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Research Article Volume 6 – February 2017 (02)

Effect of Type of Hay and Concentrate Level in Intake and Digestibility in Diets for Goats

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Summary: The aim of this study was to evaluate the effect of the level of hay and concentrate on total hay intake and supplied already, the additive/substitutive effect and total apparent digestibility of the diet intake in diets for goats. Experiment I: diets: Alfalfa hay (A1), Alfalfa hay + corn (0.5% LW/day) (A2), + 1% LW/day (A3), + 1.5% LW/day (A4). Experiment II: diets: Natural grassland hay (CN) (R1), hay CN + corn (0.5% LW/day) (R2), hay CN + corn (1% of LW/day) (R3), + 1.5% of LW/day) (R4). Intake, ratio forage/concentrate and total apparent digestibility were calculated. Experiment I: There were no effects (p> 0.05) on the CMST for the corn tested levels and recorded a linear decrease (p <0.05) in the CTFDN, CTFDA and CTPB. The CMSF decreased linearly (p <0.05) with increasing amounts of corn by verifying a hay effect on the concentrate. The F/C was different (p <0.05) in all treatments. The DTAIVMS increases linearly (p <0.05) with the content of corn in the diet. Experiment II: a linear increase (p <0.05) on the CMST and CTPB with increasing corn in diet and no differences (p> 0.05) on the CMSF, CTFDN and CTFDA is observed. The F/C and CTPB differ (p <0.05) among all the diets tested. The DTAIVMS increases linearly (p <0.05) with the content of corn in the diet. Therefore, it can be concluded that the increase of maize levels improved the total digestibility of the ration consumed and the substitute or additive effect depended on the quality of the hay used.

Keywords: goats, concentrated, fiber

Introduction

Extensive production of goats is based on the utilization of forage. Alfalfa is considered valuable forage to feed goats for their high protein content and a lower concentration of neutral detergent fiber. The high content of soluble fiber high degradability and low NDF has a positive effect on rumen fill and dry matter intake (Rapetti et al., 2005). However, there is a trend towards intensification and increased use of concentrates to sustain high levels of productivity (Russell & Rychlik 2001; Castel et al., 2003).

Goats change their feeding behavior according to the availability of forage or concentrate, and its ability to select foods high protein content and digestibility, adapting to different conditions, ranging from grassland to the desert (Provence et al., 2003; Rapetti & Bava, 2008).

The change in digestibility, by an effect of increased voluntary consumption, is recognized for the first time in the models of animal nutrition, from publications table requirements for dairy cattle NRC (NRC, 2001). In ruminant feed digestibility plays an important role in regulating consumption when digestibility is less than 68% the filling effect occurs and regulation is of mechanical type and occurs when the animal can't consume more due to a limitation physical gastrointestinal tract. Variations in digestibility caused mainly are the lignin concentration in forage. Lignin has no nutritional value and also blocks access of microorganisms to structural carbohydrates such as cellulose and hemicellulose (Relling & Mattioli, 2013). The digestibility is an intrinsic property of the forage, while the voluntary consumption is a function of the forage, the animal and the environment under which they feed. Combining both, apparent digestibility of dry matter in vivo and intake of dry matter, resulting in the intake of digestible dry matter (Coleman et al.,

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Published at: http://www.ijsciences.com/pub/issue/2017-02/
DOI: 10.18483/ijSci.1191; Online ISSN: 2305-3925; Print ISSN: 2410-4477

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1999). INRA in 1979 and improved in 1987 incorporates the concept of Ballast Unit (UL) food, to represent the ingestibilidad forage. Mertens (1987) postulates a negative effect of NDF pasture intake and maximum intake values FDN should not exceed 1.2% of live animal weight or 35% of that fraction in the diet. Mertens (2010), the equation of Van Soest (Goering and Van Soest, 1970) describes the mathematical relationship of the DM digestibility (DDM), digestibility of neutral detergent fiber (NDFD) and digestibility of its complement, soluble in neutral detergent. The equation mentioned is: DDM = 87.1 – (0.98 – DFDN) x FDN. This equation indicates a negative relation between DM digestibility and NDF. It also suggests that if the NDF concentration and its digestibility are known, it is better described the variation that most affects the DDM, which variable is related to the energy of the feed available to the animal.

Another limiting factor to intake is the proportion protein in the diet, with values less than 8% decrease intake animals (Aello & Di Marco, 2000)

When ruminants consume forage and receive supplements, consumption of dry matter forage generally decreases, which is known as replacement rate (Viglizzo, 1981; Minson, 1982; Kellaway & Porta, 1993; Stock dale, 2000). If pastored quality forage is insufficient, proper supplementation can increase the amounts ingested forage and therefore the total consumption of MS, this phenomenon is known as an addition (NRC, 1987; Minson, 1990; Mayne, 2007).

The incorporation of corn grain in ruminant feed increases the digestibility of dry matter consumed however could reduce forage digestibility (Archimède et al., 1995; Molina & Alcaide et al., 2000; Fimbres et al., 2002; Rapetti et al., 2004). Foods like mature hays and pastures induce pH values of 6.5 to 6.8, optimal for cellulolysis predominance of acetic acid with (Aello & Di Marco, 2000). High starch content reduces the fiber digestion due to microbial fermentation of nonstructural carbohydrates, reduced ruminal pH and cellulolytic lower activity (Mould & Orskov 1984; Kovacik et al., 1986; Grant & Mertens, 1992; Garces-Yepez et al., 1997; Arias et al., 2013; Arias et al., 2015).

The aim of this study was to evaluate the effect of the level of hay and concentrate on total hay intake and supplied already, the additive / substitutive effect and total apparent digestibility of the diet intake in diets for goats.

Materials and methods

This production was regulated and authorized by the Institutional Committee for the Care and Use of Laboratory Animals of the Faculty of Veterinary Sciences of the National University of La Plata. Whose file number is 0600-008961 / 12-000

The study was conducted in goat's experimental unit of the Faculty of Agricultural and Forestry Sciences of the National University of La Plata.

4 goats' crosses (Nubian x Creole) and 5 years old and 39.77 ± 1.07 kg live weight (LW) were used on average. The experimental design was a 4x4 Latin square with a repeat, with 7-day wash-out between periods. During the time in which the determinations were made, the goats were housed in individual compartments (0.80m x 1.50m) with wooden slatted floor (slats), feeders and automatic waters type pacifier with free access to water. The weight of each animal at the beginning of each period is recorded.

Experiments and tested diets.

Experiment I: 4 diets were provided:

- Alfalfa hay (A1)
- Alfalfa hay + ground grain corn (0.5% LW / day) (A2)
- Alfalfa hay + ground grain corn (1% LW / day) (A3)
- Alfalfa hay + ground grain corn (1.5% LW / day) (A4)

Experiment II: 4 diets were provided:

- Natural grassland hay (CN) (R1)
- Hay CN + ground grain corn (0.5% LW / day) (R2)
- Hay CN + ground grain corn (1% of LW / day) (R3)
- Hay CN + ground grain corn (1.5% of LW / day) (R4)

The predominant species were hay CN, *Briza subaristata, Stipa neesiana, Paspalum dilatatum, Bothriochloa legaloides; Lolium multiflorum.*
A period of fifteen days to get used to each diet was implemented prior to sampling. The quantities of corn were delivered increasingly, starting with 70 g per animal per day, reaching the proportions of each treatment at the beginning of the second week adjustment period. Diets were supplied in a single delivery at 9 am each day. Dry material of hay and corn by drying in an oven (SOMCIC) at 90-95 ° C for 24 hours was determined (AOAC, 1995). Alfalfa hay and CN was provided *ad libitum* and the chemical composition of foods used are noted in Table 1.

Determining intake, ratio forage / concentrate and total apparent digestibility

In experiments I and II determining the fodder consumption was performed during the 4 days of feces collection, after the habituation period to the different diets. To ensure ad libitum character of supply feeders they remained consistently provided the recorded amounts of spiked hay, using an electronic scale model Croma brand Systel. Intake of total dry matter (CMST) was calculated by summing the dry matter provided by the hay (CMSF) and corn (CMSMz) expressed in Kg / day. The concentrated feed ratio (F / C) was rated as the proportion of hay and concentrate consumed with respect to CMST.

It was collected and the excreted fecal matter is quantified by collecting bag. These were hollowed out once a day daily weighing all dregs and a subsample consisting of 10% of the evacuated was determined dry matter (AOAC, 1995). Total digestibility of dry matter consumed from the difference between the ingested and excreted in relation to ingested, expressed as percentages (%) was calculated.

Statistical Analyses

Statistical model:
$Y = \mu + T + UE + P + e$
Y: dependent variable
μ: average overall trial
T: treatment
EU: experimental unit
P: period
e: error

Data were analyzed by MIXED procedure (SAS, 2004) for a 4 × 4 Latin squares, using a mixed model that included the fixed effect of sampling (treatment period) and the random effect of the animal. Orthogonal polynomial contrasts were used to determine linear effects (L), quadratic (Q) and cubic (C) of increasing levels of ground corn in the variables analyzed. The differences were considered significant with a P value of <0.05 and trends 0.05 <P <0.10. In experiment II a simple linear regression was performed to determine correlation between the total dry matter intake and intake of PB and total dry matter digestibility.

Results and discussion

Experiment I: Through analysis of orthogonal polynomial contrasts, no significant effects (p> 0.05) were observed in the CMST to concentrate levels tested and recorded a significant linear decrease (p <0.05) in the CTFDN, CTFDA and CTPB. CMSF decreases linearly (p <0.05) with increasing amounts of ground corn verifying a substitute effect concentrated on alfalfa hay (Figure 1). CMSF, CTFDN, CTFDA and CTPB the A_4 diet was significantly lower (p <0.05) than the A_1 and A_2 diet. The F/C differed significantly (p <0.05) among all treatments. The DTAIVMS increases linearly (p <0.05) with the content of corn in the diet. By analyzing average DTAIVMS verified that the A_4 was significantly higher (p <0.05) than A_1 and A_2 (Table 2).

Experiment II: a significant linear increase (p <0.05) on the CMST and CTPB with increasing corn in diet and no significant differences (p> 0.05) on the CMSF, CTFDN and CTFDA is observed. The F/C and CTPB differ significantly (p <0.05) among all the diets tested. The DTAIVMS increases linearly (p <0.05) with the content of corn in the diet. The digestibility of diet with a higher proportion of corn was significantly higher (p <0.05) than the other treatments (Table 3). Figure 2 verifies the additive effect of the increase concentrated in assigned diets.
The simple regression analysis fitted a linear model (Figure 3) to describe the relation between total dry matter intake and total PB intake. Adjusted model:

$$CMST = 170.46 + 13.036*CTPB$$

The P-value in the ANOVA table (Table 4) is less than 0.05 there is a statistically significant relationship between CMST and CTPB. The R-square indicates that the adjusted model accounted for 88.9829% of the variability in CMST. The correlation coefficient is equal to 0.943308, indicating a relatively strong relation between the variables.

Following the same analysis to relate total dry matter intake and total dry matter digestibility, the results adjusted to a linear model (Figure 4). Adjusted model:

$$CMST = 449.286 + 9.2497*DTAIVMS$$

The P-value in the ANOVA table (Table 5) is less than 0.05 there is a statistically significant relationship between CMST and DTAIVMS. The R-square indicates that the adjusted model accounted for 88.9829% of the variability in CMST. The correlation coefficient is equal to 0.5969, indicating a moderately strong relation between variables.

When the animals were given supplements consumption decreased forage dry matter (Viglizzo, 1981; Minson, 1982; Kellaway & Porta, 1993; Stock dale, 2000), which is known as replacement rate. In Experiment I, the substitution effect is observed, verifying the change in feeding behavior cited by Provenza et al., (2003); Rapetti & Bava, (2008) in relation to consumption of forage or concentrated and capacity to select food goats high digestibility and adaptation to different types of diets. In experiment 2 in accordance with NRC, 1987; Minson, 1990; Mayne, 2007 the additive effect was proved due to incorporation of corn to the diet with hay CN which increased digestibility and total dry matter intake (Molina & Alcaide et al., 2000; Fimbres et al., 2002; Rapetti et al., 2004; Archimède et al., 1995).

It coincides with Coleman et al., (1999); NRC (2001) that the apparent digestibility of the dry matter in vivo and the intake of dry matter results in the consumption of dry matter digestible. In this paper according to Mertens (2010) and Relling & Mattioli (2013) it was shown an inverse relation between the fiber content of the diet and total intake. In accordance with Aello 2000, in experiment II was verified that the increase in PB diet increased the total dry matter intake.

The incorporation corn grain to the diet improved the apparent total digestibility. Although ruminal pH was not measured, it was probable that the quantities of grain tested decreased the digestibility of the fiber (Mould & Orskov 1984; Kovacik et al., 1986; Grant & Mertens, 1992; Garces-Yepez et al., 1997; Arias et al., 2013; Arias et al., 2015).

Conclusion

Therefore, it can be concluded that the increase of corn levels improved the total digestibility of the ration consumed and the substitute or additive effect depended on the quality of the hay used.

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Table 1: Chemical composition of food (*)

Ítem	Hay de Alfalfa	Hay de CN	Corn
MS%	87	88	89
PB%	13,7	5,8	7,3
FDN%	58,7	74	14,55
FDA%	46,03	44	3,68
Hemicellulose %	12,84	30	0,87
Cellulose %	35,36	26,32	2,13
Lignin %	10,67	17,68	1,55

* Laboratory of biochemistry of the Faculty of Agrarian and Forest Sciences. UNLP.
MS: dry matter.
PB: crude protein.
FDN: Neutral Detergent Fiber.
FDA: Acid Detergent Fiber.

Table 2: CMST, CMSF, CTFDN, CTFDA, CTPB, DTAIVMS, F / C of the experiment I

Ítem	Diet				EE	Contrast			P-value
	A_1	A_2	A_3	A_4		L	Q	C	
CMST (Kg/día)	1,130[a]	1,210[a]	1,256[a]	1,200[a]	0,236	0,610	0,466	0,891	0,794
CMSF (Kg/día)	1,130[a]	0,926[a]	0,774[ab]	0,534[b]	0,117	0,002	0,877	0,796	0,014
CTFDN (Kg/día)	0,665[a]	0,604[ab]	0,514[b]	0,304[c]	0,052	<,001	0,171	0,697	0,001
CTFDA (Kg/día)	0,548[a]	0,480[ab]	0,392[b]	0,274[c]	0,042	0,001	0,572	0,960	0,002
CTPB (Kg/día)	0,165[a]	0,158[ab]	0,142[b]	0,106[c]	0,014	0,006	0,312	0,862	0,033
F/C	-----	87/13[a]	71/29[b]	49/51[c]	2,074	<,000	0,904	0,875	<,000
DTAIVMS (%)	70,76[a]	72,60[a]	78,82[ab]	82,96[b]	2,253	<,000	0,616	0,523	0,004

A_1: 100% hay de alfalfa *ad libitum*.
A_2: 0.5% LW/day of ground corn and alfalfa hay ad libitum in the diet.
A_3: 1% LW/day of ground corn and alfalfa hay ad libitum in the diet.
A_4: 1.5% LW/day of ground corn and alfalfa hay ad libitum in the diet.
CMST: Total dry matter intake (Kg).
DTAIVMS: Total apparent digestibility *in vivo* of dry matter (%).
CMSTD: Total digestible dry matter intake (Kg/day).
CMSF: Dry matter intake of forage (Kg/day).
CTFDN: Total FDN intake (Kg/day).
CTFDA: Total FDA intake (Kg/day).
CTPB: Total PB intake (Kg/day).
F/C: ratio forage/concentrate (%).
EE: Standard error.
L: Probability value associated with a linear effect level of supplementation with corn in contrast orthogonal polynomial.
Q: Probability value associated with a quadratic effect level of supplementation with corn in contrast orthogonal polynomial
C: Probability value associated with a cubic effect level of supplementation with corn in contrast orthogonal polynomial.
P valor: Equal letters indicate no significant differences for the 5% probability.

Table 3: CMST, CMSF, CTFDN, CTFDA, CTPB, DTAIVMS, F / C of the experiment II

Ítem	Diet				EE	Contrast			P-value
	R_1	R_2	R_3	R_4		L	Q	C	
CMST (Kg/day)	0,713[a]	0,803[ab]	0,944[b]	1,223[c]	0,083	0,000	0,218	0,790	0,003
CMSF (Kg/day)	0,713[a]	0,560[a]	0,505[a]	0,596[a]	0,094	0,315	0,186	0,466	0,401
CTFDN (Kg/day)	0,527[a]	0,448[a]	0,449[a]	0,527[a]	0,068	0,998	0,261	0,993	0,704
CTFDA (Kg/day)	0,313[a]	0,256[a]	0,202[a]	0,287[a]	0,074	0,886	0,325	0,898	0,866
CTPB (Kg/day)	0,041[a]	0,052[b]	0,059[c]	0,080[d]	0,006	0,000	0,237	0,546	0,003
F/C	-----	69/31[a]	54/46[b]	46/54[c]	0,052	0,000	0,060	0,697	0,001
DTAIVMS (%)	35,55[a]	40,00[a]	57,86[b]	69,43[c]	4,578	0,000	0,363	0,303	0,002

R_1: 100% hay de CN *ad libitum*.
R_2: 0.5% LW/day of ground corn and CN hay ad libitum in the diet.
R_3: 1% LW/day of ground corn and CN hay ad libitum in the diet.
R_4: 1.5% LW/day of ground corn and CN hay ad libitum in the diet.
CMST: Total dry matter intake (Kg).
DTAIVMS: Total apparent digestibility *in vivo* of dry matter (%).
CMSTD: Total digestible dry matter intake (Kg/day).
CMSF: Dry matter intake of forage (Kg/day).
CTFDN: Total FDN intake (Kg/day).
CTFDA: Total FDA intake (Kg/day).
CTPB: Total PB intake (Kg/day).
F/C: ratio forage/concentrate (%).
EE: Standard error.
L: Probability value associated with a linear effect level of supplementation with corn in contrast orthogonal polynomial.
Q: Probability value associated with a quadratic effect level of supplementation with corn in contrast orthogonal polynomial
C: Probability value associated with a cubic effect level of supplementation with corn in contrast orthogonal polynomial.
P valor: Equal letters indicate no significant differences for the 5% probability.

Table 4: Variance analysis, relation between total dry matter intake and total PB intake

Item	Sum of squares	Gl	Mean square	F-Ratio	P-Value
Model	827151	1	827151	113,08	0,0000
Residue	102411	14	7315,04		
Total (Corr.)	929562	15			

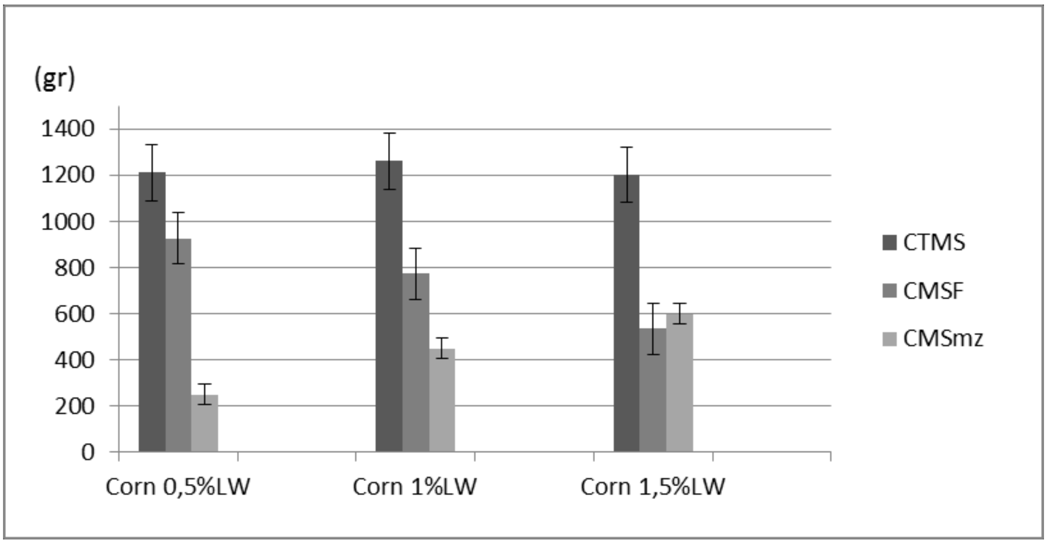
Correlation coefficient = 0,943308
R-cuadrad = 88,9829 %

Table 5: Variance analysis, relation between total dry matter intake and total and total apparent digestibility in vivo of dry matter

Item	Sum of squares	Gl	Mean square	F-Ratio	P-Value
Model	331234	1	331234	7,75	0,0146
Residue	598328	14	42737,7		
Total (Corr.)	929562	15			

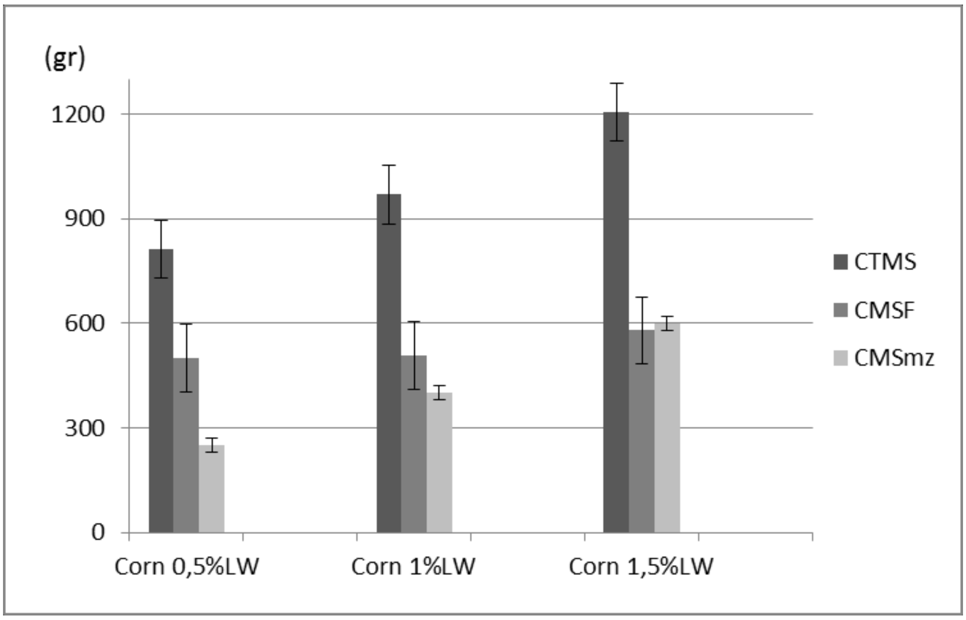
Correlation coefficient = 0,596936
R-cuadrad= 35,6333 %

Figure 1: Intake of CTMS, CMSF y CMSmz; experiment I. Substitute effect



CTMS: Total dry matter intake (gr).
CMSF: Dry matter intake of forage (gr).
CMSmz: Dry matter intake of corn (gr).

Figure 2: Intake of CTMS, CMSF and CMSmz; experiment II. Substitute additive



CTMS: Total dry matter intake (gr).
CMSF: Dry matter intake of forage (gr).
CMSmz: Dry matter intake of corn (gr).

Figure 3: Simple regression between the total dry matter intake and total intake of PB

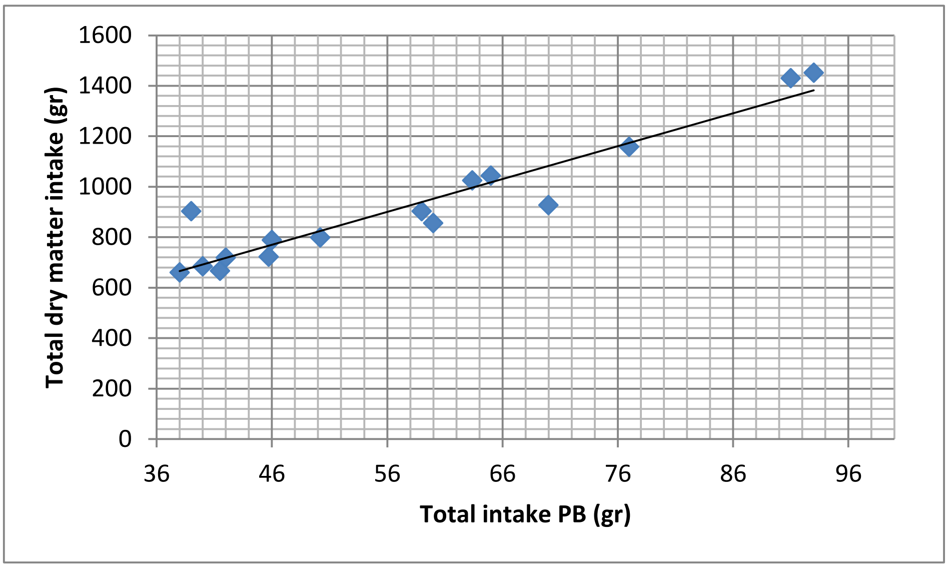


Figure 4: Simple regression between the total dry matter intake and total dry matter digestibility