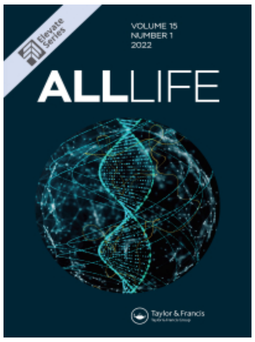

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The effect of partial substitution of *Moringa oleifera* leaf meal on the relative growth performance and incidence of scours in piglets

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ABSTRACT

The effect of *Moringa oleifera* leaf meal (MOLM) as a scour prophylaxis and on growth parameters of piglets was evaluated. A total of 168 piglets from 15 litters were cross fostered and randomly assigned to three dietary treatments; 0% MOLM (control diet), 4.5% MOLM and 8% MOLM inclusion test diets. The feed conversion ratio (FCR), average daily gain (ADG), body weight (BW) and average daily feed intake (ADFI) and faecal viscosity (FV) were measured. The effect of MOLM inclusion level on FCR, ADG, BW, ADFI and FV was analysed using PROC GLM of SAS. Dietary inclusion of 4.5% MOLM significantly reduced the ADFI of piglets when compared to 0% MOLM, however 8% MOLM had higher ADFI than either 0% or 4.5% MOLM inclusion. There was no effect of MOLM dietary inclusion on ADG; however 8% MOLM dietary inclusion had a higher FCR when compared to 0% or 4.5% MOLM. Piglets in control treatment (0% MOLM) had more incidence of scours than 8% MOLM diet and did not differ from 4.5% MOLM. There was no effect in faecal viscosity between 4.5% and 8% MOLM diets. MOLM dietary inclusion significantly reduced the cost per kilogram weight gain. It was concluded that MOLM can replace soya bean meal up to 4.5% in piglet creep diets.

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Diarrhoea prophylaxis; feed conversion efficiency; growth performance; *Moringa oleifera* leaf meal; piglets; soya bean meal

Introduction

Feed remains the major operating cost in livestock enterprises directly determining viability and growth. It is projected that by 2050 the demand for pork and other animal products would have arisen by over 70% at the backdrop of shrinking land sizes availed for agricultural activities (Alexandratos and Bruinsma 2012). There is therefore need for increase in the efficiency and sustainability of feed production, processing and utilisation. Climatic change, and the envisaged rise in competition between human beings and animals for grains and oil seeds will further constrain pig meat production (Andretta *et al.* 2017). Here lies the drive to look into and explore possible feed ingredients that have comparable nutritive value to the ones already in use but more economical to use and resilient to effects of climate change.

Moringa oleifera is one among other plants that has the potential to be used as a pig feed ingredient because of its high nutrient content (Sánchez-Machado *et al.* 2010). *M. oleifera* leaf meal has a crude protein value that is more than 30% and a crude fibre value of around 11% and is known to contain all essential amino acids (including lysine and methionine) (Gopalakrishnan *et al.* 2016 and Moyo, 2011). It is also easy to cultivate, gives good results even in poor marginal lands, is drought resistant and requires little or no fertiliser which makes its production costs to be considerably lower than that of soya beans (Acda et al. 2010 and Mathur 2005).

M. oleifera, garlic and *Aloe vera* extracts are some of the natural herbal plants that have been used in treating various diseases such as asthma, diarrhea, epilepsy and skin diseases (Velazquez-Zavala et al. 2015 and Hardy 2002). *M. oleifera* has been shown to have immune-modulatory properties and also act as natural remedy to bacterial infections (Anamika et al. 2010 and Paikra et al. 2017). A few studies have been conducted in the control of piglet scours using *M. oleifera* and its use as a protein supplement in creep diets. The study seeks to address the problem of piglet scours from birth up to weaning as well as reduce feed costs.

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The aim of this study was to evaluate the effect of partial substitution of soya bean meal with *M. oleifera* leaf meal (MOLM) on the growth and health performance of piglets.

Materials and methods

Study site

The study was carried out at the Pig Industry Board of Zimbabwe farm in Arcturus. The farm is located 25.5 km from Harare, along the Harare-Mutoko road. The farm is located at 17°44′24.30″S and 31°15′26.76″E at an altitude off 1333 m above sea level.

Experimental animals' welfare and management

One hundred and sixty eight piglets from 15 sows of Large White, Landrace, Dalland breeds and their crosses, from the commercial unit at the farm, were used in the experiment. The piglets were fed the experimental diets from 7 days of age until weaning at 35 ± 3 days. Piglets from three randomly selected sows were cross fostered after ear notching to neutralise any parental breed effects on the traits under investigation. Each cross-fostered litter then served as an experimental unit.

Each sow and its litter were housed in thoroughly cleaned and disinfected 6.2 m^2 farrowing pen which became the experimental unit. The sows were caged in 2.4 m × 0.9 m farrowing crates to allow for ease of feeding piglets with the experimental diets. The crate area was enough to allow the sow to move and rest freely during the lactation period. Feed and water was provided to piglets *ad lib*. The numbers of piglets in each experimental pen were determined by the number of piglets farrowed by the random three sows cross fostered.

Sows were provided with water *ad lib* and the farrowing house had the recommended gradient that allowed free movement of water and urine into the water drainage trench. Piglets were ear notched, navel clipped and tooth trimmed within 24 hours of life. The farrowing house creep area was heated with an infrared lamp to warm the piglets.

Analysis of *M. oleifera*

A sample of 200 g *M. oleifera* leaf meal was analysed using wet chemistry and the results are shown on Table 1. Diet formulation was done using the results from the analysis and was nutritionally similar.

Table 1. Nutritional composition of *M. oleifera* dried leaf per 100 g edible portion.

Component	Average (%)
Crude fibre	11.00
Crude protein	32.60
Nitrogen free extract	39.02
Ether extract	4.08
Ash	13.30
Calcium	2.00
Phosphorus	1.08
Sodium Chloride	< 0.10

Table 2. Formulated Creep meal dietary treatments of 22% Crude Protein.

Ingredient	0% MOLM Percentage (%)	4.5% MOLM Percentage (%)	8% MOLM Percentage (%)
Maize	53.30	52.80	52.30
Wheat bran	4.90	4.90	4.80
MOLM	0.00	1.30	2.40
Soya bean meal	39.00	38.30	37.60
Vit-Min premix	2.80	2.80	2.80
Total	100.0	100.0	100.0

Experimental diets

Three creep meal diets of 22% CP where formulated (Table 2).

The experimental units were randomly allocated the treatment diets. The control diet contained soya bean meal as the only protein supplement. Each treatment was replicated five times, each cross fostered litter acting as a block with three sows farrowing. All sick experimental piglets fed control treatment were given an antibiotic (Coliflox WS) as the normal practise at the farm. Piglets in treatments containing *M. oleifera* were not exposed to use of antibiotics. In the situations where there were incidences of scours, piglets in MOLM treatments and control diet were given vitamin mix and glucose as electrolyte replacements.

Data collection

Feed utilisation and growth parameters

Piglets were weighed at birth, then again at day 7 (experimental initial weight) and at weaning using a hanging scale with an accuracy of 100 g to measure body weight gain (BWG). Individual piglets were measured and their live-weights recorded. Average daily gain (ADG), feed intake (FI) and feed conversion ratio (FCR) were computed for each litter as follows:

BWG at week five = (day 35 weight − initial body weight).

The average daily gain of the piglets was calculated as:

ADG = BWG (kg) ÷ number of days between weighing

Feed intake was recorded in order to calculate the feed utilisation efficiency for the different treatments. To this end, each experimental litter was allocated known amounts of feed. The remaining or residual feed was also recorded and subtracted from the original recorded allocation. This gave the amount of feed that was consumed.

FI = amount of feed offered (kg) − amount of feed refusals (kg)

FCR was defined and adopted as the amount of feed required to attain one unit of live weight gain. This was calculated as:

FCR = FI/ADG

The experiment was carried out for 4 weeks and the last measurement was recorded at day 28 when the piglets where 5 weeks old and due for weaning.

Data on scours

The parameter employed to measure the effectiveness of MOLM in reducing piglet scours was faecal viscosity. This qualitative data for scours viscosity was taken using the modified Bristol Stool Chart (Table 3 2). Three levels or scores were set at 1, 2 and 3; with the highest score of 3 indicating severe scours and the lowest score 1 representing absence of scours while the median represented moderate level of scours. Using the Bristol Stool Chart, Type 1 to type 3 was regarded as normal faecal matter (score 1), Type 4–5 was regarded as moderate (score 2) and Type 6 and 7 represented severe scours (score 3).

Experimental design and statistical analysis

The study was a one factor experiment laid out in a Randomised Complete Block Design. There were five blocks, corresponding to the five different farrowing periods. Each farrowing period had random three sow litters with piglets cross fostered to randomise effects of breed and other unknown nuisance variables. The three sow litters in a block where randomly allocated to the three dietary treatments and the randomisation was repeated over all the five blocks. An average of 12 cross fostered piglets in a litter constituted an experimental unit. Data on growth and feed were analysed using the PROC General Linear Model (GLM) of Statistical Analysis Software (2018). The least significant difference (LSD) method was used to separate the means at $p < .05$.

Table 3. Bristol Stool Chart.

Type	Faecal Viscosity	Description
1		Seperate hard lumps, like nuts (hard to pass)
2		Sausage-shaped but lumpy
3		Like a sausage but with cracks on its surface
4		Like a sausage or snake, smooth and soft
5		Soft blobs with clear-cut edges (passes easily)
6		Fluffy pieces with ragged edges, a mushy stool
7		Watery, no solid pieces (Entirely Liquid)

Table adapted from Amarenco (2014).

Results and discussion

Blocking effect

Blocking against breed effect did not significantly affect ADG and FCR of pre weaned piglets ($p > .05$). Hence the data was then re-analysed without blocking.

Effect of Diet on ADFI, ADG and FCR

Diet had no significant effect on ADG ($p > .05$), but significantly affected both ADFI and FCR ($p < .05$) as presented in Table 4.

The highest ADFI and FCR were noted in the highest MOLM inclusion level of 8%, but ADG was not significantly affected by diet. The lowest feed intake was noted for the 4.5% MOLM inclusion level. FCR of the control diet and the 4.5% MOLM diet were not significantly different.

Table 4. Effect of dietary inclusion level of MOLM on FCR and ADFI in pre-weaned piglets in kg/day.

	MOLM Substitution level (%)				
Growth Parameters	0	4.5	8	SEM	*P* value
ADFI (kg/day)	0.026^{a}	0.022^{b}	0.030^{c}	0.001	.008
ADG (kg/day)	0.22^{x}	0.23^{x}	0.19^{x}	0.016	.42
FCR	0.13^{x}	0.13^{xy}	0.16^{z}	0.15	.007

[abcxyz]Means in the same row with different superscripts are significantly different.

Effect of diet on ADFI, ADG and FCR

Piglets on the 8% MOLM diet had the highest ADFI followed by those on the control diet. Piglets on 4.5% MOLM diet had the least ADFI. This is in close agreement with the findings of Mukumbo *et al.* (2014) who noted a significant increase in the average daily feed intake in 7.5% MOLM dietary inclusion level compared to 5% and below. Oduro-Owusu et al. (2015) also observed that there was no significant difference in ADFI between 0%, 1%, 2.5% up to 5% MOLM partial substitution in weaner pigs. The findings seem to suggest that MOLM inclusion rates of up to 4.5% depress feed intake or has no effect on feed intake relative to a control diet without MOLM. However, beyond 4.5% MOLM inclusion rate feed intake increased with increase in MOLM inclusion rate. The subsequent increase in ADFI with increase in MOLM dietary inclusion may be due to the increase in the level of tannins in the diet which translates to low protein digestibility thereby leading to compensatory feed intake by the animal as supported by Mukumbo *et al.* (2014). The findings of this study showed that there was no significant difference in the average daily gain of the piglets on the three diets. In close agreement with these finding, Mukumbo *et al.* (2014) also reported no significant difference in the ADG of finisher pigs fed with 0%, 2.5%, 5% and 7.5% MOLM partially substituted diets. Acda et al. (2010) also reported no diet effect on ADG of pigs fed diets that had been partially substituted with up to 10% MOLM. These results therefore revealed that *M. oleifera* can be successfully utilised as a protein supplement in pig production without adversely affecting average daily gain in piglets.

Since ADG showed no significant change it implies that high MOLM inclusion rates were associated with decline in feed utilisation efficiency. This could be explained by the fact that the piglets in the 8% treatment had the highest feed intake yet ADG was statistically similar in all treatments. The effect of tannins would need more feed for detoxification resulting in similar weight gain regardless of the high intake. These results agree with the findings of Nduku (2014) who observed an increase in daily intake of piglets which were allocated 7.5% MOLM dietary inclusion treatment than other treatment diets whilst their ADG were the same.

At 4.5% MOLM inclusion rate FCR was not significantly different to that of the control diet, but was significantly lower than for the 8% MOLM inclusion rate. This revealed that piglets that were assigned in 8% MOLM treatment were less efficient in converting feed nutrients into body mass. These findings were in support of the study that was carried out by Mukumbo et al. (2014) who reported that partial substitution of the weaner diet with 7.5% MOLM was less efficient in feed utilisation (FCR). However, Acda et al. (2010) observed that MOLM partial inclusion in finisher diet was efficient up to 10%. Considering age difference between experimental animals of these three studies, Acda et al.'s (2010) discoveries cannot be completely rejected since the digestive tract of finisher pigs is more mature and can utilise a wide range of feeds more efficiently than younger pigs (Chiba 2010). The difference could be due to allergic compounds (glycinin) anti-nutritional factors which are present in *M. oleifera* such as tannins (32 g/kg) that bind proteins and therefore decrease the nutrient availability to the animal (Moyo et al. 2011). Serem et al. (2017) also reported low feed conversion ratio in treatment diets that had 3% MOLM inclusion and 6% MOLM inclusion, however Zhao et al. (2010), observed poor performance at 12% MOLM dietary inclusion. This strongly supports the possible effect of anti-nutritional factors (tannins) over the age factor since FCR is worsening beyond 6% MOLM dietary inclusion in pre-weaned, weaned and grower pigs.

Effect of diet on faecal viscosity

The results presented in Table 5 show that there was a notable decline in scours with increase in MOLM proportion in the creep diet.

Effect of diet on scours in piglets

MOLM diets recorded significantly reduced scours compared to the control diet with no MOLM. This

Table 5. Mean (±SE) effect of diet on faecal viscosity.

	MOLM Substitution level (%)				
	0	4.5	8	SEM	*P* value
Faecal Viscosity	41.50[a]	30.85[ab]	28.22[b]	16.77	.38

a–c Means in the same row with different superscripts are significantly different.

Table 6. Cost Benefit analysis for different MOLM dietary inclusion levels in USD.

	Dietary Inclusion Rate		
Parameters	0% MOLM	4.5% MOLM	8%MOLM
Cost per kg of feed ($/kg)	0.405	0.403	0.401
Total Feed intake (kg)	35.9	31.9	35.6
Total Feed Cost ($/kg)	14.54	12.86	14.27
Weight gain (Kg)	183.2	196.5	208.2
Cost per kg of gain ($/kg)	0.079	0.065	0.069

was in close agreement with the findings of Oliver *et al.* (2015) who observed the immune-modulatory effect of *M. oleifera* in hastening the development of immature piglet immune and digestive systems. This is because M. *oleifera* has a high content of essential amino acids, minerals, vitamins, and polyphenols in addition to its antimicrobial and nutraceutical properties (Fahey 2017). Li *et al.* (2021) summarised the effects of these phytochemicals as being characterised by little residue, no resistance, and minimal side effects and serve as powerful therapeutics against pathogenic bacteria or act as functional additives, which have been reported to improve animal health and growth performance in pigs. Thus piglets feeding on the MOLM based diets made use of the pharmacological properties that either aided in preventing the growth of pathogenic diarrhoea in the piglet's gut or early maturity of the piglet's immune system, or both. These findings also mean that there will be a reduction in the antimicrobials that will be required to treat scours, a positive step towards reducing antimicrobial resistance.

Cost benefit analysis

MOLM dietary inclusion affected cost of production as shown in Table 6. 4.5% MOLM inclusion level gave the lowest feed costs per kg of weight gained.

Cost benefit analysis

The Cost Benefit Analysis revealed that MOLM diets significantly reduced feed costs as compared to the control diet. The least costs of production were reported for the 4.5% MOLM inclusion rate. This was supported by observations made by Gopalakrishnan *et al.* (2016) who reported 4% MOLM diet as the most efficient in broiler production. Higher inclusion rates may increase the diet cost since MOLM had 32.6% CP and using it as the main protein source will require more quantities when compared with solvent extracted soya meal with a CP of 46%. Piglets on the 4.5% MOLM diets consumed the least feed but gained the most weight illustrating the additive effect of M. *oleifera.*

Conclusion and recommendation

MOLM is a potential substitute of soya bean meal as a protein source in piglet creep diets, though at moderate inclusion rates of below 5%. Such diets significantly reduce production costs without altering growth rate in piglets. MOLM diets also appear to promote normal digestion process and seem to stimulate early development of the immune system of piglet thereby reducing the incidence of piglet scours, thus the meal can successfully be used as a scour prophylaxis. MOLM fed piglets had the lowest faecal viscosity, reflecting that there were healthier than piglets on the control diet. It can be concluded that MOLM can be successfully used in creep diets without detrimental effects, reducing the producer's costs of production through lowering feed and drug costs whilst subsequently lowering the mortality rates and increasing the weaning masses.

Further studies are recommended to determine the most appropriate methods to bind tannins to improve on MOLM digestibility and to assess whether these benefits of MOLM will persist to the weaner, grower and finisher stages.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data that support the findings of this study are available in Mendeley data, V1 at www.doi.org/10.17632/m7dr3r5wb9.1.

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