COMMUNIQUÉ OF THE AFRICA SCIENCE DIALOGUE SERIES, NIGERIA CHAPTER: A DAY WORKSHOP ON GENOME EDITING INNOVATIONS HELD AT THE LAW FACULTY AUDITORIUM, COLLEGE OF AGRICULTURAL SCIENCES (CAS) CAMPUS, EBONYI STATE UNIVERSITY, ABAKALIKI, EBONYI STATE ON THE 8TH OF SEPTEMBER, 2021

The workshop was well attended by expected stakeholders in the field of Biotechnology both in Nigeria and the international community. A total of 121 participants comprising of 73 physical Attendees and 48 virtual Attendees participated in the Workshop.

The opening ceremony was Chaired by the Vice Chancellor, Ebonyi State University, Elder Prof. Chigozie Ogbu, OFR, while the session presentations were Chaired by Prof. Chiedozie Ngozi Egesi, FBSN, (President, Nigeria Plant Breeders Association). The following Eminent Personalities delivered welcome remarks and goodwill messages: Prof. Ekanem Ikpi Braide, FAS [President, Nigerian Academy of Science (NAS)], Dr. Margaret Karembu, MBS, [Director, The International Service for the Acquisition of Agri-biotechnology Application (ISAAA) Africa Center & / Chair, Africa Life Science Knowledge Hub], Mr. John Komen [African Coordinator, Programme for Biosafety System (PBS)] and Dr. Augustine O. Oko [Director, Biotechnology Research and Development Center/Chair, Local Organizing Committee]. The workshop was majorly focused on the Fundamentals of gene editing and its applications in the Food, Health, Industrial, Environment Sectors, as well as its Regulatory framework and effective Communication approaches.

A total of 16 topics around genome editing out of the scheduled 21 were discussed. They include:

1. Fundamentals of genome editing: moving forward in precision genomic technologies by Prof. Celestine Aguoru, Dept. of Biological Sciences, University of Agriculture, Makurdi, Nigeria
2. Genome editing for enhanced biofortification of plant-derived foods by Prof. Sylvia Uzochukwu, Dept. of Plant Science and Biotechnology, Federal University, Oye-Ekiti, Ekiti State, Nigeria
3. Applications of genome editing in banana improvement by Dr. Valentine Otang Ntui, IITA, Nairobi, Kenya
4. Genome editing for fish/salmon improvement: the Norwegian experience by Dr. Arinze Okoli, Genok Center for Biosafety, University of Tromse, Norway
5. Genome editing: a powerful tool with potential for suppressing the tse-tse fly menace that threatens cattle farming in Southern Nigeria by Prof. A. E Onyimonyi, Dept. of Animal Sciences, University of Nigeria, Nsukka, Nigeria

6. Genome editing applications in livestock improvement – Dr. Matthew Wheto, Dept. of Animal Sciences, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
7. Genome editing applications for accelerating cassava improvement by Dr. Ihuoma Okwuonu, Biotechnology Unit, National Root Crops Research Institute, Umudike, Abia State, Nigeria
8. Genome editing: expanding the frontiers of molecular Pharming and plant-derived biopharmaceuticals by Prof. Olawole Obembe, Dept. of Biological Sciences, Covenant University, Ota, Nigeria
9. CRISPR-mediated genome editing to correct disease-causing DNA mutations in humans by Prof. Ifeoma Ezeonu, Dept. of Microbiology, University of Nigeria, Nsukka, Nigeria
10. CRISPR/Cas system for treatment of Covid and related diseases by Dr. Charles Oluwaseun Adetunji, Edo University Iyamho, Edo State, Nigeria
11. Genome editing applications for expanding the frontiers of the human microbiome for improved health by Prof. Ifeoma Enweani, Medical Microbiology and Genomics, Nnamdi Azikwe University, Akwa, Nigeria.
12. Genome editing applications for the control of insect vectors affecting human health by Dr. Emmanuel Balogun, Dept. of Biochemistry, ABU, Zaria
13. Global regulatory perspectives on genome editing by Mr. John Komen, Programme for Biosafety System (PBS), Africa Coordinator
14. Nigeria's regulatory framework on genome editing by Dr. Rufus Ebegba, DG/CEO NBMA, Abuja, Nigeria
15. Communication approaches for genome editing: lessons from ABBC2019 by Dr. Margaret Karembu, MBS, Director, ISAAA AfriCenter / Chair, Africa Life Sciences Knowledge hub
16. Genome editing applications in microalgae to produce novel products by Dr. Matthias Chia, Dept. of Botany, ABU, Zaria, Nigeria

The distribution of the speakers and the quality of the presentation justified that Nigeria has the manpower, potentials, and competence required to drive this specialized area of Science with enormous benefits to mankind. In the course of these presentations, specialized laboratories in Nigeria such as the National Root Crops Research Institute, Umudike, Ahmadu Bello University, Zaria; the University of Calabar; the host University's Biotechnology Research & Development Centre, Godfrey Okoye University, Enugu, among several others were identified to have well-equipped laboratories where genome editing could be carried out in Nigeria.

To create a baseline for a better understanding of the subject matter, fundamentals of genome editing, methods used in gene editing, and some ethical concerns to scientists were laid and discussed. Genome editing especially based on the CRISPR/Cas system is a new precise and targeted method used to introduce traits into organism via endogenous mechanisms. This can lead to an array of changes in the genome of the organism. The techniques include meganucleases, zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs) and CRISPR (clustered regularly interspaced short palindromic repeats)/Cas (CRISPR associated protein) (CRISPR/Cas) system. In a cell, gene editing always occurs naturally through insertions, deletions and replacements, which enables adaptation and survival of an organism in various environment. The necessity for the application of gene editing in agriculture and the biological sciences cannot be overemphasized, as it gives more precise relatively fast result than other approaches in the tool box for genetic modification.

Genome editing (GE) differs from Genetically Modified Organism (GMO) technology because it is site-directed, thus, more targeted and precise. Further, in cases where protein encoding genes are inserted by GE as in the site directed nucleases (SDN)-3, the insertion is not random and selection of positive mutants does not require antibiotic selection marker. The CRISPR/Cas9 induces precise double-stranded breaks (DSBs) in the genome of an organism, the breaks are then repaired by the cell's own machinery of non-homologous end-joining (NHEJ) or homology-directed repair (HDR), resulting in small insertions/deletions/substitutions (indels) for NHEJ or incorporation of a protein-encoding gene via HDR from the same species (cis-genesis) or a different species (transgenesis). CRISPR/Cas9 is the most widely used GE tool due to its relative simplicity, design flexibility, high efficiency, affordability, and applicability in all cell types, and has been applied successfully in several species including editing of sea food.

To sustain better ecosystems and environments, genome editing could be used in the control of insect vectors affecting human health such as the use of enzymes from the guts of mosquitoes containing salicylic acid to kill trypanosomes, a neglected tropical disease. It was observed that the biggest challenge in rearing cattle in the southern part of Nigeria is the tse-tse fly menace and infection on cattle. This could lead to undernourishment, loss of productivity, loss of pregnancy among others. The tse-tse fly vector biology through molecular screening techniques (genome editing) could adopt CRISPR/Cas 9 technology to generate gene-edited animals that could be resistant to tse-tse fly and inadvertently enables their eradication. More so, the tse-tse fly vector can be made sterile to reduce their reproductivity. There is a need to accelerate genome editing programmes and knowledge within Africa to improve global livestock production. Further, it was highlighted that it is important to continue community engagements and use of

effective communication strategies to alleviate the problems that are associated with safety concerns.

In medicine, can be applied in microalgae propagation to produce novel products such as antibiotics and vaccines. Further, studies have shown the potential of application of CRISPR/Cas9 system in the treatment of sickle cell anemia with the successes being recorded at clinical trial where treatments have resulted in patients devoid of the sickle cell traits. Also, editing the genome of notable microbiomes could be used in solving the problems of cardiovascular disease, liver cirrhosis, preparation of prebiotics and probiotics, which are involved in symbiotics. These generally helps to solve health related issues. Furthermore, the CRISPR/Cas9 system could aid in developing designer microalgae capable of surviving in harsh environments and are suitable for industrial usage in the future.

To ensure food and nutrition security, genome editing could be used to produce disease, pest and drought resistant crops, as well enhance biofortification of plant-derived foods by increasing its mineral or vitamin constituents such as zinc and vitamin A rice and cassava, vitamin C in tomato, and blockage of cyanide in cassava, etc. There are as yet very few gene editing biofortification projects. It was noted that of the 13 gene editing projects in Africa so far, none is on food biofortification. It is hoped that as happened with traditional transgenic technology, these would quickly follow, in order to help fight hidden hunger in developing countries. In Banana and cassava, genome editing has been shown to increase resistance to diseases, through the editing of susceptibility genes. For cassava, this technique has become imperative because of the crop's susceptibility to diseases, toxins accumulation, low performance rate etc. According to a study conducted in Umudike, Nigeria, the susceptible gene, Sugar will eventually be exported transporter (SWEET) in Cassava was edited using CRISPR/Cas9 in order to confer resistance to bacterial and fungal diseases. To further reduce the accumulation of cyanide, the two genes (*CYP/901* and *CYP/902*) responsible for cyanogen production were edited. These processes improved cassava processing and resulted in yield improvement. Editing of the susceptibility gene, Downy Mildew Resistant 6 (DMR6) in banana resulted to enhanced resistance to banana *Xanthomonas* wilt (BXW).

On the aspect of biosafety regulations for gene edited products, the National Biosafety Management Agency has been proactive in developing the Nigerian regulatory framework on genome editing which is the first to be established in Africa. It was generally accepted that Nigeria has a robust biosafety system that is effective and efficient, and to regulate any new technology within its mandate including genome editing in line with global best practices. Global regulatory perspectives on Genome editing should be adopted by scientists to ensure the safety of humans in regard to gene-edited products.

To ensure acceptability of gene-edited products, good communication of research findings is important to keep pace with the rapid advancements in science and technology. This will also encourage trust and increase knowledge sharing and understanding, leading to public acceptance and reduce negative opinions just about anything 'gene'. Good communication skills were accepted to influence stakeholders' complexity and help in conflict resolution on issues surrounding the technology.

Conclusion

This workshop established that genome editing technology exist in Nigeria, the manpower is available, laboratories to conduct researches on this technology exist and could be applied to improve livelihoods and socio-economic gains in Nigeria. However, there is need for encouragement of stronger ties and collaborations between scientists and researchers within the African continent on genome editing studies that are targeted towards solving regional problems.

WAY FORWARD/RESOLUTION OF THE WORKSHOP

1. There should be annual hosting of this programme to enable more positive synergy, collaborations, and interaction between researchers in Nigeria, West Africa, and global networks.
2. Nigeria should sustain research through funding and grants channeled towards genome editing, to solve specialized problems peculiar to our localities through propagation of products and services that are beneficial to Nigerians. There is the need to convince the government to provide funds for research. If the Tetfund could afford to sponsor a student with 50 million naira, why not use the money to equip a functional laboratory where the student could be trained locally, rather than spending the money outside the country.
3. Develop public trust in research output around genome editing through positive and effective communication and encouragement of mentorship within the University community.
4. Partners should support biotechnology and Africa Chapter of Africa Science Dialogue Series and University should break the 'silo' mentality to create dialogues opportunities among related Faculties
5. Researchers should also be more practical in transmitting the scientific information to the public. Research Groups should be formed on issues peculiar to our environment e.g. tilapia, yam, or other crops and livestock, get their genes sequenced, and continue with basic research that would cumulate to gene editing in the organism for various applications in agriculture, medicine, environment and industry.