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REGULAR ARTICLES

Effect of cow colostrum on the performance and survival rate of local newborn piglets in Benin Republic

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Abstract The effect of bovine colostrum, including its thermally labile compounds, on the survival and growth performance of local breed piglets reared by their mother, in Benin, was evaluated over a 49-day trial. Three groups of 16 piglets, stemming from two primiparous sows belonging to a unique traditional farm, were respectively fed for the first 48 h of life with either bovine colostrum heated to 85 °C for 30 min, or thawed bovine colostrum, or colostrum from the mother. Thereafter, the animals that received bovine colostrum turned back to their mother. At day 21, almost all piglets from the group that received heated colostrum died. The highest total weight gain was obtained in the group that received thawed bovine colostrum (P 0.01), followed by the group left with the mother. Corresponding average daily gains (ADGs) were 56, 34 and 2 g/day, respectively (P 0.05). At the end of the trial, the treatment effect was highly significant on the survival of piglets (100% in the thawed colostrum group vs. 00 and 50%, respectively, in the heated colostrum group and in the group left with the mother). At day 49, numerically higher weight and ADGs were obtained in the group that received thawed cow colostrum. Thawed bovine colostrum improved the growth performance and piglet survival in the local pig breed in Benin, probably owing to thermally labile components. Bovine colostrum may be used in our farms in order to reduce pre-weaning mortality, improve the profitability of livestock farmers, and ensure survival of traditional farms. The use of bovine colostrum on farms could be facilitated by collaboration between pig farmers and bovine farmers. It could also be facilitated by the creation of a colostrum bank.

Keywords Sow · Bovine colostrum · Growth performance · Survival · Local breed piglet · Benin

Introduction

In West Africa regions, the pig breed preferred by low-income farmers is from local type. This breed provides significant income and thereby contributes to fighting poverty (Chimonyo et al. 2010; Carter et al. 2013). As local breeds belonging to other animal species, the African native pigs are a valuable genetic resource that must be preserved and promoted in traditional livestock systems as it contributes to the prosperity of subsistent agricultural systems in Africa (Amills et al. 2013). In Benin, where the pig population is rebuilding following the outbreak of African swine fever in 1997, the local breed is unfortunately endangered due to uncontrolled cross-breeding observed in recent years to meet increasing demand for pork meat. In this context, three challenges are essential: sustain income for rural communities, rebuild the pig population, and meet the requirements of the Convention on Biological Diversity of Rio for the preservation of indigenous breeds.

Improving the productivity of local pig is one of the options to rebuilding the pig population and preserving the indigenous

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breed. It involves the control of piglet mortality and growth during critical periods, i.e., birth-weaning and post-weaning. Unfortunately, the growth performance of local breed piglet in traditional farms in Africa in general and Benin in particular is poor, ranging from 12 to 34 g/day according to Nonfon (2005) and Koutinhouin et al. (2009), and reported mortality rate of 32% from birth to weaning according to Koutinhouin et al. (2009), 18 and 22% according to Kiendrebeogo et al. (2012), and 19% in the first week of life, namely, 87% of the total mortality from birth to weaning according to Youssao et al. (2008).

The only feed for piglet is colostrum in the first hours of life and milk afterwards. A third of sows seem not to produce enough colostrum to meet piglet requirements (Quesnel et al. 2012), explaining most of the deaths occurring in the first days of life. Adequate colostrum intake promotes significant reduction in mortality, adequate passive immunity, and ideal weight gain (Quesnel et al. 2012; Ferrari et al. 2014). Additionally, Abdou et al. (2013, 2014) showed that offering colostrum from cow Azawak to newborn kids sharply reduced mortality, increased growth, and improved biological parameters. Boudry et al. (2008) and Rasmussen et al. (2016) showed respectively in weaned piglets and in preterm pigs that bovine colostrum improves their healthy state and development. Therefore, distribution of bovine colostrum to piglet at birth also could increase the supply of immunoglobulins, bioactive peptides, and growth factors. This study firstly aims to evaluate the overall effect of bovine colostrum on the viability and growth of piglets from local breed in Benin and to estimate whether the effect could result from the intake of thermally labile molecules.

Materials and methods

Experimental site

The study was conducted from August 2014 to January 2015 in a traditional livestock located in the 5th district of Porto-Novo, Benin. The climate is sub-equatorial with four seasons: two rainy (high from April to July and low from September to November) and two dry (high from December to March and low in July–August; Nonfon 2005), with a maximum relative humidity observed in June and July (Alassane 2004). The average prevailing daytime temperature was 27.5 °C and the average annual rainfall was 1300 mm (Osseni et al. 2014).

Housing, feeding, and management

Animal health and feeding management was traditional. Habitat is made of brick walls with separated individual box for pregnant sows. The roof was covered with sheet metal and the floor was made of concrete. The sows were fed during all the phases of reproduction with a simple diet consisting of palm kernel cake and maize bran or malt brewery, according to the availability of the products. They had free access to water.

Collection and processing of bovine colostrum

Bovine colostrum used in this trial was obtained at the experimental farm of Kpinnou. This farm is located in the southwest of Benin and almost has the same climatic environment as the experimental site. Colostrum was obtained from Girolando cows. Animal health management was mainly based on internal and external deworming, vaccination against pasteurellosis, and treatments against trypanosomiasis. The colostrum used in this trial was a mixture of two equal quantities collected from two cows within 24 h after the onset of farrowing. Half of this mixture was heated in a water bath at 85 °C for 30 min. The two halves were then aliquoted and frozen in a continuous chain of cold.

Animals and experimental design

Sixteen piglets equally born from two primiparous sows B and C were used in this study. Sows were mated with the same boar and farrowed at 3-day intervals after 112 and 118 days of pregnancy each. Farrowing times were 3 h and 50 min and 4 h and 30 min each. Sows farrowed nine piglets each, with one stillborn for the sow C and one death by crushing for sow B. Before colostrum intake, the piglets were separated from their mother and weighed to the constitution of experimental groups. Three groups per sow were formed. The groups were matched on the basis of sex and weight of the piglets so that the average weights were similar and not significantly different between groups. After the group allocation, the control group returned to the mother and was fed under the sow (sow colostrum group, SC). The other two groups remained separated from their mother and were fed for 48 h, one with the thawed bovine colostrum (TBC group) and the other with heated bovine colostrum diluted with a little distilled water and commercial milk to reduce viscosity (HBC group). These last groups were fed to satiation with a baby's bottle at intervals of 1 h during the first 6 h of their birth and then every 2 h up to 48 h. After weighing, the two groups were returned to their mother. The piglets were weighed at birth, at 24 and 48 h, and then weekly until weaning at 49 days. Their survival was also followed under the sow until weaning. The experimental design is shown in Table 1.

Statistical analysis

The growth data were analyzed in two phases. Data from birth to 21 days were analyzed including the three treatments. After 21 days of age, data from the HBC group were almost lacking, owing to deaths that were close to 100% in this batch. Thus,

Table 1 Piglet allocation in the experimental design

	Sow B						Sow C					
	SC[a]		HBC[b]		TBC[c]		SC		HBC		TBC	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
n	1	2	1	2	1	1	1	2	2	0	1	2

[a] Sow colostrum group
[b] Heated bovine colostrum group
[c] Thawed bovine colostrum group

the weight data from birth to weaning at 49 days were treated by considering the SC and TBC groups only.

Data were analyzed using a mixed model of the Statistical Analysis System paquage (SAS 1999) including the effects of treatment, sow, time, sex, and time × treatment interaction. The model allowed the inclusion of a type 1 autocorrelative covariance structure between repeated data measured on the same animal. Average body weights, average weight gains (AWGs) at different ages, and average daily gains (ADGs) were calculated. Student's *t* test adjusted for multiple comparisons was used to compare averages. Survival rates were analyzed according to the LIFEREG procedure. Data are presented as LS means.

Results

Bovine colostrum intake

The average colostrum intakes per day per piglet were 137 ± 46 ml (or 270 ml/kg body weight) and 181 ± 97 ml (376 ml/kg body weight) for groups HBC and TBC, respectively.

Piglet health and survival

Diarrhea and conjunctivitis were the visible symptoms observed during the trial. Conjunctivitis was observed in the first week in all of the piglets from sow C. Piglets of both sows showed diarrhea the first week of life in group HBC and on the third and fourth weeks in groups SC and TBC. Figure 1 shows the evolution of survival rate in the three groups. The treatment effect was highly significant on this parameter ($P < 0.01$). At day 49, the rates were 100, 50, and 00%, respectively, in groups TBC, SC, and HBC. In group HBC, all piglets died within the first to the third week of life, with survival rates from 80% in the first week to 40, 20, and 00%, respectively, at days 14, 21, and 28. In group SC, mortalities occurred during the period from the third to the seventh week, with survival rates from more than 80% at day 21 to 50% at days 42 and 49.

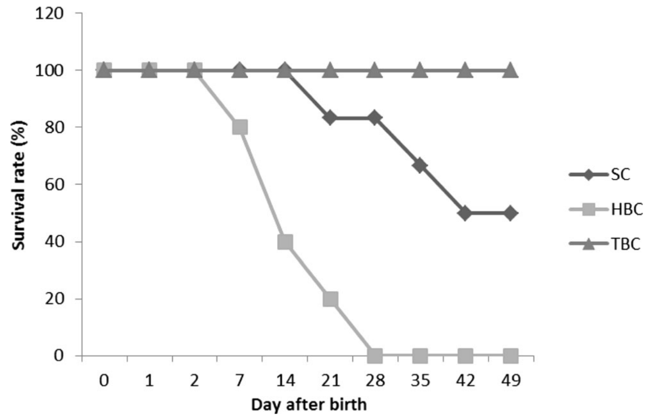

Fig. 1 Survival curve of piglets under the sow (*SC*) or having received during the first 48 h of life either heated (*HBC*) or unfrozen (*TBC*) cow colostrum

Growth

Growth performance: 0–21 days

The sow effect was not significant in any results obtained. Animal growth performance from 0 to 21 days of life is shown in Table 2. The evolution of life weight in the different groups is depicted in Fig. 2.

The average birth weights of piglets were 507 ± 119, 477 ± 119, and 454 ± 108 g, respectively, for groups HBC, TBC, and SC.

The effect of time on the previous parameters was systematically significant. From day 0 to day 2, the weight of the piglets did not change markedly. In HBC, the curve remained flat until day 21. The TBC group was characterized by a higher increase, the piglets reaching about 1600 g at day 21. In the SC group, the evolution was middle between the two previous extremes.

A positive growth was observed for groups TBC and SC from the second to the 21st day, with higher weights for the first one. In contrast, it was zero for group HBC, with even a numerical fall from the 14th to the 21st day.

From birth to 21 days of life, the average body weights of the three groups were not significantly different. As a mean, the TBC group had a numerically higher body weight (907 ± 100 g) than SC (728 ± 91 g), against the lowest for HBC (526 ± 105 g). The average body weights obtained at 21 days of age were tripled and doubled in TBC and SC, respectively, with regard to the HBC group. Weight gain and ADG differences were in line with previous results. The TBC group showed the highest value, followed by the SC and HBC groups, revealing a quasi-zero growth (20 g, $P < 0.01$). If the ADG in TBC was the highest at about 56 g/day, the value in SC was half lower and close to 0 in HBC ($P < 0.05$). At 24 and 48 h, the weight gains of the three groups were not significantly different. However, differences appeared from the seventh to the 21st day, with the best gains obtained by TBC. The

Table 2 Growth performance (0–21 days)

Weight data (g)	HBC ($n = 5$)		TBC ($n = 5$)		SC ($n = 6$)		Ttmt	T*Ttmt
	Average	SE	Average	SE	Average	SE		
Initial weight	507	119	477	119	454	108		
Weight at day 21	498	196	1631	119	1247	112		
Weight gain	20c	83	516a	72	328b	66	**	***
ADG (g/day)	2c	13	56a	8	34b	7	*	

Ttmt treatment, *T*Ttmt* time × treatment interaction

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

a, b, c for the same line, values assigned to these lowercase letters are significantly different

weight gains between 0 and 14 days in the TBC group are better than those in groups SC ($P < 0.0032$) and HBC ($P < 0.0001$). This difference is maintained at 21 days with groups SC ($P < 0.0106$) and HBC ($P < 0.0001$).

The time × treatment interaction was very highly significant for weight and weight gain.

Growth performance: 0–49 day

When considering only the TBC and SC groups, growth was low over the first 48 h. Afterwards, weight increased linearly in TBC, while in SC growth was slower until about 4 weeks and increased sharply and linearly thereafter. This regrowth allowed the SC group to catch up at day 49, the delay observed initially in comparison to the TBC group (Fig. 3). This trend was the same as that observed with weight gains and ADG (Fig. 4). Although numerical, these differences were not significant between groups at any time.

The average body weights obtained at 49 days of age were close to 3 kg in the two groups. From 0 to 49 days, the piglets' average body weights in the TBC group were not significantly higher than those of the animals in group SC (1493 ± 158 vs. 1280 ± 145 g). This resulted in a decrease in ADG for the TBC group compared to that observed for 0–21 days (52 against 56 g/day) and increased for lot SC (38 against 34 g/day). As for ADGs, weight gain at 49 days of life in the TBC group was higher than in SC (1127 ± 136 against 911 ± 126 g; Table 3).

Discussion

For some time, the experimental farm of Kpinnou has engaged stock breeding of imported Girolando cow to increase milk production in Benin. This breed is a product of the cross between Dutch Holstein breeds and Gir from Brazil (Doko et al. 2012). The average daily milk productions of that breed obtained in this farm's conditions are 7.2 kg at 8 months of lactation (Doko et al. 2012) and 4.77 l at 11 months of lactation (Kassa et al. 2016). This milk yield implies a sufficient colostrum production allowing some sampling, the need of calf having been accommodated. Thus, the colostrum of this cow breed was chosen for this study owing to its disponibility.

Piglets of the TBC and HBC groups were bottle-fed and ingested the product without constraint. No false swallowing was observed. This ease of administration shows that it is possible to artificially feed the local newborn piglet with a baby's bottle. Feed intake in both groups indicates that TBC would be better accepted than the heated form.

The symptoms of diarrhea and conjunctivitis observed in the groups of this study are part of the clinical signs found in

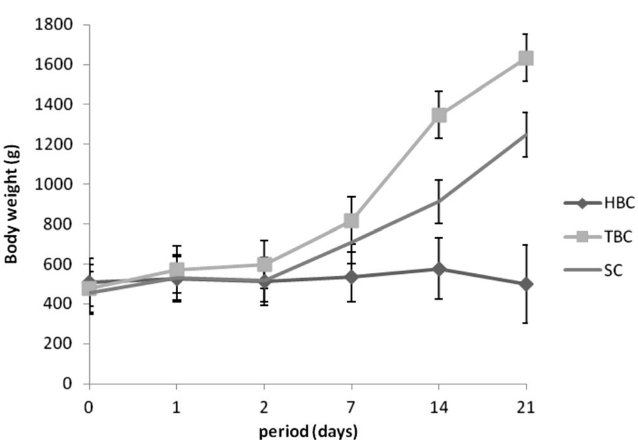

Fig. 2 Evolution of the body weight of piglets. *Bars* indicate the SE value

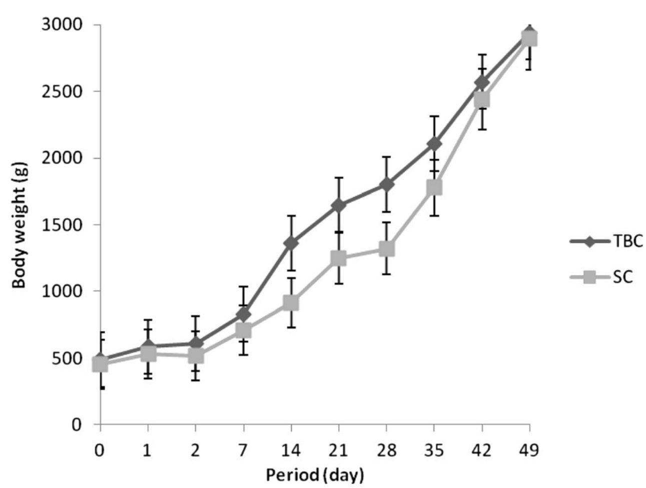

Fig. 3 Evolution of body weight at 49 days of life (TBC and SC groups)

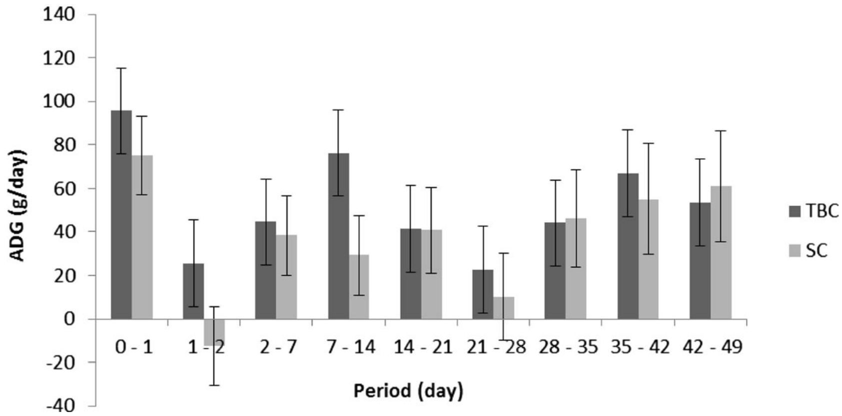

Fig. 4 Evolution of ADG at 49 days of trial (TBC and SC groups)

our traditional farms (Nonfon 2005), and diarrhea is a common cause of death in African traditional farms (Youssao et al. 2008; Kouamo et al. 2015; Munzhelele et al. 2016). Neonatal diarrhea in pigs is mainly due to viruses (transmissible gastroenteritis and rotavirus), parasites (coccidia especially), and bacteria (*Escherichia coli*, strains of *Clostridium perfringens* and *Salmonella*; Farzan et al. 2013). Among them, coccidia, viruses, *E. coli*, and *Salmonella* are the most common in Africa, and particularly in Benin (Mutua et al. 2011; Kpodekon et al. 2013; Bankole et al. 2014). Diarrhea caused by *E. coli* is often observed only in piglets under primiparous sow (Gagné – Fortin 2008), and the mothers used in this study are primiparous. The diarrhea observed in this study could be caused by some of these germs. It has been shown that no consumption of colostrum leads to piglet immunodeficiency and finally to diarrhea observed in the first week of life (Pierzynowski et al. 2014). The diarrhea observed in the first week of life in piglets from the HBC group suggests a link to the intake of colostrum low or lacking in immune factors. These animals were fed for the first 48 h of life with bovine colostrum heated at 85 °C for 30 min. In addition to specific antimicrobial factors (immunoglobulins), bovine colostrum is rich in antimicrobial factors that ensure the non-specific passive immunity and protect newborns against infections during the first weeks of life (Boudry 2009). Previous studies have shown that these factors of immunity are thermally labile. Among the bovine antimicrobial factors, lactoferrin and lactoperoxidase are considered as the most sensitive to heat (Mazri et al. 2011). At 85 °C for 30 min, lactoferrin loses its immune activity and lysozyme loses 74% of its activity (Elagamy 2000). Regarding immunoglobulin G (IgG), that from cow's milk is inactivated at 75 °C for 30 min, according to Elagamy (2000), and at 82 °C for 120 s (Li et al. 2005). The conditions of this study did not permit determining the composition of the bovine colostrum used and the immune factor concentrations of the piglet's serum. But based on these previous studies and the occurrences of diarrhea and mortality, it can be argued that the piglets in the HBC group have not received IgG, lactoferrin, and lactoperoxidase. The colostrum heated under the conditions of this experiment is probably an exclusive source of essential nutrients, but was devoid of molecules capable of transmitting passive immunity. Bovine colostrum is rich in lactoferrin, which has a role of protecting against gastrointestinal infections through its bactericidal action and inhibiting the growth of several microorganisms, including *E. coli* and rotavirus (Wu et al. 2010). Furthermore, Donovan (2016) has shown that bovine lactoferrin reduces the concentrations of *Salmonella* spp. and *E. coli* and, finally, the rate of diarrhea in piglets. All these elements reinforce the thesis of a probable relationship between the diarrhea observed in the groups and the aforementioned germs. The overall mortality rate during this test (50%) in the SC group and of 100% in the HBC group indicate that the livestock selected for this trial is a highly pathogenic environment. The survival rates at 49 days were 100, 50 and 00%, respectively, for the groups TBC, SC, and HBC. At 21 days, these rates were 100, 80, and 20%, respectively. The effect of treatment on survival was highly significant (P 0.01). Gomez et al. (1998) obtain at 19 days of age survival rates of 100, 80, and 30%, respectively, with piglets fed for 48 h after birth with porcine colostrum under the sow, with bovine colostrum, and piglets fed with basal diet without colostrum, these three groups being fed thereafter by an automatic feeding device with porcine colostrum. The survival results obtained with heated colostrum in this study are similar to those obtained by Gomez et al. (1998) in the group without colostrum. However, the survival rates obtained with groups TBC and SC in our study are different from those obtained by these

Table 3 Growth performance (0–49 days)

Weight data (g)	TBC group ($n = 5$)		SC group ($n = 6$)	
	Average	SE	Average	SE
Body weight at day 49	2940	240	2892	228
Weight gain	1127	136	911	126
ADG (g/day)	52	7	38	7

authors, but the two studies indicate the positive effect of bovine colostrum on the survival of newborn piglets. However, the group size for this study is smaller than that of those authors.

The AWG in 24 h of dead piglets in group SC is much lower than the AWG of piglets that have survived in this group (16 ± 28 against 133 ± 62 g). All these observations indicate that the mortality observed in this study was related to poor transmission of colostral immunity. The very positive effect of TBC on piglet survival may be linked to the transfer of IgGs and antimicrobial factors to piglets. These immune factors would be strengthened thereafter by those provided by the colostrum from the sow. The presumption of bovine IgG transfer to piglets in this study is based on previous studies that have shown that heterogeneous IgG could be transported into the blood by receptor FcRn of various species (Pang et al. 2015) and the transfer of bovine IgGs to exotic swine breeds is possible (Drew and Owen 1988; Gomez et al. 1998; Jensen et al. 2001; Stirling et al. 2005). If that is the case, the specificity of these immunoglobulins to the pathogens of the study environment is a research question. However, the effect of some antimicrobial compounds on the disease resistance of these study piglets is evident since it has been shown that their action is independent of the species and not specific to the antigen (Jensen et al. 2001).

In sum, bovine colostrum, administered during the first 48 h of life, may improve the survival of local breed piglets through the contribution of its immunoglobulin and, to a larger extent, to its antimicrobial compounds.

Apart from these immune factors, the thawed bovine colostrum of this study would have brought to the piglets many more growth promoters than the heated colostrum because previous studies have shown that the concentrations of growth factors such as IGF-1 of the bovine colostrum pasteurized at 63 °C for 30 min or 72 °C for 15 s were significantly (P 0.05) lower than those of the colostrum pasteurized at 60 °C for 60 min (Mazri et al. 2011), and heating of bovine raw milk at 75 and 85 °C for 15 min decreased the IGF-1 concentration by 45 and 45.2%, respectively (Ollikainen and Riihimäki 2012). Moreover, transforming growth factor-β2 was undetectable in cow's milk heated to temperatures above 76 °C for 1 or 2 min (Akbache et al. 2011). These growth promoters and IgGs can stimulate the growth of newborn piglets through trophic effects on the gastrointestinal tract (Mei et al. 2006; Wolinski et al. 2012). Furthermore, in addition to its antimicrobial role, bovine lactoferrin can also improve piglet growth performance because, administered to newborn piglets, it stimulates the proliferation of epithelial cells of pig intestine (Nguyen et al. 2014; Donovan 2016), and particularly the proliferation of crypt cells (Reznikov et al. 2014), and increases villus length and crypt depth (Donovan 2016). The low growth performances obtained at 21 days with the piglets in group HBC vs. the TBC group would be related to the low transmission of growth factors and the lack of IgGs and antimicrobials in the heated colostrum. The best growth performance obtained by the TBC group at 21 days compared to the other two groups indicates that the animals in this group would have benefited IgGs, antimicrobial factors, and growth promoters brought by TBC at the first 2 days and reinforced thereafter by those brought by colostrum from the sow.

The average weight obtained at 21 days with TBC is higher than those obtained with the heated colostrum and sow colostrum, but without significant difference. At 21 days of age, the weight obtained with TBC is higher than that obtained by Koutinhouin et al. (2009) at the same age in traditional breeding (1632 ± 119 against 1355 ± 65 g) and lower than that obtained with an improved traditional farming method (1890 ± 53 g) by the same authors. At 49 days of age, the weights of groups TBC and SC are similar (2940 and 2891 g, respectively) and are both higher than that obtained by Koutinhouin et al. (2009) at the same age in traditional breeding (2509 g) and that obtained at 56 days in traditional breeding (2621 g) by Youssao et al. (2008). However, the lot size for this study is smaller than those of these authors. The best weight gains were obtained with TBC. The weight gains of the three groups were significantly different at 21 days of trial. However, weight gain of the TBC and SC groups at 49 days of trial were no longer significant. This could be explained by the mortality of light piglets that occurred after the 21st day of trial. This also explains the evolution of body weight at 49 days. The slow growth between 21 and 28 days observed in the TBC and SC groups corresponded to the period of onset of diarrhea in these lots. This weak growth was more marked in the SC than in the TBC group. This reflects a lot better resistance of group TBC compared to SC. The ADGs obtained at 21 and 49 days of trial by SC (34 and 38 g/days, respectively) are comparable to those obtained by d'Orgeval (1997) (37 g/day) and by Koutinhouin et al. (2009) (34 g in 28 days) in the traditional farms of Benin. However, the ADGs obtained with TBC (56 and 52 g/day at 21 and 49 days of trial, respectively) are superior to all these gains and comparable to that obtained by Koutinhouin et al. (2009) with the improvement of traditional farming method (55 g/day in 28 days).

In addition to its effect on the survival of animals, bovine colostrum promoted their better growth. Of course, the number of animals in the study was low. But the difference in the mortality and growth between groups TBC and HBC suggests the positive effect of some thermally labile compounds of bovine colostrum on the survival and growth of local breed piglets under the sow. This confirms the thesis of Boudry (2009) indicating that bovine colostrum is rich in essential elements and especially in bioactive peptides known for their growth promoters and antimicrobial properties not only among bovine but also among other species (chicken, pig, and man). However, studies with large numbers of animals merit to be conducted to confirm these findings and assess the transfer of bovine IgGs to local piglets and their specificity to pathogens of pig. A priori, bovine colostrum can be used as a supplement to porcine colostrum to piglets from birth in Benin traditional farms in order to compensate for the low colostrum production by sows and to support the weaker piglets.

Conclusion

As with exotic swine breeds, sufficient absorption of nutrients, immune compounds, and growth factors of colostrum at the first hours of life is essential for the survival and growth of local breed piglets. This study proved that it was possible to artificially feed the local newborn piglet with a baby's bottle. It also showed that intake of bovine colostrum during the first 48 h of life may improve the survival rate and growth performance of piglets in difficult conditions of traditional farms in Benin. This improvement seems to be possible because of the immunoglobulin, antimicrobial compounds, and growth promoters contained in bovine colostrum and characterized by their sensitivity to heat. Bovine colostrum may be used as a supplement in the first hours of life of local pigs in our farms in order to improve their survival and growth performance through the strengthening of the effects of maternal colostrum and support for weaker piglets.

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Compliance with ethical standards

Statement of animal right The experimental protocol has been approved by the Department of Animal Production and Health of the Polytechnic School of the University of Abomey-Calavi of Benin. The methods used in this protocol involving animals were in accordance with the ethical standards of this institution. So, all applicable guidelines for the care and use of animals of this institution were followed during this study.

Conflict of interest The authors declare that they have no conflicts of interest.

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