

## PRODUCTIVE EVALUATION AND FEEDING POTENTIAL OF TSIRI PUMA AND TLAOLI PUMA MAIZE INCLUDED IN THE DIETS OF GESTATING GOATS

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### ABSTRACT

Feeding silage to goats (*Capra aegagrus hircus* L.) is a strategy used in regions with scarce fodder availability; however, the maize tested for this purpose was of commercial varieties. The goal was to assess the amount of fodder produced, the silage made, and the effects on pregnant goats and their young from two maize hybrids, Tsiri Puma and Tlaoli Puma, compared to a commercial hybrid (H-50). The yields of green matter (GM), dry matter (DM), and percentage of DM were determined. The material was chopped to 2 cm, taken to a bunker-style silo, and placed in three separate spaces for each hybrid. Once this was ready, 38 multiparous goats were distributed at random in three treatments with a diet including 50 % maize silage, and it was provided from day 64 of gestation to one weeks postpartum. Intake, weight, body condition scoring (BCS), and glucose levels were measured during gestation and up to two weeks postpartum. Kids were weighed at birth and 15 days after birth, and internal and external temperatures were measured. GM and DM yield, as well as the percentage of DM, were not different among the three maize hybrids ( $p > 0.05$ ). In the goats, food intake was greater in the Tlaoli Puma group, followed by Tsiri Puma ( $p < 0.0001$ ). Weight was greater in the Tsiri Puma and Tlaoli Puma groups ( $p = 0.0001$ ), whereas BCS and glucose concentrations were not affected by the treatments ( $p > 0.05$ ). Finally, body weight and the external temperature of the kids were greater in the Tlaoli Puma group ( $p < 0.05$ ). Maize hybrids Tsiri Puma and Tlaoli Puma had an adequate fodder yield that helps produce quality silage that favors the productive estimators in goats and their offspring.

**Keywords:** *Capra aegagrus hircus* L., *Zea mays* L., kids, silage, productivity, animal nutrition.

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## INTRODUCTION

Goat production is predominantly carried out under extensive systems; consequently, most of the animal feed comes from either native herbs, grasses or crop leftovers (Boudalia *et al.*, 2024). Occasionally, they may not provide enough nutrients to satisfy the needs of animals, and stages such as gestation and lactation can be affected (Teixeira *et al.*, 2024). In Mexico, reproductive stages coincide with the seasons of fall and winter, which are characterized by a low availability of forage and contribution of nutrients (Salinas-González *et al.*, 2016).

Nutrient restriction in goats leads to a deficient development of the fetus, which causes low birth weight, reduces offspring survival rate, affects milk production, and deteriorates the mother-offspring relationship (Terrazas *et al.*, 2009; Ramírez-Vera *et al.*, 2012; Laporte-Broux *et al.*, 2012; Castagnino *et al.*, 2015; Goetsch, 2019; Rahmani *et al.*, 2019). Likewise, it leads to a loss in live weight and body condition of the female (Castagnino *et al.*, 2015), induces birth complications (Baxter *et al.*, 2016), and causes the mobilization of fat reserves for lactation (Li *et al.*, 2020). In the case of the kids, it causes a lack of reserve fat to maintain homeothermy and reduces vitality for suckling (Terrazas *et al.*, 2009; Baxter *et al.*, 2016). This underscores the importance of providing adequate nutrition to gestating females, particularly in the final third of the gestation. During gestation and lactation, females must be provided with adequate levels of crude protein (CP) and metabolizable energy (ME). Likewise, the nutritional state of the animals must be monitored with the metabolic profile, since both the product and the placenta demand high energy levels from the maternal system when inducing changes in the metabolites in the blood. The carbohydrates derived from the circulation of the mother are the most important energy source for the developing fetus. In late gestation, the demand for this nutrient increases exponentially, so gestating goats must be provided with diets containing high levels of energy and easy availability (Nogueira *et al.*, 2017).

For the production of small ruminants, residues from crops, silage, pasture, hay, bushes, agro-industrial byproducts, poultry manure, and other alternative feed sources are frequently used (Boudalia *et al.*, 2024). The most commonly used process to preserve fodder is silage (Kumar *et al.*, 2024), which is also used as an alternative source of feed in small ruminants, particularly when there is a scarcity of forage (Boudalia *et al.*, 2024; Castillo-Hernández *et al.*, 2024). In gestating and lactating goats fed with maize silage, this allows for a better use of nutrients due to its good digestibility (Tarverdi *et al.*, 2021). However, these studies have been mostly carried out with commercial maize varieties that are not adapted to the particular conditions of each region, which may generate higher production costs.

In the High Valleys of Mexico, maize hybrids have been developed for grain production, such as Tlaoli Puma and Tsiri Puma, which contain adequate *in vitro* digestibility and high forage yields compared to commercial varieties. Likewise, they are resistant to lodging and some diseases, which suggests their potential to be used as fodder (Tadeo-Robledo *et al.*, 2016, 2021). Both hybrids have been tested for silage production

and supplied in the diets of gestating sheep, displaying a good response in productive and metabolic estimators both in mothers and in lambs (Castillo-Hernández *et al.*, 2024). However, the use of these maize hybrids has not yet been tested in goats' diets. This study proposes the hypothesis that the Tlaoli Puma and Tsiri Puma maize hybrids will produce adequate fodder yields while also promoting silage quality. Since they are supplied in the feed of gestating goats, they will allow for improved productive and metabolic parameters, as well as benefitting the viability of their offspring. The aim of this work was to evaluate the fodder yield and the productive and metabolic impacts on gestating goats and their offspring of two maize hybrids (Tsiri Puma and Tlaoli Puma) in comparison with a commercial hybrid (H-50).

## MATERIALS AND METHODS

### Site of study

This study was conducted in the caprine unit of the Agricultural Teaching Center of the Cuautitlán Faculty of Higher Studies of the National Autonomous University of Mexico (UNAM), located in the country's central highlands (19° 31' 35'' N, 99° 11' 42'' W) at an altitude of 2256 m. The weather is moderate, with rains in the summer, small temperature fluctuations, an average yearly rainfall of 600 mm, an average low temperature of 8.7 °C, an average high of 34 °C, and an annual mean of 15.7 °C (INEGI, 2020).

### Establishing crops for the silage

The hybrids were evaluated using a randomized complete block experimental design with six repetitions, with a total of 18 experimental units. Every unit corresponded to a 5 m long furrow with a distance of 0.8 m between furrows, obtaining a 4 m<sup>2</sup> useful plot. The crops were established in the spring-summer cycle of 2021. Two androsterile maize hybrids (Tsiri Puma and Tlaoli Puma) were used, along with commercial hybrid H-50 (Semillas El Trébol, Mexico). The soil was prepared by plowing, followed by two passes with a harrow, as well as furrowing and fertilization.

Sowing was carried out using the "a tapa pie" method, in which three seeds were placed per hole at a distance of approximately 15 cm. On the following day, flood irrigation was carried out to ensure seed germination. The crop was maintained under rainfed conditions. Thirty days after germination, thinning was performed to leave 32 plants per every 5 m row (corresponding to each experimental unit) to establish a density of 80 000 plants per hectare. Weed control was carried out 10 days after irrigation using a selective herbicide (Lumax Gold ZC® s-metolachlor, atrazine, and mesotron). At the same time, the crop was sown for silage for each of the hybrids on a 2000 m<sup>2</sup> area using a pre-calibrated MP-25 (John Deere, Mexico), establishing an approximate population of 80 000 plants per hectare. Fertilization was applied at the time of sowing with a dose of 80-60-00 of N-P-K.

## **Measuring of the vegetative material**

### **Green matter yield**

The yield of green matter (GM) was determined per hectare from the harvest of all the plants in the row belonging to each experimental unit. The cut was carried out 10 cm above the ground level, and the fresh weight per plant was measured according to Zaragoza-Esparza *et al.* (2019).

### **Percentage of dry matter**

Ten plants were chosen at random from every experimental unit and were chopped into pieces measuring 3 to 5 cm and manually homogenized. One kilogram of pieces was taken and placed in a paper bag labelled with the experiment number and initial weight, becoming a representative subsample as follows: the material was divided into four equal parts, and two opposite quarters were separated. The remaining quarters were mixed again, and the procedure was repeated until approximately 1 kg was gathered. The subsamples were dried at 55 °C in a forced-air oven for 48 h until a constant weight was reached and were then weighed to determine the percentage of dry matter (DM).

### **Yield of dry matter**

The yield of dry matter (DM) was calculated from the yield of GM and the percentage of DM per surface unit.

## **Harvest and preparation of the silage**

The harvest was performed on October 15 and 16, 2021, approximately 124 days after planting. The harvest was carried out when the state of optimum maturity appeared, which was determined visually after taking five plants at random and observing the state of the grain (1/4 to 1/3 progression of the milk line) for each of the hybrids of the three maize varieties (Zaragoza-Esparza *et al.*, 2019).

To cut and chop the plants, a forage harvester with a two-row header and an F-28 harvester (New Holland, Italy) were used. The plant material was chopped into 2 cm pieces and deposited into an agricultural forage dump trailer, which had been previously weighed. Once filled with the chopped fodder, it was taken to a scale for vehicles located on campus, where the trailer was weighed with each load. The fodder was later placed in a bunker-type silo, where the material of each hybrid was placed in a space of its own. Then, it was compacted with a tractor between layers, each approximately 60 cm thick. The compacted material was covered with black plastic and held in place with heavy objects to avoid air entering. This process lasted approximately 30 days. The nutritional composition of the silage prepared with the maize hybrids (Table 1) was determined by proximal chemical analysis in a private laboratory (Servicios GAQ S.A. de C.V., Mexico). These determinations were based on the description according to Shimada (2003).

**Table 1.** Nutritional composition of dry matter (DM) of maize silage (*Zea mays* L.) of the Tlaoli Puma, Tsiri Puma, and H-50 hybrids used in the diet of each group of gestating goats (*Capra aegagrus hircus* L.).

Components	Tlaoli Puma silage	Tsiri Puma silage	H-50 silage
Crude protein (% DM)	8.1	9.0	7.1
Neutral detergent fiber (% DM)	47.0	46.2	43.2
Acid detergent fiber (% DM)	29.5	29.9	27.0
Total digestible nutrients (% DM)	65.1	63.1	67.5
Net energy in DM (kcal kg <sup>-1</sup> )	1.56	1.48	1.65

### Animals and maintenance conditions

The protocol was approved by the Institutional Subcommittee for the Care and Use of Experimental Animals of the Animal Production and Health Science Postgraduate Department of UNAM, project number SICUAE.DC-2021/2-4. A herd of 38 multiparous goats was used (with more than two and up to five previous births, with  $45.5 \pm 2.27$  kg live weight and a body condition score (BCS) of  $2.53 \pm 0.12$ ) under a stabled system. The flock was made up of females from a cross between the Alpina and Toggenburg races, with an aptitude for dairy. For estrus synchronization, the goats underwent a protocol with the use of SINCRO-GEST®, intravaginal polyurethane sponges impregnated with 60 mg of medroxyprogesterone acetate (MA) for 11 days. On day 10 after the placement of the sponge, an intramuscular injection of Lutalyse® (5 mg of dinoprost tromethamine) was given; the sponges were removed 24 h later. Marker males were fitted with harnesses immediately after the sponges were removed and were kept in mating for 7 days.

During the entire experimental phase, the flock was kept stabled in three  $15 \times 15$  m pens for each experimental group. Each pen was fitted with a roof for shade, an area exposed to sunlight, cement floors, a 15 m linear cement trough, and water dispensers. At 69 days post-mating, a pregnancy diagnosis was performed using a portable device, model 9618, B Mode Ultrasonic Diagnostic Equipment (Welld 9618®, Shenzhen, China) with a convex probe operating at a frequency of 3–5 MHz.

A total of 38 gestating goats were recorded, which were distributed according to their weight and body condition in the following treatments: Tsiri Puma:  $n = 14$ , with an average weight of  $45.5 \pm 2.27$  kg and a BCS of  $2.5 \pm 0.12$ ; Tlaoli Puma:  $n = 9$ , with an average weight of  $45.24 \pm 2.26$  kg and a BCS of  $2.5 \pm 0.12$ ; and H-50:  $n = 15$ , with an average weight of  $45.81 \pm 2.29$  kg and a BCS of  $2.6 \pm 0.13$ . The weight of the goats was measured using a PLABA-12 (Rhino Maquinaria S.A. de C.V., Mexico) digital platform scale, with a capacity of 3 t and 500 g of precision. Their body condition was registered with the palpation of the lumbar region, based on a scale from 1 to 5, in which 1 is considered emaciated and 5, obese (Mendizabal *et al.*, 2011).

### Feeding

During mating and before gestation diagnosis, the goats had a maintenance diet (9.3 % CP and 2 Mcal ME kg<sup>-1</sup> DM) composed of 73 % oat, 24 % cracked maize, and 3 % concentrate, as well as water *ad libitum*. Experimental feeding began on day 64 of gestation and continued up to one week postpartum. The animals were accommodated in groups in three different pens. The ingredients and percentage of inclusion that made up their diet were: 25.48 % alfalfa hay, 24.52 % commercial concentrate, and 50 % silage. The nutritional content of the diet provided to the goats from each experimental group (Table 2) was determined in a particular laboratory (Servicios GAQ S.A. de C.V., Mexico) using a proximal chemical analysis such as described by Shimada (2003).

**Table 2.** Nutritional composition of dry matter (DM) in the diet of gestating goats (*Capra aegagrus hircus* L.) based on the feeding potential of maize (*Zea mays* L.) hybrids Tsiri Puma, Tlaoli Puma, and H-50.

Components	Tlaoli Puma diet	Tsiri Puma diet	H-50 diet
Crude protein (% DM)	17.5	16.0	16.6
Neutral detergent fiber (% DM)	34.4	38.1	32.5
Acid detergent fiber (% DM)	25.7	27.5	23.0
Total digestible nutrients (% DM)	67.5	66.7	70.8
Net energy in DM (kcal kg <sup>-1</sup> )	1.65	1.67	1.78

### Measurement of weight and body condition

The weight and BCS of the goats were measured on days 67, 128, and 134 of gestation, at 2 h postpartum, and 15 days postpartum. To take these measurements, the goats were managed in each group's pen. Using three 2 × 1 m portable panels, a smaller pen was built to contain the animals. Weights were taken using a digital PLABA-12 platform scale. The BCS was measured by palpating the sternal triangle using a scale from 1 to 5, where 1 is considered an emaciated goat and 5, an obese goat (Mendizabal *et al.*, 2011).

### Measuring food intake

Every day, after providing the experimental diets, the alfalfa and concentrate were weighed with a portable Trip2 (Wei Hang, China) digital scale with a capacity of 40 kg and an accuracy of 10 g. To weigh the silage, a digital hook scale (Crane Scane SF-915, China) was used, with a capacity of 300 kg and an accuracy of 50 g. To determine the apparent daily intake of the goats, the components of the diet were provided once a day and sequentially: first, the maize silage, followed by the concentrate, and finally alfalfa. The uneaten food in each group was gathered and weighed with a digital scale the next day early in the morning.

### Measurement of blood glucose

In each goat, blood samples were taken 67, 128, and 134 days after gestation and 2 h postpartum. The sampling was performed with fasting animals, except for the postpartum sampling. The blood sample (3 mL) was taken by puncturing the jugular vein with 21G × 25 mm Vacutainer® needles in tubes with EDTA (3 mL). The samples were refrigerated until centrifuged in the laboratory on campus premises on the same day the blood was drawn. A Hettich Universal 16 R (Andreas Hettich GmbH and Co., Germany) centrifuge was used at 4 °C and 3000 rpm (2147 × g) for 20 min to separate the plasma from the cell package. The plasma of the centrifuged samples was gathered and placed in 2mL Eppendorf tubes using Pasteur pipettes. To preserve it, the plasma obtained was frozen at -20 °C until the moment of analysis. The plasma samples were taken to a commercial laboratory (Centro de Diagnóstico Veterinario, Mexico) to determine glucose levels by spectrophotometry according to the technique described by Briseño-Castellanos *et al.* (2021).

### Measurements on kids

After birth, the goat and kids were placed in small individual pens for the first 2 h postpartum in order to ensure that the mother-offspring bond was established, as well as to verify that the kid consumed colostrum. After this period, the following measurements were taken on the kid:

Rectal temperature: The kid was held in place, and only the mercury bulb of a digital thermometer (Hergom®, Mexico) was introduced into the kid's rectum and maintained there until the alarm sounded. The temperature was noted, and the thermometer was cleaned for the next reading.

External temperature: with the kid still held down in place, its temperature was taken in the scapular area using an infrared thermometer gun with a range of -20 to 50 °C and ±2.5 °C (Steren® HER-424, Mexico), which was placed 5 cm away from the animal. Two repeated readings were taken, and an average reading was recorded.

Body weight after birth and at 15 days postpartum: every kid was weighed after taking their temperatures. A rope was used as a harness to secure the kid and place it on the metal hook of the Trip2 portable digital scale (Wei Hang, China) with a capacity of 40 kg and an accuracy of 10 g.

Sex and delivery type: The sex and size of the litter were registered.

### Statistical analysis

All variables of the experiment underwent a Kolmogorov-Smirnov test with Lilliefors probability to determine data normality. An analysis of variance (ANOVA) was conducted for repeated measurements over time using the Proc GLIMMIX procedure in SAS OnDemand for Academics (v. 3.1.0, SAS Institute Inc., Cary, NC, USA). Depending on the variable in the model, the fixed effects considered were the feeding group, litter size, and measurement time. Mean comparisons were performed using Tukey's test with a significance level of 0.05 for each variable. Data are presented as means and standard errors.

## RESULTS AND DISCUSSION

### Vegetative material

The GM, DM yield values, and percentage of DM were not affected by the hybrid ( $p > 0.05$ ). The average of these three variables was similar in the three groups (Table 3). These results may indicate that there was no variation in the planting and environmental conditions. However, they also point out that the growth of the three varieties was similar in the evaluated parameters. The DM and GM values are mainly related to the moment of harvest.

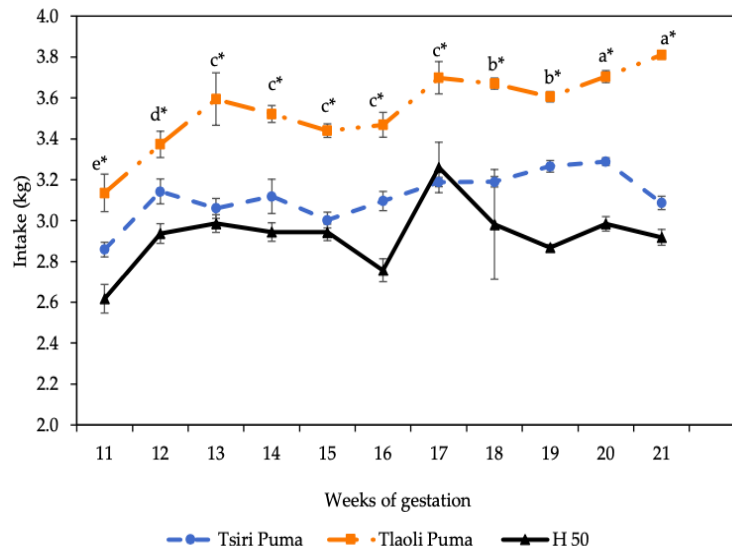
**Table 3.** Yield (mean  $\pm$  standard error) of green matter (GM), dry matter (DM), and percentage of DM of the maize (*Zea mays* L.) hybrids Tlaoli Puma, Tsiri Puma, and H-50.

Maize hybrid	Yield (Mg ha <sup>-1</sup> )		DM (%)
	GM	DM	
Tlaoli Puma	70.0 $\pm$ 3.3	17.9 $\pm$ 0.95	25.6 $\pm$ 0.6
Tsiri Puma	65.9 $\pm$ 2.2	17.9 $\pm$ 0.83	27.0 $\pm$ 0.7
H-50	66.8 $\pm$ 2.9	16.9 $\pm$ 0.69	25.0 $\pm$ 0.4
Variation coefficient	16.44	14.84	8.67
Value of $p$	0.57	0.54	0.10

The DM composition of the forage may affect its intake by the animals. Goats are known to be a species with a more selective trophic behavior than cows and sheep (Berthel *et al.*, 2022). Goats have a considerable ability to select different plants and plant parts, and the botanical composition of the diet better reflects the variety of chosen species (Goetsch, 2019; Ackermans *et al.*, 2019; Silva and Filho, 2021). However, other factors, such as the reproductive stage, can affect the intake of DM. In Creole goats, a higher DM intake was found when they were in early lactation compared to when they were not pregnant (Egea *et al.*, 2019). This may imply that the goats were able to adequately use the diets with silages from the hybrids tested here, as appropriate productive indicators were observed according to their reproductive stages.

### Feed intake

An effect on intake was found in favor of the experimental group Tlaoli Puma ( $p < 0.0001$ ) in comparison with Tsiri Puma and H-50 (Figure 1), whereas the intake of the Tsiri Puma group was only higher than H-50 ( $p < 0.0001$ ). Additionally, an effect of time was found (week of gestation), in which all groups increase their intake of feed as gestation progresses ( $p < 0.0001$ ). Finally, an interaction was found between the type of silage provided and time of gestation ( $p = 0.045$ ), implying that the intake of their diet increased as gestation progressed, although this increase magnified depending on the silage of the hybrids offered.



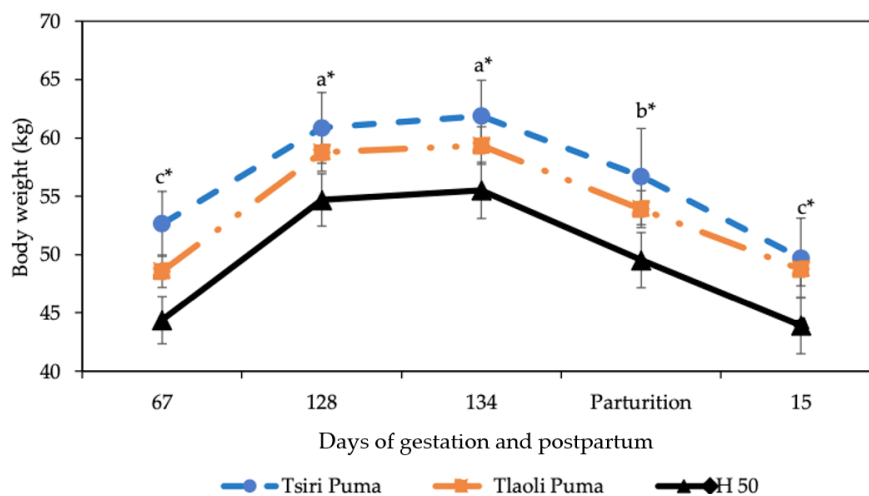
**Figure 1.** Individual intake (mean  $\pm$  standard error) of goats (*Capra aegagrus hircus* L.) fed with silage made of three maize (*Zea mays* L.) hybrids during gestation. Different letters indicate time differences ( $p < 0.05$ ), asterisks indicate differences between groups ( $p < 0.0001$ ).

These results differ from reports by Tarverdi *et al.* (2021) on gestating and lactating Mahabadi goats, where the intake of diets that included different percentages of maize silages did not differ in both stages. However, Fedele *et al.* (2002) reported that the goats that were stabled and fed *ad libitum* or with hay and concentrate increased their intake of dry matter from 12 to 62 % in the final third of their gestation in relation to the dry period. This is consistent with this investigation, since the intake in the three hybrids increased as gestation progressed, which also responds to the increase in the nutritional need in this stage; hence, giving them a diet with a higher energy value would reinforce the intake of the animals.

### Goat body weight

Differences were observed ( $p = 0.0001$ ), since goats from the Tsiri Puma and Tlaoli Puma groups had higher weights in comparison with the H-50 group (Figure 2). Likewise, differences were found for time ( $p < 0.0001$ ), in which the goats from the three groups were found to increase in weight from day 67 to day 134 and decline after giving birth (Figure 2). These results correspond with the data observed for weight and greater intake in the treatments with the hybrids Tlaoli Puma and Tsiri Puma, unlike the lower intake and goats with lower weights from group H-50.

These results may be related to the nutritional characteristics of the hybrids used and the final composition of the diet, as mentioned earlier. In this sense, Berthel *et al.* (2024) reported that goats select what they eat depending on its nutritional content, which shows a lower preference for protein components. This may not be consistent with



**Figure 2.** Body weight (mean  $\pm$  standard error) of goats (*Capra aegagrus hircus* L.) fed with silage made of three maize (*Zea mays* L.) hybrids. Different words indicate differences in time ( $p < 0.05$ ), asterisks indicate differences between groups ( $p < 0.0001$ ).

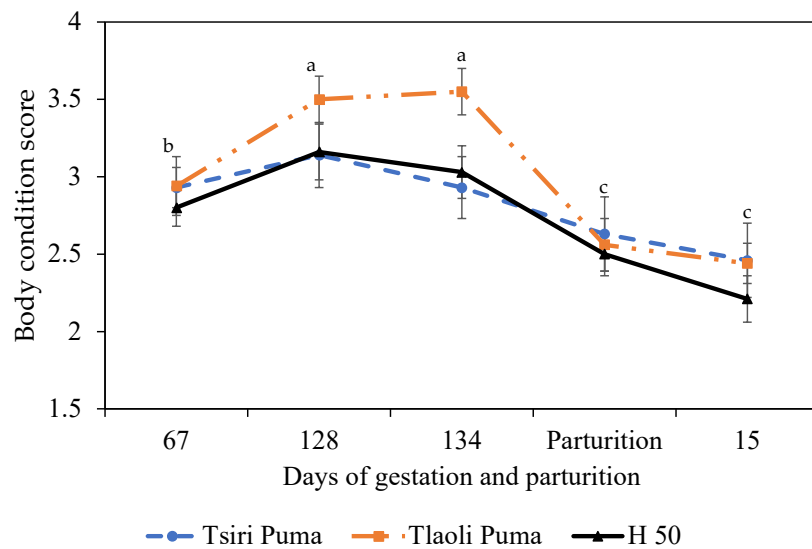
our results, since the diet composed of the hybrid H-50 contained a lower amount of protein and higher energy in comparison to the diets with Tsiri Puma and Tlaoli Puma silages. However, this assertion is hypothetical, as it is based on nutritional values obtained from a single analyzed diet sample. Therefore, it would be interesting to evaluate whether variations in the intake of goats with the fodders of the hybrids examined can be attributed to the nutritional content, particularly of protein.

#### Body conditions of goats

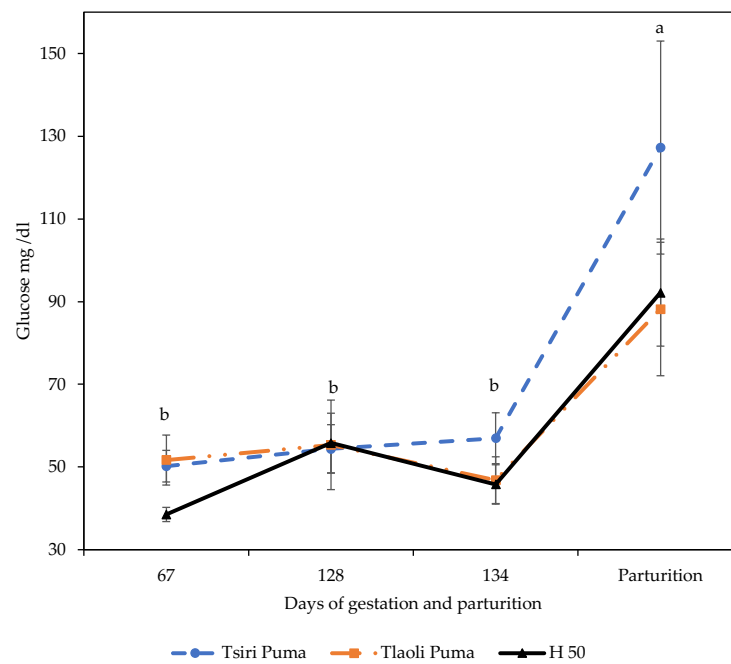
No differences were found between groups or whether there was any interaction between group and time ( $p > 0.05$ ) (Figure 3). However, there were differences ( $p < 0.0001$ ) observed for time. The BCS was higher from day 128 to day 134, with a decrease at birth. The BCS in all groups was adequate in relation to the ideal interval for the physiological stage of the goats (Ghosh *et al.*, 2019).

#### Glucose

No significant differences were found in the plasmatic concentrations of glucose between groups, nor was there any interaction observed between group and time ( $p > 0.05$ ) (Figure 4). However, for time, differences were observed at the moment of birth ( $p < 0.0001$ ). The results of the concentrations of glucose are similar to those reported by Faisal *et al.* (2022) and Abou-Elkhair *et al.* (2020) in gestating and maintenance goats fed with cornstarch and molasses or molasses meal.



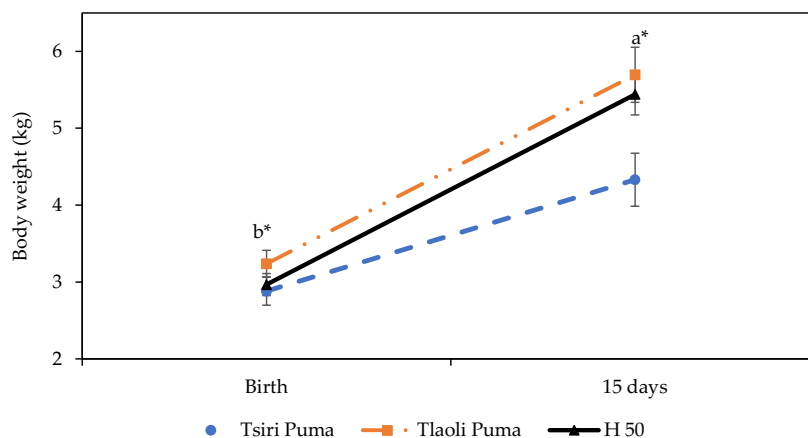
**Figure 3.** Body condition (mean  $\pm$  standard error) of goats (*Capra aegagrus hircus* L.) fed with silage made of three maize (*Zea mays* L.) hybrids. Different letters indicate time differences ( $p < 0.05$ ). A tendency ( $p = 0.073$ ) is observed for days 67 and 134.



**Figure 4.** Glucose concentration in plasma (mean  $\pm$  standard error) goats (*Capra aegagrus hircus* L.) fed with silage made with three maize (*Zea mays* L.) hybrids. Different letters indicate time differences ( $p < 0.05$ ).

### Weight of the kids

Kids in the Tlaoli Puma group presented a higher weight at birth in comparison to the two other groups ( $p = 0.005$ ) (Figure 5), and this difference was maintained until they were aged 15 days ( $p < 0.0001$ ). Throughout time, a significant effect was observed ( $p < 0.0001$ ). Finally, there was a tendency ( $p = 0.068$ ) towards the group and time interaction, which indicates that the weight of the goats increased as their age advanced, although this effect was mostly significant in the Tlaoli Puma group. This is consistent with the goats in this group having been the ones that presented the highest intake and weight gain. Abou-Elkhair *et al.* (2020) reported similar findings, stating that the kids with the highest weights were born to mothers who were fed a more nutritionally balanced diet.

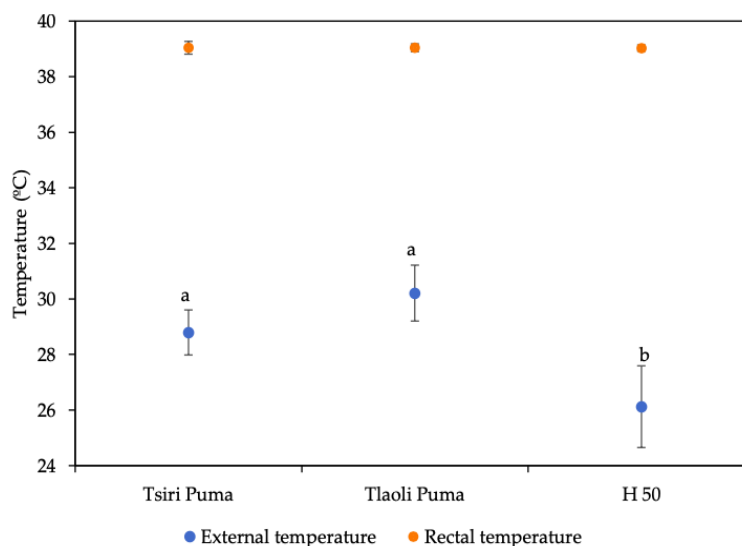


**Figure 5.** Weights of kids (*Capra aegagrus hircus* L.) (mean  $\pm$  standard error) born from goats fed with silage made with three maize (*Zea mays* L.) hybrids at the moment of delivery and 15 days afterwards. Different letters indicate time differences ( $p < 0.05$ ). Asterisks indicate differences between groups ( $p < 0.005$ ).

In the case of the effect of the litter, it was found that the weight of single kids was higher than that of twin or triplet kids. In turn, twin kids had a higher weight than triplet kids ( $p < 0.0001$ ). In the case of the sex of the kid, no differences were found ( $p = 0.555$ ). The results observed for both characteristics contrast with Vázquez-García *et al.* (2021), as these authors did not observe differences due to the type of birth, but they did for sex, since the males weighed more than the females.

### Temperature of the kids

The rectal temperature of the kids was similar in all groups ( $p > 0.05$ ) (Figure 6). However, for the external temperature, kids of the Tsiri Puma and Tlaoli Puma groups displayed values higher than those of the H-50 group ( $p < 0.05$ ). These results are similar to those observed by Vázquez-García *et al.* (2021), in which the rectal temperature displayed no significant differences between the diets used.



**Figure 6.** Comparison of the external and rectal temperatures (T) (means  $\pm$  standard error) of kids born from goats (*Capra aegagrus hircus* L.) fed with silage made with three maize (*Zea mays* L.) hybrids. Different letters indicate differences between groups for external temperature ( $p < 0.05$ ).

## CONCLUSIONS

The evaluated maize hybrids adapted to the particular production conditions of the High Valleys of Mexico provide a better plant yield and an optimum nutritional balance for the feeding of gestating goats, in comparison with the commercial hybrid. The Tlaoli Puma and Tsiri Puma hybrids had better forage yields in green matter, dry matter, and percentage of dry matter that favors their use as silages for gestating goat fodder. Feeding these diets during gestation and postpartum allowed goats to consume an adequate amount of feed, which resulted in an increase in weight during gestation, a body condition of more than 2.5, and the maintenance of adequate glucose levels. Likewise, the fodder provided helped the kids maintain an adequate homeothermy and weight increase in their first 15 days of life.

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