🗒️ Alternative Protein Symposium Report 2024

REPORT ON THE 2024 SYMPOSIUM ON ALTERNATIVE PROTEINS IN NIGERIA

Sponsors

gfi Good Food Institute[SM]

EA Funds
Animal Welfare Fund

FOOD SYSTEM INNOVATIONS

COMMON GROUND
SYNTHESIS OF BIOLOGY

THE BETTER MEAT CO.

ROLE OF STUDENTS AND ACADEMIA IN THE TRANSITION TO A SUSTAINABLE PROTEIN FUTURE, A SYMPOSIUM REVIEW February, 2024

Omale, D. M[1]., Dibua N. N[2], Kalep B.F[3]., Ishiwu C. N[4]., Nwaeze I. A[1]., Wassen S[5]., Belal J. M[6]., Leman A[7], Hunt D[8], Igene J[9], Oluwarore K[10], Adekoya T. S[11] and Fashola O[12].

Editors: Anchang M. M, Aleke J. C., Sale V. B., Ofoegbu D. C and Mbaeyi-Nwaoha I. E.

Author Affiliations:

1. Department of Food Science and Technology, University of Nigeria, Nsukka.
2. Department of Microbiology, University of Nigeria, Nsukka
3. Department of Food Science and Technology, Modibbo Adama University, Yola
4. Department of Food Science and Technology, Nnamdi Azikiwe University, Awka
5. Research Institute of Sweden and Chalmers University of Technology Gothenburg, Sweden
6. Department of Food Science and Technology, California State Polytechnic University, Pomona
7. Good Food Institute
8. Good Food Institute Europe
9. University of Benin

10. One Health Development Initiative
11. Edge Hill University
12. Casa Vegan

Abbreviations

Alt-Pro: Alternative Proteins

CO_2: Carbondioxide

EU: European Union

GFI: Good Food Institute

SDG/SDG’s: Sustainable Development Goals/ Sustainable Development Goals

UNESCO: United Nations Educational, Scientific and Cultural Organization

US: United States

USDA: United States Department of Agriculture

Executive summary

As the global food system faces inefficiencies, including excessive resource consumption, greenhouse gas emissions, and inequitable access to nutritious foods, there is an urgent need to transition towards more sustainable alternatives. This has become more imperative considering the projected increase in global population (10 billion by 2050 globally and 400 million for Nigeria) means we will have to increase food production particularly animal agriculture, which will have to be doubled to meet up with global protein demands. Animal agriculture is central to our food system as it is not only an important part of our diet but it is also important to our cultural expressions. Notwithstanding, the amount of resources it takes to get beef, chicken, milk and eggs coupled with the proliferation of factory farming has placed us on a crisis bound path which is contrary to the wellbeing of the planet, people and animals. The need to sustainably feed our population has led to the establishment of the field of **sustainable protein**. This new concept is said to hold a lot of answers to feeding our increasing population

and feeding them sustainably. To that end, the symposium was organised to enlighten relevant groups and the public in Nigeria on the pivotal role of academic institutions and students in this transition to a future of sustainable protein production. The objectives of the symposium were to (1) highlight the inefficiencies of the current food system, specifically within the context of African foods and our nutritional demands, (2) highlight the role of universities in understanding their role in transforming the food systems and the SDGs and be at the forefront of addressing them (3) describe the science of alternative proteins and (4) analyse how collaboration between science, industry and policy can lead to the commercialisation of sustainable protein products. The key takeaway was that academia can catalyse change in the global food landscape by addressing inefficiencies in the current food systems, advancing alternative protein research, and fostering industry collaboration. The discussions from this symposium have provided an idea on how future research, innovation, and policy development will help in the growth of the alternative protein sector in Nigeria.
Keywords: Food Systems, Alternative proteins, collaboration, research, innovation, policy development.

📘 Full Report

INTRODUCTION

Sub Saharan Africa is set to be one of the largest drivers of population increase in decades, and considering the increasing demand to industrialize animal agriculture, there is a need to counter these inefficient food production systems by providing sustainable food options that can counter the growth of factory farming in Nigeria and Africa at large. **Sustainable proteins (otherwise called alternative proteins)** are already being touted as a widely encompassing solution for our climate, health, nutrition, food security and animal welfare challenges. Ensuring we take advantage of these solutions in Nigeria depends on the student and academic community. It should be seen as the foundation for research, innovation, education and awareness in the field. The educational initiatives and training being carried out in space would necessitate the research outputs that can be used to drive innovation for solutions or to carry out advocacy with policymakers and amongst the public. For this purpose, the symposium explored the role of students and academia and how their activities connect and cut across **science, policy and industry** for the transition to a sustainable protein future.

THE INEFFICIENCIES OF THE CURRENT FOOD SYSTEMS: THE NIGERIAN PERSPECTIVE

(Professor Kalep Bulus Filli; Department of Food Science and Technology, Modibbo Adama University, Yola).

The first session in the symposium titled "Food Systems And The SDGs: Role of Universities" was intended to cover broad challenges that cut across food security and sustainability in our context, how the SDGs are tied to food systems transformation and how universities are the bedrock of that transformation.

Professor Filli of Modibbo Adama University enlightened the public on Nigeria's immense contribution to sub-Saharan Africa regarding population and resources. He described the food system as one that embraces the entire aggregation, processing, distribution, consumption, and disposal of food products (Kalep Bulus). Since food is a basic integral component of our lives, it is a fuel or energy source for life processes. Therefore, there is an urgent need to create pathways for food sufficiency and supply to meet the population's health needs. He opined that focusing on the bioeconomy will strengthen our food economy. Food security is essential, especially for the African Agenda. The actors driving this transformation include science, technology, data, and innovation actions. In 1990, 36% of the world's population lived in poverty, and Nigeria contributed significantly to this population.

Bulus highlighted that the Nigerian food system's challenges include conflicts, climate change, and economic headwinds. Climate change affects the food system as a result of global warming. The biosystem cannot respond ideally to this change again. He opined that the use of blockchain technology could be used in the food and agriculture industries to provide a shared food system and that we can bake resilience into our food system by:

- Cultivating a decisive, deliberate action towards conflict
- Ensuring that agricultural policies target peasant farmers, who are major contributors.
- Adoption of new technologies.
- Ensuring food quality and safety
- Input fortifications as a means of improving yield

ALTERNATIVE PROTEINS AND THE SDGs

(Prof. C. N Ishiwu, Nnamdi Azikiwe University, Awka, Anambra State and David Omale, University of Nigeria Nsukka)**.**

How will we feed 10 billion people by 2050?

Professor Ishiwu of Nnamdi Azikiwe University highlighted suggestions and concepts on the role of alternative proteins in climate change mitigation, which entails sustainability, efficiency, and safety. In comparing alternative proteins to animal agriculture, he suggested that swapping conventional meat for plant-based or cultivated meat, for instance, reduces environmental impacts. Because these proteins are obtained through the extrusion of plant material or grown in bioreactors, they help conserve farmland and, in the process, allow it to rest for a whole planting season. He further emphasised how cultivated meat reduces greenhouse gas emissions by emitting less gas than conventional meat. Swapping conventional meat for cultivated meat produced with renewable energy also reduces environmental impacts as it uses 90% less water (less water, less air pollution, produces fewer toxic chemicals and greenhouse-gas emissions, compared to conventional). Furthermore, he pointed out that more sustainability and Food Security use plant-based proteins because they use fewer natural resources. It also offers a scalable solution for feeding a growing population without overburdening the planet's resources. Unlike animal agriculture, which has the disadvantage of higher emissions, this is because livestock farming contributes heavily to methane, nitrous oxide, and CO_2 emissions, which accelerate climate change. Also, animal farming demands substantial water, feed, and land, often contributing to land degradation and water scarcity. Large-scale animal farming leads to habitat loss, ultimately impacting biodiversity. David Omale, on the other hand, used terms like land use, water use and eutrophication to describe the impacts of industrial animal agriculture on our environment. Omale taught that animal agriculture had not been generally industrialised in Nigeria or Africa on a scale as seen in global north countries like the US and Europe. He also highlighted the "give or take" situation of it all when he mentioned that industrialising African food setup, particularly in the animal agriculture sector, would mean we would not be able to keep up with climate commitments and, in the process, experience the same challenges that are being seen in US and Europe today. He also briefly introduced how cultivated meat is made and briefly introduced the experts in the field.

FUNDAMENTAL EFFICIENCY GAINS FOR ALT PROTEINS

In summary, getting meat from livestock is not gainful compared to cultivating it in a bioreactor. Livestock consumes more land than crops. Plant-based meat (beef, pork, chicken), uses less land. The deforestation rate for rearing animals is 75% compared to cultivation using a bioreactor.

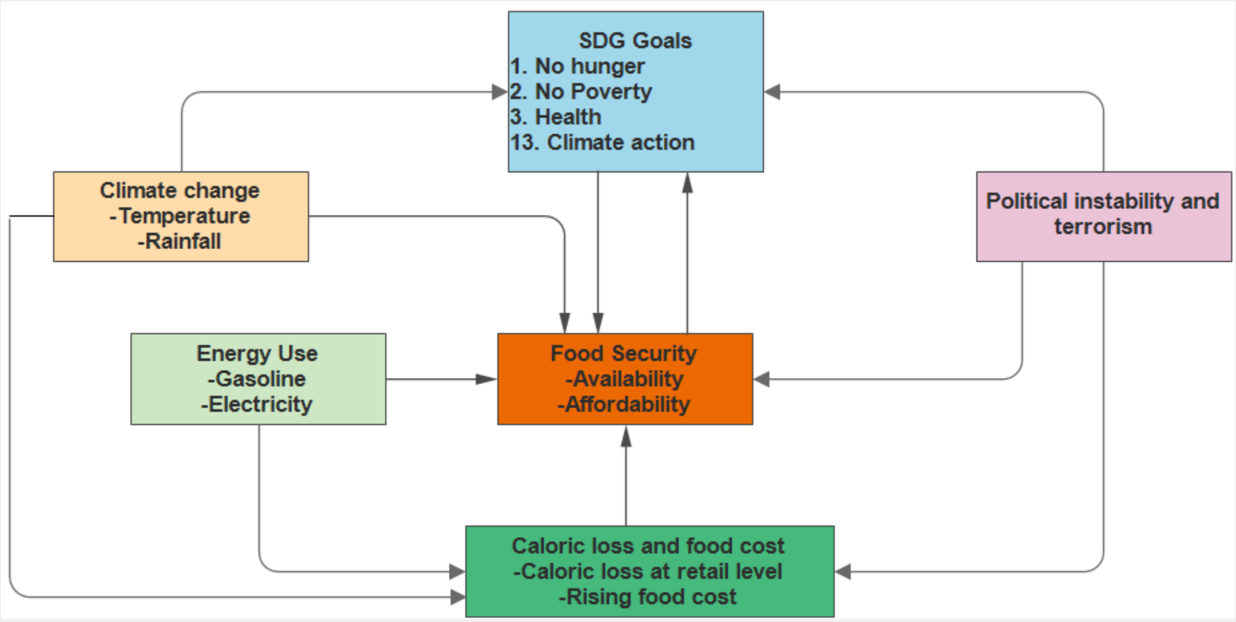

Figure 1. The interconnectivity between the components of food security and several determinants, including climate change, energy use, food costs, and political instability, *vis-à-vis* the attainment of SDGs.

THE UNIVERSITY OF NIGERIA ECOSYSTEM AND ITS POTENTIAL TO ADVANCE ALTERNATIVE PROTEIN EDUCATION, RESEARCH, AND INNOVATION

(***Nwaeze Ijeoma, Ph.D.; Department of Food Science and Technology, University of Nigeria, Nsukka***)

The University of Nigeria is the only university in Nigeria advocating for the popularization of alternative proteins. Dr Nwaeze highlighted the recommendations of the University of Nigeria Alt Protein Project and their focus on the need to develop a roadmap for a sustainable, secure and ample protein supply in Nigeria by identifying the most efficient solutions. She stated that the university can lead this call through the array of disciplines run by the school that are associated with alt proteins. These disciplines at the University of Nigeria include Agricultural Science, Agricultural Economics, Agricultural Engineering, Economics, Mathematical Biology, Biotechnology, Microbiology, Plant Biology, Synthetic Biology, and Nutrition Science, amongst many others. Several centres in UNN can potentially get involved in Alternative Proteins, some of which include the UNESCO International Center for Biotechnology, Central Science Laboratory, National Center for Energy Research and Development Laboratory, as well as the South-East Biotechnology

Development Agency (NABDA) regional centre. While these offices are focused on other research topics, there is a need for work to be done to sway them towards this revolutionary cause. Dr Nwaeze further described how disciplines at the intersection of biology and engineering could be relevant to fermentation-based alternative proteins and further recommended how the school can cultivate young minds for this endeavour.

ALTERNATIVE PLANT-BASED SOURCES FOR ENVIRONMENTAL IMPACT AND GOOD HEALTH

(***Sophia Wassen, PhD; Research Institute of Sweden Chalmers University of Technology, Gothenburg, Sweden***).

The second session explored the science behind alternative proteins, particularly in plant-based, fermentation-based and cell-based alternative proteins. Experts in the field mentioned terms like extrusion, bioreactor, cellular agriculture, cell lines, and scaffolding, amongst others, to describe these methods and their materials

RESEARCH AND DEVELOPMENTS IN ALTERNATIVE PROTEINS RELEVANT TO FOOD SECURITY NEEDS IN NIGERIA

(Emeritus Professor John Igene, University of Benin).

DISCOVERING NOVEL METHOD TO MEASURE THE DEGREE OF TEXTURIZATION OF EXTRUDED MEAT ANALOGUES

(Belal J. Muhialdin, PhD; California State Polytechnic University, Pomona)

NUTRITION QUESTIONS SURROUNDING ALTERNATIVE PROTEINS

(***Titilope Adekoya, Master of Science in Public Health, Edge Hill University, United Kingdom)***

The alternative protein landscape is divided into three:

- Plant-based protein
- Fermentation-based proteins
- Cell-based Meat

In sessions two and three, Wassen, Igene, and Bulus concentrated on various aspects of the plant-based protein.

Igene stated that alternative proteins cover diverse substitutes for traditional animal-derived proteins, addressing environmental, ethical, and food security concerns.

Plant-based proteins, like soy and peas, gained popularity for their sustainability and ethical considerations, responding to the increasing demand for diverse protein sources. Insect-based proteins offer a resource-efficient and sustainable alternative, contributing innovation to the protein landscape.

He noted that cellular agriculture introduces lab-grown or cultured meat to reduce environmental impact and ethical issues linked with traditional animal farming. Fungi-based proteins (*mycoprotein*) and marine-based proteins from algae provide additional choices, meeting the global demand for protein and promoting a resilient food system. Simultaneously, meat analogues, designed for meat eaters, deliver a sensory experience mirroring conventional meat.

Wassen emphasised that plant-based diets are low in salt, sugar, and saturated fats and are recommended to favour a healthy lifestyle. However, plant proteins do not have a complete amino acid profile. Micronutrients are not available in all crops; antinutritional factors can inhibit the uptake of micronutrients. However, she emphasised that we need to change our food system to obtain the benefits of consuming plant-rich foods. Plant-based diets have a role to play, and it is better to eat plant proteins than animals, which are not efficient protein converters. Titilope Adekoya answered questions surrounding the health and nutritional benefits of alternative proteins, particularly about how these proteins provide alternatives to red meat. She also opined that consumers see sustainable proteins as a form of clean meat which does not require the usage of antibiotics or growth hormones nor is susceptible to the threat of zoonotic diseases, and this makes it a desirable option, as seen in the growth in the market share over the years. However, she believes the label of ‘ultra-processed food' which has been attached to alternative meat, milk and eggs is not far-fetched. For that reason, claims of its nutritional benefits are still being questioned within the health and nutrition circles. She further stated that while these claims do not do justice to what alternative proteins can mean for the health and wellness of enthusiastic meat consumers, efforts should be made within academic circles and industry R&D to reduce the ingredient list and salt levels of these products and ensure they meet the definition of a “clean label” food.

Why is plant-based protein slow and taking a long time to commercialise?

According to Wassen, factors influence decision-makers, consumers, and policymakers. Plant-based products should be attractive and available.

Plant-based proteins have functional properties that help them achieve their effect in food products. The proteins have to be compressed (concentrated through dry fractionation) and can be made more functional; flour is added to them so they do not get overprocessed. They are processed for better properties; this can be done through bioprocessing, often done under wet conditions and increases retention ability.

The process window for each protein: Wassen highlighted that different proteins give different textures when extruded because of the protein type, the process temperature, extraction (fractionation) methods, and mixed systems. There is also a need for a variety of crops; during cultivation, this can secure a sustainable path. It is essential, therefore, to think about the whole value chain. Thus, cooperation is needed throughout the entire value chain, from plant breeds to cultivation and consumption. There is a need for massive work in food security. In summary, healthy diets have different contexts in different countries. Processes are to be used reasonably so they do not get overprocessed. Mixing and finding are also very important.

According to Igene of the University of Benin, Nigeria grapples with significant food security challenges, impacting the nation's growth and development. The key issues include insufficient food intake, protein and micro-nutrient deficits, and calorie consumption below the recommended 2000 Kcal/person. These challenges contribute to malnutrition, hindering the overall well-being of the Nigerian population. Addressing these challenges is paramount for fostering human growth and development and a healthier society in Nigeria. He explained that meat production contributes significantly to adverse environmental changes and resource depletion. Excessive meat consumption is linked to health issues such as overweight, obesity, cardiovascular diseases, and type-2 diabetes. He noted that exploring alternative protein sources reflects a forward-looking approach to addressing nutritional challenges and health concerns associated with meat consumption in Nigeria. Embracing alternative proteins, including plant-based foods, insect proteins, and those from unicellular organisms, is essential. The development of meat analogues emerges as an attractive solution to enhance food and nutrition security in Nigeria.

Extrusion in Plant-Based Proteins

Extrusion is a manufacturing process in which raw materials are pushed through a die to create objects with a fixed cross-sectional shape. It involves applying pressure to force materials through a shaped hole or mould, allowing them to form continuous lengths of material cut or further processed. The process can be used for various materials, including metals, plastics, and food products.

Extrusion technology is widely used in producing plant-based proteins, especially for creating meat alternatives. The process helps in texturising plant proteins to resemble the texture and mouthfeel of animal-derived meat.

According to Wassen, extrusions are used to texturise proteins; this mimics the protein fibre found in beef so that the protein can become fibrin proteins. Unfortunately, this is not an easy process. During this process, physical and chemical processes take place in the material. Soy and Pea differ during meat extrusion because they come from different plants. Their end products will be different, and their storage globulins will be different. Soy has 7s globulin, and pea has 11S globulin. Soy has ß-conglycinin, and Pea has just glycinin. Their active compositions are different.

Understanding Alternative Proteins and Meat Analogues

Uses of Soy Protein in Meat Analogue Production

According to Igene, the conversion of soy concentrates to textured soy proteins is of two variants:

The thermoplastic extrusion of soy flour to textured soy protein and the thermoplastic extrusion of soy protein concentrates. The latter has a wider variety and functional properties, less flavour, and greatly reduced flatulence than the former, textured soy flour.

Thermoplastic Extrusion Process: The first generation of products used defatted soy flour, grits, or flakes as starting materials. The soy material is first hydrated to form a dough. The dough is then fed into the extruder, which combines high shear mixing, high temperature, and high pressure to create a plasticised protein matrix. This process leads to the formation of a product called textured soy product.

Direct Steam Texturization Process: Soy flour is mixed with water to form a dough that is textured by passing through a gaseous fluid pressurised rotary chamber. The concept is similar to the puffing of cereal grains for ready-to-eat breakfast cereal.

Additionally, he highlighted further considerations for in vitro technology (culturing) using animal cells for meat analogue production. These principles encompass key aspects of plant-based meat analogue development in Nigeria, addressing protein selection, fat and oil utilisation, formulation for flavour and texture, colour considerations, taste enhancement, and fortification with essential vitamins and minerals.

Extrusion Technology for the Production of Meat Analogues

The principle is to subject a food mixture containing proteins to hydration, high temperature, high pressure, and mechanical interaction. The extrusion process consists of three main steps: mixing proteins with water in a twin-screw extruder, cooking in a chamber under high temperature and pressure, and cooling in a cooling matrix.

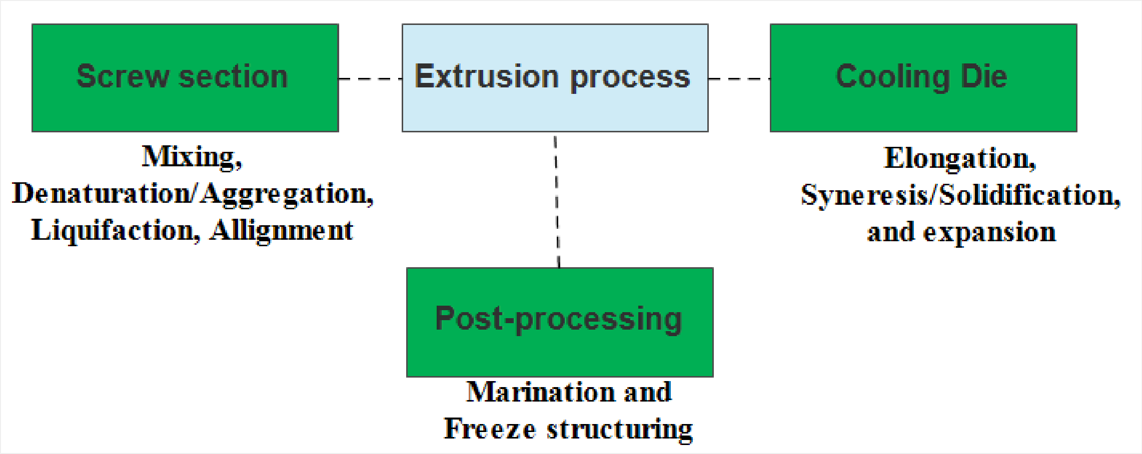

Fig. 2. Tasks subsequently performed during High Moisture Extrusion (HME) of meat analogues, divided over screw section, cooling die, and post-extrusion treatments.

The process window for each protein:

According to Belal Hassan, different proteins produce varying textures during extrusion due to protein type, processing temperature, extraction or fractionation methods, and mixed systems. It is crucial to determine the desired product by measuring the protein content of the food material. If a protein is not soluble, it should not be used in meat products. Choosing the right protein for the correct application is essential. Mixing proteins is key to ensuring the final product's complete amino acid profile.

Various crops are also needed during cultivation, which can secure a sustainable path. Therefore, it is essential to think about the whole value chain. Cooperation is required throughout the value chain, from plant breeds to cultivation to consumption and to guarantee food security. In summary, healthy diets have different contexts in different countries. Processes must be appropriately used so they do not become overprocessed.

Discovering Novel Method to Measure the Degree of Texturization of Extruded Meat Analogues

Belal Hassan described the methods used to measure the degree of texturization of extruded analogues to include,

High moisture extrusion of plant proteins, a process requiring a twin screw extruder. It is a thermomechanical process that converts globular proteins from stored plant proteins into fibrous structures by mixing the protein concentrates with water and processing them through the bioreactor or the barrel of the extruder to form a fibre-like texture, and that requires a lot of parameters, especially the screw speed and feed rate, but most importantly the temperature.

Still, the most important factor is temperature because, according to findings and a lot of data in the literature, the barrel is divided into 5 to 6 sections; the first section is the mixing zone, where the powder is introduced to the water and is mixed to form the dough, then the bioreactions start to happen in the heating zone where most of the protein bonds are broken down at a temperature between 130°C to 150°C. The cooling die operates at around 50°C-70°C to minimise the temperature difference between the extrudate and the external environment. At this zone, the meat analogues' fibrous nature is formed. If the temperature gap is too large, the product may expand, which is only desirable for low-moisture products. In high-moisture products, any expansion can damage the texture or fibrous structure. The layout of an extruder is presented in

Figure 4, which shows the different extruder compartments.

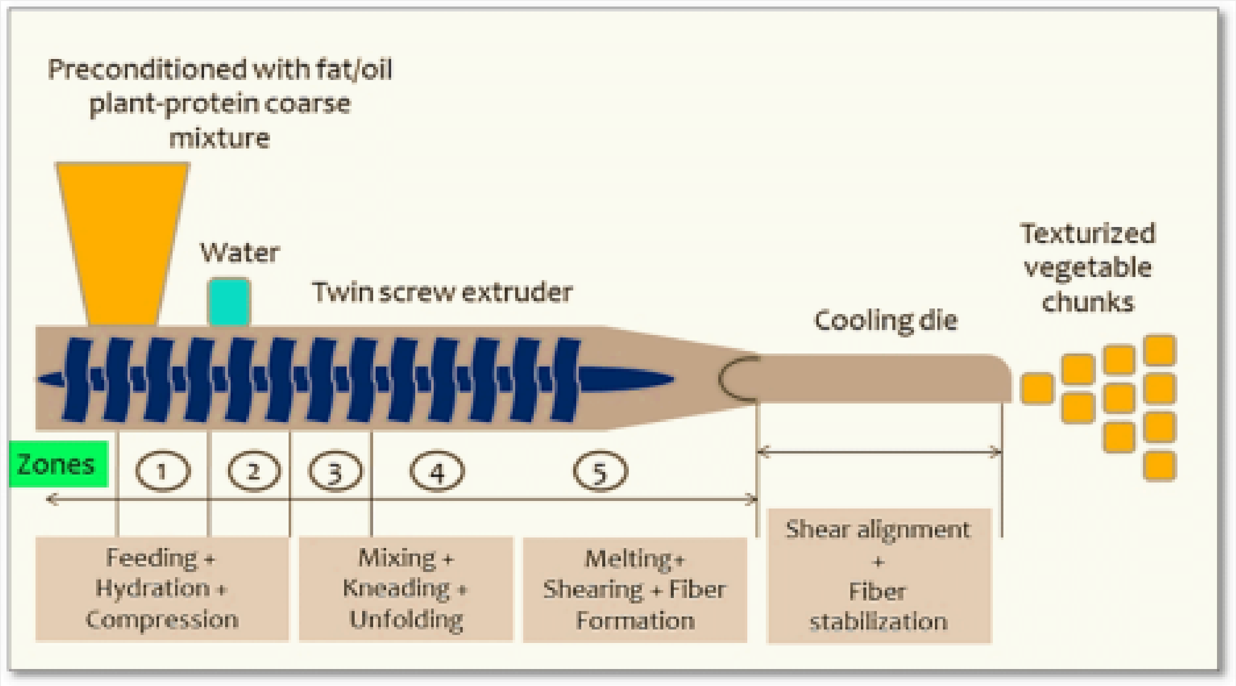

Fig. 4: High Moisture Extrusion of Plant Protein

Source: Singh *et al.,* 2021

Structural Analysis of High Moisture Meat Analogues By Confocal Laser Scanning Microscopy gives a clear view of the formed fibrous structure. The only problem is that the technique is so expensive, and it cannot quantify the texturisation.

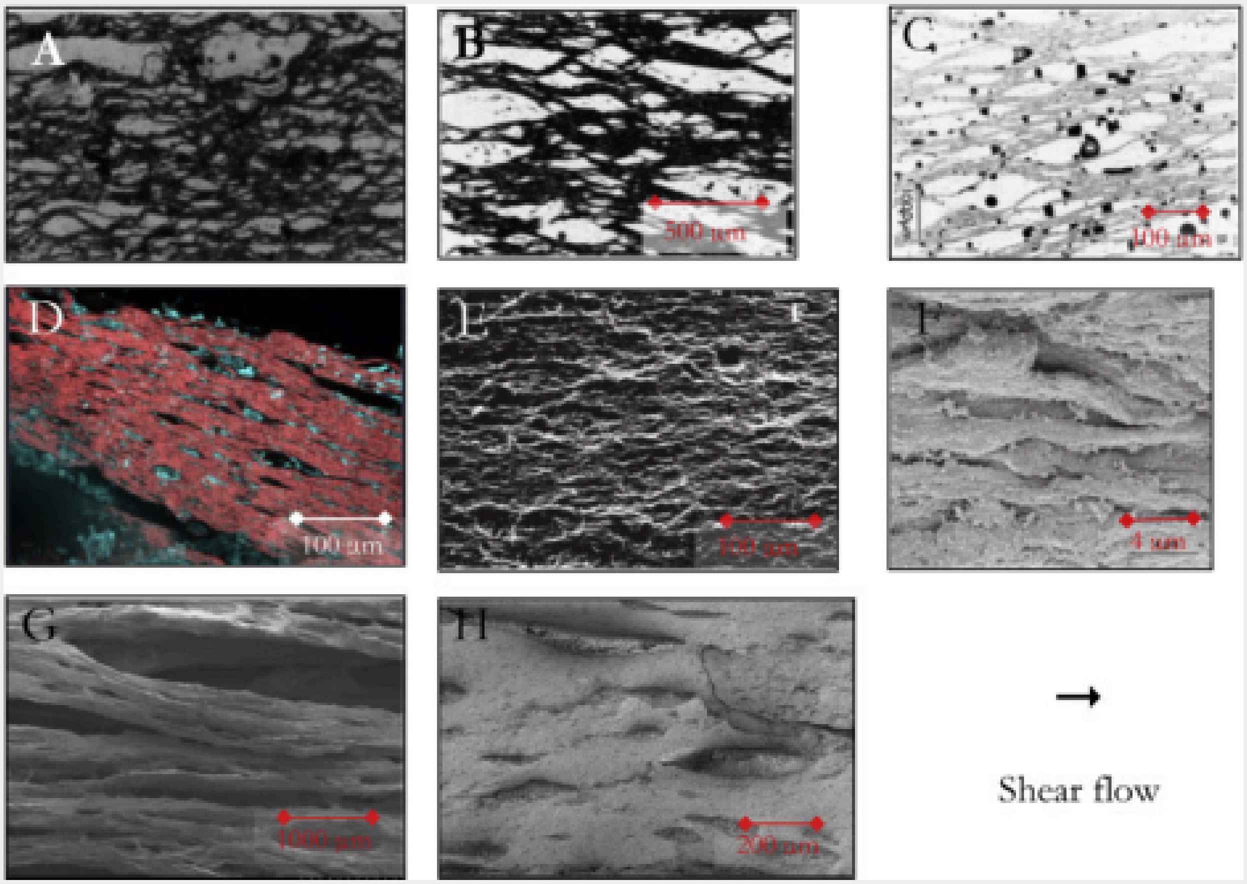

Fig. 5. Micrographs from fibrous samples

Source: Birgit *et al*. 2018

Developing lab-scale and pilot-scale research into fermentation-based alternative proteins in low- and middle-income countries (Adam Leman, PhD; Good Food Institute)

Building on the existing discussion on the alternative protein landscape, Adam Leman explored fermentation-based alternative proteins and cellular agriculture. Dr Leman introduced the concept of plant-based meats, cultivated meat, and fermentation. While previous discussions have emphasised the growing role of plant-based meats, which typically consist of protein isolates from crops like soy, pea, or wheat, and cultivated meat derived from cellular agriculture, Leman focused on fermentation as a crucial third category. He noted fermentation, which involves deriving proteins or fats from microbial growth. He highlighted how it has been a fundamental process for thousands of years, enhancing food quality and shelf life. However, Leman emphasised that fermentation has evolved far beyond traditional uses, where it is now playing an instrumental role in advancing bio-industrial production in the food sector and creating fuels, antibodies, vaccines, and pharmaceutical compounds. His insights build on the foundational work on alternative proteins, showing how fermentation has shifted from traditional food production to a modern bio-industrial approach, reshaping both the food and pharmaceutical industries.

Leman also highlighted that GFI has entered the large-scale bio-industrial age, utilising fermentation to produce transit fuels and pharmacological compounds. Still, he inferred that its early applications in food production, such as citric acid fermentation, have had a lasting impact. Citric acid production, which was industrialised in the 1920s, serves as an example of how fermentation surpassed traditional supply chains, offering cheaper and more stable sources of food ingredients. He further noted that fermentation plays a role in producing vitamins and amino acids, essential in feed and food supplements today.

According to Leman, GFI categorises protein fermentation into three approaches: traditional fermentation, biomass fermentation, and precision fermentation. He explained that traditional fermentation uses live microorganisms to modulate substrates to improve food quality, like yoghurt production. Biomass fermentation, conversely, utilises microbial growth to produce high-protein ingredients, making it particularly valuable for patties or cutlets. Leman also discussed precision fermentation, which uses microbial ingredients to create specific functional ingredients like fats or animal-derived proteins through strain engineering. He noted that this process adds small but crucial percentages of ingredients that enhance taste, texture, and other sensory attributes in food products, such as soy leghemoglobin used in the *Impossible Burger*.

Leman suggested that biomass fermentation is particularly advantageous for low- and middle-income countries due to its ability to provide high-quality protein through rapid microbial growth. He also highlighted the adaptability of microbial fermentations to different feedstocks, which makes them suitable for diverse geographic locations. However, Leman pointed out that traditional fermentation requires minimal downstream processing but longer production times, which could be optimised in precision fermentation facilities for better purity and functionality. He inferred that precision fermentation, while more complex and expensive, holds the potential for creating highly specialised ingredients like flavourings or pigments through bioprocess optimisation.

Leman also discussed the importance of strain development in fermentation, noting that brute force screening and automation through robotics have become common in the industry. While these methods offer fast results, they are often expensive and require extensive follow-up, significantly when scaling from lab conditions to larger bioreactor environments. He highlighted that mycelium and filamentous fungi are particularly useful in laboratory studies, providing insights into media conditions and bioprocess efficiency. For example, Marlow Foods uses *Fusarium venenatum* in biomass fermentation, noting that the organism's long, unbranched mycelial filaments improve product texture and quality.

He also inferred that the bioprocessing of fermentation-derived proteins involves using various microorganisms like yeast, bacteria, and microalgae, depending on the desired protein yield and biomass. He noted that biomass fermentation typically requires less downstream processing, such as pasteurisation or drying, compared to precision fermentation, which involves more complex steps like filtration and purification. He also highlighted the need for efficient bioreactors, feedstocks, and cost-effective methods to scale up production.

According to Leman, pilot systems are crucial in replicating and validating production processes at more minor scales, typically around 2,500 litres, before scaling up to industrial production. He stressed the importance of training operators and researchers on equipment relevant to food production to ensure safe and sustainable bioprocessing. Leman highlighted that controlling pH, temperature, and oxygen levels is essential for optimising fermentation. He further noted that solid-state fermentation offers a more straightforward and cost-effective alternative for biomass production, relying on semi-solid feedstocks and basic equipment like tray reactors and fluidised beds.

In conclusion, Leman emphasised that simplicity and cost-effectiveness are key in scaling fermentation processes, especially for low-income regions. He also inferred that using local feedstocks and adopting techniques from other food industries can help reduce costs and make fermentation more accessible. He suggested that the rational design of experiments and careful scaling of bioprocesses can enable the growth of the alternative protein industry sustainably and efficiently.

The science of cultivated meat: Where the key disciplines belong (David Hunt, PhD; Good Food Institute, Europe).

According to David Hunt, the Good Food Institute (GFI) operates across six regions globally, with a workforce exceeding 200 employees. David Hunt inferred that GFI's core objective is to determine how to efficiently and sustainably feed the global population by 2050. Hunt highlights that this objective involves developing and disseminating relevant knowledge and actively engaging stakeholders across the food system. Moreover, according to Hunt, consumer dietary patterns significantly shape preferences within this system. He emphasised that most individuals self-identify as either omnivores or vegetarians, with vegetarians representing a smaller demographic. Hunt also noted that foundational drivers of food choice—namely taste, price, and convenience—are key in fulfilling consumers' immediate needs. He acknowledged, however, that health, environmental impact, and animal welfare are influential factors, but they tend to be secondary, particularly during economic hardship. GFI, as Hunt observed, underscores the need to transition towards alternative proteins that are sustainable, delicious, affordable, and accessible.

David Hunt further highlighted the process of meat cultivation, explaining that it replicates biological processes found in animals by providing cells with the necessary nutrients to grow and form muscle and fat tissue. According to Hunt, this value chain begins with extracting a small cell sample from an animal, which is then used to initiate a cell culture. He elaborated that these cells are placed in a nutrient-rich liquid medium containing essential elements like sugar, proteins, amino acids, and growth factors. Once established, the cells are scaled up in bioreactors or fermenters, allowing cell proliferation. Hunt explained that the culture conditions are altered to promote tissue maturation after the cells reach a high density. This process transforms undifferentiated cells into specific types, such as fat and muscle cells, often facilitated by scaffolds. Scaffolds provide a three-dimensional environment that enables cells to adhere and mature into types like conventional meat.

According to David Hunt, technological advancements in cultivated meat production date back to 2013, when Professor Mark Post of Maastricht University developed the first cultivated burger, costing approximately 300,000 euros. He emphasised that the industry has since made significant strides, including creating the first cultivated meatball in 2016 and cultivated fish in 2017. By 2020, Singapore became the first country to approve the commercial sale of cultivated products, a move soon followed by the United States. Hunt observed that several countries have recognised the potential of cultivated meat in enhancing food security and achieving environmental targets, prompting significant investments. He cited the USDA's establishment of the National Institute for Cellular Agriculture at Tufts University in 2021 and the Dutch government's investment of 60 million euros into cellular agriculture development. Additionally, Hunt pointed to other countries like the UK, Israel, and Singapore, which have also committed considerable resources to the field.

Furthermore, he noted that the competitive landscape for cultivated meat has grown exponentially, with the number of companies rising from five in 2020 to over 50 in 2024. As he explained, these companies span the entire value chain and focus on areas such as cell culture media, bioreactors, and scaffolds. Despite the progress made, he acknowledged that scaling cultivated meat to an economically viable level remains a significant challenge. He highlighted that the current stage involves moving from pilot to demonstration scales, with some companies producing in reactors ranging from hundreds to thousands of litres. However, there is a need for substantial advancements in bioprocess optimisation and increased public support for research to transition to industrial-scale production, reaching tens or hundreds of thousands of litres.

In terms of research priorities, David Hunt highlighted several key areas. He emphasised the importance of developing standardised cell lines with high doubling rates and densities, particularly for underrepresented species like seafood. He also pointed out that innovations in cell culture media are crucial for reducing costs, especially by utilising lower-purity formulations appropriate for food production and alternative growth factors. He further emphasised the importance of scaffolding research, which focuses on biomaterials that mimic the extracellular matrix in conventional meat, allowing for efficient cell growth and maturation. Additionally, Hunt highlighted the need for improvements in bioprocess design to enhance bioreactor efficiency, reduce depreciation, and address the global shortage of bioreactors.

Hunt also inferred that cultivated meat has the potential to significantly reduce environmental impacts, including greenhouse gas emissions, water use, and feed conversion efficiency. However, he also highlighted that energy demand is expected to increase, underscoring the need for renewable energy in manufacturing. He compared the development of cultivated meat to the early stages of electric vehicles and solar panels, emphasising the need for continued investment in public research to overcome the industry's technological challenges.

Looking ahead, it is predicted that the industry's future will include a range of products, from fully plant-based to fully cultivated options, with hybrid products combining elements like cultivated fat and plant proteins. He inferred that companies capable of effectively integrating these technologies are more likely to succeed. For example, Hunt pointed to the burger, which uses fermentation for sensory enhancement, and noted that some hybrid products incorporate cultivated fat into plant-based matrices.

Finally, Hunt highlighted that advancements in this field require multidisciplinary expertise across several fields, including biochemistry, biology, food science, tissue engineering, and microbiology. He also noted that computer science and artificial intelligence are increasingly crucial in modelling bioreactor dynamics and optimising cell culture media. Hunt also emphasised the importance of expertise in public health, nutrition, and economics to address the broader implications of alternative proteins on health and the economy. He noted that collaboration across academia, industry, government, and nonprofits will be essential for advancing the field and ensuring the successful integration of cultivated meat into the global food system.

The Challenges of Building an Alternative Protein Startup in Nigeria and the Role of Academia-Industry Collaboration. By Olaoluwa Fashola (Casa Vegan).

According to Fashola, the global food industry has experienced a surge in the development of alternative proteins, driven by the urgent need for sustainable food solutions and healthier diets. However, in Nigeria, where four in five people die annually due to cardiovascular diseases primarily linked to unhealthy eating habits, the move toward alternative proteins is still in its infancy. While there is a growing awareness of the need for healthier and more sustainable protein sources, the journey toward building alternative protein startups in Nigeria is fraught with challenges, such as education and awareness, which is one of the biggest hurdles for alternative protein startups in Nigeria is the lack of education and awareness among consumers. Many Nigerians are unaware of the benefits of alternative proteins, such as plant-based or lab-grown meat alternatives, and there is a widespread perception that they are nutritionally inferior to traditional animal proteins. Without targeted education campaigns to correct these misconceptions, it will be difficult for startups to build product demand.

Secondly, he inferred that another challenge could be cultural preferences, as Nigerian cuisine is deeply rooted in consuming meat and fish. For many, animal protein is a sign of wealth and good nutrition. Introducing alternative proteins into such a culture presents a significant challenge. Overcoming the cultural resistance to plant-based or lab-grown proteins will require long-term efforts in re-educating consumers and reshaping dietary preferences.

He also highlighted the lack of adequate infrastructure as another barrier to scaling alternative protein businesses in Nigeria. The country's food production and supply chains are underdeveloped, making it challenging to produce and distribute alternative proteins on a large scale. Additionally, many startups struggle to secure funding, as investors often hesitate to support ventures in a relatively new and unproven market.

Lastly, in terms of government policy and regulation, Nigeria's regulatory landscape does not fully support the development of alternative protein products. The absence of clear guidelines on food safety standards and market entry requirements leaves startups in a regulatory grey area. Startups need more clarity and support from the government to navigate the complex process of bringing new food products to market.

However, he stated that there are opportunities for growth in Nigeria's Alternative Protein Market, especially regarding growing health awareness. With cardiovascular diseases accounting for a significant portion of Nigeria's mortality rate, there is an increasing demand for healthier food options. Alternative protein companies can position their products as more nutritious choices that offer the same nutritional benefits as traditional animal proteins while reducing the risk of heart disease. This shift in consumer preferences presents an opportunity for startups to capitalize on the growing health-conscious market.

Secondly, Nigeria has one of the youngest populations in the world, and its youth are increasingly open to innovation and new ideas, especially regarding technology and food. This demographic will likely drive the acceptance and consumption of alternative protein products. Young entrepreneurs also create new food technologies and startups that focus on sustainability.

He also mentioned that global partnerships are needed as alternative protein companies gain traction in more developed markets. Nigerian startups have an opportunity to collaborate with international players in the industry. Such partnerships can bring in much-needed investment, technology transfer, and expertise, helping Nigerian startups overcome some of the technical and financial challenges they face.

He also stated that collaboration between academia and industry is essential to building Nigeria's flourishing alternative protein market. By leveraging the strengths of both sectors, it is possible to overcome the current challenges and foster innovation in the food industry.

Regarding research and development (R&D), he stated that academic institutions can be crucial in researching local, sustainable protein sources suitable for alternative protein production. The industry can then develop these research findings into commercially viable products. Such collaboration will ensure that innovations are both scientifically sound and scalable.

Education and Public Engagement, he highlighted that universities can lead public education campaigns to raise awareness about the benefits of alternative proteins. By educating the public, academia can help shift consumer preferences and create a more receptive market for these products.

Startup Incubation and Support: He also highlighted that universities can serve as incubators for alternative protein startups, providing access to research labs, mentorship, and technical expertise. Industry players can offer real-world applications, market insights, and commercialisation pathways for these startups. Together, academia and industry can create an ecosystem that nurtures innovation and accelerates the growth of alternative protein companies.

Market Size and Potential for Alternative Proteins in Nigeria

According to Fashola, Nigeria's population is expected to exceed 400 million by 2050, making it one of the largest and fastest-growing markets in the world. This population boom and increasing awareness of the need for healthier and more sustainable food options create a significant market for alternative proteins. If companies can overcome the current challenges, this sector's growth potential is enormous.

Dr. Kikiope Oluwarore (DVM, MSc)

Founder, One Health and Development Initiative (OHDI), Co-Founder

Advancing Integrated Human, Animal and Ecosystem Health

Why Do We Need Alternative Proteins?

Dr Kikiope Oluwarore, founder of One Health and Development Initiative (OHDI), linked the need for alternative proteins to factors related to increasing intensive animal agriculture and factory farming, which causes animal welfare and land use issues, climate change, zoonoses, antibiotic resistance, one-health issues, human health and dietary concerns, nutritional needs, and increasing food insecurity.

She also stated that challenges with alternative proteins in Africa are a result of

- Poor public awareness, understanding, or perceptions of alternative proteins and their benefits to human health, animal welfare, ecosystem sustainability, and food security.
- Lower proliferation of innovations, start-ups, technology and investments in the alternative protein sector in Africa compared to other continents and countries,
- Inadequate support from the public sector—government policies, political will, etc.

Policy and Policy Makers

Kikiope also focused on the policy aspect and policymakers involved in alternative proteins. She described policy as a specific plan or a set of strategies that professionals, institutions, and businesses embrace to make decisions, address issues, establish legislation, streamline their activities, etc., used by government, universities, politicians, experts, nonprofits, and other professionals in the public and private sectors, developed by policymakers, and policymakers as all the professionals who are responsible for formulating policies for the government, firms, schools, educational institutions, companies, and other organisations.

Usually, they use evidence to make such decisions to formulate or amend policies.

She stated that there is a need for policymakers as a result of the following reasons:

- For Legislation
- To create structure, codes of conduct, ways of working, stakeholder map
- For systemic change and institutionalisation of decisions; to ensure sustainability of plans
- To guide and promote public awareness and action on an issue

Kikiope equally highlighted that the role and benefits of Government and policy in alternative proteins are to;

- Support commercialization and businesses in the Alt-Pro sector, including loans for start-ups, opportunities for exports and foreign exchange, and the sale of crops, raw materials, and Alt-Pro food products.

- Enhance science, research, training and local innovations on Alt-Pro and supplies from local resources in Africa (plant-based, fermentation and culture); research grants and scholarships
- Land use and crop output (crop farming, factory farming, climate change)
- Support education and implementation of Alt-Pro in schools (feeding and nutrition, positive dietary changes)
- Making Alt-Pro more affordable (subsidies, tax incentives, etc.)

She equally stated that for policy-making to be effective, everyone has a role to play, and this includes;

- Establishing evidence base, research and rationale behind any cause for Alt-Pro
- Understanding the policy framework of the field, checking for where the policy issue may have been addressed or not, and ensuring no duplication
- Determine and set policy goals and objectives
- Identify policy stakeholders (private sector, researchers, etc.)
- Engage stakeholders and proceed with movement building; draft policy brief
- Garner public support (utilise media)
- Consult with policy experts, lobbyists and influencers
- Draft, validate and disseminate the policy document(s)
- Donate, fund and publicise

According to Kikiope, Alt-Pro investments used to be primarily from the private sector. Countries and their governments are now more involved due to concerns about food security, health, animal welfare, inadequate farmland, climate concerns, and profit-making opportunities.
Countries have committed $1 billion to Alt-Pro in the last 3 years for research, infrastructure, and startups. Examples include the Netherlands, Australia, Canada, China, Singapore, Israel, etc. Policies are integrated into China's Bioeconomy 5-year plan, the US Biotechnology Initiative, and the EU's 10B Euro Agric agenda.

Conclusion and Recommendation

The conference on alternative proteins highlighted the pressing need for a shift toward sustainable food systems to meet global nutritional demands while addressing traditional protein production's environmental and social challenges. Universities play a critical role in this transition by fostering research, education, and innovation that drive the development of alternative proteins, thus contributing to the achievement of the Sustainable Development Goals (SDGs), particularly those related to zero hunger (SDG 2), responsible consumption and production (SDG 12), and climate action (SDG 13).

To address the inefficiencies of the current food systems in Africa, which is at the risk of climate change the most, it is essential that universities actively engage in understanding and reshaping food systems by integrating research on alternative proteins, such as plant-based, fermentation-based, and cell-based alternatives, into their programs. These alternatives represent key innovations that can reduce the environmental footprint of food production, improve food security, and promote health. Universities should update their curricula to include comprehensive studies on food systems, alternative proteins, and sustainability, enabling students to contribute meaningfully to the global transition towards more efficient and sustainable food production.

In addition to fostering academic knowledge, universities must enhance collaboration with industry to bridge the gap between research and commercialisation. Such partnerships will ensure that breakthroughs in alternative proteins can be scaled up and brought to market, accelerating the adoption of sustainable protein products. By working together, academia and industry can develop viable solutions to the inefficiencies of current food systems and significantly impact global food security and sustainability.

Acknowledgements

This article is based on a symposium at the Alternative Protein Project, University of Nigeria, Nsukka (UNN). Each speaker was responsible for the content of his or her presentation, which formed the basis of this report compiled by Dibua N.N., Oputa, O and Omale D. M. Each speaker reviewed and approved the final content. The final draft was edited and reviewed by Anchang, M. M, Aleke, J. C., Sale, V. B., Ofoegbu, D. C., and Professor Mbaeyi-Nwaoha,

REFERENCES

Birgit L. Dekkers, Remko M. Boom, Atze Jan van der Goot. (2018). Structuring processes for meat analogues. Trends in Food Science & Technology. 81: 25-36. ISSN 0924-2244, https://doi.org/10.1016/j.tifs.2018.08.011. (https://www.sciencedirect.com/science/article/pii/S092422441830311X)

Chiang, J. H., Loveday, S. M., Hardacre, A. K., & Parker, M. E. (2019). Effects of soy protein to wheat gluten ratio on the physicochemical properties of extruded meat analogues. *Food Structure*, *19*, 100102. https://doi.org/10.1016/j.foostr.2018.11.002

EITFoods (2024) Are alternative proteins good for you? Online Blog. Available at: https://www.eitfood.eu/blog/are-alternative-proteins-good-for-you Accessed: January 31, 2023

GFI (2024), Defining Alternative Proteins. Webpage. Available at https://gfi.org/defining-alternative-protein/ Accessed: February 2nd, 2024 gene, J. O.; I.T Oteku and Omorogieva (2006). Effect of Graded Levels of Soy Flour inclusion on the Physical and Sensory Properties and Cost of Composite Soy/Chicken Burgers. Journal of Raw Materials Research. 3(2): 38-48.

Kołodziejczak, K.; Onopiuk, A.; Szpicer, A.; Poltorak, A. (2022) Meat Analogues in the Perspective of Recent Scientific Research: A Review. *Foods*. 11, 105. https://doi.org/10.3390/foods11010105

Oderinde, Folasade & Akano, Oreoluwa & Adesina, Francis & Omotayo, Abiodun. (2022). Trends in climate, socioeconomic indices, and food security in Nigeria: Current realities and challenges ahead. Frontiers in Sustainable Food Systems. 6. 10.3389/fsufs.2022.940858.

R.G.M. van der Sman, A.J. van der Goot. (2023). Hypotheses concerning structuring of extruded meat analogs, Current Research in Food Science. 6. 100510, 2665-9271, https://doi.org/10.1016/j.crfs.2023.100510. (https://www.sciencedirect.com/science/article/pii/S2665927123000783)

Simon Sharp, Rayan Tabbara, Maria Najjar. (2023). Planting the Seeds of Change: Evaluating Barriers of Alternative Protein in the GCC. Global ventures. https://www.global.vc/

Singh, Meenakshi & Trivedi, Nitin & Enamala, Manoj & Kuppam, Chandrasekhar & Parikh, Punita & Nikolova, Maria & CHAVALI, Murthy. (2021). Plant-based meat analogue (PBMA) as a sustainable food: a concise review. European Food Research and Technology. 247. 10.1007/s00217-021-03810-1.