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Effects of Feeding Dried Cashew Apple Pulp on Zootechnical and Economic Performances of Local Pigs on Station in The South of Senegal

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ABSTRACT

This work carried out from December 2022 to April 2023 in Casamance was to evaluate the effects of feeding dried cashew apple pulp (CAP) on zootechnical and economic performances of local pigs. Eighty-four piglets including 39 castrated malesof 11± 0.1 kglive body weight (LBW) of 3 to 5 months were randomly divided into 4 treatment groups of 21 pigs each, subdivided into 3 replicates of 7 pigs, corresponding to 4 iso-nutritional dietary treatments viz., CAP_0, CAP_{10}, CAP_{15} and CAP_{20} for fattening pigs containing respectively 0, 10, 15 and 20% of CAP.A 12 days'adaptation period for the pigs in the pigsty and the experimental diets was observed before the start of the trial. Then theywere fed *ad libitum* with each meal diet and watered with tap drinking water. ALW, average daily gain (ADG), feed intake (FI), feed conversion ratio (FCR), carcass weights and dressings (CW and DC), and profit margins obtained per dietary treatment, were subjected to a one-factor ANOVA. The results revealed no significant difference (PÃ*0.05*) between the ALW, ADG and CW of pigs from different dietary treatments. The DFI of subjects in CAP_0 and CAP_{15} were similar, but significantly ($P<0.05$) higher than those of CAP_{10} and CAP_{20} in contrast to the FCR. The production costs and net profits per fattening pig of CAP-based diets were also similar, but significantly lower and better than those of CAP_0. Feed cost and piglet purchase accounted for the largest share of these production costs. Economically, selling CW resulted in a loss for all dietary treatments contrary to pig selling based on LW. It was concluded that CAP can be incorporated up to 20% in the diet of fattening pigs without affecting their zootechnical and economic performances.

KEYS WORDS: Diets, Dried cashew apple pulp, Local pig,Profit, Zootechnical Performances

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INTRODUCTION

Livestock plays a crucial supporting role in poverty alleviation and food security in Casamance (Senegal). Pig produced 13,831 tons of meat and offal in 2016 (ANSD, 2020). Indeed, the pig is a species with a short reproduction and production cycle, high prolificacy and able of using various types of diets due to its omnivorous nature (Serres, 1989). Despite its various advantages, the pig is still a neglected species in Senegal and its breeding has not experienced any remarkable growth compared to that of other short-cycle species. In rural areas, it is often practiced in an extensive manner that pig feeding is essentially based on household waste and available residues in nature. Thus, poorly studied breeding and feeding practices, religious and socio-cultural constraints and the lack of sanitary monitoring associated with the endemic state of African swine fever (ASF), constitute factors that still hinder the development of pig breeding. Previous studies (Ossebi et al., 2018 and 2019) have also reported that pig farming in Casamance faces a major feeding problem. While a sustainable development of pig farming must be based on the improvement of breeding practices particularly, well adapted feeding to the socio-economic conditions of the breeders (Agbokounou et al., 2016). The use of inexpensive and locally available, but often little-known, feed resources would be an alternative, taking into account the influence of the use of these resources on the animal's health. However, other studies have highlighted the availability of various alternative feed resources in the region that can be used in animal feeding, including cashew draff, a by-product of the cashew tree that is very under-exploited (less than 20% of production), even though Casamance has more than 80% of the cashew crop area in Senegal (Fanimo et al., 2003; Aboh et al., 2011; Okpanachi et al., 2016a; Sene, 2019; Ossebi et al., 2018; Venkatramana et al., 2020). Moreover, some authors (Armah, 2008; Oddoye et al., 2009; Okpanachi et al., 2016b) have reported that despite the existence of some anti-nutritional substances, this draff can be incorporated in pigs' diet at relatively low rates (less than 20%), without any negative effect on their health and zootechnical performances. Certainly, there is very little previous work on the valorization of dried cashew apple pulp (CAP) in pig feed in Casamance. So, it seemed appropriate to valorize the usable local feed resources including dried CAP in pig diet in a rational way in this region of Senegal in order to allow the breeders and farmers to make a better profit of their activity. The objective of the present work is to to evaluate the zootechnical and economic performances of local pigs fed at station in the Casamance region of Senegal with diets containing different levels of dried cashew apple pulp.

MATERIALS AND METHODS

The experiment was conducted in a piggery located at Bona in the Bounkiling department, at Sédhiou region of Casamance. It was undertaken in the full respect of ethics and animal care according to all procedures approved by the Ethics and Animal Welfare Committees of the Ecole Inter-Etats des Sciences et Médecine Vétérinaires (EISMV) of Dakar.

Experimental diets and proximate analysis

Cashew apple pulp (CAP), a residue from cashew apples after juice extractionand the other feed resources used (table 1) in the experimental dietswere purchased on the local market of Casamance, with the exception of oyster shell meal and additives (multivitamin complex, synthetic lysine and methionine), which were bought in Dakar. Based on the nutritional values of these ingredients, which are well known to pig farmers, and the interesting preliminary digestibility results of diets based on dried CAP (Ayssiwede et al., 2021), four iso-nutritional growth-finishing diets for pigs were formulated, including the control diet,CAP_0 and three others CAP_{10}, CAP_{15} and CAP_{20} containing respectively 0, 10, 15 and 20% of this CAP in partial substitution of the main feed sources of energy, protein and fiber in the diets. Samples of CAP and experimental diets were analyzed at the Laboratoire d'Alimentation et de Nutrition Animales (LANA) of the Ecole Inter-Etats des Sciences et Médecine Vétérinaires (EISMV) in Dakar. These analyses were focus on the determinationof dry matter (DM), ether extract (EE), ash, crude protein (CP), crude fiber (CF), calcium, phosphorus and digestible energy (DE) contents. The DM was estimated following to the French Association for Standardization AFNOR (1982) and the ash content was based on AFNOR (1977a). The CP and EE content were measured following to the same standard using respectively standard Kjeldahl method (Nx6.25) described by AFNOR (1977b) and Soxhlet extraction method (diethyl ether as solvent) described by AFNOR (1980a). The Crude fiber content was found according to AFNOR (1993) based on the Wende method. The calcium content was measured using the flame atomic absorption spectrophotometric method of AFNOR (1984), while phosphorus content was measured using the absorption spectrophotometric method at 430 nm of wavelength as described by AFNOR (1980b). The DE content of the different samples was calculated using the regression equation of Noblet (2000): [DE (MJ/kg DM) = 17.37 - 0.051*Ash + 0.01*CP + 0.016*EE - 0.027*CF].

Table 1. Raw materials composition and calculated nutrient values of diets containing 0 (CAP_0), 10 (CAP_{10}) 15 (CAP_{15}) and 20% (CAP_{20}) of dried cashew pulp used in pigs during the trial

Raw materials	Unit Price (FCFA[1]/kg)	Control diet	Diets based on CAP		
		CAP_0	CAP_{10}	CAP_{15}	CAP_{20}
Maize	380	49.25	43.20	42.40	41.60
Rice bran	115	28.50	28.06	25.02	22.00
Groundnut cake	290	10.00	8.50	7.62	7.00
Palm kernel cake	170	10.00	8.25	7.62	7.00
Dried cashew apple pulp (CAP)	152	0.00	10.00	15.00	20.00
L-Lysine (99%)	2,460	0.25	0.34	0.39	0.43
DL-Methionine (98%)	3,200	0.00	0.00	0.04	0.07
Natural limestone	50	1.50	1.40	1.40	1.40
MVC-fattening (0.5%)	1,400	0.50	0.50	0.50	0.50
Total	-	100.0	100.0	100.0	100.0
Diet théoretical price (Fcfa/kg)	-	280	266	266	267
Diet manufacturing cost (Fcfa/kg)	-	10	10	10	10
Diet cost price(Fcfa/kg)	-	290	276	276	276
Calculated nutrient values					
Dry matter (%)	-	90.4	90.1	90.0	89.9
Crude protein (%)	-	14.9	14.4	14.4	14.42
Ether extract (%)	-	5.61	5.19	5.06	4.93
Crude fiber (%)	-	16.6	16.9	16.5	16.11
Ash (%)	-	8.48	8.48	8.29	8.11
Calcium (%)	-	0.83	0.80	0.80	0.80
Phosphorus (%)	-	0.79	0.76	0.74	0.73
DE (kcal/g)	-	3,26	3,23	3,23	3.22
DE/Crude protein (kcal/g)	-	21.8	22.3	22.3	22.3

Fcfa: local money of french community of Africa (1€ = 655.957 FCFA); MVC: Multivitamin complex; DE: Digestible energy

Animals and experimental design

The experiment was conducted during the period from December 2022 to April 2023. It lasted 112 days and consisted of 84 local piglets aged 3 to 5 months (including 39 castrated males and 45 females) acquired in several localities in the Sédhiou region and weighing an average of 11 kg live body weight. Raised in semi-open type pigsty, built of brick and unplaster, with a single-slope zinc roof supported by a wooden framework, these piglets were evenly distributed according to live weight and sex into 4 batches of 21 subjects each, subdivided into 3 replicates of 7 subjects, corresponding respectively to the four previous dietary treatments for fattening pigs, CAP_0 (control), CAP_{10}, CAP_{15} and CAP_{20} containing respectively 0, 10, 15 and 20% of CAP. The cleaning, the disinfection and the sanitary vacuum of this pigsty were carried out with bleach as well as the breeding material (feeders, drinkers) before starting the trial, and a compulsory disinfection foot bath was installed at the entrance to the barn. This trial was conducted in two successive phases: an adaptation and an experimental phase.

During the adaptation phase, which lasted 12 days, all piglets were adapted to their new environment and different diets. They were also injected with Ivermectin 1% subcutaneously at 0.3 ml/10 kg live body weight and Levamisole orally at one bolus per 50 kg live weight for eradication of both endo and ectoparasites and received by intramuscularly a complex of amino-acids and vitamins. This deworming was repeated one month later. The usual control diet was progressively replaced by the CAP-based dietsCAP_{10}, CAP_{15} and CAP_{20}, which allowed to determine the amount of feed will be distributed to the pigs during the experimental phase. All male pigs were castrated to avoid the occurrence of early pregnancies during the trial. During the 112-days trial, all piglets were kept in permanent confinement and reared at an average density of 1.4 m^2/subject. The different mealy diets (CAP_0, CAP_{10}, CAP_{15} and CAP_{20}) were weighed early in the morning, slightly wet and then served twice a day (morning and evening) considering the feed intake levels determined during the adaptation stage for voluntary feed intake as well as water in wooden troughs. The quantities of feed distributed are readjusted each week after the pigs' live body weighing to limit refusals. The pigsty, troughs and feed troughs were cleaned daily with water, then washed with soapy water and disinfected with bleach twice a week, with access to the pigsty well regulated.

Data collection

Throughout the trial, parameters such as temperature, hygrometry, live body weight, feed and water intake and mortality were regularly recorded. The quantity of feed intake, temperature, hygrometry and mortality were done on a daily basis, while individual live body weight of the pigs was taken at the beginning and every two weeks on an empty stomach using an electronic balance.At the end of the trial, after 12-hours water diet, around 20% of the experimental herd, i.e. 16 pigs (4 subjects/dietary treatment)with a live body weight close to the batch average were selected and slaughtered by jugular vein bleeding, then dressed and completely eviscerated. Carcass, heads and legs, red and white offals were weighed and recorded by dietary treatment.

The economic data were the acquisition prices of piglets and raw materials used in the experimental diets, costs of pigsty building, feeders and drinkers, water, veterinary care and others. The overall cost of pigsty used was obtained from the owner of the pigsty, and then calculated per m^2 basis to determine the cost of the space occupied by each subject. Based on the information received, the labour cost in the study area was estimated, and that allowed us to calculate the pig maintaining cost during trial période. The cost of water used per pig during the trial period was determined on the basis of the water volume and the price applied per m^3 of water in the study area. The price of wooden drinkers and feeders was also obtained. The costs of pig pens, drinkers and feeders were thus amortized over 10 years, and those of seals and scales, over 1 and 3 years respectively, and then reported in 112 days.The selling prices of pigs in basis of kg live weight (1500 Fcfa) and kg of meat (2000 Fcfa) in the study area were used in our economic evaluation.

Zootechnical and economic parameters determination

The collected data were entered into the Microsoft Excel spreadsheet (version 2010) and different zootechnical and economics parameters were calculated. Thus, the average live body weight (LBW), average daily feed intake (DFI), average daily gain (ADG), feed conversion ratio (FCR), average carcass weight (CW) and dressing (DC), and average organs weight (OW) and dressing (DO)and economic parameters such as production cost (PC), gross income (GI), margin on feed cost (MFC), net margin (MN) per fattening pig for each dietary treatment were calculated as per the formulas mentioned below:

ALW (kg) = Sum of live weights of individuals in the same batch ÷ Batch size

DFI(g/pig/d) = [(Quantity of feed served/day - Quantity of feed refused/day) ÷ Number of pigs]

ADG (g/d) = Weight gain achieved during a period (g) ÷ Length of period (days)

FCR = Feed intake during period (g) ÷ Weight gain achieved during period (g)

DC (%) = (Pig carcass weight ÷ Pig slaughter live weight) * 100

DO (%) = (Organ weight (g) ÷ Live weight at slaughter (g)) * 100

PC (Fcfa/pig) = Total costs per barn ÷ final number of animals produced

Feed cost/pig (Fcfa) = FCR x Price per kg of diet x Weight gain (kg)

GI (Fcfa/pig) = Pig live weight or carcass (kg) x Sales price / kg live weight or carcass

MFC (Fcfa/pig) = Gross income (GI) - Feed costs

MN (Fcfa/pig) = Gross income –production cost

Statistical analysis

Data obtained including those calculated in the Microsoft Excel 2010 spreadsheet per dietary treatment, were exported to the IBM Statistical Package for the Social Science (SPSS-v.23), where they were subjected to ANOVA one-way factor analysis test, completed by the DUNCAN's post-hoc test when the first showed significant difference between means of dietary treatments at 5% threshold.

RESULTS AND DISCUSSION

Nutrients composition of diets

The nutrient composition of cashew apple pulp and experimental diets reported in table 2 shows that this resource is relatively rich in crude protein, crude fiber, energy and even nitrogen free extract and ash. Exception of the relatively higher crude fiber content of CAP_0 and CAP_{15} diets compared with the others, all dietary treatments were overalliso-nutritional, with an average ratio of digestible energy to crude protein (DE: CP) in diets equal to 21.33.

Table2. Nutrient composition of dried cashew apple pulp (CAP) and experimental diets containing it at 0 (CAP_0), 10 (CAP_{10}) 15 (CAP_{15}) and 20% (CAP_{20}) used in pigs during the trial

Nutrient composition	Diet control	Diets based onCAP			Dried cashew apple pulp
	CAP_0	CAP_{10}	CAP_{15}	CAP_{20}	
Dry matter (%)	90.9	90.0	90.2	89.9	83.2
Crude protein, CP (%)	15.7	15.5	15.6	15.4	13.02
Ether extract (%)	4.57	3.73	4.52	4.25	2.52
Crude fiber (%)	10.5	8.84	9.26	8.42	12.6
Ash (%)	6.6	6.9	6.67	7.12	8.99
Nitrogen free extract	53.5	55.0	54.1	54.7	45.9
Calcium (%)	1.35	1.70	1.41	1.63	0.30
Phosphorus (%)	0.76	0.71	0.70	0.73	0.26
Digestible energy, DE (kcal/g)	3.35	3.28	3.30	3.32	2.75
DE/ CP (kcal/g)	21.35	21.2	21.1	21.5	21.1

The nutrient composition of this CAP obtained in this study was globaly comparable to those of most other authors (Rodrigues et al., 2010 ; Okpanachi et al., 2016a ; Bhamare et al., 2016 ; Gomes et al., 2018 ;) with a slight differences depending on the type of cashew pulp (dried, dehydrated or wet) and the processing time applied, the soil, the climate, the genetic variability of the pulp used (yellow or red) as well as storage conditions.The crude protein content of the different dietary treatmentsand their digestible energy were similar to the levels recommended by INRA (1989) for improved breed pigs. Furthermore, the crude fiber contents of CAP_{10} and CAP_{20} diets were similar to the standard valuesreported by Lokossou (1982) in growing-finishing pigs, unlike those of CAP_0 and CAP_{10}diets, which were higher than the recommended standard.

Environmental parameters and pig mortality recorded during the trial

During the trial period, ambient temperature and humidity in the study area varied from 16.8 to 42.4°C and 19 to 73% respectively. The highest temperatures were recorded in the middle and in the evening of the day, while the lowest were recorded in the morning in contrast to the levels of humidity. Overall, the average temperature and humidity during the trial period were 32.5°C and 39% respectively. This average ambient temperature recorded was still higher than that obtained (29.3°C) by Ossebi et al. (2023) and the limit of 30°C below which local pigs could express their growth potential (Nonfon, 2005). The high temperature recorded during the trial could be explained by the fact that the trial took place during a dry season period when temperatures varied between 16.8 and 42.4°C. The low variation in hygrometry (39%) compared with that the value of Ossebi et al. (2023) in the area may be due to the fact that our trial taking place at the end of the rainy seasons and during the dry season.

The incorporation of CAP into the pigs' diets had no adverse effect on their health and mortality during the trial, with an overall mortality rate of 3.5%. This overall low mortality rate recorded in pigs during the trial is thought to be due to the ongoing improvement in hygiene conditions and compliance with husbandry standards, which reduced microbial loads in the pigsty and preserved the animals from disease. But this mortality rate remains higher than that of Ossebi et al. (2023), due to their larger number of pigs (102). The absence of cases of disease in pigs, indicating that these CAP-based diets did not have any negative effect on their health, was corroborated with the findingsof Oddoye et al. (2009) and Armah (2008) in Ghana.

Growth-weaning performance of local pigs fed diets based on dried cashew apple pulp

The growth curve of piglets per dietary treatment over the 112 days of trial is shown in figure 1. From the second week to the end of the trial, piglets fed the CAP_{10} diet showed the highest weight growth, followed respectively by those fed CAP_{15}, PDC_{20} and CAP_0. Despite this difference between dietary treatments, it was noted at the end of the trial that incorporating dried CAP into the diet of growing-finishing pigs had no adverse effect ($p > 0.05$) on their live body weights (LBW), and produced pigs with overall similar average LBW of 34.9 kg. For all trial duration, the ADG of pigswere similar between different dietary reatments with an overall ADG equal to 206.3 g/d, even though that obtained from 90 to 112-day period where the highest in piglets fed CAP_{15} (365.3 g/d) diet, followed respectively by those in CAP_{10} (346.7 g/d), CAP_{20} (309.6 g/d) and CAP_0 (262.3 g/d).

Other parameters recorded in pigs during the trial, including daily feed intake (DFI) and feed conversion ratio (FCR) per dietary treatment, are reported in Table 3. It can be seen that during the first two months of the trial, the DFI of pigswas similar between the different treatments. However, from the 3rd month to 112 days and over the entire trial period, pigs on CAP_0 and CAP_{15} diets (1010.9 g/d) consumed significantly more feed, followed by those on CAP_{10} (963.1 g/d) and CAP_{20} (906.3 g/d) diets respectively. As for FCR, it was noted during the experimental period that the incorporation of CAP into the pigs' diet significantly reduced FCR in these subjects compared to that of control subjects. Indeed, pigs fed CAP_{10} and CAP_{20} diets recorded the similar and significantly best FCR (H" 5), followed respectively by those fed CAP_{15} (5.6) and CAP_0 (6) diets. For all experimental subjects, overall, the average DFI and FCR of pigs during the trial were 972.8 g/pig/d and 5.4, respectively.The similarity of the ALBW noted in pigs at the end of the trial between the different dietary treatments could be explained by their equal initial average live weights, the same rearing conditions and the nutrient composition of the diets, which overall remained similar. The final ALBW obtained (34.9 kg) in this trial is higher than that obtained (29.9 kg) by Ossebi et al. (2023) with a diet containing 15% dried cashew apple pulp. This difference may be due to the duration of fattening, the quality of the diets used, the method of monitoring the pigs and the rigour of husbandry. Indeed, with theseprevious authors, the pigs were monitored by the farmers themselves and fed with diet containing 13.5% crude protein for 90 days. The lower final ALW than thoses values obtained by Armah (2008) in Ghana and Acero et al. (2013) in the Philippines are due to the difference in breeds used, the initial weight of piglets at the start of fattening and the duration of the trial. In fact, the latter authors used Large White and Landrace x Large White mixed-breed whole male piglets whose initial live weights (13.3 and 10.87 kg) were higher than those of our local breed pigs.

Furthermore, the overall ADG (206.3 g/d) recorded in the pigs is slightly lower than the range observed in several studies conducted under traditional and improved conditions in low-income countries (Oddoye et al., 2009 ; Keambou et al., 2010; Armah 2008; Acero et al., 2013; Ossebi et al., 2023). In most of these studies, dried cashew apple pulp was fed to pigs at a rate of 15-20%. However, this ADG we obtained in pigs, is higher than those recorded by Hedji et al. (2015) in Benin and Mopate (2008) in Chad who used an improved diet to feed local pigs.

The high DFI of pigs on CAP_0 (1033.9 g/d) and CAP_{15} (987.9 g/d) diets compared to that recorded with subjects on CAP_{10} and CAP_{20} diets could be attributed to their higher fiber contents. Farias et al. (2008) had justified this increase in DFI of CAP_0 and CAP_{15} pig diets by a compensatory phenomenon of possible nutritional deficiencies, due to reduced nutrient utilization in high-fiber diets. In fact, high-fiber diets lead to increased desquamation of the intestinal mucosa and production of mucus, limiting the absorption of nutrients from higher-fiber diets and increasing peristaltic movements, thus limiting the permanence of nutrients in the pigs' intestinal tract.The low overall DFI recorded (972.8 g/d/pig) in pigs compared with the value of Ossebi et al. (2023) could be explained by the high heat (32.5°C) recorded during our trial, in contrast to the work of these authors, which took place during the rainy season with an average ambient temperature around 29.3°C. This overall DFI remains lower than those reported by Oddoye et al. (2009) and Armah (2008) for Large White pigs in Ghana. The better feed conversion ratio (FCR) obtained with CAP_{10} and CAP_{20} diets (5) compared to CAP_0 and CAP_{15} could be explained by their lower feed intake and the higher mineral composition oftheir diets. The FCR recorded (5.4) is better than the value obtained by Ossebi et al. (2023), but higher than those obtained by Armah (2008) and Oddoye et al. (2009).

Table 3. Effects of dried cashew apple pulp (CAP) incorporation in the diet at on growth performance in local pigs in Senegal

Zootechnics performance	Trial period (Days)	Experimental dietary treatments				Eror. Stand.	*p*-Value
		CAP_0	CAP_{10}	CAP_{15}	CAP_{20}		
ADG (g/d)	d 0 - 30	170 ± 58	205 ± 78	166 ± 59	162 ± 51	6.9	-
	d 30 - 60	195 ± 59	194 ± 82	177 ± 47	187 ± 58	6.8	-
	d 60 - 90	195 ± 52	200 ± 63	193 ± 33	203 ± 73	6.1	-
	d 90 - 112	262 ± 56^a	347 ± 82^{bc}	365 ± 53^c	310 ± 81^b	8.6	***
	d 0 - 112	197 ± 40	221 ± 65	205 ± 38	202 ± 62	5.7	-
DFI (g/pig/d)	d 0 - 30	760 ± 104	73 ± 86	740 ± 38	744 ± 96	9.2	-
	d 30 - 60	980 ± 71	951 ± 96	942 ± 25	907 ± 196	12.7	-
	d 60 - 90	1235 ± 174^c	1082 ± 57^b	1142 ± 60^b	963 ± 203^a	18.5	***
	d 90 - 112	1288 ± 161^b	1200 ± 99^{ab}	1265 ± 72^b	1117 ± 263.7^a	19.2	*
	d 0 - 112	1034 ± 113^b	963 ± 68^{ab}	988 ± 30^b	906 ± 173^a	12.8	***
FCR	d 0 - 30	5.3 ± 2.2	4.2 ± 1.6	5.7 ±3.4	5.0 ± 1.3	0.3	-
	d 30 - 60	6.1± 2.6	5.6 ± 1.4	6 ± 2	5.1 ± 1.1	0.2	-
	d 60 - 90	7.1 ± 2^c	6.1 ± 1.3^b	6.3 ± 1.3^{bc}	5.1 ± 1.1^a	0.2	***
	d 90 - 112	5.2 ± 1.5^b	3.8 ± 1.4^a	3.6 ± 0.7^a	3.8 ± 1^a	0.1	***
	d 0 - 112	6 ± 1.5^b	5.1 ± 1.1^a	5.6 ± 1.6^{ab}	4.9 ± 1.1^a	0.2	*

a, b, c:different letter exponents assigned to means within the same line indicate significant differences between groups at the 5% level (p<0.05). (* and ***): means that p < 0,01, p < 0,001 respectively.

Dressing performance of pigs fed diets based on dried cashew apple pulp

The dressing performances (carcass weight, carcass and organ dressings) obtained in pigs per dietary treatment studied are reported in table 4. Dressing carcass(DC) was significantly higher in pigs fed the CAP_0 diet (63.0%), followed by CAP_{20} (62.9%), CAP_{10} and CAP_{15} (62.7%), while carcass weight (CW) was similar between dietary treatments. In addition, total organ dressing (white, red, head and leg offal) was significantly higher with the CAP_{20} diet (26.2%), followed respectively by those obtained with the CAP_{15} (26.0%), CAP_0 (25.9%) and CAP_{10} (25.6%) diets. Overall, carcass weight and average carcass and organ dressings recorded globally for pigs on the different diets were 21.9 kg, 62.8% and 25.9% respectively.

Table 4.Effects of dried cashew apple pulp (CAP) incorporation in the diet at on carcass and organ characteristics of local pigs in Senegal

Characteristics carcass	Experimental dietary treatments				Eror. Stand	*p-value*
	CAP_0	CAP_{10}	CAP_{15}	CAP_{20}		
CW (kg)	21.1 ± 3.2	22.9 ± 5.2	22 ± 2.7	21.7 ± 5.3	0.5	-
DC(%)	63 ± 8.5^c	62.7 ± 2.6^a	62.7 ± 3.7^a	62.9 ± 3.2^b	0.02	***
DHL (%)	14.9 ± 6.1^c	14.8 ± 0.3^b	$14.7 \pm 0,1^a$	15 ± 3.8^d	0.01	***
DRO (%)	5 ± 1.2^c	5 ± 1.1^a	5.2 ± 0.4^d	5 ± 0.6^b	0.01	***
DWO (%)	6 ± 1^b	5.9 ± 2.2^a	6 ± 1.9^c	6.2 ± 0.8^d	0.01	***
DTO (%)	25.9 ± 2.8^b	25.6 ± 1.2^a	26 ± 0.8^c	26.2 ± 1.7^d	0.02	***

a, b, c, d : different letter exponents assigned to means within the same line indicate significant differences between groups at the 5% level (p<0.05). (***): means that p< 0,001.DHL: Dressing of head + legs; DRO: Dressing of red offal (heart, spleen, liver, lungs); DWO: Dressing of white offal (viscera); DTO: Dressing of total organ.

The similarity of carcass weights (21.9 kg) in pigs from the different dietary treatments at the end of the study could be explained by the fact that final average live weights are similar. However, this carcass weight is higher than that (19.1 kg) reported by Ossebi et al. (2023). The significantly higher dressing carcass obtained with the CAP_0 diet (63.0%) could reflect the relatively higher crude protein content of this diet, which would have promoted muscle growth and minimized fat deposition. The overall carcass dressing obtained (62.8%) in our trial is almost the same as that reported by Ossebi et al. (2023) for local pigs (64.1%). However, this dressing is still lower than those obtained with local pigs (71.55% and 80.15%) by Codjo (2003) in Benin and Hoffman et al. (2005) in South Africa.

Economic results obtained in pigs fed diets based on dried cashew apple pulp

The economic results (production costs per pig and per kilogram of meat, cost breakdown, profit margins) obtained from the economic evaluation are reported in table 5. The results show that the incorporation of dried CAP into the pigs diets significantly reduced the production costs per pig, kg live weight and kg of meat by 7.9%, 12% and 11.6% respectively for pigs fed CAP-based diets, compared with those fed the control diet (CAP_0). There was also a significant improvement in feed costs per pig fed the CAP-based diets, compared with the CAP_0 control diet (33,560 Fcfa). In fact, the lowest feed cost per pig was obtained with the CAP_{20} diet (28,067 Fcfa), followed respectively by the CAP_{10} (29,732 Fcfa) and CAP_{15} (30,574 Fcfa) diets. Overall, the production cost of 34.9 kg live body weight pig is estimated at an average of 47,956 Fcfa, i.e. 1,408 Fcfa/kg live body weight and 2,241 Fcfa/kg meat.

The breakdown of the production cost of pig reveals that expenses (labour, veterinary care, water, maintenance products, equipment and rearing pens) were significantly higher with the CAP_{20} diet, followed respectively by those of the CAP_{10}, CAP_{15} and CAP_0 diets, in contrast to feed expenses. Piglet purchase costs were similar between the different dietary treatments. Overall, the breakdown of production costs revealed that sustainable investments were extremely low (2%) compared with operating expenses, which accounted for 98% of total costs for the production of a pig butcher. The purchase of feed (64%) and piglets (30%) were the most important expense items.

With the exception of gross income per pig and per carcass, profit margins (gross feed and net margins) generated by selling live pigs and their carcass weight (CW) showed significant differences between the different dietary treatments. Indeed, the gross margins on feed (GMF) per pig and per carcass generated by diets CAP_{10} (25,104 and 16,074 Fcfa), CAP_{15} (22,061 and 13,421 Fcfa) and CAP_{20} (23,739 and 15,381 Fcfa) are similar and significantly better than those generated by CAP_0 diet. Net margins (NM) from the sale of live pigs in treatments CAP_{10} (7,716 Fcfa), CAP_{15} (4,662 Fcfa) and CAP_{20} (6,060 Fcfa) are positive, similar and significantly higher than the loss generated by the CAP_0 diet (655 Fcfa). However, the option of selling pigs as carcasses, generated negative margins (losses) for all dietary treatments used.

Table 5. Effects of dried cashew apple pulp (CAP) incorporation in the diet at on economic results in local pigs in Senegal

Economic parameters		Experimental dietary treatments				Eror. Stand.	p-value
		CAP_0	CAP_{10}	CAP_{15}	CAP_{20}		
Production cost (Fcfa)	Feed/pig	33560^c	29732^{ab}	30574^b	28067^a	430	***
	Pork live	50985^b	47120^a	47973^a	45746^a	548	*
	kg live weight	1547^b	1332^a	1388^a	1364^a	22	***
	kg Meat	2456^b	2126^a	2214^a	2169^a	35	***
Breakdown of production costs(%)	Feeding	65.8^b	63.4^{ab}	64^{ab}	61^a	0.5	*
	Pig purchase	28.4	30.3	29.9	32.4	0.5	-
	Fixed costs[1]	1.6	1.7	1.6	1.8	0.024	***
	Others costs[2]	4.1	4.5	4.4	4.8	0.05	***
Selling price (Fcfa)	Live hog	50330	54836	52635	51806	1,108	-
	Carcass weight (CW)	42277	45806	43996	43448	926	-
Profit margins (FCFA)	Feed gross margin-FGM /LW	16770	25104	22061	23739	1,095	*
	FGM/kg-LW	479	655	614	660	18	***
	Net margins/LW	-655	7716	4662	6060	966	*
	FGM/CW	8,717	16,074	13,421	15,381	928	*
	FGM/kg-CW	379	651	587	664	29	*
	Net margin/CW	-8,708	-1,314	-3,977	-2,298	811	***
	Net margin/kg-CW	-456	-126	-214	-169	35	***

a, b, c : different letter exponents assigned to means within the same line indicate significant differences between groups at the 5% level ($p<0.05$). (* and ***): means that $p<0,01$, $p<0,001$ respectively, Fcfa: local money of french community of Africa (1€=655.957 FCFA) [1]Total costs of housing and breeding equipment (drinker, feeder, seals and Balance) ; [2]Total costs of veterinary care, water, maintenance products and workforce.

The relatively low cost price (276 FcfA/kg) of CAP-based diets compared with that (290 Fcfa/kg) of the control diet would be due to the lower cost of CAP. The higher cost price of the diets compared with that (140 Fcfa/kg) obtained by Ossebi et al. (2023) could be explained by the unavailability and soaring prices of local feed resources at the time of this trial. The low production costs per pig, kg live weight and kg meat obtained in pigs fed CAP-based diets compared with control subjects would be linked to their low feed intake and the low cost price per kg of these diets. The higher production cost per kg live weight (1408 Fcfa/kg) obtained in pigs than those (492 - 966 Fcfa/kg) obtained in semi-intensive farming in West Africa (Ayssiwede et al., 2009; Tra Bi Tra, 2009; Umutoni, 2012; Ossebi et al., 2019) could be explained by the low number of pigs operated, which does not allow an economy of scale. However, this cost remains higher than those respectively (1,163 and 1,092 Fcfa/kg) obtained by Tra Bi Tra (2009) and Ossebi et al. (2023) when the farmer produces his own feed. The studies of these authors show the hegemony of feed costs (40-90%) over total expenses. Although within this cost range, the feed cost per pig obtained in this study followed the same trend as those of these previous authors, even though most did not take into account the integration of acquisition costs for fattening piglets. Fixed costs, at 2% total costs, remain significantly lower than those found (14.4 - 44.1%) by most of these authors, to the detriment of operating costs (98% of total costs). The selling price of pigs, the breed used and the development of the sector in other countries in the West African Sub-region are all factors of difference. However, the fixed and operating expenses recorded in this study remain almost similar to those respectively reported (3% and 97%) by Ossebi et al. (2023). The positive net margins (6,146 Fcfa) generated by the sale of live pigs on CAP-based diets compared with the loss generated by the CAP_0 diet (655 Fcfa) are due to the lower feed costs recorded with these diets as opposed to those of the control diet. The average net margin obtained with these CAP-based diets remains far higher than that (137 Fcfa) obtained by Ossebi et al. (2023). This could be justified by the fact that these authors conducted their study in a real environment throughout the Casamance region, where pig monitoring was carried out by the farmers themselves, and selling prices per kg live weight ranging from 965 to 1,151 Fcfa were applied. However, this net margin remains almost similar to those (5,435 - 5,902 Fcfa) obtained by Ayssiwede et al. (2009) and Ossebi et al. (2019), but higher than the negative one (-5,597 Fcfa) reported by Tra Bi Tra (2009). In Casamance, sellingpigs by live weight provides modest income in improved traditional livestock farming. Considering the average purchase price of piglet (14, 482 Fcfa), it is clear that the average gross feed margin per fattening pig does not allow farmers to start a new fattening cycle. As for the sale in kg carcass, this generates losses for all diets used, due to the high cost of production (2,241 Fcfa) compared with the selling price (2,000 Fcfa/ kg meat) practiced in the study area. This observation corroborates that reported by Ossebi et al. (2023), according to which the sale of pig by carcass weight had generated substantial losses (12.8% and 39.6% of sale prices) in the Sédhiou and Kolda regions respectively.

CONCLUSION

Incorporation of dried cashew apple pulp (CAP) up to 20% into the diet proved to be a resource of substitution for energy, fiber and protein-rich inputs in pigs, and had no adverse effect on their health, ADG and CW. On the other hand, this improved the feed conversion ratioof pigs, the production cost, gross feed margins per live pig and per carcass, and net margins per live pig. Under current conditions for the sale of live pigs, fattening pigs is only profitable with diets based on dried cashew apple pulp if all production factors are taken into account. The option of selling pigs by carcass weight generates losses for all diets. Thus, increasing the level of this CAP in pig diet would enable farmers to reduce their production costs and improve the incomes of farmers and apple processors, as well as combating environmental pollution at processing sites. It would be useful to carry out a longer study on growing piglets fed diets containing CAP in excess ratesof 20%, in order to identify the maximum level of incorporation of this feed resource for the best zootechnical and economic performances.

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