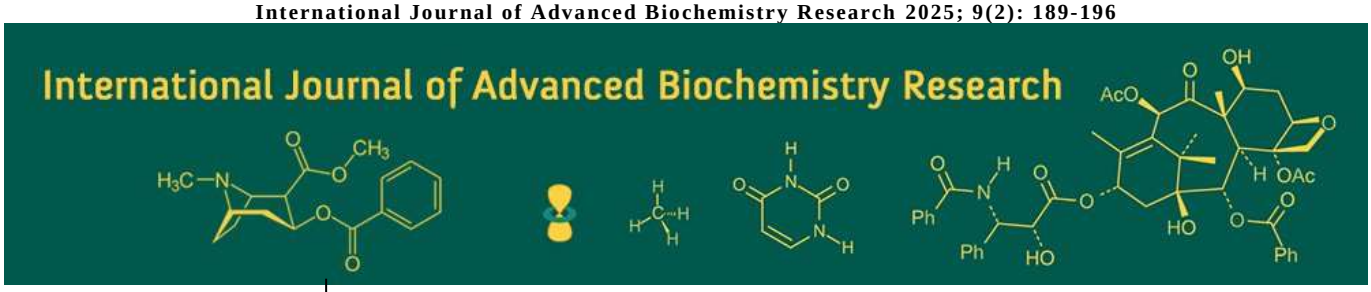

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Study on the beneficial effects of supplementing *M. oleifera* leaf powder on growth and health of early weaned LWY piglets

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Abstract
Present study reports the effects of dietary supplementation of *Moringa oleifera* leaf powder (MOLP) on growth of early weaned piglets in terms of body weight gain as well as on their health as assessed by occurrence rate of diarrhoea and haematological analysis. For the experiment, eighteen (18) numbers of clinically healthy piglets were randomly selected and weaned at 28 days of age. All the weaner piglets were of approximately same body weight. The selected piglets were grouped as control (C), treatment-I (T-1) and treatment-II (T-2) with six piglets in each group. The control group was fed only basal diet, while treatment-I and treatment-II groups were fed basal diet with inclusion of MOLP @ 1% and 2%, respectively. The feeding trial was conducted for a period six weeks i.e from day 28 to day 70. Occurrence of diarrhoea was recorded day to day basis, whereas body weight of the piglets was measured on the day of weaning (Day 28) and then till day 70 at 14 days intervals i.e on day 42, 56 and 70. Four (4) ml of blood was also collected on day 28, 42, 56 and 70 from each piglet of all three groups, which were immediately subjected to haematological analysis. Result of the study revealed that overall occurrence rate of diarrhoea was significantly lower in treatment groups as compared to control group. Nonetheless, the gain of body weight was higher in both the treatment groups than the control group although the variation was non-significant. Haematological data showed that Hb and PCV were significantly higher in the treatment groups, but MCV, MCH and MCHC were comparable amongst the experimental groups. TLC was higher, but neutrophil count dropped in the treatment groups. The variation observed in lymphocyte, monocyte and eosinophil counts between the control and treatment groups were statistically non-significant. Based on the results, it is concluded that dietary inclusion of MOLP is beneficial for growth and health of early weaned piglets as evidenced by higher body weight gain, lower incidences of post weaning diarrhoea and improved haematological indices.

Keywords: Weaning, piglets, moringa, diarrhoea, body weight, haematology

Introduction
Early weaning practices are often followed in modern intensive swine production, which improves productivity by increasing annual litter size of sows and fetch more economic returns for pig farmers (Faccin *et al*., 2020) [16]. Nonetheless, suckling-weaning transition is the most critical phase in the life of a pig. The pig famers face many challenges to ensure growth and health of piglets, particularly during post weaning period (Holman *et al*., 2021) [19]. Abrupt separation of the piglets from the sow and sudden changes from milk to plant based diet significantly induce stress and effect the growth and health of the young piglets (O'Doherty *et al*., 2024) [30]. Previous studies reported that interplay of multiple stressors including social separation, environmental change and dietary shift collectively effect immune system, gastrointestinal health and overall physiology of the weaned piglets (Xiong *et al*., 2019; Canibe *et al*., 2022) [44, 9]. The feed intake of the piglets also drastically reduced immediately after weaning. Consequently, the growth and development of the piglets are severely affected. Further, weaning stress often cause changes in the gut morphology of the piglets, disrupts intestinal gut microbiota that alters digestion and absorption capacity, which in turn lead to post weaning diarrhoea and retardation of growth (Tang *et al*., 2024) [39]. Weaning stress also alters the balance between reactive oxygen species (ROS) and body's antioxidant arsenals to counteract them. Thus, it induces oxidative stress that significantly affects the health of the piglets leading to high morbidity and mortality (Novais *et al*., 2021) [28].

Therefore, to ameliorate weaning stress is major concern of the farmers for profitable pig production. Many different feeding regime and management practices have been tried time to time for minimizing weaning stress though with little success. Nonetheless, in recent years, the use of phytobiotics is gaining momentum in feed industry owing to their potential roles in growth, health and productivity of livestock (Pandey *et al*., 2023) [35]. The phytobiotics are bioactive compounds derived from plants that can be used as feed additives (Martel *et al*., 2020; Kikusato, 2021) [25, 24]. They exhibit wide range of therapeutic efficacy including antimicrobial, anti-oxidative and anti-inflammatory effects. One very important plant that is considered to be a significant source of phytobiotics is *Moringa olerifera*, commonly called as 'moringa' or 'drumstick tree'. Various parts of moringa tree have been widely used for centuries in folk medicine as well as for production of many pharmacologically important compounds (Senthil kumar *et al*., 2018, Tshabalala *et al*., 2020) [37, 42]. In modern husbandry practises, dietary inclusion of moringa leaves for animal production has received immense attention with some encouraging results. Moringa leaves are found to be a natural alternative to increase gut health by controlling of gastrointestinal parasites in equines (Elghandour *et al*., 2023) [15]. A study also demonstrated that supplementation of *Moringa oleifera* leaf powder (MOLP) as an additive in total mixed ration increased digestibility and reduced methane emission in ruminants (Keshri *et al*., 2022) [22]. The fresh MOLP is also found to increase milk production and attenuate oxidative stress in peri-parturient goats (Afzal *et al*., 2022) [1]. Feeding of these leaves have improved anti-oxidant status and reproductive performance in mice and sows (Zeng *et al*., 2019, Sun *et al*., 2020) [46, 38]. Present study was aimed to evaluate the beneficial effects of MOLP on growth and health of early weaned piglets during post weaning period.

Materials and Methods

Location of the experiment

The location of the experiment was College of Veterinary Sciences and A.H., Central Agricultural University, Aizawl, Mizoram, India.

Grouping and feeding management of experimental animals

For the study, eighteen (18) Large White Yorkshire (LWY) piglets of almost same age and body weight were selected from the piggery unit of Instructional Livestock Farm Complex (ILFC) of the college. All the piglets were weaned at 28 days of age and immediately shifted to weaner pens. Considering apparent health and birth weight, all the selected piglets were grouped into Control (C), Treatment-I (T_1), Treatment-II (T_2) in a completely randomized block design with 6 piglets in each group. Standard routine management practices like iron injection, deworming etc. were carried out during the study period. The piglets were fed with standard rations prepared as per NRC (2012) [29] specification by using conventional feed ingredients with the inclusion of *Moringa oleifera* leaf powder (MOLP). The control group was fed only basal feed; whereas T_1 and T_2 groups were fed basal feed with inclusion of MOLP @ 1% and 2%, respectively. The feeding trial was carried out for a period of six weeks. Piglets of all the experimental groups were provided with similar care and management throughout the study period. Clean and fresh water for drinking were provided round the clock. Feed were provided *ad libitum*, twice daily at 9:00 AM and at 3:00 PM and proper record of feeding were maintained.

Proximate analysis of MOLP

Analysis of proximate composition of moringa leaf powder was done following standard procedures (AOAC, 2000) [5] in the Department of Animal Nutrition, College of Veterinary Sciences and A.H., Central Agricultural University, Selesih, Aizawl, Mizoram, India.

Health management of the weaned piglets

Routine management practices were followed throughout the study period. Strict surveillance was kept to ensure that the young pigs remain healthy. Deworming of piglets was also done on day 42 of age with Albendazole at a rate of 5 mg/kg body weight. Good hygiene and sanitary measures were maintained for better health the piglets. Sick animals were dealt with appropriately as and when necessary. Incidences of diarrohea and body weight of the piglets were also measured.

Occurrence rate of diarrhoea (%)

All the animals were visually inspected regularly on a daily basis for any occurrence of diarrhoea and were recorded accordingly. The occurrence rate of diarrhoea was then calculated on weekly basis using appropriate formula.

Body weight gain (kg)

Body weights (kg) of the piglets were also measured in the morning just before feeding by using digital weighing balance on the day of weaning (day 28) and then till day 70 at 14 days intervals i.e on day 42, 56 and 70. A representative figure of measuring body weight of the piglets is shown in Figure 3.7.

Collection of blood sample

Four (4) ml of blood was collected aseptically by Venipuncture of anterior vena cava in heparinized vacutainers from each animal of experimental groups at fortnightly interval during the study period i.e on the day of weaning (day 28), 14 days post weaning (day 42), 28 days post weaning (day 56) and 42 days post weaning (day 70). The collected blood samples were immediately subjected to haematological analysis in the laboratory by using Automated Blood Cell Counter Analyser ($MS4S^2$, France). The haematological indices estimated were haemoglobin (Hb), total erythrocyte count (TEC), packed cell volume (PCV), mean corpuscular volume (MCV),mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), total leukocyte count (TLC) and differential leukocyte count (DLC) *viz*. neutrophils (%), lymphocytes (%), monocytes (%), eosinophils (%) etc. All the recorded values were expressed in their standard unit.

Statistical analysis

Data generated in the study were analysed by one way ANOVA using SPSS version 25.0 and the significant values in ANOVA were further tested for Tukey and Tukey'b multiple range test. Results are presented as Mean ±SE. The difference were considered significant when $p<0.05$.

Results

The proximate composition of moringa leaf powder is presented in Table-1.The percentage of dry matter, crude protein; ether extract, crude fibre, total ash and nitrogen free extract were found to be 92.40, 26.23, 6.50, 10.39, 8.43 and 48.45, respectively (DM basis).

Table 1: Proximate composition of *M. oleifera* leaf powder

Sl. No.	Particulars	Percentage (%)
1.	Dry matter (DM)	92.40
2.	Crude protein (CP)	26.23
3.	Ether extract (EE)	6.50
4.	Crude Fibre (CF)	10.39
5.	Total ash	8.43
6.	Nitrogen Free Extract (NFE)	48.45

Table-2 depicts the mean (±SE) average body weight (kg) of the piglets of different experimental groups recorded during the study period. The average body weight of the piglets on the day of weaning i.e. on day 28 in groups C, T-1 and T-2 were 5.59±0.35, 5.47±0.35 and 6.01±0.15, respectively. Whereas, on day 70, the average body weight in groups C, T-1 and T-2 were 15.74±0.71, 16.00±0.19 and 17.02±0.18, respectively. Statistical analysis revealed that there is non-significant variation in average body weight between the control and treatment groups. However, the gain of body weight was found be higher in both the treatment groups as compared to control group during the study period. The highest gain of body weight of the piglets was observed to be on day 70 in T-2 group.

Table 2: Mean (±SE) average body weight (kg) of LWY piglets

Age (Days)	Control (C)	Treatment-I (T-1)	Treatment-II (T-2)	P Value
28	5.59±0.35	5.47±0.35	6.01±0.15	0.161^{NS}
42	7.52±0.53	7.91±0.12	8.06±0.13	0.501^{NS}
56	10.94±0.72	11.43±0.08	11.81±0.0	0.373^{NS}
70	15.74±0.71	16.00±0.19	17.02±0.18	0.127^{NS}

NS means Non-significant.

Table-3 depicts the occurrence rate of diarrhoea (%) in different experimental groups of piglets from 1st to 6th weeks post weaning. It was found that occurrence rate of diarrhoea was the highest during the first weeks of post weaning period i.e 38.38%, 24.27%, 18.94% for control group (C), Treatment-I group (T-1) and Treatment-II (T-2) group, respectively. The overall occurrence rate of diarrhoea was 14.92%, 9.43%, 5.75% for control, T-1 and T-2 group, respectively. Statistical analysis revealed that occurrence rate of diarrhoea decreased significantly ($p<0.05$) in the treatment groups from 2nd week onwards. There was no occurrence of diarrhoea at all in both T-1 and T-2 group on 5th week. Nonetheless, the overall occurrence rate of diarrhoea was recorded to be significantly lower in treatment groups as compared to control group.

Table 3: Occurrence rate of diarrhoea (%) in LWY piglets

Age (Weeks) (Post weaning	Control (C)	Treatment-I (T-1)	Treatment-II (T-2)	P Value
1st	38.38^{b}	24.27^{ab}	18.94^{a}	0.05*
2nd	26.50^{b}	16.02^{a}	10.91^{a}	0.00**
3rd	12.12^{b}	10.91^{b}	3.61^{a}	0.03*
4th	7.11	3.13	1.75	0.07^{NS}
5th	5.41	0.00	0.00	0.29^{NS}
6th	1.39	0.60	0.00	0.07^{NS}
Overall	14.92^{b}	9.43^{a}	5.75^{a}	0.00**

Mean± SE bearing different superscript differs significantly.
(*/**) means significant and NS means Non-significant

Table-4 depicts the mean (±SE) values of erythrocytic indices recorded during the study in different experimental groups of piglets. The Hb concentration was found to be increased in the treatment groups. The variation observed in hemoglobin level between the control groups and treatment groups was highly significant on 56 days and on 70 days. There was no significant difference in TEC between the control and treatment groups although the values were apparently higher in both the treatment groups. Similarly, PCV did not vary significantly between the control and treatment groups upto 56 days although the values were little bit elevated in the treatment group. However, there was significant hike in PCV values in treatment groups on day 70. The MCV, MCH and MCHC varied apparently between the experimental group, but variations were non-significant during the study period.

Table 4: Mean (±SE) values of erythrocytic indices in LWY piglets

Parameters	Days	Control (C)	Treatment-I (T-1)	Treatment-II (T-2)	P Value
Hb(g/dL)	28	11.43±0.30	11.58±0.23	12.11±0.48	0.123^{NS}
	42	11.35±0.71	13.00±0.50	13.50±0.62	0.214^{NS}
	56	10.84^{b}±0.30	14.06^{a}±0.16	13.86^{a}±0.19	0.000**
	70	10.80^{b}±0.61	14.36^{a}±0.18	13.89^{a}±0.41	0.004**
TEC (x10^{6}/µl)	28	6.83±0.33	6.89±0.29	7.10±0.15	0.090^{NS}
	42	6.70±0.41	7.11±0.32	7.35±0.31	0.110
	56	6.24±0.45	7.19±0.31	7.31±0.13	0.142
	70	6.23±0.37	7.21±0.41	7.43±0.30	0.187
PCV (%)	28	32.30±0.14	33.08±0.10	33.32±0.17	0.06^{NS}
	42	31.95±0.14	33.14±0.003	33.26±0.07	0.062^{NS}
	56	31.84±0.15	33.16±0.20	33.20±0.21	0.075^{NS}
	70	31.70^{b}±0.26	33.17^{a}±0.09	33.50^{a}±0.20	0.024*
MCV(fL)	28	52.88±1.19	53.10±1.21	52.90^{a}±1.00	0.54^{NS}
	42	54.03±1.26	53.60±1.26	53.21^{a}±1.56	0.29^{NS}
	56	53.06±1.34	54.16±1.31	56.88^{b}±1.51	0.08^{NS}
	70	54.33±1.39	15.82^{ab}±1.16	57.88^{b}±1.60	0.06^{NS}
MCH (pg)	28	16.20±0.43	16.12±0.54	16.18±0.21	0.60^{NS}
	42	17.11±0.73	17.30±0.65	16.73±0.66	0.58^{NS}
	56	17.28±0.20	17.51±0.37	17.22±0.33	0.91^{NS}
	70	17.17±0.87	17.64±0.59	17.47±0.55	0.684^{NS}
MCHC(g/dL)	28	31.81±0.37	30.62±0.35	30.46±0.36	0.589^{NS}
	42	33.26±0.41	30.76±0.41	32.38±0.55	0.452^{NS}
	56	32.72±0.47	30.76±0.51	31.48±0.52	0.683^{NS}
	70	29.86±0.49	30.00±0.51	31.93±0.53	0.345^{NS}

Mean± SE bearing different superscript differs significantly. (*/**) means significant and NS means Non-significant

Table-5 depicts the mean (±SE) values of leukocytic indices recorded during the study in different experimental groups of piglets. It was found that variation in TLC was highly significant (p<0.01) between the control and treatment groups on day 56 and 70. The neutrophil count was found to be decreased in the treatment groups than those of control group. The decrease was significant (p<0.01) in treatment-I and treatment-II group on 42 days. Further, there was a decreasing trend within the groups during the study period as the day progressed. The lymphocyte count was found to be higher in the treatment groups than the control group though the hike was not significant. Nonetheless, no significant differences were observed in monocyte count between the experimental groups although the monocyte percentages got elevated as the age advances during the study period. The eosinophil count was found to be varied within the group as well as between the control and treatment group, but variation was non-significant.

Table 5: Mean (±SE) values of Leukocytic indices in LWY piglets

Parameters	Days	Control (C)	Treatment-I (T-1)	Treatment-II (T-2)	P Value
TLC (x10^{3}/µl)	28	15.13±0.21	14.92±0.17	15.13±0.04	0.143^{NS}
	42	15.21±0.01	15.77±0.16	15.51±0.13	0.622^{NS}
	56	14.98^{a}±0.03	17.58^{b}±0.27	17.41^{b}±0.16	0.006^{NS}
	70	15.10^{a}±0.12	17.46^{b}±0.03	17.27^{b}±0.24	0.008^{NS}
Neutrophil (%)	28	62.43±0.18	62.15±0.25	62.28±0.72	0.426^{NS}
	42	58.47^{a}±0.11	52.30^{b}±0.25	52.11^{b}±0.33	0.006**
	56	50.35±0.01	50.24±0.13	50.01±0.20	0.543^{NS}
	70	49.17±0.008	49.07±0.02	48.24±0.019	0.092^{NS}
Lymphocyte (%)	28	23.29±0.07	22.99±0.008	23.12±0.01	0.141^{NS}
	42	33.05±0.34	32.17±0.005	33.14±0.01	0.704^{NS}
	56	34.52±0.03	35.02±0.03	34.09±0.02	0.684^{NS}
	70	35.48^{a}±0.02	35.10^{a}±0.02	35.06±0.01	0.396^{NS}
Monocyte (%)	28	13.15±0.05	13.22±0.03	13.26±0.07	0.453^{NS}
	42	12.18±0.104	12.52±0.36	12.40±0.10	0.331^{NS}
	56	13.55±0.12	11.62±0.35	11.00±0.32	0.547^{NS}
	70	14.31±0.06	14.39±1.12	14.13±0.31	0.650^{NS}
Eosinophil (%)	28	0.91±0.005	0.93±0.007	0.93±0.008	0.088^{NS}
	42	1.07±0.02	1.13±0.005	1.13±0.005	0.272^{NS}
	56	1.10±0.02	1.07±0.008	1.05±0.01	0.082^{NS}
	70	1.13±0.008	1.13±0.02	1.17±0.032	0.552^{NS}

Mean± SE bearing different superscript differs significantly. (*/**) means significant and NS means Non-significant

Discussion

The body weight (kg) of the weaned piglets increased significantly (p<0.01) both in control and treatment groups. However, rate of body weight gain in treatment groups was higher as compared to that of control groups. Our findings are in accordance with the results of Onu and Aniebo (2011) [32], who observed that broiler birds fed with diet supplemented with Moringa *oleifer* leaf powder (MOLP)

gained significantly higher body weight than those birds fed with only basal diet. Similar findings were also observed by Zhang *et al*. (2019) [47], who recorded a significantly higher body weight in finisher pigs fed with diet with incorporation of 6% MLOP. Nonetheless, a study conducted by Onunkwo and Okoro (2015) [33] on broiler chicken fed with MOLP recorded non-significant variation in different growth parameters *viz*. feed conversion ratio and average body weight gain. Similarly, few previous studies also reported that piglets fed with diet supplemented with MOLP showed no significant differences in growth rate and final body weight (Yentumi, 2021) [45].

Higher body weight gain observed in our study can be attributed to the abundance of good quality protein and nutrients as well phytonutrients in moringa leaves. Further, Moringa leaves are also as very much rich in both macro and micro-minerals such as Mg, Ca, K, Fe, Cu and Zn as well as various vitamins including vitamin A, C, D, E, pyridoxine, folic acid and nicotinic acid, which play an important role in regulating metabolic process and thus lead to growth and development of different body tissues (Mbikay, 2012) [26].

Present study revealed that incidence of diarrhea was highest in both control and treatment groups during the first week of post weaning period, which gradually decreases as age advances. There was significant decrease (p<0.05) in occurrence rate of diarrhoea in the treatment groups from 2nd week onwards. Nonetheless, the overall occurrence rate of diarrhea was recorded to be significantly lower in treatment groups as compared to control group. Post weaning diarrhea is common incidence in pig farming and a serious threat to the pig farmers worldwide. It occurs within first 10 days of weaning, mostly within 4-5 days. The Affected piglets pass brownish and greyish watery faeces with or without traces of blood (Rhouma *et al*., 2017) [36]. It is mostly due to excessive growth of entero-toxigenic *E.coli* in pig intestine. The lower incidence of diarrhoea recoded in our study may be ascribed to anti-inflammatory and antibacterial activities of the various phytochemicals present in the moringa leaves (Hadis *et al*., 2020) [18].

Analysis of haematological profile revealed that hemoglobin (Hb) level is relatively higher in the treatment groups as compared to control group. The hike in Hb concentration was significant (p<0.01) in T-1 and T-2 group on 56 and 70 days. Our finding corroborates the reports of Otitoju *et al.* (2014) [34], who reported that Hb content of female Wistar rats fed on aqueous extract of *M. oleifera* increased significantly as compared to the control group. Similarly, El Tazi and Tibin (2014) [14] recorded an increase Hb in in broilers fed with MOLP. Further, many other previous reports found a significant increase of Hb in goats fed on Moringa leaves (Babekar and Abdalbagi, 2015; Meel *et al*., 2018) [27]. Our findings, however, are in contradiction with those of Onu and Aniebo (2011) [32], who noticed a non-significant increase in Hb level in case of broiler fed with MOLP supplemented diet. Significantly higher level of Hb measured in this study may be because of high content of minerals, particularly iron (Fe) in moringa plant, which is essential for haemoglobin formation by the animals (El Tazi and Tibin, 2014) [14].The more is the Hb concentration, the better is the circulation of oxygen in the body, which in turns result in better growth of the piglets (Olugbemi *et al*., 2010) [31]. Nevertheless, the numerically lower value of Hb in the T-2 group fed diet with 2% MLP may be due to toxicities by tannins and flavonoids present in the leaves (El Tazi and Tibin, 2014) [14].

Total erythrocyte count (TEC) was non-significantly higher in treatment groups than that of control group. This finding is in tandem with that of Daghash *et al.* (2024) [10], who recorded that lambs fed with 20% *Moringa oleifer* leaves exhibited higher TEC than that of control group. Ali (2018) [4] also observed a non-significant variation in TEC in goats fed with ration incorporated with Moringa leaves. On the contrary to this, some earlier studies conducted on goats reported a significant hike in TEC when concentrate mixture was substituted with moringa leaves in goat feed (Babeker and Bdalbagl, 2015; Jiwuba *et al*., 2016) [6, 21]. In present study, the TEC values were within the physiologically normal range established for pigs. The normal values of TEC suggest that feed supplemented with MLP promoted good health status of the piglets and hence the piglets were not anemic. The slightly higher levels of TEC in piglets of treatment groups could possibly due to higher content of haematinic agents like Vitamin B6, folic acid and iron in Moringa leaves that stimulate erythropoiesis (Nurhayati *et al*., 2023) [2]. The greater values obtained in the treatment groups is suggestive of better effect as level of MLP incorporation increases.

Packed cell volume (PCV) was found be varied non-significantly amongst the experimental groups upto 56 days, but the values were numerically higher in treatment groups. Nonetheless, the value was significantly high (p<0.05) in both T-1 and T-2 groups on 70 days when compared to that of control group. Our result corresponds to that of Tijani *et al*. (2016) [41], who observed that broiler chicken supplemented with 5% and 15% *Moringa oleifer* leaf meal had higher (p< 0.05) PCV than control group. Similarly, Meel *et al*. (2018) [27] found that substitution of concentrate mixture with Moringa leaves led to significantly higher packed cell volume. Whereas, a study carried out by Wankhede *et al*. (2022) [42] on goat kids revealed that values of PCV were analogous amongst the different treatment groups. Further, Ali *et al*. (2018) [4] reported that PCV is not influenced by inclusion of Moringa leaf meal in feed of sheep and goats. However, the PCV data obtained in our study are well within the acceptable ranges set from 30% to 50% in pigs.

The mean corpuscular volume (MCV) did not vary much between the control and treatment groups. We observed that MCV was slightly higher in the treatment groups as well as within the group itself as the age of the piglets' advances the vales of mean corpuscular hemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) also did not vary significantly although there was some degree of numerical variation. These findings are in consistence with earlier reports (Jiwuba *et al*., 2016; Meel *et al*., 2018; Wankhede *et al*., 2022) [21, 27, 42].

We have noticed that there were inconsistent findings reported by various workers time to time on the impact of dietary inclusion of moringa leaf on haematological parameters of the animals. The observed differences may be ascribed to a number of factors such as the type of Moringa leaves product used for the study i.e. 'fresh *vs* dried', 'meal *vs* extract' etc. It may also be due to level (dose) of MLP supplementation, composition of the basal feed, time and stage of harvesting the moringa leaves and so on.

Our results revealed that total leucocyte count (TLC) increased significantly (p<0.01) in T-1 and T-2 groups of

piglets on 56 days and 70 days during the study period. However, the variation observed between the groups on 42 days was non-significant. Nevertheless, the TLC values were within the normal physiological values of piglets. Similar observation was also reported in Dienye and Olumuji (2014) [13]. A study by Tijani *et al*. (2016) [41] also observed similar pattern of variation and reported that TLC increased significantly in broiler birds fed with *Moringa oleifer* leaf meal. The TLC hike found in our study could be due to the result of the stress induced by weaning of the piglets (Chandra *et al*., 2012) [10]. It may also be attributed to the hematopoietic factors present in Moringa leaves (Ajugwo *et al*., 2017) [3]. Further, Gupta *et al*., (2012) [17] explained the hike in total leucocyte count study could be attributed to the immune-modulatory effect of the phytochemicals *viz*. flavonoids, polyphenols and terpenoids present in moringa leaves.

The neutrophil count decreased during the study in both control and treatment groups. The drop in neutrophil count observed on T-1 and T-2 were not found to be significant except on 42 days. Our findings are in accordance with those of Dhillod *et al*. (2023) [12], who noticed that feeding of moringa leaves to Murrah buffaloes did not alter the neutrophil percentage significantly during the period of experiment among various treatment groups. Likewise, Ketpanyapong and Marupanthorn (2023) [23] also reported that supplementation of diet containing Moringa leaf extract @ 0.5% level resulted in decreased neutrophil count. On the contrary, Tijani *et al*. (2015) [40] documented significantly ($P < 0.05$) higher neutrophils in the birds fed with moringa leaf meal. The significantly higher value noticed on day 28 may be due to the stress induced due the process of weaning. Previous report demonstrated that corticosteroid level increases during stress, which in turn leads to higher neutrophil count (Bandoli *et al*., 2017) [7]. The slight decrease seen in the treatment groups can be the result of anti-inflammatory effects of flavonol glycosides such as 'isoquercetin' present in Moringa leaves (Izuegbuna *et al*., 2019) [20]. Isoquercetins have been found to hinder the production of inflammatory mediators like leukotriene (LTB4) and prostaglandin (PG-E2) in neutrophils (Bouriche *et al*., 2005) [8]. The lymphocyte count (%) found in our study exhibited an elevating trend of variation from the day of weaning till the end of feeding trial i.e day 70.Theree was only apparent variation in lymphocyte percentage between the control and treatment groups. Nevertheless, the difference in the values between the days were highly significant ($P<0.01$). The alteration in monocyte (%) was very minimal between the control group and the treatment groups. However, the monocyte count was higher on 70 days both in control and treatment groups. Similarly, the values of eosinophil count (%) measured in the experimental piglets did not differ amongst the groups, but the values were slightly increased in all the groups during the study period. All the values recorded pertaining to differential leucocyte count (DLC) were within the physiological range. Neutrophils, lymphocyte, monocytes and eosinophils are key players of immune mechanism. All the data recoded in our study for all these immune arsenals fall within the normal physiological range, which signify better health of the piglets during the period of study. Findings of present study are similar with those of earlier reports (Meel *et al*., 2018; Dhillod *et al*., 2023) [27, 12].

Conclusions

In view of the results of the current study, it is evident that dietary inclusion of *M. oleifera* leaf powder improved the growth and health status of Large White Yorkshire piglets during post weaning period. Although inclusion of both 1% and 2% resulted in positive outcome, but 2% level of inclusion was found to be more effective. Nonetheless, a comprehensive study with large sample size and different level of dietary inclusion of MOLP is needed to explore and establish potential beneficial effects of MOLP in improving post weaning growth and health status of the piglets.

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References

1. Afzal A, Hussain T, Hameed A, Shahzad M, Mazhar MU, Yang G. Dietary *Moringa oleifera* alters peri-parturient plasma and milk biochemical indicators and promotes productive performance in goats. Frontiers in Veterinary Science. 2022;8:787719.
2. Nurhayati T, Fathoni MI, Fatimah SN, Tarawan VM, Goenawan H, Dwiwina RG. Effect of *Moringa oleifera* leaf powder on hematological profile of male Wistar rats. Journal of Blood Medicine. 2023;14:477-485. DOI: 10.2147/JBM.S407884.
3. Ajugwo AO, Mounbegna PE, Kemajou TS, Ofokansi VC. Effects of *Moringa oleifera* leaves extract on haematological parameters of phenylhydrazine anaemia induced Wistar rats. International Journal of Public Health and Safety. 2017;2(4):139.
4. Ali SB, Kawitkar SB, Deshmukh AD, Dhok AP, Jawale MR, Chopde SV, *et al*. Performance of goats fed *Moringa oleifera* leaf meal incorporated in concentrate mixture. Indian Journal of Animal Nutrition. 2018;35(2):239-241.
5. AOAC. Official Methods of Analysis. 17th ed. Association of Official Analytical Chemists; c2000. Washington DC, USA.
6. Babeker EA, Abdalbagi YM. Effect of feeding different levels of *Moringa oleifera* leaves on performance, haematological, biochemical and some physiological parameters of Sudan Nubian goats. Online Journal of Animal and Feed Research. 2015;5(2):50-61.
7. Bandoli G, Palmsten K, Smith CJF, Chambers CD. A review of systemic corticosteroid use in pregnancy and the risk of select pregnancy and birth outcomes. Rheumatic Disease Clinics of North America. 2017;43(3):489-502.
8. Bouriche H, Miles EA, Selloum L, Calder PC. Effect of *Cleome arabica* leaf extract, rutin and quercetin on soybean lipoxygenase activity and on generation of inflammatory eicosanoids by human neutrophils. Prostaglandins, Leukotrienes and Essential Fatty Acids. 2005;72(3):195-201.
9. Canibe N, Hojberg O, Kongsted H, Vodolazska D, Lauridsen C, Nielsen TS, Schonherz AA. Review on preventive measures to reduce post-weaning diarrhoea in piglets. Animals. 2022;12(19):2585. https://DOI.org/10.3390/ani12192585
10. Chandra R, Chatlod LR, Kumar S, Toppo S, Haque N, Rahman H. Nutritional evaluation of NB-21 hybrid Napier grass for goats. Indian Journal of Small Ruminants. 2012;18(2):261-263.

11. Daghash HA, Kobeisy MA, Soliman IA, Farouk N. Effect of partial substitution of the crude protein of the concentrated feed mixture with *Moringa oleifera* leaves on growth performance and some blood constituents of growing lambs. Assiut Journal of Agricultural Sciences. 2024;55(3):29-42.
12. Dhillod S, Bidhan DS, Sihag S, Singh N, Sharma V, Singh M. Pre-partum and postpartum supplementation effect of *Moringa oleifera* leaf meal on haematological and biochemical parameters of Murrah buffaloes reared under a loose housing system. Journal of Animal Research. 2023;13(2):217-223.
13. Dienye HE, Olumuji OK. Growth performance and haematological responses of African mud catfish *Clarias gariepinus* fed dietary levels of *Moringa oleifera* leaf meal. Net Journal of Agricultural Science. 2014;2(2):79-88.
14. El Tazi SM, Tibin IM. Performance and blood chemistry as affected by inclusion of *Moringa oleifera* leaf meal in broiler chicks diet. Journal of Veterinary Medicine and Animal Production. 2014, 5(2). https://api.semanticscholar.org/CorpusID:55554602.
15. Elghandour MMMY, Maggiolino A, Vázquez-Mendoza P, Alvarado-Ramírez ER, Cedillo Monroy J, De Palo P, *et al*. *Moringa oleifera* as a natural alternative for the control of gastrointestinal parasites in equines: A review. Plants (Basel). 2023;12(9):1921.
16. Faccin JEG, Laskoski F, Hernig LF, Kummer R, Lima GFR, Orlando UAD, *et al*. Impact of increasing weaning age on pig performance and belly nosing prevalence in a commercial multisite production system. Journal of Animal Science. 2020;98(4):1-8. DOI: 10.1093/jas/skaa031
17. Gupta A, Gautam MK, Singh RK, Kumar MV, Rao CV, Goel RK, *et al*. Immunomodulatory effect of *Moringa oleifera* Lam. extract on cyclophosphamide-induced toxicity in mice. Indian Journal of Experimental Biology. 2012;48(11):57-60.
18. Hadis M, Gebreyohannes Y, Gemeda N. Potential therapeutic uses of *Moringa stenopetala*: A scoping review. Journal of Global Health Science. 2020, 2(2). DOI: 10.35500/jghs.2020.2.e26.
19. Holman DB, Gzyl KE, Mou KT, Allen HK. Weaning age and its effect on the development of the swine gut microbiome and resistome. mSystems. 2021;6:e00682-21. https://DOI.org/10.1128/mSystems.00682-21
20. Izuegbuna O, Otunola G, Bradley G. Chemical composition, antioxidant, anti-inflammatory, and cytotoxic activities of *Opuntia stricta* cladodes. PLOS One. 2019;14(1):e0209682.
21. Jiwuba PDC, Ahamefule FO, Okechukwu SO, Ikwunze K. Feed intake, body weight changes, and haematology of West African dwarf goats fed dietary levels of *Moringa oleifera* leaf meal. Agricultura. 2016;13(1-2):71-77.
22. Keshri A, Dixit S, Tyagi AK. Effect of different levels of *Moringa oleifera* leaves on rumen fermentation pattern: An *in vitro* study. Indian Journal of Animal Nutrition. 2022;39(3):282-291.
23. Ketpanyapong W, Marupanthorn K. Effect of *Moringa oleifera* leaf extract on growth performance, blood indices, diarrheal rate, and fecal microbial shedding in weaned pigs. Journal of Animal Health and Production. 2023;11(4):410-419.
24. Kikusato M. Phytobiotics to improve health and production of broiler chickens: Functions beyond the antioxidant activity. Animal Bioscience. 2021;34:345. DOI: 10.5713/ab.20.0842.
25. Martel J, Ojcius DM, Ko YF, Young JD. Phytochemicals as prebiotics and biological stress inducers. Trends in Biochemical Sciences. 2020;45:462-471. https://DOI.org/10.1016/j.tibs.2020.02.008.
26. Mbikay M. Therapeutic potential of *Moringa oleifera* leaves in chronic hyperglycemia and dyslipidemia: A review. Frontiers in Pharmacology. 2012;3:24.
27. Meel P, Gurjar ML, Nagda RK, Sharma MC, Gautam L. Effect of *Moringa oleifera* leaves feeding on hemato-biochemical profile of Sirohi goat kids. Journal of Entomology and Zoology Studies. 2018;6(5):41-48.
28. Novais AK, Deschene K, Martel-Kennes Y, Roy C, Laforest JP, Lessard M, *et al*. Weaning differentially affects mitochondrial function, oxidative stress, inflammation, and apoptosis in normal and low birth weight piglets. PLoS One. 2021;16(2):e0247188. DOI: 10.1371/journal.pone.0247188.
29. National Research Council. Nutrient Requirements of Swine. 11th ed. Washington, D.C.: National Academy Press; 2012.
30. O'Doherty J, Dowley A, Conway E, Sweeney T. Nutritional strategies to mitigate post-weaning challenges in pigs: A focus on glucans, vitamin D, and selenium. Animals. 2024;14(1):13. https://DOI.org/10.3390/ani14010013.
31. Olugbemi TS, Mutayoba SK, Lekule FP. Effect of *Moringa oleifera* inclusion in cassava-based diets fed to broiler chickens. International Journal of Poultry Science. 2010;9(4):363-367.
32. Onu PN, Aniebo AO. Influence of *Moringa oleifera* leaf meal on the performance and blood chemistry of starter broilers. International Journal of Food, Agriculture and Veterinary Science. 2011;1(1):38-44.
33. Onunkwo DN, Okoro IC. Egg production performance of three varieties of Guinea fowls in humid tropics. International Journal of Current Research and Review. 2015;7:1-6.
34. Otitoju O, Nwamarah JU, Otitoju GTO, Okorie AU, Stevens C, Baiyeri KP. Effect of *Moringa oleifera* aqueous leaf extract on some haematological indices in Wistar rats. Chemical Process Engineering Research. 2014;18:26-30.
35. Pandey S, Kim ES, Cho JH, Song M, Doo H, Kim S, *et al*. Cutting-edge knowledge on the roles of phytobiotics and their proposed modes of action in swine. Frontiers in Veterinary Science. 2023;10:1265689. DOI: 10.3389/fvets.2023.1265689.
36. Rhouma M, Fairbrother JM, Beaudry F, Letellier A. Post-weaning diarrhea in pigs: Risk factors and non-colistin-based control strategies. Acta Veterinaria Scandinavica. 2017;59:1-19.
37. Senthilkumar A, Karuvantevida N, Rastrelli L, Kurup SS, Cheruth AJ. Traditional uses, pharmacological efficacy, and phytochemistry of *Moringa peregrina* (Forssk.) Fiori.- A review. Frontiers in Pharmacology. 2018;9:465.
38. Sun JJ, Wang P, Chen GP, Luo JY, Xi QY, Cai GY, *et al*. Effect of *Moringa oleifera* supplementation on productive performance, colostrum composition, and

serum biochemical indexes of sow. Journal of Animal Physiology and Animal Nutrition. 2020;104(1):291-299.
39. Tang X, Xiong K, Fang R, Li M. Weaning stress and intestinal health of piglets: A review. Frontiers in Immunology. 2022;13:1042778. DOI: 10.3389/fimmu.2022.1042778.
40. Tijani LA, Akanji AM, Agbalaya K, Onigemo M. Haematological and serum biochemical profiles of broiler chickens fed diets containing *Moringa* leaf meals. Agricultural Science. 2015;14(3):7-11.
41. Tijani LA, Akanji AM, Agbalaya K, Onigemo M. Comparative effects of graded levels of *Moringa* leaf meal on haematological and serum biochemical profile of broiler chickens. Journal of Agricultural Science. 2016;3:137-146.
42. Tshabalala T, Ndhlala AR, Ncube B, Abdelgadir HA, Van Staden J. Potential substitution of the root with the leaf in the use of *Moringa oleifera* for antimicrobial, antidiabetic, and antioxidant properties. South African Journal of Botany. 2020;129:106-112.
43. Wankhede SD, Dutta N, Tambe MB, Kaur N, Jadhav SE, Pattanaik AK. Effect of dietary inclusion of *Moringa oleifera* foliage on nutrient metabolism, metabolic profile, immunity, and growth performance of goat kids. Emerging Animal Species. 2022;3:100005.
44. Xiong X, Tan B, Song M, Ji P, Kim K, Yin Y, *et al*. Nutritional intervention for the intestinal development and health of weaned pigs. Frontiers in Veterinary Science. 2019;6:46. DOI: 10.3389/fvets.2019.00046.
45. Yentumi AD. Effect of including graded levels of *Moringa oleifera* leaf (MOLM) in fed diets on carcass characteristics of pigs and pork quality. International Journal of Innovative Science Research and Review. 2021;3(04):1129-1135.
46. Zeng B, Luo J, Wang P, Yang L, Chen T, Sun J, *et al*. The beneficial effects of *Moringa oleifera* leaf on reproductive performance in mice. Food Science and Nutrition. 2019;7(2):738-746.
47. Zhang T, Si B, Tu Y, Cui K, Zhou C, Diao Q. Effect of including different levels of *Moringa oleifera* leaf meal in the diet of finishing pigs: Performance, pork quality, fatty acid composition, and amino acid profile. Czech Journal of Animal Science. 2019;64(3):141-149.