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Influence of Mango Feed-Based Diets on the Production and Economic Profitability of Montbeliarde Cows' Milk at the End of Lactation in Burkina Faso

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Abstract

The study evaluated the effects of a diet incorporating a mango-based feed on the technical-economic performance of milk production of Montbeliard cows at the end of lactation in a dairy farm in Bobo-Dioulasso, Burkina Faso. To do so, 14 cows were subjected to 3 diets, including an experimental diet incorporating mango (ED) in comparison to a balanced control diet (BCD) and to the feeding practice of the farmer (FCD) during 60 days. Results show that the average amount of milk milked per day from ED (10.93 ± 0.17 L) was significantly higher ($p < 0.05$) than BCD (8.80 ± 0.19 L) and RTA (5.39 ± 0.14 L). The conversion index of FPD (4.24 ± 0.14) was significantly higher ($p < 0.05$) than that of BCD (1.75 ± 0.19) and ED (1.26 ± 0.16). Average feed costs per liter of milk (FC/L) were significantly different ($p < 0.05$) between FPD (125.95 ± 4.56 FCFA), BCD (83.67 ± 6.36 FCFA) and ED (60.06 ± 5.49 FCFA). The average gross profit margins (GPM) were significantly higher and decreasing ($p < 0.05$) between ED (231,953 ± 5031 FCFA), BCD (167,157 ± 5831 FCFA) and FCD (74,188 ± 4185 FCFA). Mango feed can be used in the diet of dairy cows. Its use contributes to the reduction of production costs and the generation of substantial profits. The valorization of mango residues is an alternative for a greater availability of feed at lower cost for the animals. It could contribute to a better management of processing residues that pollute the environment and to the reduction of fruit flies that affect orchard yields through reinfestation. The increased use of mango in dairy cattle feed should be encouraged.

Keywords

Mango-Based Feed, Montbeliarde Cows, Milk Production, Technical and Economic Performance, Burkina Faso

1. Introduction

In Burkina Faso, the livestock sector contributes more than 18% of the GDP [1]. It is practiced by all social strata and remains the primary source of monetary income for rural households [2]. The country has a diversified and numerically important livestock population [3]. Milk is one of the 3 main animal products in addition to meat and eggs. However, domestic production is not sufficient to cover the demand for milk and dairy products of a population estimated at more than 20 million inhabitants [4]. Indeed, despite the numerical importance of the cattle herd estimated at 9,000,000 million head [3], the country imports milk and dairy products. Between 2010 and 2016, these imports would average 71,506 tons per year for a value of 20,887,000 US dollars [5]. This low production is essentially ensured by extensive livestock farms that represent 95% of dairy farms and by local breed cows whose milk productivity is very low [6]. With rapid urbanization and the increase in demand for dairy products, urban and peri-urban dairy farming has been growing for nearly three decades around large cities such as Ouagadougou and Bobo-Dioulasso. In this context, and with a view to significantly improving the supply of milk and dairy products, exotic dairy breeds, including the Montbeliarde, have been introduced. However, this impetus is faced with many constraints that hinder milk production, among which feeding is the main one [7]. As with other types of livestock, this constraint is expressed in terms of the low availability and increasingly expensive cost of conventional feeds including agricultural and industrial by-products (AIBP) used in the supplementation or rationing of dairy cows. Moreover, the intensification of dairy farming systems and the trend towards the use of specialized breeds in dairy production make the feed constraint crucial. Faced with this constraint that affects the breeding of the diversity of animal species in Burkina faso, research is increasingly oriented towards the development of feed production processes based on non-conventional food resources such as mango [8] [9]. Mango feeds have been particularly used in the rationing of growing pigs [10], laying hens [9], COB500 broilers [11] and local breed hens [12]. In this context, the present study is devoted to the evaluation of the effects of mango feed use on the technical and economic performance of milk production of Montbeliarde cows at the end of lactation (8 months on average) in a dairy farm in the outskirts of Bobo-Dioulasso in Burkina Faso.

2. Material and Methods

2.1. Study Site

The study was conducted on a farm located within the National School of Agri-

culture in the Hauts Bassins region of Burkina Faso. The National School of Agriculture is located 10 km south of the town of Bobo-Dioulasso on the Bobo Dioulasso-Banfora-Côte d'Ivoire border road. Its geographic coordinates are 4˚22'0" west longitude and 11˚4'60" north latitude. This site has a south Sudanese climate with a wet season of 5 to 6 months from May and a dry season of 6 to 7 months (November to April). Temperatures vary between 17˚C and 37˚C in the dry season and 10˚C to 32˚C in the wet season [13].

2.2. Cows' Housing

The cow house is built of permanent materials in accordance with the standards recommended in the tropics: east-west orientation, good ventilation and good lighting. The floor is cemented with a slope towards a slurry channel that drains into a collecting septic tank. The floor is therefore easy to maintain (cleaning and disinfection). The building has a sheet metal roof with a double slope and a height of 5 m from the ground. An individual box is built to allow individual feeding of the cows (**Figure 1**).

2.3. Animals Used for Experimentation

The animal material is made up of fourteen (14) lactating Montbeliarde cows aged five (05) years, all at their second calving and at the end of their lactation. The cows were divided into 3 batches corresponding to 3 diets, including an experimental diet incorporating mango feed (ED) (04 cows), a standard control diet without mango (BCD) (03 cows) and a usual farmer diet (FPD) (07 cows). The experimental design was an unevenly randomized Fisher block with three treatments (diets), each cow constituting a replicate. The cows did not receive any health treatment at the beginning of the trial as they were under a health monitoring protocol (vaccination and deworming). During the entire trial period, the

Figure 1. Lactating Montbeliarde cows in individual stalls at feeding time on the farm.

cows were kept in a permanent free stall in a pen. At feeding time, each cow was placed in an individual box to be milked and receive her meal.

2.4. Diets' Formulation

Three diets were tested, 02 of which were formulated for the needs of the trial: an experimental diet incorporating mango (ED), and a standard control diet without mango feed (BCD), meeting the recommended nutritional requirements. The third diet represents the rationing practice of the farmer (FPD). A daily follow up allowed to inventory the ingredients and their proportions used by the farmer and to calculate the centesimal composition and the nutritional contribution of this last diet. The diet was composed of 2 parts: a first part which is a concentrate composed of all the non-coarse ingredients, pelleted for the ED and BCD diets and not for the FPD diet; and a second part composed only of rice straw, a coarse food served ad libitum after milking and serving the concentrate. The rice straw was served ad libitum because its energy and nutrient contribution was almost zero. For the ED and BCD diets, the formulation aimed to meet the main requirements estimated in Table 1, according to the recommendations of milked cows' feeding guide [14]. The centesimal composition and Energy and nutrient contribution of the diets are presented in Table 2.

Table 1. Energy and nutrient requirements for cows producing 12 - 15 liters of milk/day.

Energy/Nutrient	Values
MS (kg/100kg Life weight)	3
CP (%)	13.5
DE (kcal)	1500
CF (%)	17
ADF (%)	21
NDF	28
Ca (%)	0.47
P (%)	0.305
NaCl (%)	0.18

Table 2. Centesimal composition and nutritional contribution of the diets distributed.

----------Centesimal composition----------			
Feed	Distributed diets		
	ED	BCD	FPCD
Provende mange SM	42.35	0.00	0.00
Cotton seed cake	31.35	22.50	21.58
Maize bran	0.00	42.70	11.51
Rice bran	0.00	0.00	20.14

Continued

Rice straw	23.00	31.50	46.77
Oyster shells	2.00	2.00	0.00
NaCl	0.30	0.30	0.00
VMC	1.00	1.00	0.00
Total	100.00	100.00	100
----------Energy and nutrient contribution----------			
Parametters			
ED (Kcal/kg)	0.88	0.88	0.64
CP (%)	13.5	14	13.29
CF (%)	17	19.83	29.15
ADF (%)	21	35.79	36.95
NDF (%)	28	63.52	56.14
Calcium (%)	0.47	0.81	0.19
Phosphorus. (%)	0.3	3.3	3.34
Cost/kgDM (XOF)	148	145	112.7

ED = experimental diet incorporating mango food; BCD = standard control diet without mango food; FPCD = diets served by the famer considered as absolute control diet.

2.5. Data Collection and Analysis

For the evaluation of milk production, the quantities of milk milked in the evening (EMQc) and morning (MMQc) were measured at each milking. The quantity of milk milked per day (DMQ) was then calculated according to the following formula: $\mathrm{DMQ}(\mathrm{l}) = \mathrm{EMQc}(\mathrm{l}) + \mathrm{MMQc}(\mathrm{l})$. The weight of milk milked was calculated by multiplying the quantity of milk by the density which is 1.03 kg/liter [15].

For the economic analysis, the daily feed consumption of dry matter (DM) per cow (DFCSc) (kg) was measured:

- the feed cost per day (DFCT) was calculated according to the formula $\mathrm{DFCT}(\mathrm{XOF}) = \mathrm{DFCS}(\mathrm{kg}) \times \mathrm{DCT}/\mathrm{kgDM}(\mathrm{XOF})$ A) with DFCS the daily feed consumption, and DCT/kg of Dry Matter of each diet;
- the cost of production of a kg of fresh milk MPCT/L was calculated by the formula $\mathrm{MlFCTP}(\mathrm{XOF}) = \mathrm{DFCTc}(\mathrm{XOX}/\mathrm{DMQc}(\mathrm{l}))$ with DFCTc = food cost of daily milk production per calve and DMQc the daily quantity of fresh milk per cow;
- the conversion index $\mathrm{IC} = \dfrac{\mathrm{DFCSc}(\mathrm{kg})}{\mathrm{DMQc}(\mathrm{kg})}$ with DFCSc = daily feed consumption per cow and DMQc = daily milk production per cow
- the gross margin per liter of milk per cow (GMlc) were calculated according the formula $\mathrm{GMlc}(\mathrm{XOF}) = \mathrm{MSIlc}(\mathrm{XOF}) - \mathrm{PElc}(\mathrm{XOF})$ with MSIlc(XOF) = Income from the sale of milk per liter per cow considering the cost of a litter

of milk at XOF500 practiced in Bobo-Dioulasso, and PElc(XOF) the expenses per cow per litter which include depreciation, health-maintenance-hygiene expenses, labor costs, and the cost of feed over the entire period. Total revenue, expenses and gross margins per diet were obtained by multiplying each indicator by the number of cows in the lot for each diet.

Data were analyzed using XLSTAT 2016.02.28451 software. Analyses of variance (ANOVA) using Fisher's model (LSD) at the threshold of ($p < 0.05$) were performed for the separation of averages of the different parameters according to the diets.

3. Results

3.1. Energy and Nutrient Intake per Ration Fed

Table 3 shows the energy and nutrient intakes of the different diets fed. The energy content of the ED and BCD diets was equal and 0.24 UFL higher than the FPCD one distributed by the farmer. The CP contents were almost equal for the BCD and FPCD diets. The CP content of the ED diet was 1.09% and 0.67% lower than that of the ED. The BCD diet had lower fiber content (CB, ADF, and NDF) than the ED and FPCD diets, which were nearly equal for CP, and slightly higher for ADF and NDF. Diet cost was higher and decreasing for the ED, BCD and FPCD diets.

3.2. Quantitative Milk Production According to the Ration Distributed

Table 4 shows the results of milk production. The total amount of milk produced was 6857 L in 60 days of testing. The average quantities of milk produced in the evening (EMQ), in the morning (MMQ) and during the day (DMQ) were significantly different between diets ($p = 0.000$). For milk milked in the evening, in the morning and during the day, the average quantities of the experimental

Table 3. Energy and nutrient intake per diet.

Compoments	Distributed diets		
	ED	BCD	FPCD
DE (UFL/kgMS)	0.84	0.90	0.64
CP (%)	11.62	13.71	13.29
CF (%)	27.17	16.95	29.15
ADF (%)	42.18	26.68	36.95
NDF (%)	68.10	44.98	56.14
Ca (%)	0.83	0.64	0.19
P (%)	3.24	1.59	3.34
Cost (XOF/kgDM)	148.00	145.00	112.66

ED = experimental diet incorporating mango food; BCD = standard control diet without mango food; FPCD = diets served by the famer considered as absolute control diet.

Table 4. Milk production per day according to the milking period and the diets distributed.

Diets distributed	Parametters			
	EMQc (L)	MMQc (L)	DMQc	
			L	Kg
ED	3.50a	7.43a	10.93a	11.28a
BCD	2.00b	6.84b	8.84b	9.13b
FPCD	1.79b	3.60c	5.39c	5.56c
Pr > F	0.000	0.000	0.000	0.000
Significative	Yes	Yes	Yes	Yes

ED = experimental diet incorporating mango food; BCD = standard control diet without mango food; FPCD = diets served by the famer considered as absolute control diet; EMQc = quantity of milk produced during evening milking per cow; MMQc = quantity of milk produced during morning milking per cow; DMQc = daily milk milked per cow; Averages values with the same letter in the same column are not significantly different (p = 0.000).

diet (ED) were significantly higher than those of the balanced (BCD) and famer practice control (FPCD) diets ($p < 0.05$).

3.3. Conversion Index and Cost of Production/L of Milk

The results presented in Table 5 show a highly significant difference in CI, FCTkgMP, and CTkgMP between diets. The average costs were significantly lower and increasing from ED, BCD to FPCD (p = 0.000).

3.4. Estimation of Economic Profitability from April to May

The results in Table 6 show the production count for the 60-day trial. Gross margin per cow (GMC) was higher in the ED diet (4 cows) than in the BCD (3 cows) and FPCD (7 cows) diets. With the same number of cows milked, the diet incorporating the mango feed produced 1.3 times and 1.5 times more milk than the BCD and FPCD diets respectively.

4. Discussion

4.1. Quantitative Milk Production as a Function of Rations Fed

Our results show that the average amount of milk produced by cows fed the experimental mango diet (ED) is significantly higher than that of the control diets BCD and FPCD. These results prove that the experimental mango diet has a positive influence on the milk production of Montbeliarde cows at the end of lactation. Our results concerning the average production of the ED diet of cows on the experimental diet of more than 11 kg of milk on average are close to the 13 kg of milk obtained by Si [16] on Montbeliarde cows in Algeria. Our results concerning the average production of the ED diet of cows under the experimental regime of more than 11 kg of milk on average are close to the 13 kg of milk

Table 5. Conversion index and cost of production/L of milk.

Diets	Parametters		
	IC	FCTkgMP (XOF)	CTkgMP (XOF)
FPCD	4.49 ± 0.27c	128.90 ± 8.53c	380.55 ± 23.42c
BCD	1.75 ± 0.10b	81.08 ± 3.62b	208.18 ± 10.52c
ED	1.26 ± 0.01a	58.20 ± 0.79a	149.66 ± 1.75a
Pr > F	0.000	0.000	0.000
Significative	Yes	Yes	Yes

ED = experimental diet incorporating mango food; BCD = standard control diet without mango food; FPCD = diets served by the famer considered as absolute control diet; IC = conversion index; FCTkgMP = food cost of the production of 01 kg of milk; CTkgMP = production cost of 01 kg of milk; Averages values with the same letter in the same column are not significantly different (p = 0.000).

Table 6. Milk production count according to the diets distributed.

Parametters	Distributed diets			
	ED (n = 4)	BCD (n = 3)	FPCD (n = 7)	AMONT (n = 14)
CDCT (XOF)	27,895	20,921	41,842	90,657
HMHCT (XOF)	10,690	8017	16,034	34,741
LCT (XOF)	22,316	16,737	33,474	72,526
FCT (XOF)	163,580	122,685	245,371	531,636
TE (XOF) (1)	224,481	168,360	336,721	729,562
TI (XOF) (1)	1,158,396	630,195	1,522,719	3,311,310
GM (FCFA) (3 = 2 − 1)	933,916	461,835	1,185,998	2,581,748
GMc (FCFA) (3/n)	233,479	153,945	158,133	645,437

ED = experimental diet incorporating mango food; BCD = standard control diet without mango food; FPCD = diets served by the famer considered as absolute control diet; CDCT = capital depreciation cost; HMHCT = health, maintenance and sanitation cost; LCT = labor cost; FCT = feed cost; TE = total expenses; TI = total income, GMd = total gross margin per diet and GMc = gross margin per cow.

obtained by Si [16] on Montbeliarde cows in Algeria. This could be explained by the fact that the diet incorporating the mango feed meets the production needs of the cows. Indeed, the availability of energy was correlated with a good fiber content of the diet. These results corroborate those of Si [16] who states that in addition to being rich in energy, the diet must contain sufficient fiber (minimum of 17% fiber or 19% ADF or lignocellulose for good rumen function and milk with a normal fat content). Beyond the effect of fiber, it can be noted that mango is a food rich in carotenes, as reported by Sawadogo-Lingani and Traoré [17], and in vitamins of the B group reported by Evans and Philippe [18], which may have increased the quantitative and qualitative production of the milk from cows on the ED diet compared to BCD and FPCD diets. Indeed, Daniel and coauthors

[19] had shown that a diet incorporating alfalfa rich in carotenes allowed an average quantitative production of 14.7 kg/day milk significantly higher than that of a control one which was 13.4 kg/day ($p = 0.09$). In addition, this diet significantly improved the protein and lactose content of the milk. Evans and Phillipe [18] reported that when 3 g/cow/day of protected B vitamins were fed in an experimental diet, the cows in this group (all categories, primiparous and multiparous) produced significantly more milk per day compared to the control group that did not receive its ($p < 0.05$). The results of this experiment also showed that the protein and butter yields of the experimental group improved compared to the control group.

However, our results are lower than the 17 kg of milk observed by Manishimwe [20] on Montbeliarde cows in Senegal. This difference could be explained by the very advanced stage of lactation of our cows (8 - 10 months). Environmental factors related to the host climate, less adapted than the original temperate climate, could also justify these low production levels. The differences reported by Boujenane and coauthors [21] who found a lower milk production in Morocco than in France with Montbeliarde cows confirm this assumption. The low quantities of milk produced could also be explained by the fact that the study was conducted during the dry season. This period corresponds to the critical period for the animals in terms of feeding. These results corroborate those of Sidibé-Anago and coauthors [6] and Sib and coauthors [22], who found that milk production varies between the dry season and the rainy season in our regions. According to these authors, milk production is higher in the rainy season than in the dry season.

4.2. Conversion Index and Milk Production Costs

Our results show significantly different and increasing conversion indices (CI), feed costs per 01 kg of milk (FCTkgMP) and production costs per 01 liter of milk (CTkgMP) for the ED, BCD and FPCD diets. Our results on production costs per liter of milk for ED (XOF149.66 ± 1.75) and BCD (XOF208.18 ± 10.52) diets are lower than the XOF371.41 and XOF315.56 and the range of XOF284-410 reported by [23], respectively for Montbeliard and Holstein dairy farms in Senegal. This could be explained by the low cost of our diets due to the incorporation of non-conventional mango-based feeds. Similar results were reported by Kiendrébéogo and coauthors [24], Zagré and coauthors [25] and Kiendrebeogo coauthors [12], who respectively used cassava by-products for pig fattening, pineapple by-products for pig fattening, and mango-based feeds for growth and finishing of local chickens.

4.3. Economic Profitability of the Rations Tested

The gross margin per cow (GMc) is used to compare the different diets tested. The results show that the Total Gross Margins (TGM) and Gross Margins per Cow (GMc) are all positive. These results show the best profitability of the ED diet, followed by the BCD and FPCD. This performance of the experimental ra-

tion could be explained by the coupled factors of the higher milk productivity of the ED diet, the low food cost of production per kg of milk (FCTkgMP) and the low cost of production per liter of milk when all production factors are equal for each batch and each cow.

5. Conclusion

At the end of this study, it was found that the incorporation of mango feed in the diet of Montbeliarde cows allowed to increase the quantitative production of milked milk per day, to obtain conversion indexes and the lowest production costs in all the phases of the trial compared to BCD and the FPCD. The mango feed is therefore an alternative for a greater availability of feed for the animals, especially for the cows. Furthermore, over the trial period, the experimental diet (ED) is economically more profitable than the standard control (BCD) and absolute control (FPCD) diets. In terms of production costs and profitability, the ED diet shows the best results on an equal number of cow's basis. The need for further investigations with trials covering all lactation's periods, the weight growth of calves and dams, as well as nutritional, hygienic and sanitary quality of the milk is necessary to cover all zootechnical aspect. In conclusion, despite the need to conduct others investigations to better refine recommendations to users, diets incorporating mango feed can be recommended to be used in milk production.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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