Veterinary and Animal Science 25 (2024) 100370

Contents lists available at ScienceDirect

Veterinary and Animal Science

journal homepage: www.elsevier.com/locate/vas

Assessment of the digestibility, growth performance, hematological and serum biochemical profile of Bandjock Local Pigs (BLP) and Duroc X Large White pigs (DLW)

Sandra Olivia Magne Ghomsi [a,b,*], Sylvain Nsangou Pechangou [a], Regine Sandra Maafo [a], Hippolyte Tene Mouafo [b], Agbor Kingsley Etchu [c], Felix Charles Bilong Bilong [d], Paul Fewou Moundipa [a]

[a] Department of Biochemistry, Faculty of Science, University of Yaoundé 1, P.O. Box 812, Yaoundé, Cameroon
[b] Centre for Food, Food Security and Nutrition Research, Institute of Medical Research and Medicinal Plant Studies, P.O. Box 13033, Yaoundé, Cameroon
[c] Institute of Agricultural Research and Development (IRAD), P.O. Box 2067, Yaoundé, Cameroon
[d] Department of Animal Biology and Physiology, Faculty of Science, University of Yaoundé 1, P.O. Box 812, Yaoundé, Cameroon

ARTICLE INFO

Keywords:
Digestibility
Growth performance
Biochemical and hematological parameters
Bandjock local pigs
Duroc X Large White pigs

ABSTRACT

The study aimed to assess the digestibility, growth performance, and selected biochemical and hematological parameters of Bandjock Local pigs (BLP) and Duroc X Large White pigs (DLW). We hypothesize that the use of local ingredients in diet formulation associated to improved rearing conditions, enhance the growth performance, digestibility, biochemical and hematological parameters of BLP. The trial involved dividing twenty-four eight-week-old weaner pigs into two groups. Each group was randomly assigned to separate pig units. Animal management and feeding were consistent between both groups. The trial lasted for 120 days during which the growth performance, the digestibility of ingested nutrients, and biochemical and hematological parameters were evaluated. The results indicate that DLW pigs registered a weight gain (46.56±5.19 kg) significantly higher than BLP pigs (34.02), with a statistically similar feed conversion ratio. Except for albumin which was significantly higher in DLW and urea in BLP, there were no significant differences ($p > 0.05$) in total protein, cholesterol, globulin, triglycerides, creatinine, AST, and ALT as well as hematological parameters between the breeds. However, the exotic DLW had a relatively high mean blood platelets and white blood cell concentration. Although the fecal nitrogen was higher in BLP and the urinary nitrogen was lower in the DLW, there were significant differences ($p < 0.05$) for urine, fecal, and total excreted nitrogen in both breeds. The lowest scores in nutrient digestibility were recorded with BLP compared to DWL, except for crude fibers. The results of this study demonstrated that using diet formulated with local ingredients and improved rearing conditions, Cameroonian local indigenous pigs have a better productivity compared to exotic breeds. It suggests that efforts should be made by authorities to promote and valorize the rearing of indigenous pigs in complement to exotic pig breeds in view of strengthening the Cameroonian pig industry.

1. Introduction

The world pig population is estimated at 784 million including exotic, crossbreed and indigenous pigs (Yu & Jensen, 2022). In Cameroon, the estimated pig population is 3.11 million among which the great majority are exotic breeds while the native ones are underestimated. The pork production reached about 40,000 tonnes in 2016 and projections for 2020 indicate an increase of about 10% (Mfewou & Lendzele, 2018). Current consumption is estimated at 2.02kg/person, considerably lower than the expected 5kg/person (Kouamo, Tankou, Zoli, Bah & Ongla, 2015). The low productivity is mainly attributed to the production system and underutilization of the production potential of local pigs (Ghomsi et al., 2022).

Opposite to exotic breeds, the indigenous pigs are known for their slow growth, poor reproductive and production characteristics, but, on the other hand, for producing quality meat (Franco, Vazquez & Lorenzo,

* Corresponding author.
E-mail address: ghomsi85@gmail.com (S.O.M. Ghomsi).

https://doi.org/10.1016/j.vas.2024.100370

Available online 3 June 2024

2014). Their wide genetic diversity makes them resistant to diseases and better adapted to harsh environments (Depres, Naves, Tamisier, Xande & Rinaldo, 1994). The local breeds, although being less productive, are adapted to the harsh conditions of the tropics. This advantage might constitute an inheritance worth to preserve in terms of innovation for the breeding of the future (Nevrkla, Václavková & Rozkot, 2021).

In Cameroon, indigenous local pigs are represented by Bakweri, Makon long nose, and Bandjock local pig (Ghomsi et al., 2022). With Bandjock local pig being the most widespread indigenous pig breed reared in the country. However, their populations are gradually decreased due to the lack of planned breeding programs and the relentless pursuit of profit of most breeders with exotic breed endowed with high productivity like Duroc X Large White pigs (Mfewou & Lendzele, 2018). The factors affecting their productivity are the breeding management system, feeding, and health (Ghomsi et al., 2022; Thutwa et al., 2020). Indeed, indigenous local pig are not reared in controlled environment. Most of them feed themselves in nature and the quality of their diets is not always necessary to satisfy the daily requirement. Besides, they are also exposed to several diseases which stunted their growth. Hence, acting on these factors (breeding in controlled environment, feeding with a specific diet, etc.) might improve the productivity of indigenous local pig breeds.

However, the livestock productivity depends on several factors including the reproductive efficiency, health status, growth rate, and feed conversion efficiency (Kouamo et al., 2015). According to Martins et al. (2020), animal productivity is best achieved when the animals concerned are healthy. Access to animal health is most commonly obtained through the determination of their hematological and biochemical profiles (Perri, O'Sullivan, Harding, Wood & Friendship, 2017). This enables, not only the assessment of some physiological and biochemical characteristics but also constitutes an intrinsic indicator to predict animal growth performance (Palova et al., 2019). Regarding feed conversion efficiency, the nutrients' digestibility indicate the physiological status of an animal's growing performance (Ndindana, Dzama, Ndiweni, Maswaure & Chimonyo, 2002).

Despite extensive documentation on the growth performance, nutrient digestibility, hematological and biochemical profiles of exotic pigs (Martins et al., 2020; Nevrkla et al., 2021a; Pawlowsky et al., 2017; Yeom, Cho, Park & Lee, 2012), there are no data for the Cameroonian local indigenous pigs. There is also a gap regarding the effect of breeding local indigenous pigs in controlled conditions with a specific formulated diet on their productivity.

Knowing the specific requirements of exotic pig breeds like the breeding environmental conditions that is not adapted in all parts of the country, and the feeds that are almost imported and not accessible to person with limit resources, the research question arising from these research gaps in the literature is related to the potential enhancing of the productivity of Cameroonian local indigenous pigs through an improved breeding conditions and diet formulation. Therefore, the present study was designed in view of boosting the pig production potential of the country. The aims of this study was to compare the digestibility, growth performance, hematological and serum biochemical profiles of Bandjock Local Pig (BLP) and a crossbred pig Duroc X Large White (DLW) reared in the same conditions.

2. Materials and methods

2.1. Ethics statement

Prior authorization for the use of laboratory animals in this study was obtained from the **Joint Institutional Review Board for Animal & Human Bioethics** (**Reference No: BTC-JIRB2021–011**). The use handling and care of animals were done in adherence to the European Convention (Strasbourg. 18. III.1986) for the protection of vertebrate animals used for experimental and other purposes (ETS-123). With particular attention to Part III. articles 7. 8 and 9.

2.2. Site of the study

The trial was conducted at the experimental farm of the Institute for Research for Agricultural Development (IRAD) Nkolbisson. The experimental farm is located in an area of medium altitude (730m above sea level) between 3°51′ to 3°53′ N and 11°25′ to 11°27′ E. The latter is characterized by an average annual temperature of 25 °C, a bimodal rainfall varying between 1500 and 2500mm/year and a relative humidity of 70 to 90% (Djoufack, 2011).

2.3. Housing

The piggery used for the experiment was 30m long, 6m wide and of semi-open type with low walls 1m high. It was subdivided into 12 boxes 2.5m long and 5m wide a surface area of 12.5 m^2. Each box was equipped with a drinking and feeding troughs. The roof was made up of corrugated sheet metal and the cement floor was gently sloping towards the urine-drainage gutters. The piggery was oriented in a north-south direction and built perpendicularly to the prevailing wind direction to ensure good ventilation.

2.4. Animals

A total of 24 weaned piglets (12 females and 12 castrated males), aged between 6 and 8 weeks were divided into 2 treatments (T1 and T2) including 12 Bandjock local pigs (BLP) and 12 exotic crossbreeds of Duroc × Large White pigs (DLW) weighing on average 6.40±1.20kg and 7.87±1.70kg, respectively. After 2 weeks of accommodation, pigs were divided in six groups of two animals and each group was housed separately in crates. Fresh drinking water was provided *ad libitum* throughout the trial.

2.4.1. Digestibility of Bandjock local pigs and Duroc X Large White pigs

2.4.1.1. Digestibility tests. A digestibility trial was carried out to better assess the level of assimilation of the nutrients contained in the basal diet by the different local and exotic pig breeds. Eight male pigs (04 BLP and 04 DLW) grew from an average weight of 29±10.4 to 37±3.60kg were placed in metabolism cages of dimensions 1.09m×0.54m×0.97m and subjected to a digestibility test according to the completely randomized model with 5 days of adaptation and 4 days of total feces collection (Prak Kea, Preston & Ly, 2003). The total duration of the experiment was 9 days. Each cage was equipped with plastic food and water troughs. Animals were given standard chow as presented in Table 1.

Table 1
Feed ratio composition.

Ingredients	Quantities (kg)
Maize	45
Wheat bran	20.25
Soya meal	10
Cotton seed cake	4
Fish meal	8
Groundnut cake	5
Palm kernel cake	5
Bone meal	2
Premix	0.25
Salt	0.50
Total	100
Calculated chemical composition	
EM (kcal/kg)	2656
Crude Protein (%)	20.31
Fat Mater (%)	4.95
Calcium (%)	1.58
Phosphorus (%)	1.13
Total Lysine (%)	1.10
Total Methionine (%)	0.40

2.4.1.2. Analysis of feed, feces and urine

Daily fecal samples (10g) were sprayed with a 2% (v/v) H_2SO_4 solution to limit nitrogen losses (Huang et al., 2018). They were then dried at 80 °C for 72h, crushed, and stored in plastic bags. Then, they were mixed to obtain a representative sample per treatment. The urine (nitrogen trapped with 10% sulphuric acid) was quantified each morning using a 250ml graduated burette; 10mL of this urine was taken and stored in the refrigerator (5 °C). The bromatological analyses were carried out on these samples (feed, feces and urine) and included the determination of the dry matter, crude protein, organic matter, and crude fibres, according to the procedures described by AOAC (Horwitz, 2000). For dry matter, samples were weight, heated at 105 °C for 24h, and weighted again. For crude protein, the samples were mineralized in presence of concentrated sulfuric acid and a catalyst. The nitrogen formed was converted into ammonia. The ammonia was steam distilled into excess boric acid solution and titrated against a hydrochloric acid (1M). For crude fibres, samples undergone acid digested in sulfuric acid solution (0.25N) followed with heating at 100 °C for 1h and filtration; then alkaline digestion using a sodium hydroxide solution (0.35N) followed with heating at 100 °C for 1h and filtration. The residue was washed three time with hot distilled water and two times with acetone before being dried and weighted. The dried residue was incinerated at 550 °C for 3h.

2.3.1.3. Apparent digestibility

The comparative apparent digestibility coefficients of dry matter, organic matter, crude proteins, and crude fibers were determined according to the formula of Ranjhan (1981):

$$\text{Apparent digestibility coefficient} = \frac{\text{Quantity ingested (g)} - \text{Quantity excreted in the feces (g)}}{\text{Quantity ingested (g)}}$$

2.4.2. Assessment of growth performance, serum biochemical and hematological analyze of local (BLP) and exotic (DLW) pig breeds

2.4.2.1. Growth performance. Piglets were individually weighed at the beginning of the study to establish baseline weight and every two weeks to evaluate growth rate. Feed were also weighed before being given to the piglets. Weekly feed intake was calculated as the difference between the amount consumed and the amount refused in each experimental unit. There were strict controls on feeding, pens, and cage washing during experimentation.

2.4.2.2. Blood collection. The blood sample was collected from jugular vein in two types of tubes. The first type without anticoagulant were for parameters which are assessed in the serum while the second type with heparin, were for parameters which are determined in the plasma. A total of 3mL of blood was collected in each tube.

2.3.2.3. Biochemical analyses. The blood samples collected in tubes free of anticoagulant were allowed to stand at room temperature (25±1 °C) for 1h. The serum collected was then centrifuged at 3000rpm for 15min and kept for analyses. Total serum proteins were determined by the Biuret method (Gornall, Bardawill & David, 1949). In the protocol, 100 µL of serum sample was mixed with 900 µL of buffer (Tris–HCl 50mM KCl 150mM pH 7.4) and 2mL of Biuret reagent. After 30min of incubation at room temperature (25±1 °C), the optical density was read at 540nm against the blank. Bovine Serum albumin (BSA) solution at different concentrations was used as standard. Albumin was determined by the bromocresol green (BCG) method and total cholesterol (TC) by the CHOP-PAP method (Gindler & Westgard, 1973). Globulin content was assessed by subtracting albumin from total proteins. Other parameters measured were: high-density cholesterol (HDL-cholesterol), triglycerides, glucose and transaminases. HDL-cholesterol and triglycerides were determined using a colorimetric enzymatic method (Trinder, 1969). Alanine aminotransferase (ALT) and Aspartate aminotransferase (ASAT) activities were assessed spectrophotometrically using SGM Italia diagnostic kits (SGM Italia, Rome, Italy).

2.4.2.4. Hematological analyses. The blood contained in heparin tubes was introduced into a hematometer, which measured the number of red blood cells, the mean blood cell volume (MGBV), and the hemoglobin level. The hematocrit was represented by all red blood cells in the blood, mean corpuscular hemoglobin concentration (MHC) and mean corpuscular hemoglobin content (MCHC)

2.5. Statistical analyses

The results obtained were presented as means ± standard deviation. All data collected were subjected to analysis of variance using SPSS 21.0 and SAS statistical software (Clark & SAS Institute, 2004). The Duncan multiple range test and LSD (Least Significant Difference) were used to compare means at the significance level of 5% through Graph Pad Prism 8.0.1 software. Testing of significant differences was carried out according to the following mathematical-statistical one analysis model:

$$\gamma i = \mu + \alpha i + ei$$

Where:

γi = is the dependent variable (average feed intake, average initial live weight, average final live weight, average weight gain, feed conversion).

µ = overal mean

αi = treatment effect ei = residual error of means and variances

Table 2
Effect of breed on nutrient ingested, digestibility and nitrogen excreted.

Parameters		BLP	DLW	*p*-value
DM	Intake (%MS)	43.51±0.19^{a}	29.53±0.36^{b}	0.001
	Digestibility (%)	46.45±0.04^{b}	59.47±0.22^{a}	0.001
CP	Intake (%MS)	6.40±0.23^{a}	3.15±0.05^{b}	0.001
	Digestibility (%)	53.37±0.34^{b}	68.68±0.25^{a}	0.001
CF	Intake (%MS)	38.56±0.32^{a}	25.48±0.31^{b}	0.001
	Digestibility (%)	98.58±0.23^{a}	96.4 ± 0.34^{b}	0.001
EE	Intake (%MS)	38.47±0.30^{a}	25.61±0.3^{b}	0.001
	Digestibility (%)	54.47±0.33^{b}	67.62±0.22^{a}	0.001
N	Urine	1.02±0.03^{a}	0.45±0.02^{b}	0.001
	Faecal	1.81±0.03^{b}	2.00±0.061^{a}	0.001
	Total	2.83±0.05^{a}	2.46±0.09^{b}	0.001

BLP: Bandjock Local Pig, DLW: Duroc X Large White DM: Dry matter, CP: Crude proteins, CF: Crude fibers, EE: Ether extract. ^{ab} Means along the same row with different superscripts are significantly different ($p<0.05$).

3. Results

3.1. Comparative digestibility of the basal ration of BLP and DLW

The feed used in this study contained 12.54% of water. It was made of 10.33g/100g DM of inorganic matter represented here by ash and 89.66g/100g DM of organic matter. In that organic matter, 18.61g/100g DM was proteins, 4.25g/100g DM was ether extract and 7.66g/100g DM was crude fibers. The Crude Energy and the Metabolize Energy were respectively 4152.415 and 3081.21kcal.

In order to assess the effect of the breed on nutrients ingested, digestibility, and nitrogen excreted, the digestibility study was performed and the results obtained are shown in Table 2. BLP pigs significantly ($p< 0.05$) ingested more elements in terms of dry matter than the DLW (43.51±0.19vs 29.53±0.36%). However, the digestibility of all nutrients was lower in the BLP pig compared DLW ($p< 0.05$), except for the crude fibers digestibility for which the opposite observation was noticed (98.58±0.23vs 96.4 ± 0.34%). On the one hand, there were significant differences ($p< 0.05$) between the two breeds for urine, fecal, and total excreted nitrogen. Considering the nitrogen excretion route, it generally appears that the quantity of fecal nitrogen was quite higher than that of urine nitrogen independent of the breed. While considering the breed, the urine and total nitrogen were significantly higher in BLP compared to DLW. However, DLW scored the highest quantity of fecal nitrogen (2.00±0.061) compared to BLP (1.81±0.03).

3.2. Assessment of growth performances, and serum biochemical analysis of local and exotic pig breeds

3.2.1. Growth performances

Table 3 shows the growth performances of the local and exotic pig breeds. The average final weights were significantly higher ($p< 0.05$) in DLW than in BLP. The highest feed intake was obtained with DLW (139.5). The weight gain was significantly higher in the exotic breed (46.56±5.19) compared to the local breed (34.023±7.77). However, the feed conversion ratio was quite similar in exotic DLW (3.015±0.033) and BLP pigs (3.87±0.85). No significant difference was observed between the daily feed intake and daily growth rate for the DLW and BLP pigs.

The percentage of weight gained by pigs as time passes is illustrated in Fig. 1. It can be observed that the percentage of weight gained during the whole experimental period for the exotic breed was statistically similar to that for the local breed ($p> 0.05$).

3.2.2. Serum biochemical parameters

Some biochemical parameters including proteins, albumin, cholesterol, globulin, HDL-cholesterol, urea, triglycerides, creatinine, AST, and ALAT, were assessed in the serum of both pig breeds and the results are presented in Table 4. It can be seen that total proteins and creatinine levels were not significantly different independently of the pig breeds. However, a significant difference ($p< 0.05$) was noticed for the urea and serum albumin levels. The albumin level was higher in BLP (3.62 ±0.20g/dL) than DLW (3.013±0.049g/dL). The urea quantity was lower in BLP (13.08±2.46μmol/L) compared to DLW (53.63±5.50μmol/L).

The lipidic profile of both pig breeds was indicated by the concentration of total cholesterol, HDL-cholesterol, and triglycerides. Triglycerides and total cholesterol levels were significantly higher ($p< 0.05$) in DLW than BLP, while HDL-cholesterol was relatively higher in BLP compared to DLW.

With regards to enzymatic activities, no significant difference ($p>0.05$) in ALAT and ASAT levels between the two breeds was observed.

3.2.3. Hematological analysis

The results of hematological analyses of BLP and DLW pigs fed with the same diets are presented in Table 5. It is worth noting that no significant differences (p>0.05) were observed between the breeds for all parameters. However, the mean concentration of blood platelets and white blood cells were significantly ($p< 0.05$) high in exotic DLW.

4. Discussion

This study was conducted to valorise local indigenous pigs as a sustainable alternative to supply the demands of pig meat in Cameroon. In this light, feed and rearing conditions were considered as the keys factors to improve the productivity of local indigenous pigs. For that, a local indigenous pig breed (BLP) was fed with the same diet as an exotic pig breed (DLW) and both were reared under the same conditions. Then, some productivity parameters including growth performance, digestibility of ingested nutrients, and biochemical and hematological parameters, were assessed.

Regarding the digestibility of ingested nutrients, the focus was made on proteins and crude fibres. The results obtained in the present study revealed that DLW pigs have a protein digestion rate higher than BLP pigs. This result was confirmed by the high fecal nitrogen excretion observed in DLW. Indeed, a key parameter that indicates protein digestion is nitrogen excretion which might occur through several routes (Cheng, Ding, Azad, Song & Kong, 2023). This difference could be associated to metabolic activities which vary from one breed to another.

However, some food constituents are known for their ability to increase the fecal excretion of nutrients thus resulting in a decrease in both apparent and fecal digestibility coefficients (Cheng et al., 2023; Meffeja et al., 2006). Dietary fibres are among these non-digestible substances. They can hinder the access of digestive enzymes to the cell contents, and thus affect the digestibility of other nutrients (Huang et al., 2018). They can cause an increase in the secretion of mucus within the gastrointestinal tract and reduce the ileal digestibility of nutrients by increasing endogenous losses (Meffeja, et al., 2007). It therefore appears interesting to have pig breeds that can metabolize dietary fibres as they are present in almost all feeds. In this study, we compared the crude fiber digestibility of BLP and DLW. The results showed that the crude fiber digestibility was higher in BLP than DLW. This could be due to the variation in colon diameters of the local breed. Indeed, due to anatomical adaptation, the largest colon diameters of local indigenous breeds result in increased fermentation and cellulose digestion capabilities (Ndindana et al., 2002). Hence, this study indicated that local

Table 3
Growth performances of local (BLP) and exotic (DLW) pigs.

Parameters	DLW	BLP	*p*-value
Average initial weight (AIW, kg)	7.41 ± 1.67[a]	6.47 ± 1.45[a]	0.42
Average final weight (AFW, kg)	54.00 ± 6.63[a]	40.00 ± 8.58[b]	0.04
Average Weight gain (AWG, kg)	46.56 ± 5.19[a]	34.023 ± 7.77[b]	0.04
Average feed intake (AFI, kg)	139.50 ± 10.34[a]	127.09 ± 9.30[a]	0.12
Feed conversion ratio (FCR)	3.01 ± 0.33[a]	3.87 ± 0.85[a]	0.11
Average Daily feed intake (ADFI, g/day)	1162.50 ± 86.16[a]	1059.08 ± 77.5[a]	0.10
Average daily gain (ADG) (g/day)	388.00 ± 43.25[a]	285.52 ± 64.75[a]	0.3
Percentage of weight gain (%)	86.00 ± 1.88[a]	83.80 ± 3.40[a]	0.23

BLP: Bandjock Local Pig, DLW: Duroc X Large White. [ab] Means along the same row with different superscripts are significantly different at $p < 0.05$.

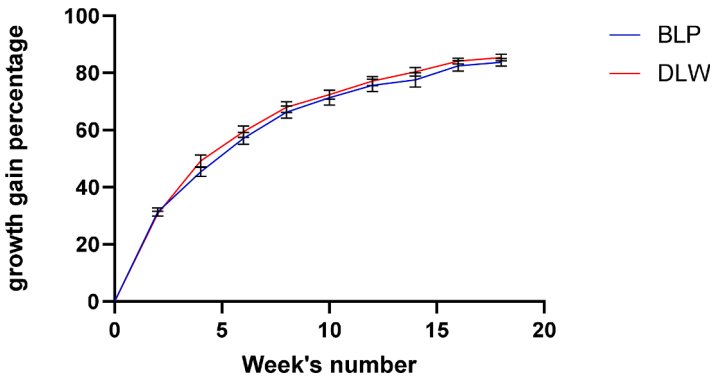

Fig. 1. Percentage weight gain per week for DLW and BLP pigs.

Table 4
Serum biochemical parameters of BLP and DLW.

Parameters	DLW	BLP	SEM	*p*-value
Total Protein (g/dL)	4.49 ± 0.44	4.55 ± 0.369	3.135	0.691
Albumin g/dL	3.013 ± 0.049^{b}	3.62 ± 0.20^{a}	0.635	0.001
Total Cholesterol (mg/dL)	2.96 ± 0.60^{a}	2.48 ± 0.26^{b}	0.219	0.03
Triglyceride (mmol/L)	0.80 ± 0.28^{a}	0.45 ± 0.08^{b}	0.093	0.04
Urea (μmol/L)	53.63 ± 5.50^{a}	13.08 ± 2.46^{b}	1.99	<0.00001
Creatinine (μmol/L)	300.87 ± 117.91	249.09 ± 174.75	73.17	0.640
ALAT (U/l)	20.41 ± 11.69	16.36 ± 4.52	4.054	0.542
ASAT (U/L)	11.13 ± 1.96	11.96 ± 1.95	0.799	0.476
HDL-cholesterol (mmol/L)	1.98 ± 0.15	2.10 ± 0.23	0.097	0.405

BLP: Bandjock Local Pig, DLW: Duroc X Large White. ^{ab} Means along the same row with different superscripts are significantly different at $p < 0.05$.

indigenous pig are more adapted to feed with high crude fiber contents which can be found all over the country. Their rearing by local inhabitants with low income and industries, as well as development of research on that field should be encouraged by authorities as it is sustainable. A similar observation was reported by Ndindana et al. (2002)) with local pigs reared in Zimbabwe. Considering the fact that most of food ingredients rich in crude fibres available in the country are less expensive and do not compete with human nutrition, their valorization in the production of pigs with high value-added will strengthen the meat industry in Cameroon.

One of the final markers of nutrient digestibility in animal production is the growth performance. After assessing the nutrient digestibility, the growth performance of both breeds was evaluated based on ADFI, ADG, AWG, and FCR. Our observations revealed no significant differences in ADFI, ADG, and FCR between BLP and DLW pig breeds, except for AWG which was higher for DLW pigs. These findings suggest that under the same rearing conditions, the Cameroonian local indigenous pigs exhibit a growth performance comparable to the exotic breed. Hence, an improvement in the rearing conditions of local indigenous pigs will enhance their productivity and boost the development of meat industries for which one of the main issues are the lack of raw materials. A similar conclusion was also stated by Keambou, Manjeli, Hako, Meutchieye and Awono (2010), who demonstrated the possibility of improving the productivity of local indigenous pigs in North region of Cameroon. However, it differs from those of Franco et al. (2014)), Renaudeau, Hilaire and Mourot (2005)), Touma and Oyadomari (2020)., and Abonyi, Arinzechukwu, Eze, Eze and Machebe (2018)), who found that Creole, Celta, Angu, and Nigeria local pigs had the lower growth performance, higher age at initial and final weights, and lower ADG than modern pig breeds, respectively. It is well known that hybrid pigs show higher growth intensity than indigenous breeds (Martins et al., 2020). This is not only due to intensive breeding, but also to the heterosis effect based on the genetic variability of the original pig populations used to create the hybrid (Nevrkla et al., 2021). The results obtained in the present studies suggest that, there is a need to improve the feeding and rearing practices of local indigenous pigs through optimization studies. The development of this sector will increase pig meat supply and thus develop the Cameroonian meat industry. It will also insure a sustainable production of pigs because, considering the global climate change and the current context of international crises, they might be issue with exotic pig breeds.

Table 5
Effect of feed on hematological parameters of animals.

Parameters	DLW	BLP	SEM	*p*.value
WBC (10^3 mm^3)	19.52 ± 1.44^{a}	11.45 ± 4.12^{b}	1.47	0.03
Lymp (%)	57.22 ± 8.98	58.22 ± 6.64	4.70	0.84
Mid (%)	8.32 ± 0.59	9.20 ± 2.40	2.249	0.53
Gran (%)	33.42 ± 6.87	33.57 ± 8.37	5.423	0.98
RBC (10^6/mm^3)	8.53 ± 0.35	7.45 ± 0.75	0.513	0.15
HCT (%)	49.30 ± 1.55	43.65 ± 6.05	2.658	0.12
HGB (g/dL)	14.22 ± 0.56	13.37 ± 1.57	1.240	0.26
MCV (fl)	57.90 ± 3.84	57.73 ± 2.54	1.481	0.91
MCH (pg)	16.70 ± 1.01	17.70 ± 0.54	0.334	0.06
MCHC g/dl	28.85 ± 0.87	30.72 ± 0.73	0.601	0.05
PLT (10^3 /mm^3)	227.25 ± 109.47	200.75 ± 129.54	92.45	0.79
PCT (%)	0.19 ± 0.07	0.17 ± 0.18	0.075	0.88

BLP: Bandjock Local Pig, DLW: Duroc X Large White. HGB: hemoglobin; HCT: hematocrit; Lymph: Lymphocytes; Mid%: lymphocyte percentage Gran%; MCH: Corpuscular Mean hemoglobin; MCHC: Mean concentration corpuscular WBC: WBC: White Blood Cell; MCV: Mean corpuscular volume; Gran%: monocytes percentage; PLT: platelets; RBC: Red Blood Cell. ^{ab} Means along the same row with different superscripts are significantly different at $p < 0.05$.

Nutrient digestibility and growth performance cannot be sufficient to conclude on the productivity if the obtained animals have health issues. In this light, the animal health was assessed through their hematological and biochemical profiles. The health status of pigs can be assessed through the functioning of their organs. One way to check the functioning of organs is generally through the measurement of some serum blood parameters. The biochemical profile of the pigs was determined because of understanding their physiological changes (Halimani, Muchadeyi, Chimonyo & Dzama, 2012). All the serum blood parameters

obtained in our study were within normal reference limits as defined in the literature (Yeom et al., 2012).

Protein deficiency has been reported to reduce most hematological and serum parameters through reduced or impaired synthesis of the largely proteinaceous blood cells (Orororo, Tonukari, Avwioroko & Ezedom, 2014.). Our study indicates that both the pig breeds showed no significant difference in serum total proteins. This result is consistent with the findings of Abonyi et al. (2018). Albumin is an important protein that is involved in the transport of nutrients in the bloodstream. Although the albumin levels of both breeds were within the normal range, they were higher in BLP than in DLW. This difference could arise from a difference in the metabolism of proteins between BLP and DLW. In fact, BLP might have better ability to metabolize proteins from feed into amino acids that are used for the production of albumin. However, this observation made in the present study differs from those of Abonyi et al. (2018) highlighting that the serum albumin level of local Nigerian pig is not significantly different from that of exotic pig breeds. The results obtained in this study suggest that BLP can be more adapted to feed made with local ingredients. Hence, the rearing of local indigenous pigs might reduce cost associated with importation of feed for exotic breed.

Regarding serum lipids profile, higher total cholesterol and triglyceride levels were observed in DLW compared to BLP. This could be due to the high backfat thickness of the exotic breed which causes fat accumulation and prevents purine excretion. Given that high levels of total cholesterol and triglycerides negatively impact the pork meat flavor (Yi, Huang, Wang & Shan, 2023) and also the consumers' health, local pigs rearing should be encouraged. The HDL-cholesterol which plays an important role in the transportation of the lipids (Islam, Haque & Nishibori, 2022) was present in the serum of the two breeds at levels that were not significantly different ($p > 0.05$). Similar observations were noticed by Nevrkla et al. (2021)).

Besides the serum lipids profile, serum urea and creatinine were assessed. Urea is the main nitrogenous end product arising from the catabolism of amino acids that are not used for biosynthetic roles in mammals (Perri et al., 2017). Therefore, the production of that indicator of muscular wastage reflects alterations in the dietary intake of protein and pattern of utilization (Orororo et al., 2014). The results obtained in this study revealed that the urea level was lower in BLP compared to DLW. The high urea levels observed in DLW may result from poor digestibility or inefficient utilization of the proteins as highlighted by Pawlowsky et al. (2017). This result suggests the rearing of local pig breeds compared to exotic ones. However, the creatinine values were significantly different ($p > 0.05$) among the two breeds. The values of urea and creatinine obtained in our study are comparable to those reported by Adesehinwa, Oluwole, Saka and Olaseinde (2010).

Considering the hematological parameters assessed in this study, the results obtained between the two breeds of pigs showed that there was no significant difference ($p > 0.05$) except for the blood platelets which showed a relatively high level in DLW compared to BLP. A similar observation was noticed by Tengan, Boateng and Karbo (2012)) in their studies on growth performance, blood profile and carcass characteristics of pigs fed with diets containing different levels of soya milk residue. However, the differences between the white blood cell values recorded did not appear to have any negative effect on the two breeds of pigs. They could be attributed to blood samples that were taken, the condition of the animal, and other environmental factors (Mayengbam & Tolenkhomba, 2015; Palova et al., 2019). Exercise, excitement, ambient temperature and other factors could also be the leading cause of the variations in these hematological indices between the two breeds of pigs (Perri et al., 2017).

5. Conclusion

The study shows that there was no significant difference in the growth performance of BLP and DLW pig breeds reared under the same conditions. BLP pigs were more adapted to feeds containing crude fibers and might be more suitable for rearing, particularly in our regions where most available and affordable animal feeds contained fibers. The DLW with high urea levels showed poor digestibility or inefficient utilization of the proteins compared to the local ones BLP. The high total cholesterol and triglyceride levels observed in DLW compared to BLP indicate that the meat from BLP is more suitable for human consumption as it might reduce the risk of cardiometabolic diseases. This study suggests that Bandjock Local Pigs may be suitable as an alternative breed, increasing the income of the farmers and improving the sustainability of the production system, where the demands on the growth parameters of the local pig population are still of primary priority.

Funding information

No funding support.

Ethical statement

Prior authorization for the use of laboratory animals in this study was obtained from the **Joint Institutional Review Board for Animal & Human Bioethics** (**Reference No: BTC-JIRB2021–011**). The use handling and care of animals were done in adherence to the European Convention (Strasbourg. 18. III.1986) for the protection of vertebrate animals used for experimental and other purposes (ETS-123). With particular attention to Part III. articles 7. 8 and 9.

Availability of data and material

The data used in this study will be made available upon reasonable request from the corresponding author.

CRediT authorship contribution statement

Sandra Olivia Magne Ghomsi: Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Sylvain Nsangou Pechangou:** Validation, Methodology, Conceptualization. **Regine Sandra Maafo:** Writing – review & editing, Methodology, Conceptualization. **Hippolyte Tene Mouafo:** Writing – review & editing, Visualization, Validation, Software, Data curation. **Agbor Kingsley Etchu:** Writing – review & editing, Conceptualization. **Felix Charles Bilong Bilong:** Writing – review & editing. **Paul Fewou Moundipa:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors would like to acknowledge all the participants.

References

Abonyi, F. O., Arinzechukwu, U., Eze, D., Eze, J. I., & Machebe, N. S. (2018). Comparative evaluation of growth performance, serum biochemical profile and immunological response of the Nigerian indigenous and large white x landrace crossbred pigs. *Nigerian Veterinary Journal, 39*(1), 81. https://doi.org/10.4314/nvj.v39i1.10

Adesehinwa, A. O. K., Oluwole, O. O., Saka, J. O., & Olaseinde, T. O. (2010). Growth performance, blood parameters and return on investment of growing weaner pigs of Nigerian indigenous pig (NIP), Exotic (large white × Landrace) and hybrid (F1crossbred of NIP × exotic) origins under intensive management system. *Conference on International Research on Food Security. Tropentag, ETH Zurich, 1*(39), 81–91.

Cheng, Y., Ding, S., Azad, Md. A. K., Song, B., & Kong, X. (2023). Comparison of the Pig Breeds in the Small Intestinal Morphology and Digestive Functions at Different Ages. *Metabolites, 13*(1), 132. https://doi.org/10.3390/metabo13010132

Clark, V., & Institute, S. A. S. (2004). *SAS/STAT 9.1: User's guide*. SAS Pub.

Depres, E., Naves, M., Tamisier, F., Xande, A., & Rinaldo, D. (1994). Growth performance and meat quality of large white and local pigs reared in the tropics. *Livestock Research for Rural Development 6, 10, 6*(2), 10. http://www.lrrd.org/lrrd6/2/xande.htm.

Djoufack, V. (2011). *Étude multi-échelles des précipitations et du couvert végétal au cameroun: Analyses spatiales, tendances temporelles, facteurs climatiques et anthropiques de variabilité du ndvi*. Phdthesis, Université de Bourgogne. https://tel.archives-ouvertes.fr/tel-00690359.

Franco, D., Vazquez, J. A., & Lorenzo, J. M. (2014). Growth performance, carcass and meat quality of the Celta pig crossbred with Duroc and Landrance genotypes. *Meat Science, 96*(1), 195–202. https://doi.org/10.1016/j.meatsci.2013.06.024

Ghomsi, O. S. M., Wirnkar, C. N., Etchu, K. A., Fontanesi, L., Bilong, C. F. B., & Moundipa, P. F. (2022). Morphological and serum biochemical characterizations of local pig populations from three different agro-ecological areas of Cameroon. *International Journal of Livestock Production, 13*(2), 33–42. https://doi.org/10.5897/IJLP2021.0794

Gindler, E. M., & Westgard, J. O. (1973). Automated and manual determination of albumin with bromcresol green and a new ionic surfactant. *Clinical Chemistry, 6*, 4, 4 (6).

Gornall, A. G., Bardawill, C. J., & David, M. M. (1949). Determination of serum proteins by means of the biuret reaction. *Journal of Biological Chemistry, 177*(2), 751–766. https://doi.org/10.1016/S0021-9258(18)57021-6

Halimani, T., Muchadeyi, F., Chimonyo, M., & Dzama, K. (2012). Some insights into the phenotypic and genetic diversity of indigenous pigs in southern Africa. *South African Journal of Animal Science, 42*(5), 507–510. https://doi.org/10.4314/sajas.v42i5.13

Horwitz, W. (2000). *Official methods of analysis of aoac international* (17th ed). AOAC International.

Huang, C., Li, P., Ma, X., Jaworski, N. W., Stein, H. H., Lai, C., et al. (2018). Methodology effects on determining the energy concentration and the apparent total tract digestibility of components in diets fed to growing pigs. *Asian-Australasian Journal of Animal Sciences, 31*(8), 1315–1324. https://doi.org/10.5713/ajas.17.0761

Islam, M. A., Haque, A., & Nishibori, M. (2022). Growth performance, meat yield and blood lipid profile of broiler and Sonali chickens. *Veterinary and Animal Science, 18*, Article 100272. https://doi.org/10.1016/j.vas.2022.100272

Ke, Praa, k., Preston, T. R., & Ly, J. (2003). Feed intake, digestibility and N retention of a diet of water spinach supplemented with palm oil and /or broken rice and dried fish for growing pigs. *Livestock Research for Rural Development, 15*(8). http://www.lrrd.org/lrrd15/8/kea158.htm.

Keambou, T. C., Manjeli, Y., Hako, B. A., Meutchieye, F., & Awono, J. C. (2010). Effets comparés d'un aliment concentré et de l'aliment traditionnel des éleveurs sur les performances de croissance et économique des porcelets de race locale au Nord Cameroun. *Revue d'élevage et de médecine vétérinaire des pays tropicaux*, 63–77. https://doi.org/10.19182/remvt.10101

Kouamo, J., Tankou, W. F. T., Zoli, A. P., Bah, G. S., & Ongla, A. C. N. (2015). Assessment of reproductive and growth performances of pig breeds in the peri-urban area of Douala (Equatorial Zone). *Open Veterinary Journal, 5*(2), 64–70. https://doi.org/10.5455/OVJ.2015.v5.i1.p64

Martins, J. M., Fialho, R., Albuquerque, A., Neves, J., Freitas, A., & Nunes, J. T. (2020). Growth, blood, carcass and meat quality traits from local pig breeds and their crosses. *Animal : An International Journal of Animal Bioscience, 14*(3), 636–647. https://doi.org/10.1017/S1751731119002222

Mayengbam, P., & Tolenkhomba, T. C. (2015). Seasonal variation of hemato-biochemical parameters in indigenous pig: Zovawk of Mizoram. *Veterinary World, 8*(6), 732–737. https://doi.org/10.14202/vetworld.2015.732-737

Meffeja, F., Njifutié, N., Manjeli, Y., Dongmo, T., Tchakounté, J., & Fombad, R. B. (2006). Digestibility and effects of diets containing graded level of cocoa pod husk on the performance of growing-finishing pigs. *Livestock Research for Rural Development, 11*, 18. http://www.lrrd.org/lrrd18/11/meff18165.html.

Mfewou, A., & Lendzele, S.S. (.2018). Urban-Pig Farming: Easy Gain and Danger to the Environment (Yaounde-Cameroon). 2, 190–198. doi:10.31058/j.as.2018.24018.

Ndindana, W., Dzama, K., Ndiweni, P. N. B., Maswaure, S. M., & Chimonyo, M. (2002). Digestibility of high ®bre diets and performance of growing Zimbabwean indigenous Mukota pigs and exotic Large White pigs fed maize based diets with graded levels of maize cobs. *Animal Feed Science and Technology, 97*, 199–208. https://doi.org/10.1016/S0377-8401(01)00345-5

Nevrkla, P., Václavková, E., & Rozkot, M. (2021). The Indigenous Prestice Black-Pied Pig Breed Differs from a Commercial Hybrid in Growth Intensity, Carcass Value and Meat Quality. *Agriculture, 11*(4), 331. https://doi.org/10.3390/agriculture11040331

Orororo, O. C., Tonukari, N. J., Avwioroko, O. J., & Ezedom, T. (2014). Effect of Supplementation of Animal Feed with Dried Cassava (Manihot esculenta) Peels, and Stems of Vernonia amygdalina and Pennisetum purpereum on Some Biochemical Parameters in Pigs. *Nigerian Society for Experimental Biology Journal, 14*(4), 1595–6938. http://www.nisebjournal.org.

Palova, N., Marchev, Y., Nedeva, R., Krusheva, D., Slavov, T., Nedeva, I. et al. (2019). Hematological and serum biochemical profile in east balkan pigs at different age and seasons. 4(3), 164–175. https://doi.org/10.7251/AGRENG1903164P.

Pawlowsky, K., Ernst, L., Steitz, J., Stopinski, T., Kögel, B., Henger, A., et al. (2017). The Aachen Minipig: Phenotype, Genotype, Hematological and Biochemical Characterization, and Comparison to the Göttingen Minipig. *European Surgical Research, 58*(5–6), 193–203. https://doi.org/10.1159/000471483

Perri, A. M., O'Sullivan, T. L., Harding, J. C. S., Wood, R. D., & Friendship, R. M. (2017). Hematology and biochemistry reference intervals for Ontario commercial nursing pigs close to the time of weaning. *The Canadian Veterinary Journal, 58*(4), 371–376. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5347327/.

Ranjhan, S. K. (1981). *Animal nutrition in tropics* (Second Revised Edition, p. 480). Vikas, Publishing House.

Renaudeau, D., Hilaire, M., & Mourot, J. (2005). A comparison of carcass and meat quality characteristics of Creole and Large White pigs slaughtered at 150 days of age. *Animal Research, 54*(1), 43–54. https://doi.org/10.1051/animres:2004042

Tengan, Okai D. B., Boateng, M., & Karbo, N. (2012). Nutritional evaluation of African Locust Bean Pulp (ALBP) –fruit fraction nutrient profile and effects of the pulp on the growth performance, blood constituents and carcass characteristics of growing pigs. *Ghanaian Journal of Animal Science*, (6), 1.

Thutwa, K., Chabo, R., Nsoso, S. J., Mareko, M., Kgwatalala, P. M., & Owusu-Sekyere, E. (2020). Indigenous Tswana pig production characteristics and management practices in southern districts of Botswana. *Tropical Animal Health and Production, 52*(2), 517–524. https://doi.org/10.1007/s11250-019-02037-3

Touma, S., & Oyadomari, M. (2020). Comparison of growth performances, carcass characteristics, and meat qualities of Okinawan indigenous Agu pigs and crossbred pigs sired by Agu or Duroc boar. *Animal Science Journal, 91*, E13362. https://doi.org/10.1111/asj.13362

Trinder, P. (1969). Determination of Glucose in Blood Using Glucose Oxidase with an Alternative Oxygen Acceptor. *Annals of Clinical Biochemistry: International Journal of Laboratory Medicine, 6*(1), 24–27. https://doi.org/10.1177/000

Yeom, S.C., Cho, S.Y., Park, C.G., & Lee, W.J. (2012). Analysis of reference interval and age-related changes in serum biochemistry and hematology in the specific pathogen free miniature pig. 28(4), 10. https://doi.org/10.5625/lar.2012.28.4.245.

Yi, W., Huang, Q., Wang, Y., & Shan, T. (2023). Lipo-nutritional quality of pork: The lipid composition, regulation, and molecular mechanisms of fatty acid deposition. *Animal Nutrition, 13*, 373–385. https://doi.org/10.1016/j.aninu.2023.03.001

Yu, W., & Jensen, J. D. (2022). Sustainability implications of rising global pork demand. *Animal Frontiers, 12*(6), 56–60. https://doi.org/10.1093/af/vfac070