

EFFECTS OF MILKING FREQUENCY ON MILK YIELD, DRY MATTER INTAKE AND EFFICIENCY OF FEED UTILIZATION IN WAD GOATS

EFFECTOS DE LA FRECUENCIA DE ORDEÑO EN LA PRODUCCIÓN DE LECHE, CONSUMO DE MATERIA SECA Y EFICIENCIA DEL ALIMENTO EN CABRAS WAD

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ADDITIONAL KEYWORDS

Hand milking.

PALABRAS CLAVE ADICIONALES

Ordeño manual.

SUMMARY

Effects of milking frequency on milk yield, dry matter intake (DMI) and efficiency of feed utilization for milk production was investigated in West African Dwarf (WAD) goats at Abeokuta in the humid zone of South Western Nigeria. Seventeen WAD goats were fed a ration comprising (on dry matter basis) 50% grass (*Pennisetum purpureum*) and 50% concentrate (17% crude protein) at 5% body weight. The study involved hand milking once (at 6.00 am), twice (at 6.00am and 6.00pm) and thrice (at 6.00 am, 2.00 pm and 10.00 pm) daily for 21 and 35 days covering two periods, from June-October 2004 (Trial I) and April-July 2005 (Trial II) in a randomised complete block design. Kids were separated from their dams at day 14 and artificially reared. Compared to twice (2x) daily milking (322.2 mL/day), the milk yield for once (1x) daily milking (181.5 mL/day) was significantly ($p < 0.001$) lowered by 43.7%. Milk yield for thrice (3x) daily milking (334.8 mL/day) was however, higher by 3.8% compared to 2x. Twice and thrice daily milking were not significantly different ($p > 0.05$). As lactation progressed, day of lactation significantly ($p < 0.001$) affected milk yield and declined by 2.5 mL for each additional day of lactation. Dry matter intake (DMI) significantly ($p < 0.05$) increased with milking frequency. The DMI was 6.7% higher in trial I compared to trial II. Day of lactation had significant effect ($p < 0.001$)

on DMI increasing by 3.73 g for each additional day of lactation. The DMI for 2x and 3x daily milkings were however not different ($p > 0.05$). Milking frequency had significant effect ($p < 0.001$) on efficiency of feed utilization for milk production. The findings of this study indicate that milk yield and DMI increase with milking frequency. Therefore, it is concluded that twice daily milking of WAD goats optimises milk yield.

RESUMEN

En Abeokuta, en la zona húmeda de Nigeria, se estudiaron los efectos de la frecuencia de ordeño sobre la producción de leche, la ingestión de materia seca (DMI) y eficiencia de la utilización del alimento en cabras Enanas de Africa Occidental (WAD). Diecisiete cabras WAD fueron alimentadas con una ración compuesta (sobre materia seca) de 50% de gramíneas (*Pennisetum purpureum*) y 50% de concentrado (17% de proteína bruta) en la proporción de 5% del peso corporal. Se realizaron uno (a las 6:00 am), dos (a las 6:00 am y 6:00 pm) y tres (a las 6:00 am, 2:00 pm y 10:00 pm) ordeños diarios durante 21 y 35 días en dos periodos de junio a octubre de 2004 (ensayo I) y de abril a julio de 2005 (ensayo II) en un diseño de bloques completamente al azar. Los chivos fueron separados de sus madres el día 14

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y alimentados con lactancia artificial. Comparado con los dos ordeños (2x) diarios (322,2 mL/día), el rendimiento de un solo (1x) ordeño (181,5 mL/día) fue significativamente ($p < 0,001$) menor en un 43%. El rendimiento lácteo para tres (3x) ordeños diarios (334,8 mL/día) fue sin embargo sólo el 3,8% más elevado que para dos ordeños. Los rendimientos para dos o tres ordeños diarios no fueron diferentes. A medida que la lactación progresaba, el día de lactación afectó de modo significativo ($p < 0,001$) al rendimiento, que disminuyó 2,5 mL por cada día adicional de lactación. La ingestión de materia seca incrementó ($p < 0,05$) con la frecuencia de ordeño. La DMI fue 6,7% mayor en el ensayo I respecto del ensayo II. El día de lactación influyó ($p < 0,001$) incrementando la DMI en 3,73 por día adicional. La ingestión de materia seca fue similar con dos o tres ordeños. La frecuencia de ordeño mostró un efecto significativo ($p < 0,001$) sobre la eficiencia de utilización del alimento para la producción de leche. Los hallazgos de este estudio indican que la producción de leche y la DMI aumentan con la frecuencia de ordeño. Por ello, se concluye que la práctica de dos ordeños diarios en las cabras WAD, optimiza el rendimiento lácteo.

INTRODUCTION

Regular and complete milking is one of the requirements for continuance of lactation. The effect of changes in milking frequency on milk yield varies widely between individual species (Davis *et al.*, 1999). Reducing milking frequency from 2x daily milking to 1x daily milking decreased milk yield from 7 to 38% in dairy cows (Stelwagen and Knight, 1997), 15 to 48% in ewes (Negrao *et al.*, 2001), 6 to 35% in dairy goats (Capote *et al.*, 1999) and increased the rate of loss of udder tissue (Carruthers *et al.*, 1993). However increasing milking frequency from 2x to 3x increased milk yield by 7 to 20% (Stelwagen, 2001). The mechanisms responsible for the increase in milk yield have not been identified but some researches suggest an increase in mammary epithelial cell (MEC) number (Hale *et al.*, 2003), reduction in MEC apoptosis (Li *et al.*, 1999), increased cell activity (Knight *et al.*, 1992) and frequent removal of feedback

inhibitor of lactation (FIL) from the glands (Erdman and Varner, 1995).

Milking frequency stimulates mammary functions and milk synthesis is manipulated specifically by a non-invasive method. These increases are achieved with little loss of body weight or condition, the extra nutrient requirement being met by an increased feed intake. The aim of this study therefore, is to investigate the effects of milking frequency on milk yield, dry matter intake and efficiency of feed utilization for milk production in West African Dwarf goats.

MATERIALS AND METHODS

HERD MANAGEMENT AND EXPERIMENTAL PROCEDURE

The research was conducted at the Goat Unit of the College of Animal Science and Livestock Production Teaching and Research Farm, University of Agriculture, Abeokuta, Nigeria. The animals used for the experiment were part of the goat breeding flock of the College of Animal Science and Livestock Production at the University farm. They were managed under intensive system with zero grazing, housed in cross-ventilated pens with slatted floor and had free access to water. The does were naturally mated and were checked 18-21 days later for non-returns to oestrus (conception). The trial was conducted from June to November 2004 (Trial 1) and April to July 2005 (Trial 2) respectively. Efficiency of feed utilization for milk production was determined by dividing the milk yield (quantity of milk produced) by dry matter intake (feed consumed) daily.

The animals were fed at 5% body weight consisting of roughage (elephant grass) and concentrate in the ratio of 50:50 (offered on dry matter basis). The dry matter intake was deducted as the difference between quantities offered and left over. Freshly cut elephant grass (*Pennisetum purpureum*) was chopped and offered to the animals. The composition of the elephant grass and

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Table I. Proximate nutrient composition of elephant grass (per 100 g). (Composición nutritiva de *Pennisetum purpureum*).

Composition	Fresh	Hay
Water	77.8	10.9
Crude protein	1.0	8.2
Ether extract	0.5	1.8
Crude fibre	-	34.0
Ash	3.1	20.5
Total carbohydrate	17.6	68.6

Source: Duke (1983).

concentrate is shown in **tables I** and **II** respectively.

DATA COLLECTION AND ANALYSIS

Kids were allowed to stay with their dams for 14 days and milking commenced from the third week of lactation of each animal. Kids were then artificially reared. Animals were milked for 21 days in the first trial. The animals were re-mated and milking was repeated for 35 days for the second

Table II. Gross composition of concentrate fed to West African Dwarf goats. (Composición del concentrado suministrado a las cabras West African Dwarf).

Ingredients	% Composition
Maize	5
Dry brewers grain (BDG)	35
Palm kernel cake (PKC)	18
Wheat offal (WO)	40
Bone meal (BM)	1
Common salt	1
Total	100
Calculated analysis	
Crude protein	16.84
Crude fibre	12.66
Ether extract	4.78
Calcium	0.52
Available phosphorus	0.34
Metabolizable energy (kcal/kg)	2004.2

Table III. Milking protocols. (Protocolo de ordeño).

Milking frequency	Milking interval	N° animals/treatment
1	6.00am	7 does
2	6.00am & 6.00pm	5 does
3	6.00am, 2.00pm & 10.00pm	5 does

trial. Dams were hand milked three times daily (**table III**) and the milk was recorded daily in mL. Data collected were subjected to least square analysis (SYSTAT, 1992) in a randomised complete block design. Efficiency of feed utilization for milk production was analysed using the model below:

$$Y_{ijk} = \mu + R_i + P_j + RP_{ij} + D + E_{ijk}$$

where:

Y_{ijk} = Efficiency of feed utilization for milk production

μ = The overall mean,

R_i = The fixed effect of the i^{th} milking frequency ($i=1-3$),

P_j = The fixed effect of the j^{th} trial number ($j=1-2$),

D = Day of lactation as co-variate,

E_{ijk} = Random error associated with each record.

RESULTS

MILK SECRETION

The milk yield for 1x, 2x and 3x daily milking were 181.5, 322.2 and 334.8 mL/day/goat respectively. The analysis of the results (**table IV**) showed that milking frequency had significant effect ($p < 0.001$) on daily milk yield. The milk yield for 1x daily milking (181.5 mL/day) was significantly lower ($p < 0.001$) by 43.67% and 45.79% to 2x (322.2 mL/day) and 3x (334.8 mL/day) daily milking respectively, though the latter two were not significantly different ($p > 0.05$). Day of lactation had significant effect ($p < 0.001$) on milk yield. Milk yield declined from the 6th day of milking averagely by 2502 mL/day/goat for each additional day of lactation.

Table IV. Effects of milking frequency and trial number on milk yield (ml/day) in West African Dwarf goats. (Efecto de la frecuencia de ordeño y del ensayo sobre el rendimiento lechero en cabras West African Dwarf).

	Milking frequency			Mean ± SEM
	1	2	3	
I (June-November, 2004)	199.4±10.2 ^c	252.5±12.4 ^b	299.0±12.6 ^b	250.3±6.9
II (April-July, 2005)	163.6±6.9 ^d	391.9±7.9 ^a	370.6±7.8 ^a	308.7±4.4
Mean±SEM	181.5±6.1	322.2±7.3	334.8±7.4	-

^{abcd}Means with different superscripts differ significantly (p<0.05).

DRY MATTER INTAKE

Similarly milking frequency had significant effect (**table V**) on dry matter intake (p<0.05). Dry matter intake for 1x, 2x and 3x daily milking were 749.1 g/goat, 772.2 g/goat and 800.0 g/goat per day respectively over the two trial periods. The dry matter intake for 1x daily milking was significantly lower (p<0.01) compared to 2x and 3x daily milking. However, 2x and 3x daily milking were not significantly different (p>0.05). Day of lactation also had significant effect (p<0.001) on dry matter intake. Intake increased by 3733 g/day/goat for each additional day of lactation.

EFFICIENCY OF FEED UTILIZATION FOR MILK PRODUCTION

The result showed that milking frequency had significant effect (p<0.001) on efficiency of feed utilization for milk production (**figu-**

re 1). Efficiency of feed utilization for milk production for 1x, 2x and 3x daily milking were 0.237, 0.412 and 0.431 respectively. Also efficiency of feed utilization for milk production increased with increase in milking frequency. Efficiency of feed utilization for 3x daily milking was significantly higher (p<0.01) than 2x. Twice daily milking was also significantly higher (p<0.01) than 1x daily milking.

There was significant difference (p<0.001) between the two trial periods. Efficiency of feed utilization for milk production in trial 1 was 0.313 while it was 0.406 in trial 2. Also there was a significant interaction (p<0.001) between milking frequency and efficiency of feed utilization for milk production. There was significant effect of day of lactation on efficiency of feed utilization for milk production (p<0.001).

Table V. Effects of milking frequency and trial number on dry matter intake (g/day) in West African Dwarf goats. (Efecto de la frecuencia de ordeño y del ensayo sobre la ingestión de materia seca (g/día) en cabras West African Dwarf).

	Milking frequency			Mean ± SEM
	1	2	3	
I (June-November, 2004)	855.9±18.6 ^a	691.0±22.7 ^{bc}	855.0±23.0 ^a	800.7±12.6
II (April-July, 2005)	642.2±12.5 ^c	853.4±14.4 ^a	745.0±14.3 ^b	746.9±8.0
Mean±SEM	749.1±11.1	772.2±13.4	800.0±13.5	-

^{abc}Means with different superscripts differ significantly (p<0.01).

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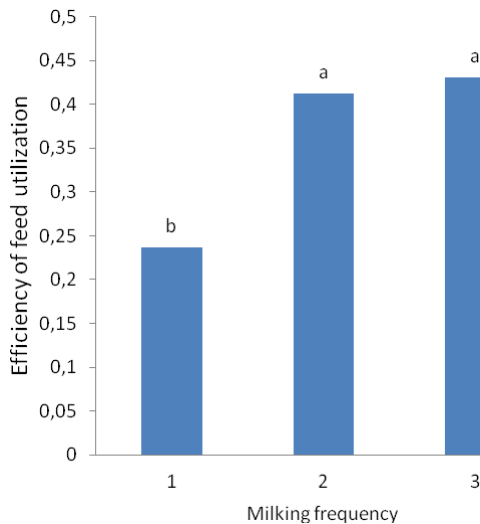


Figure 1. Efficiency of feed utilization for milk production in West African Dwarf goats. a,b- Bars with different letters are significantly different ($p < 0.01$). (Eficiencia de la utilización de piensos para la producción de leche en cabras West African Dwarf. a,b-Letras diferentes indican diferencias significativas ($p < 0,01$)).

DISCUSSION

The result of the study clearly showed the yield promoting effect of milking frequency in West African Dwarf goats. The result agree with several authors who reported significant increase in milk yield with increased milking frequency (Pearson *et al.*, 1979; Poole, 1982; Archer, 1983; Stelwagen, 2001; Salama *et al.*, 2003; VanBaale *et al.*, 2005). The mechanisms responsible for the increase in milk yield include, increase in mammary epithelial cell (MEC) number, (Hale *et al.*, 2003), reduction in MEC apoptosis (Li *et al.*, 1999), increased cell activity (Knight *et al.*, 1992) and frequent removal of FIL from the glands.

Milk yield for 1x daily milking was significantly lowered ($p < 0.001$) by 43.67% and 45.79% compared with 2x and 3x daily milking respectively. These reductions were greater than the values previously reported

in Canarian goats (6%) by Capote *et al.* (1999); Murciano-Granadina goats (18%) by Salama *et al.* (2003); and Alpine goats (36%) by Mocquot (1978). Wilde and Knight (1990) also reported a loss of 26% in Saanen goats in a short-term experiment in early lactation, while losses ranged between 6 and 7% in Damascus goats during middle and late lactation respectively (Papachristoforou *et al.*, 1982).

The wide variation in yield losses during 1x milking reported by different authors may be due to differences in breed, lactation stage, level of production, duration of 1x milking and nutrition level. Moreover, the increase in the concentration of the putative feedback inhibitor of lactation (FIL), synthesized by the mammary gland (Wilde *et al.*, 1995) and intramammary pressure (Peaker, 1990) may cause the decrease in milk synthesis in 1x daily milked goats. In addition, the loss of tight junction (TJ) integrity after about 20 h of milk accumulation may play a role in milk yield losses in once milking (Stelwagen *et al.*, 1994a). It should also be noted that when less frequent milking is prolonged, the decrease in milk yield is sustained by sequential developmental adaptations, initially as a down-regulation of cellular differentiation (Wilde *et al.*, 1987) and later as a net loss in mammary cell number via apoptosis (Li *et al.*, 1999).

The non-significant difference ($p > 0.05$) observed with 2x and 3x daily milking in this study completely deviated from results published by other authors. While Stelwagen (2001) reported that changing milking frequency from 2x to 3x in cattle resulted in 18% increase, Erdman and Varner (1995); Jurjanz *et al.* (1993) and Van der Iest and Hilerton (1989) reported an increase of 10-20% in cows when daily milking frequency was changed from 2x to 3x. The disparity in the result and in this study might be attributed to the breed of goat used, size of data and the plane of nutrition the animals were placed.

Day of lactation had significant effect

($p < 0.001$) on milk yield. Yield declined by 2.5 mL for each additional day of lactation. This result agrees with that of Chamberlain (1989) who reported that milk production in cows gradually declines after reaching its peak. This decline (Linzell, 1966) was mainly due to the loss of secretory tissue and decrease in rate of secretion per cell. Similarly, in non-pregnant cows, the decline in milk yield after peak lactation was very gradual, with each month's yield being 95% of preceding month (Chamberlain, 1989).

The study revealed that milking frequency had significant ($p < 0.05$) effect on dry matter intake. It showed that there is a positive correlation between milking frequency and dry matter intake. This result agrees with that by Bar-Peled *et al.* (1995) who reported that cows milked 6x daily consumed more dry matter than did cows milked 3x daily. Similarly, Barnes *et al.* (1990) and Royle *et al.* (1992) stated that a measurable increase in dry matter intake in cows accompanied the rise in milk production from higher milking frequencies.

It was noticeable that as the day of lactation progressed, most of the animals did not gain weight. In fact, some actually lost weight during the milking period (especially animals on 3x daily milking) indicating higher demands for dry matter intake at higher milking frequency. This result corroborates the findings of Bar-Peled *et al.* (1995) that increased dry matter intake by cows milked 6x daily did not compensate for the increased energy demands, thus these cows lost BW, had a lower body condition scores during the initial lactation period and displayed a longer recovery period than did cows milked 3x daily. Barnes *et al.* (1990) also reported that cows milked 3x daily did tend ($p < 0.1$) to be lighter than their counterparts milked 2x daily during lactation. They observed further, that dry matter intake increased by approximately 15% and cows on 2x and 3x daily milking consumed 10 and 11% more dry matter than controls during lactation respectively.

Although, Amos *et al.* (1985) reported that increased dry matter intake was too small to be measurable or nonexistent, Pearson *et al.* (1979) reported that cows milked 3x daily actually had lower dry matter intake than those milked 2x daily. On the contrary, however, Hansen *et al.* (1979) and Amos *et al.* (1985) noted that milking frequency was not associated with a significant change in body weight.

DePeters *et al.* (1995) reported that milking 3x daily reduced body weight gains in cows and there was a tendency for goats milked 3x daily to lose weight in the present study. Even though, cows were allowed *ad libitum* dry matter intake (Barnes *et al.*, 1990), the cows milked 3x daily did not respond to the increased energy demand associated with increased yield by consuming more ration. Thus in agreement with Amos *et al.* (1985), it appears that increasing milking frequency results in either preferential utilization of nutrients for milk production or a higher rate of tissue catabolism. Blake and Custodio (1984) suggested that increased milk yield and milk yield: feed intake occurs only as long as tissue reserves are able to subsidize the nutrient needed for milk yield.

Day of lactation had significant effect ($p < 0.001$) on dry matter intake increasing by 3.73 g for each additional day of lactation. These results agree with those of Bell (1995) who reported that the onset of lactation results in a dramatic increase in the requirements of nutrients, for example glucose, amino acids and fatty acids. This increase in requirements is met partly by increased voluntary intake partly by an array of metabolic adaptations. According to Tulloh (1966), changes which are of major importance for the establishment and maintenance of high milk production include hypertrophy of the gastro intestinal tract, increased fatty acid metabolism from adipose tissue and an increased rate of gluconeogenesis.

The study showed that milking fre-

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quency had significant effect ($p < 0.001$) on efficiency of feed utilization for milk production. The efficient utilization of feed by the animals could be attributed to the breed, physiological status of the animals and the quality of the feed offered. This observation agrees with the findings by Blake and Custodio, (1984) who reported that feed efficiency for milk production depends on diet, environmental factors and on genetic ability of the animal to utilize these inputs to produce milk. Furthermore, White (1989) noted that efficiency of carbohydrate utilization (carbohydrates being the major nutritive portion of ruminant animal feed) can be increased by treatments which encourage the animals to produce propionate rather than acetate or butyrate from carbohydrates. Consequently, if the animal is making more propionate, it will be found to be using its feed more efficiently. The elephant grass offered to the animals was chopped and fresh thereby increasing the surface area of the roughage. This may therefore, contribute to its efficient utilization by the animals. According to Bauman *et al.* (1979), Tyrrell *et al.* (1982) and Peel *et al.* (1983) hormones (e.g. growth hormone, insulin, prolactin) interact to control partitioning of dietary energy into milk and body tissue; this interaction is associated with genetic differences for milk within and between breeds. Consequently the animals could also be under favourable hormonal interaction.

The result also revealed that the higher the milking frequency, the higher the efficiency of feed utilization for milk production [1x (0.237), 2x (0.412) and 3x

(0.431)]. Animals on 3x milking frequency utilized their feed better than 2x and 1x milking frequencies. This result agrees with those of Barnes *et al.* (1990) who reported that cows milked 3x daily had efficiency ratios approximately 14% greater than for cows milked 2x. In the present study, animals on 3x daily milking frequency had efficiency ratio of 4.6% greater than 2x milking frequency. Therefore, animals on 3x milking frequency could have performed better if they were fed according to yield. This could probably explain the non significant difference recorded between 3x and 2x milking frequency in this study.

CONCLUSIONS

Higher milking frequency increased milk yield in West African Dwarf goats.

One daily milking reduced milk yield by up to 43.67% and 45.79% compared with 2x and 3x milking respectively.

Milk yields in 2x and 3x daily milkings are not different.

Increasing the milking frequency, increases dry matter intake by the animals.

Animals on 2x and 3x milking frequencies had better efficiency of feed utilization than animals on 1x milking frequency.

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