DOI: https://doi.org/10.54393/fbt.v4i01.91

FUTURISTIC BIOTECHNOLOGY

https://fbtjournal.com/index.php/fbt
ISSN (E): 2959-0981, (P): 2959-0973
Volume 4, Issue 1 (Jan-Mar 2024)

Original Article

Impact of Dietary Supranutritional Selenium on Improving the Meat Quality of Goats

Muhammad Anees Memon[1], Moolchand Malhi[1], Allah Bux Kachiwal[1] and Ghulam Shabir Barham[2]

[1]Department of Veterinary Physiology and Biochemistry, Sindh Agriculture University Tandojam, Pakistan
[2]Department of Animal Product Technology, Sindh Agriculture University Tandojam, Pakistan

ARTICLE INFO

Keywords:
Dietary Selenium, Glycogen, Goat Meat, Semimembranosus, Longissimus Dorsi

How to Cite:
Memon, M. A., Malhi, M., Kachiwal, A. B., & Barham, G. S. (2024). Impact of Dietary Supranutritional Selenium on Improving the Meat Quality of Goats: Supranutritional Selenium and Goat Meat. Futuristic Biotechnology, 4(01). https://doi.org/10.54393/fbt.v4i01.91

***Corresponding Author:**
Moolchand Malhi
Department of Veterinary Physiology and Biochemistry,
mcmalhi@sau.edu.pk

Received Date: 6th February, 2024
Acceptance Date: 22nd March, 2024
Published Date: 31st March, 2024

ABSTRACT

Selenium (Se) a crucial micronutrient, is required in many biochemical processes in animals. Supranutritional levels of Se in the diet have been suggested to potentially enhance meat quality in livestock. However, limited research exists on the impact of dietary supranutritional Se on meat quality in goats. **Objective:** To evaluate the influence of dietary supranutritional Se on goat muscle meat quality, examining pH, water holding capacity (WHC), cooking and drip losses, moisture, protein, fat, ash, and glycogen contents. **Methods:** Sixteen male goats were randomly grouped into two viz., A and B (n = 8 per group) and offered basal diets without (group A) or with addition of Se (group B) for 10 weeks. Meat samples were collected from the longissimus dorsi (LD) and semimembranosus (SM) muscles at the completion of trial and the physico-chemical characteristics were determined. **Results:** Supranutritional Se supplementation resulted in significantly higher ($P < 0.05$) WHC and lower ($P < 0.05$) cooking and drip losses in both LD and SM muscles compared with control. Additionally, the protein and fat contents were significantly elevated ($P < 0.05$) and the ash contents lowered ($P < 0.05$) in both LD and SM muscles of goats fed Se supplemented diet compared with control. However, the pH and glycogen contents were not altered ($P > 0.05$) between the two groups. **Conclusions:** The findings of present trial demonstrated that supranutritional Se supplementation improved the quality of goat meat, contributing to its nutritional value and consumer acceptance.

INTRODUCTION

Meat characteristics encompass attributes such as color, texture, firmness, tenderness, marbling, and more. Among these, the degree and method of fat deposition hold particular significance. The dressing percentage serves as a crucial metric for assessing carcass quality. In general, an increased eye muscle area correlates with a higher proportion of lean meat [1]. The inclusion of Se in diet modified the metabolism of lipid in cattle and lowered the meat's cholesterol content [2]. In developing Polish Merino lambs, selenium consumption also affected the mRNA expression of genes linked to lipid metabolism and cholesterol in the liver and longissimus dorsi (LD) muscle [3]. Meat quality is improved by selenium, which also improves the meat's flavour and keeping qualities. Glutathione peroxidase (GSH-Px) has antioxidant properties that help to prevent oxidation events that might harm meat products' nutritional value and flavour [4]. The content of selenium (Se) in bovine tissues rises when they are fed dietary Se [5]. The concentration is influenced by several variables, including the animal species involved, the length of the experiment, the diet's selenium content, and the source of selenium. Although selenium is found in various amounts in all organs, the liver, kidneys, and spleen have higher concentration of mineral. Conversely, it is present in the lungs, intestines, heart muscles, and skeletal muscles to a lesser degree [6].

This research was intended to examine the influence of high dietary selenium levels on the meat quality of goat

DOI: https://doi.org/10.54393/fbt.v4i01.91

muscles, addressing a gap in understanding how increased selenium intake influences various aspects of meat quality. By examining key indicators such as pH, water holding capacity, cooking and drip losses, moisture, protein, fat, ash, and glycogen content in specific muscle groups, the study seeks to determine whether supranutritional selenium positively or negatively impacts meat quality in goats. The findings from this research are essential for farmers, researchers, and stakeholders in the livestock industry, providing valuable insights for optimizing dietary Se levels to enhance meat quality, thereby contributing to the sustainability and profitability of goat farming.

METHODS

Ethical Approval

The methodology of present trial including animal handling, sampling and analytical protocols were carried out after the approval from directorate of advanced studies (No. DAS/1334/of 2023), Sindh Agriculture University (SAU) Tandojam.

Animal Selection and Adaptation

Sixteen male goats (aged 3-4 months, weighing 10-13 kg) were obtained from a local market and housed at livestock experimental station, SAU Tandojam. Animals were given a minimum two weeks of time as an adjustment period during which they were ear-tagged for identification, dewormed, and vaccinated. Goats were offered a basal diet (BD) comprising of concentrate (supplied at 2% body weight) and roughage (freely accessible) (Table 1). Water was provided ad libitum.

Table 1: Chemical Composition of Diets Offered to Goats

Chemical composition	Concentrate	Roughage
Dry Matter (%)	87.75	89.81
Crude protein (%)	20.89	7.32
Crude fat (%)	3.64	2.02
Crude fiber (%)	6.67	28.25
Crude ash (%)	7.73	6.4
Metabolizable Energy (ME, MJ/kg)	10.85	6.96

Experiment Design and Feeding Management

After adaptation, animals were randomly assigned to two groups, i.e., control (A) and Se supplemented (B), with eight animals in each group. They were individually housed and fed either BD (A) or BD supplemented with Se (B) for 10 weeks.

The Se Source and Dosage

The background Se levels (mg kg-1 diet) in concentrate (0.15) and roughages (0.03), were analyzed through inductively coupled plasma mass spectrometry (ICP-OES Optima 2100-DV, Perkin Elmer). Animals in group B received a BD diet supplemented with supranutritional dose (0.5 mg kg-1 diet). The Se was fed from organic source i.e., Selenium yeast (SY) (Sel-Plex®, Alltech®, USA).

Slaughtering and Skeletal Muscle Collection

After the completion of feeding trial, goats were humanely sacrificed via the Halal method by cutting the jugular veins. The skin was immediately removed and then the muscles were carefully extracted from two different regions, washed with a cold phosphate buffer solution (PBS), and collected in a clean container.

Physico-Chemical Characteristics of Meat

To examine the physical and chemical features of the meat, the samples were obtained from longissimus dorsi (LD) and semimembranosus (SM) muscles, respectively [7]. The LD muscle was extracted from the left carcass (between the 8th and 11th thoracic vertebrae) as described by Honikel [8]. Before conducting any physical and chemical analyses, all visible fat was meticulously removed from the muscles.

Determination of Meat Quality

Meat samples were evaluated for pH, water holding capacity (WHC), cooking loss, drip loss, and chemical characteristics including moisture content, total protein, total fat, ash, and glycogen content.

Statistical Analysis

The Statistix (SXW) student edition (Copyright 2005, Analytical Software, USA) was employed to compute the least significant differences following the detection of significant mean differences through analysis of variance (ANOVA).

RESULTS

Physical Properties of Muscle Meat

1. pH: Effects of supranutritional Se treatment on pH of goat meat are shown in Table 2. The pH of LD muscle and SM muscle (thigh muscle) was non-significant between A and B group.

2. Water Holding Capacity (WHC, %): Dietary supranutritional Se produced significant effect on WHC in LD and SM muscles in goats. WHC in LD muscle raised ($P < 0.05$) in B (82.3 %) than in A (78 %). Likewise, WHC in SM muscle raised ($P < 0.05$) in B (79 %) than in A (74 %). In addition, the WHC was detected higher ($P < 0.05$) in LD compared with SM muscle in goats fed Se supplemented diet (table 2).

3. Cooking Loss (%): Cooking loss in LD and SM muscles was significant ($P < 0.05$) between groups. Cooking loss in LD muscle elevated ($P < 0.05$) in A (37 %) compared with B (33.66 %). Similarly, cooking loss in SM muscle was higher ($P < 0.05$) in A (34.1 %) compared with B (28.29%). In addition, cooking loss was observed higher in LD muscle compared with SM muscle in goats fed Se supplemented diet (table 2).

4. Drip Loss (%): Drip loss in LD and SM muscles was significantly ($P < 0.05$) affected by Se treatment (table 2). Drip loss in LD muscle was higher ($P < 0.05$) in A (2.4 %) compared with B (2.2 %). Similarly, drip loss in SM muscle was higher ($P < 0.05$) in A (2.29 %) compared with B (2.17 %).

DOI: https://doi.org/10.54393/fbt.v4i01.91

Moreover, the drip loss (%) was determined higher in LD muscle compared with SM muscle in goats fed Se supplemented diet.

Table 2: Effects of Dietary Supranutritional Selenium on the Physical Properties of Muscle Meat in Goat

Groups	pH		WHC (%)		Cooking Loss (%)		Drip Loss (%)	
	LD	SM	LD	SM	LD	SM	LD	SM
A	5.93	5.90	78.00	74.00	37.00	34.10	2.40	2.29
B	5.76	5.94	82.33	79.00	33.66	1.4530	2.21	2.17
SEM	0.1972	0.2028	1.0541	1.6330	1.0541	1.4530	0.0493	0.0320
P-value	0.4456	0.8774	0.0147	0.0376	0.0341	0.0214	0.0183	0.0218

LD = Longissimus Dorsi Muscle; SM = Semimembranosus Muscle, A = Control; B = Selenium Yeast (0.5 mg kg-1 feed); Values are Mean, Significance level P < 0.05.

Chemical Properties of Muscle Meat

1. Moisture Content (%): Supranutritional Se treatment exerted significant (P < 0.05) effect on moisture content (%) in muscle meat of goat as shown in table 3. Moisture content in LD muscle was reduced (P < 0.05) in B (71.63 %) compared with A (74.37 %). Similarly, significant drop (P < 0.05) in moisture content of SM muscle was seen in B (74.52 %) compared with A (76.42 %). Moreover, the moisture content was observed higher in SM muscle compared to LD muscle in goat fed Se supplemented diet.

2. Protein Content (%): The protein content in LD muscle and SM muscle was significant (P < 0.05) between A and B groups. The protein content in LD muscle was higher (P < 0.05) in B (23.82 %) compared with A (21.34 %). Similarly, the protein content in SM muscle was higher in B (21.34 %) compared with A (19.78 %). Moreover, the protein content was observed higher in LD compared with SM muscle in goat fed Se supplemented diet.

3. Fat Content (%): Muscle fat content (%) was significantly (P < 0.05) affected by Se treatment between A and B groups. Fat content in LD muscle was higher (P < 0.05) in B (2.84 %) compared with A (2.54 %). Similarly, the fat content in SM muscle elevated (P < 0.05) in B (2.46 %) compared with A (2.28 %). Moreover, the fat content was determined higher in LD compared with SM muscle in goat fed Se supplemented diet.

4. Ash Content (%): The ash content (%) in LD muscle and SM muscle was non-significant (P > 0.05) between A and B groups. However, the ash content in LD muscle was higher in A (0.75%) compared with B (0.61%). Similarly, the ash content in SM muscle was higher in A (0.68%) compared with B (0.43%). Moreover, the ash content was determined higher in LD muscle compared to SM muscle for both A and B group.

5. Glycogen Content (%): The glycogen content in LD and SM muscles was significant (P > 0.05) between A and B group (table 3). The LD muscle glycogen was higher in B (1.1 %) compared with A (0.9 %). Similarly, the SM muscle glycogen was higher in B (1.05 %) compared with A (0.84%). Moreover, the glycogen content was determined higher in LD muscle compared with SM muscle for both A and B group.

Table 3: Effects of Dietary Supranutritional Selenium on the Chemical Properties of Muscle Meat in Goat

Groups	Moisture %		Protein (%)		Fat (%)		Ash (%)		Glycogen (%)	
	LD	SM	LD	SM	LD	SM	LD	SM	LD	SM
A	74.37	76.42	21.44	19.78	2.54	2.28	0.75	0.68	0.90	0.84
B	71.63	74.52	23.82	21.34	2.84	2.46	0.61	0.43	1.10	1.05
SEM	1.776	1.802	0.793	0.328	0.066	0.045	0.058	0.035	0.037	0.025
P-value	0.021	0.033	0.04	0.009	0.011	0.016	0.064	0.002	0.043	0.001

LD = Longissimus Dorsi Muscle; SM = Semimembranosus Muscle, A = Control; B = Selenium Yeast (0.5 mg kg-1 feed); Values are Mean, Significance level P < 0.05.

DISCUSSION

In this study, goats receiving supranutritional Se at 0.5 mg kg-1 diet, exhibited significantly higher levels of WHC, moisture, protein, and fat in longissimus dorsi (LD) and semimembranosus (SM) muscle compared with control. Conversely, control goats showed significantly higher cooking loss, drip loss, and ash content in both LD and SM muscles compared with Se treated goats. In terms of meat's physical properties, including pH, WHC, cooking loss, and drip loss, our findings are consistent with previous research [9]. This aligns with other studies showing that supplementing with Se did not significantly affect these meat characteristics in lambs and calves [10]. Additionally, it was demonstrated that dietary treatment did not lead to substantial differences (P > 0.05) in pH, water loss percentage, drip loss, or cooking loss [11]. The high Se exhibited comparatively darker meat color. However, according to Silva *et al.*, Se supplementation, whether organic or inorganic, did not affect carcass pH, drip loss, or cooking loss [12]. In another study, Markovic *et al.*, reported the decrease in pH of meat from broilers fed high Se in diet [13]. In addition, extra Se supplementation increased both protein and lipid contents in breast muscle meat of broilers. Moreover, the protein content was comparatively higher in thigh muscle meat compared with breast muscle meat in broilers fed extra-Se diet [13]. The ash content in breast muscle meat decreased in broilers receiving high-Se diet [13]. One study demonstrated that supplementing the diet with Se did not affect the meat's pH levels [14]. However, previous studies have shown that Se addition decreased muscle meat pH in dose-dependent manner, leading to much decrease in pH with extra dose of Se in broilers diet [15]. Another investigation observed an upward trend in the pH of loin muscle in beef treated with Se [16], likely due to greater hydrogen peroxide depletion. Oxidative stress, linked to increased drip loss in breast

DOI: https://doi.org/10.54393/fbt.v4i01.91

meat, accelerated pH decreases after slaughter, and increased lightness (color) of thigh meat, has been implicated in previous research [17]. In our study, the meat's moisture, protein, and ash concentrations were significantly higher in Se treated goats compared with control. Previous research found no appreciable effects of a diet supplemented with Se on moisture, protein, and ash levels, which is not consistent with our results [18]. In contrast, calves given a diet deficient in Se, they did note a non-significant rise in meat fat content of 11.76 % in the former group. Given that insulin has been shown to have anabolic effects on fat [19], the increased synthesis of fat in the muscles of goats given SY may be due to the Se's insulin-like properties. Similarly, another research discovered that broilers given supplemental Se had muscles with a greater crude protein content than those fed unsupplemented Se [20]. The higher protein absorption brought on by Se-enhanced thyroid hormone metabolism may be the cause of this rise in protein content. Several investigators have noted that greater doses of Se supplementation were associated with an increase in the intramuscular fat content of meat [15]. Overall, it has been shown that Se enhances the nutritious content, flavour, and keeping quality of meat. Oxidation processes may have a detrimental effect on the nutritional content and flavours of meat products, although glutathione peroxidase (GSH-Px) has the antioxidant capacity to counteract these effects [4]. The concentration of Se in ruminant tissues is increased by dietary Se [5]. This phenomenon is regulated by several parameters, including the animal species, the amount of Se in the diet, the length of the experiment, and the source of Se [21]. Although Se may be found in several tissues at different concentrations, the liver, kidneys, and spleen have the highest concentrations of this mineral, while skeletal muscles, cardiac muscles, intestines, and lungs have lower concentrations [6]. Se supplements to ruminant diets may improve the meat's oxidative stability. Oxidative processes have a substantial influence on the qualitative features of meat [4]. Reducing oxidation is one way to maintain meat quality [22] and having antioxidants in the meat itself is essential to doing this.

CONCLUSIONS

The findings of present study indicate that dietary supranutritional Se addition positively affected the muscle meat quality in goat, presenting the opportunities to enhance consumer satisfaction and marketability. However, additional studies are required to optimize supplementation levels and fully to understand the underlying mechanisms.

Authors Contribution

Conceptualization: MM
Methodology: MAM, ABK
Formal analysis: MAM, MM, ABK, GSB
Writing-review and editing: MAM, MM, ABK, GSB

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Source of Funding

The authors received no financial support for the research, authorship and/or publication of this article.

REFERENCES

[1] Mickan FJ, Thomas GW, Spiker SA. A comparison between Friesian bulls and steers on pasture for lean meat production. Australian Journal of Experimental Agriculture. 1976 Jun; 16(80): 297-301. doi: 10.1071/EA9760297.

[2] Netto AS, Zanetti MA, Del Claro GR, de Melo MP, Vilela FG, Correa LB. Effects of copper and selenium supplementation on performance and lipid metabolism in confined brangus bulls. Asian-Australasian Journal of Animal Sciences. 2014 Apr; 27(4): 488. doi: 10.5713/ajas.2013.13400.

[3] Juszczuk-Kubiak E, Bujko K, Cymer M, Wicińska K, Gabryszuk M, Pierzchała M. Effect of inorganic dietary selenium supplementation on selenoprotein and lipid metabolism gene expression patterns in liver and loin muscle of growing lambs. Biological Trace Element Research. 2016 Aug; 172: 336-45. doi: 10.1007/s12011-015-0592-0.

[4] Gatellier P, Mercier Y, Juin H, Renerre M. Effect of finishing mode (pasture-or mixed-diet) on lipid composition, colour stability and lipid oxidation in meat from Charolais cattle. Meat Science. 2005 Jan; 69(1): 175-86. doi: 10.1016/j.meatsci.2004.06.022.

[5] Scholz RW, Todhunter DA, Cook LS. Selenium content and glutathione peroxidase activity in tissues of young cattle fed supplemented whole milk diets. American Journal of Veterinary Research. 1981 Oct; 42(10): 1718-23. doi:10.3168/jds.S0022-0302(84)81598-2.

[6] Pond WG, Church DB, Pond KR, Schoknecht PA. Basic Animal Nutrition and Feeding. John Wiley & Sons. 2004.

[7] Das AK and Rajkumar V. Comparative study on carcass characteristics and meat quality of three Indian goat breeds. Indian Journal of Animal Sciences. 2010 Oct; 80(10): 1014.

[8] Honikel KO. Reference methods for the assessment of physical characteristics of meat. Meat Science.

DOI: https://doi.org/10.54393/fbt.v4i01.91

1998 Aug; 49(4): 447-57. doi: 10.1016/s0309-1740(98)00034-5.

[9] Samo SP, Malhi M, Gadahi J, Lei Y, Kaciwal AB, Soomro SA. Effect of Organic Selenium Supplementation in Diet on Gastrointestinal Tract Performance and Meat Quality of Goat. Pakistan Journal of Zoology. 2018 Jun 1;50(3).doi:10.17582/journal.pjz/2018.50.3.995.1003.

[10] Hernandez-Calva LM, Ramirez-Bribiesca JE, Guerrero-Legarreta I, Hernandez-Cruz L, Avendaño-Reyes L, Dominguez Vara I *et al*. Influence of dietary magnesium and selenium levels in finishing diets on growth performance and carcass meat quality of feedlot Pelibuey lambs. Archives Animal Breeding. 2013 Oct; 56(1): 303-14. doi:10.7482/0003-9438-56-030.

[11] Tian XZ, Li JX, Luo QY, Wang X, Xiao MM, Zhou D *et al*. Effect of supplementation with selenium-yeast on muscle antioxidant activity, meat quality, fatty acids and amino acids in goats. Frontiers in Veterinary Science. 2022 Jan; 8: 813672. doi: 10.3389/fvets.2021.813672.

[12] Silva JD, Rodriguez FD, Trettel M, Abal RT, Lima CG, Yoshikawa CY *et al*. Performance, carcass characteristics and meat quality of Nellore cattle supplemented with supranutritional doses of sodium selenite or selenium-enriched yeast. Animal. 2020 Jan; 14(1): 215-22. doi: 10.1017/S1751731119001265.

[13] Markovic R, Ćirić J, Drljačić A, Šefer D, Jovanović I, Jovanović D *et al*. The effects of dietary Selenium-yeast level on glutathione peroxidase activity, tissue Selenium content, growth performance, and carcass and meat quality of broilers. Poultry Science. 2018 Aug; 97(8): 2861-70. doi: 10.3382/ps/pey117.

[14] 1Göçmen R, Yazgan O, Cufadar Y. Effect of different organic and inorganic selenium levels on performance, selenium concentrations of some tissues, glutathione peroxidase enzyme activity and meat quality in broilers. JAPS: Journal of Animal & Plant Sciences. 2016 Aug; 26(4).

[15] Baltić MŽ, Starčević MD, Bašić M, Zenunović A, Ivanović J, Marković R *et al*. Effects of selenium yeast level in diet on carcass and meat quality, tissue selenium distribution and glutathione peroxidase activity in ducks. Animal Feed Science and Technology. 2015 Dec; 210: 225-33. doi: 10.3382/ps/pey117.

[16] Zhan X, Wang M, Zhao R, Li W, Xu Z. Effects of different selenium source on selenium distribution, loin quality and antioxidant status in finishing pigs. Animal Feed Science and Technology. 2007 Jan; 132(3-4): 202-11. doi:10.1016/j.anifeedsci.2006.03.020.

[17] Wang RH, Liang RR, Lin H, Zhu LX, Zhang YM, Mao YW *et al*. Effect of acute heat stress and slaughter processing on poultry meat quality and postmortem carbohydrate metabolism. Poultry Science. 2017 Mar; 96(3): 738-46. doi: 10.3382/ps/pew329

[18] Marounek M, Skřivanová E, Skřivanová V. Selenium content and antioxidant status in tissues of veal calves fed a diet supplemented with selenium yeast. Slovak Journal of Animal Science. 2006 Jun; 39(1-2): 51-4.

[19] Berg EA, Wu JY, Campbell L, Stapleton SR. Insulin-like effects of vanadate and selenate on the expression of glucose-6-phosphate dehydrogenase and fatty acid synthase in diabetic rats. Biochimie. 1995 Jan; 77(12):919-24. doi: 10.1016/0300-9084(95)80002-6.

[20] Ibrahim MT, Eljack BH, Fadlalla IM. Selenium supplementation to broiler diets. Animal Science Journal. 2011; 2(1): 12-7.

[21] Grace ND and Watkinson JH. Distribution and the amounts of Se associated with various tissues and liveweight gains of grazing sheep. In: Trace Elements in Man and Animals: TEMA 5: proceedings of the fifth International Symposium on Trace Elements in Man and Animals/editors CF Mills, I. Bremner, & JK Chesters 1985. Farnham Royal, Slough: Commonwealth Agricultural Bureaux, c1985. doi:10.1079/9780851995953.0285.

[22] Faustman C and Cassens RG. Strategies for improving fresh meat color. In: 35. International Congress of Meat Science and Technology, Copenhagen (Denmark), 20-25 Aug 1989. SFI. doi: Org/10.1111/J.1745-4573.1990.