Periódico Eletrônico "Fórum Ambiental da Alta Paulista"
Electronic Journal "Environmental Forum of Alta Paulista"

ISSN 1980-0827 – Volume 19, Number 4, Year 2023

Influence of magnetically treated water on blood biochemical parameters in beef cattle

Allan Leon Casemiro da Silva
Phd, FCE/UNESP, Brazil.
allan.leon@unesp.br

Camila Pires Cremasco Gabriel
Professor Phd, FCE/UNESP, Brazil.
camila.cremasco@unesp.br

Fernando Ferrari Putti
Professor Phd, FCE/UNESP, Brazil.
fernando.putti@unesp.br

Marcelo George Mungai Chacur
Phd, FMVZ/UNESP, Brazil.
marcelo.chacur@uol.com.br

Luís Roberto Almeida Gabriel Filho
Professor Phd, FCE/UNESP, Brazil.
gabriel.filho@unesp.br

Isamara Batata Andrade
Master's, UNOESTE, Brazil.
isamaraandrade@gmail.com

ISSN 1980-0827 – Volume 19, Number 4, Year 2023

ABSTRACT
As with any technology to increase productivity in beef cattle, good herd management and improvement practices must be integrated to obtain superior quantitative and qualitative productivity rankings. Therefore, this study aimed to verify the effects of the use of magnetically treated water on productive parameters of beef cattle, especially animal blood biochemistry, final weight, and carcass finishing traits. A comparison was performed with a group of 10 animals in the state of São Paulo, Brazil. The use of magnetically treated water (MTW) did not influence the improvement in the blood biochemical indices of animals regarding the variables potassium (K), ionic calcium (iCa), chlorine (Cl), and cholesterol. The MTW group presented a 1.2% concentration index for the variable sodium (Na) in the blood compared to the control group.

PALAVRAS-CHAVE: Beef cattle, magnetized water, blood biochemistry.

1 INTRODUCTION

The increase in Brazilian meat exports to more demanding markets has led to the need to improve the quality of herd grading and finishing.

Brazil led global beef exports in 2021, with 2.40 million tons (17% of the total), with Asian countries being the largest buyer markets, corresponding to about 65% of the destination of these products (XIMENES and SOARES, 2021). These markets require levels of standardization in carcass finishing and sanitary standards (DIAS, 2021).

An increase in agricultural production is still necessary, given the increased world population. Thus, production efficiency should increase in the coming decades to meet the global demand for food. Global meat consumption is also expected to increase by 30%, which will require a 72% increase in current meat production by 2050 (COOKE et al., 2020; FAO, 2009).

Directing toward a more efficient and sustainable livestock production requires the production of quality beef, with lower operating costs (ARTEGOITIA, 2022). It demands studies of new techniques and technologies of livestock production.

The use of magnetically treated water (MTW) in cattle has increased calcium levels in the body, which increases its availability for metabolic functions, especially in its connection with calmodulin, allowing the stimulation of a large number of enzymes of lipid metabolism (ALFONSO et al., 2009).

MTW in ruminants resulted in improved nutrient digestibility, reducing water consumption, and optimizing ruminal fermentation parameters, with a positive effect on animal health. It also generated an increase in milk production and improved blood indicators and antioxidant capacity (YACOUT et al., 2015).

Considering a biotechnological function, MTW has presented several uses, showing its potential related to its conductivity characteristics, with a reduction of free radicals and antioxidant function. The formation of clusters of its molecules suggests higher absorption and permeability in cells (LEE et al., 2014).

Studies have shown that the results on the effects of MTW consumption on the physiology of animals are more favorable than in animals that received conventional water, mainly regarding a) increased permeability of the intestinal epithelium and the nutrients

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dissolved in it, b) improved hematopoietic response, c) improved immune system response, d) decreased occurrence of kidney stones, and e) increased general metabolism (ALFONSO et al., 2009).

Magnetic water treatment is a promising technique for improving agricultural results and further studies on different crops are required to understand the mechanism that leads to increased productivity (AGHAMIR et al., 2015).

The results obtained from the use of magnetically treated water in agriculture and the advances brought by its irrigation systems (PUTTI, 2014) have led to the questioning of whether positive results would also be obtained by its ingestion by beef cattle.

Moreover, MTW consumption by animals may be an alternative for the improvement of zootechnical standards, increasing their health and animal welfare indices, in addition to production parameters.

This study aimed to verify the effects of using magnetically treated water on the blood biochemistry of animals, final weight, and carcass fat finishing quality using a statistical approach as a method of analysis through a descriptive data analysis and the elaboration of an analysis of variance (ANOVA) and G-test.

2 THEORETICAL FRAMEWORK

For the theoretical contextualization of the present study, an in-depth exploration was conducted on the terminology to be used for water under the effect of a magnetic field, or magnetically treated water.

The main benefits and results found in the use of magnetically treated water in the biochemistry of animals were also characterized, to serve as a reference for discussion of the results found in this work.

2.1 MAGNETICALLY TREATED WATER (MTW)

In seeking this concept, various similar terminologies are found which, however, cannot be considered synonymous. Various authors introduce concepts such as "magnetized water," "magnetic water," or "charged water," which do not always refer to the type of water used in this study. These concepts may also refer to water that has been influenced by a prayer, or the imposition of hands, which transfers certain energy and attributes to this water (MOURA, 2010).

Thus, for the characterization of the present study, magnetically treated water (MTW) was used as that which, under the influence of an electromagnetic field, modifies its molecular structure. To transform water into magnetically treated water, the action of electromotive force is necessary, which is induced in a coil when the number of magnetic field lines is varying as it passes through it (AGHAMIR et al., 2015).

Studies suggest that the properties of MTW are different from conventional water. This is attributed to the forces of intermolecular interactions (hydrogen bonds) and nucleation processes (impurity, frequency, and growth of molecules) (BALIEIRO NETO et al., 2013b).

Magnetization allows for the obtaining of a physically modified liquid, with lower surface tension and higher electrical conductivity. There is also the creation of a magnetic memory that gives greater solubility, coagulation, crystallization. This makes the water lighter, purer, and with greater fluidity compared to its normal state (ALFONSO et al., 2009).

2.2 BENEFITS OF MTW IN BIOCHEMICAL PROCESSES

The physicochemical changes caused in water by the magnetization process can have positive impacts on living beings, making their biological processes more efficient, stimulating in animals and humans greater cellular irrigation and better blood circulation. The ingestion of MTW by animals has shown satisfactory results (ALFONSO et al., 2009).

The biological application of MTW is a promising and growing field of study, as presented in Chapter I. Considering a biotechnological function, the use of MTW has shown various uses demonstrating its potential, due to its conductivity characteristics, there is a reduction of free radicals and antioxidant function. The formation of clusters of its molecules suggests greater absorption and permeability in cells (LEE et al., 2014).

Alfonso et al. (2009) point out that the use of MTW in cattle increased calcium levels in the body, which increases its availability for metabolic functions, especially in its binding with calmodulin, allowing the stimulation of a large number of enzymes in lipid metabolism.

In ruminants, Yacout et al. (2015) show that magnetic treatment resulted in improved water quality, as a result, improves the digestibility of nutrients, reducing water consumption and optimizing ruminal fermentation parameters, being a positive effect on animal health. It also led to an increase in milk production and improvement of blood indicators and antioxidant capacity.

Studies have shown that the results on the effects of MTW consumption on the physiology of animals are more favorable than in animals that received conventional water mainly in: a) increased permeability of the intestinal epithelium and the nutrients dissolved in it; b) improvement of the hematopoietic response; c) improvement of the immune system response; d) decrease in the occurrence of kidney stones; e) increase in overall metabolism (ALFONSO et al., 2009).

Thus, it is worth questioning how the consumption of MTW by animals can be an alternative to improve zootechnical standards, increasing their health and animal welfare indices, in addition to productive parameters.

3 MATERIAL AND METHODS

According to TIMOL (2018), Sylocimol Rural is composed of alternating magnets covered with stainless steel protection that subjects the water to a magnetic field of 32,400 Gauss, which changes polarity 60 times per second, with constant emission of an ionizing flux of

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directed electrons breaking the water clusters, capable of magnetizing 5000 liters of water per hour.

The equipment was installed at the center of a 1000-liter circular water trough for cattle, producing a static magnetic field in the geometric center of the device. The experiment was carried out from December to July at Fazenda Santo Antônio in the municipality of Mirandópolis, SP, Brazil (ANDRADE, 2017).

Two groups of 10 animals each were used. The animals consisted of Nelore aged 14 ± 1 months and an average weight of 264.6 ± 7.33 kg. The two experimental groups were divided into the MTW group, which received magnetically treated water ad libitum by submerging the magnetizer in the water trough, and the common water (CW) group, which received water ad libitum from a water trough similar to that of the MTW group (ANDRADE, 2017).

Stage 1 – Animals maintained in a semi-intensive grazing system: The two groups (MTW and CW) were placed on pastures in contiguous fields in the same area with *Urochloa decumbens* grass forage for 120 days, with ad libitum water supply.

Arterial blood samples were collected from the caudal auricular artery at 18 ± 1 months.

Stage 2 – Animals maintained in an intensive grazing system: The two groups (MTW and CW) were placed on contiguous paddocks in the same area under a confinement regime. The animals received an adaptation feed from the 1st to the 7th day composed of sorghum silage, corn, citrus pulp, cottonseed meal, protected fat, nucleus, and urea, with 71.8% TDN (total digestible nutrients) and 15.5% of CP (crude protein). Moreover, the animals received a feed from the 8th to the 14th day with 75.2% TDN and 15% CP, followed by feed with 79.5% TDN and 14% CP after the adaptation period until the end of the experiment (ANDRADE, 2017).

Blood collection was performed at 20 and 21 months of age. The collection procedures followed the same procedures as in Stage 1.

The procedures described above were approved by the Ethics Committee on the Use of Animals in Experimentation (CEUA) of the University of Western São Paulo (protocol no. 2952).

The "Slaughter Characteristics Report," provided by a large slaughterhouse to the producer at the time of slaughter and final sale of animals, was used to collect data on final carcass weight and fat finishing quality.

3.3 DATA PROCESSING

The blood biochemistry and final carcass weight data were compared by an ANOVA test to verify the difference in the analyzed factors, as well as the interaction between them, in which the factors consisted of three ages and two treatments (type of ingested water). The analysis scheme was 3×2 with p=0.05.

The G-test was used to analyze the influence of the use of treated water on the fat finishing of animals, as it is indicated for categorical data and the sample n<20, with α=0.05.

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4 RESULTS AND DISCUSSION

4.1 ANALYSIS OF BLOOD BIOCHEMICAL INDICES

Still, few are the studies aimed to understand the effects of magnetically treated water consumption on animals. Thus, improving the understanding of its role in biological processes that lead to an improvement in animal performance is necessary (BALIEIRO NETO et al., 2013a; SARGOLZEHI et al., 2009; ALFONSO et al., 2000).

Biochemical tests were performed to verify the interactions of the consumption of magnetically treated water by cattle, as shown in Table 1 and Figure 1.

Table 1 – Comparative result of blood biochemistry between groups (MTW and CW) at different ages.

		ANIMAL AGE		
Variable	**Treatment**	**18 months**	**20 months**	**21 Months**
Na mmol/L	CW	135.9 ± 2.8	136.7 ± 4.8	141.4 ± 1.3
	MTW	140.7 ± 4.4	139.1 ± 6.4	139.6 ± 2.5
K mmol/L	CW	4.355 ± 0.477	4.496 ± 0.323	6.592 ± 0.836
	MTW	4.836 ± 0.410	4.509 ± 0.494	6.678 ± 0.484
iCa (mg/dL)	CW	0.349 ± 0.079	0.463 ± 0.109	0.520 ± 0.116
	MTW	0.382 ± 0.072	0.527 ± 0.166	0.451 ± 0.114
Cl (mg/dL)	CW	98.6 ± 2.1	98.6 ± 3.1	102.5 ± 1.7
	MTW	100.6 ± 3.2	100.3 ± 4.4	101.6 ± 2.4
Cholesterol (mg/dL)	CW	130.6 ± 23	249.8 ± 44.1	283.3 ± 73.2
	MTW	131.9 ± 20.2	252.4 ± 23.7	295.9 ± 59.8

Source: Research data.

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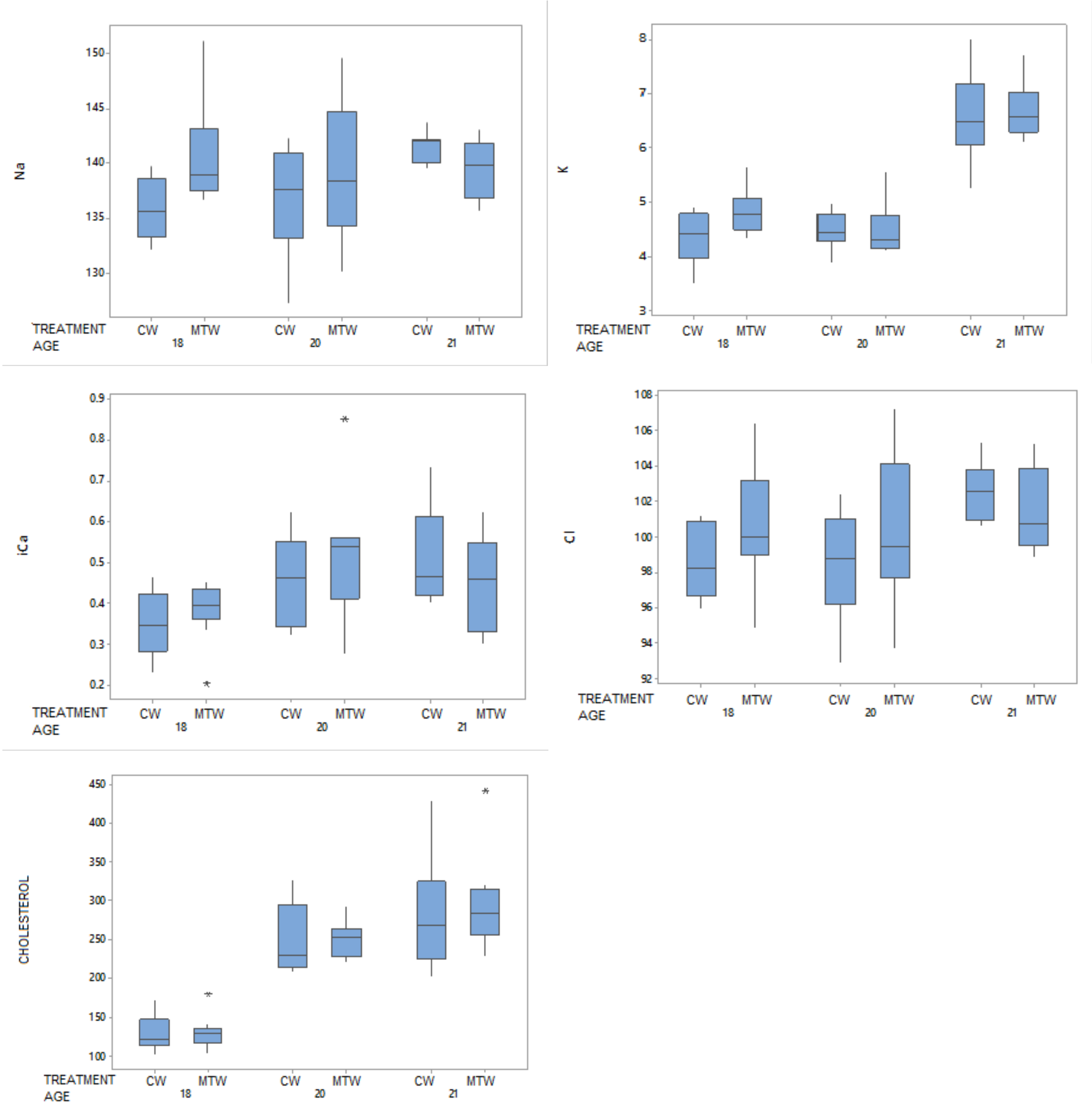
Figure 1 – Distribution of blood biochemistry data of animals (Na, K, iCa, Cl, and cholesterol).



Source: Research data.

Table 1 shows that the *P*-value obtained for the variable sodium (Na) presents a correlation, being significant (*P*=0.049). Thus, the null hypothesis (**H_0**) is rejected, while the alternative hypothesis (**H_1**) is accepted. The test shows that Na concentration in the blood of animals in the MTW group is influenced by the magnetically treated water compared to the CW group, that is, the control group.

Table 2 – Analysis of variance for age × treatment for the variables Na, K, iCa, Cl, and cholesterol.

	Source	DF	SS (Adj.)	MS (Adj.)	F-value	P-value
Na	AGE	2	73.23	36.61	2.26	0.115
	TREATMENT	1	42.71	42.71	2.64	0.111
	AGE* TREATMENT	2	103.20	51.60	3.19	0.049
	Residual	48	776.93	16.19	-	

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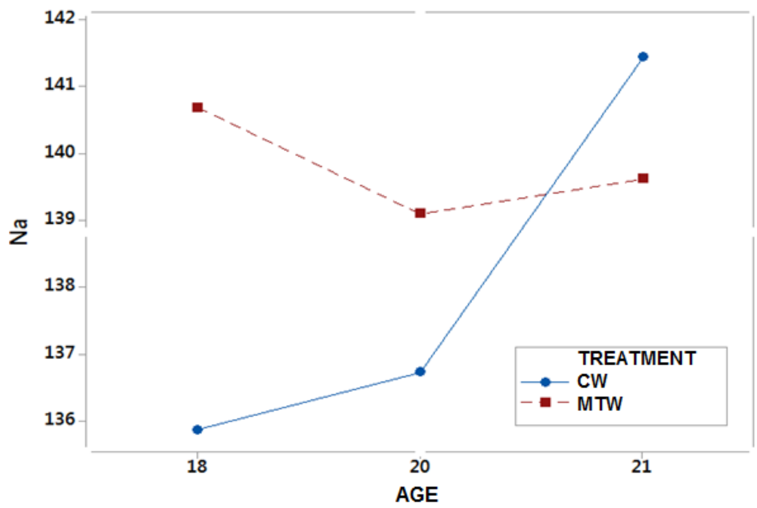
	Total	53	986.73			
K	AGE	2	53.3713	26.6857	95.91	0.000
	TREATMENT	1	0.5004	0.5004	1.80	0.186
	AGE* TREATMENT	2	0.5600	0.2800	1.01	0.373
	Residual	48	13.3551	0.2782		
	Total	53	67.5000			
iCa	AGE	2	0.18550	0.09275	7.40	0.002
	TREATMENT	1	0.00117	0.00117	0.09	0.761
	AGE* TREATMENT	2	0.04433	0.02216	1.77	0.182
	Residual	48	0.60169	0.01253		
	Total	53	0.82295			
Cl	AGE	2	77.73	38.867	4.59	0.015
	TREATMENT	1	12.01	12.015	1.42	0.239
	AGE* TREATMENT	2	23.37	11.683	1.38	0.261
	Residual	48	406.31	8.465		
	Total	53	515.61			
Cholesterol	AGE	2	246810	123405	58.07	0.000
	TREATMENT	1	401	401	0.19	0.666
	AGE* TREATMENT	2	356	178	0.08	0.920
	Residual	48	102002	2125		
	Total	53	352326			

Source: Research data.

Figure 2 shows the interaction between the variables in the correlation age × treatment.

Figure 2 – Interaction of sodium (Na) concentration in the blood biochemistry of animals in the MTW group compared to the control group.



Source: Research data.

The variables potassium (K), ionic calcium (iCa), chlorine (Cl), and cholesterol showed non-significant *P*-values. Thus, the null hypothesis (**H_0**) is accepted, while the alternative hypothesis (**H_1**) is rejected. The test shows that the concentration of these indices in the blood of animals in the MTW group is not influenced by the magnetically treated water compared to the CW group, that is, the control group.

The results corroborate previous research (SARGOLZEHI et al., 2009), which did not indicate alteration of minerals (Na, K, Mg, and P), glucose, urea, and cholesterol in the blood of animals that received magnetically treated water.

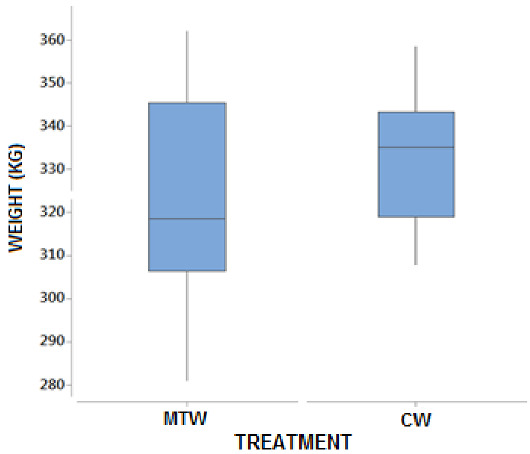
Benefits related to the increase in the absorption capacity of nutrients by the intestinal epithelium in the animal organism, such as glucose, calcium, and other minerals have been reported (ALFONSO et al., 2000). However, these results were not observed in the analyzed groups, as shown in Table 7.

4.2 FINAL CARCASS WEIGHT

No difference was found in the weight of the group that received magnetically treated water relative to the control group, in live animals at 20 and 21 months (ANDRADE, 2017). Thus, the final carcass weight was measured by the slaughterhouse after the animal was slaughtered, consisting of the reference weight for the producer's remuneration.

Figure 4 shows that the carcasses of animals in the MTW group presented an average weight of 321 ± 23.8 kg, with higher variability, while the animals in the CW group had an average weight of 332 ± 15.8 kg, with higher uniformity.

Figure 3 – Distribution of the carcass final weight (kg) of the animals.



Source: Research data.

Considering the data distribution, a single-factor ANOVA test was carried out with a decision level $\alpha = 0.05$, according to the hypotheses classified below:

- **H_0** – The use of magnetically treated water does not influence the final carcass weight: $\mu_1 = \mu_2$.
- **H_1** – The use of magnetically treated water influences the final carcass weight: $\mu_1 \neq \mu_2$.

Table 3 shows that the obtained F-value is not significant (F = 1.44). Thus, the null hypothesis (**H_0**) is accepted, while the alternative hypothesis (**H_1**) is rejected. The test shows that the carcass weight of animals in the MTW group was not influenced by the magnetically treated water compared to the CW group, that is, the control group.

Table 3 – Single-factor ANOVA for final carcass weight.

Source of variation	Sum of squares	Degree of freedom	Mean square	F	P-value	Critical F
Treatment	601.88	1	601.9	1.44	0.247	4.45
Residual	7117.66	17	418.7			
Total	7719.54	18				

Source: Research data.

Other studies have shown divergent conclusions from those obtained in this experiment, with significantly lower levels of subcutaneous fat thickness in dairy cows that consumed magnetically treated water (BALIEIRO NETO et al., 2013b).

Increased ionic calcium and increased lipid metabolism enzymes are among the main factors for lower weight gain and fat reduction (BALIEIRO NETO et al., 2013a). This process requires an additional energy source, reducing the conversion of dry matter intake into final weight. However, feed conversion was not measured in this study because we worked with carcass weight data and the animals were under a semi-intensive grazing system.

4.3 FAT FINISHING

Animals with a better fat finishing provide better quality meat, adding more value. Demand from more demanding markets has led slaughterhouses to pay a premium price to animals that meet a certain meat quality standard.

The grading systems aim to evaluate the carcass characteristics that are directly or indirectly related to yield and quality characteristics (SAINZ and ARAUJO, 2001).

Finishing scores were used based on the National Standards for Grades of Cattle Carcass, established by MAPA (2004), as shown in Table 9.

Table 4 – Classification of animal fat finishing according to Normative Instruction 09/2004 by MAPA.

Class	Classification	Fat thickness (mm)
1	Absent	0
2	Scarce	1–3
3	Medium	3–6
4	Uniform	6–10
5	Excessive	>10

Source: Adapted from MAPA (2004).

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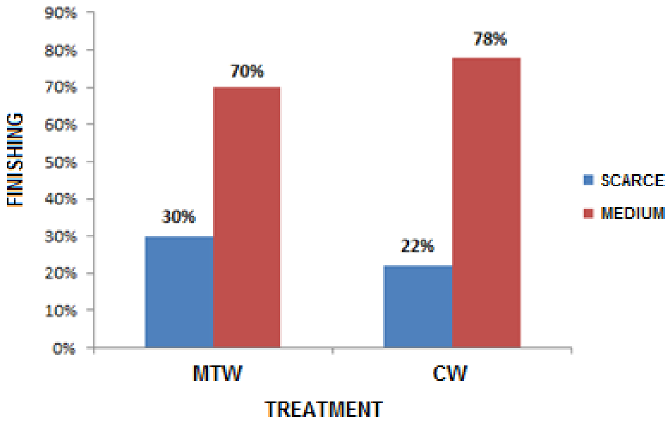
Based on previous studies, we sought to characterize whether the animal's fat finishing is influenced by magnetically treated water consumption.

The classification detailing was analyzed based on the Slaughter Characteristics Report, provided by the slaughterhouse, according to the parameters of the National Standards for Grades of Cattle Carcass (Table 9).

Figure 5 shows that the carcasses of animals of the MTW group had 70% medium fat finishing against 30% that had a scarce fat finishing, while animals of the CW group presented 78% medium fat finishing and 22% scarce fat finishing.

Figure 1 – Characterization of the percentage of fat finishing of animals in the MTW and CW groups.



Source: Research data.

Considering the data distribution, the G-test was performed with a decision level α = 0.05, according to the hypotheses classified below:

- **H_0** – The use of magnetically treated water does not influence the final fat finishing.
- **H_1** – The use of magnetically treated water influences the final fat finishing.

Table 5 – G-test for fat finishing of animals.

G-TESTE – α = 0.05	
Contingency table =	2 x 2
Sum of categories =	19
Degrees of freedom =	1
F-teste =	0.1487
(p) =	0.6998
G-teste (Williams) =	0.1340
(p) =	0.7143
G-teste (Yates) =	0.0188
(p) =	0.8908

Source: Research data.

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Table 5 shows that the obtained p-value is not significant (p=0.6998). Thus, the null hypothesis (**H_0**) is accepted, while the alternative hypothesis (**H_1**) is rejected. The test shows that the fat finishing of animals of the MTW group was not influenced by the magnetically treated water in comparison with the CW group, that is, the control group.

The results point to different conclusions from other studies. A study with calves showed that their meat had less fat even with an increase in weight after using MTW (LIN and YOTVAT, 1990). Another study showed lower fat content in the meat of male calves that consumed MTW (LEVY et al., 1990) and lower subcutaneous fat thickness in dairy cows (BALIEIRO NETO et al., 2013a).

5 CONCLUSIONS

The use of MTW did not influence the improvement of biochemical indices in the blood of animals for the variables K, iCa, Cl, and cholesterol, maintaining the standard of the control group. The MTW group had a lower concentration index for the variable Na in the blood than the control group.

The final carcass weight and fat finishing were also not influenced by the consumption of magnetically treated water, which contradicts the results of other studies. These variables still need to be further explored to determine whether the final quality of meat has improved, which could increase its value in the consumer market.

A deeper understanding of the interaction between magnetically treated water and the biological processes of animals is necessary for future studies. In addition to the qualitative improvement in health, the correct understanding of these processes may lead to better use of this technology in livestock.

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