







Research Article

Evaluation of Carcass Quality in Pigs Resulting from Crossbreeding Between Piétrain Stress Negative and Local and Improved Pig Breeds in Southern Benin

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Abstract

The carcass of the local pig breed and the improved pig breed of Benin is observed to contain a high proportion of fat cover. The objective of the study was to evaluate the carcass quality of pigs obtained through the process of crossbreeding, specifically between the Stress-negative Piétrain and local and improved pig breeds. To achieve this objective, five lots of pigs of different genetic types were constituted: lot 1 (local pigs), lot 2 (Piétrain X local pig), lot 3 (Piétrain X Improved), lot 4 (Improved), and lot 5 (Piétrain). A sample of 10 pigs (5 males and 5 females) was selected from each lot and fattened and slaughtered at 8 months of age. The slaughter live weight, hot and cold carcass weights, and hot and cold carcass yields of Piétrain pigs were found to be significantly higher than those of local and improved pigs ($p < 0.001$). Furthermore, the slaughter weights, hot and cold carcass weights, and slaughter carcass yields of Piétrain-local breed crossbreeds were observed to be higher than those of local pigs ($p < 0.001$), and a similar trend was evident between Piétrain-improved breed crossbreeds and Improved. The Piétrain exhibits the highest carcass yield, at a minimum of 70%, in comparison to other breeds. In contrast to the local and improved breeds, the Piétrain has a markedly reduced back fat thickness. The cross-breeds of the Piétrain with the local and improved breeds exhibited a significantly lower back fat thickness than their respective parent breeds ($p < 0.001$). The same differences were observed for the backfat ($p < 0.001$). The heterosis effect was observed to be positive for live weight at slaughter, hot carcass weight, cold carcass weight, and lean cuts (rack, ham, and shoulder) in Piétrain-local breed and Piétrain-improved breed crossbreeds. Conversely, the heterosis effect was negative with regard to fatty cuts, particularly the backfat, belly wall, and back fat thicknesses in both crossbreeds. The findings indicate that the Piétrain breed enhances carcass quality in crossbreeds derived from local and improved breeds by reducing the proportion of fatty cuts and increasing those of lean cuts.

Keywords

Piétrain, Local Breeds, Improved Breeds, Crossbreeding, Heterosis, Carcasses

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1. Introduction

The pig herd in Benin is comprised of three distinct categories: local, crossbred, and improved pigs [1, 2]. The term "improved breed" is used to refer to exotic breeds such as the Large White and Landrace, as well as the products of various crossbreeding carried out between these breeds [2]. The cross-breeds are the result of crossbreeding between the improved breed and the local breed. Each breed possesses distinctive zootechnical and butchery characteristics. Local pigs are highly regarded by butchers and consumers [3, 4], whereas farmers perceive them as unprofitable in semi-intensive or intensive farming [4-6]. The crossbreeds and improved pigs are appreciated by breeders for their growth and prolificity. However, butchers and consumers find them to be fatty, with a technological, organoleptic, and sensory quality that is less appealing than that of local pigs [4, 7]. Nevertheless, breeders have observed that local pigs exhibit greater resistance to African Swine Fever compared to crossbred and improved pigs. In summary, crossbreeds and improved breeds demonstrate robust growth and prolificity; however, their carcass and meat quality are not highly regarded due to their high fat content and increased susceptibility to African Swine Fever. To correct these deficiencies, the Large White and Landrace pig, which constitute the majority of the improved breeds and a portion of the crossbreeds, can be replaced in crossbreeding schemes by the Piétrain, a hypermuscular breed of Belgian origin (culard gene). In contrast to the Large White and Landrace breeds, the Piétrain has been demonstrated to possess a high-quality, low-fat carcass with exceptional organoleptic qualities [8]. The Piétrain's susceptibility to stress has historically constrained its distribution in tropical regions. The development of the so-called "stress-negative" line with the NN or Nn halothane-sensitive genotype [9-11] has enabled the breed to adapt to tropical environments. It is now found in Burkina Faso, the Democratic Republic of Congo, and Vietnam [12, 13].

The crossbreeding of stress-negative Piétrain with local Benin pigs and improved pigs, respectively, revealed that Piétrain improved reproductive performance in both local and improved pigs [14]. Similarly, crossbred piglets (F1) showed significantly higher weights and average daily gains than local piglets, and Piétrain had significantly higher growth performance compared with the other two [15]. If stress negative Piétrain improves the zootechnical performance of both local and improved pigs, what is the impact of this on the carcass quality of these two breeds?

The objective of this study is to evaluate the carcass quality of pigs resulting from negative-stress Piétrain crossbreeding with local and improved pig breeds. The findings will provide farmers with high-performance genetic types that can benefit breeders, butchers, and consumers.

2. Materials and Methods

2.1. Study Area

The study was carried out in the pig farms of the Genetic Improvement Unit of the Laboratory of Animal Biotechnology and Meat Technology of the Polytechnic School of Abomey-Calavi of the University of Abomey-Calavi (Benin), from July 2019 to June 2022. This laboratory is located in the commune of Abomey-Calavi between 6°24'42" north latitude and 2°20'22" east longitude. This commune enjoys sub-equatorial climatic conditions characterized by two rainy seasons: the long season (April to July) and the short season (October to November). These two seasons are interspersed with dry seasons, the longest of which lasts from December to March. Temperatures vary from 25 to 30°C, and rainfall ranges from 900 mm to 1,500 mm per year.

2.2. Experimental Design

The work was conducted at the Polytechnic School of Abomey-Calavi. In total, two lots of six primiparous sows of the local breed, two lots of six primiparous sows of the improved breed, and a lot of six primiparous Piétrains were constituted. The first lot of local females was mated with a local boar (Lot 1), while the second lot of local females was inseminated with Stress-Negative Piétrain semen (Lot 2). The first lot of improved breed females was inseminated with a Piétrain semen (lot 3), while the second lot of improved females was inseminated with the semen of improved males (lot 4). Finally, the Piétrain females were inseminated with Piétrain semen (lot 5). The Piétrain breed was imported from Belgium. Following its delivery, the females in lots 2 and 3 were inseminated after heat synchronization. Those that were not pregnant were inseminated again. The occurrence of pregnancies and parturition was recorded for each of the five lots.

The animals utilized in this experiment were provided with ad libitum access to a feed containing 20% protein and an energy content of 3000 kcal/kg feed from the time of their birth until they reached the age of 2.5 months, at which point they were weaned. Subsequently, the animals were fattened on a growth-finish feed comprising the following ingredients: wheat bran (38%), fish meal (2%), corn bran (30%), palm kernel meal (28%), dicalcium phosphate (0.2%), lysine (0.1%), methionine (0.1%), cooking salt (0.5%), and oyster shell (1%). The energy content of the feed was 2,900 or 2,500 kilocalories per kilogram, and the total nitrogen content was 16%. During the fattening phase, which spanned from 2.5 to 8 months of age, water and feed were provided in unlimited quantities.

From a health and medical perspective, the animals were subject to regular monitoring throughout the course of the experiment. Prior to their placement in the fattening pens, all animals were administered anti-stress treatment. At the outset

of the experiment, the animals were dewormed against gastrointestinal parasitosis and also received preventive treatment against trypanosomiasis. The same treatments were administered to the animals two months later. Animals exhibiting signs of illness were treated in a systematic manner, in accordance with the clinical cases presented. In order to ensure the implementation of sanitary prophylaxis, two foot baths were installed at the entrance to the buildings.

2.3. Slaughtering Procedures

A total of 10 pigs, comprising 5 males and 5 females, were randomly selected from each lot for slaughter. On the day preceding the slaughter, the animals were fasted from 6 p.m. until slaughter at 7 a.m. the following morning. Once the animal was slaughtered and the jugular vein severed, it was first scalded and then depilated and eviscerated. Subsequently, the carcass was divided into two halves and subsequently re-dried at room temperature. The carcass was separated from the left half carcass, which was maintained in a cold storage environment at 4 degrees Celsius for a period of 24 hours. The leg (comprising the portion of the thigh containing the pelvic bones, femur, tibia, fibula, and associated muscles) was divided into sections at the ilium and tarsal joints using a clean cutting technique. Subsequently, the shoulder (portion of the anterior limb) was sectioned at the carpal joint. The rack (portion of the loin) has been sectioned at the 2nd thoracic vertebra and at the last lumbar vertebra, thus containing the filet and the rate of filet. The backfat (rind and adipose tissue) was detached from the loin. The dissection proceeded in accordance with the procedure described by Desmoulin *et al* [16].

2.4. Carcass Characteristics

The carcass characteristics were evaluated on the left half carcass. Carcass length is defined as the distance between the first thoracic rib and the pubis. The thickness of the back fat is gauged with a caliper at the level of the neck, extending from the last thoracic rib to the rump. The mean back fat thickness is calculated as the mean of the three aforementioned measurements. The slaughter yield is defined as the ratio of carcass weight to final live weight, which is measured prior to fasting. The hot and cold carcass yields were calculated using the following formulas:

$$\text{Hot carcass yield} = \frac{\text{Hot carcass weight} \times 100}{\text{Live weight at slaughter}}$$

$$\text{Cold carcass yield} = \frac{\text{Cold carcass weight} \times 100}{\text{Live weight at slaughter}}$$

The head and legs were subjected to a weighing procedure, after which their respective weight percentages in relation to the carcass weight were calculated.

The heterosis effect of each trait was calculated using the following formula:

$$\text{Heterosis (\%)} = \frac{F_1 - \frac{(\text{Parent 1} + \text{Parent 2})}{2}}{\frac{(\text{Parent 1} + \text{Parent 2})}{2}} * 100$$

Where:

1. F1 is the performance value of the crossed individual (Piétrain X local breed or Piétrain X improved breed),
2. Parent1: Father, is the performance value of the F1 individual's father;
3. Parent 2: Mother, is the performance value of the F1 individual's mother.

2.5. Statistical Analysis

The statistical analysis was conducted using the Statistical Analysis System Software [17]. A fixed-effects linear model was employed for the analysis of live weight data and carcass characteristics. The fixed effects of this model were breed and sex. The interaction between breed and sex was found to be statistically significant and was therefore incorporated into the Analysis of variance model. The mathematical expression of this model is as follows:

$$Y_{ijk} = \mu + B_i + S_j + B*S_{ij} + e_{ijk}$$

With:

1. Y_{ijk} is the live weight or a carcass characteristic of animal k ; of breed i and sex j ;
2. μ is the overall average;
3. B_i is the fixed effect of breed i (Local, Improved, Petrain, Petrain X Local, Petrain X Improved);
4. S_j is the fixed effect of sex j (male and female);
5. $B*S_{ij}$ is the interaction between race i and sex j ;
6. e_{ijk} is the random residual error.

The generalized linear model procedure of Statistical Analysis System Software [17] was employed for the analysis of variance. The F-test was employed to determine the significance of each model effect, and the least-squares means were estimated and compared in pairs by Student's t-test.

3. Results

3.1. Breed Effect on Carcass Characteristics

Table 1 presents the findings regarding carcass characteristics of the five genetic types. The slaughter live weight, hot and cold carcass weights, and hot and cold carcass yields of Piétrain were observed to be higher than those of local and improved pigs ($p < 0.001$). The slaughter weights, hot and cold carcass weights, and slaughter carcass yields of Piétrain-local crossbreeds were observed to be higher than those of the local breed ($p < 0.001$). A similar trend was noted between Piétrain-improved cross-breeds and the improved breed. The Piétrain breed exhibited the highest carcass yield, at a minimum of 70%, in comparison to other breeds.

Table 1. Body composition of piétrain, local, improved and crossbred pigs.

Variables	Piétrain		Local		Improved		Piétrain X Local		Piétrain X Improved		Significant
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Live weight (kg)	77.78a	3.75	25.47c	4.19	53.75b	4.10	55.34b	2.30	68.09b	2.30	***
Hot carcass (kg)	59.22a	3.22	16.19d	3.57	35.58c	3.59	38.94c	1.96	49.22b	3.22	***
Hot carcass (%)	76.36b	6.24	64.06d	5.80	66.38c	4.42	70.26c	6.42	72.26a	5.01	***
Cold carcass (kg)	53.87a	2.68	14.34d	3.00	34.58c	3.00	35.09c	1.64	46.76b	1.64	***
Cold carcass (%)	72.29b	5.13	56.30c	8.63	64.45c	5.53	63.52cb	4.95	68.67a	5.03	***
Thickness of back fat (cm)	0.18b	0.77	3.41a	0.87	0.75a	0.87	0.30b	0.47	0.35b	0.47	NS
Neck fat thickness (cm)	0.18c	0.26	1.05bc	0.29	1.88a	0.29	0.52c	0.16	0.95ab	0.16	***
Rump fat thickness (cm)	0.18c	0.08	0.74b	0.09	1.32a	0.09	0.28c	0.05	0.39b	0.05	***
Average back fat thickness (cm)	0.18c	0.10	0.97b	0.12	1.35a	0.12	0.37c	0.06	0.57b	0.07	***
Rack of pork (kg)	3.76a	0.36	1.49c	0.40	2.50b	0.40	3.48a	0.22	3.19ab	0.22	**
Rack of pork (%)	13.96	1.81	9.77a	2.91	7.33b	0.93	9.88a	1.01	7.13b	2.13	***
Ham (kg)	6.27a	0.41	2.70d	0.45	3.10c	0.45	4.84b	0.25	5.18b	0.25	***
Ham (%)	11.80b	2.33	11.57b	1.60	8.90c	0.65	11.80a	2.33	9.37c	2.55	***
Shoulder (kg)	4.54a	0.33	1.67c	0.38	2.69b	0.38	3.49b	0.21	3.81b	0.20	***
Shoulder (%)	8.45b	1.53	11.43a	0.84	7.87b	1.17	10.02a	0.73	7.60b	2.03	***
Backfat (kg)	0.36b	0.06	0.53b	0.06	0.80a	0.07	0.42b	0.04	0.39b	0.03	***
Belly wall (kg)	1.10a	0.14	0.71b	0.16	1.16b	0.16	0.97ab	0.09	1.07a	0.09	NS
Viscera (kg)	1.76b	0.53	1.19b	0.53	2.16b	0.53	1.44a	0.28	2.01b	0.28	*
Remaining carcass (kg)	6.78a	0.63	2.21c	0.63	5.96ab	0.63	5.33ab	0.33	4.90b	0.33	**
Head (kg)	6.50a	0.60	1.94c	0.60	4.50b	0.59	6.01ab	0.31	5.35ab	0.31	***
Head (%)	12.99b	2.19	13.96ab	1.85	13.99ab	3.13	16.44a	2.19	12.11b	1.66	***
Legs (kg)	1.30a	0.12	0.40d	0.12	0.96b	0.12	1.31a	0.06	1.20ab	0.06	***
Carcass length (cm)	63.50bc	3.79	19.17	3.79	73.83a	3.79	58.75c	2.01	66.87ab	2.01	***

p>0.05; *: p<0.05; **: p<0.01; ***: SE: Standard Error

Improved breeds exhibit higher slaughter weights, heavier carcasses, and higher hot and cold carcass yields at slaughter compared to local pigs ($p < 0.001$). The performance of the breed was enhanced through crossbreeding with the Piétrain. The carcass length of the improved breeds was observed to be longer than that of the Piétrain ($p < 0.01$), while the carcass length of the local breeds was found to be the shortest ($p < 0.001$).

In contrast to local and improved breeds, Piétrain exhibited a markedly reduced back fat thickness. Furthermore, Piétrain crosses with local and improved breeds, respectively, demonstrated a diminished back fat thickness compared to local and improved breeds ($p < 0.001$). The same trend was observed in the backfat ($p < 0.001$).

In terms of lean cuts, the Piétrain exhibited a heavier rack, ham, and shoulder than the local and improved breeds, while the crossbreeds demonstrated a cut weight that was intermediate between the parent breeds.

Additionally, the Piétrain exhibits a greater weight of the head, while the Piétrain and local crosses demonstrate the highest proportion of the head.

3.2. Effect of Sex on Carcass Characteristics

The overall slaughter weight of males and females within the same breed was found to be statistically indistinguishable. However, in the improved breed, males exhibited a higher hot carcass weight than females, while females demonstrated a

higher belly wall weight than males ($p < 0.05$). No significant difference was observed between carcass characteristic measurements of males and females of Piétrain-improved crosses, and the same observations were made in Piétrain and Piétrain X Locale crosses. In local pigs, females exhibit a

greater degree of dorsal fat thickness, a more substantial backfat, and a heavier belly wall ($p < 0.05$). Table 2 presents the results of carcass characteristics for the five genetic types by sex.

Table 2. Body composition of piétrain, local, improved and crossbred pigs according to sex.

Race	Improved		Improved X Piétrain		Local		Piétrain		Piétrain X Local		Significant
Sexe	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	
Live weight (kg)	52.50±3.54b	55.00±6.08b	57.74±7.31b	58.45±9.07b	27.83±2.98c	23.12±1.72c	82.75±13.38a	72.81±13.27a	53.95±12.93b	56.74±6.32b	NS
Hot carcass (kg)	33.50±2.12a	37.67±7.23cd	51.74±7.55ab	49.18±7.86bc	17.26±3.94e	15.13±0.16e	62.70±8.71a	55.73±11.45ab	38.28±9.33cd	39.61±7.36cd	NS
Hot carcass (%)	63.82±0.26de	68.09±5.29cde	89.40±2.67a	84.17±5.56ab	61.61±7.56e	65.70±5.35de	76.33±9.38bd	76.38±3.06bc	70.98±4.64cd	69.53±8.1cde	NS
Cold carcass (kg)	32.50±2.12e	36.67±8.14cde	45.32±4.66bc	44.20±5.68bcd	7.72±8.93f	14.96±0.07f	56.76±9.65a	50.99±11.11ab	34.87±7.90de	35.31±4.96de	NS
Cold carcass (%)	61.91±0.13d	66.15±7.10cd	78.94±6.37a	75.86±2.90ab	51.38±4.48e	64.98±5.30cd	68.83±7.41bcd	69.75±3.18bc	64.96±6.45cd	62.09±2.48cd	*
Thickness of back fat (cm)	0.70±0.14bc	0.80±0.17b	0.27±0.1de	0.44±0.24cd	1.95±0.64a	4.88±8.27e	0.19±0.0de	0.18±0.0de	0.33±0.19de	0.29±0.09de	NS
Neck fat thickness (cm)	2.00±0.14a	1.77±0.72ab	1.69±0.62ab	1.31±0.53abc	2.00±0.71a	0.10±0.0d	0.19±0.0d	0.18±0.0d	0.89±1.08bcd	0.55±0.40cd	NS
Rump fat thickness (cm)	1.30±0.42a	1.33±0.35a	0.49±0.8b	0.30±0.17bc	1.38±0.54a	0.10±0.0c	0.19±0.0bc	0.18±0.0c	0.29±0.10bc	0.26±0.00bc	***
Average back fat thickness (cm)	1.33±0.14b	1.37±0.39b	0.81±0.8c	0.68±0.25cd	1.85±0.26a	0.10±0.0e	0.19±0.0e	0.18±0.0e	0.50±0.42cde	0.36±0.13de	***
Rack of pork (kg)	2.28±0.36bcd	2.73±0.41	3.32±1.05	3.06±1.10	1.79±0.30	1.18±0.22	3.75±1.15	3.78±0.64	3.47±0.99	3.49±0.60	NS
Rack of pork (%)	6.98±0.65c	7.56±1.14bc	7.35±2.23bc	6.90±2.15c	12.56±1.84a	7.91±1.51bc	6.78±2.76c	7.46±0.45bc	9.90±1.25b	9.87±0.79b	NS
Ham (kg)	3.09±0.16de	3.12±0.76de	4.32±1.11cd	4.05±1.43cd	1.70±0.43e	1.70±0.16e	6.08±1.08ab	6.38±1.09a	4.82±0.98bc	4.88±0.54abc	NS
Ham (%)	9.50±0.12cd	8.50±0.49d	9.63±2.64cd	9.10±2.61cd	11.88±2.79abc	11.36±1.03abcd	10.98±3.21bcd	12.61±1.10ab	13.89±0.61a	13.86±0.69ab	NS
Shoulder (kg)	2.58±0.49cd	2.81±0.31cd	3.43±0.85bc	3.39±1.32bc	1.62±0.27d	1.72±0.3d	4.85±0.86a	4.22±1.19ab	3.42±0.61bc	3.57±0.47bc	NS
Shoulder (%)	7.99±2.02bc	7.78±0.81c	7.61±1.88c	7.59±2.30c	11.37±1.66a	11.47±0.17a	8.68±2.02bc	8.23±1.28bc	9.90±0.81abc	10.14±0.67ab	NS
Backfat (kg)	0.80±0.21a	0.80±0.26a	0.39±0.15b	0.39±0.17b	0.78±0.08a	0.28±0.05b	0.38±0.13b	0.34±0.17b	0.43±0.16b	0.41±0.08b	*
Belly wall (kg)	1.49±0.24a	0.83±0.17bc	1.05±0.28ab	1.09±0.53ab	1.09±0.14ab	0.33±0.0c	1.28±0.15ab	0.93±0.11b	0.97±0.42ab	0.98±0.34ab	NS
Viscera (kg)	2.10±0.00ab	2.21±0.36ab	2.18±0.22ab	2.12±0.22ab	1.33±0.00b	1.04±0.07b	0.88±0.00b	2.65±0.07ab	3.66±1.88a	3.23±1.24a	NS

Race	Improved		Improved X Piétrain		Local		Piétrain		Piétrain X Local		Significant
Sexe	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	
Remaining carcass (kg)	5.60±0.00ab	6.31±0.92 ab	4.86±0.9 b	4.96±1.49 b	2.05±0.00 c	2.37±0.2 0 c	7.44±0.0 0 cd	6.13±1.13 ab	5.59±1.1 7 ab	5.07±0.7 3 a	NS
Head (kg)	3.88±0.00bc	5.12±0.31 ab	5.27±1.2 9 ab	5.42±0.68 ab	1.69±0.00 d	2.18±0.2 5 cd	6.64±0.0 0 a	6.35±0.41 a	6.12±1.2 8 a	5.91±1.4 0 ab	NS
Head (%)	12.52±0.00b	14.49±3.63 ab	11.67±2.24 ab	12.33±1.41 ab	12.05±0.00 c	14.59±1.65 c	13.44±0.00 ab	12.84±2.6 6 ab	16.07±2.88 ab	16.63±2.37 a	***
Legs (kg)	0.91±0.00ab	1.01±0.14 ab	1.19±0.1 9 b	1.22±0.17 ab	0.32±0.00 ab	0.47±0.0 2 ab	1.31±0.0 0 ab	1.29±0.03 ab	1.26±0.2 5 ab	1.36±0.3 1 a	NS
Carcass length (cm)	74.00±0.00a	73.67±4.51 a	65.00±6.88 ab	68.75±6.32 ab	18.00±0.00 c	20.33±1.53 c	61.00±0.00 ab	66.00±6.5 6 ab	58.25±7.93 b	59.25±7.36 b	NS

NS: $p>0.05$; ***: $p<0.001$

3.3. Heterosis Effect

The heterosis effect was observed to have a positive impact on live weight at slaughter, hot carcass weight, cold carcass weight, and lean cuts (rack, ham, and shoulder). Conversely, the heterosis effect was observed to have a negative impact on the fatty cuts, particularly backfat, belly wall,

and back fat thickness. The heterosis effect was observed to have a positive impact on head weight, carcass length, liver weight, and testicle weight in Piétrain-Local Breed crosses, while in improved crosses, the effect was noted to be negative for these same traits. Table 3 illustrates the heterosis effect values for carcass characteristics in Piétrain-local breed and Piétrain-improved breed crosses.

Table 3. Heterosis effect on carcass characteristics of Piétrain x local breed and Piétrain x Improved breed crosses.

Variables	Piétrain	Local	Improved	Piétrain x Local	Piétrain x Improved	Piétrain x Local	Piétrain x Improved
Live weight (kg)	77.78	25.47	53.75	55.34	68.09	7.20*	3.54*
Hot carcass (kg)	59.22	16.19	35.58	38.94	49.22	3.28*	3.84*
Cold carcass (kg)	53.87	14.34	34.58	35.09	46.76	2.89*	5.73*
Thickness of back fat (cm)	0.18	3.41	0.75	0.3	0.35	-43.29***	-24.73**
Neck fat thickness (cm)	0.18	1.05	1.88	0.52	0.95	-15.45**	-7.77*
Rump fat thickness (cm)	0.18	0.74	1.32	0.28	0.39	-39.13**	-48.00***
Average back fat thickness (cm)	0.18	0.97	1.35	0.37	0.57	-35.65**	-25.49**
Rack (kg)	3.76	1.49	2.5	3.18	3.49	21.14**	11.50*
Ham (kg)	6.27	2.7	3.1	4.84	5.18	7.92*	10.57*
Shoulder (kg)	4.54	1.67	2.69	3.49	3.81	12.40*	5.39*
Backfat (kg)	0.36	0.53	0.8	0.42	0.39	-5.62*	-32.76**
Belly wall (kg)	1.1	0.71	1.16	0.97	1.07	7.18*	-5.31*
Viscera (kg)	1.76	1.19	2.16	1.44	2.01	-2.37*	2.55*
Remaining carcass (kg)	6.78	2.21	5.96	5.33	4.9	18.58**	-23.08**
Head (kg)	6.5	1.94	4.5	6.01	5.35	42.42***	-2.73*
Legs (kg)	1.3	0.4	0.96	1.31	1.2	54.12***	6.19*

Variables	Piértrain	Local	Improved	Piértrain x Local	Piértrain x Improved	Piértrain x Local	Piértrain x Improved
Carcass length (cm)	63.5	19.17	73.83	58.75	66.87	42.13***	-2.61*
Rate (kg)	0.1	0.06	0.12	0.1	0.088	25.00**	-20.00**
Lungs (kg)	0.67	0.15	0.3	0.49	0.49	19.51**	1.03 ^{NS}
Heart (kg)	0.3	0.1	0.19	0.25	0.28	25.00***	14.29**
Kidney (kg)	0.18	0.08	0.15	0.21	0.17	61.54***	3.03*
Liver (kg)	0.94	0.49	0.83	0.79	0.73	10.49*	-17.51**
Testes (g)	23.68	13.11	10.68	19.79	6.71	7.58*	-40.94***

NS: $p > 0.05$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

4. Discussion

4.1. Breed Effect on Carcass Characteristics

The live weight at slaughter, hot and cold carcass weights, hot and cold carcass yields, and lean cuts of Piértrain pigs exhibited higher values than those of local and improved pigs. This difference can be attributed to genetic factors. In contrast to local and improved pig breeds, the Piértrain is a hyper-muscular pig, exhibiting a pronounced muscular development at the shoulders, a well-defined back (rack, 27%) and exceptional hams (27%) [9-11] in temperate environments. In tropical environments, the lean meat content is 63% [18]. The improved genetic type is the result of a series of crossbreeding events between pure exotic breeds (such as Large White and Landrace) and other genetic sources. Its weight performance is superior to that of local pigs and improved crosses with local breeds [2, 19].

The crossbred Piértrain-local breed exhibited higher slaughter weights, hot and cold carcass weights, and slaughter carcass yields than the local breed. A similar trend was observed between the crossbred Piértrain-improved breed and the Improved breed. The disparity observed between the cross-breeds and their two parental breeds can be attributed to the influence of the dominant Piértrain genes, which are responsible for the expression of these traits, and which prevail over the recessive genes present in the local and improved breeds.

In contrast to local and improved breeds, the Piértrain breed is characterized by a relatively low backfat thickness. In Vietnam, the mean backfat thickness for Piértrain CC genotypes was 0.88 cm, while for CT genotypes it was 0.83 cm [18]. These values are higher than those obtained in this study on Piértrain. The range of backfat thickness measurements for Duroc-Piértrain crossbreeds is reported to be between 0.22 cm and 0.41 cm [20], which is comparable to the values obtained for crossbreeds in our study.

The weight of the backfat and the thickness of the back fat are both relatively low in the Piértrain. Consequently, Piértrain carcasses exhibit a higher ratio of muscle to fat content, which is more highly regarded by butchers and consumers. The Piértrain crossbreeds exhibited lower back fat thicknesses and backfat weights than the local and improved breeds, indicating that the Piértrain contributes to an improvement in the lean meat content of the carcass in crossbreeds.

The carcass yield of the Piértrain was 76%, a figure that is significantly higher than that of the local and improved breeds. This elevated carcass yield can be attributed to the hyper-muscular phenotype (culard gene) observed in the ham, shoulder, and back muscles of the Piértrain. Similar results are reported by Bo *et al.* [18] in Vietnam and by Kowalski *et al.* [21, 22] in Piértrain pig lines in Belgium. This yield is higher and can even reach 83% in Piértrain pigs that are TT halo-thane-sensitive.

As carcass quality is linked to yield, lean meat content, and low-fat cover, the Piértrain breed is utilized in industrial crossbreeding schemes on farms to provide consumers with lean meat [23, 24]. In Thailand, the Piértrain has been employed in terminal crosses with Duroc and local Thai pigs with the objective of enhancing the carcass quality of the latter [25].

4.2. Effect of Sex on Carcass Characteristics

In general, there is no significant difference in slaughter weight between males and females within the same breed. The absence of a difference between males and females can be attributed to the fact that the animals are slaughtered at the age of eight months, which is the typical mating age for this breed. At this age, the influence of sex hormones on weight performance was not discernible. Despite the absence of a difference between the sexes in terms of slaughter weight, disparities were nonetheless discernible with respect to specific cuts. In the improved breed, females exhibit a greater degree of belly wall development than males. This discrepancy can be attributed to the development of adipose tissue in the ab-

dominal wall of females.

No significant difference was observed in the backfat thicknesses of male and female Pietrain pigs slaughtered at 8 months of age. In contrast, a study conducted in Vietnam revealed that at 7.5 months of age, females exhibited a thicker back fat than males (0.82 vs. 0.89 cm) [18]. The lack of significant differences observed in our study may be attributed to the relatively low weight at slaughter, although it should be noted that the animals in our study are threshed at eight months of age. In Vietnam, for instance, the average slaughter weight for males is 93.85 kg, while that for females is 101.11 kg [18]. This is in stark contrast to the findings of the present study, where the average slaughter weight for males and females was 72.81 kg and 82.75 kg, respectively. The observed trend in the present study indicates that Piétrain females have a higher slaughter weight than whole Piétrain at 8 months of age. In the local pig, females have a thicker dorsal lard, a backfat, and a heavier belly wall than males. This trend is also observed in the Pietrain in Vietnam [18].

4.3. Heterosis Effect of Carcass Characteristics

The heterosis effect was observed to have a positive impact on live weight at slaughter, hot carcass weight, cold carcass weight, and lean cuts for both crossbreeding schemes. In regard to these traits, the expression of the genotype of individuals from the first generation (F1) was observed to exceed the average performance value of the parents. This finding is contrary to what would be expected if there were a simple additive combination of traits. The process of crossbreeding has been demonstrated to reduce the frequency of homozygous alleles, which are pairs of identical genes, while simultaneously increasing the number of heterozygous alleles [26, 27]. Consequently, the majority of recessive, deleterious traits are obscured by advantageous dominant traits. This is the reason why hybrids frequently exhibit genetic traits that are significantly above the mean of their parental lines. In the present study, heterosis values are high for live weight at slaughter, hot carcass weight, cold carcass weight, and lean cuts. These results can be explained by the Piétrain's distance from the local and genetically improved breeds.

The heterosis effect was negative for fatty cuts, particularly backfat, belly wall, and back fat thicknesses. Consequently, the Piétrain breed enhances the carcass quality of crossbreeds derived from local and improved breeds, respectively, by reducing the proportion of fatty cuts and increasing those of lean cuts.

5. Conclusion

A study of carcass quality in pigs derived from Stress-negative Piétrain crosses and local and improved pig breeds in southern Benin demonstrates that the Piétrain breed exhibits superior slaughter weight and carcass quality

compared to local and improved breeds. The proportion of fatty cuts is reduced and that of lean cuts is increased in crossbreeds from local and improved breeds, respectively, as a result of this improvement in carcass quality. Overall, no significant differences were observed in the slaughter weight or carcass characteristics of males and females within the same breed. A further study is required to elucidate the relationships between the carcass characteristics of these genetic types.

Abbreviations

SE	Standard Error
NS	No Significant

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Conflicts of Interest

The authors declare no conflicts of interest.

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