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Response to iodine supplementation in the growth and quality of Texel lamb meat

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Abstract

Iodine deficiency determines reproductive problems especially in the production of thyroid hormone, affecting the functions that thyroidal hormones regulate, such as energy metabolism, thermoregulation, reproduction, growth, muscle and bone tissue function. Indeed a certain concentration of iodine in the diet can promote performance in production in terms of fattening and growth. The main goal of the work was the supplementation with iodine salt from weaning to work on the production and quality of carcass and meat of early lambs of the Texel breed. Three random groups were formed. In one group, iodine salt was administered daily individually, in another group salt without iodine and finally a third "control" group without salt aggregate. All these animals were fed on natural field with an energy-protein supplement. The weaning weight and its evolution (daily gain) were determined, fortnightly until the work weight (35 kg) was reached. Blood levels of thyroid-stimulating hormone (TSH) and Selenium (Se) were evaluated. In the carcass were measured the hot and cold carcass weight, pH, colour; GR point and in the meat tenderness will be determined in the *Longissimus dorsi* muscle. Se concentrations, neutral detergent fiber, crude protein and iodine in pastures were also determined. The results show that no significant differences were found for any of the characters measured.

Keywords: Sheep; Texel; Iodine; Growth; Meat quality

1. Introduction

In our region the pastoral systems have limitations for the use of iodine at the metabolic level involved in pastures. *Trifolium repens, Panicum coloratum* and *Paspalum dilatatum* transform hydrocyanic acid into thiocinate and this causes the inhibition of the thyroid gland in the function of capturing iodine [31]. In the Uruguayan natural pasture *Paspalum dilatatum* is the most common [36].

The iodine limiter in pastures can be affected by the distance from the sea, since minerals are transferred by wind and integrated into the ground through rainfall [45]. McDowell and Conrad [29] classify Uruguay in the group of countries where iodine deficiencies exist. In particular, the effects of iodine deficiency in lambs in the north of the country have been found [35]. The availability of iodine in animals is fundamental, since in the thyroid gland the greatest amount of this mineral is concentrated (8 mg). This gland in turn is responsible for synthesizing thyroid hormones that participate in the regulation of the metabolic rate of different tissues and in calcium-phosphorus homeostasis. The metabolic hormones are thyroxine (T4) and triyodothyronine (T3), which are produced in the follicular cells surrounding the thyroid follicles [13] it is possible that an adequate concentration of iodine allows a better performance of these hormones, and therefore a greater fattening efficiency and better performance in the final product [17, 33, 43].

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The supplementation of iodine in lambs after weaning until slaughter could optimize their productive performance, since it is a micromineral that participates in the activation of certain hormones and the homeostasis of calcium and phosphorus [37]. Indeed, synthesis of thyroid hormones depends fundamentally on the availability of iodine in the diet [14]. The main objective of this work was to evaluate the effect of iodine supplementation on the production and quality of the carcass and meat in lambs.

2. Material and methods

2.1. Animals

102 lambs of the Texel breed were used. The date of birth of the lambs was from August 2 to September 10, and their average weight at the experiment start was 33.2 ± 2.0 kg with an average body condition of 4.0 ± 2.0 (scale 1-5) [22].

Animals used in this study were maintained in the facilities and environment of "Los Abuelos" farm (32°56´36.6" S; 55° 21´23.9" W, Uruguay), following the regulations of the University´s ethics committee. Protocol used in this work was approved by the Ethical Commission for the use animal (CHEA).

11th January lambs received drug treatments of Levamisole and Closantel (5.0 mg per kg body weight; Closamisol®, IVU Lab.) and Rafoxanide (13th February) (7.5 mg per kg body weight; Rafoxan®, Anvet Pharma) in order to minimize the parasitic burden.

2.2. Treatments and experiment diets

The lambs were selected at random and divided into three treatments: T1: mineral salt with iodine; T2: mineral salt without iodine and T3 (Control): without salt. Thus, the experiment design was random parcels with two repetitions.

The animals were fed on natural pastures and supplemented at the rate of 400 grams per animal per day, distributed during the morning and afternoon (200 grams) with a protein energy supplement. 0.5 mg of iodine/Kg MS per animal per day were supplied, according to recommendations [31].

The salt without iodine composition was: Cl Na 61.8%, bicalcium phosphate 18%, calcium carbonate 21%, magnesium oxide 0.5%, magnesium sulfate 0.11%, cobalt sulfate 0.02%, sodium selenite 0.0008%, molasses powder 2.5%, zinc oxide 2.027% and salts with iodine are added potassium iodide 0.0081%. The supplement was composed of 13% crude protein, metabolizable energy 2.75 Mcal/kg, neutral detergent fiber 16.5%, NDT 76% and monensin (20 m).

2.3. Determinations in animals

Body weight (BW) (kg) was measured every 15 days. Blood samples were collected from the jugular vein from each animal at weaning and slaughter. The blood collect will be performed in the early hours of the morning (three extractions in the hour). Blood samples were placed in tubes with anticoagulants, and then were frozen at -20 °C, until further analysis.

All of the lambs were slaughtered for the measurements made in the carcass. The variables measured were weight of hot carcass weight (kg) (HCW) shell at the time of slaughter and cold carcass weight (CCW) (kg) after 48 hours of cooling. 8 lambs from each treatment were random selected for measured fatness (GR tissue depth, mm) and meat characters. GR was measured like the total depth of tissue over the 12th rib at a point 11 cm from the midline of the carcass [23]. From a sample of the *Longissimus dorsi* muscle, which was vacuum packed and placed in a freezer, the pH was recorded and the cutting force (kgf, Warner Bratzler) [23] and the color of the muscle (CieLab) was determined with 6 days of maturation, in the laboratory of the quality of the carcass and the meat belonging to National Institute of Agricultural Research (INIA, Tacuarembó).

2.4. Pasture determinations

Dry matter production per hectare (kg DM/ha) at the start (January) and the end (March) of the experiment was determined, by means of cages (square 0.5 x 0.5 m), one of them will be destined to dry and fresh matter, and in the next sample grasses, legumes and weeds with their respective weights will be differentiated.

Pasture growth rate was determined prior to put the animals in the paddocks. Cages will be placed (with the pasture cut flush) and cut when a height greater than 20 cm is estimated to make the fresh and dry matter. Samples of pasture were subjected for one minute in the microwave, and then removed from it and calculated weighs it with a precision balance, so on until it reaches its constant weight. Subsequently, samples of 1g were ashed in a covered crucible at 550°C in a muffle furnace, with temperature ramp (Thermolyne, USA) for 16 h to obtain a white residual ash.

2.5. Analytical determinations

Pasture quality was evaluated: dry matter (DM), crude protein (CP) (AOAC) [2], Neutral Detergent Fiber (NDF: Van Soest) [46], Selenium (Se) and Iodine (I) were performed by spectrophotometer (ASS Perkin Elemer, Analyst) according to Suttle [42] modified by Cabrera et al. [5].

Se and thyroid-stimulating hormone (TSH) were measured in blood. An aliquot was treated with anticoagulant (EDTA) for the determination of Selenium, [27], and another was centrifuged at 2500 rpm for 10 minutes, from the serum obtained TSH was determined.

She was determined by dosing glutathione peroxidase (GSH-Px), according to Ceballos et al. [9] using a Randox test combination (RANSEL) (deficiency <60, low-marginal=61-100, marginal =101-130, good >130 UI/gHb).

For determination of TSH TOSOH- AIA reagent (ST AIA-PACK TSH) and AIA900 equipment (Tosoh Automated Immunoassay System, USA) were used. The minimal detectable concentration was estimated to be 0.03 µIU/mL TSH. Precision assays was 4.8 % (calculated as RSD), percentage determine by the duplicate assay of three controls in 20 separate runs. The mean of each run were used to calculate the standard deviation and coefficient of variation.

2.6. Statistical analysis

A completely random design with two repetitions was used. Statistically analyzed according to this design statistical model corresponds to: $Yij = \mu + \alpha i + \varepsilon ij$ Yij: response variable µ: general mean α: treatment effect i εij: experimental error. Effect of the treatments will be analyzed by an ANOVA (analysis of variance). If significant differences ($\alpha<0.05$) or a trend ($\alpha<0.1$) are detected, the method of comparison of means will be Tukey. All analyses will be performed with INFOSTAT Version 2017 software [10]. Prior to the analysis of variance, a normality test will be performed on all variables in case they did not give the modified Shapiro-Wilks Test.

For tests that do not present normality, Kruskal Wallis non-parametric tests and generalized and mixed linear models will be performed.

3. Results and discussion

3.1. Content of Se, I, NDF and CP in natural pastures

There were no significant differences ((Table 1; p>0.05) for the analysis of Selenium, NDF, CP, Iodine at the star and the end of experiment.

Table 1 Selenium, neutral detergent fiber, crude protein and Iodine levels

Experimental	Se (mg/kg DM)		NDF (%)		CP (%)		I (µg /kg DM)	
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Star	0.18	± 0.10	64.3	± 0.02	8.02	± 0.05	739.25	± 0.32
End	0.36	± 0.11	67.3	± 0.06	7.17	± 0.06	480.67	± 0.55
Significant	0.25		0.15		0.16		0.49	

The values obtained from Se were similar to those obtained in the region; being for Se of 0.03 mg/Kg DM at least and 0.52 mg/Kg DM maximum [38], for NDF values between 69.5% and 79.6% at admission and discharge respectively [34] and for CP variable values between 7% and 11.5% [12, 21, 39].

Iodine levels are similar to those obtained by Guerra et al. [16] in Uruguay. According to Suttle [42] the iodine requirements in animals of 50 kg average are in a range of 50-100 µg / kg DM so in the present study the requirements of this mineral were covered during the experiment. Similarly, Grace [15] reaffirms that this range of values that was obtained are sufficient for the growth of lambs.

The changes in the percentages of CP and NDF would be explained according to Pastorin [34] by the incidence of two main factors, first the selectivity of sheep in grazing, which increases to a greater or lesser extent according to the heterogeneity of the pasture, finding in the natural tapestry the greatest availability of plant species to select. Sheep prefers leaf versus stem, green material versus dry, and legumes versus grasses, which would generate a decrease after a grazing time in CP values and antagonistically affects NDF levels. The second factor is the physiological state of the pasture, as the plant matures, increases the content of the most difficult to digest structural components (lignin).

3.2. Lambs live weight

Table 2 shows that the evolution of weight was similar, there were no significant differences between treatments (p>0.05). At the beginning of the study, the animals had an average initial weight of 33.4±0.38 kg and an average final weight of 39.6±0.39 kg.

Table 2 Live weight (kg) according to treatment

	T1		T2		Control	
	Mean	**SEM**	**Mean**	**SEM**	**Mean**	**SEM**
10th January	33.35	3.14	33.26	2.99	33.60	3.21
24th January	34.24	2.91	34.16	2.62	34.83	3.09
8th February	34.62	3.04	34.88	2.67	36.13	3.33
23th February	35.72	3.23	35.96	2.76	37.40	3.64
6th March	39.26	3.33	39.38	2.55	40.11	3.71

According to Garcia Sacristan et al. [14] the level of iodine in the blood is very important, since the greatest amount of this mineral is found in the thyroid gland which is responsible for synthesizing thyroid hormones (T3 and T4) that participate in the metabolic regulation of muscle and bone tissue. It is possible that an adequate concentration of iodine allows a better performance of these hormones and therefore a greater efficiency in the evolution of live weight.

3.3. TSH and selenium levels in blood plasma

No significant differences (p>0.05) were found in the treatment and time variables, nor in the interaction between them.

Table 3 TSH levels (µg IU/mL) according to treatment and time

Treatment							Time				
T1		**T2**		**Control**		**P**	**Start**		**End**		**P**
Mean	**SEM**	**Mean**	**SEM**	**Mean**	**SEM**		**Media**	**SEM**	**Media**	**SEM**	
0.035	0.007	0.028	0.005	0.036	0.006	0.4771	0.042	0.007	0.029	0.004	0.09

The levels of TSH in the present work were similar between the treatments such iodine supplementation was insufficient to generate a change in the activity of thyrotrophic. Even though our experimental farm was 200 km from the sea, no significant differences were found (p>0.05). Indeed, remoteness of the sea is a determining factor to find deficiencies of this mineral (Mc Dowell and Conrad, 1977; Mufarrege, 2007).

When analyzing by treatment we can say that in the T2, TSH mean was in absolute values slightly lower (0.035µg IU/mL) in the first extraction with respect to the second (0.042 µg IU/mL). This is explained by a biological factor, in which the supply of iodized salt generates an increase in the concentration of TSH in the blood (Hernandez et al., 2015).

Table 4 Blood glutathione peroxidase (GSH-Px) concentration (UI/gHb) at start (weaning) and end (slaughtered) of experiment period

Experimental	T1		T2		Control		P
	Mean	SEM	Mean	SEM	Mean	SEM	
Start	54.6	2.4	54.1	3.3	55.3	2.5	0.95
End	33.1b	1.1	46.6a	1.1	33.1b	1.2	0.0001

Blood concentrations of selenium were deficiency according to the RANSEL test. Despite the selectivity of grazing of sheep, the low assimilation rate of Se (19%), compared to that of monogastric (85%), did not allow improving blood levels [7]. However, supplementation with sodium selenite contained in salt (T1 and T2) did not increase Se levels at the end of the experiment (Table 4). This can be explained by the increase in the blood activity of GSH-Px occurs in a span of 1 to 4 weeks, since the increase in the organic concentration of Se does not lead to the immediate synthesis of the enzyme [28], but is associated with its incorporation into erythrocytes in the process of erythropoiesis according to Knight and Sunde [24]. Besides, the rainfall could partly explain selenium's fall into blood. Rainfall generates problems of leaching of soluble nutrients from the forage [38]. The high rainfall recorded (January: 218 mm; February: 122 mm) higher than historical average (National Institute of Agricultural Research: INIA) [20] especially in summer times, was prosperous environment to determine gastrointestinal parasites [19]. Despite the drugs used, the level of parasitic infection affected se levels and limited the growth of lambs.

According to Lopez et al. [26] rumen bacteria incorporate inorganic selenometionine, and competition with the animal can be generated. The enzymes composed by Se are important in the per oxidation of iodine and the subsequent synthesis of thyroid hormones [13] by having low levels of Se in the blood, consequently a metabolic inefficiency can be generated in the thyroid gland [32].

3.4. Carcass and meat characteristics

No significant differences (p>0.05) were observed for treatments in HCW, CCW, meat yield and GR.

Table 5 Lamb carcass characteristics

	T1		T2		Control		P
	Mean	SEM	Mean	SEM	Mean	SEM	
Hot carcass weight (HCW)	18.58	0.55	18.73	0.55	18.8	0.55	0.96
Cold carcass weight (CCW)	18.39	0.54	18.38	0.54	18.43	0.54	0.99
Yield (%)	43.26	0.55	43.72	0.55	43.5	0.55	0.84
GR (mm)	10.63	0.98	9.38	0.98	10.6	0.98	0.59

The results of the study of the carcass were to be expected, since the variables analyzed have a high correlation (r = 0.91) with the live weight of the animals. The GR values obtained in the following study are similar to those obtained by Dighiero et al. [11] in the category of super-heavy lambs (>45kg) Romney Marsh being this 10.9 mm. According to Brito [4] the level and type of food supplied in the fattening stage, within certain ranges, modifies the composition and quality of the carcass. Lord et al. [25] mention that carcass weight can be affected to a greater extent by a genetic factor than a nutritional one. In our case (Table 5) the difference of a higher value of GR with respect to lambs of similar BW, HCW and CCW would be given by the genetic factor and not by the diet that is sullied to them. This is explained because the diet offered in our work was lower than in terms of nutritional values (CP, NDF).

The results presented in Table 6 show that there were no significant differences (p>0.05) between treatments in cooking temperature, luminosity, degree of red, degree of yellow and pH.

Table 6 Lamb meat characteristics

	T1		T2		Control		P
	Mean	SEM	Mean	SEM	Mean	SEM	
Cooking temperature	73.33	0.86	72.65	0.86	73.75	0.86	0.67
Meat colour (brightness)	41.83	0.57	41.02	0.57	39.86	0.57	0.08
Meat colour (degree of red)	18.73	0.53	20.12	0.53	19.66	0.53	0.20
Meat colour (degree of yellow)	6.27	0.45	6.73	0.45	5.81	0.45	0. 37
pH	5.57	0.01	5.55	0.01	5.55	0.01	0.47

The values obtained for meat were predictable [1]. In ruminants, the nature of the food supplied (grass, cereals) practically does not influence the colour, due to the important transformations suffered by these foods at the rumen level. San Julian [41] did not observe differences in the characteristics of the meat comparing four different treatments, in lambs slaughtered at 10 month of age.

According to Trujillo et al. [44] age in sheep affects the coloration of meat, explaining that younger animals tend to have a lighter coloration. When comparing our values of red, yellow and luminosity with those obtained by San Julian [41] contrasting results since we obtained values higher than those obtained with lambs that are 3 months older, in particular for the red color. However, the results can be explained by the use of different breeds, since precocity generates an early deposition of fat, consequently increases the level of myoglobin (pigment) by a greater demand for oxygen [6, 40].

In the cutting force of the carcass no significant differences were obtained between the treatments (Figure 1).

The trend in the values obtained was expected for the maturation time in which the evaluation was made, according to Bianchi et al. [3] the maturation time directly influences the cutting force, the longer the maturation days the cutting force values (kgf) will be lower which reflects a greater tenderness. In our case the means were for T1 (iodine): 3.63, T2: 3.52 and Control: 3.09; which are within the normal range for the maturation time (6 days). San Julián [41] obtained values in cutting force somewhat lower than those obtained in the present trial, with 10 days of maturation: a maximum of 3.27 in lambs with a diet exclusively to pasture and a minimum of 2.38 kgf for lambs in confinement, which is consistent with what has already been mentioned above. In addition, these authors performed other treatments with different levels of supplementation, yielding intermediate values to those already mentioned for cutting force.

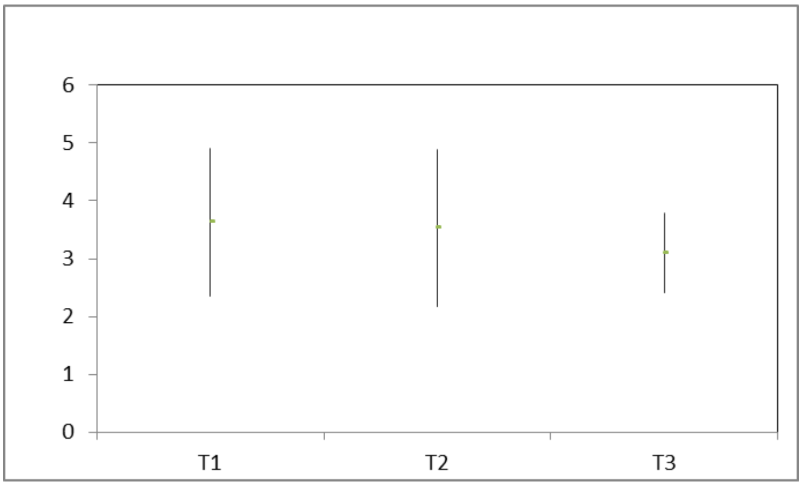

Figure 1 Cutting force (kgf) of the *Longissimus dorsi* muscle

Taking into account the values in kgf used in the USA [30] the maximum limit is considered 4.5 of tenderness, above these it is considered less tender Taking this criterion, we obtained for the T1 and T2 treatments a percentage of 25% for both cases, which are above the maximum value of tenderness.

The values for T1 and T2 that were higher than the mean were of the same animals that present a minimum GR located between 5-10 mm. It is reported a lower degree of greasing is related to a higher value of cutting force [8].

4. Conclusion

The amounts of iodine supplemented to the lambs did not determine differences in the growth, nor in the characteristics of the carcasses evaluated. However, according to the iodine deficiencies that occur in Uruguay supplementation is essential. In our conditions it is necessary to continue researching iodine supplementation in the diet of lambs to determine the requirements that increase their growth.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declared no potential conflicting of interest with respect to the research, authorship and/or publication of this article.

Statement of ethical approval

Protocol used in this work was approved by the Ethical Commission for the use animal (CHEA).

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