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Oat Pellets and Hay in Alpacas of Pastures of the Andean Zone, Perú

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Abstract: The research was carried out at the INIA's Quimsachata experimental center in Puno, Peru; with the purpose of evaluating oat pellets and hay in Alpaca pastures in the Andean Zone. A total of Sixty-three 15-month-old female alpacas were used to evaluate their weight gain and feed consumption. The experiment was conducted with three treatments and 21 replicates under a completely randomized design where three sub-samples were included for weight gain. The results showed that weight gain varied significantly ($p<0.05$) among treatments. Alpacas supplemented with oat-vicia pellets showed an average weight gain of 3.10±0.27 kg, while those fed oat hay showed 0.98±0.33 kg. In contrast, Un-supplemented alpacas experienced an average weight loss of -0.64±0.22 kg. In addition, differences in feed intake were observed, being 575.60, 579.50, and 502.00 g/alpaca/day for alpacas supplemented with oat-vicia pellets, oat hay, and no supplement, respectively. Supplementation with oat-vegetable pellets proved to be significantly ($p<0.05$) superior in terms of weight gain, attributed to their nutrient supply, digestibility, and palatability. This practice can be crucial to prevent metabolic disorders in animals, especially in critical periods. In the high Andean zone, several nutritional supplements are used, such as oat hay, multi-nutritional blocks, urea-treated straw, and cultivated pasture silage. Pellets offer advantages, such as reduced transportation costs, ease of handling, and extended storage time, thanks to their compact format. During production, binders such as cane molasses or cassava starch are used to ensure proper consistency. Haymaking preserves the cut fodder but can lose nutrients through chemical changes during drying.

Keywords: Alpaca, Hay, Pellets, Oat-Vice, Oat Hay

Introduction

The alpaca (*Vicugna pacos*) is the most important fiber-producing species of South American camelids, domesticated more than 6,000 years ago and adapted to high Andean environments with a high capacity to efficiently use dietary energy (Wheler, 1995).

It is estimated that 99% of alpacas are in the hands of individuals, known as small breeders, while the remaining 1% are under different organizational structures, such as medium and large companies, cooperatives, associations, and peasant communities.

Likewise, alpaca breeding involves approximately 82,459 agricultural producers (Rios, 2023). Alpaca breeding is considered of great importance in the high Andean zone, as it contributes greatly to the family economy contribute to a great extent to the family economy, it also works a contribution to food and nutritional food and nutritional security for the people, these aspects are sustained thanks to the fiber and the meat that the alpacas. These aspects are sustained thanks to the fiber and meat that alpacas provide to the producers (Carhuallanqui, 2018). The pastures where alpacas graze are generally dominated by: Eleócharis albibractiata (Quemillo), Poa spp (K'acho), Calamagrostis vicunarum (Crespillo), Achemilla pinnata (Silu sillu), Mulhembergia fastigiata (Grama dulce); species of lower abundance but high preference are Hypochoeris taraxacoides (Pilli) Poa pymnantha (Q'acho), Mulhembergia peruviana (Ñapha pasto), Trifolium amabile (Layo), Festuca dolichophylla (chiligua), Bromus catharticus (Cebadilla); in

addition, they consume considerable quantities of grass seeds (Tapia and Flores, 1984).

Digestibility efficiency in South American camelids is related to greater feed retention time in the digestive tract, ample salivary flow ratio, the presence of glands in the stomach, higher ammonia (NH_3) concentration, and the presence of urease in the C1 and C2 compartments versus other ruminants (San Martin and Bryant, 1989), being more selective to tall grasses in the rainy season due to the greater availability of forage in terms of quantity and variety, with values ranging between 34 and 25% respectively (Vivar, 2018).

Alpacas are adapted to high Andean climatic conditions, where food is of low quality during the dry season (Silvestre *et al*., 2019). Nutritional requirements vary according to age, sex, physiological state, production, growth, and management (NRC, 2007). Due to their peculiar digestive characteristics, they take advantage of true ruminants (sheep and cattle) with the consumption of low-quality pastures containing less than 7% protein and metabolizable energy and 2.8 Mcal/kg DM, respectively (San Martin and Bryant, 1989).

Supplementation is the supply of complementary nutrients to the diet, to prevent some metabolic disorders in the animal (Universidad Nacional del Altiplano, 2015). The use of nutritional supplements during critical periods may be an appropriate strategy to alleviate some nutritional deficiencies (Van Saun, 2006). Therefore, nutritional supplements commonly used in high Andean conditions include oat hay, multi-nutritional blocks, urea-treated straw, and cultivated pasture silage (Organización de las Naciones Unidas para la Agricultura y la Alimentación, 1996). The pellet is a conglomerated and compressed feed that is used in cattle feeding (De los Santos, 2012); the use of pellets has many advantages such as reduced transportation costs, ease of handling, avoided feed losses, and prolonged storage time (Carril, 2018). During the pelleting process it is necessary to have some type of binder, commonly used binders are cane molasses, 12% cassava starch, synthetic binder, and even the use of water spray to achieve a good pellet consistency (Kaliyan and Morey, 2009). Haymaking is the process that consists of subjecting the cut forage to desiccation until the humidity (below 20%) prevents the activity of microorganisms during its conservation (Cortez, 2010).

During the drying process, chemical changes are made generating nutrient losses, which are dependent on the speed of drying, to achieve a good quality hay, it is necessary to know the haymaking processes that determine the quality of the product (INTA, 2015). Consequently, the present study aims to evaluate the effect of supplementation with oat-vetch pellets and oat hay on weight gain and consumption of alpacas during the dry season on natural pastures.

Materials and Methods

The experiment was carried out at the INIA Quimsachata experimental unit, located in the District of Santa Lucía, Province of Juliaca, Puno Region, at an altitude of 4200 meters above sea level. This area is characterized by an average annual temperature of 7°C, with maximums of 15°C and minimums of 3°C, and belongs to the dry Puna life zone.

The experimental unit covers an area of 63 hectares and continuous grazing was carried out without grazing, with an animal load of 1 alpaca per hectare. Evaluations were carried out every 28 days during the dry season (July to October) of 2017.

Animals

Sixty-three female Huacaya alpacas, all 15 months old, were used. Grazing began at 8:00 a.m. and lasted 8 h per day. After returning to the confinement pens, feed in the form of oat-vetch pellets and oat hay was provided at 16:00 h.

Vegetation

The physiography of the grasslands was characterized by intermediate slopes and hills. To evaluate the floristic composition of the site, the method of "Transaction at the passage" was applied. The predominant flora includes tall grasses such as Festuca michelada, Stipa ichu, Stipa obtusa, and Calamagrostis macrophylla, along with Muhlenbergia peruviana, Alchemilla pinnata, Carex spp., Luzula peruviana, Diplostephium tovarii and Baccharis tricuneata (Ministerio de Desarrollo Agrario y Riego, 2022). These plant species grow on soils unsuitable for cultivation.

Supplement

Pellets were produced at the INIA Illpa Puno experimental station using a piston press briquette pelletizer with the following specifications: Pellet size of 12 mm, diameter of 8 mm, humidity of less than 12%, and durability of 94%. The alpacas were supplemented with 400 g of oat-vetch pellets and alpaca oat hay per day at 16 h. The oat hay was purchased from the experimental agricultural station (INIA) Illpa Puno and is offered to local farmers to feed their cattle during the dry season.

In both cases, a digital scale (OHAUS®, Ranger 500) with a capacity of 500 g and an accuracy of 0.1 g was used. The Experimental Station follows the following protocol for the production of oat hay bales: The forage is cut using agricultural machinery, which is dried in the environment until it has an approximate humidity of <18%, then with the use of a semi-industrial baler, the 15 kg oat bales are made.

Variables Studied

Dry matter intake of pasture was calculated with 0.9% NDF of live weight of alpacas, supplementation was

measured daily based on residual feed (g/animal/day) by simple difference. Weight gain (g/day) was evaluated using a digital scale (Quantum) considering that the three groups were as homogeneous as possible in weight and color. The animals started at 34.2 kg live weight; weight was recorded every 28 days during 84 days of the experiment in the mornings before razing.

Experimental Design

From a population of 250 alpacas, 63 female animals were randomly selected, whose weight range was (26-40kg BW). The animals were grouped into 3 groups of 21 alpacas, to which the following treatments were applied: (T1) natural pasture, (T2) supplementation with oat-vice pellet + natural pasture, and (T3) supplementation with oat hay + natural pasture. Each treatment had 21 replicates. The three groups of animals grazed the same pasture together.

Statistical Analysis

Variables were evaluated by analysis of variance using a completely randomized design with 3 treatments and 21 replicates with 3 subsamples of 7 animals per pen. A Comparison of means was performed by Tukey with a significance level of ($p<0.01$). The statistical software used was R® study.

Results and Discussion

The highest feed intake in dry matter was 579.5, 575, and 502 g/d for oat hay supplementation, oat-vice pellet supplementation, and natural pasture, respectively; being in natural pasture and oat hay supplementation with the highest intake at 56 days of evaluation with 509 and 585.9 g, respectively, while in oat-vice pellet supplementation at 84 days with 585.6 g (Table 1). Feed consumption is influenced by the type of pasture and season of the year, with more feed consumed in the dry season (Gómez *et al*., 2024). The higher consumption of oat-vice pellets (227.4 g) is seen from the beginning of the experiment compared to oat hay (280.5 g), it is worth mentioning that the supplementation of oat-vice pellets and oat hay was 400 g/bale/day. Oat-vetch pellet consumption increased over time, which is consistent with Meier *et al*. (2012), reaching the highest consumption at 56 days and then maintained until the end of the experiment. The higher consumption of oat-vetch pellets is due to higher palatability and digestibility due to and nutrient supply by vetch.

The nutritional requirements for alpacas with an average live weight of 40 kg recommended by the NRC (2007) are: "For" dry matter intake (1.59% of live weight), total digestible nutrients (0.42 kg/d), metabolizable energy (152 Mcal/d), crude protein (70g/d), calcium (2.6g) and phosphorus (1.4g/d). The protein intake of the alpacas was 30.6, 44.3, and 37.0 g/d when they consumed natural pasture, oat-vicia pellet supplementation, and oat hay supplementation, respectively (Table 1). However, the amount of protein recommended by the NRC is (70g/d), consequently, alpacas were protein deficient in all groups evaluated. The dry matter feed intake of 15-month-old female alpacas with an average live weight of 34.2 kg was calculated taking into account the limiting intake of 0.8-0.9 percent NDF of live weight (Van Saun, 2006).

The average supplement intake of oat-vetch pellets and oat hay in dry matter was 327.4 and 280.5 g/bale/day, covering 57 and 48% of the ration, respectively (Table 1).

Natural pasture had low crude protein and Ca content compared to oat-vetch pellets and oat hay; also, in vitro organic matter digestibility was low (44.40), coinciding with the report of

Sumar (2010) who points out that the maturity and lignification of pasture decreases the nutrient content in dry season. Metabolizable energy (Mcal/kg) was lower in the natural pasture, being similar in oat-vetch pellet and oat hay (Table 2).

The average live weight of alpacas used in this experiment was 34.2 at 15 months of age. The average live weight (Kg) of female alpacas of the Huacaya breed at one year of age as mentioned by Espinoza (2018) were 30 and 31 Kg respectively and for 14-month-old alpacas was 38.5 Kg ; the group of alpacas in the experiment had average weight lower than 38.5 Kg probably because the weights were recorded in two different zones.

Table 1: Dry matter intake (g) and nutrient supply of natural grass, at-vetch pellets, and oat hay

	Natural	Supplement					Supplement					
	grass	Pellets AV		PN		Total	Hay Oats		PN		Total	p-value
	g	g	%	g	%	g	g	%	G	%	g	
1-28 days	507[b]	269.1	48.1	289.9	51.9	559.0[a]	256.8	45.1	312.1	54.9	568.9[a]	<0.05
29-56 days	509[b]	356.1	61.2	226.2	38.8	582.3[a]	293.6	50.1	292.3	49.9	585.9[a]	<0.05
57-84 days	489[b]	357	61	228.6	39	585.6[a]	291	49.9	292.7	50.1	583.7[a]	<0.01
Average	502	327.4	57	248	43	575.6	280.5	48	299	52	579.5	
Protein (g)	30.6	29.1	65.8	15.1	34.2	44.3	18.8	50.7	18.2	49.3	37	
Ca (g)	1.5	1.6	68.7	0.7	31.3	2.4	0.8	48.4	0.9	51.6	1.7	
P (g)	1	0.7	56.9	0.5	43.1	1.2	0.3	31.9	0.6	68.1	0.9	
EM (Mcal)	0.85	0.76	64.2	0.42	35.8	1.2	0.65	56.1	0.51	43.9	1.2	

Table 2: Chemical composition of natural grass, oat-vetch pellets, and oat hay

Variables	Natural grass	Oat-vicia pellets	Oat hay
Dry matter, %	91.7	89.7	89.8
Crude protein, %	6.1	8.9	6.7
FDN, %	61.3	55.7	46.6
Ca, %	0.3	0.5	0.3
P, %	0.2	0.2	0.1
DIVMO, %	44.4	60.1	60.4
EM Mcal	1.70	2.31	2.32

The live weight of alpacas (1-28 days) supplemented with oat-vicia pellets was higher than alpacas supplemented with oat hay and alpacas without supplementation. The alpacas supplemented with oat hay and Un-supplemented alpacas were similar, this similarity is probably due to the consumption of reserved pastures, supplementation habituation, and "the fact that the dry season was just beginning (Argote, 2013). In the second phase of evaluation (28-56 days), the values obtained from the treatments were similar to those described in the first phase of evaluation of alpaca weight. At this stage, the effects of supplementation with oat pellets and oat hay were noticed due to the maximum consumption of the supplement (0.356 and 0.294 kg/alpaca/day, respectively) as a consequence of the dry season and scarcity of pasture.

In the third evaluation phase (56-84 days), the responses were different, being superior the treatment supplemented with oat-vetch pellets, followed by oat hay supplementation, and finally the treatment without supplementation (Table 3), this may be due to the shortage of pasture as a result of the dry season and the adverse effects of climate (Flores, 2012). The site where the experiment was conducted has a physiography characterized by medium slopes and hills, with a dominance of natural grass species of grassland type and a part of wetlands on the shore of the Sara chocha lagoon (Argote *et al*., 2013); which were affected by the dry season and the presence of frosts.

Concerning weight gain in alpacas at 28 days, the treatment supplemented with oat-vicia pellets was superior to the other treatments. In addition, the values obtained for the treatment supplemented with oat hay and the treatment without supplementation were similar. The evaluation at 56 days, was similar among treatments, in this evaluation period the effects of climate (heat and frost) were evident affecting all the Alpacas in the study. In the last evaluation phase (84 days), the treatment supplemented with oat-vicia pellets was superior ($p<0.01$) compared to the other treatments, this is probably due to the higher consumption and higher nutrient intake.

Total weight gain (Kg) was different among treatments, being superior the treatment supplemented with oat-vicia pellets ($p<0.01$), this superiority is probably because pellets improve palatability and digestibility (Cáceres, 2023); in addition, they are influenced by their higher consumption of the supplement and acceptability of oat-vicia pellets as determined in the present research work, these results agree with the supplementation works of Mamani-Linares and Gallo (2013) using concentrated feed in llamas. The gain in g/day was higher for the treatment supplemented with oat-vicia pellets (36.9 g), followed by the treatment supplemented with oat hay (17.9 g), and the treatment without supplementation lost weight (-0.01 g), this weight loss was due to the low nutrient supply of the natural pasture. According to Van Saun (2006), weight loss occurs when the animal does not meet its net maintenance energy requirements, coinciding with the results obtained in alpacas without supplementation that lost weight during the experiment (Table 4).

The weight gain obtained in the present experiment was lower than that reported by Turin Canchaya (1999) in male alpacas from 18-21 months of age fed on natural pastures of 55 g/day, this low weight gain is because the alpacas were grazed in the dry season with low- quality pastures. The higher weight gain in alpacas supplemented with oat-vicia pellets was due to the fact that pellets, as mentioned by Universidad de Investigación y Desarrollo (2019), have many advantages compared to other feeds, this feed improves palatability, digestibility, consumption, and lower feed loss.

Table 3: Live weight variation (Kg) every 28 days

	Treatments			p-value
	Witness	S-pellets	S-heno	
Initial weight	33.9±0.94	34.5±1.22	34.0±1.00	
01-28 days	34.5^{b}±0.94	36.4^{a}±1.31	34.6^{b}±1.09	>0.05
28-56 days	34.7^{b}±0.90	37.4^{a}±1.31	35.3^{b}±1.04	<0.05
56-84 days	33.3^{c}±0.94	37.7^{a}±1.31	35.0^{b}±1.09	<0.05

S-pellets = Supplementation with oat-vice pellets
S-hay = Oat hay Supplementation
a,b,c Superscripts with different letters within the same row indicate significant differences (p>0,05)

Table 4: Weight gain (Kg) every 28 days

	Treatments		
Weight gain	Witness	S-pellets	S-heno
01-28 days	0.57^{b}±0.24	1.81^{a}±0.33	0.57^{b}±0.25
28-56 days	0.19^{a}±0.24	1.05^{a}±0.31	0.67^{a}±0.20
56-84 days	1.14^{b}±0.19	0.24^{a}±0.18	0.24^{a}±0.05
Gain total	0.64^{c}±0.22	3.10^{a}±0.27	0.98^{b}±0.33
Gain (g/alpaca/day)	0.01	36.9	17.9

S-pellets = Supplementation with oat-vice pellets
S-heno = Supplementation with oat-vice pellets
a,b,c Superscripts with different letters within the same row indicate significant differences

Conclusion

The alpacas supplemented with oat-vice pellets were superior in weight gain in relation to animals supplemented with oat hay and alpacas without supplementation. In addition, oat hay supplementation was superior in weight gain to Follow the previous comment alpacas. The alpacas supplemented with oat-vice pellets were superior in supplement consumption about animals supplemented with oat hay.

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Author's Contributions

Marcial Enciso Altamirano, Jimny Núñez Delgado and Alejandrina Sotelo Méndez: Designed the research plan and organized the study, participated in all experiments, coordinated data analysis, and contributed to the writing of the manuscript.

Wilfredo Ruiz Camacho: Coordinated the research work, participated in all experiments, and contributed significantly to the writing of the manuscript.

Ítalo Maldonado Ramirez: Coordinated the research work and data analysis, participated in all experiments, and contributed to the writing of the manuscript.

Juan Eduardo Suarez Rivadeneira: Coordinated the research work, participated in all experiments, and contributed to the writing of the manuscript.

Ethics

All references related to the enrichment of this scientific knowledge have been included in the bibliography of the journal.

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