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Intake and Digestibility of Four Rations With Different Fiber Levels in Alpacas (Vicugna Pacos)

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Research Article

Keywords: digestibility, faecal nitrogen, nutrient intake, South American camelids

Posted Date: January 16th, 2024

DOI: https://doi.org/10.21203/rs.3.rs-3830989/v1

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Abstract

The aim of this study was to evaluated the effect of different dietary fiber levels on intake and apparent nutrient digestibility of nutrients in alpacas, and to estimate the digestibility of organic matter (OMD) from the content of crude protein (CP) in feces. The study was carried out with twelve alpacas (36.7 ± 6.4 kg BW), which were offered 4 treatments with different neutral detergent fiber content (NDF. T1: 40.3%; T2: 62.1%; T3: 67.8%; T4: 71.6%) under a switch back design. Dry matter intake (DMI) was higher for T1 (612 g/d) while T4 consumed less (470 g/d. $p \leq 0.05$), when correcting DMI for body weight (BW) and metabolic weight (MW) was equal between treatments ($p \geq 005$). NDF intake was similar between treatments when related to BW or MW (on average 1%BW and 23.2 g/kg BW0.75. $p \geq 0.05$). Water intake (L/day) was higher in T1 compared to the other treatments, with values ranging from 1.8 L/day (T1) to 1.4 L/day (T4), respectively ($p \leq 0.05$). Digestibility of dry matter, organic matter and crude protein was higher in T1 than in the other treatments, with average values ranging from 65% for T1 to 48% for T4 ($p \leq 0.05$). NDF digestibility was similar among treatments ($p \geq 0.05$). The regression equation generated to predict OM digestibility (y) was as follows: y = 0.07635-(-0.33866*exp (-(-0.51457)*Fecal CP(g/kg OM)/100)). Further studies will indicate whether faecal nitrogen can be used to estimate digestibility and hence diet quality in South American camelids.

INTRODUCTION

Peru has approximately 56% of the global population of South American Camelids (SAC) with an estimated 4,500,000 animals (INEI, 2012). Animals are raised in an extensive system, where feeding is based on grazing of natural pastures (Chino *et al.*, 2022). The extreme Andes conditions make grasslands scarce and highly fibrous, which affects the productive system of traditional ruminants, such as cattle and sheep (Cordero et al., 2018:). However, SAC exhibit digestive characteristics that make a difference since they are more efficient at using high fiber feed in comparison to traditional ruminants (Allen, 1996). The SAC feed consists mostly of a low-quality forage, which means neutral detergent fiber (NDF) concentration is the factor that predominantly regulates intake and hence passage time, because it affects stomach filling and dry matter (DM) digestibility (Arelovich et al., 2008). Across domestic and nondomestic mammalian herbivores, voluntary forage intake typically decreases with increasing fibre level (Meyer et al., 2010). In contrast, the relationship between a wider range of feed fiber levels and feed intake has not been well studied in alpacas.

According to Van Saun (2006), dry matter intake (DMI) varies between 1.25 and 1.5% of body weight (BW) for alpacas on maintenance diet and pregnant females, while another study has reported a range of 1.08 to 2.3% with an average of 1.8% of the BW for maintenance (San Martin and Bryant, 1989). When directly compared to domestic sheep or goats, food intake of SAC is typically lower, which has been linked to a lower metabolic rate (Dittmann et al., 2014). The available information about feed digestibility for SAC is relatively scarce. However, there is a concordance among authors which suggests these animals are more efficient than other species, in terms of the use of high fibre rations, characterized by their low protein content and/or high cell wall content (López et al., 2000).

Several methods to estimate digestibility have been developed. One of them is the fecal crude protein (CP) method, which allows to estimate organic matter (OM) digestibility from diets selected by animals during grazing without the need of collecting representative ingested forage samples in cattle (Lukas et al., 2005) as well as in sheep (Wang et al., 2009). Considering the digestive capacity of different animal species, regression equations have been proposed for the prediction of OM digestibility from forage-based diets (Leite and Stuth, 1990; Schmidt, 1993; Boval et al., 2003; Lukas et al., 2005; Wang et al., 2009). However, until now, there is no equation that allows the estimation of OM digestibility in alpacas.

The aim of this study was to evaluate the impact of different feed fibrosity levels on alpaca intake and apparent digestibility. In addition, a regression equation was generated to estimate the organic matter digestibility (OMD) from the crude protein (CP) content in faeces.

MATERIAL AND METHODS

Location and time of the study

The experiment was performed at the Center of Investigation and Production (CIP) “Quimsachata” of the National Institute of Agrarian Innovation (INIA), located on the district of Santa Lucía, in the department of Puno, at 4 200 m.a.s.l. It took place during January and February 2019, and was approved by an animal use committee.

Experimental animals

Twelve 2-year-old male “Huacaya” alpacas were used for the experiment, with an average weight of 36.7 ± 6.4 kg, clinically healthy and well adapted to the region. These animals were kept on 6 m^2 individual boxes, designed to protect the alpacas from rain, and equipped with plastic drinkers and feeders that allowed for control of water and feed intake. Each animal had a harness attached to a collecting bag for daily total feces collection.

Experimental rations

Four experimental rations were formulated at the Agrarian Experimental Station “Illpa” of the National Institute of Agrarian Innovation (INIA), located in the district of Paucarcolla, province and department of Puno, at 3 822 m.a.s.l. The raw materials used in different proportions were: oat hay (*Avena sativa*) variety INIA 902, oat hay variety INIA 904, common vetch (*Vicia sativa*) and *Stipa ichu (Ruiz & Pav.) Kunth.* These forages from the rations were cut using a mincer, obtaining cut sizes of 2 cm, and only the content that passed through a calibrated sieve 5 mm was considered to be offered to the animals. Each ration had a different fiber level (Table 1). The animals did not receive any other type of supplementation

Table 1. Chemical composition of diets offered to alpacas (% of dry matter)

Treatment	Composition	DM (%)	OM (%)	CP (%)	NDF (%)
T1	100% INIA 902-African Oat + common vetch	92.3	92.4	7.3	40.3
T2	100% INIA 904-Vilcanota Oat + common vetch	93.7	92.7	9.2	62.1
T3	50% *Stipa ichu* + 50% INIA 904-Vilcanota Oat + common vetch	94.1	93.6	6.1	67.7
T4	80% *Stipa ichu* + 20% INIA 904-Vilcanota Oat + common vetch	94.7	94.3	5.4	71.5

Abbreviations: DM = dry matter; OM = organic matter; CP = crude protein; NDF = neutral detergent fiber.

Experimental design

The study was conducted with a Switch Back design for 4 treatments, which uses the same animals in 3 different experimental periods and where a treatment is tested on the animal in both the initial and final periods, and then compared with the second (Jones and Kenward, 2003. Annex 1). In each period, the animals were distributed in 3 blocks and in turn, in each block the 4 treatments were tested, that is, one animal per treatment was distributed in each block).Each of the periods had a total duration of 18 days where the first 8 days was a phase of adaptation of the animals to the diets, the following 10 days was an experimental phase for the evaluation of voluntary feed and water intake (from days 8 to 13) and the evaluation of apparent digestibility (from days 13 to 18).

During the first 5 days of the experimental phase, the evaluation of voluntary feed and water intake was carried out. For this purpose, alpacas were fed *ad libitum* with each of the corresponding experimental rations. The amount of feed supplied at 07:00 h was calculated to obtain a 10% of refused feed at 06:00h the following day. Both supply and refusal were weighed to obtain by difference the voluntary intake.. The feed was weighed on a digital scale with a precision of ± 10 g. Simultaneously, the same methodology was used for the evaluation of water intake, during the experiment was offered in an amount of 5 L/day at 08:00 h. During the last 5 days, an apparent digestibility test was performed, using the controlled feed supply and total fecal collection methodology (Tapia, 1993). For this purpose, alpacas were fed daily at 07:00 h with 90% of the registered voluntary intake, while the feces were collected and weighed daily at 05:00 h on the next day. Finally, 20% of the feces were stored at -20 °C for further analysis.

Sample management and Laboratory analysis of samples

At the beginning of each experimental period, a sample of each ration was collected, which totaled 12 samples (3 per ration) at the end of the experiment. Likewise, at the end of each period, 5 daily fecal samples obtained from each animal were unfrozen and mixed, which resulted in a total amount of 36 fecal samples at the end of the experiment (Tapia, 1993).

The conditioning and analysis of samples were performed at the Laboratory of Feed Nutritional Evaluation (LENA) of the Faculty of Zootecnics, at the Universidad Nacional Agraria La Molina, during

March and April 2019. Furthermore, experimental rations and collected feces were tested for DM (AOAC, 2005; 950.46), OM (AOAC, 2005; 950.05), CP (AOAC, 2005; 920.115) and NDF (Van Soest et al.,1991 in the Ankom Fiber Analyzer AN 200 (Ankom® Technology Corp. USA)).

Statistical analysis

The evaluation of the effects of each ration on the intake and apparent digestibility coefficients was estimated by the analysis of variance (ANOVA) for a Switch Back design for 4 treatments. The comparison between means was performed with the Tukey Test ($p < 0.05$). The model is as follows:

$$Y_{ijk} = \mu + \pi_i + \tau_j + \varsigma_k + (i - 2)s_k + \delta_{ijk}$$

Where:

Y_{ijk} = Response variable

μ = Effect of the general mean

π_i = Effect of the *i*-nth period

τ_j = Effect of the *j*-nth treatment

ς_k = Effect of the *k*-nth block

s_k = Effect of the variation between periods

δ_{ijk} = Random effect of the experimental error

To describe the relationship between the ration OM digestibility and the fecal OM nitrogen or CP concentration, the equation generated by Wang et al. (2009) was adjusted. The statistical analysis was performed manually using Microsoft Excel®.For this, the non-linear mixed regression model of the statistical software NCSS 2012 was used. The model is as follows:

$$Y_{ij} = a - b * \exp((-c * X_{ij})/100) + e_{ij}$$

Where:

Y_{ij} = OM digestibility on the *i*th ration (%)

a, *b* and *c* = Fixed effect parameters

X_{ij} = Concentration of CP in fecal OM (g/kg OM)

eij = Residual error

In nonlinear regressions, RMSE and MPE are indicators of precision and fit. RMSE is a measure of how accurately the model predicts the response, and it is the most important fit criterion when the main purpose of the model is prediction. Lower values of RMSE indicate a better fit.

RESULTS

Assessment of voluntary intake

A comparison of dry matter intake (DMI) relative to BW (%) and MW (g/kg $BW^{0.75}$) was made. Table 2 shows means of the recorded values. When analyzing the obtained DMI values in terms of BW and MW, ranges of 1.3 to 2.0% BW, and 31.9 to 48.3 g/kg $BW^{0.75}$ were found. Statistical analysis showed significant differences (*p<0.05*) between the values obtained for the experimental rations T1 and T4. A comparison of the neutral detergent fiber intake (NDFI) expressed on the basis of BW (%) and MW (g/kg $BW^{0.75}$) was made. Table 3 shows the means of the recorded values.

When analyzing the values obtained for NDFI expressed in terms of BW and MW, ranges of 0.8 to 1.0% of the BW, and 20.4 to 24.8 g/kg $BW^{0.75}$ were observed, with an average value of 0.95 ± 0.07 % of BW and 23.2 ± 1.6 g/kg $BW^{0.75}$. According to the statistical analysis, no significant differences were observed (*p>0.05*).

Table 2. Dry mater intake (DMI), Neutral detergent fiber intake and water intake in alpacas

Treatment	DMI			NDFI		WI[1]
	g/day	BW[1] (%)	MW[2] (g/kg $BW^{0.75}$)	BW[1] (%)	MW[2] (g/kg $BW^{0.75}$)	(L/day)
T 1	612.7 ± 100[a]	1.0 ± 0.4	1.0 ± 0.4	1.0 ± 0.4	24.8 ± 8.2	1.8 ± 0.4[a]
T 2	553.7 ± 134[a,b]	1.0 ± 0.2	1.0 ± 0.2	1.0 ± 0.2	23.9 ± 6.2	1.6 ± 0.3[b]
T 3	549.8 ± 86[a,b]	1.0 ± 0.2	1.0 ± 0.2	1.0 ± 0.2	23.8 ± 5.4	1.6 ± 0.2[b]
T 4	470.2 ± 195[b]	0.8 ± 0.3	0.8 ± 0.3	0.8 ± 0.3	20.4 ± 7.4	1.4 ± 0.3[c]

[a, b] Superscripts with different letters within columns are statistically different from each other (*p < 0.05*). [1] Intake based on body weight (expressed as percentage). [2] Intake based on metabolic weight (g/kg $BW^{0.75}$). ***Abbreviations***: DMI: dry matter intake: NDFI: neutral detergent fiber intake; WI: Water intake; T1: 100% INIA 902-African Oat + common vetch; T2: 100% INIA 904-Vilcanota Oat + common vetch; 50% *Stipa ichu* + T3: 50% INIA 904-Vilcanota Oat + common vetch; T4: 80% *Stipa ichu* + 20% INIA 904-Vilcanota Oat + common vetch.

Additionally, a comparison of the water intake (WI) expressed in L/day was made. Table 2 shows the means of the recorded values. When analyzing the obtained WI values, ranges of 1.4 to 1.8 L/day were

found. Statistical analysis showed significant differences (*p<0.05*) among the experimental rations T1, T2 and T4, and the experimental rations T1, T3 and T4.

Assessment of apparent digestibility

Comparison of the apparent digestibility coefficients obtained for DM, OM, CP and NDF of the experimental rations was performed and Table 3 shows the means of the registered values. Regarding the apparent digestibility coefficients, ranges of 50.3 to 66.4% were found for the DM, 53.4 to 68.5% for the OM, 41.5 to 61.1% for the CP, and 50.4 to 60.7% for the NDF. Statistical analysis showed significant differences between the coefficients obtained for DM, OM, and CP. Furthermore, our results show that digestibility coefficients of these parameters were significantly higher as levels of NDF decrease. However, no significant differences (*p>0.05*) were observed between the coefficients obtained for NDF.

Table 3. Apparent digestibility coefficients for the parameters of DM, OM, CP and NDF in alpacas

Treatment	FCP (%)	DMD (%)	OMD (%)	CPD (%)	NDFD (%)
T 1	5.78	66.4 ± 13.5^{a}	68.5 ± 12.9^{a}	61.1 ± 13.1^{a}	60.7 ± 11.0
T 2	6.29	56.1 ± 8.3^{a,b}	58.2 ± 7.9^{b}	52.0 ± 15.3^{a,b}	54.6 ± 7.9
T 3	8.94	56.0 ± 12.1^{b}	58.2 ± 11.6^{b}	51.3 ± 16.9^{a,b}	54.1 ± 11.9
T 4	10.37	50.3 ± 14.2^{b}	53.4 ± 13.0^{c}	41.5 ± 33.2^{b}	50.4 ± 10.7
p-value	nd	0.023	0.003	0.042	0.265
SEM	nd	4.12	3.86	4.87	2.83

$^{a, b}$ Superscripts with different letters within columns are statistically different from each other (*p < 0.05*). ***Abbreviations***: T1: 100% INIA 902-African Oat + common vetch; T2: 100% INIA 904-Vilcanota Oat + common vetch; 50% *Stipa ichu* + T3: 50% INIA 904-Vilcanota Oat + common vetch; T4: 80% *Stipa ichu* + 20% INIA 904-Vilcanota Oat + common vetch. DM = dry matter; OM = organic matter; CP = crude protein; NDF = neutral detergent fiber; FCP = fecal crude protein; SEM: standard error of mean; nd: not determined

Prediction equation

By adjusting the prediction equation of Wang *et al*. (2009), originally for sheep, the following equation was developed to estimate the digestibility of the ration OM based on the content of CP in the fecal OM in alpacas (Figure 1):

y = 0.07635- (-0.33866*exp (-(-0.4484)*fecal CP (g/kg OM)/100))

Where:

y = ration OM digestibility (%)

Statistical analysis determined that probability values of estimated parameters of the equation were higher than 0.05. The RMSE and the mean prediction error MPE as proportion of observed mean were 0.09 and 0.15, respectively. The RMSE and MPE of our prediction equation were relatively low, suggesting that model accuracy and fit of the equation are good.

DISCUSSION

Assessment of voluntary intake

The results of the present study show a progressive decline in DMI as diet NDF content increases. The trend found is similar to that reported in alpacas by Paredes *et al.* (2014), who observed a variation of the DMI from 1.4 to 1.7% of the BW (36.3 to 45.7 g/kg $BW^{0.75}$), working with 4 rations made from leaves, stems and oat hay, with a range of NDF between 70.2 to 58.2%. Likewise, López *et al.* (2001) found a similar trend when comparing 4 rations of hay from red clover and Italian ryegrass, and bean and oat straw, in alpacas where the DMI decreased from 38.8 to 20.9 g/kg g/kg $BW^{0.75}$ as the NDF increased from 53.5 to 78.5%. Similarly, López *et al.* (2000) studied 3 rations of alfalfa hay in combination with wheat straw in alpacas, with an increasing percentage of NDF from 46.3 to 58.4%, finding that the DMI was reduced from 45.8 to 33.2 g/kg $BW^{0.75}$. The current study includes a wider range of NDF values than these previous studies.

San Martín and Bryant (1989), reported two experiments. In the first, llamas were fed with rations containing 7, 11 and 15% of CP, and 69, 55 and 27% of NDF; which resulted in DMIs of 59, 58 and 54 g/kg $BW^{0.75}$, respectively. These values were higher than the ones we obtained in our alpacas using rations of similar levels of CP and NDF. In the second experiment, the authors fed llamas with isonitrogenous rations (11-13% CP) with low, medium and high NDF levels (42, 58 and 68% dry matter basis), obtaining DMIs of 53, 50 and 47 g/kg $BW^{0.75}$, which are also higher than those of our study. For their part, Stölzl *et al.* (2014) fed llamas with hay of different qualities: hay 1 (15.1% CP and 52.6% NDF per kg DM) and hay 2 (6.6% CP and 64.3% NDF per kg DM); which resulted in DMIs of 1.26% and 0.89% of the BW, respectively. These values were lower than the ones we obtained using rations of similar levels of CP and NDF.

The decreasing tendency of the ration DMI while its NDF content increases can be attributed to the presence of high cell wall content in the forage (Mertens, 1994), which provide physical fill and stimulate the mechanoreceptors of the muscular layer (Forbes, 1996), thus limiting feed intake. However, many other factors affect fill, including particle size, chewing frequency and effectiveness, particle fragility, indigestible NDF fraction, rate of fermentation of the potentially digestible NDF, and characteristics of reticular contractions (Allen, 1996).

Regarding the intake of NDF (INDF), our results (Table 3) coincide with those found by Paredes *et al.* (2014), who reported an average INDF of 0.9 ± 0.1% BW (24.2 ± 1.6 g/kg $BW^{0.75}$) for a range of NDF from 58.2 to 70.2%, and pointed out that regardless of the NDF level of the rations, alpacas have a similar intake of this component when it is between 60 to 70% in the ration. Our results coincide with the NDF intake (0.9% ± 0.3% BW) in alpacas and llamas reported by San Martín and Van Saun (2014) from a collection of data in which individual maintenance DMI intake and forage nutrient content were determined. These data suggest dietary NDF content could be used to predict the potential capacity for intake. The expected maintenance DMI would be based on a NDF intake in the range of 0.6% to 1.2% BW, with the lowest and highest values representing low and high fibrous forages, respectively (San Martín and Van Saun, 2014).

The results of the present study show a decrease in WI as DMI decreases and NDF content increases in the experimental rations. This trend is similar to that reported by Llanos *et al.* (2018), who observed a reduction in WI of 4.3 to 0.5 L/day in llamas fed barley hay and straw hay, at the same time that the DMI decreased from 3.3 to 1.3 kg of DM, and the crude fiber (CF) content increased from 1.8 to 28.3% in the experimental rations. Likewise, our results coincide with those reported by San Martin (1996), who mentions the existence of a directly proportional relationship between the DMI and WI. On the other hand, Velez-Contacayo *et al*. (2011) reported a reduction of the WI from 1.9 to 0.2 L/day in llamas fed with oats and Brazilian grass, at the same time that the DMI increased from 2.1 to 2.2 kg of DM, and the CF content decreased from 52.5 to 47.7%, respectively. This could be due to Brazilian grass presenting a higher water content than oat.

Assessment of apparent digestibility

The results of this study show a decrease in the apparent digestibility coefficients obtained for the parameters of DM, OM, CP and NDF as the percentage of NDF of the experimental rations increases with no difference in NDF digestibility. Various studies carried out in llamas and alpacas fed with rations made from alfalfa hay and wheat straw demonstrate a similar trend in which the apparent digestibility for OM and CP decrease as the energy-protein levels decrease, and the percentage of NDF increases (San Martín and Bryant, 1989; López *et al*., 2000). However, these results were obtained with a smaller number of animals and a smaller range of ration NDF.

San Martín (1987), using isonitrogenous rations (average CP of 12%), with low, medium and high NDF levels in llama rations (42 to 68%), obtained digestibility coefficients for OM in a range of 67 to 58% and for CP between 61 to 52% respectively. These results present trends similar to those observed in our study. Likewise, López *et al*. (2001), using llama rations based on red clover and Italian ryegrass, and bean and oat straw, with NDF levels of 53 to 78%, reported digestibility coefficients for DM in a range of 52 to 50.2 %, for OM in a range of 55.5 to 53.4%, and for CP in a range of 55.3 to -1.4%, respectively, lower than those in our study, even when presenting a similar level of NDF. These results suggest that the digestibility coefficients of the DM, OM and CP decrease as the percentage of NDF in rations increases. However, besides the quantity of NDF in the ration, it has been suggested that the quantity of INDF

(indigestible component of NDF) plays a significant role in the regulation of the digestibility and feed intake in ruminants (Harper and McNeil, 2015).

Although the tendency to decrease is evident, no statistically significant differences were found between the digestibility coefficients of the NDF of our 4 experimental rations. This is in agreement with the results reported by Paredes *et al.* (2014), who suggest that the digestibility of the NDF can be maintained as the fibrosity of the ration increases. However, San Martín (1987), using isonitrogenous rations, with low, medium and high levels of NDF (42 to 68%) in llamas, obtained statistically significant differences for digestibility coefficients for NDF in a range of 48 to 53%, respectively, results that present a different trend from ours. Likewise, López *et al.* (2001), using llamas rations based on red clover and Italian ryegrass, and bean and oat straw, with NDF levels of 53 to 78%, reported digestibility coefficients for NDF in a range of 44 to 57 %, respectively, digestibility values that present a different trend from the current study. López *et al.* (2001) suggests increasing digestibility coefficients for NDF as dietary NDF content increases, could be due to the greater capacity of SAC to use structural carbohydrates. Also, Yaranga (2009) suggest increasing digestibility coefficients for NDF as dietary NDF content increases, could be due to the longer retention time in compartment 1 with low quality forages compared to higher quality forages.

Prediction equation

The RMSE and MPE of our prediction equation were higher than that obtained by Wang *et al.* (2009), who obtained an RMSE of 0.05 and an MPE of 0.07, working with 721 observations obtained from sheep subjected to 159 types of rations with ranges of crude fiber between 178 and 373 g/kg DM; or Peripoli et al. (2011 who estimated intake and digestibility in grazing ruminants from fecal nitrogen and obtained R2= 0.36 and MPE = 0.13 or Oliveira in sheep (R=24, MPE= 0.17).

The difference between the RMSE and the MPE value of our equation and that obtained for the equation of Wang *et al.* (2009) could be associated to the number of observations used for the elaboration of the equation. Boval *et al.* (2003) mentions that the reliability of the fecal CP method depends on the range and number of observations of *in vivo* digestibility tests, as well as on the regression model applied.

Under the conditions in which the present study was carried out, it was concluded that dry matter intake (DMI. g/d) in alpacas was lower as the level of fibrosity of the rations increased, while the intake of neutral detergent fiber (NDFI) did not vary according to fibrosity. The digestibility of dry matter (DMD), organic matter (OMD) and crude protein (CPD) in alpacas was significantly lower as the level of fibrousness of the rations increased, while the digestibility of NDF did not vary as the level of fibrousness increased. The regression equation generated to predict OM digestibility (y) was as follows: y = 0.07635-(-0.33866*exp(-(-0.51457)*Fecal CP(g/kg OM)/100)) with relatively low RMSE and MPE values, suggesting that the model accuracy and equation fit are good. Further studies will indicate whether fecal nitrogen can be used to estimate digestibility and hence diet quality in South American camelids.

DECLARATIONS

ACKNOWLEDGEMENTS

The authors would like to acknowledge PhD. Jose Velarde Guillen for reviewing the manuscript, and Dra. Isabel Cristina Molina Botero for her support in the corrections made.

FUNDING

The present study was funded by the Master Nutrition Program conducted by “CIENCIAACTIVA- CONCYTEC- FONDECYT” and UNALM.

AUTHOR CONTRIBUTIONS

The conceptualization was performed by Ana Obregón Cruz, Carlos Alfredo Gómez Bravo and Cesar Mauro Osorio Zavala. The methodology was designed by Ana Obregon and Carlos Gómez. The formal analysis and investigation were performed by Ana Obregon. The writing-original draft preparation was prepared by Ana Obregon. The writing-review and editing was performed by Carlos Gomez and Robert John Van Saun. The funding acquisition was conducted by Carlos Gomez and Cesar Osorio. The general supervision was performed by Carlos Gomez. All authors commented on previous versions of the manuscript, and all authors read and approved the final manuscript.

DATA AVAILABILITY

The datasets generated and analyzed during the current study are available in the UNALM repository on the following link: https://repositorio.lamolina.edu.pe/handle/20.500.12996/5295

STATEMENT OF ANIMAL RIGHTS

The animals were cared in accordance with Peru’s Law on Animal Protection and Welfare, No. 30407

CONFLICT OF INTEREST STATEMENT

This research was financing and supported by “CIENCIAACTIVA- CONCYTEC- FONDECYT”.

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Figures

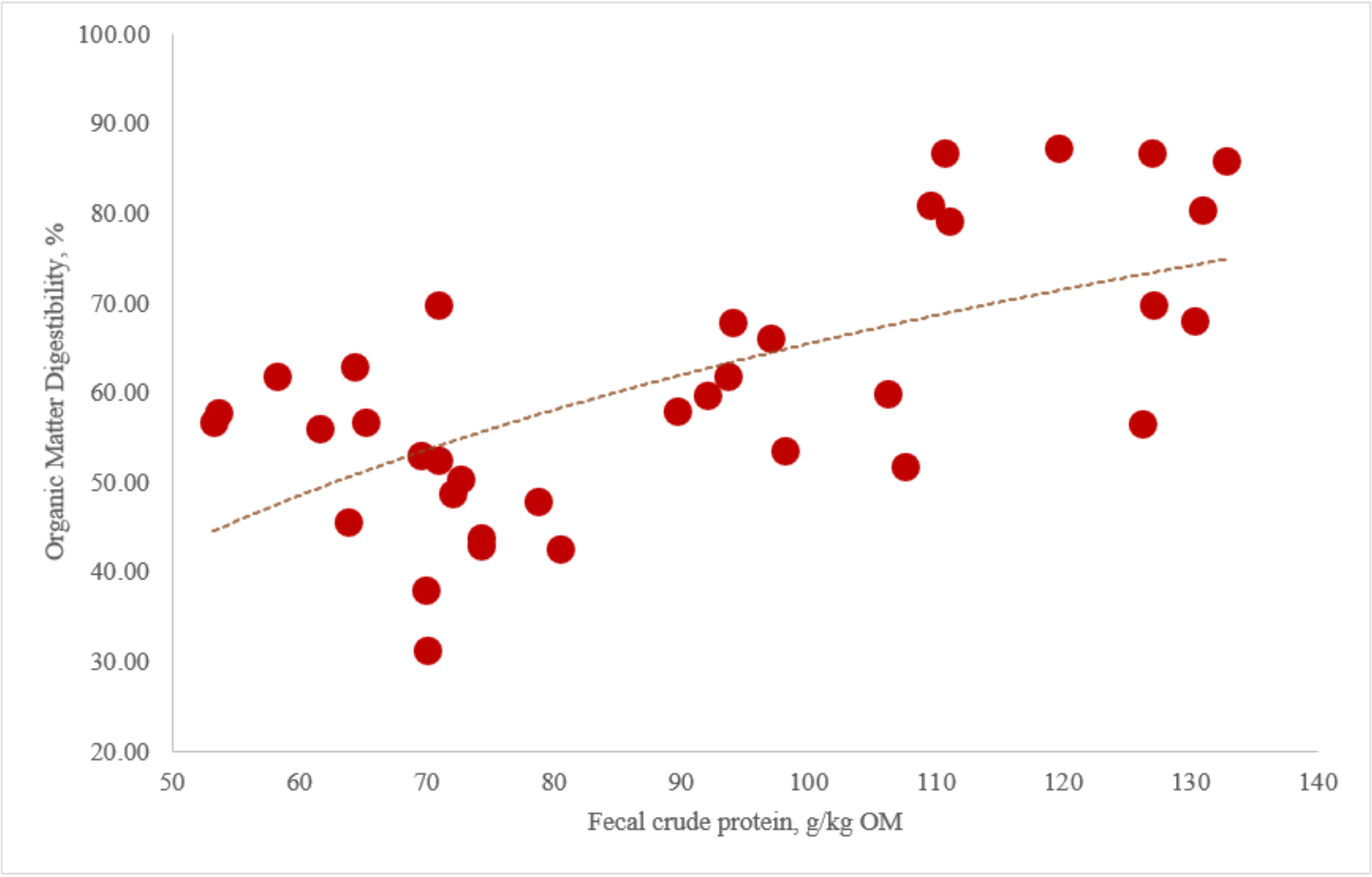

Figure 1

Equation proposal for Organic Matter Digestibility (OMD, %) estimation using the fecal crude protein (g/kg OM) on alpacas

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