Title of Proposal: Innovative Feed Solution: A Research Investigation into the Production and Utilization of Black Soldier Fly Larvae For Low -Cost Poultry Feed

II. Thematic Area: Agriculture and Food Manufacturing

III. Background to Research

The current high cost of poultry products (2-3kg broilers at N12-N15,000 and a crate of egg at N5,500-N6,000) is attributed to skyrocketed cost of fishmeal: the major animal protein ingredient in poultry feeds (from $608/mt in 2001 to $1.739/mt in July 2024), making poultry products unaffordable to consumers (Ebenebe, 2021). The use of cheaper plant-based protein like soyabeans is limited by deficiency of essential amino acids and require large expanse of land for its cultivation. While the use of alternative animal protein like housefly maggots is stalled by presence of harmful bacteria, Black soldier fly larvae (BSFL) a cheap, environmentally-friendly, harmless alternative with potential to destroy highly resistant bacteria as well as naturally occurring contaminants in feed (Gasco *et al.* 2023) has remained unharnessed.

Black soldier fly (BSF) is a wasp-like fly, with gluttonous larvae that feed on organic waste, reducing their bulk and odour and developing into nutrient-rich larva capable of replacing fish meal in poultry feeds (Mutafela, 2015). The organic waste reduction potential of BSFL is about 83% (Mutafela, 2015). Gasco *et al.* (2023) noted that BSFL contains natural antibiotics which destroy disease organisms while Ebenebe (2021) posited the nutritional benefits as well as the economic advantages of large-scale production of BSF larvae for poultry feed formulation.

IV. Statement of Problem

Report of the Chairman of Poultry Association of Nigeria (PAN) indicates that farmers and feed millers are dropping out of business because of high cost and scarcity of poultry feed ingredients (Ebenebe 2021); unaffordable prices of poultry products (2-3kg broilers at N12-N25,000 and a crate of egg at N5,500-N6,000); low animal protein intake in Nigeria and the country listed among the countries with highest maternal-infant mortality, stunting of children associated with animal protein shortage. Alternative animal protein ingredients like BSF larvae capable of decomposing organic waste to nutrient-rich larva useful in the production of low cost livestock feed is still unharnessed (Sajid 2023, Shah et al., 2022). Yet, waste management in urban centres remains an environmental issue (Mutafela , 2015). Nigeria generates 42 million tons of solid wastes annually that ought to yield tons of BSF larva for livestock feed production.

V. Objectives of the Research

The research project is aimed at increasing the number of poultry feed producers/farmers using black soldier fly larvae (*Hermetia illucens*) for replacement of costly fishmeal in the production of cheaper poultry feed by 20 to 30% in the Southeast region and at least 10% in Nigeria by 2026, through popularization of the technology for large-scale black soldier fly larvae production.

The specific objectives are to:

1. Develop a demonstration centre for BSF larvae production and farmersTraining module
2. Evaluate nutritional contents and quality of two forms of BSF larvae
3. Develop sample BSFL-based feed formula for poultry
4. Investigate the effects of BSFL meal diets on growth performance, carcass and egg quality
5. Determine the nutrient composition and organoleptic properties of poultry products
6. Determine cost benefit analysis of the new diet
7. Design a functional lavarium for BSFL larval production
8. Develop a scalable model for the production and marketing of BSFL meal

VI. Research questions

i. What are the optimal operational parameters and infrastructure required to establish a high-yield demonstration center capable of producing at least 10 tons of BSFL per week?

Ii. What are the essential components and pedagogical approaches for a training module that effectively teaches poultry farmers the production protocol for large-scale BSFL?

iii. How do the nutritional profiles, including protein and amino acid content, of defatted and full-fat BSF larvae compare, and how does this affect their suitability for poultry feed?

iv. What is the most cost-effective and nutritionally balanced BSFL-based feed formulation for broilers and layers that can be developed for on-farm use?

v. How does the inclusion of BSFL larval meal in poultry diets affect the growth rate, feed conversion ratio, and overall meat and egg quality of broiler and layer chickens?

vi. How do the proximate nutrient composition and sensory properties of chicken meat and eggs from a BSFL-based diet compare to those from conventional feeds?

vii. What is the economic return on investment and cost-benefit ratio of utilizing a BSFL-based diet for poultry meat and egg production compared to conventional feed?

viii. What are the key elements of a scalable and sustainable business model for the production and marketing of BSFL larval meal to local poultry farmers?

ix. How can user-friendly and affordable technologies, such as ready-to-use lavarium, pupa cages, and vibrating harvesting machines, be designed and effectively promoted to farmers to streamline BSFL production?

x. How does a comprehensive training program on BSFL production techniques impact farmers' knowledge, adoption rates, and subsequent efficiency in utilizing BSFL as a poultry feed source?

VII. Literature review

Feed cost represents 50 to 70% of total poultry production cost, strategies that reduce the feed cost will make poultry products affordable to consumers (Ebenebe, 2021). The high production cost of feed is the result of escalating cost of protein ingredients. Plant proteins are limited by presence of anti-nutritional factors, deficiency of some essential amino acids and competition with man (Sajid et al., 2023). Replacement of costly protein ingredient with cheap, nutrient-rich BSF larvae can sustain low-cost poultry feed, thus, making poultry products affordable to consumers (Ebenebe, 2021).

Black soldier fly larvae (BSFL) contain up to 40 -60% of crude protein with essential amino acids, more than 30% of lipids, minerals and vitamins (Mutafela 2015). BSFL amino acid profile is comparable to fishmeal (Ebenebe, 2021)

VIII. Theoretical Framework

Production cost refers to the cost a company incurs from manufacturing a product or providing a service that generates revenue. Profitability arises when the aggregate revenue is greater than the aggregate expenditure in a reporting period. Strategies that ensure low-cost feed production, lowers aggregate expenditure resulting in profit are paramount. Trials with animal proteins like feather meal, offal meal, maggot meal and earthworm meal were limited either by poor digestibility, unavailability at commercial quantity, and disease -related problems (Ebenebe, , 2021). BSF larva is not subject to these limitations and thus its suitability as a replacement for costly fishmeal in poultry feed formulation. Besides, BSFL decomposition of organic waste maintains environmental health (Mutafela, 2015).

IX. Research Methodology

In the first phase, facilities and materials needed for up-scaling existing BSF farm to one ton/ day capacity will be itemized and purchased. This will be followed by arrangement with input suppliers for steady and sustained supply of organic wastes (Breweries for spent grain and yeast, livestock farmers for waste, fruit and vegetable market leaders). Then assessment of the Waste Load Rate (WLR) needed in meeting 30 tons larvae/month, a lot of literature will be reviewed.

Ten thousand 5-Day- Old -Larvae (DOL) will be halved, one group defatted using N-hexane, the other full fat, milled separately and subjected to proximate, mineral and amino acid analysis to ascertain the form that yields better nutrient composition. The one with better nutrient composition will be incorporated into poultry feed to replace fishmeal at 25%, 50%, 75% and 100% for broilers at starter and finisher stage, layers at chick, grower and laying stage to ascertain the inclusion level that will give optimal yield of products. Two hundred and fifty DOC broiler chicks will be subjected to each of the dietary treatments for eight weeks and 150 point-of-lay pullets for 52 weeks, growth and egg production will be monitored.

Thereafter, proximate composition and organoleptic properties of poultry meat and eggs from birds fed with conventional and BSFL-based diets will be compared, while the cost-benefit

analysis of raising broilers and layers on conventional and BSF larval- based diet will be checked. Large scale lavarium for rearing of insect larva and dark cages will be fabricated locally by the Mechanical engineering experts as well as vibrating machine for harvesting of larva and popularized. Conduct a comprehensive hands-on training program on BSL production and feed utilization and a post-training evaluation on adoption rate, cost-effectiveness and impact on poultry production among selected farmers.

X. Expected Results

- Twenty to thirty percent reduction in feed cost
- Ten to twenty percent reduction in cost of poultry products
- Increase in animal protein consumption
- Use of locally fabricated harvesting equipment by farmers and feed-millers
- Publication of findings in reputable journals
- Graduation of two (2) Master of Science students

XI. Innovation: How different is it from earlier projects

Techniques for farm based large scale production of black soldier fly larvae (BSFL) and locally fabricated lavarium, dark cages for pupa management as well as vibrating machine for larva harvesting will be developed. Nutrient rich, low cost poultry feed based on BSF larva will be produced.

X. Estimated budget: N49, 466, 873.96

XI. References

Ebenebe C. I. (2021). Harnessing Alternative Ingredients for Livestock and Fish Feeding. Invited Paper Presented at the 1st National Feed Summit, Federal Ministry of Environment and Rural Development. 23rd to 25th September, 2021.

Hayes A. (2021). Production Costs. The Evolution of Accounting Investopedia.com

Mutafela R. N. (2015). High Value Organic Waste Treatment via Black Soldier Fly Bioconversion: Onsite Pilot Study. M.Sc. Thesis, KTH, Royal Institute of Technology, Stockholm

Sajid Q. U., Asghar, M.U.et al (2023). Insect Meal as Alternative to Protein Concentrate in Poultry Nutrition with Future Perspectives. Agriculture 2023: 13 (6).1239

Shah A.A., Pajaree T., et al. (2022). Anim. Biosc. 35 (2): 317 331. DOI: 10.5. 5713/ab.21.0447

Research team (Name/Rank/ Highest Qualification/Area of Specialization)

i. Prof. Samuel Ndubisi Samuel Machebe / Professor/PhD/ Animal Physiology

ii. Prof. Cordelia Ifeyinwa Ebenebe/ Professor/ PhD/ Animal Production & Management

iii. Dr. Chukwuemeka Jude Ohagwu/Senior Lecturer/Food and Bioresources Engineering

iv. Leonard Ugwuowo/ Reader/ PhD/ Animal Nutrition & Biochemistry

v. Bright C. Amaefule/Senior Lecturer/ PhD/ Animal Physiology

vi. Jervas Ikechukwu Ugwuoke/Lecturer 1/PhD/ Animal Nutrition & Biochemistry

vii. Vincent C, Anopu (M.Sc)/ Student

viii. Nwachinemere Samuel Ekwu (M.Sc)/ Student