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Comparison of daily weight gain in two groups of female kids fed with whole milk or biocholine-supplemented milk

Comparación de la ganancia diaria de peso en dos grupos de cabritas alimentadas con leche entera o leche entera suplementada con biocolina

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ABSTRACT

Artificial lactation is increasing in goat farms due to its innumerable advantages. The aim of this study was to compare daily weight gain (DWG) in female kids fed with biocholine-supplemented milk or whole milk without supplementation. The study was carried out with 16 French Alpine goats separated from their mother at birth and distributed into 2 groups; the control group (CG) (n=8) from mothers fed without supplementation with biocholine and the experimental group (n=8) from mothers fed with a diet supplemented with 8 g of biocholine (BSG) (n=8). They were fed under an artificial lactation system and weighed daily until 2 months of age; the amount of milk produced by mothers was measured weekly and the percentages of protein, fat and lactose were analyzed. No statistically significant differences (P>0.05) were found for DWG, nor for any of the milk components, but statistically significant differences (P<0.05) were found for milk production. It is concluded that biocholine at a dose of 8 g increases the amount of milk, but it does not increase main milk components, so the offspring did not have higher DWG.
Keywords: goats, biocholine, milk, weight gain.

RESUMEN

La lactancia artificial va en aumento en las granjas caprinas por sus innumerables ventajas. El objetivo de este estudio fue comparar la ganancia diaria de peso (GDP) en alimentadas con leche suplementada con biocolina y cabritas alimentadas con leche entera sin suplementación. El estudio se llevó a cabo con 16 cabritas de raza Alpina Francesa separadas de su madre al nacer y distribuidas en 2 grupos; el grupo control (GC) (n=8) proveniente de madres alimentadas sin suplementación con biocolina y el grupo experimental suplementado con 8 gramos de biocolina en su alimentación (GSB) (n=8). Se alimentaron bajo un sistema de lactancia artificial y se pesaron diariamente hasta los 2 meses de edad; se midió semanalmente la cantidad de leche producida por las madres y se analizaron los porcentajes de proteína, grasa y lactosa. No se encontraron diferencias estadísticamente significativas (P>0.05) para la GDP, ni para ninguno de los componentes de la leche, pero si se encontraron diferencias estadísticamente significativas (P<0.05) para la cantidad de leche producida. Se concluye que la biocolina a dosis de 8 gr aumenta la cantidad, pero no aumenta los principales componentes de la leche producida, por lo que las crías no tuvieron mayor GDP.
Palabras clave: cabras, biocolina, leche, ganancia de peso.

INTRODUCTION

Globally, the production and demand of goat milk derivatives, present a growing level, because of the increase in *per capita* consumption in both developed and developing countries (Rúa, 2019). One of the most relevant points in milk production is feeding, since nutritional management can help improve milk composition with verifiable effects in a short period, increasing or decreasing the concentration of the main milk components and generating an increase in product quality (Bedoya & Rosero, 2012). Milk composition is the result of several extrinsic and intrinsic factors of the animal. The nutritional factor has the greatest impact on milk composition; in this sense, dry matter intake, structural and non-structural carbohydrates present in the ration, particle size, the use of additives, probiotics and energy supplements, as well as the interaction between each of these elements are the main points that affect milk composition at the nutritional level (Bedoya & Rosero, 2012). The fat content of goat milk is the component most sensitive to nutritional changes in the animals' diet while the protein content, besides being modified by the diet, its major effect depends on the genetic component. Similarly, the type of diet hardly directly influences concentrations at lactose and minerals in milk (Bedoya & Rosero, 2012). Milk production levels are related directly to the nutrients consumed during the last third of pregnancy and the first 30 to 40 days of lactation (Meneses, 2017). Through feeding, it is possible to maximize nutrient intake in a given period and manipulate the rumen ecosystem for greater efficiency in the use of these nutrients. Additives are a strategy to positively influence production, performance or animal welfare and thus increase production. Feed additives are defined as substances, microorganisms and preparations other than feed raw materials and premixtures, which are intentionally added to feed or water (Cavini, 2014). Biocholine is a nutrient tentatively classified as one of the B-complex vitamins (McDowell, 2000), but unlike vitamins it does not participate in the enzyme system, and is required in gram amounts compared to vitamins that are required in milligram amounts (NRC, 2007). The biocholine level in all feeds is less than 0.68 mg/g dry matter and its digestibility varies from 80 to 84% (Supriyati *et al*., 2016), as it is highly degradable in the rumen (Pacheco *et al.,* 2011).

Unlike most vitamins, biocholine can be synthesized by most species, although in many cases not in sufficient or rapidly sufficient amounts to meet all animal needs, so supplementation is necessary in animals managed with efficient production criteria (Jones, 2014). A deficiency in biocholine results in symptoms such as growth retardation and poor productivity; fatty infiltration of the liver and, in acute stages, liver cirrhosis, especially in ruminants (Aldaz, 2012). The common source of biocholine supplementation is choline chloride, produced by chemical synthesis. Choline chloride is available in liquid form at 70% and powder form at 60% (Jones, 2014). Both are corrosive in nature and have very low bioavailability, since of the biocholine present in them, microorganisms in the gastrointestinal tract consume two-thirds and it is transformed into trimethylamine

(TMA). TMA is a toxic metabolite for animals and is the cause of fishy odor in carcasses (Jones, 2014). Biocholine, a herbal product made from Indian plants (*Achyrantes Aspera*, *Trachyspermum ammi*, *Azadirachta Indica*, *Citrullus* Colocynthis and *Andrographis paniculata*) (Mendoza *et al*., 2018), contains phosphatidylcholine, a source of esterified biocholine, conjugated to a phosphate molecule. In addition to other lecithin-type components such as phosphatidylinositol and phosphatidylethanolamine, molecules with an emulsifying activity that may also participate in the activation of cellular receptors of metabolism and fat mobilization (Mendoza *et al*., 2018). Supplementing biocholine in the natural form (phosphatidylcholine) may represent advantages such as greater stability and bioavailability with respect to the use of choline salts produced by chemical synthesis (Jones, 2014). Phosphatidylcholine compared to free choline is much more effective in reaching higher blood levels and for longer (Valencia, 2019). It is a powder product, non-hygroscopic and thermostable, its stability is not affected by the presence of water, high temperatures and/or ultraviolet radiation, thus surviving pelleting processes or being in contact with mineral premixes (Jones, 2014). Supplementation with biocholine of herbal origin improves milk production in ruminants due to the galactopoietic activity of some of its compounds mainly *Trachyspermum ammi*, which acts as galactogogue, hypotensive, oxytocic, stimulates the milk ducts of the mammary gland tissue, promoting milk ejection. It also has immunomodulatory and anti-inflammatory properties, decreasing the amount of somatic cells that improves the health of the udder, thus improving the quantity and quality of milk (Chandra *et al.,* 2017).

The aim of this work was to compare the daily weight gain (DWG) of two groups of kids fed on artificial lactation with whole goat milk and milk from goats with biocholine-supplemented diet, from the time of birth to two months of age. Besides, to determine if milk from goats fed biocholine-supplemented diets has better quality and it is reflected in growth.

MATERIAL AND METHODS

General

This work was performed at the Center for Practical Teaching and Research in Animal Health and Production (C.E.P.I.P.P.S.A.) belonging to the Faculty of Veterinary Medicine and Zootechnics of the National Autonomous University of Mexico (FMVZ-UNAM). The Internal Committee approved all methods and handling of the animals used in this study for the Care and Use of Animals (CICUA) of the FMVZ-UNAM, with institutional approval reference number 617.

Animals

Sixteen female goats of the French Alpine breed were used, which were separated from their mother from the moment of birth and were reared on artificial lactation until they were two months old, at which time they were weaned, divided into two groups. For the CG, 8 female goats of the French Alpine breed born of goats that were not supplemented with biocholine were used. Goats were separated from their mothers from birth to avoid mother-calf recognition and they were housed in an artificial lactation pen measuring 9.78 X 8.10 m divided into 4 pens of 5.30 X 2.45 m and a common corridor of 2.8 X 9.78 m, protected from the cold and with an infrared lamp to generate heat. Goats were fed 100 to 150 mL of colostrum from their mothers by bottle at birth; subsequently, they were fed at two different times: 8:00 am and 4:00 pm, starting with a minimum of 250 mL of milk per goat and as they grew, the maximum amount fed was 1.5 L per day. One week prior to weaning, the amount of milk supplied was reduced progressively until the amount of 250 mL in one feeding was reached. Weaning was performed at two months of age. For the BSG, 8 female goats of the French Alpine breed born of goats supplemented with 8 g of biocholine in their diet were used; the protocol and conditions for providing artificial lactation were the same as those used in the CG. In both groups, daily weights were recorded using a digital scale and daily weight gain (DWG) was calculated.

Feeding

Two diets were administered according to the physiological stage of the goats, following the recommendations of the NRC (2007) for late gestation and early lactation. In addition, a mixture of 70g of the following mineral salts Ca (20%), Mg (2%), Zn (20mg) and Se (30mg) was administered daily (Table 1). Prior to formulation, a proximate chemical analysis of the ingredients was performed (Table 2).

Table 1. Ingredients and composition of diets administered

Ingredients	Gestation (g/kg)	Lactation (g/kg)
Pelleted alfalfa	193	217
Oat hay	207	224
Commercial concentrate (Ingredients: corn, sorghum, cottonseed, oilseed meal, cereal by-products, cane molasses)	196	238
Corn silage	404	321

Table 2. Chemical composition of diets administered

	Gestation (g/kg MS)	Lactation (g/kg MS)
Crude protein	94	100
Crude fat	20	20
Neutral detergent fiber	580	585
Acid detergent fiber	356	338
Ash	102	102
Dry matter	668	718

Biocholine supply

The herbal supplement biocholine (Biocholine Powder, Nuproxa, Mexico), was pelleted using soy hulls as a vehicle (1:1), the daily portion (8g/day) was administered orally individually during the transition period (from day 130 of gestation to day 90 postpartum). The dose was established based on previous research by Supriyati *et al*. (2016) in which this supplementation had a positive effect mainly on increasing milk yield and fat, protein and lactose yield.

Milk quality.

A weekly sampling of both types of milk taken from the storage tanks at milking was performed, the determinations of the main dairy components were carried out in the Dairy Products laboratory of the Metropolitan Autonomous University (Xochimilco Unit), by infrared spectrophotometry method (Milko-Scan 133 B, Mca. Foss Electric, Denmark), to know their fat, protein, and lactose content.

Data analysis

The following parameters were evaluated: daily weight gain, milk production, fat, protein and lactose of both experimental groups. The information obtained in the present study was evaluated by descriptive statistics and an analysis of variance for a linear model with repeated means, in order to evaluate the effect of biocholine supplementation on the physicochemical quality of milk and the productive behavior of goats subjected to artificial lactation. The analysis of the information was performed using the statistical program JMP 13 (SAS Institute Inc, 2018).

RESULTS

The effect of biocholine supplemented milk compared to un-supplemented goat milk is not related to any change in daily weight gain of kids, so no significant differences were found between both groups (P>0.05) (Table 3). There is a significant difference (P<0.05) for milk production for both groups. The BSG group had higher averages (Table 4). There is no significant difference (P>0.05) for fat, protein and lactose between the CG and BSG. For the fat component, it is observed that the milk without supplementation maintains its percentages during the first 10 weeks and tends to decrease until the end of lactation, while the milk supplemented with biocholine reaches its maximum percentage in the second week and after that, it remains below the milk without supplementation (Table 5).

Table 3. DWG results for CG and BSG, adjusted means for DWG

	CG	BSG
Week 1	3.74 kg	3.87 kg
Week 2	4.42 kg	4.79 kg
Week 3	5.10 kg	5.55 kg
Week 4	6.00 kg	6.27 kg
Week 5	6.93 kg	7.12 kg
Week 6	8.17 kg	7.97 kg
Week 7	9.19 kg	8.96 kg
Week 8	10.15 kg	10.05 kg
Week 9	10.87 kg	10.92 kg
SEM	0.86 kg	0.80 kg

SEM (Standard error of mean), (P>0.05)

Table 4. Weekly averages for milk production for the GC and BSG. Adjusted means for milk quantity, expressed in liters

	CG	BSG
Week 1	8.16	14.06
Week 2	8.49	17.09
Week 3	9.68	18.2
Week 4	8.4	20.42
Week 5	8.69	20.24
Week 6	8.46	21.22
Week 7	8.46	21.27
Week 8	9.47	17.82
SEM	0.19	0.88

SEM (Standard Error of Mean), (P<0.05)

Table 5. Percentage values obtained for fat, protein and lactose for CG and BSG

	CG			BSG		
	Fat%	Protein%	Lactose%	Fat%	Protein%	Lactose%
Week 1	5.42	3.32	4.39	5.04	3.18	4.53
Week 2	4.86	3.35	4.24	5.49	3.03	4.32
Week 3	5.08	3.35	4.24	4.64	2.88	4.34
Week 4	5.07	3.32	4.21	2.42	1.43	2.45
Week 5	5.21	3.24	4.03	4.85	2.98	4.21
Week 6	4.23	2.7	4.17	4.74	2.68	4.12
Week 7	3.51	2.16	3.19	5.29	2.8	4.03
Week 8	5.18	3.03	4.18	4.78	2.87	3.95
Week 9	5.09	3.07	4.03	4.54	2.62	4.0
Week 10	4.85	2.68	4.05	3.76	2.5	4.0
Week 11	3.92	2.75	3.97	4.35	2.53	3.94
Week 12	4.22	2.55	3.49	3.7	2.46	3.78
SEM	0.17	0.11	0.10	0.24	0.13	0.15

SEM (Standard Error of mean), (P>0.05)

DISCUSSION

According to the results obtained, no statistically significant association (P>0.05) was found for daily weight gain between the group fed with milk supplemented with biocholine and the group without supplementation. There was a progressive increase in milk production (P<0.05). The components (fat, protein, lactose) were not affected (P>0. 05), decreasing as lactation progressed, a coherent result since as production increases. The main components present a dilution effect, since the only thing that increases is the quantity; thus causing that the milk of supplemented goats was not of higher quality compared to CG and thus calves did not obtain higher daily weight gain (Pinotti *et al.,* 2008). Milk production is directly associated with the amount of feed available to goats, as well as with the quality and availability of nutrients in the feed. In the work done by Pinotti *et al.* (2002) where encapsulated choline chloride was added to the cows' feed, there was an increase in milk production in supplemented animals, without changing the levels of fat and protein in the milk, as well as the levels of glucose and cholesterol in plasma. In this work, higher levels of total solids were not found in the milk of BSG

consuming the biocholine-supplemented diet, so further studies using different doses of biocholine are needed in the future. In the study by Xu *et al.* (2006), encapsulated biocholine supplementation in multiparous cows promoted higher milk production in animals receiving 30 g per day, also without changing milk composition as the results obtained in this work. According to Pinotti *et al.* (2002) and Baldi & Pinotti (2006), choline supplementation in diets of high-yielding dairy cows is essential to maintain milk production and milk quality, since choline deficiency can be a limiting factor for production Alba *et al.* (2021). These results coincided with those obtained by Martínez *et al.* (2019) in which they reported that with herbal biocholine supplementation 30 days before lambing in ewes, milk yield increased, however, there were no differences in the amount of milk fat, protein, lactose, non-fat solids and total solids. Another study by Mendoza *et al.* (2018) indicated that milk yield in Holstein cows increased three. With the supplementation of biocholine (2%) and herbal methionine, which were administered orally in a mixture of molasses and corn meal, which contained 15 grams of biocholine and 10 grams of herbal methionine per day, this mixture was kept at refrigeration temperature (3 °C). It was administered individually during milking for 60 days, and although the protein and fat content decreased numerically, no effects were detected in the other milk components, attributing it to the time of administration of the supplementation. Another study by Valencia (2019), in which cows were supplemented with herbal biocholine at 2 grams per day for 30 days before calving, indicates that no significant difference was found for milk production and quality, colostrum quantity and calf weight at birth, since the only component that was modified was fat, which increased by 1.45%. Roque *et al.* (2019) directly supplemented ewes during gestation with 4 g/day of biocholine of herbal origin and obtained higher colostrum and milk production, in addition to higher levels of protein, fat, lactose and non-total solids. These results are associated to the galactopoietic activity of some of the compounds of biocholine of herbal origin and to the time of administration. These studies indicate that supplementation with biocholine of herbal origin throughout gestation may have better results than if it is only administered 30 or 60 days before parturition or postpartum, as in the current study. It is also important to mention that the optimal dose of supplementation must be found to improve the quantity and quality of milk without economically affecting production, since Montoya *et al.* (2015) indicate that, although there is greater availability of biocholine at intestinal level, greater absorption is not guaranteed, however, in goats studies are very limited. Regarding the weight of the kids, there was no statistically significant association ($P>0.05$) between the two groups.

These results are in agreement with those obtained by Morales *et al.* (2019) in which he reports that supplementation showed no significant effect on the weight of the offspring at birth, attributing it directly to the feeding of pregnant goats, as they suggest that a greater amount of concentrated feed should be used. In the same study by Roque *et al.* (2019), no significant difference was obtained for birth weight, weaning weight and daily weight gain in lambs attributing it to the fact that methyl donor. In this case biocholine, do not

produce effects on cells, tissues and organs during gestation of the offspring, however, it can alter genetic regulation and decrease the risk of metabolic diseases during growth and adult life; although. It can be mentioned that some works carried out with biocholine on the offspring weight at birth, show the importance of this vitamin. It demonstrating that supplementation with biocholine can improve the methionine availability for protein synthesis for the fetus or milk, directly, either by *in vivo* synthesis, or indirectly, by controlling the amount of methionine used for biocholine synthesis in these stages (Valencia, 2019). It is likely that the link between biocholine supplementation and milk response has been attributed mainly to the metabolic exchange of choline and methionine, in the sense that both can provide free methyl groups for protein formation. This implies that feed composition, mainly protein supply and methionine availability, influence biocholine supplementation effects as mentioned by D' Ambrosio *et al.* (2007), in their study reports that Saanen breed goats supplemented daily in feed with 4 g/day of rumen-protected choline chloride 30 days before parturition and 35 days post parturition. All this gave favorable results, having a higher milk production, being 9% more than CG, and with a higher fat content. In another study by Pinotti *et al.* (2008) in which they supplemented Saanen goats with rumen-protected choline chloride 30 days before and 35 days post parturition at a dose of 4 g/day, milk yield and milk fat increased significantly. In the case of the present study, pregnant French Alpine goats were supplemented with biocholine of herbal origin, in comparison with other studies with favorable results, which supplemented with rumen-protected choline chloride. This type of biocholine presents fewer advantages than biocholine of herbal origin. Therefore, to have satisfactory results with biocholine of herbal origin it is necessary to find the optimal dose of supplementation, combine it with the administration of methionine or administer it during the entire gestation period. We must emphasize that feeding plays a very important role, because as mentioned, a greater availability of protein is needed in the body so that the methionine and free biocholine administered can be used to increase the protein and fat in the milk, and in turn we can increase the daily weight gain in calves.

CONCLUSION

The supplementation with biocholine of herbal origin in the feeding of French Alpine goats, increases the amount of milk produced, however, it does not increase the main components of milk (fat, protein, lactose), thus causing that the offspring do not have higher daily weight gain when consuming it. Supplementation with biocholine of herbal origin at different doses, during the 5 months of goat gestation or in conjunction with other additives such as methionine, it is suggested to increase the quantity and quality of milk components causing a better daily weight gain in the kid during lactation, generating greater productivity in production.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest with respect to the research, authorship and/or publication of this article.

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Errata Erratum

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