Acta Scientiae Veterinariae, 2023. 51: 1905.

RESEARCH ARTICLE
Pub. 1905

ISSN 1679-9216

Calves with Arthritis - Changes in Antioxidant Parameters

Selvinaz Yakan

ABSTRACT

***Background*:** In a healthy organism, oxidants and antioxidants are in balance. However, in cases such as inflammation, infection, and stress, this balance is disrupted in favor of oxidants, creating oxidative stress that can cause damage to cells or tissues. It is known that oxidative stress plays a role in the pathogenesis of many diseases. Determination of oxidant and antioxidant balance, especially in inflammatory diseases, plays an important role in elucidating the pathogenesis of the disease and developing treatment strategies. This study, it was aimed to reveal the oxidant status in inflammatory disease of calves with septic and aseptic arthritis.

***Materials, Methods & Results*:** The material of the study consisted of 21 calves up to 2 months old, of different races and genders, 14 (9 male, 5 female) with arthritis and 7 healthy (control, 5 male, 2 female). Of the calves with arthritis, 11 were septic and 3 were acute aseptic. In the calves with arthritis, the affected joint or joints were determined by clinical examinations. By palpating the joints, swelling, local temperature increase, tension in the joint capsule, presence of pain, and the presence and severity of lameness were examined. The color, clarity, viscosity, odor, and clot formation of the synovial fluid were examined and determined to be septic or aseptic. To determine the antioxidant status, the levels of malondialdehyde (MDA), which is the most important oxidative stress marker, and superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), and catalase (CAT), which are the enzymatic antioxidant enzymes, were measured spectrophotometrically in serum samples. Vitamin E, C, and A levels, which are nonenzymatic antioxidants, were also measured colorimetrically. In the clinical examination, lameness was detected in the relevant extremity of all patients with arthritis. In the macroscopic examination of the synovial fluids taken from animals with arthritis, the colors of the synovial fluids varied between yellow and yellow tones in 11 cases; in 3 cases, it was determined that they were red and brown. It was observed that the colors of the synovial fluids were transparent in the subjects in the control group. It was observed that the synovial fluid clarity of the calves with arthritis was lost, with severe turbidity (+++) in 3 cases, moderately turbid (++) in 6 cases, slightly turbid (+) in 2 cases, and clear (-) in 3 cases. It was observed that the viscosity of synovial fluid taken from calves with arthritis decreased in varying degrees according to the severity of the disease, severe (+++) in 5 cases, moderately decreased (++) in 4 cases, slightly decreased (+) in 2 cases, and normal in 3 cases. It was determined that the viscosity of the synovial fluid taken from the calves in the control group was normal. There was a statistically significant difference between the groups in terms of MDA ($P < 0.01$), SOD ($P < 0.01$), GSH-Px ($P < 0.05$), vitamin E ($P < 0.001$), and vitamin C ($P < 0.01$), while MDA levels increased in calves with arthritis, SOD and GSH-Px activities and vitamin E and C levels decreased significantly. Although there was no statistically significant difference in CAT ($P > 0.05$) enzyme activity, it was determined that it was at a lower level in calves with arthritis, and there was no significant difference between the groups in terms of vitamin A ($P > 0.05$).

***Discussion*:** According to the results of the study, there is an increase in oxidative stress and a decrease in antioxidant status in calves with arthritis. It is thought that these changes may be due to efforts to reduce tissue damage by reducing lipid peroxidation. As a result, it was determined that oxidant and antioxidant balance was impaired in calves with arthritis, and oxidative stress and lipid peroxidation developed due to the increase in free radicals. It is thought that giving additional antioxidants to the calves may contribute to the recovery of the disease and reduce treatment costs.

Keywords: calf, inflammatory disease, oxidative stress, lipid peroxidation, lameness, malondialdehyde (MDA).

DOI: 10.22456/1679-9216.128989

Received: 27 November 2022 Accepted: 20 February 2023 Published: 15 March 2023

Department of Animal Health, Eleşkirt Celal Oruç Animal Production School, Ağrı İbrahim Çeçen University, Ağrı, Türkiye. CORRESPONDENCE: S. Yakan [syakan@gmail.com]. Department of Animal Health, Eleşkirt Celal Oruç Animal Production School, Ağrı İbrahim Çeçen University. TR-04100 Ağrı, Türkiye.

INTRODUCTION

Arthritis, an inflammatory disease of the joints, is of great importance in terms of prevalence, treatment, and economy in calves [1,9,30]. Joint inflammations in calves can be acute-chronic and aseptic-septic. Aseptic joint inflammations develop as a result of traumas, luxations, distortions, and excessive strain. Septic joint inflammations, on the other hand, are shaped when the infectious agents are either directly transmitted to the joint or adjacent tissues by traumatic effect, or are settled in the joints in a hematogenous way as a result of infectious diseases such as septicemia, omphalitis, pneumonia [1,7,20,21].

In a healthy organism, oxidants and antioxidants are in balance. However, in cases such as inflammation, infection, and stress, this balance is disrupted in favor of oxidants, creating oxidative stress that can cause damage to cells or tissues. Free radicals whose concentration increases in oxidative stress; cause oxidative damage by affecting molecules such as lipids, carbohydrates, proteins, and nucleic acids [4,5,12-14]. The organism has enzymatic (such as superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GSH-Px)) and nonenzymatic (such as vitamins A, E, and C) antioxidant defense systems that metabolize free oxygen radicals [11,26-28]. Whether oxidative stress develops the determination of lipid peroxidation (malondialdehyde, MDA) is the most common method used [13].

This study, it was aimed to determine the changes in antioxidant parameters in aseptic-septic joint inflammations (arthritis), which is common in calves, causing loss of productivity and high economic losses.

MATERIALS AND METHODS

Animals

The material of the study consisted of 21 calves up to 2 months old, of different races and genders, 14 (9 male, 5 female) with arthritis and 7 healthy (control, 5 male, 2 female). Of the calves with arthritis, 11 were septic and 3 were acute aseptic.

Clinical examination

The affected joint or joints were determined by performing the necessary clinical examinations. By palpating the joints, swelling, local temperature increase, tension in the joint capsule, presence of pain, and the presence and severity of lameness were examined. The severity of arthritis was tried to be determined by making passive movements to the joints. After cleaning and disinfection of the area, a physical examination was performed by puncturing the relevant joint and aspirating the inflamed joint synovium. Arthritis cases detected as a result of physical examination of synovial fluid and clinical examinations were included in the study. The cases were evaluated as septic and aseptic according to the synovial fluid characteristics and the presence of other findings in the animal.

Macroscopic examination of synovial fluid

The color, clarity, viscosity, odor, and clot formation of the synovial fluid were examined and determined to be septic or aseptic. Color changes of synovial fluid were determined by comparing it with normal synovial fluid findings. The change in viscosity was detected by distilling the synovial fluid from a syringe needle or by holding it between two fingers and stretching it. The appearance of the synovial fluid was determined by comparing it with the normal fluid properties.

Collection of blood samples

Blood samples were taken from the vena jugularis of the animals in both the study and control groups into sterile glass tubes without anticoagulant, centrifuged at 3000 *g* for 5 min, the samples were taken into Eppendorf tubes and frozen at -20°C for analysis as soon as possible.

Serum biochemical analysis

The levels of MDA [29], SOD [25], GSH-Px [22], and CAT [8] from the serums obtained were measured using a spectrophotometer [model Shimadzu UV-1700][1] following the procedure.

Vitamin E [Vitamin E (VE) Colorimetric Assay Kit][2] and vitamin A [Vitamin A (VA) Colorimetric Assay Kit][2] levels, which are antioxidant vitamins, were determined in High-Performance Liquid Chromatography (HPLC) [model Shimadzu][1] device with the help of commercial test kits following the technique. Vitamin C levels were determined colorimetrically using the phosphotungstic acid method [15].

Statistical analysis

The SPSS [Statistical Package for Social Sciences for Windows- 20.0 program][3] was used on the Windows software base for the statistical evaluation of

the data obtained from the study. Data are presented as mean ± standard deviation. Student *t*-test and Mann-Whitney U test were used to determine the significance levels between groups. Values with a significance level of $P < 0.05$, and $P < 0.001$ were considered statistically significant.

RESULTS

Of the 14 calves with arthritis included in the study, 9 were male, and 5 were female, it was determined that 7 of the case with arthritis were Montofon, 6 of them were Simmental, and 1 of them were Holstein's calves. Of the 7 Montofon calves in the control group, 5 were male and 2 were female. In 14 calves diagnosed with arthritis as a result of clinical examination, it was determined that 12 of the lesioned joints were Articulatio cubiti, 1 was Articulatio genu, and 3 were Articulatio carpi. It was observed that arthritis was in the form of polyarthritis in 2 of the calves (Table 1).

Clinical examination findings

The findings obtained as a result of the clinical examination are given in Table 1. In the clinical examination, lameness was detected in the relevant extremity of all cases with arthritis. Severe lameness was observed in 3 of the cases (cases 2, 7, 10), moderate lameness was observed in 9 cases (cases 1, 3, 4, 5, 6, 8, 11, 13, 14) and mild in 2 cases (cases 9, 12) lameness was observed. Omphalitis was observed in 2 of the cases (cases 2, 10, 14), and the fistula was observed in case 11.

Synovial fluid findings

The synovial fluid findings of the animals with arthritis included in the study are given in Table 2. In the macroscopic examination of the synovial fluids taken from animals with arthritis, the colors of the synovial fluids varied between yellow and yellow tones in 11 cases; In 3 cases, it was determined that they were red and brown. It was observed that the colors of the synovial fluids were transparent in the subjects in the control group. It was observed that the synovial fluid clarity of the calves with arthritis was lost, with severe turbidity (+++) in 3 cases, moderately turbid (++) in 6 cases, slightly turbid (+) in 2 cases, and clear (-) in 3 cases. It was observed that the viscosity of synovial fluid taken from calves with arthritis decreased in varying degrees according to the severity of the disease, severe (+++) in 5 cases, moderately decreased (++) in 4 cases, slightly decreased (+) in 2 cases, and normal in 3 cases. It was determined that the viscosity of the synovial fluid taken from the calves in the control group was normal. Synovial fluids; It was determined that 3 cases (+++) had a bad smell. In synovial fluids kept at room temperature for 1 hour; Severe coagulation in the synovial fluid in 3 cases (+++), moderate coagulation in 7 cases (++), mild coagulation in 1 case (+), and coagulation did not occur in 3 cases (--).

Biochemical findings

The mean values of oxidant and antioxidant parameters and statistical significance levels of healthy (n=7) and arthritis calves (n=14) are presented in Table 3. When this table is examined; There was a statistically significant difference between the groups in terms of MDA ($P < 0.01$), SOD ($P < 0.01$), GSH-Px ($P < 0.05$), vitamin E ($P < 0.001$), and vitamin C ($P < 0.01$). While MDA levels increased in calves with arthritis, SOD and GSH-Px activities and vitamin E and C levels decreased significantly. Although there was no statistically significant difference in CAT enzyme activity, it was determined that it was at a lower level in calves with arthritis, and there was no significant difference between the groups in terms of vitamin A ($P > 0.05$).

DISCUSSION

Many studies are showing that free radical formation plays a direct or indirect role in the development and progression of inflammation in inflammatory diseases. It has been reported that the oxidant-antioxidant balance is disrupted and oxidative stress occurs in bacterial/viral diseases such as brucella, smallpox in sheep, traumatic reticuloperitonitis, peritonitis, osteoarthritis, and tuberculosis [4,5,19,23,31]. Oxidative damage to essential cell components by free oxygen radicals; plays an important role in the pathogenesis of many diseases such as cardiovascular diseases, atherosclerosis, diabetes mellitus, and rheumatism [4,5,11,24]. In these diseases, it is reported that due to the oxidative damage caused by lipid peroxidation against cells, membrane integrity is disrupted, DNA chains are broken, and the structure and functions of proteins are changed, as a result, the levels of various biological indicators increase, and these modifications are clinically associated with inflammation. It is stated that it is directly related to the findings [13,17].

Table 1. Clinical examination findings of calves with arthritis.

Cases	Age	Gender	Race	Localization of the Lesion	Swelling	Sensitivity	Temperature rise	Decreased mobility	In flexion ache	Lameness
1	13 days	Male	Montofon	Rigt Articulatio cubiti	++	+	+	++	++	++
2	22 days	Male	Montofon	Right Articulatio cubiti	+++	++	++	++	++	+++
3	16 days	Female	Simmental	Left Articulatio cubiti	+++	+++	++	++	++	++
4	40 days	Male	Montofon	Left Articulatio genu	++	++	++	+++	++	++
5	27 days	Male	Montofon	Left Articulatio cubiti	+++	++	+	++	+++	++
6	7 days	Male	Simmental	Right Articulatio cubiti	+++	+++	++	++	++	++
7	11 days	Female	Montofon	Right Articulatio cubiti	++	+	+	+	++	+++
8	60 days	Male	Simmental	Right Articulatio cubiti	+	+	+	++	+++	++
9	16 days	Male	Simmental	Right Articulatio carpi	+++	+++	++	++	+++	+
10	28 days	Female	Simmental	Right and Left Articulatio cubiti	+++ ++	++ ++	++ ++	+++ ++	+++ ++	+++ +++
11	49 days	Male	Montofon	Left Articulatio cubiti	++	++	++	++	++	++
12	8 days	Male	Montofon	Right Articulatio cubiti	++	++	+	++	++	+
13	30 days	Female	Holstein	Right Articulatio cubiti	++	+++	+++	++	++	++
14	15 days	Female	Simmental	Right and Left Articulatio carpi	++ ++	++ +	+ +	++ ++	+ ++	++ ++

+ Mild, ++ Moderata, +++ Severe.

Table 2. Macroscopic examination findings of synovial fluid from calves with arthritis.

Cases	Joints	Color	Clarity*	Viscosity**	Smell	Clotting
1	Right Articulatio cubiti	Yellow	++	++	+++	++
2	Right Articulatio cubiti	Brown	+	+++	++	++
3	Left Articulatio cubiti	Light yellow	++	++	++	++
4	Left Articulatio genu	Light yellow	--	Normal	--	--
5	Left Articulatio cubiti	Red-Brown	+++	+++	+++	+++
6	Right Articulatio cubiti	Yellow	--	Normal	--	--
7	Right Articulatio cubiti	Dark yellow	+	+	+	++
8	Right Articulatio cubiti	Yellow	++	++	++	+++
9	Right Articulatio carpi	Dark yellow	++	+++	++	++
10	Right and Left Articulatio cubiti	Brown	+++	+++	+	+++
11	Left Articulatio cubiti	Yellow	+++	++	+	++
12	Right Articulatio cubiti	Yellow	++	+++	+++	++
13	Right Articulatio cubiti	Light yellow	++	+	++	+
14	Right and Left Articulatio carpi	Light yellow	--	Normal	--	--

*Clarity: - Clear; + Slight; ++ Moderately blurred; +++ Severely cloudy. **Viscosity: Normal; + Slightly decreased; ++ Moderately decreased; +++ Severely decrease.

Table 3. MDA, SOD, GSH-Px, CAT, Vitamin E, Vitamin C, and Vitamin A levels in arthritis (n = 14) and healthy calves (n = 7).

Parameters	Control group Mean ± Sd	Arthritis Mean ±Sd	*P*
MDA (nmol /L)	1.96 ± 0.04	3.21 ± 0.16	**
SOD (U/L)	7.24 ± 2.36	4.51 ± 0.73	**
GSH-Px (U/L)	2.11 ± 0.27	1.13 ± 0.01	*
CAT (U/L)	234.67 ± 10.84	221.88 ± 9.93	NS
Vitamin E (mg/L)	6.07 ± 1.54	1.16 ± 1.73	***
Vitamin C (mg/L)	5.13 ± 0.66	3.24 ± 0.54	**
Vitamin A (mg/L)	0.33 ± 0.21	0.29 ± 0.11	NS

Results are expressed as mean ± standard deviation. *$P < 0.05$. **$P < 0.01$. ***$P < 0.001$. NS= No Significant: $P > 0.05$.

Oxidative stress acts as a secondary and aggravating factor in many diseases. When the oxidative defense system against reactive oxygen species is insufficient, clinical symptoms and disease may occur [14]. Determination of lipid peroxidation (MDA concentration) is among the most widely used methods for the determination of oxidative stress. Lipid peroxidation is a non-enzymatic chain reaction based mainly on the oxidation of unsaturated fatty acids, and increased MDA concentration in plasma is an indicator of lipid peroxidation. By-products of lipid peroxidation affect the properties of the cell membrane, and the most common of these by-products is MDA [6,12,13,17]. In particular, the erythrocyte membrane is rich in unsaturated fatty acids and is highly sensitive to lipid peroxidation [13].

Mycobacteria can stimulate the formation of reactive oxygen species through the activation of phagocytes, and although this reaction is important in host defense, increased reactive oxygen species production can increase tissue damage and inflammation. This may cause immunosuppression, especially in patients with an impaired antioxidant capacity [10,13]. In addition, malnutrition in calves with arthritis may also cause deterioration in antioxidant capacity. In the current study, higher MDA levels detected in calves with arthritis compared to controls can be considered as an indicator of oxidative stress that develops during the disease.

Under normal conditions, living organisms have enzymatic (such as SOD, CAT), GSH-Px) and nonenzymatic (such as vitamins A, E, and C) antioxidant defense systems that can metabolize free oxygen radicals. While SOD functions as a catalyst in the conversion of superoxide anions (O2-) to hydrogen peroxide (H_2O_2), the resulting H_2O_2 is eliminated by the CAT and GSH-Px enzymes. In addition, the GSH-Px enzyme plays a role in the inhibition of other long-chain peroxides [2,3,11].

Although lower values were found in the catalase levels in the arthritic calves in the study compared to the controls, these decreases were not found to be statistically significant. However, significant decreases were detected between the groups in SOD and GSH-Px levels. Although the reductions in catalase levels were not found to be significant, it is thought that the reductions in this enzyme level and SOD and GSH-Px levels in arthritic calves are due to their use to neutralize radicals that occur due to oxidative stress that develops during the disease.

While vitamin C increases the antioxidant effect of vitamin E, it also reduces its consumption. It reduces the body's defense power against infections in vitamin C deficiency [13,18,16]. In the current study, it is noteworthy that vitamin E and C levels were significantly reduced in calves with arthritis when compared to the control group. The reason for this situation is thought to be due to both the decrease in milk and feed consumption, which is likely to develop during the disease and the increased use due to the developing oxidative stress. No statistical significance was found between the groups in terms of vitamin A levels. This may be related to the use of vitamins such as E and C during the developing oxidative stress.

CONCLUSION

According to the results of the study, there is an increase in oxidative stress and a decrease in antioxidant status in calves with arthritis. It is thought that these changes may be due to efforts to reduce tissue

damage by reducing lipid peroxidation. As a result, it was determined that the oxidant and antioxidant balance was impaired in calves with arthritis, and oxidative stress and lipid peroxidation developed due to the increase in free radicals. It is thought that giving additional antioxidants to the calves may contribute to the recovery of the disease and reduce treatment costs.

MANUFACTURERS

[1]Endress Hauser A.Ş. Istanbul, Turkey.

[2]Bioelsa Inc. Chino, CA, USA.

[3]SPSS Inc. Chicago, IL, USA.

***Funding*.** This research was supported by Ağrı İbrahim Çeçen University Scientific Research Projects Unit by ECO-HÜYO.22.001 number project.

***Acknowledgments*.** For the help he made during the biochemical measurements of the research, Prof. Dr. Onur ATAKİŞİ thank you.

***Ethical approval*.** The study was approved by The Animal Local Ethics Committee (KAÜ, HAYDEK Number: 2016-064), Kafkas University.

***Declaration of interest*.** The authors declare no conflicts of interest. The authors alone are responsible for the content and writing of this manuscript.

REFERENCES

1 **Arican M., Elma E. & Ozkan K. 1998.** Buzağılarda ekstremitelerde görülen enfeksiyöz artritis olgularının klinik değerlendirilmesi. *Veteriner Cerrahi Dergisi*. 4(1-2): 5-7.

2 **Arslan H.H., Nisbet C., Saripinar D., Cenesiz S. & Cenesiz M. 2008.** Effects of combination of asetylmethionine, L-carnitine, vitamin E and vitamin B12 on some clinical, haematological and biochemical parameters in cattle. *Van Veterinary Journal*. 19(1): 9-14.

3 **Atakisi E., Bozukluhan K., Atakisi O. & Gokce H.I. 2010.** Total oxidant and antioxidant capacities and nitric oxide levels in cattle with traumatic reticuloperitonitis. *Veterinary Record*. 167: 908-909.

4 **Bozukluhan K., Atakisi E. & Atakisi O. 2013.** Nitric oxide levels, total antioxidant and oxidant capacity in cattle with foot-and-mouth-disease. *The journal of the Faculty of Veterinary Medicine, University of Kafkas*. 19(1): 179-181.

5 **Bozukluhan K., Merhan O., Ogun M., Cihan M. & Gokce G. 2016.** Determination of the levels of some oxidative stress parameters in calves with omphalitis. *Fırat Üniversitesi Sağlık Bilimleri Veteriner Dergisi*. 30(2): 79-81.

6 **Castillo C., Hernandez J., Lopez-Alonso M., Miranda M. & Benedito J.L. 2003.** Values of plasma lipid hydroperoxides and total antioxidant status in healthy dairy cows: Preliminary observations. *Archives Animal Breeding*. 46: 227-233.

7 **Cihan M., Ozaydin I., Baran V. & Kilic E. 2002.** Buzağılarda akut artritislerin intraartiküler Dimethylsulfoxide (DMSO) ile sağaltımı. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*. 8(1): 11-15.

8 **Goth L. 1991.** A simple method for determenation of serum catalase activity and revision of serum catalase activity and revision of reference range. *Clinica Chimica Acta*. 196(2-3): 143-152.

9 **Gokhan N. & Ozturk S. 2008.** Buzağılarda Artritislerin tanısında klinik, radyolojik, ultrasonografik ve histopatolojik bulguların değerlendirilmesi. *Journal of Faculty of Veterinary Medicine, Erciyes University*. 13(1): 19-29.

10 **Grimble R.F. 1994.** Malnutrition and the immune response. Impact of nutrients on cytokine biology in infection. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 88: 615-619.

11 **Gurgoze S.Y., Sindak N., Yilmaz S., Sertkaya H. & Ozan S.T. 2003.** The effects of corticosteroid treatment of some antioxidant enzymes and the level of lipid peroxidation in cattles with burcitis precarpalis. *Van Veterinary Journal*. 14: 97-101.

12 **Kizil M., Baydar E. & Kizil O. 2011.** Tayleriyozisli sığırlarda antioksidan parametrelerdeki değişiklikler. *Fırat Üniversitesi Sağlık Bilimleri Veteriner Dergisi*. 25(2): 53-56.

13 **Kizil O. & Keltek Y. 2017.** Tüberkülozisli sığırlarda antioksidan parametrelerdeki değişimler. *Fırat Üniversitesi Sağlık Bilimleri Veteriner Dergisi*. 31(1): 1-4.

14 **Kizil O., Ozdemir H., Karahan M. & Kizil M. 2007.** Oxidative stres and alterations of antioxidant status in goats naturally infected with Mycoplasma agalactia. *Revue de Médecine Vétérinaire*. 158: 326-330.

15 **Kyaw A. 1978.** A simple colorimetric method for ascorbic acid determination in blood plasma. *Clinica Chimica Acta*. 16: 151-157.

16 **Leung H.W., Vang M.J. & Mavis R.D. 1981.** The cooperative interaction between vitamin E and vitamin C in suppression of peroxidation of membrane phospholipids. *Biochimica et Biophysica Acta*. 664: 266-272.

17 **Meral O., Ercan N. & Fidanci U.R. 2017.** Lipid peroxidation level and antioxidant enzyme activities in septicemic calves. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*. 64: 161-164.

18 **Naziroglu M. & Gunay C. 1999.** The levels of some antioxidant vitamins, glutathione peroxidase and lipoperoxidase during the anaesthesia of dogs. *Cell Biochemistry and Function*. 17: 207-212.

19 **Nisbet C., Yarim G.F., Ciftci A., Cenesiz S. & Ciftci G. 2007.** Investigation of serum nitric oxide and malondialdehyde levels in cattle infected with Brucella abortus. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*. 54: 159-163.

20 **Ozaydin I. 1990.** Eklem hastalıklarının tanısında sinovial sıvı bulgularının önemi. *Veteriner Hekimler Derneği Dergisi*. 60(1-2): 35-42.

21 **Ozaydin I., Okumus Z., Marasli S., Cihan M., Acarer N. & Celebi F. 1995.** Sığırlarda artritis, bursitis ve tendosinovitislerin sağaltımında lokal Flunixin meglumine (Finadyne)' in klinik ve biyokimyasal etkileri. *Veteriner Cerrahi Dergisi*. 1(1-2): 68-74.

22 **Paglia D.E. & Valentine W.N. 1967.** Studies on the quantitative and qualitative characterization of erythrocyte glutathione peroxidase. *Journal of Laboratory and Clinical Medicine*. 70(1): 158-169.

23 **Plachta H., Bartnikowska E. & Obara A. 1992.** Lipid peroxides in blood from patients with atherosclerosis of coronary and peripheral arteries. *Clinica Chimica Acta*. 211: 101-102.

24 **Sezer K. & Keskin M. 2014.** Role of the free oxygen radicals on the pathogenesis of the diseases. *Fırat Üniversitesi Sağlık Bilimleri Veteriner Dergisi*. 28(1): 149-156.

25 **Sun Y., Oberley L.W. & Li Y.A.A. 1988.** Simple for clinical assay of superoxide dismutase. *Clinical Chemistry*. 34: 497-500.

26 **Yakan S. & Atakisi O. 2021.** Effects on the lipid peroxidation and the antioxidant defense systems of the use of ısoflurane or sevoflurane in calves undergoing surgery. *Acta Scientiae Veterinariae*. 49: 1811. 8p.

27 **Yakan S., & Duzguner V. & Aksoy O. 2018.** Effects of flunixin meglumine on oxidant and antioxidant system after disbudding with caustic paste in calves. *Acta Scientiae Veterinariae*. 46: 1602. 8p.

28 **Yakan S. & Duzguner V. 2019.** Effects of meloxicam on stress and oxidative stress in dairy cows undergoing hoof trimming. *Fresenius Environmental Bulletin*. 28(4): 2697-2702.

29 **Yoshioka T., Kawada K., Shimada T. & Mori M. 1979.** Lipid peroxidation in maternal and cord blood and protective mechanism against activated- oxygen toxicity in the blood. *American Journal of Obstetrics & Gynecology*. 135(3): 372-376.

30 **Yurdakul G. & Saritas Z.K. 2013.** Buzağılarda artritis olgularının klinik, radyografik, kanda ve sinoviyal sıvıda bazı biyokimyasal parametreler yönünden değerlendirilmesi. *Kocatepe Veteriner Dergisi*. 6(2): 13-22.

31 **Yurdakul I. & Yildirim B.A. 2018.** Assessment of oxidative status in foot diseases of sheep. *Acta Scientiae Veterinariae*. 46: 1621. 6p.