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Bypass Fat Increases Milk Production and Quality in Goats under Extensive Management

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ABSTRACT

Background: Lactating goats show a negative energy metabolism, which is why supplementation during this period is beneficial for the female, improving the production and chemical composition of milk. Various studies have shown that the use of protected fats in ruminants increases the quantity and quality of milk. The objective of the study was to evaluate the effect of a bypass fat on milk production and quality in grazing goats.

Methods: In an extensively managed goat herd in the Comarca Lagunera, goats (n=30) were selected and distributed in 3 treatments: (GCON), this group only consumed the vegetation in the grazing sites, (GHP95) this group received grazing plus bypass fat and (GLM45) this group received grazing plus bypass fat, the supplementation with bypass fat was 100 g/goat/d. During the study, live weight, body condition, milk production and quality were determined.

Result: The research shows that supplementation with bypass fat is sufficient to increase production ($p<0.05$) and quality of milk (fat; $p<0.05$) after calving in the different samplings ($p<0.05$). The results favored GHP95. This supplementation makes the use of protected fats in animal feed more efficient, increasing productive parameters and income for grazing goat producers.

Key words: Chemical composition, Goats, Lactation, Protected fat.

INTRODUCTION

Goat farming is a livestock activity that allows obtaining income supporting the rural population, mainly in the rural areas (Castel *et al*., 2010). The Comarca Lagunera region located in the arid northeast of Mexico stands out in goat production at the national level with an inventory of more than 400 thousand heads (SIAP, 2024). This region occupies first place in milk production nationwide with a volume of more than 60 million liters per year (Escareño *et al*., 2012; Isidro-Requejo *et al*., 2019; Navarrete-Molina *et al*., 2020, SIAP, 2024). At this latitude, goats are reproductively classified as seasonally polyestrous, which generates seasonality in the production of milk, goat and its derivatives (Álvarez and Zarco, 2001), which represents a variability in the perception of economic income for goat farmers. On the other hand, the predominant production system in the region (>90%) is developed under extensive grazing conditions of grasses, native forage plants and herbs, giving an imbalance or variability in the quality of the ration throughout the year, which effects the quantity and quality of the milk produced (Chauhan *et al*., 2020) The lipid content of common ruminant diets (2 to 5%, according to Lock *et al*., 2006) can be raised to increase the energy concentration of the diet, reduce the risk of ruminal acidosis and milk fat drop (Demeyer and Doreau 1999; Bauman *et al*., 2003). Increasing the fat content of the diet requires the addition of raw materials especially rich in lipids or fat sources. The addition of protected fat sources to the ruminant diet increases the number of fatty acids available for intestinal absorption while reducing the negative effects on the rumen microbial population (Jenkins and Bridges, 2007; Bionaz *et al*., 2020). On the contrary, the inclusion of unprotected lipids (oilseeds, oils and fats) in the diet can negatively affect the rumen microbial population (Yang *et al*., 2009). The addition of protected fat rich in palmitic acid increases milk production and milk quality in lactating ruminant females (Sampelayo *et al*., 2007; Goetsch *et al*., 2011; León, 2022). Taking this background into account, we establish the following hypothesis: the use of a bypass fat in lactating goats will increase milk production and quality in an extensive production system.

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MATERIALS AND METHODS

All experimental procedures, methods, test management and experimental units used in this study complied with the guidelines for the ethical use, care and welfare of research animals at international (FASS, 2010) and national levels (NAM, 2010). With institutional approval and reference number FAZ-UJED/03-02 0214-2026. This study was carried out in a goat establishment under extensive conditions in the Municipality of Francisco I. Madero, Coahuila, Mexico, geographically located at 25°50′ north latitude and 103°16′ west longitude. Precipitation is 266 mm annually, with an average annual temperature of 21°C (INEGI, 2015). All analyzes carried out in the study were carried out in the dairy laboratory of the Faculty of Agriculture and Zootechnics of the UJED. The experimental period with goats began in January 2023 and ended in March of the same year, with a duration of 60 days. From a herd of 80 multiracial goats managed under extensive conditions, 30 were selected based on their average live weight (50.2 ±1.21 kg) and average body condition (2.1±0.28 units), the goats were multiparous with 2-3 lactations. The goats were fed under the extensive sedentary grazing system predominant in the Comarca Lagunera, shrubs and eventually crop residues, (INIFAP, 2010). Of the selected goats (n=30), three groups were formed: 1) the first group only consumed the native vegetation in the grazing sites (GCON). 2) the second group consumed native vegetation plus 100g/goat/d of bypass fat (GHP95 with 95% palmitic acid; Table 1). 3) the third group consumed native vegetation plus 100 g/goat/d of bypass fat (GLM45, with 45% palmitic acid). The bypass fat It was offered individually to the goats, at 07:00 h, once a day, before leaving for the grazing sites. The goats were milked once a day in the morning and returned from grazing at 06:00 p.m. All goats were dewormed, with ivermectin (Zeuz, 1% LA) subcutaneously; vitaminized with vitamins A, D, E (Vigantol: ADE 100ml + Selenium 250 ml) intramuscularly one month before the start of the study. Water and minerals were provided *ad libitum.* The females were weighed for two days in a row, at the beginning of the experimental period (Fig 1), in the same way they were weighed two days in a row at the end of the experiment. A digital electronic scale with a capacity of 250 kg and an accuracy of 50 g was used to determine the weight. The body condition score was determined using the method of Walkden-Brown *et al.* (1997). The determination of body condition for all the goats in this study was carried out by a specialist to avoid bias in the interpretation of this variable.

The variable of milk production was determined by weighing milk production at 15, 30, 45 and 60 d after delivery. The calves were separated the afternoon before sampling to avoid weighing errors due to breastfeeding. Once the milk production was weighed, a subsample was taken for subsequent quality analysis. The samples were refrigerated at that time and subsequently frozen at -20°C for further analysis. The variable of milk quality was calculated using the 20 ml milk production subsample. Four samplings were carried out at 15, 30, 45 and 60 d postpartum. the LactiChekTM equipment was used (RapiRead LC-01 RR Hopkinton, MA USA) with this equipment the fat, protein and lactose content were calculated.

The response variables of live weight, body condition, milk production and quality were analyzed through an ANOVA for repeated measures and subsequently a Tukey means test was performed when required. Differences between treatments were accepted if p<0.05. The SAS statistical package was used to analyze these variables. (SAS Inst. Inc. version 9.4, Cary, NC, USA).

RESULTS AND DISCUSSION

The results obtained in this study support our working hypothesis, which proposes that supplementation with a bypass fat based on palmitic acid in different percentages is effective in increasing milk production and quality in goats managed under extensive conditions. Indeed, the highest values for the response variables, production and milk quality favored GHP95. That is, supplementation with bypass fat with 95% palmitic acid during the first 60 days postpartum increases milk production and quality in goats under extensive management. Unlike the variables live weight and body condition, in which there was no difference. In this sense, bypass fat facilitates an increase in the availability of fatty acids, which translates into greater absorption in the small intestine, passing into the bloodstream, which facilitates the availability for an increase in milk production, including an increase in the chemical composition of milk (Singh *et al*., 2015; Duarte *et al*., 2016).

Live weight and body condition score

For the response variable of change in live weight (Table 2) there were no differences (p>0.05), however the GHP95 goats were the ones that showed the least weight loss during the study (1.15 kg, p>0.05). Similarly, about body condition score, at the end of the experimental period there

Table 1: Chemical composition of supplements based on bypass fat offered to goats managed in an extensive production system in the comarca lagunera (25°LN).

Components	Lacto Mil HP95GHP95	Lacto Mil 45GLM45
Chemical composition		
Palmitic acid	95% (C:16)	45% (C:16)
Other palm fatty acids	4.0% Max.	5% Max
Humidity	1.0% Max.	3.5% Max
Protein	0%	0%
Total fatty acids	99%	83.5%
Recommended dose	100 g	100 g

were no differences between treatments (p>0.05), furthermore, there were no differences (p=0.30) in the variable of loss of body condition, the three. They behaved in the same way. That is, there was no effect of supplementation with bypass fat after birth, this information coincides with what was reported by (Ahmad *et al*., 2019) who evaluated the effect of bypass fat on growth, development and body condition in goats of the Beetal breed during the summer and conclude that the addition of bypass fat in the diets did not improve the growth performance of yearling bucks. In this sense, the possible explanation for our study is that protected fat had no direct effect on the change in weight and body condition, probably the absorption of protected fat led to other physiological processes such as lactation (Vieitez *et al*., 2016). However, in other studies different results have been reported in this variable, such is the case of (Vahora *et al*., 2013) who evaluated the effect of bypass fat in lactating buffaloes and found a positive effect in the lower weight loss in lactation of the supplemented group with respect to the control, a similar situation occurred with the GHP95 goats which showed less weight loss with respect to GCON and GLM45 during the experimental period, a possible explanation for why these results are the goats were in a negative energy metabolism and protected fat passed into the bloodstream and promoted better milk production and quality, but not weight and body condition, it is interesting to establish that in other studies where the effect of fat supplementation was evaluated of overshoot on weight gain, body condition and performance in fattening buffaloes, the supplemented group showed better performance (p<0.05) with respect to the rest of the treatments, as reported (Mohd *et al*., 2021) considering that the supplementation was given to males and not to lactating females as in our study.

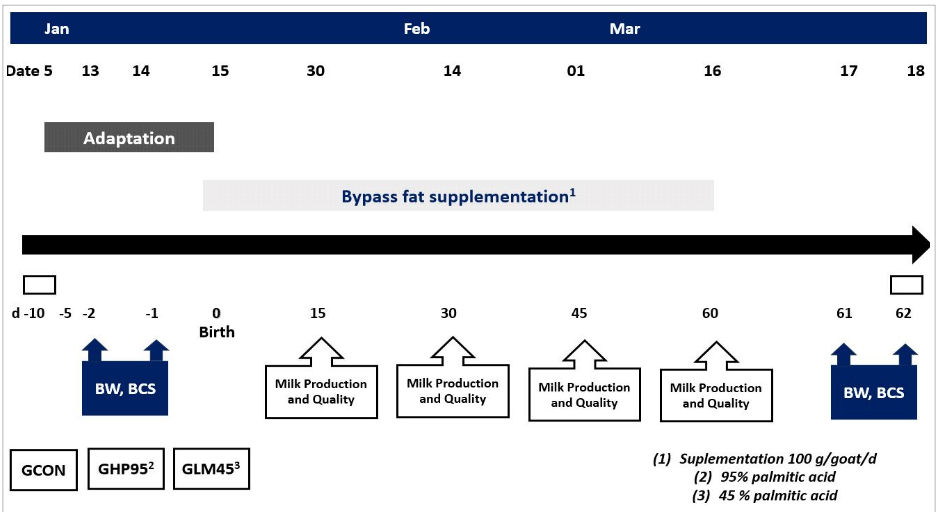
Milk production

The milk production of the goats of the three groups during the different periods of lactation is shown in (Fig 2). In it, it is clearly observed that there were differences in the milk production, obtained from the GCON, GLM45 and GHP95 females, favoring this last group in the four sampling

Table 2: Initial live weight (ILW), final live weight (FLW), live weight loss (LWL), initial body condition (IBC), final body condition (FBC), loss of body condition (LBC) and (± SEM) in goats kept under extensive management and plus supplementation with bypass fat in a goat herd in the Comarca Lagunera (25°LN).

Variables	Groups			p value
	GCON (n=10)	GHP95 (n=10)	GLM45 (n=10)	
ILW (kg)	49.85±0.59^{a}	50.55±0.66^{a}	50.20±0.23^{a}	0.95
FLW (kg)	48.34±0.54^{a}	49.40±0.69^{a}	48.45±0.24^{a}	0.24
LWL (kg)	1.51^{a}	1.15^{a}	1.75^{b}	0.20
IBC (units)	2.5±0.21^{a}	2.5±0.26^{a}	2.6±0.24^{a}	0.12
FBC (units)	2.3±0.49^{a}	2.4±0.36^{a}	2.4±0.54^{a}	0.64
LBC (units)	0.2^{a}	0.1^{a}	0.2^{a}	0.30

No differences (p>0.05) occurred for any variable between the experimental groups.



Supplementation with bypass fat (100 g/goat/d) with 45 and 95% palmitic acid was for 60 d after birth.

Fig 1: Schematic representation of the experimental protocol.

periods (p=0.04), as well as in the total production accumulated at the end of the study, as reported by (Tolemariam *et al*., 2009) who evaluated bypass energy and protein supplementation in lactating crossbred goats in India and reported up to 15% more milk production compared to groups with lower levels of supplementation. Goat milk production is affected by various factors; as a production system, management, health, genetics, nutrition and feeding practices, (Goetsch *et al*., 2011) physiological state, lactation stage (Vieitez *et al*., 2016). The physiological process of lactation in goats is directly related to lactogenesis, which can be defined as the beginning of milk secretion and is considered the final phase of the reproductive cycle (Cowie *et al*., 2012). According to Goetsch *et al*. (2011), this physiological process can be divided into two stages. The first stage occurs during gestation, when the gland differentiates enough to secrete small amounts of specific milk components, such as caseins and lactose. The second stage can be defined as the beginning of abundant milk secretion associated with childbirth (Clark and García, 2017). Therefore, the goat after giving birth requires an adequate nutritional status to maintain an adequate metabolic state due to the adverse effects of the negative energy metabolism that it undergoes during lactation (Cowie *et al*., 2012), in this sense a strategic supplementation during lactation results in higher levels of milk production (Clark and García, 2017) and using protected fat increases milk production as reported by (Tyagi *et al*., 2009) who evaluate the effect of an bypass fat on the milk production in lactating crossbred cows, resulting in cows supplemented with protected fat with higher milk production records compared to the control group.

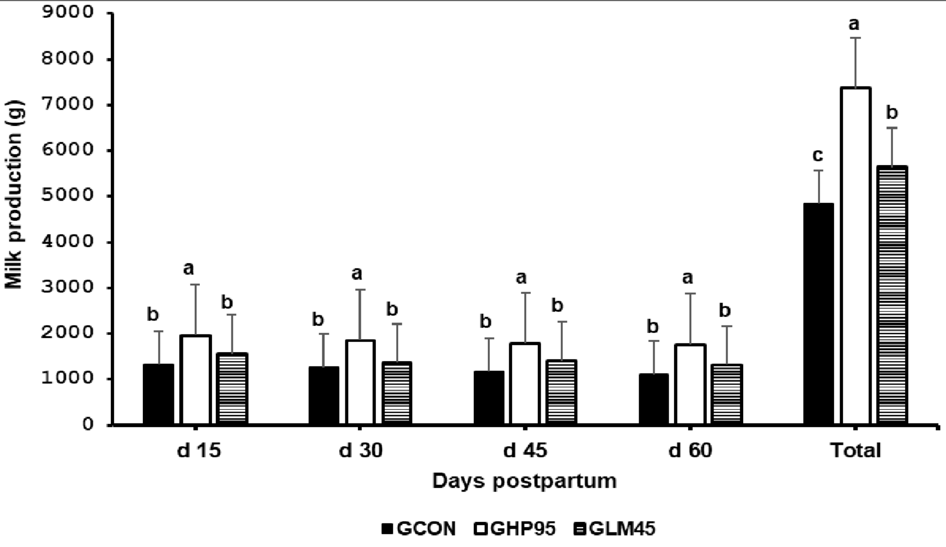
Milk quality

Regarding the milk quality variable, during the first 60 days of lactation, it was different between treatments for the fat component (Table 3; p<0.05), while for protein and lactose the three groups behaved similarly (p>0.05). Furthermore, it is observed that some components of the milk produced by the goats of the three groups showed variations over time during the first 60 days of lactation (p=0.02). With higher values for goats supplemented with bypass fat compared to GCON; That is to say, there was a positive effect of supplementation on the best quality of milk (fat), with respect to the goats they did not receive bypass fat in the daily ration, a situation like that reported by (Shingfield *et al*., 2010) who evaluated the effect of trans fatty acids in the nutritional regulation of mammary lipogenesis in ruminants and report that the variation in the secretion of mammary fatty acids and lipogenic responses to changes in diet composition among ruminants reflects species-specific differences in metabolism. of rumen lipids, which is why the use of a protected fat promotes mammary lipogenesis in goats, fat being the most important component that contributes to the organoleptic, physical and processing properties of ruminant milk (Chilliard *et al*., 2003; Park *et al*., 2007; Markovic *et al*., 2020; Hammam *et al*., 2022). In this sense, in our study the GHP95 goats received 100 g of bypass fat with 95% palmitic acid, which is a long-chain saturated fatty acid and represents one of the most common saturated fatty acids in animals, plants and microbes. Palmitic acid owes its name to palm oil and has been used in the feeding of different species of lactating ruminants (Toyes-Vargas *et al*., 2013) who determine the composition of fatty acids in milk from Creole goats in an extensive production system in an arid region of the Baja California peninsula, Mexico, in two seasons and found that the most abundant fatty acids were palmitic, myristic and stearic acid in both seasons. The quality of the milk throughout the 60 days of the study decreased as we carried out the four postpartum samplings (15, 30, 45 and 60 days) for both fat, protein and lactose, which is produced naturally (Bidot-Fernandez, 2017; Clark and García, 2017; Prosser, 2021), however, the highest values during the four

Table 3: Average quality (± SEM) of milk on different days after calving in goats kept under extensive management and with supplementation of 100 g/goat/day, in a goat herd from the Comarca Lagunera (25°LN).

%	Days after bith	GCON (n=10)	GHP95 (n=10)	GLM45 (n=10)	p[1]
Fat	15	4.90±0.25[a]	7.91±0.24[a]	5.89±0.37[a]	0.02
	30	4.23±0.89[b]	7.01±0.69[b]	4.59±0.54[b]	0.03
	45	4.01±0.24[b]	6.87±0.57[c]	4.25±0.41[b]	0.03
	60	4.07±0.36[b]	6.56±0.46[c]	4.07±0.26[b]	0.04
Protein	15	4.56±0.12[a]	5.87±0.78[a]	4.84±0.74[a]	0.45
	30	3.54±0.25[b]	4.65±0.87[b]	3.65±0.47[b]	0.67
	45	3.68±0.37[b]	4.51±0.63[b]	3.86±0.65[b]	0.98
	60	3.52±0.24[b]	4.01±0.58[b]	3.15±0.87[c]	0.54
Lactose	15	4.11±0.58[a]	4.98±0.24[a]	4.82±0.62[a]	0.41
	30	4.24±0.47[a]	4.87±0.29[a]	4.63±0.57[a]	0.98
	45	4.09±0.63[a]	4.07±0.48[b]	4.22±0.49[b]	0.34
	60	4.07±0.24[a]	4.01±0.63[b]	4.17±0.96[b]	0.24

p1= Probability of the comparison between groups. [a, b, c]= In each component, within the same column, different letters indicate differences in the different days after birth (p<0.05).



Statistical difference between groups (p=0.04).

Fig 2: Average production (± SEM) of the amount of milk at 15, 30, 45 and 60 days after parturition in goats under extensive management and of goats that received daily supplementation based on bypass fat 100 g/goat/d with different percentages of palmitic acid in a goat herd from the Comarca Lagunera (25°LN).

samplings were for fat, protein and lactose; for GHP95 goats due to the effect of supplementation with protected fat, considering that the type of diet in small ruminants, added to strategic supplementation, has an effect on milk constituents in the first months of lactation (Sampelayo *et al*., 2007; Zazharska *et al*., 2018). Goat milk is made up of 85.5% water and 14.5% total solids, which are made up of fats, proteins, carbohydrates and minerals; This composition largely demonstrates the high quality of goat milk, compared to the milk of other ruminants (Isidro-Requejo *et al*., 2019; Schettino-Bermúdez *et al*., 2018).

CONCLUSION

The variables of milk production and quality favored GHP95, which translates into an effect of supplementation with bypass fat with 95% palmitic acid, the first two months of lactation in an extensive system, hat is, the surplus fat was absorbed at the intestinal level and was reflected in greater productivity and chemical composition of the milk. The present study contributes to a better understanding of the use of protected fats in goat feeding, as an alternative solution to the problem faced by goats due to the heterogeneity in production and quality throughout the year, which is reflected in a lower economic income, fat being the component that has the greatest impact on this income. These results are of physiological and productive importance for the goat industry and can cover possible future applications with new research related to the quantity and quality of fatty acids present in goat milk, in addition to considering the results obtained under extensive conditions. It is interesting to be able to use this type of supplementation in goats, but for a longer period and at another time of year where the nutritional impasse is more marked by the seasonality in the availability in quantity and quality of vegetation and native crops waste in the grazing areas of this marginal production system.

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Conflict of interest

On behalf of all authors of the manuscript accepted for publication in Asian Journal of Dairy and Food Research, We declare that there is no conflict of interest for the publication of the manuscript.

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