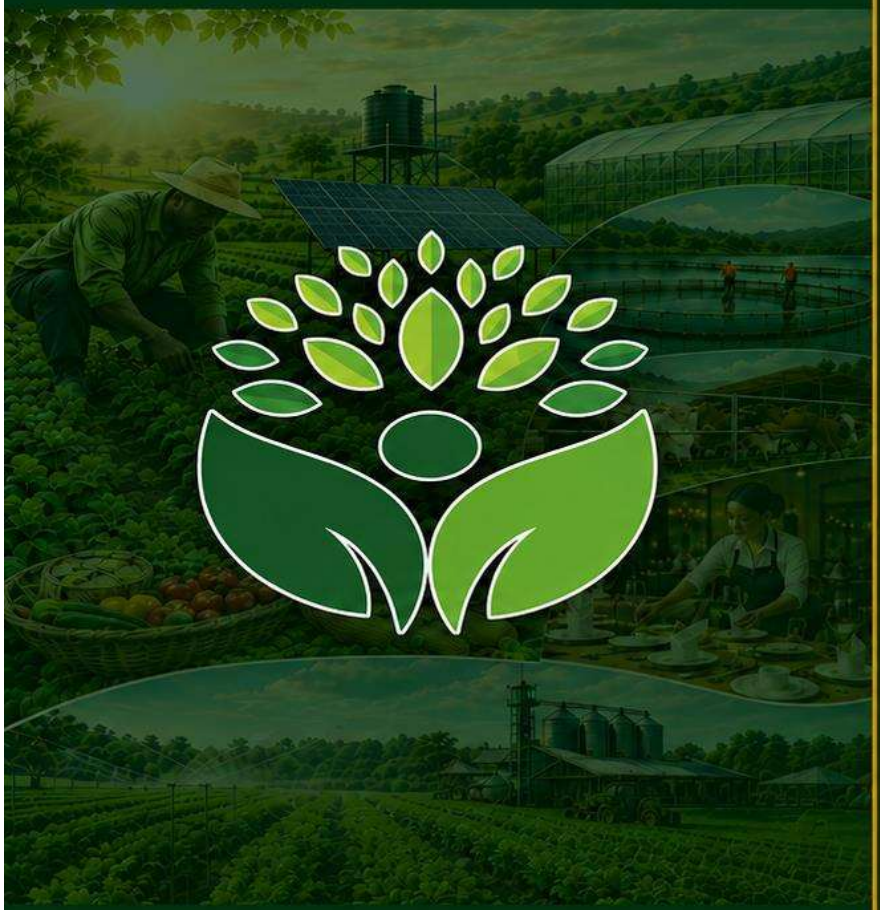

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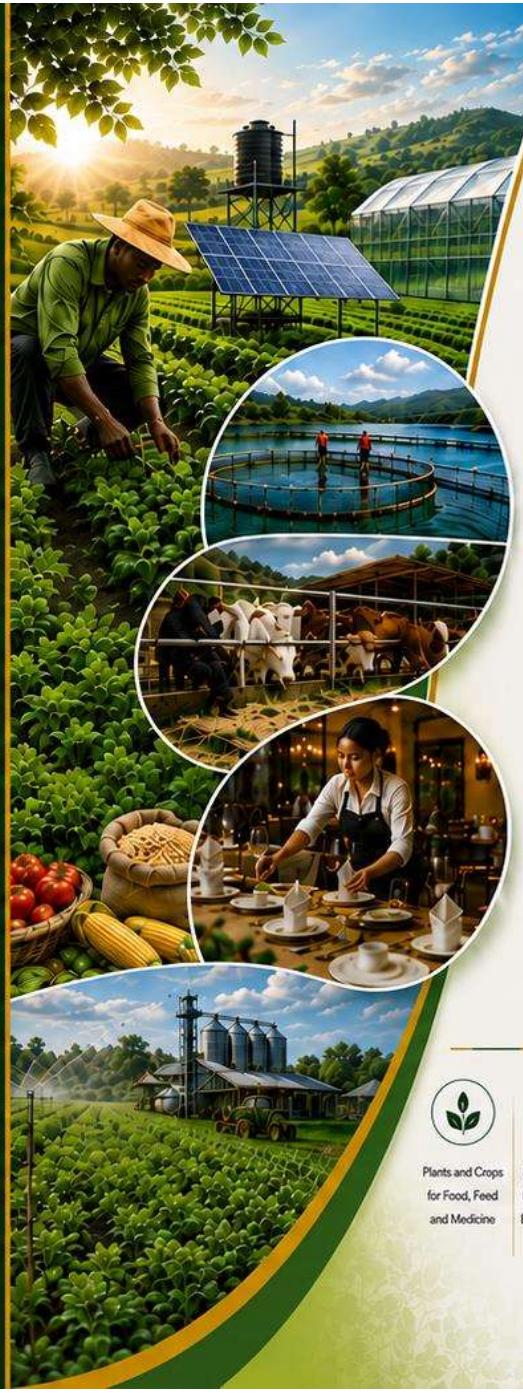

# BOOK OF PROCEEDINGS

FOR THE

## 1ST INTERNATIONAL CONFERENCE
## FACULTY OF AGRICULTURE

FEDERAL UNIVERSITY OYE-EKITI

**HELD AT:**

New Agriculture Twin Hall,
Faculty of Agriculture,
Federal University Oye Ekiti
(Ikole Campus)

[29th June – 2nd July 2026]

*Theme:*

**"Sustainable Agriculture and Food Security in a Changing World"**

**SUB-THEMES**

- Plants and Crops for Food, Feed and Medicine
- Soil, Water and the Environment – Our Basis for Productivity
- Livestock Production, Fisheries and Management for Disease Control
- Agriculture and Fisheries Management
- Food Security, Nutrition and Sustainable Food Systems
- Demand-driven and Policy-focused Agriculture and Agricultural Research

# BOOK OF PROCEEDINGS

FOR THE

## FACULTY OF AGRICULTURE 1ST INTERNATIONAL CONFERENCE
## FEDERAL UNIVERSITY OYE-EKITI (FUOYE)

**HELD AT**

NEW AGRICULTURE TWIN HALL
FACULTY OF AGRICULTURE, FEDERAL UNIVERSITY OYE-EKITI
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BOOK OF PROCEEDINGS

FOR THE

FACULTY OF AGRICULTURE 1ST INTERNATIONAL CONFERENCE
FEDERAL UNIVERSITY OYE-EKITI (FUOYE)

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SOUTHWEST, NIGERIA. - IDOWU O., AND OLOWOKERE-AYODELE O. O. .....99

## SECTION C: LIVESTOCK PRODUCTION, BREEDING, RANGE MANAGEMENT & DISEASES CONTROL (LPBRC)

LPBRC01 – EFFECTS OF PLANTING SPACING AND HARVESTING AGE ON THE PROXIMATE AND DETERGENT FIBRE COMPOSITION OF CONGO GRASS (BRACHIARIA RUZIZIENSIS) – DANDARA G. B., OLUWADELE J. F., EKEOCHA A. H., OMOSOFE P. O., ADELUSI T. O., DAKUNA D. S., SULAIMAN D. AND AGANGA A.A .....104

LPBRC02 – PREVALENCE OF GASTROINTESTINAL HELMINTHS OF INDIGENOUS ADULT MALE PIGEONS KEPT UNDER INTENSIVE SYSTEM OF MANAGEMENT IN MINNA METROPOLIS. – IBRAHIM D.Y., USMAN A. AND ADAMA J.Y .....110

LPBRC03 – GENETIC ARCHITECTURE OF FEED EFFICIENCY TRAITS AT EARLY-LIFE IN BROILER BREEDERS – JESUYON, OLUWATOSIN M. A.....116

LPBRC04 – BLACK SOLDIER FLY LARVAE MEAL AS A SUSTAINABLE ALTERNATIVE PROTEIN SOURCE IN BROILER PRODUCTION: A REVIEW – IBIKUNLE, R.O., AKANDE, K.E. AND IJAIYA, A.....123

LPBRC05 – PERFORMANCE AND BIOECONOMIC RESPONSE OF GROWING RABBITS FED GRADED DIETARY LEVELS OF FERMENTED SORGHUM WASTE – KEHINDE, O. A ., GABRIEL, O. G. FOLAYAN, T. A., KOLAWOLE, B. J., KUYETI, O. O., ATAYERO, G. O., OLA-ALAWODE, I. A., ODUNJO, T. D., OLAWALE, V. O., AND DAIRO, F.A.S .....130

LPBRC06 – SUSTAINABLE MICRO-ANIMAL PRODUCTION AND FOOD SECURITY IN A CHANGING WORLD – A REVIEW – KOLAWOLE, B.J AND AGANGA, A.A .....137

LPBRC07 – COPPER DEFICIENCY IN LIVESTOCK: EFFECTS ON IMMUNE FUNCTION, DISEASE RESISTANCE AND MICROBIAL INFECTIONS – A REVIEW – AKANDE, K.E. AND AKANDE, J.O.....143

LPBRC08 – THERMAL RESPONSE AND OXIDATIVE STRESS MARKERS OF RABBIT FED DIFFERENT CONCENTRATION OF BETAINE DURING DRY SEASON – GABRIEL G. O ., OGUNLADE J. T., OKE I. T.,





IBRAHIM A. A., KOLAWOLE T., TAOFEEK F., IBIKUNLE O., ADOEGUN A. A., DANDARA G. B., KEHINDE O. A., AND FOLAYAN A. T .....149

LPBRC09 – SUSTAINABLE PRODUCTION OF AFRICAN GIANT POUCHED RAT, GRASSCUTTER, GUINEA PIG AND RABBIT – A REVIEW – KOLAWOLE, B.J AND AGANGA, A.A.....156

LPBRC10 – MOLECULAR AND STATISTICAL APPROACHES FOR IDENTIFYING HEAT ADAPTATION IN SHEEP AND GOATS IN THE TROPICS: A SYSTEMATIC REVIEW – ADETUNMBI T., ADUBAZI G. I, AJADI P. M., AKINBINU, A .J., AND OSUNKEYE J.O .....163

LPBRC11 – EFFECT OF GENOTYPE ON REPRODUCTIVE TRAITS OF IMPROVED CHICKENS REARED IN HUMID ENVIRONMENT – AKINSOLA, K. L., OYEWOLE, Y. O., OLAWALE, A. S., AND ASAOLU, S. O .....170

LPBRC12 – PERFORMANCE OF GROWING WAD GOATS OFFERED DIFFERENT SOURCES OF ORGANIC AND INORGANIC SALTS IN TUBER-BASED SUPPLEMENT – OCHEJA M. E., ARIBIDO S.O, AJAGBE A.D AND ADUBAZI G. I.....180

LPBRC13 – PHYTOGENIC FEED ADDITIVES IN RUMINANT PRODUCTION: A REVIEW OF RUMEN MODULATION, PERFORMANCE, AND ENVIRONMENTAL SUSTAINABILITY – FABUSORO, O. T. KEHINDE, O. A. GABRIEL, G. O. AND FOLAYAN, T. A .....187

LPBRC14 – INSECT MEAL IN LIVESTOCK PRODUCTION: BENEFITS, LIMITATIONS AND POSSIBLE SOLUTIONS - EGBEYEMI1 O. B, AGANGA A. A, EKEOCHA A.H .....194

## SECTION D: AQUACULTURE AND FISHERIES MANAGEMENT (AQFIM)

AQFIM01 – EVALUATING EXOTIC MEDICINAL PLANT EXTRACTS AS ANTIBACTERIAL AGENTS IN AQUACULTURE: A CRITICAL REVIEW OF FISH PATHOGEN CONTROL STRATEGIES – AKINYEMI, I. G., AJAGBE, S. O ., AYOOLA, O. A., ADEREMI, T. F., FADIMU, O. B., OLOMOLA, A. O., SHORUNGBE, M. F. AND OYEDIRAN O. O .....202

AQFIM02 – ANTIBACTERIAL POTENTIAL OF INDIGENOUS MEDICINAL PLANTS AGAINST FISH PATHOGENS: AN ANALYTICAL SYNTHESIS FOR SUSTAINABLE AQUACULTURE – AKINYEMI, I. G., AJAGBE, S. O ., AYOOLA, O. A., OLOMOLA, A. O., ADEREMI, T. F., FADIMU, O. B, SHORUNGBE, M. F., AND OYEDIRAN O. O.....209

# COPPER DEFICIENCY IN LIVESTOCK: EFFECTS ON IMMUNE FUNCTION, DISEASE RESISTANCE AND MICROBIAL INFECTIONS – A REVIEW

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**ABSTRACT**
Nutrition is essential for immune competence and disease resistance in livestock, with trace minerals playing important roles in these functions. Copper is a key micronutrient involved in physiological and immunological processes, acting as a cofactor for metalloenzymes responsible for antioxidant defence, cellular metabolism, and immune regulation. This review synthesises literature on copper deficiency and its effects on immune function, disease resistance, and microbial infections in livestock. Relevant studies were selected based on copper nutrition, immune responses, and livestock health outcomes. Adequate copper status supports both innate and adaptive immunity, while deficiency impairs immune function, lowers vaccine responsiveness, increases susceptibility to infections, and reduces productivity. Copper deficiency negatively affects neutrophils, macrophages, lymphocytes, and antibody-producing cells, weakening host defence mechanisms. Associated conditions include mastitis and respiratory disease in cattle, gastrointestinal parasitic infections in sheep, and bacterial infections in poultry and goats. Hypocuprosis remains common in grazing animals and affects health and performance. Although inorganic copper supplementation is widely used, copper nanoparticles show improved bioavailability and immunological potential, offering opportunities to enhance livestock health and productivity.

***Keywords:***
*Copper, immunity, livestock, microbial infections, micronutrients.*

## INTRODUCTION

The interrelationship between nutrition and immune responsiveness is well documented (Beisel, 1982). Nutritional deficiencies can impair the ability to fight infections, ranging from increased susceptibility to opportunistic infections to suboptimal vaccine responses and various immune disorders (Powell *et al*., 2000). Deficiency of essential nutrients can reduce resistance to viral infections and consequently increase viral load, overwhelming the body's defence mechanisms (Calder *et al*., 2020). Micronutrients are nutrients required in trace amounts and include vitamins and minerals. Copper is one of the indispensable micronutrients necessary for normal physiological functions and proper immune system performance and serves as a component of several metalloenzymes involved in metabolic and immune processes.

Copper deficiency has been associated with immunologic dysfunction and increased susceptibility to diseases (Stabel and Spears, 1989; Kies, 1989). Evidence suggests that some immune disorders are nutritionally induced rather than inherited, and these effects are often reversible following correction of nutrient deficiencies (Beisel, 1982). Immune dysfunction associated with malnutrition is referred to as Nutritionally Acquired Immune Deficiency Syndrome (NAIDS) (Beisel, 1996), which may be corrected through appropriate nutritional supplementation. Therefore, adequate nutrition plays a crucial role in maintaining effective immune function. Interactions among nutrients should also be considered during supplementation to avoid inducing deficiencies while correcting others. For example, although zinc plays an important role in immunity, excessive zinc intake may interfere with copper absorption and contribute to copper deficiency. Therefore, balanced supplementation approaches are essential. Despite extensive evidence supporting the importance of copper in immune function, important knowledge gaps remain regarding copper metabolism across livestock species, particularly variations in copper absorption, utilisation, storage, nutrient interactions, and their influence on immune responses and disease resistance. Furthermore, limited information exists on the long-term effectiveness and safety of emerging copper supplementation strategies. Therefore, this paper reviews the immunological roles of copper and its effects on infectious disease control in livestock while identifying current knowledge gaps and highlighting areas requiring further research to improve animal health and nutritional management.

## METHODOLOGY

This paper presents a review of published research findings. A literature search was conducted using electronic databases to identify original research articles, conference papers, and systematic reviews that reported on copper deficiency in livestock and its effects on immune function, disease resistance, and microbial infections.

### *The Effect of Copper Deficiency on Microbial Infections and Disease in Livestock*

Copper deficiency has been associated with increased susceptibility to microbial infections and diseases in livestock (Spears, 2000; Stabel and Spears, 1989). Deficient animals often

exhibit weakened immune responses, poor vaccine efficacy, delayed recovery from infections, and increased disease severity. Viral infections become more severe when the immune system is compromised due to inadequate micronutrient supply (Calder *et al*., 2020). Copper deficiency reduces antibody production and impairs the ability of neutrophils and macrophages to destroy pathogens, thereby reducing resistance to infectious diseases. Copper contributes to antiviral defence by supporting epithelial integrity, enhancing phagocytic activity, and promoting antibody and cytokine production. Copper-dependent enzymes also reduce oxidative stress generated during infections. Inadequate copper status weakens antioxidant defence systems and impairs immune cell function, thereby creating conditions favourable to viral replication and disease progression (Percival, 1998; Bonham *et al*., 2002). Copper also plays important roles in leukocyte migration, phagocytosis, cytokine production, and antibody secretion.

In grazing animals, hypocuprosis remains one of the most common mineral deficiencies. Hefnawy and El-Khaiat (2015) reported that goats with copper deficiency are more susceptible to infectious diseases and respond poorly to vaccination. Similar observations have been made in cattle and sheep, where copper deficiency negatively affects disease resistance and productivity (Suttle and Jones, 1986; Spears, 2000). Copper-deficient animals demonstrate reduced bactericidal activity and weakened immune responses. In cattle, copper deficiency has been linked with increased severity of mastitis, an inflammatory disease of the udder commonly caused by bacterial pathogens such as *Staphylococcus aureus*, *Escherichia coli,* and *Streptococcus agalactiae* (Scaletti *et al*., 2003). Reduced phagocytic activity in copper-deficient cattle limits bacterial clearance and contributes to more severe infections (Cerone *et al*., 1998). Copper deficiency in calves has also been associated with a greater occurrence of respiratory disease complex (pneumonia) caused by pathogens including *Mannheimia haemolytica*, *Pasteurella multocida*, and respiratory viruses. Impaired immune cell function reduces the animal's capacity to eliminate respiratory pathogens, increasing disease susceptibility (Spears, 2000). In sheep, hypocuprosis is associated with reduced resistance to gastrointestinal parasitic infections, especially infections caused by *Haemonchus contortus* and other gastrointestinal nematodes. Copper deficient sheep may show poor body condition, diarrhoea, anaemia, and increased parasite burdens due to compromised immunity. In severe deficiency cases, animals become more susceptible to secondary bacterial infections due to immune suppression (Underwood and Suttle, 1999). In goats, copper deficiency has been associated with poor immune responsiveness, increased vulnerability to infectious diseases, and reduced vaccine responsiveness (Hefnawy and El-Khaiat, 2015).

In poultry, copper deficiency may increase susceptibility to infectious diseases through suppression of immune responses and impairment of epithelial barrier integrity. Increased



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susceptibility to pathogens such as *Salmonella enterica* and *Escherichia coli* has been suggested because deficient birds exhibit weakened immune defences and reduced resistance to infection (Klasing, 2007).

*Copper Supplementation in Livestock Nutrition*

Copper supplementation is commonly practised in livestock feeding programmes to prevent deficiency and improve productivity. Traditionally, copper has been supplied in the form of inorganic salts such as copper sulphate. However, inorganic copper salts may dissociate in the digestive tract, producing reactive free ions that interact with dietary compounds and reduce mineral absorption and utilisation (Spears, 2003). The supplementation of copper in commercial poultry feed in the form of inorganic salts breaks down in the digestive system, producing free ions that are highly reactive and can bind to dietary molecules, hampering their absorption, bioavailability, and utilisation (Dozier *et al*., 2003). Advances in nanotechnology have introduced copper nanoparticles as an alternative source of copper supplementation. Several studies have reported that copper nanoparticles possess better absorption, improved bioavailability, and enhanced immune benefits compared with conventional inorganic copper salts. Ognik *et al*. (2018) observed improved growth performance, antioxidant status, and immunity in animals supplemented with copper nanoparticles. Copper nanoparticles are promising alternatives, but their use in livestock is limited by concerns over dose-dependent toxicity, tissue bioaccumulation, oxidative stress, and possible cellular damage, while long-term effects on animal health, product safety, and environmental impact require further study.

## CONCLUSION

Copper is an essential micronutrient for immune function, antioxidant defence, and disease resistance in livestock. Copper deficiency impairs immunity, reduces vaccine response, increases susceptibility to infections, and lowers productivity across animal species. However, important research gaps remain, particularly regarding the mechanisms linking copper to immune regulation, species-specific copper requirements, and nutrient interactions. Although copper nanoparticles show promise due to improved bioavailability, their long-term safety and effectiveness require further investigation. Future studies should focus on clarifying copper's immunological mechanisms and developing safe, species-specific supplementation strategies to improve livestock health and sustainable production.

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