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DRY BREWER GRAINS AS REPLACEMENT FOR ALFALFA IN DIETS FOR LACTATING EWES

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ABSTRACT

The settlement of small and medium breweries in cities leads to the production of nutrient-rich organic residues, the quick decomposition of which causes unpleasant odours and attracts large amounts of flies. Under the hypothesis that replacing alfalfa (lucerne) with dry brewer grains (DBG) for lactating ewes would modify their milk production and physicochemical quality. The aim was to determine the effect of the DBG supplementation in the feed of ewes in milk production and quality, as well as in the physical condition of the animals. Fifteen 18-month-old ewes from a cross between Friesian × Rambouillet resulting from a first birth (30 days on milk) were distributed into 3 treatments with 0, 150 or 300 g of DBG. The experiment had a duration of 30 days, in which milk production, feed intake and physicochemical characteristics of the milk (fat, non-fatty solids, density, cryoscopic point, protein, lactose, and salts) were measured and each week the intake of feed in dry mass and the change in body weight were registered. Milk production displayed no differences between treatments and a decrease was observed in the production of milk for all treatments between weeks one (462 mL) and four (162 mL). Physicochemical variables of the milk displayed no differences between treatments, and quality was not affected. The change in body weight was the highest in the 300 g DBG treatment, with a modification of approximately 12.8 ± 0.45 kg ($p \leq 0.05$) during the trial time, daily weight gain was 440 ± 0.08 g d^{-1} ($p \leq 0.05$). The implementation of DBG in the feeds of ewes reduced the intake of dry matter, food conversion improved, and the cost of feed per ewe was reduced by up to 33.8 %.

Keywords: barley husk, milk, first birth, food byproducts, totally mixed portion

INTRODUCTION

The production of sheep milk is extremely important on a global scale, but mainly in Turkey and China, where 1 521 455 and 1 166 323 Megagrams were produced in 2019 (FAOSTAT, 2020). In the region of the Mediterranean, sheep milk is important since most is made into cheeses such as pecorino, caciocavallo and feta (FAO, 2021).

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In Mexico it is a scarcely practiced activity since there are no data on the national demand or economic impact, along with no technically improved production.

Sheep and goat are fed mainly on grazing in pastures, concentrated fibrous, preserved fodder, and only occasionally, agro-industrial byproducts (Flores-Najera *et al*., 2021). Due to the low availability of planted fodder, the use of agro-industrial products is justifiable. Olajire (2020) mentioned that food industries such as breweries produce large amounts of organic residues every year and explained that if these residues were not treated and released into the environment without some adequate elimination procedure, they could cause contamination and harmful effects on human and animal health, or they could also cause problems such as the production of greenhouse gases by burning. For example, in the industrial and craft beer industry, most of the residues of the process consist of humid barley grain (around 85 %), also known as barley malt grain, bran or husk (Mussatto, 2014). For example, for every 100 L of beer, 20 kg of solid residues are produced, with a protein content of 15 to 37 % w/w (Lynch *et al*., 2016).

This by-product has been used, in both dry and humid forms, as a supplement for animal feed, particularly for ruminant species, as a substitute for other ingredients in the diet due to high concentration of protein, phenolic compounds and dietary fibre, which stimulates the proper functioning of the rumen (Faccenda *et al*., 2018). Rivas-Jacobo *et al*. (2017) indicated that humid barley husk can be used to supplement the diets of grazing lambs and that the daily weight gain is equal to the other supplements composed of grains such as maize and sorghum. It is worth pointing out that this residue has a high percentage of humidity (75 – 80 %) and a significant amount of residual fermentable sugars that make it susceptible to the development of an undesirable microbiota.

Therefore, it is important to dehydrate the barley bran so that the grains contain no more than 10 % of moisture, thus extending shelf life (Ferrari *et al*., 2017). Vargas and Pérez (2018) reported that the use of DBG has a positive impact on the economy and the reduction of environmental pollution, whereas not making the best use of the residue lead to the loss of potential income; moreover, elimination implies additional costs and pollution to the environment. Thus, using this residue is an effective measure to strengthen a sustainable beer production system. On this basis, under the hypothesis that the replacement of alfalfa for dry brewer grains (DBG) in the diets of lactating ewes will modify the production of milk and physicochemical quality, the aim of this research was to study the effect of supplementing the feed for crossed ewes (East Friesian × Rambouillet) with dry brewer grains (DBG) in the production response and the quality of milk, as well as evaluating the change in body weight of the animals.

MATERIALS AND METHODS

The humid barley (brewer grain) husk was donated by the craft beer factory "Raíces" in San Luis Potosí. The barley grain was dehydrated in a forced air oven (SHEL LAB) at a temperature of 60 °C until constant weight.

Formulation of the portions

To produce the totally mixed portions, rolled maize was used along with sorghum, poultry litter, alfalfa, stubble, a premixture of vitamins and minerals (Microfos 12®), and dry brewer grains in different proportions (0, 150 or 300 g DBG in the mixture), obtaining three treatments (Table 1), which were designed according to the requirements stated in the NRC (2007) for ewes with a body weight of 60 kg, with a production of 0.87 kg milk d^{-1}. In the three diets, dry matter, raw protein, ethereal extract and ashes were determined following the methods by the AOAC (2005), whereas the content of neutral detergent fibre and acid detergent fibre was analysed using the method by Van Soest *et al*. (1991).

In vivo study

The study was carried out in the "Las Ardillas" farm, located in the community of "Las Colonias" (22° 33′ N 101° 47′ O), Municipal area of Salinas, S.L.P. in March of 2019. Fifteen ewes, of an East Friesian × Rambouillet cross, 18 months-old, weighing 60 ± 8.1 kg were used 30 d after birth after the lambs were weaned, which were treated following the Official Mexican Standard (NOM-062-ZOO-1999). The animals were placed in individual pens (1.2 × 1.5 m) in a ventilated stable; the ewes were assigned at random in the three treatments described (n = 5) and they were given water and

Table 1. Design of the diets with different levels of dry brewer grains (DBG).

	DBG (g kg^{-1} de DM)		
	0	150	300
Ingredient (g kg^{-1} DM)			
Rolled maize	150	150	150
Poultry litter	50	50	50
Sorghum	130	130	130
Dry brewer grains	0	150	300
Alfalfa	300	150	0
Ground stubble	300	300	300
Molasses	60	60	60
Vitamins and minerals †	10	10	10
Chemical composition			
Dry matter (g kg^{-1})¶	902 ± 2.0	903 ± 1.9	904 ± 2.1
Raw protein (g kg^{-1} DM)¶	116 ± 1.8	131 ± 2.1	146 ± 1.9
Ethereal extract (g kg^{-1} DM)¶	26 ± 0.9	35 ± 1.1	44 ± 2.3
Neutral detergent fibre (g kg^{-1} DM)¶	380 ± 3.1	391 ± 2.8	402 ± 2.9
Acid detergent fibre (g kg^{-1} DM)¶	258 ± 2.8	245 ± 3.2	232 ± 3.5
Ash (g kg^{-1} DM)¶	77 ± 0.9	67 ± 1.3	56 ± 0.7

†Dry matter (DM) base: calcium 220 mg kg^{-1}; phosphorous 280 mg kg^{-1}; magnesium 0.5 %; urea 102 g kg^{-1}; salt 845 g kg^{-1}; vitamin A 150 MUI kg^{-1}; vitamin B 25 MUI kg^{-1}; vitamin E 150 UI kg^{-1}; sulphur 30 g kg^{-1}; selenium 10 mg kg^{-1}; potassium 215 mg kg^{-1}; iron 50 mg kg^{-1}; cobalt 20 mg kg^{-1}; zinc 50 mg kg^{-1}; manganese 1600 mg kg^{-1}; copper 300 mg kg^{-1}; lasalocid 1.3 g kg^{-1}. ¶n =3 (mean ± standard deviation).

feed *ad libitum*, which was distributed twice a day at 8:00 and 17:00 h (2.5 kg d^{-1} of dry matter, DM).

The period of adaptation to the diets was of 7 d, the duration of the experiment was 30 d, and every week before each morning feed, the body weight of the animals was recorded with a BAC 300 scale. Weight gain was calculated by subtracting the final weight from the initial weight. The daily weight gain (DWG) was calculated by dividing the total weight gain over the experiment period, in days. The food conversion was estimated by dividing the dry mass intake (DMI) over the DWG. The costs of the ingredients in the market were used to calculate the total feed cost.

In addition, the daily milk production of each ewe was measured. They were milked by hand twice a day before feeding (7:00 and 16:00 h). The milk gathered from both daily milking of each individual was refrigerated at 6 °C and mixed. On the following day, the amounts of protein, fat, lactose, salt contents, non-fatty solids, cryoscopic point and density were recorded, the latter using a lactoscan (Milkotester, Master Eco).

Statistical analysis

The analysis of the productive variables was performed for a mixed model with a completely randomized design. To compare the total weight gain and per day, an analysis of covariance was carried out using the initial weight as a covariable and the production of milk was analysed with measurements repeated in time (4 weeks). In the variables in which the analysis of variance indicated differences of treatments, a Tukey means comparison test ($p \leq 0.05$) was performed using statistical software R (2019).

RESULTS AND DISCUSSION

The chemical compositions of the diets with DBG are shown in Table 1. The levels of raw protein, ethereal extract (EE) and neutral detergent fibre (NDF) rose with the supplementation of DBG in contrast with the control diet. For example, the protein content went from 12.8 to 16.1 % and the content of EE, from 2.8 to 3.8 % when contrasting the control treatment and the one with 300 g of DBG. The percentages of acid detergent fibre (ADF) and ashes decreases as the proportion of DBG in the diet increased.

Change in body weight

The results of the productive variables are shown in Table 2. When we adjust for the initial weight as a covariable, differences are observed in the final weight ($p \leq 0.05$) between treatments 0 and 300 g of inclusion of DBG, being greater with 0 g of DBG, where the initial weight did apparently have a bearing. The final weight also showed statistical differences ($p \leq 0.0001$), the treatment with 0 g of DBG obtained the highest body weight (75.4 kg) and the treatment with 300 g of DBG, the lowest body weight (67.7 kg). Regarding the total weight variable, statistical differences were observed between treatments ($p \leq 0.05$) and Tukey's test indicated that the highest gain was

Table 2. Feed intake, cost of portions, live weight, gain and food conversion of ewes supplemented with 0, 150 and 300 g of DBG.

Variable	DBG (g kg^{-1} DM)			Value of p	SEM
	0	150	300		
Initial weight (kg)	66.0 a	62.6 ab	51.6 b	0.05	3.23
Final weight (kg)	75.4 a	72.4	66.7 b	0.0001	7.01
Weight gain (kg)	11.5 ab	10.6 b	12.8 a	0.02	0.45
Daily weight gain (kg d^{-1})	0.37 ab	0.35 b	0.44 a	0.01	0.08
DMI (kg d^{-1})	1.87 a	1.53 b	1.25 c	0.0001	0.02
Food conversion	5.9 a	5.3 ab	3.7 b	0.04	0.93
Cost of feed ($ per animal d^{-1})	8.7 a	7.7 ab	6.5 b	0.05	0.52

DM = dry matter. Values with different letters in each row are statistically different ($p \leq 0.05$). The mean final weight, weight gain and weight gain d^{-1} were adjusted by the initial weight used as a covariable.

obtained with 300 g of DBG (12.5 kg). The average daily weight gain also displayed significant differences between treatments ($p = 0.01$) and the highest daily weight gain recorded was with the treatment with 300 g of DBG (0.40 kg d^{-1}).

DMI was lower with 300 g than with 0 g of DBG ($p \leq 0.0001$), therefore the food conversion was also lower, with 300 g DBG ($p \leq 0.04$), which indicates that with this treatment, less feed is required in dry matter to produce a kilogram of meat in live weight.

A higher protein content in diets for gestating bovines is obtained by replacing grass for brewer grain ensilage, since it improves the productive performance of the animals. In other words, there is a higher gain in live weight during gestation, a higher weight of ewes during birth and a greater weight gain of the ewes during development (Rooke *et al*., 2016). This coincides with the results obtained with similar live weights, because the diets offered to the ewes containing a greater percentage of dry brewer's grains (DBG) also contained a higher percentage of raw protein, which was observed in the growth and weight gain of the animals. In this regard, Faccenda *et al*. (2019) pointed out that the DBG supplements in diets for fattening cattle do not modify the intake of dry matter in feed, although they did observe a slight tendency to reduce feed intake, since they point out that a diet with DBG increases protein content. This is similar to the results of our study, in which a reduction was found in the feed intake as the inclusion of DBG was increased, along with a higher food conversion, which may be due to a proportional increase in the percentage of protein in diets with a higher amount of DBG.

Likewise, Rivas-Jacobo *et al.* (2017) observed that replacing maize and sorghum grains for humid brewer husk in the grazing of Rambouillet sheep produced a greater gain in body weight, with a lower feed intake. They also mentioned that this treatment was the best compared to the one with maize and sorghum grain, mainly due to the lower feed cost and the adequate physical condition of the animals. In contrast to our study, the results were similar, since the greater weight gain and the lower feed cost was found with the highest level of DBG.

The comparison of the results for some variables such as changes in weight, milk production and quality in lactating ewes with the results of other studies was complicated due to the scarcity of similar publications. In this study, the incorporation of DBG and the reduction in the content of alfalfa in the diets reduced the cost of feed per kg. Finally, the cost of feed per animal displayed significant differences ($p \leq 0.05$) between the three treatments; the one with 300 g of DBG displayed the lower cost (6.5 $ per animal d^{-1}).

Analysis of milk production

The statistical analysis displayed no differences in milk production due to the treatments ($p = 0.8201$). However, the same analysis did display differences due to time ($p \leq 0.01$) in the three treatments, where a reduction in the production of milk from week 1 to week 4 (Figure 1), with an initial production of 462 mL of milk per animal per week, which later fell to 162 mL of milk per animal per week, respectively. The treatments of 150 and 300 g od DBG maintained a more stable production during the four weeks, with a reduction in the final week. Even when no differences were found between treatments, the treatment with 150 g of DBG was the one with the highest production of milk in each and every week. The reduction in milk production was due to a physiological process, given that the lactation curve was ahead by 30 days.

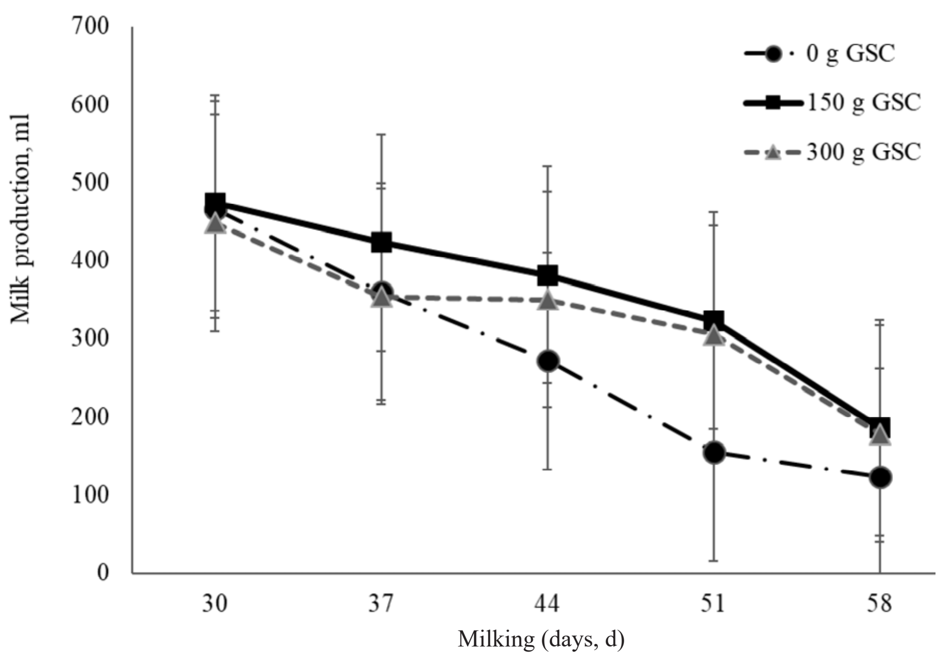

Figure 1. Production of milk in ewes supplemented with different levels of dry brewer's grains. Error bars are represented by the standard error of the mean.

Nava-García *et al.* (2019) followed the lactation curve of multiparous creole sheep for a 12-week period and pointed out that the highest peak in milk production was in the first eight days (539 g d^{-1}), and after that, milk production begins to drop due to physiological processes. In another study, Angeles-Hernández *et al*. (2013) indicated that the time of the year in which lactation begins is also a determining factor in milk production, with winter being the season in which the lactation curve is lower and production stays at around 400 mL d^{-1}, in contrast to the other seasons of the year. The results by these authors coincide with those obtained in this study, whereby in week 4 the highest milk production level was approximately 400 g d^{-1} and then it decreased gradually until 250 g d^{-1} in the 8th week.

Kremer and Rosés (2016) indicated that the milking routine simplification affects the milk of Frisonas-Milchschaf sheep fed with pastures in a negative way. The production values were affected by the number of times per day the animals were milked, since they observed that the production when milking twice a day was higher than that observed when milking once a day, which explains that the decrease in production depends on each individual, lactation stage and duration of the treatment. In the same study, the sheep displayed a good weight increase and body condition, indicating that their diet was adequate. By contrast, their results are similar to ours. The decrease in the production of milk may be explained because those animals were not used to be milked, thus leading in each one of them to a continuous reduction in milk production.

Nava-García *et al*. (2019) specified that most studies related to milk production in sheep have been implemented with pure dairy breeds and there are few studies on breeds with zootechnical aptitude for meat or wool. The adaptation of dairy sheep to being milked by hand or mechanically has helped establish reliable values of the amount of milk produced, since it can be weighed every day after being produced.

Physicochemical analysis of milk

In all the physicochemical variables of East Friesian × Rambouillet sheep milk, no statistical differences were found between treatments ($p \leq 0.05$) (Table 3). It is worth

Table 3. Physicochemical composition of milk from East Friesian × Rambouillet ewes.

Variable	DBG (g kg^{-1} DM)			Value of p	SEM
	0	150	300		
Fat (%)	6.20	6.50	6.68	n.s.	1.37
Protein (%)	4.13	4.31	4.43	n.s.	0.23
Lactose (%)	6.26	6.71	6.84	n.s.	0.35
Non-fatty solids (%)	11.39	11.93	12.25	n.s.	0.64
Density (kg m-3)	1023.35	1023.76	1023.91	n.s.	1.71
Salts (%)	0.88	0.91	0.98	n.s.	0.05
Cryoscopic point (°C)	-0.83	-0.89	-0.93	n.s.	0.05

n.s. = not significant; SEM = standard error of the mean.

mentioning that the inclusion of DBG is a feasible option, since the results regarding the quality of milk are the same as with the use of alfalfa.

The results of the physicochemical variables obtained in this study, such as fat content or lactose, are higher than those reported in studies with East Friesian and Rambouillet sheep by Kremer *et al*. (2015); these differences may be due to the origins of the breeds. In a study by Ochoa-Cordero *et al.* (2007), they describe that in pure breed Rambouillet sheep, milk quality is affected depending on whether it is their first or second birth. For example, milk fat content is lower in second birth sheep (5.0 %) in comparison with first birth sheep (5.7 %). In addition, they reported that the percentage of fat decreases when the weaning of lambs is postponed, although the authors did not mention what type of diet the animals had or the amount of feed given every day, nor did they mention the amount of milk produced by the ewes. By contrast, the results obtained in this study indicate the opposite. That is, with longer weaning times (eight weeks), the amount of fat and lactose became higher, possibly due to the low amounts of milk produced by the animal every day. Further similar studies are required on the use of DBG in diets for other milk-producing species such as cows and goats, or even in multiparous sheep and fattening animals, since weight gain was favoured in this study.

CONCLUSIONS

The inclusion of 300 g of dry brewer grain in the diets for East Friesian x Rambouillet ewes displayed an effect on the increase of body weight. In addition, the residue complemented reduced the intake of dry matter, improved food conversion and reduced the cost of the feed per animal by up to 33.8 %. Throughout the study, the quality of the milk was not affected.

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