Short Communication

The Reduction of Bacterial Load and Total Solid in Drinking Water Qualified as "Clean" for Livestock, Increases Growth Performance and Reduce Diarrhea Frequency in Finishing Lambs

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Abstract |Twenty four Pelibuey × Katahdin male intact lambs (33.22±4.02 kg) were used in order to evaluate the effect of filtering-sanitization of water offered as drink water on growth performance, dietary energetics, carcass traits, and diarrhea frequency in finishing lambs. Lambs were fed with a cracked corn-based high-energy diet during 89-d. Treatment consisted in filtering and sanitization of raw dam water qualified as "clean and safe" comparing it as follows: 1) dam water (RAW), and 2) dam filtered-sanitized water (FILT). Water filtered-sanitized decreased three-fold total solids and remove coliforms, E, coli, and salmonella. Filtered-sanitized water increased 10% water intake, 8% daily gain, and 3% dietary net energy utilization. There was no evidence of infectious diarrhea during the experiment. Non-infectious diarrhea frequency and days on diarrhea were decreased 33% by FILT. Hot carcass weight (HCW) and longissimus muscle area (LM) were increased by FILT. Lambs drank FILT shown lower relative weight of stomach complex and tended (P=0.06) to have lower relative intestinal weight. It is concluded that reduction of TDS and the bacterial load in water qualified as "clean and safe" decreases frequency and days of diarrhea during diet period adaptation, promoting better diet energy utilization, improving weight gain, and HCW and LM area.

Keywords | Water quality, Finishing lambs, Growth-performance, Carcass traits, Diarrhea

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The role of drinking water in productive efficiency and health in small ruminants is well known (NRC, 2007). However, drinking water can be a transport of contaminants and bacterial that can affect animal health and productivity. In this sense, several studies have been conducted to determine the impact of high total dissolved solids (TDS) concentration and bacterial count load in drink water on performance and health of ruminants. High concentration (>1000 mg/L) of TDS and infectious bacterial (> 100 CFU/mL) can reduce growth performance and health (mainly scours; Rinella et al., 2021). Then, when water had lower TDS (<1000 mg/L) and bacterial count load

(CFU<100/mL) is enough to qualified it as "clean and safe water for livestock" (Van Eenige et al., 2013). Recently, the introduction of "best management practices" in dairy herds has led to improving the quality of the water used in production processes by drastically reducing total solids and eliminating infectious bacteria by filtering and sanitizing. Even when there is not enough evidence, it is mentioned that the increase of quality drinking water by filter and sanitizing improves performance and health in dairy cattle (Beede, 2019). To our knwoldege, there are no studies that directly assess the effects of improve the quality of drinking "clean and safe" water by filtering-sanitation process on growth performance, dietary energetics, and carcass characteristics of feedlot lambs. Therefore, the objective of this experiment was to evaluate the effects of the filtration and sanitization of drinking water on growth performance, dietary energetics, carcass traits, and diarrhea frequency in fattening lambs.

This experiment was conducted at the Universidad Autonoma de Sinaloa Feedlot Lamb Research Unit. All animal management and care procedures were in accordance with the guidelines approved by the Universidad Autónoma de Sinaloa Animal Use and Care Committee (Protocol #7042021). During the course of the experiment, ambient air temperature averaged 26.8 °C, and relative humidity averaged 45.6%. In order to evaluate the treatments, 24 Pelibuey × Katahdin male intact lambs (33.22±4.02 kg) were used in a randomized complete block design experiment in a growth-performance trial which lasted 89-d. Four weeks before initiation of the experiment, lambs were adapted to the basal diet offered during the trial (a total mixed corn-based diet containing 14.10% crude protein, 16.87% neutral detergent fiber, 55.28% non-fiber carbohydrates, 5.65% ether extract, and 1.98 Mcal/kg of net energy of maintenance). The health management and weighing procedures of lambs were performed as is described by Arteaga-Wences et al. (2021). Lambs were blocked by initial weight and randomly assigned within weight groupings to 12 pens (2 lambs/pen). Treatments were randomly assigned to pens within weight blocks. Pens were 6 m^2 with overhead shade and 1 m fence-line feed bunks. Plastic waterers type bucket (25 L cap. Induplastic de México, Tlalneplantla, México) was used. Treatments consisted in the offer ad libitum local dam water as follows: 1) dam raw water (RAW), and 2) dam filtered-sanitized water (FILT). The source of dam water was located 25 km from research facilities. Approximately 1500 L of water was taken and transported weekly in plastic containers (cap. 250 L, Rotoplas México, Los Mochis, Sin.). Half of the transported water was treated by filtering-sanitation process including coagulation, flocculation, sedimentation, filtering and adsorption, and sanitation. Filtration was performed through carbon filters (Polyglass, 33 × 137 cm mesh 0.057 m^3 of activated carbon from coconut shell, capacity 28 L/min), reverse osmosis (Water IXC, double membrane Hydron BW-4040 1.11 kW) and sanitation was reached by UV light (Viqua lamp, Pro10) and chlorination (0.5 to 1.0 ppm). Water intake was measured daily at 0700 h by dipping a graduated rod into the bucket drinker (Fairgate Rule #FG14-101,Thomaston, CT, USA). Once the measure was taken, the remaining water was drained, and buckets were cleaned and refilled with fresh water. Lambs were fed the diet provided fresh twice daily at 0800 and 1400 h. Residual feed was collected daily between 0740 and 0750 h each morning, and weighed. Feed intake was determined as the difference between quantities offered minus refusals. Feed samples and feed refusal were collected daily and were composited weekly. Feed and feed refusal composited samples were subject to DM analysis (method 930.15; AOAC, 2000). Lambs were weighed just prior to the morning feeding on days 1 and 89 (final day).

Physicochemical and microbiological analyses of the RAW and FILT water, were carried out weekly. The samples (500 mL taken in sterile plastic bottles) were subjected to the following determinations: total alkalinity, hardness, total dissolved solids, turbidity, sulfates, chlorides, total coliforms, fecal coliforms, *E. coli,* and salmonella (evaluated by most probable number). The procedures for collection and analysis of water samples were carried out following the standard methods for the examination of water and wastewater established by the American Public Health Association (APHA, 2017).

Average daily gain (ADG) was computed by subtracting the initial weight from final weight and dividing the result by the 89 days on feed. Feed efficiency was computed by dividing ADG by average daily dry matter intake (DMI). Dietary net energy estimations were performed based on the averages of weight, ADG, and DMI of fattening period following the equations and energetic derivations exposed by Arteaga-Wences et al. (2021). Lambs immobilization, the slaughter procedure, as well as the measures taken to the carcass and visceral mass were carried out as described by Castro-Pérez et al. (2021).

Performance data (DMI, gain, gain efficiency, observed dietary NE, observed-to expected dietary NE ratio), carcass characteristics, and visceral organ mass data were analyzed as a randomized complete block design using the MIXED procedure of SAS software (SAS, 2007). All the data were tested for normality using the Shapiro-Wilk test. Water intake was analyzed as a completely randomized design using linear mixed model for analysis of repeated measures (SAS, 2007). Diarrhea frequency between experimental treatments were analyzed with Chi-square test using FREQ procedure of SAS (2007). Treatment means were

Table 1: Physicochemical and microbiological characteristics of filtered and unfiltered dike water offered to lambs.

Item	Dam water	
	Filtered	Raw
Total alkalinity as CaCO3, mg/L	133.4	151.0
Chlorides, mg/L	59.3	45.8
Total hardness, mg/L	156.0	156.0
Total dissolved solids, mg/L	256.0	776.0
Total solids, mg/L	269.0	909.0
Sulfates, mg/L	36.1	39.2
Turbidity, FTU	1.1	5.4
pH	7.1	8.0
Total coliforms, MLN/mL	UNDECTABLE	93.0
Fecal coliforms, MLN/mL	UNDETECTABLE	47.0
E. coli, MPN/mL	UNDETECTABLE	43.0
Salmonella in 1000 mL	ABSENT	ABSENT
Residual free chlorine	1.5	-

Table 2: Treatments effect on growth performance, dietary energy and diarrhea cases in finishing lambs receiving unfiltered and filtered dam water as drinking source water

Dam water				
Item	Raw	Filtered	SEM	P-value
Live weight (kg)[1]				
Initial	33.10	33.34	0.2724	0.56
Final	54.13	56.21	0.4316	0.02
Water consumption (L/d)	3.829	4.255	0.1092	0.04
Daily gain (kg)	0.239	0.260	0.0048	0.03
Dry matter intake (kg/d)	1.322	1.389	0.0304	0.30
Gain to feed (kg/kg)	0.180	0.187	0.0023	0.06
Observed dietary NE				
Maintenance	1.96	2.02	0.014	0.03
Gain	1.31	1.36	0.012	0.03
Observed-to-expected dietary NE				
Maintenance	0.99	1.02	0.007	0.04
Gain	0.99	1.02	0.009	0.04
Diarrhea				
Frequency (%)	26.96	17.97	1.78	0.03
Average days on diarrhea	2.0	1.33	0.022	0.05
Diarrhea relative to fattening period (%)	15.7	11.2	1.47	0.05

Table 3: Treatments effect on carcass characteristics and visceral mass of lambs

Dam water				
Item	Raw	Filtered	SEM	P-value
Hot carcass weight (kg)	31.80	33.58	0.519	0.02
Dressing percentage	58.92	59.70	0.010	0.43
Cold carcass weight (kg)	31.38	33.10	0.533	0.02
Longissimus muscle area (cm^2)	18.31	20.17	0.695	0.04
Fat thickness(mm)	2.41	2.47	0.279	0.84

Kidney-pelvic-heart fat (%)	2.06	2.30	0.091	0.06
Organs (g/kg of EBW)				
Stomach complex[1]	26.86	24.91	0.383	0.02
Intestines[2]	47.95	46.04	0.742	0.06
Heart/lungs	20.60	19.80	0.764	0.34
Liver/spleen	16.95	16.34	0.667	0.40
Kidney	2.51	2.50	0.102	0.92
Visceral fat	31.79	31.67	3.420	0.97

EBW = empty body weight.

[1] Stomach complex = (rumen + reticulum + omasum + abomasum), without digesta.

[2] Small and large intestines without digesta

separated using the "honestly significant difference test" (Tukey's HSD test). Treatment effects were considered significant when the P-value was ≤ 0.05 and were identified as trends at P >0.05≤0.10.

Chemical characteristics of RAW and FILT water are shown in Table 1. According to the chemical composition, RAW and FILT meets the characteristics to be qualified as "clean and safe water for livestock" (Van Eenige et al., 2013). The main effects of water filtration-sanitization were decreased three-fold total solids and the totally removal of bacterial. This confirms the effectivity of UV and chlorination of water as disinfection treatments (Hruskova et al., 2016). Filtered-sanitized water increased (P≤0.04) 10% water intake, 8% daily gain, and 3% dietary net energy utilization (Table 2). The behavior of a higher water consumption for FILT was maintained throughout the experiment (Figure 1). When compared low TDS (<1000) vs high TDS (>8000) it have been reported increases of water intake by low TDS in cattle (López et al., 2016). However, there are no information about comparing water intake between groups that drink water containing lower than 1000 mg/L TDS, even so, the result obtained here could be more associated with acceptability of water (Sharma et al., 2017). In healthy animals grown under non-stressful ambient conditions, the expected ratio of observed-to-expected dietary NE would be 1.0. That is, lamb ADG is consistent with DMI and energy density of the diet. If ratio is greater than 1, the observed dietary NE is greater than anticipated based on diet composition NRC (2007), and efficiency of energy utilization is enhanced. In this case, RAW lambs performed as expected (ratio=0.99), but FILT lambs enhanced the energy utilization of diet (ratio=1.02). Improves on diet energy utilization by FILT was not expected. However, this could be promoted by better nutrient utilization as consequence of greater nutrient dilution and passage rate by greater water intake (Fraley et al., 2015) and by healthy and thinner gastrointestinal walls (Estrada-Angulo et al., 2021) by lower bacterial load in water. There was no evidence of diarrhea caused by infectious agents during the experiment. All cases of diarrhea were minor and declared by a practicing veterinarian as "moderato-to-low feed scours" and were majority presented (>90%) in the first 14-d of the experiment. The frequency of non-infectious diarrhea during the first days of fattening (i.e. first 14 days) when cattle fed with high-energy diets is variable but, it is to be expected (Gouws, 2019). In this case, diarrhea frequency and days on diarrhea were decreased 33% by FILT. The faster recovery in FILT lambs could be promoted by reduction of guts stressors such the lower bacterial load in FILT lambs (Salvin et al., 2020).

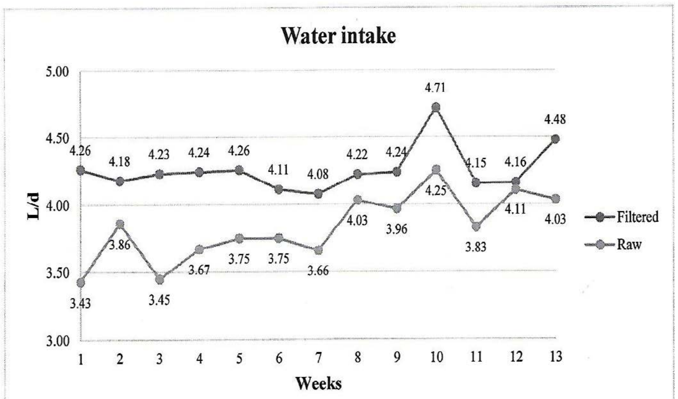

Figure 1: Average daily water intake (L/lamb) behaviour during the 13 week of the experiment

Hot carcass weight (HCW) and longissimus muscle area (LM) were increased (P≤0.04) 5.2 and 9.2% by FILT (Table 3). This increases were a direct reflection of the greater daily gain rate resulted in greater (3.7%, P=0.02) final weight observed to FILT lambs (Rivera-Villegas et al., 2019), in addition, the tendency (P=0.06) of greater (10.4%) KPH deposition could be an indicative to a greater energy utilization of the diet with FILT (Estrada-Angulo et al., 2021). Lambs drank FILT shown lower (7.2%, P=0.02) relative weight of stomach complex and tended (P=0.06) to have 3.9% lower relative intestinal weight (Table 3). The lower relative weight of stomach complex observed to FILT was a direct reflex of 9% lower of rumen fill (data not shown). This is uncertain since lambs received the same diet and no difference on DMI was observed. The relative reduction in intestinal mass observed in the present study may be evidence of decreased inflammation of the intestinal wall by absent infectious bacterial in water with FILT treatment (Arteaga-Wences et al., 2021).

It is concluded that increasing water quality of the water qualified as "clean and safe" by reduction of total solid and elimination of the bacterial load as consequence of filtering and sanitization decreased diarrhea duration promoting better energy utilization of diet, increasing weight gain, as well as HCW and LM area. Due to the cost of water filtering and sanitization, it is necessary evaluate the economic feasibility to applied in lambs feedlot system.

AUTHOR'S CONTRIBUTION

ACN, NLU, and BICP, run the experiment; ELB, evaluated carcass traits; AB analyzed the data. AEA designed the research work, advice the experiment. AC and GLV designed the research work; AP designed the research work, data curation, corrected, interpreted and write the manuscript.

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