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Effects of *Piliostigma Reticulatum* and *Faidherbia Albida* Pods on Growth Performance and Economic Profitability of Cattle Fattening

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ABSTRACT: *The present study was carried out from 1st March to 30th June in the Diamaré Department (Far North of Cameroon). It focused on the effect of Piliostigma reticulatum* and *Faidherbia albida pods on the growth and economic performance of cattle in fattening. The general objective was to contribute to the improvement of the productive potential of cattle through the valorisation of available and poorly known local resources in animal feed. Specifically, the aim was to determine the nutritional values of ingredients and rations formulated with P. reticulatum and F. albida pods,* and to *evaluate the effect of P. reticulatum and F. albida pods on the zootechnical and economic performance of cattle undergoing fattening. A total of 12 bulls divided into 4 batches of 3 subjects were fed 4 rations formulated by substituting the cottonseed cake in the control ration with 100% cottonseed cake (C_{100}%) by 75% P. reticulatum ($C_{25}P_{75}$), then by 75% F. albida ($C_{25}F_{75}$) and finally by 100% of an equivalent mixture of P. reticulatum and F. albida ($P_{50}F_{50}$). At the end of this study, the bromatological analysis shows that cottonseed cake is richer in MAT (25.27%) and poorer in BC (13.6%), unlike cotton hulls which are rich in CF (57%), NDF (61.11%), ADF (53%) and ADL (38%). The pods of P. reticulatum and F. albida show intermediate values with MAT of 13.53% and 16.1% respectively. The highest amount of feed intake was recorded with the $C_{25}F_{75}$ ration (9739.06 ± 1379.26 g) and the lowest with the C_{100} (control)*

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ration (7513.46 ± 136.11 g). The highest average daily gain (829.31 ± 130.68 g/d) was obtained with the $C_{25}P_{75}$ ration) In terms of economic analysis, the net profit margins from fattening were higher with the $C_{25}P_{75}$ ration (36658.15 CFA francs) and lower with the C_{100} ration (11108.82 CFA francs). The same trend was observed for capital productivity, but contrary to the break-even point. However, the use of P. reticulatum *and* F. albida *pods for bull feed represents a real source of savings for the community.*

KEYWORDS: feeding trial, pods, *Piliostigma reticulatum*, *Faidherbia albida*, cattle fattening, semi-arid zone of Cameroon.

INTRODUCTION

The demographic growth of underdeveloped countries and the change in eating habits, linked in particular to the urbanisation of the population, are leading to a very strong increase in the demand for animal protein in both urban and rural areas (MINEPIA, 2011). The average level of animal protein consumption is estimated at 13.3 kg/capita/year, compared to the 42 kg/capita/year recommended by the FAO and WHO (MINEPIA, 2011). This represents a deficit of approximately 28.7 kg/capita/year. The annual world production of meat is estimated at 228 million tonnes and that of milk at 679 million tonnes (FAO, 2009a) should be multiplied by 1.75 and 2.0 respectively in developing countries, against 1.15 and 1.05 for rich countries by the end of 2020 (FAO, 2009; FAO, 2010). This deficit would be due to the fact that the livestock system most practiced in tropical African countries is extensive due to the reduction of land allocated to forage crops (Kibwana *et al.*, 2012). Furthermore, in tropical Africa, nutritional deficiencies remain the main cause of low ruminant productivity (Kambale et *al*., 2018). Indeed, fodder is only of good nutritional value at the beginning of the rainy season, and this deteriorates as the season progresses (Kambale et *al.*, 2018).

In addition, agroindustrial by-products (mainly cottonseed cake and cottonseed) are expensive and sometimes inaccessible to livestock farmers. Faced with this situation, the use of available and little-known fodder resources such as *Piliostigma reticulatum* and *Faidherbia albida* pods could constitute a more accessible feed alternative in the Sahelian zone for ruminants in general and cattle in particular. *Piliostigma reticulatum* and *Faidherbia albida* are woody fodder species whose pods are used in livestock feed in some African countries (Sarr *et al.*, 2013). They are a stabilising factor in production systems (Ouédraogo, 2002). *F. albida*, known for its particular phenology, is a fodder species whose leaves and fruits are highly palatable (Sarr *et al*., 2013). It has the advantage of providing quality leaf biomass to livestock during the lean season and particularly its "pod" fruits which are available during the dry season and are increasingly traded with the development of urban and peri-urban livestock (Sanou, 2014). The high crude protein and crude fibre contents in woody pods suggest that they could be used to replace more expensive protein supplements (Sèwadé, 2016). Furthermore, the use of *P. reticulatum* and *F. albida* pods is not well known in cattle fattening. It is in this perspective that the present study was initiated with the general objective of contributing to the improvement of the productive potential of cattle in fattening through the valorization of available and poorly

known local resources in animal feed. More specifically, it was a question of: Determine the nutritional values of the ingredients and of the feed rations formulated from the pods of *P. reticulatum* and *F. albida;* Evaluating the effect of *P. reticulatum* and *F. albida* pods on the growth performance of cattle under fattening and evaluating the effect of *P. reticulatum* and *F. albida* pods on the economic performance of cattle in fattening.

MATERIALS AND METHODS

Study area

The work took place in the Sudan-Sahel zone, Far North Region of Cameroon, Diamaré Department, and more precisely in the commune of Meri. The commune of Meri is bordered to the North by the Commune of Tokombéré, to the West by the Commune of Soulede-Roua, to the South by the Communes of Gazawa and Mokolo, to the South-East by the Commune of Maroua I and to the East by the Communes of Maroua II and III. It has 10 cantons or 2nd degree chieftaincies which are among others: Meri, Douvangar, Douroum, Ouazzang, Kalliao, Doulek, Godola, Tchere, Mbozo and Manbang. Meri is located between 10°46'34" North latitude and 14°06'00 East longitude. The experimental phase took place in Ouazzang (latitude 10°65'68'92" N and longitude 14°08'15'00" E).

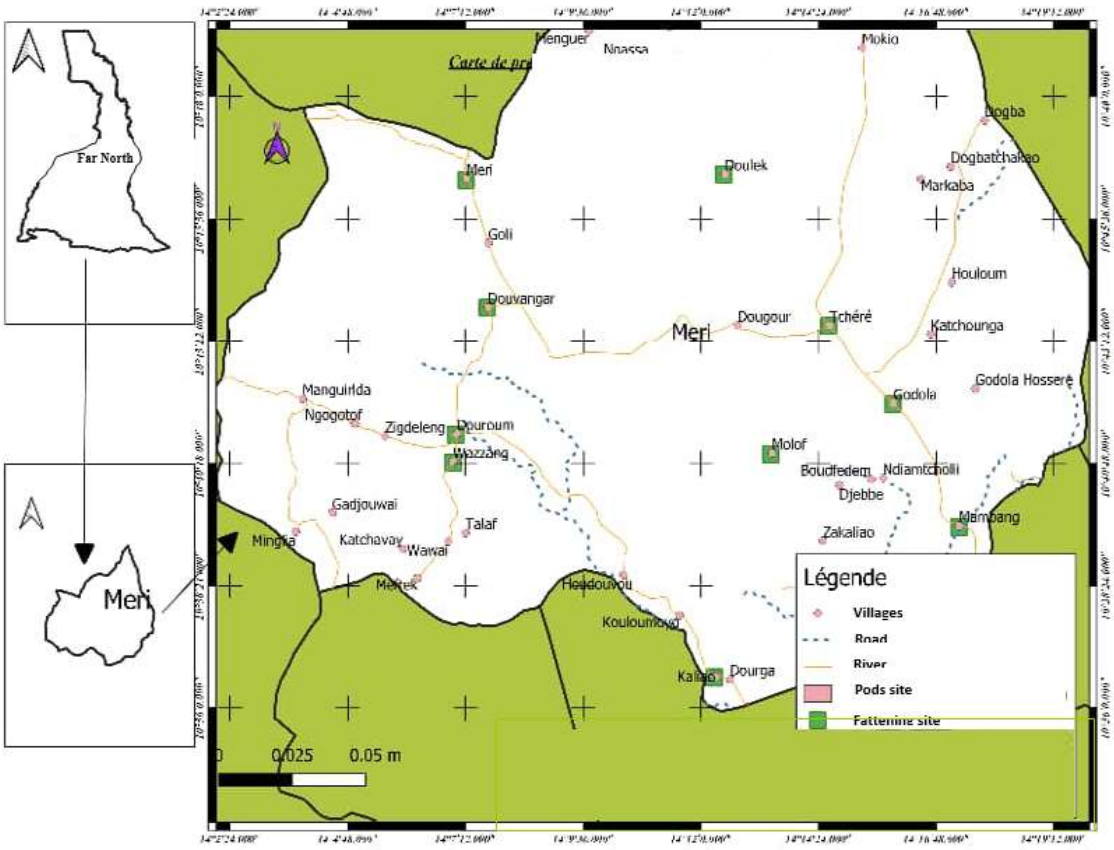

Figure 1: Location of the study area

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Biological material

Animal material

For this study, a total of twelve (12) Zebu bulls (Red Fulani or Djafoun or Rahadji), all aged between 3 and 5 years, were purchased in the markets of the Diamaré department. This breed was chosen because of its gregarious, disciplined instinct, fearful of strangers but docile towards their shepherd.

Plant material

The plant material consisted of *Faidherbia albida* and *Piliostigma reticulatum* pods. These were purchased from January to April 2021 in the markets of the commune of Meri. The latter were first taken to the Jericho centre where they were dried, crushed with mortar and put in 50kg bags for conservation; then some composite samples were sent to the Biochemical and Biophysical Food Analysis Research Laboratory (LABBAN) of ENSAI at the University of Ngaoundéré to determine its chemical composition.

Experimental rations

Four feed rations (RC_{100}, $RC_{25}P_{75}$, $RC_{25}F_{75}$, $RF_{50}P_{50}$) were formulated using *Faidherbia albida* and *Piliostigma reticulatum* pods, cotton hulls and cottonseed cake at different levels of incorporation in the ration. The different rations according to the level of incorporation of the ingredients are presented in Table 1.

Table 1 : Rations according to the level of incorporation of ingredients

Ration	Ingredients				Total
	Cotton hull	Cotton seed cake	*P. reticulatum*	*F. albida*	
RC_{100}	6 Kg	6 Kg (100%)	0 Kg	0 Kg	12Kg
$RC_{25}P_{75}$	6 Kg	1,5 Kg (25%)	4,5 Kg (75%)	0 Kg	12Kg
$RC_{25}F_{75}$	6 Kg	1,5 Kg (25%)	0 Kg	4,5 Kg (75%)	12Kg
$RF_{50}P_{50}$	6 Kg	0 Kg	3 Kg (50%)	3 Kg (50%)	12Kg

P: *Piliostigma*; F : *Faidherbia*

Experimental set-up and conduct of the trial

A total of sixteen (16) Zebu (Red Fulani or Djafoun) bulls, all between 3 and 5 years of age, were randomly divided into 4 groups of 3 subjects (4x3) with an average weight of 224.59 ± 12.67 per treatment. The latter were subjected to 4 treatments:

TC_{100}: 6Kg cotton husk + 6Kg cotton cake;

$TC_{25}P_{75}$: 6Kg cotton hull + 1.5Kg cotton cake + 4.5Kg *P. reticulatum*;

$TC_{25}F_{75}$: 6Kg cotton hull + 1.5Kg cotton cake + 4.5Kg *F. albida*;

$RF_{50}P_{50}$: 6Kg cotton hull + 3Kg *F. albida* + 3Kg *P. reticulatum*.

The animals were fed in batches (i.e., 36 kg of feed per day) and the daily ration was divided into two equal meals (in the morning at 7.30 am and the rest in the afternoon at 2.30 pm). To further control the parameters that could influence the fattening of the bulls, the animals were placed in strict stalling and fed the formulated feeds. Mineral supply was permanently provided in the stalls in the form of lickstone. In addition, the animals were provided with free water for drinking. At the beginning of the trial, and then every week, data on their growth was collected: quantity of feed ingested (IAQ), height at the withers, thoracic circumference and scapulo-ischial length. Then the economic performance of the fattening systems was evaluated.

Data collected and parameters studied

Measurement of growth parameters

Amount of feed intake (IAQ)

The evaluation of the quantities of feed ingested was done by the difference between the quantities distributed and the refusals in each batch, the feed consumption per bull is obtained by dividing the total quantity consumed by the number of bulls per batch.

IAQ = Amount of feed distributed(g) - Amount of feed rejected (g)/Number of days

Measure height at withers (T)

The height at the withers or height measurement at the withers (vertical distance from the ground to the top of the withers, immediately behind the hump, on the top of the scapulum); The measurement of the height at the withers was carried out with the help of the flexible metric tape measure used as a measuring stick.

Barymmetry

To reduce the task and facilitate data collection, the equation developed by Dodo *et al*. (2001) in Niger for weight estimation in zebu was used. Thoracic girth and scapulo-ischial length measured with a flexible metric tape measure were retained because of their higher correlation with weight. Several types of relationships between weight. (y), chest circumference (x) and scapulo-ischial length (z) were reported. The barymmetric equation chosen for the estimation of live weight of bulls is therefore the polynomial regression (y) on thoracic girth (x) and scapulo-ischial length (z):

$Y = 0{,}0260x^2 - 3{,}856x + 1{,}211z + 96{,}114$; With $r^2 = 0.990$ and Sy = 10.33 kg

The data collected during the trial were used to calculate feed quantities, average daily gains (ADG) and feed conversion ratios (FCR), and mortality rates (MR).

Average daily gain (ADG)

Using the assessed weight, we calculated the average daily gain at the end of each week as the ratio of the average gain during a period to the duration in days (42 days). It is expressed in grams per day.

ADG = Final weight (PF) - Initial weight (PI) / Number of days

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Consumption Index (CI)

It was calculated as the ratio of the average amount of food ingested during a period to the average weight gain during the same period.

CI = Average amount of food(g)during a considered period/Average daily gain(g/day) during a considered period

Mortality rate (MR)

The mortality rate is the ratio of the number of deaths recorded during the rearing period to the total starting population, expressed as a percentage (%).

TM (%) = Number of deaths in a period/total starting staff x 100

Assessment of the economic performance of fattening systems

The assessment of the economic profitability of the implemented systems was done by determining some key parameters (indicators). These indicators include gross and net profit margins, capital productivity and break-even point (Gnanda *et al*., 2015).

Gross profit margin (GP): the difference between the selling price of a cattle and the value of the variable charges (costs) (production charges).

Marge brute = VP – VCV

VP: Value of revenues; VCV: Value of variable expenses

Net profit margin (NM): this is the difference between the selling price of a bovine and all expenses incurred (total expenses).

Marge nette = VP – VCT

VP: Value of products; VCT: Value of total expenses (variable + fixed)

Capital productivity or benefit/cost ratio: this is the relationship established between production and the capital that enabled that production. It is the ratio of the value of the product(s) to the value of the expenses used to produce it. In other words, it expresses the return to the farmer for each unit of money invested.

Capital productivity = Value of income / Value of total expenses

Break-even point: corresponds to the minimum number of animals to be put into fattening for which the fattener makes neither a loss nor a profit. It corresponds to the ratio between the total fixed costs and the unit gross margin (gross margin per animal).

Breakeven point = CF / (PVU - CVU)

FC: Fixed charges; PVU: Unit selling price; CVU: Unit variable charges

Variable costs: include the cost of purchasing animals, the cost of feed, the cost of maintaining animals, operating costs and any other extraordinary costs. Fixed costs include the annual depreciation values of infrastructure and equipment based on their duration.

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Analysis of the data

The data collected according to the summary was ordered and classified in Microsoft Excel spreadsheet. 2016 and transferred to Statgraphics plus 5.0 software for analysis of variance (ANOVA). Duncan's test was applied to judge the difference between the means of the different treatments.

RESULTS

Bromatological composition of ingredients and formulated rations

The bromatological composition of the ingredients and the formulated rations are presented in Table 2. From Table 2 it can be seen that the chemical composition varies according to the type of ingredient and the proportions of substitution of cottonseed cake by *P. reticulatum* and *F. albida* pods. The highest dry matter (DM) content was recorded with the cotton hull (92%). *P. reticulatum* (84.21%) and *F. albida* (90%) pods had the lowest DM values. As for the rations, the lowest percentage of dry matter (88.84%) was obtained with $RC_{25}P_{75}$ (75% substitution of cotton cake by *Piliostigma reticulatum*) and the highest (91.05%) with RC_{100} (control ration without substitution). The highest mineral matter (MM) value was observed with cottonseed cake (7%) and the lowest with *P. reticulatum* (3%). As for the rations, the highest percentage of MM was observed in RC_{100} (5%) and the lowest in RF50P50 (3.66%). The lowest organic matter (OM) content (81.42% DM) was obtained with the cotton hull and the highest (93.32% DM) with *P. reticulatum*. For the rations, the lowest OM content was recorded with RF50P50 (86.18% DM) and the highest with RC_{100} (87.29% DM). The lowest crude fibre (CF) content (13.6% DM) was obtained with cottonseed cake and the lowest (57% DM) with cottonseed hull. As for the rations, the lowest BC content was recorded with $RF_{50}P_{50}$ (40.78% DM) and the highest with $RC_{25}F_{75}$ (56.23% DM). The lowest total nitrogen matter (TNM) content (5% DM) was obtained with cottonseed hull, and the highest (25.27%) with cottonseed cake. For the rations, the highest TAM content was recorded with RC100 (15.14% DM) and the lowest with $RC_{25}F_{75}$ (9.48% DM). The lowest total wall content (NDF) (25.1%) was obtained with cottonseed cake and the highest (61.11%) with cottonseed hull. While for the rations, the lowest (25.1%) was obtained with RC100 and the highest (59.24%) with $RC_{25}F_{75}$. Cotton hull (38%) and *P. reticulatum* pods (34.76%) were found to be richer in lignin (ADL) compared to cotton cake (17.11% DM) and *F. albida* pods *(*22.14% DM). For the rations, the highest LDA content was recorded with $RC_{25}F_{75}$ (36.92% DM) and the lowest with RC_{100} (17.11% DM). The lowest lignocellulose (ADF) content was observed with cottonseed cake (17.11% DM) and the highest (61.11% DM) with cotton hulls. For the rations, the highest value was recorded with $RC_{25}F_{75}$ (36.92%) and the lowest with RC_{100} (17.11% DM). The lowest fat content of the ingredients was recorded with *Faidherbia albida* pods (0.02%) and the highest with cottonseed cake (3.1%). As for the rations, the lowest fat content (1.59%) was obtained with $RP_{50}F_{50}$ and the highest (2.85%) with RC_{100}.

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Table 2: Bromatological values of the main ingredients and rations used

	DM (%)	MM (%)	MO (%)	CF (%)	TNM (%)	NDF (%)	ADF (%)	ADL (%)	FM (%)
Ingredients									
F. albida	90	3.8	88.55	1.1	16.1	41.8	30.7	22.14	0.02
P. reticulatum	84.21	4.82	93.32	28.6	13.53	55.65	39.36	34.76	1.13
Cottonseed cake	90.1	7	92.7	13.6	25.27	25.1	26.8	17.11	3.1
Coton hull	92	3	81.42	57	5	61.11	53	38	2.6
Rations									
RC100	91.05	5	87.06	42.01	15.14	25.1	26.8	17.11	2.85
RC25P75	88.84	4.18	87.29	52.66	10.73	54.56	44.61	34.17	2.11
RC25F75	89.42	3.99	88.83	56.23	9.48	59.24	46.79	36.92	1.88
RF50P50	89.55	3.66	86.18	40.78	9.91	54.92	44.02	33.23	1.59

OM: Organic Matter, DM: Dry Matter, TNM: Total Nitrogenous Matter, CF: Crude Fiber, MM: Mineral Matter, NDF: *Neutral Detergent Fiber* or complex polysaccharides (completely indigestible), ADF : *Acid Detergent Fiber (*lignin andproteins damaged by heat), FM: Fat.

Table 3 shows that MS and MM, MAT, MG as well as MO and CB showed strongly positive correlations ($p > 0.05$). Other strongly positive correlations were observed between ADF, ADL and NDF. Furthermore, MS, MM, MAT and MG correlated negatively with NDF, ADF and ADL. This indicates a control relationship between the elements.

Table 3 Correlation between elements

Variables	DM	MM	MO	CF	TNM	NDF	ADF	ADL	FM
MS	1								
MM	0.767	1							
MO	-0.186	0.048	1						
CB	-0.612	-0.206	0.868	1					
MAT	0.869	0.947	-0.249	-0.510	1				
NDF	-0.918	-0.913	0.285	0.580	-0.993	1			
ADF	-0.931	-0.902	0.292	0.598	-0.988	0.999	1		
ADL	-0.924	-0.886	0.336	0.630	-0.985	0.998	0.999	1	
MG	0.750	0.999	0.030	-0.207	0.947	-0.910	-0.897	-0.883	1

OM: Organic Matter, DM: Dry Matter, TNM: Total Nitrogenous Matter, CF: Crude Fiber, MM: Mineral Matter, NDF: *Neutral Detergent Fiber* or complex polysaccharides (completely indigestible), ADF: *Acid Detergent Fiber (*lignin andproteins damaged by heat), FM: Fat.

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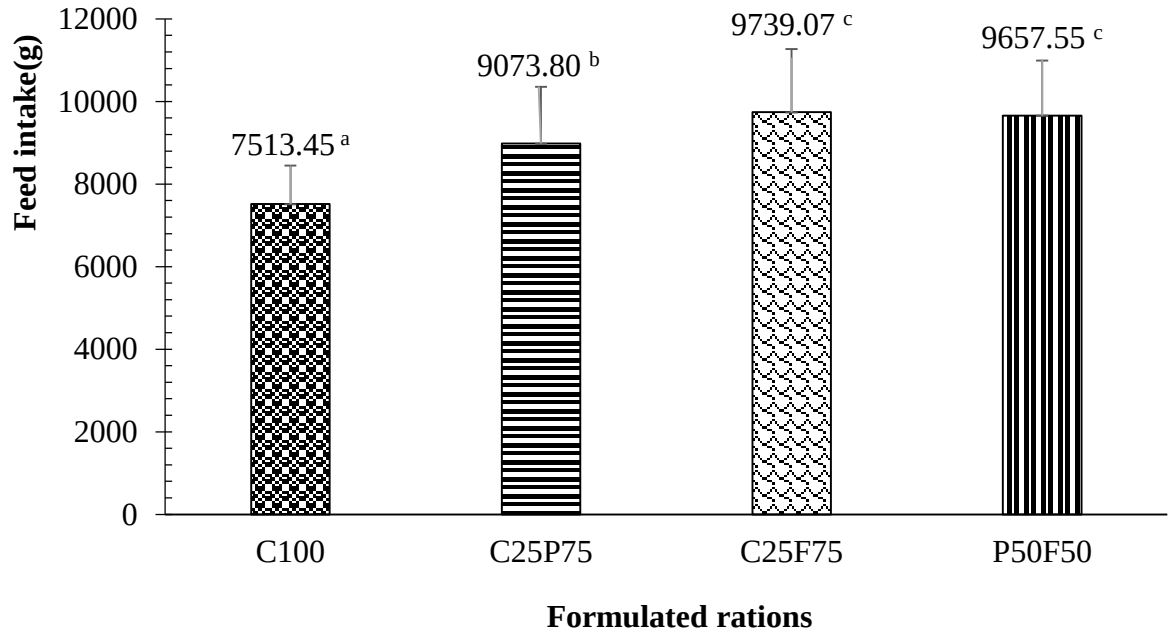
Effect of *P. reticulatum* and *F. albida* pods on growth performance of cattle under fattening

Amount of feed intake (AFI)

Figure 2 shows the average feed intake (ration) per fattening bull during the trial period. The statistical analysis shows a significant difference between the average feed intake of the different rations ($p < 0.05$). The highest value was recorded with the $C_{25}F_{75}$ ration containing 75% *F. albida* pod and 25% cottonseed cake as concentrate (9739.06 ± 1379.26 g), followed by the $P_{50}F_{50}$ ration containing 100% of a fair mix of *P. reticulatum* pod and *F. albida* as concentrate (9657.55 ± 2531.78 g). The $C_{25}P_{75}$ ration containing 75% *P. reticulatum* pod as concentrate (9073.80 ± 1432.31 g) and the C_{100} ration containing 100% cottonseed cake as concentrate (7513.46 ± 136.11 g) were the lowest comparable ($p > 0.05$) between them.



a, b, c: means with no letters in common are significantly different ($P < 0.05$)

Figure 2: Average amount of feed intake during the 42-day trial

Evolution of height at withers (HW)

The evolution of the wither's height of the bulls according to the rations is presented in figure 3. The withers height of fattening bulls generally increased from 1er to 42ème days of the experiment for the four batches fed the four different rations (figure 3). The value obtained with the $C_{25}P_{75}$ ration (123.83 ± 4.79 to 127.2 ± 6.39 Cm) was significantly lower ($p < 0.05$) compared to the other rations which otherwise remained comparable ($p > 0.05$).

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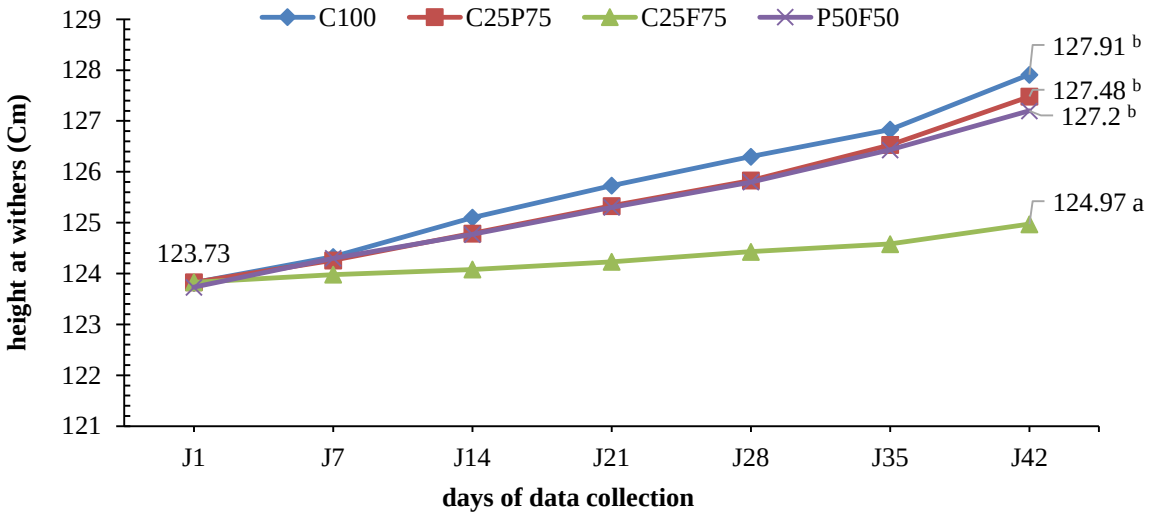
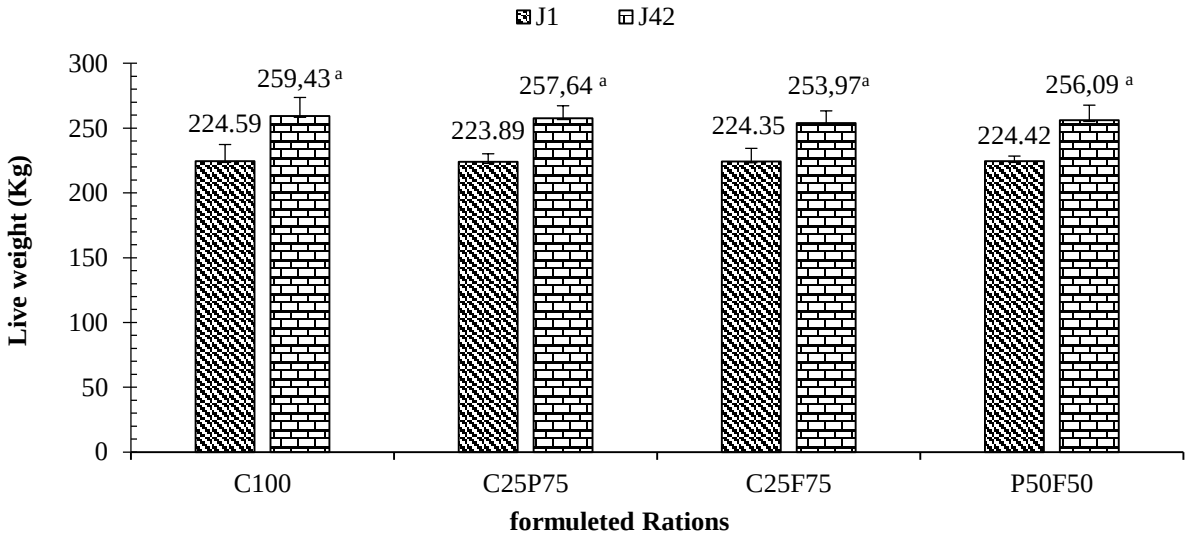


a, b, c: means with no letters in common are significantly different (P < 0.05)

Figure 3: Evolution of withers height of bulls according to rations

Effect of rations on the weight evolution of bulls

Figure 4 below shows the weights of the fattening animals on day 1er and day 42nd of the experiment. It can be seen from figure 4 that the rations had no significant effect (p > 0.05) on the live weight of the animals on day 42nd (256.09 Kg).



a, b, c: means with no letters in common are significantly different (P < 0.05)

Figure 4: Live weight of bulls at 1er and 42ème days of the trial

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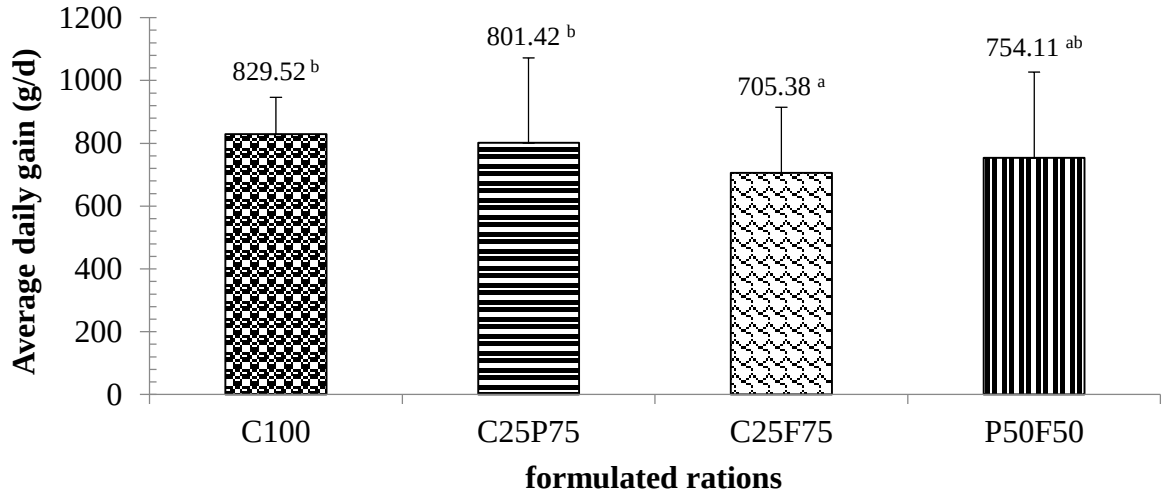
Effect of rations on average daily gain (ADG) of bulls

The effect of rations on average daily gain (ADG) of bulls is presented in Figure 5. From Figure 5, it can be seen that average daily gain differed significantly ($P < 0.01$) between rations during the 42nd day trial (Figure 7). The average daily gains recorded with the C_{100} (829.31 ± 130.68 g/d) and $C_{25}P_{75}$ (801.67 ± 286.52 g/d) rations were comparable ($p > 0.05$) to each other and significantly higher ($p < 0.05$).



a, b, c: means with no letters in common are significantly different ($P < 0.05$)

Figure 5: Average daily gain of bulls during the 42-day trial

Effect of rations on the feed conversion ratio of bulls

Table 4 shows the evolution of the feed conversion ratio during the 42nd days of the trial. It can be seen that the feed conversion ratio decreased for all four rations. The average feed conversion ratio differs significantly ($P < 0.05$) between the four rations. The lowest average feed conversion ratio was found in the C_{100} ration (9.34 ± 1.93), followed by the $C_{25}P_{75}$ ration (13.89 ± 6.63), the $P_{50}F_{50}$ ration (15.34 ± 4.72) and the $C_{25}F_{75}$ ration (15.55 ± 5.83), which remained comparable ($P > 0.05$).

Table 4: Evolution of the consumption index during the 42nd days of the trial

CI	Ration C_{100}	Ration $C_{25}P_{75}$	Ration $C_{25}F_{75}$	Ration $P_{50}F_{50}$
d7	12.53 ± 3.21	21.89 ± 4.89	21.27 ± 2.19	22.72 ± 4.64
d14	9.67 ± 0.55	16.98 ± 2.15	18.55 ± 2.11	17.12 ± 4.17
d21	8.96 ± 0.52	13.74 ± 1.51	15.95 ± 0.34	17.19 ± 3.68
d28	8.87 ± 0.37	11.61 ± 1.31	14.01 ± 3.20	12.95 ± 1.48
d35	8.23 ± 0.44	9.29 ± 1.01	12.83 ± 1.32	11.91 ± 1.25
d42	7.40 ± 0.34	7.84 ± 0.87	10.66 ± 1.75	10.13 ± 4.74
Averages	**9.34 ± 1.93[a]**	**13.89 ± 6.63[b]**	**15.55 ± 5.83[c]**	**15.34 ± 4.72[c]**

a, b, c: means with no letters in common are significantly different ($P < 0.05$)

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Table 5 shows that AFI and CI as well as HW and LWO, ADG showed strongly positive correlations ($p > 0.05$). While AFI and HW, LWO, ADG, FC correlated negatively. This implies an increase in CI with AFI and ADG with HW and LWO.

Table 5 Correlation parameters

VARIABLES	AFI	HW	LWE	LWO	ADG	CI
AFI	1					
HW	-0.661	1				
LWE	-0.373	-0.004	1			
LWO	-0.892	0.919	0.092	1		
ADG	-0.855	0.923	-0.018	0.994	1	
CI	0.999	-0.648	-0.403	-0.882	-0.840	1

AFI: Average amount of feed intake; HW: Height at Withers; LWO: Live weight on entry; LWO: Live weight at outside; ADG: Average Daily Gain and CI: Consumption Index;

Effect of *P. reticulatum* and *F. albida* pods on economic performance of fattening systems

The operating account of the fattening operations of the four rations is presented in Table 6. Batch 1 fed with the C_{100} ration (100% cottonseed cake as concentrate) has the highest production cost (659673.55 CFA francs), followed by batch 3 (645590.5 CFA francs) fed with the $C_{25}F_{75}$ ration (645590.5 CFA francs), where 75% of the cottonseed cake is substituted by *F. albida* pods. *albida pods*, then batch 4 (625290.67 Fcfa) fed the $P_{50}F_{50}$ ration where the cotton cake is 100% substituted by the combination of *F. albida* and *P. Reticulatum* pods taken together. It also appears that the net profit margins of fattening on the $C_{25}P_{75}$ ration (36658.15 CFA francs) are the highest. This trend is similarly observed for capital productivity and cash flow.

Table 6: Operating account of fattening operations for the four rations

1. Variable costs	**Ration C_{100}**	**Ration $C_{25}P_{75}$**	**Ration $C_{25}F_{75}$**	**Ration $F_{50}P_{50}$**
1.1. Labour force	35000	35000	35000	35000
1.2. Health costs	6000	6000	6000	6000
1.3. Power supply	100406	81648	86323	78624
1.4. Watering	12600	12600	12600	12600
1.5. Conveying the animals	6000	6000	6000	6000
1.6. Purchase of animals	480000	480000	480000	480000
1.7. Miscellaneous services	3000	3000	3000	3000
Total variable costs	**643006**	**561359**	**628924**	**608624**
2. Fixed costs				
2.1. Buiding depreciation	16667	16667	16667	16667
Total fixed costs	16667	16667	16667	16667
Total expenses	**659673.55**	**578026**	**645591**	**625290.7**

3. sales				
3.1. Sales of live animals	690000	686000	680000	683000
3.2. Manure and other values	3000	3000	3000	3000
Total income	**693000**	**689000**	**683000**	**686000**
Overall gross margin (Fcfa)	49993.12	127641	54076.1	77376
Overall net margin (Fcfa)	33326.45	110974	37409.5	60709.33
Gross margin / animal (Fcfa)	16664.3733	42547	18025.4	25792
Net profit margin/animal	11108.8167	36991.5	12469.8	20236.44
Capital productivity	1.05051961	1.19199	1.05795	1.09709
Break-even point	**1.00013782**	**0.39172**	**0.92462**	**0.646195**
Cash-flow	**16659.78**	**94307.8**	**20742.8**	**44042.66**

Figure 6 shows the co-relation circle that examines the relationship between ingredients and bromatological elements (Figure 6 A) on the one hand and between bromatological elements and rations on the other (Figure 6 B). Figure 6 A shows that axis 1 (horizontal) explains 88.89% of the total variation of feed ingredients in relation to bromatological elements. This axis is positively correlated to TNM, MM, OM, cottonseed cake, *F. albida*, ADL, ADF, NDF, CF and cottonseed hull. As for the second axis, it explains 21.24% of the total variation; this axis is correlated mainly with FM, DM, OM and P. recticulatum. Axis 1 (horizontal) in Figure 6 B explains 93.74% of the total variation in the relationship between bromatological elements and rations. This axis is positively correlated with TNM, DM, ADF, NDF, RC25 F75 and RC100. While the second axis, explains 30.89% of the variation. This axis is correlated to FM, MM, CF, OM, RF50 P50 and RC25 P75.

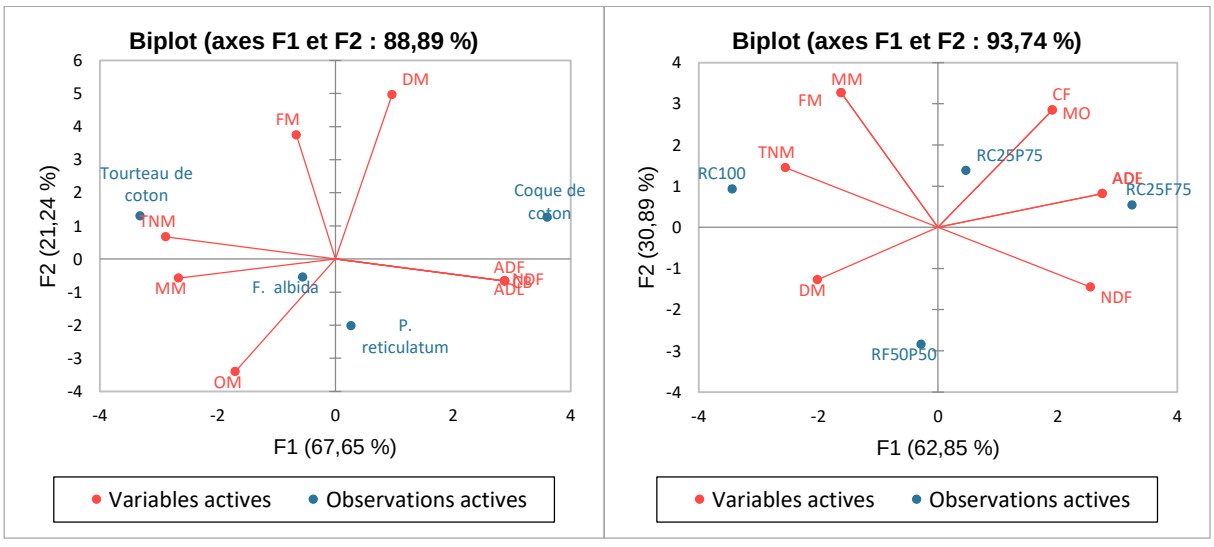

Figure 6: Co-relation between bromatological elements, ingredients and bromatological elements

DISCUSSION

Bromatological composition of ingredients and formulated rations

The chemical composition of the ingredients and the formulated feed rations differ from each other. Thecontent of dry matter (DM: 84.21 to 90.1% DM/100g DM), mineral matter (MM: 3 to 7% DM/100g DM), organic matter (OM: 81.42 to 93.32% DM/100g DM), crude fibre (CB: 13.6 to 57% DM/100g DM), total nitrogenous matter (9.91 to 25.57% DM/100g DM), total wall (NDF: 25.1 to 61.11% DM/100g DM), lignin (ADL: 17.11 to 36.92% DM/100g DM), lignocellulose (ADF: 26.8 to 53% DM/100g DM) and fat (MG: 0.02 to 3.1% DM/100g DM). The range of total nitrogenous matter obtained in this study for the experimental feed rations are close to the range of 10.45 to 21.90% DM/100g DM found by Wogar *et al.* (2013) and higher than those of Blama *et al*. (2016) on the nutritive value and economic efficiency of feed ingredients used in ruminant diets in the semi-arid zone of Cameroon. However, the crude ash contents obtained for the ingredients and the four feed rations are lower than the range of 8.5 to 11.0% DM/100g DM recommended by Mensha *et al*. (1993). Furthermore, the dry matter (DM), organic matter (OM), crude ash (CA) and total wall contents obtained in this study are close to those reported by Traoré *et al*. The differences observed in the bromatological element content between the ingredients and the rations are respectively due to the particularities of the genetic heritage and the different levels of incorporation of the ingredients in the formulation of the rations. The digestibility of woody plants by ruminants is largely determined by their total wall content (TWC). The NDF content of a feed is negatively correlated with digestibility and intake (Einkamerer, 2008). The proposed rations are acceptable for cattle feeding because the NDF of the four rations studied are favourable. The NDF threshold abovewhich the feed intake of ruminants is negatively affected is 60% DM (Meissne *et al.*, 1991).

Effect of *P. reticulatum and F. albida* pods on zootechnical performance of cattle in fattening

Feed consumption of bulls

The amount of feed ingested differed from one ration to another. The ration with the highest intake was the one containing 25% cottonseed cake and 75% *F. albida* pod ($C_{25}F_{75}$) as concentrate (9739.06 ± 1379.26 g). These results are higher than those of Fall-Touré *et al.* 1997 (7.8 kg) in cattle fattened by farmers in the groundnut basin in Senegal. This difference could be due to the granulometry of the four rations formulated. Indeed, following the grinding of the different ingredients contained in each ration, the $C_{25}F_{75}$ ration followed by the P50F50 ration presented larger particle sizes compared to the C_{100} ration and the $C_{25}P_{75}$ ration which had a finer aspect. This could lead to a change in the grip of the bulls from one ration to another, which probably led to a higher consumption of the *F. albida* pod containing ration by the bulls compared to the C_{100} fed group.

Effect of rations on the weight development of bulls

The highest average weight of the bulls at 42 days was noted with the C_{100} ration (259.43 Kg) and the lowest were observed in the batches fed the $C_{25}F_{75}$ ration (253.97 kg) and the $P_{50}F_{50}$ ration (256.09 Kg). These weights are lower than those obtained by Gnanda *et al.* (2015) (330kg) after 60 days using *P. reticulatum* pods + cotton seeds and rice straws in the ration of bulls in farmer fattening. The low weight gain of bulls fed *F. albida* pods compared to bulls fed the control ration could be explained by the high crude cellulose content of *F. albida* pods and their possible content of anti-nutritional factors such as tannins and lectins. Tannins are also responsible for an increase in endogenous protein losses by increasing digestive enzyme secretions (Duc, 1996). According to the same authors, lectins have the property of binding to the intestinal mucosa, where they could have various anti-nutritional effects: reducing absorption, promoting the proliferation of intestinal cells, increasing the secretion of mucins, thus increasing endogenous losses, and disturbing intestinal permeability. They cause growth retardation and inflammation of the epithelial cells of the intestine (Duc, 1996).

Effect of rations on average daily gain (ADG) of bulls

The average daily gain was 829.31 ± 130.68 g/d, 801.67 ± 286.52 g/d, 705.23 ± 190.48 g/d and 754.11 ± 162.73 g/d for the batches fed C_{100}, $C_{25}P_{75}$, $C_{25}F_{75}$ and $P_{50}F_{50}$ rations respectively. The observed average daily gain was different from one batch to another, which illustrates a beneficial effect of the rations. These results are close to those of Fall-Torné *et al* (1997) (1100; 615 and 773 g/d) after incorporating 21% *F. albida* pods in rations for cattle undergoing fattening in the groundnut basin of Senegal. This heterogeneity in the response of the batches to the rations could be explained by the content of bromatological elements (dry matter, total nitrogenous matter, mineral matter and fatty matter) of the latter. Thus, the TNM or crude protein with the help of the MM, FM and DM contained in the feed rations provides the amino acids that are essential for the bulls to ensure their growth and maintenance.

Effect of rations on the feed conversion ratio (CI) of bulls

Over the whole trial period, the feed conversion ratio decreased. In addition, it remained better for the control ration (C_{100} ration), i.e. 9.34 ± 1.93, followed by the $C_{25}P_{75}$ ration, i.e. 13.89 ± 6.63 (containing 75% *P. reticulatum* instead of cottonseed cake) than for the $C_{25}F_{75}$ ration containing 75% *F. albida* instead of cottonseed cake (15.55 ± 5.83). These results are lower than the 18.34 reported by Seck (1981) on the fattening of bulls with *F. albida* as a substitute for cottonseed cake. The high values of the indices observed for the ration containing 75% *F. albida* as a substitute for cotton cake indicate a poor valorization of this feed compared to the other rations. This could be explained by the higher presence of cellulose and anti-nutritional factors that cause the bulls to fail to adequately assimilate nutrients compared to the other three rations. However, the CI results of the C_{100} and $C_{25}P_{75}$ rations indicate that the intensive feeding technique was well implemented. However, the efficiency of the ration is not proportional to the rate of incorporation of woody material. This rate, by influencing in vivo digestibility, rumen cellulolytic capacity, growth and health of the ruminants (Traoré *et al*., 1995), seems to be an important factor to take into account in the formulation of rations based on woody fodder.

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Evaluation of the economic performance of fattening systems

The results of the study show net profit margins of 11108.81 CFA francs; 12469.8 CFA francs; 20236.44 CFA francs and 36991.5 CFA francs for the C_{100}, $C_{25}F_{75}$, $P_{50}F_{50}$ and $C_{25}P_{75}$ rations respectively. The break-even points range from 0.39 for the $C_{25}P_{75}$ ration to 1.00 for the C_{100} ration. The net profit margins obtained in this study are similar to the range between 9906 CFA francs and 50405 CFA francs reported by Blama *et al*. (2016) in the semiarid zone of Cameroon for fattening units of 3 to 5 cattle. Furthermore, the recorded profitability thresholds are lower than those of Gnanda *et al*. (2015) who reported a value of 4.45 in the cattle fattening system in Burkina Faso. The higher profit margin and lower break-even point for the $C_{25}P_{75}$ ration, followed by the $P_{50}F_{50}$ ration compared to the C_{100} ration and the $C_{25}F_{75}$ ration could be explained by the lower cost of these rations compared to the others and their ability to promote good animal finishing. It is therefore self-evident that the return on a unit of invested capital increases when the investment cost is lower and good products are obtained as a result.

CONCLUSION

Feed rations containing *P. reticulatum* and *F. albida* pods improve the technical and economic performance of cattle fattening workshops. The differences between the technical and economic results of the different rations confirm the value of formulating the feed using local ingredients and training farmers in modern cattle fattening techniques. This progress would undoubtedly allow the Meri zone to play an important role in the meat production strategy of the Far North of Cameroon. Under the conditions set out in the economic analysis, cattle fattening with pods as concentrate is a profitable speculation. This profitability is explained by the low production cost of the finished animals. Cattle fattening with *P. reticulatum* and *F. albida* pods is a promising activity, especially in the current context of poverty alleviation, dwindling grazing areas, and the scarcity and high cost of agro-industrial concentrate byproducts.

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