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A Prooxidant and an Antioxidant Sow's Status with Hepathopathy

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ABSTRACT

The role of lipid peroxidation in the pathogenesis of liver diseases in sows was studied. The state of the antioxidant system in these diseases was also assessed. The liver of sows has been examined after slaughter. There were four groups formed: healthy, acute and chronic hepatosis (HS), and liver cirrhosis. An increase in the level of endogenous intoxication has established, the content of primary (diene conjugates), secondary (malondialdehyde, ketodienes, ketotrienes), and final (Schiff base) products of lipid peroxidation in the blood of sows with hepatopathy. Also noticed that sows with hepatopathy had decreased antioxidant protection, catalase activity, and concentration of tocopherol and ascorbic acid. The level of change was growing with a gravity of hepatopathy. The most expressed disturbance has been observed in sows with liver cirrhosis.

Introduction

In animal and human cells, reactive oxygen species (free radicals) are constantly formed. Free radicals are highly reactive and easily change from one form to another, oxidizing various molecules. Polyunsaturated fats (PUFAs) with a large number of unsaturated bonds in their carbon are especially sensitive to oxidation (Vladimirov, 2000, Lyahovich,et al., 2005). With an excess of reactive oxygen species, a cascade of reactions occurs in the destruction of PUFAs and the formation of new free radicals. This process is called lipid peroxidation (LPO). Control throughout oxidative reactions in the body and their timely termination is carried out by the antioxidant system (AOS). This system is represented by enzymatic (catalase, superoxide dismutase, glutathione peroxidase, ceruloplasmin) and non-enzymatic (vitamins E and C, glutathione, and others) parts (Ore and Akinloye., 2019, Abramov, et al., 2007). Uncontrolled LPO is the cause of destabilization and disruption of barrier, transport, receptor, and other functions of biological membranes, breaking of DNA strands, oxidation of proteins, etc. (Boldyreva, et al., 2021).

It is known that the imbalance between LPO and AOS is an important component of the pathogenesis of many internal diseases, in particular liver diseases (Ore and Akinloye, 2019, Plieva, et al., 2023, Bulatova, et al., 2014). This imbalance is accompanied by the development of endogenous intoxication in patients, provoking the progression of pathological processes (Krutikova, et al., 2022).

At the same time, a relatively small number of scientific works are devoted to the study of the state of LPO and AOS in pigs. In particular, the positive effect of high antioxidant status on the growth performance of piglets (Balogh, et al., 2012), an increase in LPO and inhibition of AOS during malnutrition in piglets (Piatrousky, et al., 2010), and normalization of the imbalance between LPO and AOS when using microelements in growing piglets has been determined (Vorobiev, et al., 2015). The problem of the state of LPO and AOS in weaned piglets with toxic hepatodystrophy is the subject of research by V.V. Velikanov. The authors established an increase in LPO products in the blood of sick animals with simultaneous inhibition of their antioxidant status (Velikanov, 2017).

Thus, information on assessing the state of LPO, and AOS in sows with liver pathologies (hepatopathies) of varying severity is not presented in the available literature. Meanwhile, these diseases (primarily toxic hepatosis with an acute and chronic course) in sows in industrial pig farming are significantly common (Piatrouski, et al., 2023). In this regard, the goal of our work was to determine the states of LPO, AOS and endogenous intoxication in sows during the development of hepatopathy.

Materials and methods

In the conditions of swine breeding complexes, after the planned and forced slaughter of the main sows, an inspection of the liver was carried out. Based on the examination, four groups of animals were formed: the first - conditionally healthy sows without macroscopic changes characterizing hepatopathy (n=23), the second - sows with signs of acute HS (n=10), the third - sows with signs of chronic HS (n=10)), fourth – sows with liver cirrhosis symptoms (n=8). The results of macroscopic studies were subsequently confirmed by histological studies (Piatrouski, et al., 2023). Before slaughter, two groups of blood samples were collected from all sows: with heparin (to obtain plasma and hemolysate) and without heparin (to obtain serum). The content of diene conjugates (DC), ketodienes and conjugated ketotrienes (KD and CKT), Schiff bases (SBs), ascorbic acid (ASC), total tocopherol (TT), substances with medium and low molecular weight (MLMWS) were determined in the blood plasma, in the hemolysate - the concentration of malondialdehyde and other products that react with thiobarbituric acid (TBA) (MDA) and catalase activity, in the serum - antioxidant activity (AOA) and the level of a several biochemical blood parameters (Piatrouski and Kotovich, 2023).

The oxidative status of animals was assessed by the content of DC, KD and KT, SBs (Volchegorsky, et al., 1989, Lvovskaya, et al., 1991), MDA (in reaction with thiobarbituric acid) (Abramov, et al., 2007). The enzymatic link of antioxidant status was assessed by the levels of catalase activity (Kondrakhin, et al., 2004, Góth, 1991), non-enzymatic - at the levels of concentrations of TT (Kholod and Ermolaev, 1988), and ASC (Kholod and Ermolaev, 1988). In general, antioxidant status in the blood was determined by the level of AOA (Erel, 2004), and the degree of endogenous intoxication was determined by the level of MLMWS.

The content of DC, KD+KT, andSBs was determined in heptane–isopropanol fractions, since mainly neutral lipids (including triglycerides) are extracted in heptane (n-C7) and phospholipids are extracted in isopropanol (IPA).

Digital material was subjected to statistical processing. The tables present group averages (X), standard deviations (σ), and statistical significance of the nonparametric Mann-Whitney test (U) for differences between group indicators (p). The results were considered statistically significant based on a significance level of 0.05.

Results and discussions

Our studies have shown that the content in the blood of sows of both primary (DC) and secondary (KD and KT, MDA), and final (SBs) lipid peroxidation products were significantly lower in healthy animals (Table 1).

The research results indicate that the content of primary and secondary lipid peroxidation products in the blood plasma of sows with liver pathologies was statistically significantly higher than that of sows of the first group.

In both heptane and isopropanol fractions, the levels of DC, KD, and KT, MDA were the highest in the blood plasma of sows of the fourth group. The final product of LPO (Schiff base) in the heptane fraction of blood plasma of sows of the second and third groups turned out to be higher than that of sows of the first group.

Table 1. Indicators of prooxidant status in the blood of sows*

Index	Number groups of sows			
	First	Second	Third	Fourth
DC, optical density units/ml plasma (n-C7)	0.43±0.097	0.68±0.160	0.98±0.124	1.07±0.150
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			
DC, optical density units/ml plasma (IPA)	0.57±0.132	1.17±0.162	1.50±0.266	1.59±0.329
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			
KD и KT, optical density units/ml plasma (n-C7)	0.20±0.057	0.58±0.062	0.80±0.137	0.77±0.088
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			
KD и KT, optical density units/ml plasma (IPA)	0.65±0.166	1.34±0.096	1.49±0.116	1.64±0.156
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}<0.05$			
SBs, optical density units/ml plasma (n-C7)	0.11±0.048	0.08±0.021	0.12±0.043	0.20±0.039
p	$p_{1-2}>0.05$, $p_{1-3}>0.05$, $p_{1-4}<0.01$, $p_{2-3}>0.05$, $p_{2-4}<0.01$, $p_{3-4}<0.05$			
SBs, optical density units/ml plasma (IPA)	0.12±0.024	0.17±0.026	0.20±0.062	0.38±0.118
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}>0.05$, $p_{2-4}<0.01$, $p_{3-4}<0.01$			
MDA, mkmol/l	1.26±0.265	2.93±0.374	3.29±1.006	4.30±0.705
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}>0.05$, $p_{2-4}<0.01$, $p_{3-4}<0.05$			

*Composed by the authors.

As for the content of SBs in the blood of sows of the fourth group, their concentrations were higher in both the heptane and isopropanol fractions. The fact that the SBs content of the isopropanol fraction in the plasma of sows of the second and third groups was statistically significantly higher than that of animals of the first group indicates pronounced peroxidation processes in phospholipids. Considering their presence in the composition of cell membranes, the established changes are associated with their active destruction in hepatopathy.

The maintenance of physiological homeostasis in the body of sows is ensured by the presence of a certain balance between the pro-oxidant and antioxidant systems. AOS in sows varied variably, depending on the severity of the corresponding hepatopathy (Table 2).

The revealed dynamics of antioxidant and catalase activities, as well as the content in the blood of sows of the second group, indicate that during the acute course of hepatosis, the AOS of liver protection did not exhaust its functional reserve, which allowed it to effectively resist the action of pro-oxidant factors. This is indicated by both a statistically significant increase in the level of AOA and catalase activity (by 13.4 and 21.1 %, respectively) and relatively insignificant (by 3.3 and 4.9 %) decreases in the concentrations of vitamins *E* and *C* in the blood of pigs of the second group.

However, in sows with chronic hepatosis and liver cirrhosis, “suppression” of both enzymatic and non-enzymatic components of AOS occurred. Statistically significant decreases in catalase activity, TT, and ASC concentrations were noted in the blood of these animals.

Table 2. Indicators of antioxidant status of sows' blood*

Index	Number groups of sows			
	First	Second	Third	Fourth
AOA, mmol tocopherol /l	2.77±0.513	3.14±0.546	1.12±0.337	0.69±0.139
p	$p_{1-2}<0.05$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}<0.05$			
TT, mkmol/l	19.47±5.226	18.85±5.132	12.50±1.281	5.89±1.924
p	$p_{1-2}>0.05$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}<0.01$			
ASC, mkmol/l	72.38±22.730	68.97±5.955	35.83±7.340	29.88±6.202
p	$p_{1-2}>0.05$, $p_{1-3}<0.01$, $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			
Catalase, kIU/l	54.61±5.664	66.16±8.677	45.98±5.080	38.91±5.032
p	$p_{1-2}<0.01$, $p_{1-3}<0.01$. $p_{1-4}<0.01$, $p_{2-3}<0.01$, $p_{2-4}<0.01$, $p_{3-4}>0.05$			

*Composed by the authors.

The latter is due to a decrease in the absorption of fat-soluble vitamin *E* (against the background of the chronic course of hepatopathy) (Ziyamutdinova, et al., 2023), and the synthesis of vitamin *C* in the liver (Kondrakhin and Levchenko, 2005). In addition, low appetite in sick animals leads to a decrease in the supply of vitamins to the body.

It should also be noted that against the background of an imbalance of LPO and AOS in the blood of sows of the second to fourth groups, an increase in the level of endogenous intoxication was noted, which was characterized by an increase in the content of MLMWS (Figure).

The development of hepatopathy in sows causes the presence of a "vicious circle": development of hepatopathy – activation of lipid peroxidation – destruction of hepatocytes – inhibition of the antitoxic function of the liver – increase in endogenous intoxication – development of hepatopathy. In this regard, the development of pharmacoprophylactic measures aimed at increasing the antioxidant protection of the body of sows becomes an urgent task in veterinary hepatology.

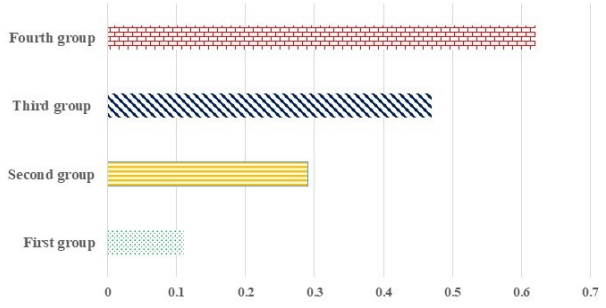

Figure. Content of MLMWS in the blood of sows, optical density units.

Conclusion

According to our sindings, in sows with hepatopathy there is an increase in the level of endogenous intoxication. This is due to the content of diene conjugates, diene ketones and conjugated trienes, malondialdehyde and TBA-active products, Schiff bases in blood.

These changes occur against the background of a decrease in the activity of the general antioxidant defense system. This includes catalase activity, and concentrations of tocopherol and ascorbic acid in the blood. High production of free radicals, "accumulation" in the body of primary and secondary end products of lipid peroxidation provoke, further irreversible destruction of the membrane structures of hepatocytes.

When hepatosis becomes chronic with the development of its terminal phase - cirrhosis, the intensity of oxidative changes in the body will increase, which will lead to a further increase in destructive processes in the liver. Therefore, the most significant changes in LPO and AOS parameters were detected in sows with liver cirrhosis.

Carrying out active pharmacoprophylactic measures in the early stages of the development of hepatopathy using natural and synthetic antioxidants will increase the antioxidant status of the sows' body, reduce the level of lipid peroxidation and prevent the development of irreversible processes in the liver.

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Declarations of interest

The authors declare no conflict of interest concerning the research, authorship, and/or publication of this article.

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