RESEARCH ARTICLE

THE ALPINE GOAT'S MILK PRODUCTION AND CHEESE YIELD IN BENIN

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ARTICLE INFO	ABSTRACT
	In order to diversify milk production, which still comes from cows only, in Benin, dairy goats from Alpine race are being adapted in a private farm located in Allada since 2005. The study had examined not only the level of the goats' milk production, but also the cheese productivity associated with it. Thus, dairy and cheese productions had been recorded for 73 days (j25 to j97). These data had been extrapolated for the whole lactation period, with Puillet dairy mechanistic model prediction. The average daily production was 1.28 ± 0.03 kg, with a peak of 1.49 ± 0.39 kg which had occurred at 41 ± 16 days of lactation. Lactation rank had significantly influenced the milk production with a peak in row 3. The cheese yield is 1 kg of cheese for 5.3liter of milk. **Résumé:** Dans le but de diversifier la production laitière encore exclusivement bovine au Bénin, des chèvres laitières de race alpine sont en adaptation dans une exploitation privée de la région du plateau d'Allada depuis 2005. L'étude a évalué leur dynamique de production et le rendement fromager. Les productions laitières et fromagères ont ainsi été enregistrées sur 73 jours (j25 à j97) et estimées pour l'ensemble de la lactation par le modèle mécaniste de prédiction laitière de Puillet. La production moyenne journalière est de $1,28 \pm 0,03$ kg, avec le pic de $1,49 \pm 0,39$ kg intervenu à 41 ± 16 jours de lactation. Le rang de lactation a significativement influencé la production de lait avec un pic au rang 3. Le rendement fromager est de 5,3l de lait pour 1 kg de fromage.

INTRODUCTION

With a potential of 1,427,200 goats, 742,000 sheep, 1,810,000 cows, the daily milk production in Republic of Benin is about 2 to 3 liters for cows and 0.5liter for goats (MAEP, 2006). These low level of milk productions forces Benin to import about 40,000 tons of milk per year, which results in loss of foreign exchange estimated at 10 billion FCFA each year (FAO, 2008). Consumption per capita / year of milk in Benin hardly exceeds 12kg, whereas the World health Organization (WHO) recommends a standard of 50 kg / capita / year (FAO, 2007). Increasing milk production has become a major concern in many West African countries (Oudet, 2005) Benin's objective is to attain 124,000 tons of milk in 2015 (MAEP, 2006). Thus, beyond bovines milk production, goat's milk production is able to be supported, on the basis that some countries had experienced it successfully (Vallerand *et al*., 2007;

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Kalantzopoulos G., 1993; Gnanda *et al*, 2006; Kouniba *et al*, 2007). Actually, the multi functionality of breeding goats is well known (Morand-Fehr *et al*., 2004), because of its ability to maintain and diversify activities in rural areas, thereby helping to improve the quality of the environment, to secure families through the capitalization of resources and facilitating their economic and social integration. Also in terms of nutritional value, goat milk contains casein 75.6% of which 70.9% of coagulated proteins (Grappin *et al,* 1981), 48% of β-casein, casein $\alpha s2$ 21% and 15% κ-casein (Gelais *et al*, 2000), with less fat (Le Jaouen, 1986; Roudj*et al,* 2005) and small fat globules (Holmes *et al,* 1945, Heinlein and Caccese, 2006). The lactose of the milk, varies from 44 to 48g / l (Veinoglou *et al*, 1982; Roudj *et al*, (2005), but is overflowing with minerals such as sodium, potassium magnesium, calcium, sulfates and phosphates (Mahieu *et al*, 1977; Jenness, 1980; Zeller, 2005). Finally, goat's cheese is highly prized for its dietary qualities (Zeller, 2005). Definitely, goat's milk represents a valuable production goal, a cultural reference, a social value product to be promoted. Therefore, this article is part of a series of studies in order of mastering goat milk production in Benin.

MATERIALS AND METHODS

Study environment and management of animals

The Alpine breed goats (Raveneau 1993; Le Gal, 1993) of this study were imported from France since 2005 by the Non Governmental Organization (NGO) "Elevage sans frontières" to boost milk production in some selected farms in the Plateau of Allada (2 East longitude 00 °, 6 ° 20 'and 6 ° 50' North) latitude in Benin Republic. A nuns farm located in Tèlokoué was followed for its goat milk production. In that part of Benin, there are one large rainy season (from mid-March to mid-July), one small dry season (mid-July to mid-September), one small rain season (mid-September to mid-November and one large dry season (mid-November to mid-March). The rainfall varies from 800mm to 1271mm and the average temperatures fluctuates between 27 ° C and 31 ° C. The goats in the nuns' farm are marked by loops and kept in permanent confinement. They are fed in trough in an above ground sheepfold. The feedings are essentially composed of green fodder and *panicum maximum, phyllanthus discoideus* with periodic intake of *mangifera indica* and *Moringa oleifera* leaves. Each morning, a supplement made from corn grain (41.6%), soybean meal (25%), wheat bran (25%) and palm kernel cake (8.4%) is given to animals, at the rate of 500g per head. The annual prophylactic program includes immunizations against small ruminants plague, the administration of anthelmintics, anti-anemic, vitamins and trypanocides based on each clinical case. The drying up is done at 3 months of gestation. Copulation is natural and organized at the sight of the first signs of heat, which allows grouping birth between November and February each year.

Cheese technology

The technological process for cheese production evaluated in this study, is similar to the Fulani traditional cheese making technology described by Kees (1996) except that the raw material used here is the goat milk and the coagulant is extracted from the leaves of papaya (*Carica papaya*). There are mainly three (03) stages in that process: milk filtration, coagulation-cooking, molding-draining. The milk is filtered by passage through a skimmer covered with a nylon cloth to remove any foreign particles (fly, fur, etc.). The plant coagulant which is here the extract of *Carica papaya* leaf homogenate, is added to the milk also by filtration. The whole mélange is then burned at 90°C until the formation of a curd which is divided into small pieces and floats whey (or whey). Cooking is optimal when the whey is light yellow and transparent. The curd with a spoon is transferred into cylindrical shape plastic molds and pierced with small holes to allow drainage that lasts about 2 hours. The Cheese pots are then placed in storage in a refrigerator.

Data collection

871 lactation data were collected for 73 days (at j25 J97) on 4 lots of 3 Alpine breed goats, lactation rank 1 to 4. All these data are obtained from two daily milking (morning at 08: AM, afternoon at 03: PM) after weaning at 30 days *post partum*. The weight of the two milkings had been recorded by goat and for the whole studied goats.. The weights had been taken with an electronic scale (range: 5kg, sensitivity ± 0.01kg). The Cheeses

weight which result from the milkings, is determined after 2 hours of draining. Cheese yield (RF) is evaluated as following:

$$RF = (Milk\ quantity(l))/(Quantity\ of\ cheese\ obtained\ (kg))$$

Statistical analysis

The procedure of the generalized linear model (*Proc GLM*) of SAS (*Statistical Analysis System, 9.2, 2008*) was first applied to the weight of milk for analysis of variance. The mean values were compared by *t-test*. The fixed effect considered is the rank of lactation goats and daily milking frequency. This model is as following:

$$Yijk = \mu + Ti + Sj + eijk$$

With *Yijk:* the weight of k^e goat milk, and lot *i* and daily milking frequency *j*; *μ:* the value of the overall average; *Ti*: fixed effect of lactation rank (1, 2, 3 and 4); *Sj*: fixed effect of daily milking frequency (t1 and t2); *eijk*: random residual effect.

The cheese yield (RF) daily average herd was calculated (*mean proc*) and compared by *t test.*

The mechanistic model of Puillet *et al.* (2007) simulating milk production dynamics in goats was then applied to data to predict the lactation in 300 days of 12 goats. This model is a combination of two subjects effects exponential decay, the decay constants are respectively (b) and (c). Milk production in the initial time is also dependent on two parameters: (a) and (d). The parameter (d) being set to 0.6 by the author, the model Puillet given by the following formula, becomes a function with three parameters (a, b and c), and a variable t (time)

$$PLJ(t) = a \times (b/c - b) \times (exp(-b \times t) - exp(-c \times t)) + 0,6 \times a \times exp(-c \times t)$$

With *PLJ*, the daily milk production and t the time in days

To calibrate this model, the daily milk production of 12 lactating goats over a period of about two months, and the days of lactation were considered relevant. The least squares method proposed by Legendre (1752-1833) and Gauss (1777-1855) was used. It consists in choosing the parameters a, b and c to obtain the smallest possible difference between the theoretical curves obtained using the equation of the curve Puillet and corresponding actual values. Noting that P milk production actually measured at a goat, and recording A, B, C and selected the optimal values for the parameters respectively a, b and c, the procedure of least squares means:

$$(A, B, C) = Argim \left(\sum_{t=0}^{T} (PLJ(t, a, b, c) - P(t))^2 \right)$$

The NLS SAS function was used to estimate these parameters by least squares. Some choices, including maximum and minimum values eligible for a, b and c were made as part of this implementation. The parameter (a) was taken between 0.1 kg and 6 kg. This assumption is reasonable a priori, as all the goats produce around 1 kg of milk per day. It has also been confirmed a posteriori since the optimum values found there

are in the strict sense. The parameters (b) and (c) homogeneous to the inverse of time, were investigated in the range [0.01 to 0.1] equivalent to [10-100] in terms of days. Once the parameters a, b and c are determined for each goat milk, the Puillet prediction model formula was then applied to determine the daily milk production (kg) per goat, that might be expected from the entire lactation period.

RESULTS AND DISCUSSION

By following Puillet model, the average daily milk production was 1.28 ± 0.03 kg (Table 1), with a peak of 1.49 ± 0.39 kg occurred at 41 ± 16 days of lactation (Figure 1). , Conversely, Puillet et al. (2007) evoke an average peak of 3.96 ± 0.86 kg of milk at 61 ± 23 days. This means that the goats in this current study come earlier and faster in the exponential decay phase of production (Figure 1). This could be explained as the consequence of a decrease in the rate of synthesis, and the earlier disappearance of alveolar cells specialized in milk production with these goats (Delouis, 1981). During 73 days of lactation, each goat has produced $93.22 \pm 25,97$kg (Table 1) and the model of Puillet predicts 267.7 kg of milk in 300 days per goat, with nearly half of this production obtained during the first three months of lactation (Figure 1).
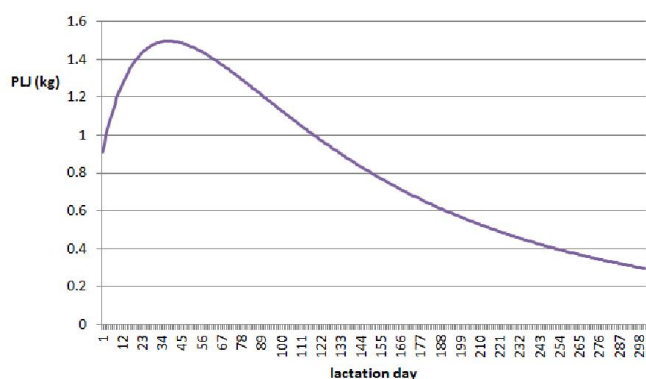

Figure 1. Kinetics of milk production of the Alpine goat kept in stabling

1999) and 398 kg in 225 days (Gal et al., 1993). Genetic type, quality and quantity of food resources, driving mode and the production's environment (Alderson and Pollak, 1980; Montaldo et al, 1981; Mavrogenis et al, 1984; Boichard et al., 1989; Brito et al., 2011) are all unidentified factors in this study, and which could affect the milk production of these alpine goats. The rank of lactation significantly influenced (p <0.01) milk production (Table 1): for PITJ73 the difference between rank 1 and 2 is 29.9kg; rank 2 and rank 3 is 30.7 kg; rank 3 and 4 is -14,6kg (Table 1). Some authors have also found that the goats from the first rank of lactation have always shown less production (Mourad, 1992; Browning et al., 1995; Crepaldi et al., 1999; Fernández, 2000; Antunac et al, 2001; Milerski and Mareš, 2001; Ciappesoni et al., 2002; Rodrigues et al., 2006).

Peak production obtained by the rank 3 in this study is similar to the results found by Ciappesoni et al. (2002) at rank 3, while Zeng and Escobar (1995) have pointed this result for rank 2. Increased milk with lactation rank could be explained by the amplification hormones development and activity mammary gland in older goats, which present a higher volume of the udder of the first lactation goats. Furthermore, the proportion of cells of the preceding lactation mammary not completely regress, and the secretory parenchyma increases (Knight et Peaker, 1982; Houdebine, 1986). However, Brito et al. (2011) found no effect of lactation rank on production. The rank of milking has also significantly influenced (p <0.05) production. The amount of milk in the first milking (T1) is the double of the second: 0.86 kg vs 0.42 kg (PILJ), 62.6 kg vs 30.6 kg (PITJ73) and 187.7kg vs 92.2kg (PTLJ73). Therefore, the loss would be important if we had realized a single milking. Komara and Marnet (2009) also have highlighted the advantage of a double-daily milking; 1,78kg 2,66kg and respectively for T1 and T2. However, a double-daily milking is a labor surplus, and the resulting gain must be confirmed by other subsequent studies carried on the economy and quality of milk. Furthermore, as far as breeding is concerned, milk recording performed on two milking has the advantage of offering less

Table 1. Distribution of milk production for 73 days of lactation, in the Alpine goat lactation rank 1-4 kept in stables

Parameters	Lactation rank				Average ±SD
	1	2	3	4	
PILJ					
T1	0.46±0.02[a]	0.87±0.02[b]	1.14±0.02[c]	0.96±0.02[d]	0.86±0.03
T2	0.35±0.01[a]	0.35±0.01[a]	0.50±0.01[b]	0.48±0.01[b]	0.42±0.08
T1 et T2	0.82±0.03[a]	1.22±0.03[b]	1.64±0.03[c]	1.44±0.03[d]	1.28±0.03
PITLJ73					
T1	33.6±0.42	63.5±0.60	83.2±0.32	70.1±0.36	62.6±20.99
T2	25.5±0.32	25.5±0.52	36.5±0.38	35.0±0.44	30.62±5.94
T1 et T2	59.1±0.38	89.0±0.55	119.7±0.35	105.1±0.41	93.22±25.97
PTLJ73					
T1	101.7±0.33	190.1±0.48	248.6±0.30	210.4±0.42	187.70±62.25
T2	77.1±0.36	76.3±0.32	109.6±0.36	106.9±0.46	92.47±18.25
T1 et T2	166.2±0.34	224.9±0.40	287.8±0.33	249.6±0.45	232.12±51.00
PFJ73					
TFP	31.4	42.4	54.3	47.1	43.8±9.60
RFR	5.3	5.3	5.3	5.3	5.3±0.00

T1.first milking; T2.second milking; PITLJ73.total individual milk production in 73 days; PTLJ73.total daily milk production in 73 days; PFJ73.cheese production in 73 days; TFP total weight of the cheese; RFR. cheese yield.

Literature reports several values related to the duration of lactation within Alpine goats: 1000kg in 273 days of lactation (Zeller, 2005); 777 to 968 kg in 305 days of lactation (Browning et al., 1995); 567 ± 6 kg 231 ± 1day (Crepaldi et al.,

precision loss (about 1%) and resolve potential problems of bias attributable to morning and night variations that exist in the amount of milk and butterfat content (Dickinson and McDaniel, 1970).

The cheese yield obtained in this study is one kg of cheese /5.3liters of milk (Table 1). In opposition with this result, other studies reported at one hand in the same alpine goat, a yield of 1kg of cheese for just 5.0liters of milk (Zeller, 2005) andin the other hand, a yield of 1kg of cheese for 5.79liters (Kouniba *et al*., 2007). For factors that could influence the performance of cheese production, one can evoke the rate of useful materials, that is to say, the fat and protein contents, cheese type products (fresh, hard, dry) (Le Jaouen *et al*. 1990), the physico-chemical composition of milk (Collin *et al*, 1991), all of which have been highlighted by this study. The effect of lactation rank and trafficking in milk production has also performed on the total cheese production (PTFJ73) and between rank 1 and 2 of lactation, superiority is + 11kg, between rank 2 and 3, of + 12kg and rank between 3 and 4 of -7kg (Table 1).

Conclusion

The study assessed the performance of alpine goat's milk and cheese production in Benin. The results reveal a milk production below the potential of the breed in its referenced ecological zone. However the observed performance is significantly high compared to those of our local non-dairy goat breeds. The prospects of creating a dairy goat sector in Benin are doable and studies should be continued to assess the adaptability of the Alpine goat, including crossing arrangements between this race and the local goats, *Sahelian* and *Djallonké* for rational management of genetic resources.

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