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Review on Iron Deficiency in Piglets

[1]Leweyehu Basie, [2]Takele Adugna and [3]Endeshawu Demil

[1]University of Gondar Colledge of Veterinary Medicine and Animal Science,
Department of Veterinary Medicine, P.O.Box 196, Gondar, Ethiopia
[2]University of Gondar Colledge of Veterinary Medicine and Animal Science,
Department of Veterinary Clinical Medicine, P.O.Box 196, Gondar, Ethiopia
[3]University of Gondar Colledgeof Veterinary Medicine and Animal Science,
Department of Veterinary Epidemiology and Economics, P.O.Box 196, Gondar, Ethiopia

Abstract: This paper provides information on the review of iron deficiency in piglets and reviews the diagnosis, treatment and prevention measures of iron deficiency. Swine production, among other species has a high potential to contribute to high economic gain in the world. In the tropics, pigs have been raised under various husbandry practices including free range feeding tethering and confinement. Pigs require feeds that contain balanced nutrients for their normal body activities, minerals are essential parts of nutrients required for the maintenance of regular body functions in pigs. Among those minerals, the trace element iron occurs commonly in soil and is actually more abundant than many of the macro element and it also widely distributed in foods. Iron is a vital component of every living thing. The deficiency of iron, caused by lower composition of iron in the body of piglets, produces major problems including a wide range of abnormalities such as anemia, growth retardation and epithelial changes. Roughness of hair coat, loss of pigmentation of mucous membrane, edema of the head and the forequarters, a mild diarrhea and a lean, white hairy look are more common clinical findings of iron deficiency. The most useful laboratory tests for the diagnosis of iron deficiency are plasma ferritin test and hemoglobin determination in clinically affected piglets. Erythrocyte counts are also a better index of iron status than hemoglobin levels. Treatment of iron deficiency as parenteral iron replacement is available using organic iron preparations. Hence, iron deficiency problem is a major constraint of piglets, it should be advisable to prevent iron deficiency problem in piglets by proper supplementationof iron preparations at early life of birth.

Key words: Anemia · Iron · Iron deficiency · piglet

INTRODUCTION

World pig population is estimated to be 923 million, of which 552 million are found in Asia, 72 million in North America,194 million in Europe, 81 million in south and Central America i.e.LatinAmerica and 18 million in Africa [1]. The population size of pigs in an area of the world depends mostly on climate and social and religious beliefs. The pig population is outnumbered by cattle, sheep and poultry but as a higher meat output, indicating greater productivity [2].

Swine production, among other species has a high potential to contribute to high economic gain, because pigs have fecundity, high feed conversion efficiency, early maturing, short generation interval and relatively small space requirement, any they are multipurpose animals providing about 40% of meat in the world market, cooking fats and bristles. It is produced under a varietyof production systems ranging from simple backyard pigs,pigsliving on garbage belts to family operated farms or large scale integrated pig industries with sophisticated biosafety measures [3].

In the tropics, pigs have been raised under various husbandry practices including free range feeding, tethering and confinement. Free range is practiced by small farmers mainly in rural areas in Africa, Latin America and South East Asia where pigs are mostly on grass, brewery and cereal by product or waste products or food remnants. Additionally, a commercial small scale system are found and characterized by improved breeds, feed

Corresponding Author: Leweyehu Basie, University of Gondar Colledge of Veterinary Medicine and Animal Science, Department of Veterinary Medicine, P.O.Box 196, Gondar, Ethiopia.

concentrates and having relatively good performance. They are confined mainly to government and institutional farms [4].

Pigs require feeds that contain balanced nutrients for their normal body functions [5]. Sound feeding practices that provide for adequate nutrient needs are integral to the health and well being of pigs in all stages of production. Pigs require many minerals for normal biologic function. Minerals are essential parts of nutrients required for the maintenance of normal body function. Although naturally occurring mineral elements are found in animal tissues, many of these are thought to be present merely because they are constituents of animal's food and may not have an essential function in animals' metabolism [6]. Among those minerals, trace elements are needed by the animals only in small amounts [7]. Animals acquire trace elements naturally by oral ingestion of plants and herbage which is soil contaminated [8]. The trace element iron, inorganic elements, is important components of oxygen-transport and oxidation system and it is important component of hemoglobin and a vital metal for the proliferation of all cells including those of the immune system [9].

Iron deficiency is of limited practical importance in farm animals except for suckling piglets, where piglets are the most likely to suffer frommineral deficiencies [10].Though deficiency of iron causes the major problems, relatively little is known about the impact of neonatal iron deficiency on the body function including immune system in pigs and also neutrophil count depletion was reported in iron deficient piglets. A low leukocyte count, resulting from a low neutrophil count, was also found [11].

Therefore, the objective of this seminar paper is:

- To review on iron deficiency in piglets
- Reviewing the diagnosis, treatment and prevention measures of iron deficiency

History of Pigs Origin in Eastern Africa: There are two conflicting theories as to the origin of domestic pigs. One is: they were independently domesticated at centers in several different regions. The other is they were domesticated at one center in Western Asia and that domesticated pigs were gradually diffused to other parts of the world [12].

Pigs are wide spread and an apparently popular domestic species in Egypt. The first records of pigs in the Upper Egypt are at Toukh in the second half of fourth millennium. Pigs seem to have spread down the Nile at least as far as sennar, where

they are still kept. Ethnographic records suggest that domestic pigs are very common in the omotic-speaking regions of Ethio-Sudan border. It is usually accepted that there were no pig population in Eastern Africa prior to European contact. The pig population of Eastern Africa todayis usually assumed to result from European introductions; later Indian Ocean trade brought South East Asian pigs as well as Mediterranean breeds. Exotic pigs in Africa that arrived in the colonial period came originally from Europe, America and the Far East [13].

Iron Requirement in Piglets: Iron is a vital component of every living thing. The concentration in the pig at birth is approximately 20 to 30 parts per million. Of this concentration in the newborn pig, 47% is associated with blood, 1.6% is in the spleen, 15% is in the liver and the remaining 44% is found in body tissues. Following the neonatal period 80% of the iron in the pig is associated with hemoglobin. The majority of body iron is bound to proteins as heme complexes or nonheme complexes. The most common heme complexes consist are hemoglobin and myoglobin, while common nonheme complexes consist of two storage forms, ferritin and hemosiderin and one transport form, transferrin. The newborn pig contains approximately 50 mg of iron at birth, mostly in the form of hemoglobin [14].

Table 1: Daily iron requirement for growing pig.

Live weight (kg)	Iron requirements (mg)
(1-5)	38
(5-10)	70
(10-20)	80
(20-35)	90
(35-60)	100
(60-100)	120

Source:[15]

Source of Iron and its Metabolism: Source of iron:-Iron occurs widely in soil and is actually more abundant than many of the macro elements, although required in trace quantities [16,17]. It also widely distributed in foods. Good source of the element are green leafy materials, most leguminous plants and seed coats[18,19]. Feeds of animal origin such as; meat, blood and fish meals are excellent source of iron [18]. Legumes tend to contain more iron than cereal grains [16]. Contamination of feed stuffs with soil often supplies sufficient iron, as does iron consumed by herbivores while grazing [20].

Metabolism of Iron: Iron absorption can occur throughout the gastrointestinal tract. Iron is taken up by the mucosal cells in one of three forms, i.e. ferrous, ferric or as part of an organic compound. Upon absorption ferrous iron is oxidized to the ferric form for incorporation into ferritin. As mucosal cells become saturated with ferritin, absorption ceases until the ferritin can be converted to transferrin for removal to the plasma [14].

Mechanism for the regulation of iron metabolism is unique since there is no excretory pathway for iron and less iron is absorbedby an animal which in not iron depleted. Most iron in animal product is in the oxidized, ferric form in combination with organic compounds and must be released in the GIT for the absorption to occur. Hydrochloric acid secreted in the stomach plays a vital role in facilitating iron absorption by the intestinal mucosa, since acids promote solublizationbothin organic and organic form of iron and reduce ferric iron to ferrous form, which is less likely to precipitate under alkaline condition of upper small intestine and is more readily to be absorbed in the entrocytes[16,21].

Regulation of iron metabolism by reduced absorption and lack of an excretory pathway makes the animal susceptible to poisoning by administration of iron. Pigs are frequently poisoned by excess iron administration. Excess iron accumulates as hemosiderin in liver and may cause extensive damage to this organ [22].

Deficiency Problem of Iron: Iron deficiency has impact on proliferation of all cells including immune cells. So, it leads to susceptibility to different disease.In iron deficiency piglets there is a report for the depletion of neutrophil and eosinophil count. Impairment of cytochrome function for the oxidative burst that follows phagocytosis is also reported in iron deficient piglets [11].

The variability in the nutrient composition of most feed ingredients present in the animal ration is an important factor leading to nutritional deficiency problem. In general, a nutritional deficiency may be considered simple or multiple in which case the total feed intake may contain an insufficient amount of one or more of the essential nutrients [23].

Iron deficiency is not a common problem in livestock, but it is a problem of young pigs kept off soil and while they become dependentmostly on milk diet [20,24]. It is a leading cause of anemia, affecting pigs worldwide. The high demand for iron created by neonate growth spurts occasionally produces iron deficiency in piglets. Depletion of iron stores precedes impaired production of iron- containing proteins, the most prominent of which is hemoglobin [11]. The two key stages of iron deficiency are depletion of iron stores without anemia and depletion of iron stores with anemia. Iron deficient anemia is an important animal disease. It is the problem that makes the RBC very small size and its central part wide and pallor. It also causes the blood not to carry enough oxygen for different body parts [22].

Predisposing Factors of Iron Deficiency: Iron deficiency is primarily associated with the nursing pigs being reared in confinement or animals dependent on milk- based diets [25]. A number of environmental factors can produce dietary iron deficiency, including metals that share the iron absorption machinery, such as lead, cobalt and strontium. Of these, only lead is a significant problem [26]. Some elements, like calcium and molybdenum, may interfere with the absorption and activity of the other elements.

This is important factor in animal nutrition and an imbalance of mineral elements as a distinct form. A simple deficiency is important in the etiology of mineral disorders in animals [18]. Dysfunction of the gastrointestinal absorption machinery is a very rate cause of iron deficiency [28].

Risk Factors for Iron Deficiency: Iron deficiency is a common problem of piglets rather than other newborns. This is due to the reason that restricting them without availability of soil due to fear of parasitic infection. Pigs not supplemented with iron while dependent on sows milk quickly develop iron deficiency [18]. Due to the minimal concentration of iron in sows milk (1 milligram per liter), neonatal pigs reared in confinement highly susceptibility to iron deficiency [6]. Certain dietary constituents affect iron availability by altering its solubility and/or oxidation state. Ascorbic acid, dicarboxylic acids, some sugars and amino acids can form chelates with iron, which enhance its solubility. So, shortage in these constituents has effect on iron availability in blood [16,18].

Although the element iron is the second most abundant metal in the earth's crust, iron's low solubility makes its acquisitions for metabolic use a major challenge. Most environmental iron exists as insoluble salts [28]; high gastric pH reduces the solubility of inorganic iron and impeding absorption. The impaired function of the gastric parietal cells associated with anemia not only reduces the production of intrinsic factors, but also lessens gastric acidity and impaired iron absorption [29].

The incidence of iron deficiency in pigs has increased because of modern husbandry practices which have produced rapidly growing pigs, winter farrowing and housing of the animal on artificial surfaces. Certain areas are deficient in iron. Hence, animals reared in these areas require supplementation to correct difficulties face on animals.Pigletskept on concrete area not able to get this much of iron and consume less creep feed cause problem on hemoglobin and make considerably slower weight gains after the first three weeks of life than supplemented piglets [6].

Consequences of Iron Deficiency: Although anemia is most prominently linked to iron deficiency, the condition produces a wide range of abnormalities, depending on its severity and duration [29].

Anemia: Iron deficient anemia, termed hypochromic microcytic anemia is generally associated with young, rapidly growing animals deprived of iron in their diet or from their environment. Since most iron is directed to hemoglobin synthesis, erythrocyte production is among the first casualties of iron deficiency. This is an important problem, especially for young piglets kept indoors. Suckling piglets with nutritional anemia, caused by a lack of iron show swollen head and other signs [15]. Iron is the only nutrient markedly becomes deficient in relation to other nutrients in milk, so it cause low sized RBC and abnormal color of hemoglobin [2]. Since more than half of the iron present in the body occurs in hemoglobin, iron deficiency affects the formation of hemoglobin which result anemia [24].

Shortage of iron cause hemoglobin and myoglobin compounds not to function well and results in shortage of oxygen in the blood [10, 11]. The plasma membranes of iron deficient red cells are abnormally rigid. This rigidity could contribute to poikilocyticchanges, seen particularly with severe iron deficiency. These small, stiff, misshapen cells are cleared by the reticuloendothelial system, contributing to the low- grade hemolysis that often accompanies iron deficiency [30]. In iron deficient piglets, lymphocyte activity is impaired resulting in decreasing of circulating B- lymphocyte number and decrease immune competence [10]. This iron deficiency in turn results in depletion of eosinophil andneutrophilcount in anemic piglets compared to healthy piglets. It also causes impaired ability of polymorphonunclear granulocytes to kill ingested bacteria [11].

Growth Retardation: Iron deficiency, with or without concomitant anemia, commonly impairs growth. Affected pigs may be well grown, but the growth rate of anemic pigs is significantly 10 % lower than that of normal pigs and feed intake is reduced. The extremely rapid growth rate of young pigs (5 times birth weight at 3 weeks) results in a dilution effect of total body iron stores unless iron is fed or injected [31]. In deficiency of iron, the piglet has very pale mucous membrane a few weeks after birth and their growth slows down [32].

Epithelial Changes: Iron deficiency produces significant gastrointestinal tract abnormalities, reflecting the enormous proliferative capacity of this organ. A marked impairment of gastric secretion of acid and chloride and atrophic gastritis occur in iron deficient piglets. Villous atrophy of the small intestine and changes in the GIT flora also occur in iron deficient piglets which contribute to the increase susceptibility to diarrhea [10].

The carcass is characterized by pallor, watery blood and moderate anasarca. The heart always dilated, sometimes extremely so. The cardiac dimension is severely anemic, neonatal pigs indicate that dilation and hypertrophy consistently. The liver in all cases is enlarged and has a mottled tan-yellow appearance and also the muscle become edematous[6,10].

Clinical Findings: The clinical sign appears most commonly in piglets of three weeks of age, by which time a severe anemia may have developed, particularly in pigs in good body condition. The iron deficiency anemia can occur up to ten weeks of age [6].

The first signs of iron deficiency are often roughness of hair coat and loss of pigmentation or color of mucous membrane. The skin can become wrinkled and the pigs emit a general listlessness. Characterized by drooping of the head and ears combined with a loss of appetite. In severe cases pigs may be characterized or identified by labored breathing, increased heart and respiratory rates and even systolic murmurs due to reduced blood viscosity. The largest, fastest growing pigs are susceptible to sudden death from anoxia; affected pigs have a higher prevalence for subcutaneous edema in the neck, shoulder and limb areas[33].

A mild diarrhea may occur but the feces are usually normal in color. Dispnea, lethargy and a marked increase in the amplitude of the apex beat of the heart can be felt after exercise. The skin and the mucosa are pale and may appear yellow in white pigs.

Edema of the head and the forequarters, giving the animal a fat, puffed up appearance may be present. A lean, white hairy look is probably more common. It also causes loss of appetite, slow growth, susceptible to disease and thumps. Severely affected piglets may die suddenly [10].

Diagnosis: The diagnosis of nutritional deficiencies by observation of signs alone is not complete. Observing the response to nutritional supplementation is not always evident particularly for chronic cases of deficiencies. For most nutritional deficiencies, the signs are not specific. Since many deficiency diseases result in the same clinical signs stunted growth, poor appetite and unthriftiness, nutritional deficiency problem could only be confirmed after observance of several of the clinical signs expected and a careful review of the dietary, disease and management histories of the animal (34).

The most useful laboratory test for the diagnosis of iron deficiency is the plasma ferretin test. Ferretin is the cellular storage protein for iron. Plasma ferretin differs from its cellular in several respects and appears to be a secreted protein of a different origin [34]. The plasma ferretin value often falls to under10% of its baseline level with significant iron deficiency. The quantity of the iron –carrying protein, transferring, in the circulation increase over baseline by 50 % to 100% the quantity of iron on transferrin can fall by as much as90% consequently the transferrin saturation frequently declines from its usual 30% to under 10% [35].

The diagnosis may by confirmed in piglets by the finding of low blood hemoglobin levels (below70g/l) in 3rd weeks of age, in clinically affected animals, 40g/l or less. The hemoglobin level at which clinical signs appear in piglets is about 40g/l. Erythrocyte counts also fall from a normal of 5-8x10^{12}/l down to 3-4x10^{12}/l and may be better index of iron status than hemoglobin levels. Iron deficiency anemia appears in piglets is a microcytic hypochromic anemia (characterized by smaller than normal red cells and less than normal hemoglobin) [10,31]. Newer tests, such as assay of circulation transferrin receptors, can help with the diagnosis of iron deficiency in many instances. If all else fails, a bone marrow biopsy with Prussian blue staining for iron is the touchstone for the diagnosis [36].

Treatment: The most important steps in the evaluation and treatment of iron deficiency are determining the cause of the deficiency and correcting the abnormality. After the cause of the iron deficiency has been ascertained, parenteral iron injection and oral iron supplementation replaces stores most efficiently [37].

Treatment as parentral iron replacement is available using organic iron preparation such as iron dextran, iron orbital citric acid complex iron saccharate or gluconate. Organic iron preparation can be administered via intramuscular or intravenous injection. Intramuscular injection of this preparation can by painful and leakage into the subcutaneous tissues produces long standing skin discoloration, irritation and causing large sloughs. These muse be give exactly as prescribed by the manufacturer. The dose rate of this preparation is 0.5- 1g elemental iron in one injection per week [10].

Control and Prevention Measures: A total dose of 200 mg is recommended as being required to avoid clinically manifest iron deficiency anemia, but in order to avoid any chance of a subclinical deficiency, the food should containadditional iron at the level of 240 mg/kg. Contrasting information is that one injection of 100mg of iron is adequate for baby pigs [6].

Preventive measures must be directed at the neonatal piglets because treatment of the sows before orafter farrowing is generally ineffective. When indoor housing on impervious floors is necessary, iron should be provided at a rate of 15mg/day until weaning either by oral dosing with iron salts of a commercial grade or by intramuscular injection of organic iron preparations. These methods are satisfactory, but the results are not usually as good as piglets raised outdoors [10]. For prevention, piglets should be injected in the neck rather than the hind limb at 1-3 days of age with at least 200mg elements iron. Recently 200mg in 1ml iron preparations have given into the neck muscles where three weeks weaning is practiced and there is evidence that, where creep feed is available, only 100mg is required [6].

Feeding sows a diet supplemented with 2000 mg/kg DM of diet will satisfactorily prevent iron deficiency anemia in piglets. The piglets ingest about 20g of sow's feces per day, which will contain sufficient iron and obviate the need for IM injection of iron- dextran. The piglets grow and thrive as well as those receiving the iron-dextran [6]. Granules containing iron-dextran may also be given under lamps in the creep feed and pastes containing iron-dextran are also available for oral therapy. Recently soluble products for water medication have been used in piglet drinkers. In a few cases, farmers may wish to provide iron by including soil, peat or coal in the pen [6].

CONCLUSION

Pig production in the tropical countries including Ethiopia has a considerable importance as a source of income generation. This production system is mainly affected by climate, social and religious beliefs and deficiency problems. Iron deficiency is a major deficiency problem that occurs in newborn pigs whose sole source of iron is the milk of dam. The major factors that compound the deficiency problems are very low iron store at birth, low levels of iron in sow's milk and very rapid growth rates of piglets. In addition, a number of environmental factors also cause iron deficiency problem. Iron deficiency primarily produces anemia as a major consequence. Moreover, the deficiency problem also causes a wide range of abnormalities including growth retardation and epithelial changes in piglets. Diagnosis of the problem is mainly performed by plasma ferritin test, hemoglobin determination and erythrocyte count. Iron preparations of dextran lonely or combined with iron supplementation have used successfully in the treatment of iron deficient piglets.

In sight of this fact, the following recommendations are forwarded.

- Pig owners should be advised and educated about proper feeding and management of piglets.
- Supplementation of iron to piglets and pregnant sows should be encouraged in order to prevent iron deficiency problem.
- Further detailed studies should be conducted on major risk factors of iron deficiency in piglets together with rich database documentation.

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