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BIOTECHNOLOGY CAPACITY BUILDING: THE GATEWAY TO FOOD SECURITY

By

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The Vice Chancellor, Sir,
The Deputy Vice-Chancellor (Academic),
The Deputy Vice-Chancellor (Development),
Principal Officers of the University,
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Other Deans and Directors,
The Head, Department of Food Science and Technology,
Other Heads of Departments and Units,
My Lords Spiritual and Temporal,
Academic and Professional Colleagues,
Other Colleagues in the FUNAAB Community,
Special Guests,
Ladies and Gentlemen of the Press,
Distinguished Ladies and Gentlemen,
Lions and Lionesses,
Ndi nne Maa-ma
Great FUNAABITES.

1.0 INTRODUCTION

Mr. Vice-Chancellor, Sir, it is with immense gratitude to God that I come here today to deliver this Inaugural Lecture. Many have dreamt of giving Inaugural Lectures, but could not

qualify to give one. Others qualified to give one, but never got the opportunity to do so. Yet others got the opportunity, prepared their lectures, fixed a date, but for one reason or the other, never got to deliver them. Therefore it is a priviledge and a blessing that I am able to give this lecture today. I am most grateful to Almighty God for making today a reality for me. May all those who are aspiring to achieve this bar, so do in the name of Jesus; *Ire a kari wa o, Amin.*

I thank the Vice-Chancellor Professor Olusola Oyewole specially, for making it possible for me to give this inaugural lecture. It was not in the original schedule of Lectures for this year, but by the kind use of his executive powers, I was able to get this slot. I feel also greatly honoured and humbled, to be given the opportunity to deliver the first inaugural lecture for our dear young but vibrant and dynamic College, the College of Food Science and Human Ecology (COLFHEC), (The hand of God, you may say). I am very grateful to the Dean, Prof. Folake Henshaw, and the entire College Board of COLFHEC, for their graciousness in according me this honour.

An Inaugural Lecture is by tradition, a Professor's academic account of himself or herself. It is an opportunity for Professors to inform colleagues, the University community and the public, of their work to date, their contributions to

knowledge, the relevance of their work to the wider academic community and to the general public, as well as to discuss their present research and their future plans.

The focus of this discourse is that modern biotechnology, is a *sine-qua-non* for food security, for an end to hunger, poverty and deprivation in Nigeria, in Africa, and the world at large, and that sustained capacity building to develop core competence in the technology, is vital for the benefits to be realized in Nigeria.

2.0 DEFINITIONS

2.1 Biotechnology

Biotechnology is the science of making useful products and services from biological systems and their parts. The Food and Agricultural Organization (FAO) defines it as "any technique that uses living organisms or substances from these organisms to make or modify a product for a practical purpose" (FAO, 2004). Biotechnology therefore, has been with us for many thousands of years, as the processes of wine-, bread- and cheese-making are all biotechnology, so are the processes for making traditional foods and condiments such as iru, ogiri, fufu, ogi/akamu, pito and burukutu. The domestication, breeding and selection of choice plants and animals by man which has gone on for thousands of years, are also biotechnology. These are generally referred to as "traditional biotech-

nology" as opposed to modern biotechnology which has gene cloning and genetic engineering at its core.

Modern methods of breeding significantly increased crop and animal yields over the past 50 years, and contributed to the green revolution in developed countries. However, the future potential of these methods is constrained by the limitations in the natural diversity of trait genotype within crop and animal species, as well as by sexual incompatibilities between species. This led scientists to seek more effective and efficient methods for introducing new traits, into all species, which led to modern biotechnology.

2.2 Modern Biotechnology

Modern biotechnology, is defined as the application of *in vitro* nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA), and direct injection of nucleic acid into cells or organelles; or fusion of cells beyond the taxonomic family that overcome natural physiological reproductive or recombination barriers, and that are not techniques used in traditional breeding and selection (Cartagena Protocol on Biosafety, 2000). Any reference to biotechnology these days, usually refers to modern biotechnology unless otherwise indicated.

Modern biotechnology employs molecular techniques to identify, select and modify DNA sequences for a specific genetic

trait (e.g. insect resistance) from a donor organism (microorganism, plant or animal), and transfer the sequence to a recipient organism so that it expresses this trait. A DNA molecule referred to as a vehicle or vector (which is usually plasmid or viral DNA) is usually required to carry the DNA into the cell. A successful transfer, is referred to as a transformation of the receiving cell. Various transformation methods are used to transfer recombinant DNA into recipient species to produce a genetically modified organism (GMO). For plants, these include transformation mediated by *Agrobacterium tumefaciens* (a common soil bacterium that contains genetic elements for infection of plants), as well as biolistics — shooting recombinant DNA coated on microparticles such as gold, into recipient cells. The techniques used in the transformation of various animal species include microinjection and electroporation. The insertion of foreign genes into organisms has often been a source of controversy for GMOs. In response to that, scientist will now, whenever possible resort to gene silencing to achieve their end, so that no new gene is introduced at all. This is often achieved by a technique known as RNA interference. Newer techniques continue to be developed everyday in this rapidly changing field.

2.3 Genetic engineering

Genetic engineering is the core of modern biotechnology. It is the manipulation of DNA to produce useful traits in living

organisms. DNA is the blue Print of life. DNA, is the genetic information that provides instructions for the development and survival of all organisms.

Fig. 1: DNA strands showing the constituent molecules
Source: Access Excellence www.accessexcellence.org

DNA consists of a nitrogen base, a ribose sugar and a phosphate group . Two strands are wound together to form a double helix. The nitrogen bases, adenine (A), thymine (T), cytosine (C) and guanine (G), constitute the "alphabets" of DNA.

After the discovery of the structure of DNA by Watson and Crick in 1953, there was a lull in the life sciences, because no one knew how to cut or join the molecule. Science had to wait till the 70s and the discovery of restriction enzymes which cut DNA at specific sequences, and DNA ligases that join it together again, before modern biotechnology, driven by gene cloning and other DNA manipulations, made possible by the new molecular biology techniques, could take off. When it did take off, it did so on a roller coaster, and there is as yet no sign of a slowdown. The biotechnology revolution has thus been on for more than 30 years. Our country Nigeria needs to be part of it.

How genetic engineering is done:

1. **A gene of interest is attached to a suitable vehicle for expression in a new cell, such as a plant cell. The gene which is a sequence of DNA can be obtained either by cutting donor-DNA with a restriction enzyme, or by copying it out by the polymerase chain reaction (PCR) using the appropriate primers. The gene fragments are mixed with the**

cut or linearized vector DNA. They recombine to form recombinant molecules and the enzyme DNA ligase is added to seal the nicks or junctions. The recombinant molecules are transfered into bacteria cells where they multiply, and the cells also multiply.

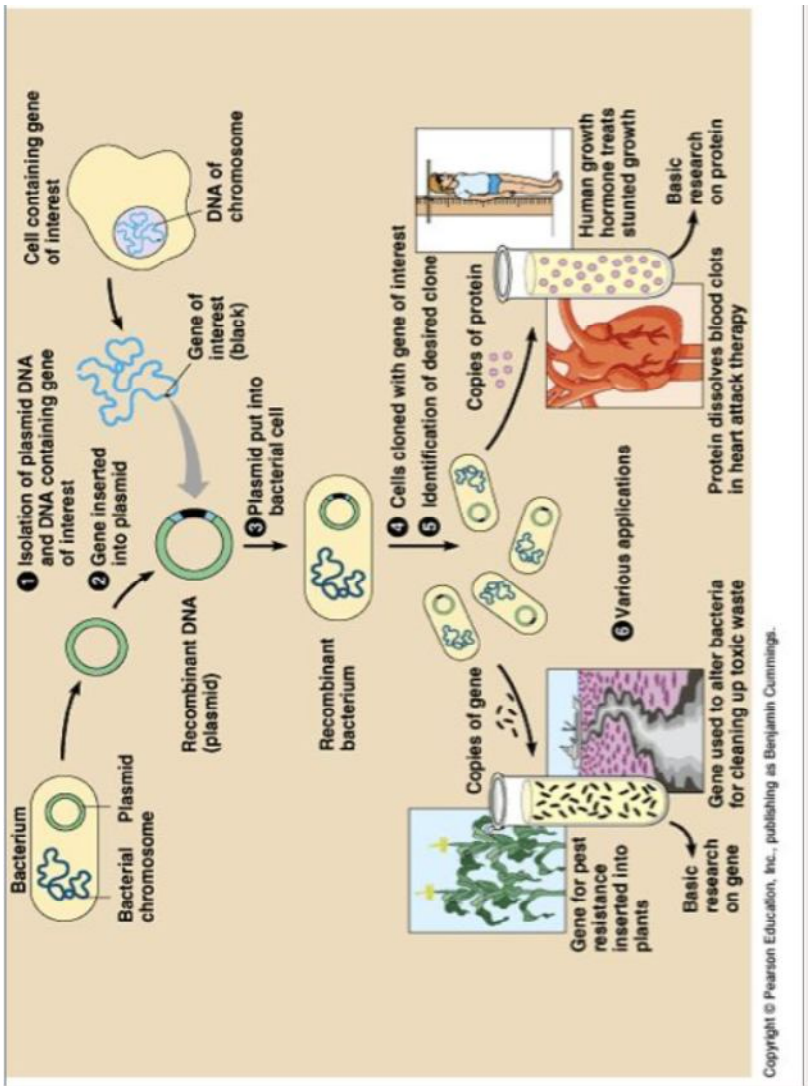

Fig. 2: Gene cloning
Source: bahs.rsu20.org bahs.rsu20.org

2. The engineered gene is transferred into cells of the desired plant (or other organism) – transformation, and a whole plant or animal is regenerated from the cell containing the new gene, using tissue culture techniques, or the new cell is employed for recombinant protein for therapy, for environmental remediation, or for basic research.

Biotechnology has changed the world and will continue to do so, because a secret once revealed, cannot become a secret again, for that particular age.

3.0 FOOD SECURITY

According to the 1996 World Food Summit, "food security exists when all people at all times have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences, for an active and healthy life." Food insecurity remains a significant challenge for most developing countries, which are especially vulnerable to economic and weather-related shocks to food production and distribution systems. The need to improve food security is particularly important in sub-Saharan Africa and Asia, which account for almost 90% of the undernourished people in the world. As it is, the food security situation in SSA is worsening, as shown in Fig. 3.

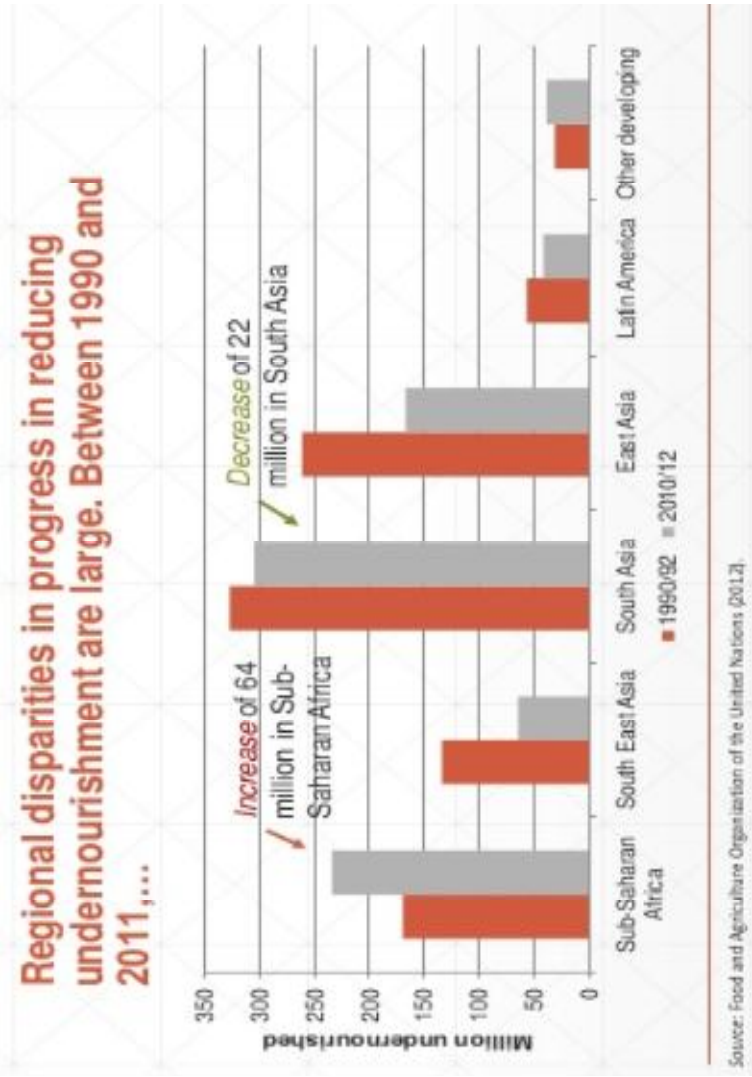

Fig. 3: Increasing undernourishment in SSA between 1990 and 2011, while everywhere else there is a decrease.
Source: Food and Agricultural Organization of the United Nations (2012).

3.1 The role of Agricultural biotechnology in global food security

Evidence shows that spending on agricultural research and innovation is one of the most effective types of investments for sustained poverty reduction. Agriculture-led growth addresses rural poverty directly because it uses rural people, including poor subsistence farmers, as the key agents of change, linking them with other parts of the economy through networks of suppliers, buyers, and markets. Up to 80% of Nigerians are rural people. Hence, investment in agricultural research and development, has spillover effects beyond the sector, spurring broader economic growth in developing countries. This is the concept being recognized, adopted and pursued by the Federal Government's Agricultural Transformation Agenda (ATA). Sustained commitment to the ideals of that agenda, will propel Nigeria to greater heights.

Genetic engineering has been recognized as a necessary input for the success of any agricultural programme and food security in the world today. A compelling body of scientific evidence, generated in 29 countries around the world during the last more than 16 years, clearly indicate that genetically engineered crops (also called biotech crops), should be an essential element in any strategy designed to achieve food security, sustainability and a more just society (James, 2011). Clive James in his February 2013 launch of the 2012 annual report

of the International Centre for Acquisition of Agric-biotech Applications (ISAAA), stated that from 1996 when genetically engineered (GE) crops or biotech crops were first commercialized in the USA and 6 other countries, to 2011, biotech crops have contributed to food security, agricultural sustainability, and climate change amelioration. The contributions include: increasing crop production valued at US$98.2 billion; contributing to a better environment by saving 473 million kg of pesticides; in 2011 alone, reducing CO_2 emissions by 23 billion kg, equivalent to taking 10.2 million cars off the road; conserving biodiversity by saving 108.7 million hectares of land; and helping alleviate poverty by improving the lives of more than15.0 million small farmers and their families, totaling more than 50 million people who are some of the poorest people in the world. He (Clive James) admits that biotech crops are not a magic wand, but that they are an essential part of any food security strategy for the world today, and that they too, require adherence to good farming practices such as rotations and resistance management, just like conventional crops. He continued, that global food insecurity, exacerbated by high and unaffordable food prices, especially in Africa, is a formidable challenge which biotech crops can play an important role in meeting. According to the report, in the year 2012, 17.3 million farmers grew biotech crops worldwide. Over 90 percent of these farmers, were small resource-poor farmers in developing countries. This is in sharp contrast to earlier

contentions by critics that the technology was only for rich countries and that the poor farmers of the developing world would not be able to benefit from it. ISAAA's report also confirmed that the rate and scale of biotech crop adoption in developing countries is now much higher than that of industrialized nations.

Today, 29 countries in the world have adopted genetically modified (GM) crops, (Fig. 4) and the total world acreage is now 170 million hectares, which is a 100 fold increase over the 1.7 million hectares planted in 1996. In the U. S., 88% of all maize, 93% of all soybean, and 94% of all upland cotton are GM, with both insect and herbicide – resistant traits (James 2013). The simple reason the adoption of biotech crops is so unprecedented, is that they offer significant and multiple benefits such as higher yields, less chemical and labour input, soil conservation and more nutritious food, resulting in increased wealth, cheaper food, cleaner and safer environment, and a healthier population. India's experience is particularly dramatic. In 2008, a record five million smallholder farmers planted Bt cotton in India, on 7.6 million hectares, realizing a 39 percent reduction in insecticide usage, 31 percent increase in yields, and 88 percent ($250/ha) increase in profitability (James, 2008).

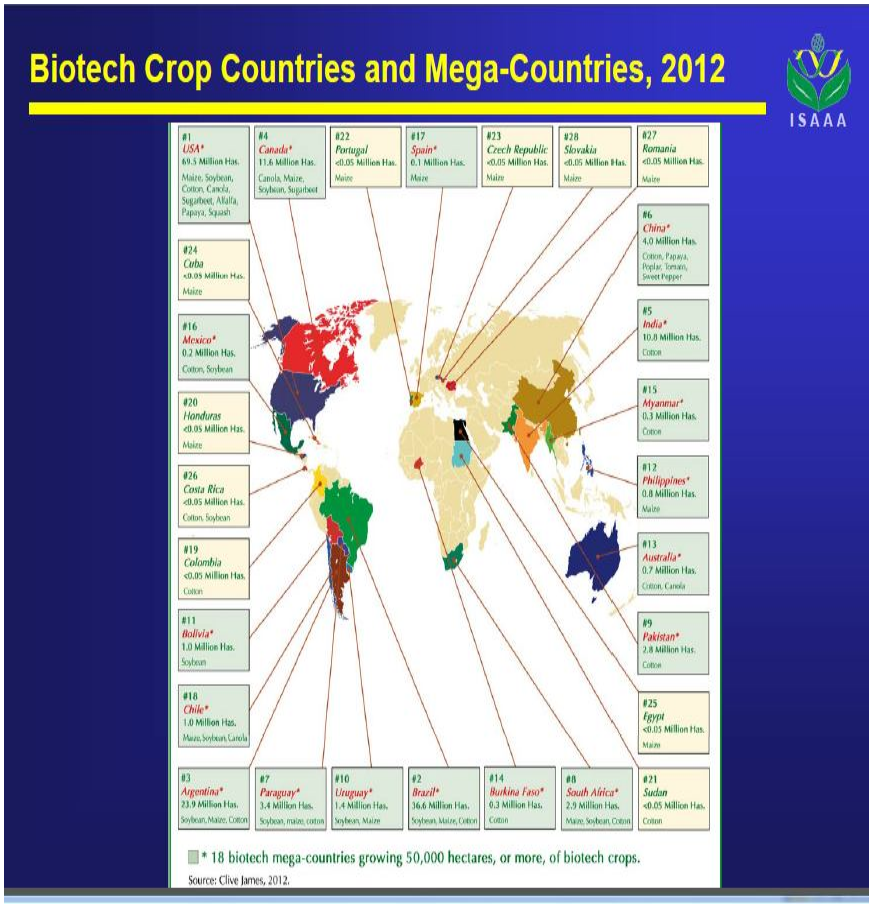

Fig. 4: Biotech Crop countries, 2012
Source: James, (2012)

Genetically modified crops, have been adopted, by the USA and Canada in North America, Brazil, Mexico and Argentina in South America, India, China and even Europe, for more than 16 years now. South Africa has planted biotech crops for over a decade, and Egypt and Burkina Faso joined in 2008. Sudan made history in 2012 by becoming the fourth African nation to grow biotech crops, with biotech cotton. Cuba also joined in 2012 by growing biotech maize. Adoption of GM crops by Sudan in 2012 was unexpected. The question is, why have Nigeria and most African countries south of the Sahara not joined?

3.2 Biotechnology and food security in Africa

Some fifty years ago, the green revolution took place in the world, starting with the industrialized nations. Asia, China and South America joined the revolution. Africa, surviving only on subsistence farming, with more than half its population going to bed hungry, just stood by and watched. The effects of that apathy, are still with us today. Those developing countries are now way ahead of Africa, especially sub-Saharan Africa, and the region depends on them for food. Today, another, more important and enduring revolution has started – the biotechnology revolution. Again the industrialized nations, Asia and Latin America have embraced the technology and are forging rapidly ahead, investing massively in the technology. Once more, Africa, with over 200 million people facing serious

food shortages, and therefore in much greater need, is just looking. As much as 80 percent of Africa's population depends on agriculture, but per capita productivity from this activity remains the lowest in the world. This very poor productivity is due to minimum application of available modern scientific and agricultural technologies (Karembu, 2009) (i.e., failure to join the green revolution earlier, and failure to join the gene revolution now). This failure to join in, is usually due to a lack of political will, among other things.

African Union heads of states and Governments did decide during their Extra Ordinary Summit held in Sierte, Libya in February 2004 and at the 5th Ordinary Session held in Sierte Libya 2005, to explore the potentials of Genetically Modified Organisms (GMOs) in agriculture. Scientists in Africa, see in the "Gene Revolution" the ultimate answer to the perennial epidemics related to hunger and poverty in Africa, and have been calling on one another to rally round and empower African farmers with available technologies in order to boost food production (Mataruka, 2010). Alhassan (2010) expressed confidence that most of the negative socio-economic indicators for sub-Saharan Africa (SSA), can be changed for the better if there is a conscious effort to apply biotechnology, to the production challenges of agriculture in an enabling policy environment. President Blaise Compaore of Burkina Faso, the only country in West Africa that has started growing

Genetically Modified (GM) crops, said in 2010 "In a continent that is hungry, biotechnology, provides one of the best ways to substantially increase agricultural productivity, and thus ensure food security to the people" (James, 2011). Thus, in principle, Africa accepts, but in practice, there is foot-dragging.

African countries, with the exception of Burkina Faso, Egypt, South Africa, and now Sudan, have not yet planted any GE crops for commercial production. Paarlberg, (2008), attributed Africa's foot-dragging, to the extreme precautionary attitude of Europe to GM foods. This is also the view of the leadership of Farmers' Associations in Burkina Faso, where GM cotton has made farmers rich and dramatically improved the economy of the country (Musi, 2009). Europe itself appears to be thawing towards GM crops. For instance, according to James (2011), UK Chief Scientist, Sir John Beddington counseled that, whereas GM is not a silver bullet, they (GM foods) are key to food security. This is consistent with the findings of UK Government Foresight Report "The Future of Food and Farming" and the French " Agrimonde Report". Mr. George Lyon (MEP), said "GM crops are an essential technology"… and "the impasse in Europe must be broken if we are not to fall further behind". Similarly, the comprehensive 2010 global study by the EU Commission, confirmed the safety and benefits of biotech crops currently commercialized (James 2011). Paarlberg, (2008), further attributed the apathy,

to a lack of infrastructural and human capacity and reiterates, the need for African scientists to be trained and assisted to acquire the technologies needed for modern crop biotechnology, in order to enhance agricultural production. Johnston *et al*., (2008), attributed the lack of agricultural biotechnology research and development (R& D) in Africa, to stagnating levels of government investment in agricultural research. They also see the adoption of the Precautionary Principle by Africa, as making it almost impossible for the few biotech crop products developed, to reach the common man.

3.3 Food Biotechnology and Food security in Nigeria

The Federal government's Agricultural Transformation Agenda (ATA), launched in 2012, has a vision to achieve a hunger-free Nigeria through the agricultural sector, that will drive income growth, accelerate achievement of food and nutritional security, generate employment and transform the country into a leading player in global food markets, to grow wealth for millions of farmers. The agenda states that one of the strategies for achieving this is to empower farmers on the adoption and application of research results, technologies, and techniques for agricultural production. Part of the action plan, is the provision and availability of improved inputs, such as seeds and fertilizer, and the action plan focuses on some priority agricultural commodities namely; rice, cassava, sorghum, cocoa, cotton, maize, oil palm, dairy, beef, leather, poultry and

fisheries.

Most of the commodities to be focused upon already have varieties genetically modified for superior performance, disease resistance or nutrition, and should form part of the improved imputs to drive this highly commendable agenda. The beginning of the strategy for production of improved seeds and planting materials should be a sustained and massive human and infrastructural capacity building in agricultural biotechnology research and development (R&D). Rice and cassava, the most widely consumed staples in our country, have varieties genetically modified to deliver high levels of provitamin A to fight vitamin A deficiency in the war against high maternal and infant mortality, as well as blindness, in our society. Cassava and sorghum varieties are being modified to provide low cyanide, higher protein, zinc and iron, to improve consumers' health in Nigeria and are undergoing field trials in our country. GM insect-resistant cotton is already being enjoyed by farmers in Burkina Faso, and insect resistant GM maize as well as drought resistant maize, are undergoing field trials in Kenya. Kenya has also approved importation of GM foods. Cows genetically modified to provide healthier milk and beef, as well as GM fish modified for faster growth, have been developed. Oil palm and cocoa, so important to us for foreign exchange earnings, are begging to be similarly improved under the Agricultural Transformation Agenda (ATA).

Our cocoa can be made harder, in order to command a higher price in the international market, by modifying its fatty acid profile, so that it has a higher content of Palmitc-Oleic-Stearic (POS) triglycerides. The scientific strategies for achieving this, are already available. Similarly, palm oil fatty acid profile can be genetically modified to give a product with 70 – 80% oleic acid, as against the present 30 – 40%, so that the oil is not discriminated against in the international market as being "saturated" and therefore "heart unfriendly". Such a modification will also impact positively on the heart health of our own consumers, with the heart – friendly oleic acid. Various improvements to benefit the poultry industry in Nigeria are also begging for attention, for funding of research and development efforts.

We may all be wondering why a food scientist is talking so much about food production, rather than food processing. If there is not enough food, there will be nothing to process. If the food is not of the right type, processing may be hindered or inferior products generated. Food processing plants in our country, especially small and medium scale outfits, fold up, as a result of insufficient raw material to process. Yes, surprisingly, in this sector, power is only the second constraint. Raw food to process is the first. All the tomato sold in Abeokuta in one month, can be processed by a medium scale factory in one day, then the factory lies idle the rest of the month. This

has been our experience as food processors in Nigeria. Nigeria needs to adopt available emerging technologies in agriculture in order to produce enough food for her teeming populace. To do this, Nigeria needs to build up a critical mass of scientists with competence in modern agricultural biotechnology, to drive its various agricultural transformation strategies. Our agriculture cannot be rebuilt for the long term without massive agricultural biotechnology research and development (R&D) capacity building now.

4.0 ADVANTAGES AND BENEFITS OF GM FOODS

Genetic modification of food raw materials offers several potential advantages and benefits compared to traditional selective breeding techniques. A summary of some of the major advantages are:

4.1 It can provide more food, more economically

Yield is increased due to decreased loss to pests and disease, as in Bt corn, soybean, sugar beet and canola. Yield increase could also be direct as in the GE salmon which is expected to be the first GE animal to be approved for food.

4.2 It is faster, cheaper and more versatile

A change that could take decades to effect with conventional breeding, when it is possible at all, can be achieved in a small fraction of that time, and also at a small fraction of the cost,

and between species between whom it was previously impossible to exchange genes.

4.3 It is more precise in selecting particular desirable characteristics

Conventional breeding or improvements mix entire genomes and hope that the desired combination will be obtained in one of the off springs. Genetic modification cuts out or copies and transfers, only the desired gene, and now Zinc finger nucleases are making even the insertion more precise.

4.4 It allows more traits to be improved

Most GM foods in the market today are either herbicide tolerant, insect resistant or both. Abiotic-stress-resistant crops, including crops that are resistant towards heat, cold, water, drought, and salt, as well as crops with improved nutrients etc, are also being developed for the market. A drought-resistant maize under the Water Efficient Maize for Africa (WEMA) programme, is undergoing trials in Kenya, and is expected to be released by 2014 to Kenya farmers. Such crops can bring much of the dry lands in the North of Nigeria into cultivation and boost food production.

4.5 GM crops reduce the number of food-deficient regions in the world

This is achieved through the development of stress-resistant

varieties more amenable to growing on poor and marginal soils.

4.6 GM technology improves the shelf life of fresh fruits and vegetables

Apart from Flavr Savr, the first genetically modified food to be commercialized, a long-shelf-life tomato was produced in India in 2010 by using RNA-interference to "silence" two genes encoding N-glycoprotein modifying enzymes, α-mannosidase and β-D-N-acetylhexosaminidase, which make fruits to soften. This strategy can be applied to other fruits such as paw-paw, mango and cashew.

4.7 Genetic modification helps to produce safer food by more easily reducing the levels of allergens, naturally-occurring toxicants and other undesirable constituents in food crops

Post-transcriptional gene silencing, most recently via RNA interference, has been used in efforts to remove allergens from rice, soybean, apple, tomato, and peanut. Similarly, RNA silencing, as well as the over-expression of a beneficial gene, have been used in transgenic cassava to reduce toxic cyanogens. (Gallo and Sayre, 2009). Scientists in China, have created a cow that can produce milk low in lactose. They inserted the genes from archaea for an enzyme that breaks down the sucrose, into a cow embryo (Didymus, 2012). Lactose intoler-

ance is very common among people of black African descent.

4.8 Genetic modification, is helping to increase the levels and availability of desirable disease-resisting and health-promoting constituents in our food

Food is no longer eaten only for nutrition. The consumer now expects his food to help him cure and prevent disease. Genetic engineering makes possible, increases in levels of beneficial disease-fighting and prevention components in food, as well as the introduction of such components in foods where they naturally do not occur, but which are more convenient for us to eat. Some of such foods are:

4.9 High Omega 3 fatty acid foods: Omega 3 (ω-3) fatty acids which occur naturally in fish such as salmon, sardine (Titus), makerel (fote), herring (sabonde), have been found to help people live longer, healthier lives. They are associated with heart and brain health, and protect the body against a myriad of diseases such as inflammatory diseases, including cancer, and joint diseases, and promoting general well being. Many people however, do not like fish, hence the need to engineer the life-saving fatty acids into other foods that people can choose from, such as milk, pork, beef, and vegetables. Chinese scientists led by Dr. Guang-Peng Li, announced in 2012 the creation of a cow whose milk contained 4 times the amount the ω-3 fatty acids Eicosapentaenoic acid (EPA) and

Docosapentaenoic acid (DHA) in ordinary cow milk.

4.10 High Oleic acid oils: The levels of health-promoting oleic acid which helps lower LDL (bad) cholesterol in the human body have also been increased in soy and canola oil for improved cardiovascular health of consumers, and superior frying properties. Again, it is important that Nigerian scientists look into increasing the oleic acid content of palm oil, for better cardiovascular health of our people.

4.11 High anthocyanin tomato: Anthocyanins offer protection against certain cancers, cardiovascular disease and age-related degenerative diseases. They are also said to have anti-inflammatory activity, promote visual acuity and hinder obesity and diabetes. Blue berries are high in anthocyanins, but how much of them can one eat? The team of Prof. Cathie Martin from the John Innes Centre, Norwich, UK, by using transcription factors from snapdragon, increased the anthocyanin content of tomato, which everyone likes to eat. The resulting tomato had so much anthocyanin that it was purple. What makes this tomato so potent, is the combination of the water-soluble flavonoid with the oil-soluble lycopene already in the tomato.

4.12 Isoflavone – containing tomato: Isoflavone is known for fighting cancer, but not everyone likes soybean and soy

products. A high isoflavone tomato has been created by inserting a soybean isoflavone synthase into tomatoes.
Scientists continue to investigate ways to increase the levels of health-promoting compounds in more commonly eaten fruits and vegetables and to reduce the levels of objectionable components.

4.13 Edible vaccines: The idea of expressing recombinant vaccines against important human diseases such as hepatitis, alzheimer's, rabies and HIV AIDS in fruits such as banana, have been long with us, though slowed down because of complicated and expensive regulatory hurdles. They were developed to overcome the difficulties experienced by developing countries such as Nigeria, in maintaining the cold chain required for conventional vaccines.

4.14 Genetic engineering improves the sensory and nutritional qualities of foods (e.g. levels of vitamins A, E, desirable fatty acids, iron, fibre)
The Biocassava Plus program for instance is testing cassava modified to have high levels of pro vitamin A, iron, zinc and, protein, to address malnutrition in sub-Saharan Africa

4.15 Produce a variety of ingredients and processing aids

Since 1993, more than 50% of industrial enzymes, have been produced by recombinant microorganisms. Industrial lipases were cloned in *Humicola* (a fungus) and industrially produced by *Aspergillus. oryzae*. They have applications as food emulsifiers. Mammalian chymosin was cloned and produced by *A. niger* or *E. coli* and most cheese is now made with recombinant chymosin which is half the price of calf chymosin and without the ethical problems of calf chymosin. Today, with the aid of recombinant DNA technology and protein engineering, enzymes can be tailor-made to suit the requirements of the users or of the process.

4.16 Enable optimum feed composition and quality for optimal conversion by animals selected for such feeds, with concomitant benefits for the environment. Plant phytase, produced in recombinant *Aspergillus niger* is used as feed for over 50% of all pigs in Holland. A 1000- fold increase in phytase production was achieved in *A. niger* by the use of recombinant technology as far back as 1993 (Van Hartingsveldt et al., 1993). Low-phytate feeds reduce phosphorus and nitrogen levels in animal farm wastes, resulting in environmental benefits.

4.17 Reduce pesticide and herbicide usages, with environmental and cost reduction benefits

Bt crops which are insect resistant GE crops have drastically reduced agricultural use of insecticides, thereby saving money, labour, fuel, and creating wealth, improving health and cleaning up the environment. Use of GE herbicide-resistant crops such as Roundup Ready crops means the farmer can spray post emergence, thus less herbicide is needed, saving costs and the environment.

4.18 GM crops reduce tillage and reduce hand-weeding, with consequent soil benefit

Herbicide resistant crops encourage low- or no-till agriculture, resulting in low run-off and high soil conservation. The South East of Nigeria with their erosion problems, will benefit tremendously from herbicide-resistant crops.

4.19 GE is used to improve desired features of farmed animals, including fish, such as disease resistance

Genetic engineering is being used to modify animals to secrete useful compounds such as growth hormones and drugs in their milk, blood or urine. GM animals approved for use now, fall into this group. Iran produced a transgenic goat on April 19 2013 and makes therapeutic proteins in its milk. No GM animal is yet approved for food, but many have been modified to resist disease, to contain less fat and others such as modify-

ing poultry to produce only female chicks in order to boost egg production have been done.

5.0 CONCERNS ABOUT GM FOODS

Many concerns have been raised about GM foods. Some are based on facts, and some are not. Whether a concern is justified or not, once a concern exists, it must be addressed. Because of this, GM foods are among the most highly regulated items in the world today.

Concerns about GM foods include the following issues:

- The safety of GM foods, especially in the long term: can they be 'proven' to be safe, and are there unintended consequences?
- The environmental impacts of GM organisms and crops,
- The role of "big business" in patenting GM organisms and preventing public access to GM technologies, especially in developing countries
- Potential allergenicity/toxicity of novel proteins in GM foods.
- Potential development of antibiotic resistance.

5.1 Safety and safety evaluation

GM crops and foods have now been available and consumed for over 16 years, and there has been no single report of ad-

verse effect traceable to a food as a result of its being genetically engineered. There appears to be no credible scientific evidence to show that the ingestion of transgenic products is injurious to human health or the environment. GM foods and ingredients currently available on the international market have passed risk assessments conducted by appropriate national and international bodies. Risk is usually defined as "the probability of harm", while a hazard is anything that might conceivably go wrong. Risk is thus a combination of the hazard involved, the probability of its occurrence, and the consequences of that occurrence. Thus:

Hazard x Exposure = Risk.

Few traditional foods consumed today have been subjected to any detailed safety or toxicological study, yet they are generally regarded as safe (GRAS). "Food is considered safe to eat if there is a reasonable certainty that no harm will result from its consumption under anticipated conditions of use" (OECD 2000). The concept of substantial equivalence was developed for the safety evaluation of GM foods. Substantial equivalence is not in itself a safety assessment, but a starting point to identify any intended and unintended differences between the GM organism (plant, animal or microorganism) and its traditional counterpart.

5.2 Safety Assessment

Thus the safety assessment of a GM food compares its characteristics with a conventional counterpart, and involves assessment of factors such as:

• identity, • source, • composition, • effects of processing/ cooking, • transformation processes
• the recombinant DNA (e.g. stability of insertion, potential for gene transfer) • protein expression product of the novel DNA (e.g. effects on function, potential toxicity and, allergenicity), • possible secondary effects on gene expression or disruption of host DNA or metabolic pathways, (e.g. macro/ micronutrients, anti-nutrients, toxicants, allergens), • potential intake and dietary impact of the GM food , (FAO/WHO 2003).

Factors are assessed on a case-by-case basis. To enable modified cells to be easily recognized in the laboratory, marker genes coding for characteristics such as antibiotic resistance, have been included, and this has led to some concerns that these traits may be transferred into microorganisms of public health significance in the human body (e.g. the gut), thus increasing their resistance to therapeutic antibiotics. While scientific opinion about the risk of antibiotic resistance marker genes is that it is very low in most cases, alternative makers have been developed, over the years or the markers are carried

on separate vectors and removed after the experiment by recombination during crossing.

5.3 The precautionary principle

The precautionary principle, which Africa is subscribing to, states that where scientific evidence for safety is insufficient, inconclusive or uncertain, it should be invoked or be considered as part of the assessment. Some have interpreted this as a means of blocking all progress. It should, however, be recognised that scientific evidence can never be conclusive. Science can never prove that anything in life, including food, is safe, i.e. without hazard, because absence of evidence is not evidence of absence (IFST 2004). It is now recognized that there is no scientific justification for requiring long-term animal feeding studies for GM foods or major ingredients as they would be unlikely to provide meaningful information in the great majority of cases (FAO/WHO 2000, OECD 2000).

Some countries such as China, are beginning to relax the stringent testing protocols for GE foods before approval, because after 16 years of being consumed in more than 3 trillion meals, without a single substantiated adverse effect, the GE foods are also beginning to qualify as food that have been eaten over the years without harm, and will themselves, therefore, soon be Generally Regarded As Safe (GRAS).

5.4 The Anti GM Movement

There is a strong anti GM movement, with various agenda, in the Western world, where food is already surplus, who are also trying to negatively influence attitude to GM foods in Africa. One of the founders of the movement, apologized to the world in 2010 for his anti GM activities. The anti GM activist and environmental campaigner Mark Lynas said in a speech to the Oxford Farming Conference late 2010, that he had been wrong to campaign against GM. He said and I quote "I apologise for having spent several years ripping up GM crops, I am also sorry that I helped to start the anti-GM movement back in the mid 1990s, and that I thereby assisted in demonizing an important technological option which can be used to benefit the environment. As an environmentalist, and someone who believes that everyone in this world has a right to a healthy and nutritious diet of their choosing, I could not have chosen a more counter-productive path. I now regret it completely".

He said that in over a decade and a half, with three trillion GM meals eaten, there had never been a single substantiated case of harm. Mark Lynas added that the anti GM activists Greenpeace and the Soil Association, claim to be guided by consensus science, but that there was a "rock-solid" scientific consensus, backed by the American Association for the Advancement of Science, the Royal Society, UK, health institutes

and national science academies around the world (on the safety of GM foods), yet this inconvenient truth was ignored (by the activists).

6.0 MY CONTRIBUTIONS

Biotechnology as already defined, is the use of biological entities or their parts thereof, to produce useful products and services. My contributions to biotechnology in the country are in the following areas:

1. Palm wine research
2. Fermented legume research
3. Cassava waste research
4. Molecular biology consumables research
5. Biosafety research
6. Capacity building
7. Extension

6.1 Palm wine research

My research in biotechnology started with what falls into the realm of traditional biotechnology. Wines and beverages are meant to go with food. Apart from providing their own nutrients, they increase the joy of eating and help us eat more. Working with a research institute that produced and processed palm wine, the question naturally arose as to what happens when palm wine is out of season and a factory has to run?

Can we extend or formulate acceptable alternatives? There are various approaches to this – chemical and biological. We could chemically analyze the beverage and attempt to reconstitute it using the determined constituent components. We could also determine its biocontents – enzymes and /or microorganisms, and use them to reproduce the beverage, or a combination of the two could be used. We adopted a chemical – biological approach.

6.1.1 Formulated Palm wine

Palm wine was simulated by preparing a sugar solution and inoculating with palm wine dregs and allowing to ferment. The hypothesis was that given the correct substrate, the flora would replicate the beverage. The hypothesis was tested and found to be valid. The resulting brew termed Formulated Palm wine as well as its various blends with natural palm wine termed Extended Palm wine, passed for palm wine in sensory evaluation tests (Table 1). The product was seen as a first step to large-scale in-vitro production of palm wine extensors (Mmegwa *et al.,* 1985). However sensory evaluation also showed that the formulated palm wine resembled palm wine in everything but colour and consistency. It was also found (Figs. 5 and 6) that the formulated version produced more ethanol and less acid than the natural one (Mmegwa *et al*., 1988) – a clear indication that the acid-producing microbes in

Table 1: Summary of sensory evaluation results of formulated (P_1) and extended (P_2) palm wines against natural (P_3) palm wine

Sensory attributes	Samples exhibiting no significant difference from palm wine (P3)	
	At 5% level	At 1% level
Colour	-	-
Consistency	-	-
Taste	P1, P2	P1, P2
Aroma	P1, P2	P1, P2
Overall acceptability	P1, P2	P1, P2

Mmegwa *et al*., 1985

palm wine were not fully catered for, in the formulated sap. This led to a more comprehensive analysis of the beverage to determine the factors controlling these parameters in the natural beverage, with a view to facilitating their manipulation in the natural product and improving the formulated beverages.

6.1.2 Palm wine and palm sap

A study of palm sap and palm wine by simple centrifugation, showed, that the colour of palm wine, was a product of fermentation, and that the metabolites responsible, were

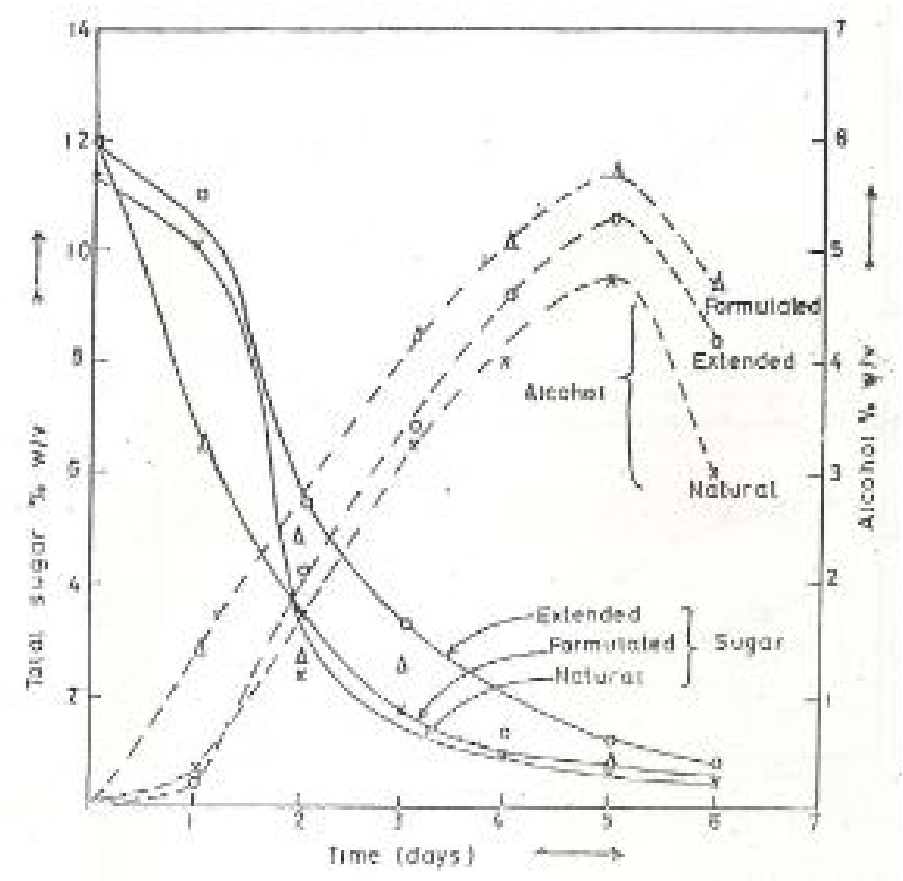

Fig. 5: Rate of utilization of sugar and accumulation of alcohol in Natural, Formulated and Extended palm wine

Source: Mmegwa *et al*., (1988).

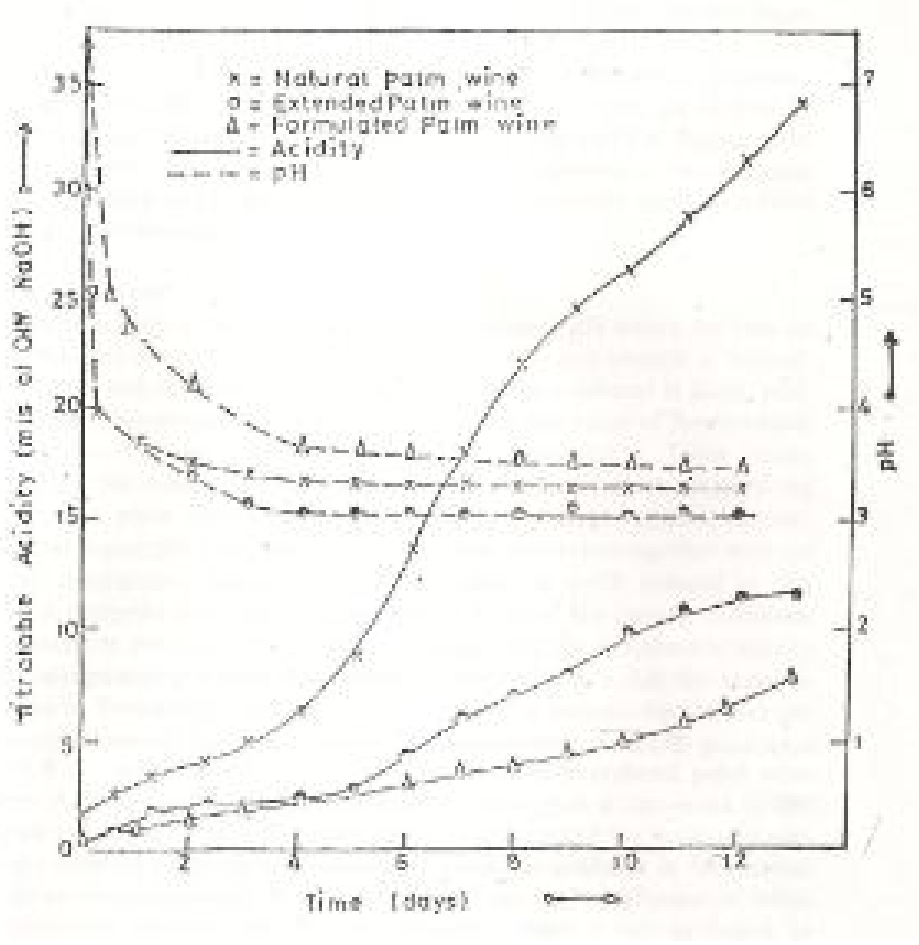

Fig. 6: Variation in titratable acidity and pH during the fermentation of three types of palm wine: natural, extended (25%) and formulated
Source: Mmegwa *et al*., (1988)

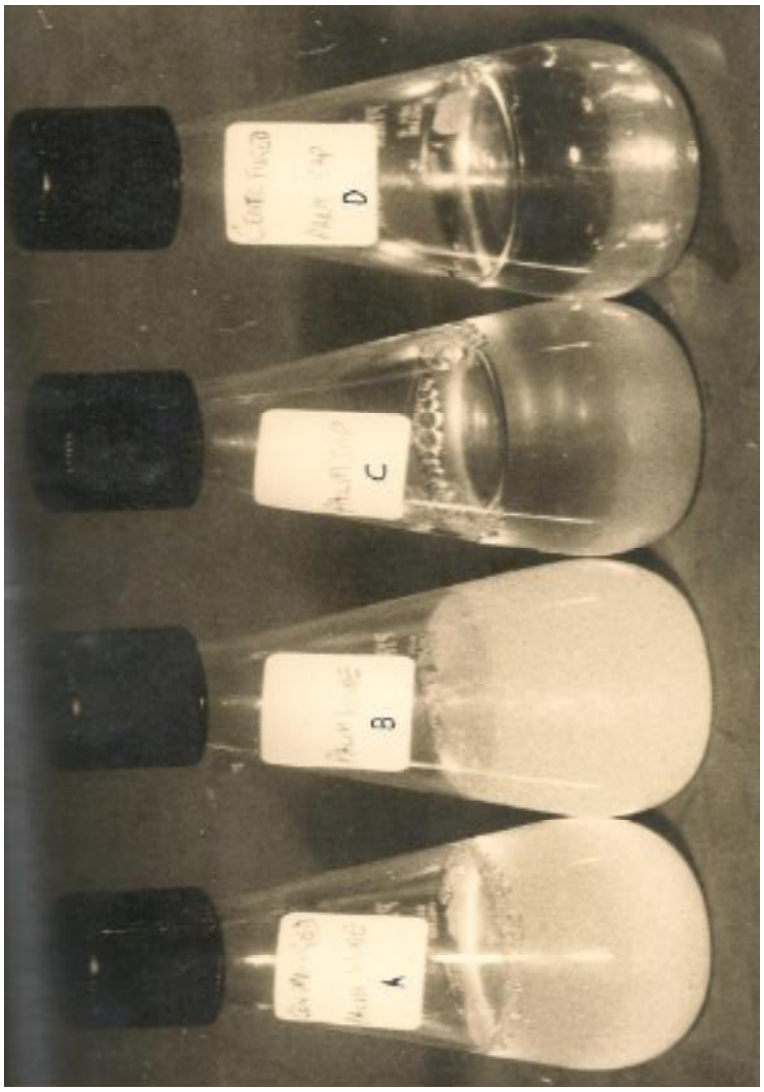

Plate 1: Centrifuged (A) and Uncentrifuged (B) palm wine, Uncentrifuged(C) and Centrifuged (D) Palm sap.
Source: Uzochukwu *et al.*, (1994)

soluble (Plate 1). This was contrary to the generally held opinion that palm wine, derived its white colour from the turbidity caused by the microorganisms suspended in it (Okafor, 1978). Sniffing of the palm sap and palm wine samples, also showed that palm sap lacked palm wine aroma, and that the aroma also developed during fermentation, as against generally held beliefs that the peculiar palm wine odour derived from the tree. Chemical analysis of palm wine showed a beverage composed before fermentation, of mainly sucrose. This fermented spontaneously to another beverage made up of about 4% ethanol. Microorganisms in the beverage multiplied profusely during this transformation. Analysis of the microflora showed that when the palm wine was collected with non-sterile implements, many species of yeasts and bacteria were found, but on collection with sterile implements, only *Saccharomyces* and *Candida* yeasts were found. The lactic acid bacteria *Leuconostoc* and an unidentified (Plate 2) *Lactobacillus (AW)* and one unidentified gum producing bacteria (Table 2) were the bacteria detected. This suggested that many microorganisms reported previously in palm wine, were incidental contaminants depending on the level of asepsis applied to implements used for collection. Uzochukwu, working with Okolie (Okolie, 2008), crosschecked these results, using 16S ribosomal gene sequence analysis, and obtained similar results (Plate 3, Table 3).

Table 2: Yeasts and bacteria in palm wine collected with and without sterile implements

Microorganisms in palm wine collected Without sterile implements		Microorganisms in palm wine collected With sterile implements	
Yeasts	Bacteria	Yeasts	Bacteria
Saccharomyces chevalieri	*Leuconostoc mesenterides*	*Saccharomyces chevalieri*	*Leuconostoc mesenterides*
Saccharomyces cerevisiae	*Leuconostoc dextranicum*	*Saccharomyces cerevisiae*	*Leuconostoc dextranicum*
Candida	*Lactobacillus casei*	*Candida*	*Lactobacillus Casei*
Geotrichum	*Serratia*		*Lactobacillus Casei ss casei*
Trichosporon	*Bacillus*		*Lactobacillus (unidentified)*
Kloekera	*Micrococcus*		*Unidentified gum producer*
Torulopsis	*Pediococcus*		
	Acetobacter		

Source: Uzochukwu *et al.* (1991)

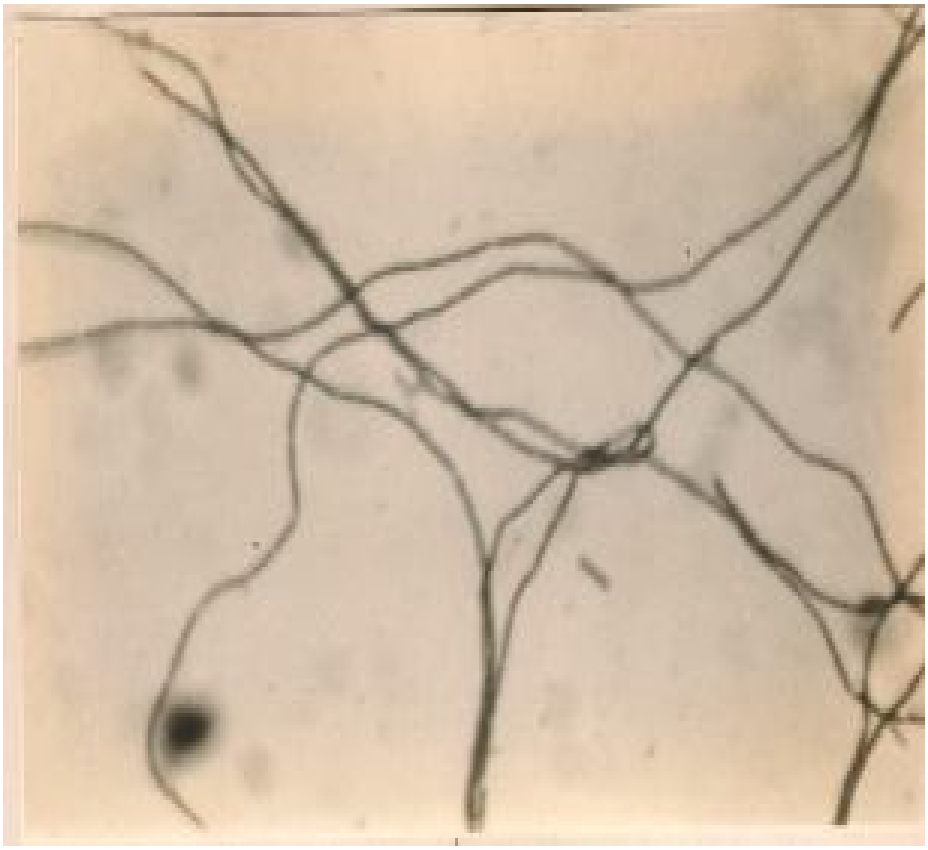

Plate 2: Unidentified Lactobacillus (AW) with unusual morphology isolated from palm wine
Source: Uzochukwu, 1987

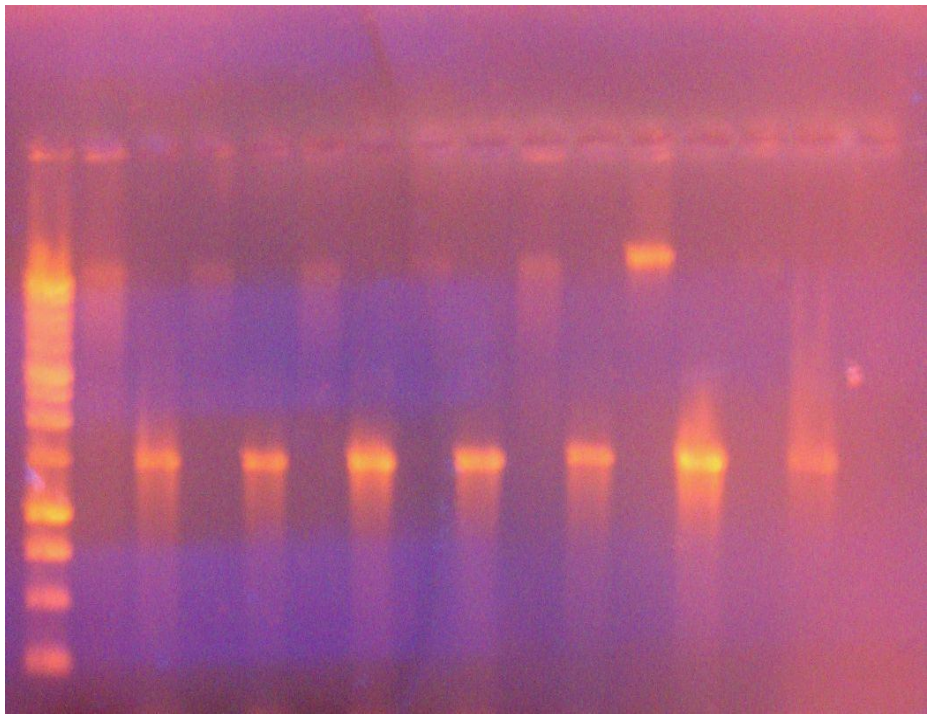

Plate 3: Genomic DNA of palm wine bacteria with the corresponding 16S rRNA gene fragment amplified by PCR
Source: Okolie, 2008

Table 3: Palm wine Bacteria identified by 16S rRNA gene analysis

Isolates Clones	References from NCBI data-base	Nucleotide Number	Identity (%) Match
IP01	*Lactobaccilus plantarium*	773	100
IP02	*Lactobacillus spp*	604	100
IP03	*Leuconostoc mesenteroides*	801	100
IP04	*Lactobacillus spp*	561	99
IP05	*Leuconostoc mesenteroides*	900	100
IP06	*Lactobacillus*	791	99
IP07	*Acetobacter spp*	970	100
IP08	*Acetobacter ghanensis*	840	100

Source: Okolie, 2008

These studies opened up a new series of questions. It was clear that the odour, and colour of the beverage were imparted during fermentation, and that only a few organisms were involved, but which organism produced what, and which component was responsible for what? To answer these questions all microorganisms isolated were employed singly in pure culture fermentations of palm sap.

6.1.3 Palm wine aroma

Sensory evaluation of the pure culture ferments, showed the yeasts to be the major producers of the aroma of palm wine.

What was now left was to determine the components produced by these organisms which were responsible for the sensory qualities being observed.

6.1.4 Palm wine flavor volatiles

The question about palm wine flavor volatiles was whether there was any one volatile that was responsible for palm wine aroma. Such a compound could simply be mixed with sugar, alcohol and acid in an aqeous solution to get a formulated palm wine. Analysis of the headspace gas of palm wine and palm sap by gas chromatography-mass spectrometry (GC-MS) confirmed that the flavor volatiles of palm wine were virtually absent in palm sap, as already concluded by just sniffing the samples (Fig. 7). Analysis of the headspace gas of pure cultures of palm wine bacteria and yeasts in palm sap by (GC-MS), and by sniffing effluent volatiles at a sniffing port with the flames extinquished, showed that no one compound was responsible for palm wine aroma. Yeasts were shown by pure culture fermentations to reproduce palm wine aroma (Fig. 8), while bacteria appeared to contribute no significant flavor volatiles (Fig. 9). The lactic bacteria did produce sulphur compounds and carbonyls, but sniffing port experiments showed these to be relatively neutral, odour-wise. This confirmed what was deduced by ordinary sniffing which showed that the bacteria pure cultures, tended to retain the odour of palm sap.

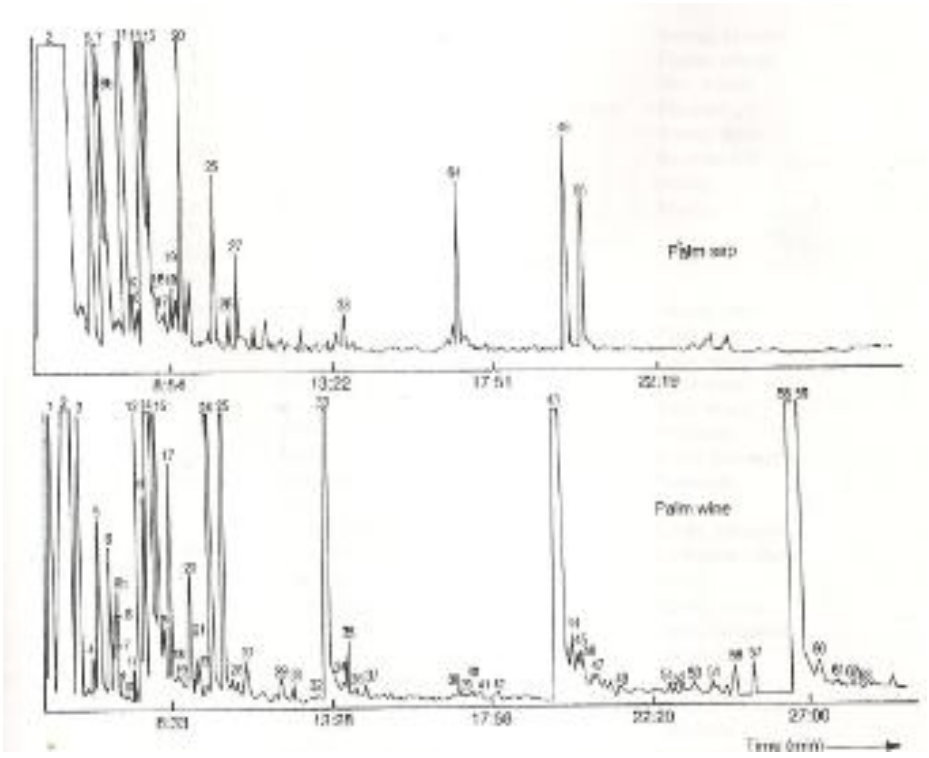

Fig. 7: Gas chromatogram of pasteurized palm sap (top) and palm wine (below). Peak numbers correspond to those of the compounds in Table 4.

Source: Uzochukwu *et al.*, 1994.

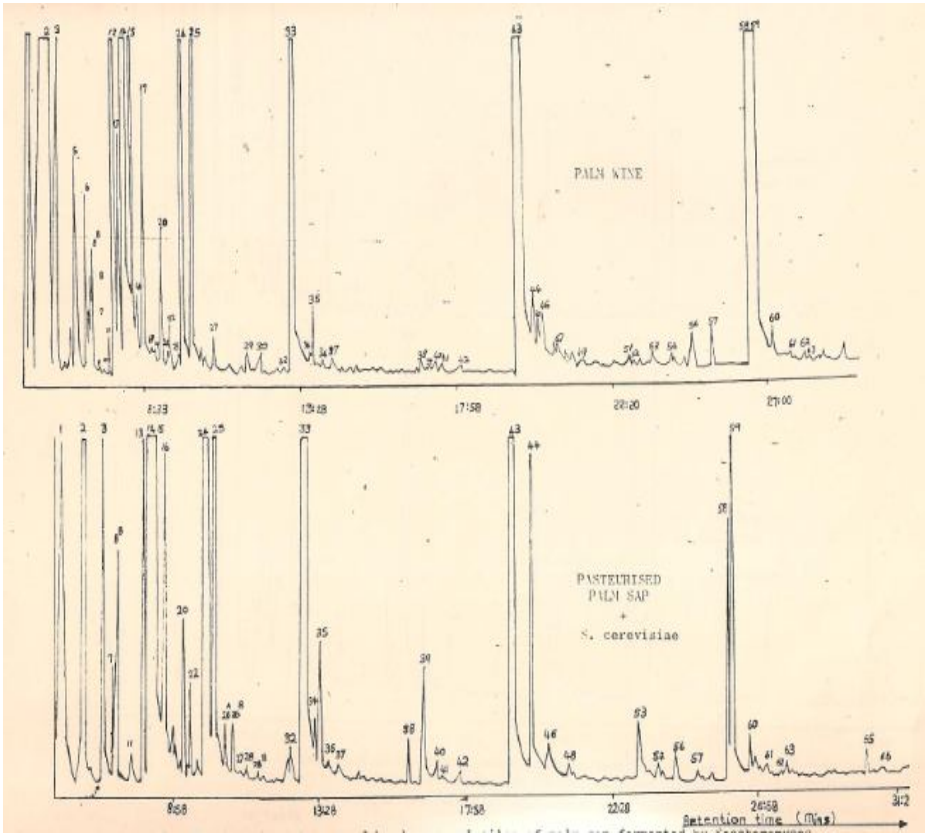

Fig 8: Gas chromatograms of the headspace volatiles of pasteurized palm sap fermented by *Saccharomyces cerevisiae* (below) compared with that of palm wine (above). Peak numbers correspond to those in Table 4.

Source: Mmegwa, 1987

Table 4: Key to peaks of chromatograms

1.Acetaldehyde
2.Ethyl acetate
3.Unknown
4.Unknown
5.Isobutano
6.Diethyl ether
7.Ethyl propanoate
7B. 3-Pentanone
8A. an Acetal
8B. Propyl acetate
9.Unknown
10. Unknown
11. Toluene (A) + ethyl isobutyrate (B)
12. Acetic acid
13. Isobutyl acetate
14. Isoamy alcohol
15. Ethyl n-butyrate
16. n-butyl acetate
17. 2,3, Butanedione
18. Unknown
19. Unknown
20. Ethyl 3-methyl butyrate
20A. Ethyl 2-methyl butyrate
21. Dimethyl Benzene
22. Ethyl 2-butenoate
23. Unknown
24. Isoamyl acetate
24A. a Terpene
25. Styrene
26A. n-pentanol
26B. n-amyl acetate
27A. Unknown
27B. 2-Heptanone
28. n-decane
29. Unknown
30. Unknown
31. Unknown
32. Limonene
33. Ethyl hexanoate
34. Unknown
35. Hexyl acetate + Dichlorobenzene
36. Hexanol
37. Unknown
37B. Unknown
38. Octanol
38B 2-nonanal

Table 4: Key to peaks of chromatograms (contd.)

39. Heptyl acetate
40. Aliphatic hydrocarbon
41A a Terpene
41. Ethyl styrene
42 Unknown
43. Ethyl octanoate
44. Octyl acetate
45. Unknown
46. Naphthalene
47. an aldehyde
48. Isoamyl hexanoate
51. Propyl octanoate
52. Ethyl nonanoate
53. Phenethyl acetate
54. Methyl naphthalene
56. Methyl naphthalene
57. Terpene
58. Ethyl decanoate
59. Ethyl decanoate
60 n-decyl acetate
61. Aliphatic hydrocarbon
62. Isoamy octanoate
63. Ethyl naphthalene
65. Unknown
66. Unknown
67. Unknown
70. Acetone
71. Propanol
72. 2-Pentanone
73. Unknown
74. Benzthiazole
76. Terpene
77. Trimethyl bebzene
78. Phenethyl ester
80. Vinyl acetate
81. C-5 branched aldehyde
83. 2-Nonanone
84. 2 phenethyl butyrate
85. Diethyl sulphide
86. n-Hexanal
87. Di-methyl trisulphide
88. Ketone
89. Butyrate
90. a butyl butyrate
91. an Amyl butyrate
92. Unknown
93. Unknown
94. 2 Butanone

Source: Mmegwa 1987

6.1.5 Palm wine acids

The *Lactobacillus* spp and the *Leuconostocs* spp produced the bulk of the acids, with acetic acid being the major volatile acid produced. It appeared from GC-MS of acids extracted from palm wine at different fermentation stages, that the yeasts also contributed to palm wine acidification, by producing acetic acid early in palm wine fermentation. Acetic acid was produced in palm wine as early as 3 hrs after collection of sap with sterile implements, contrary to the expectation that it would be produced at the end of fermentation from ethanol. The practical implication of this, is that a strategy must be devised to completely prevent fermentation of palm sap when it is to be employed for the preparation of products in which acetic acid would be objectionable, such as table wines. Alternatively, the processing should include a step for getting rid of the acid.

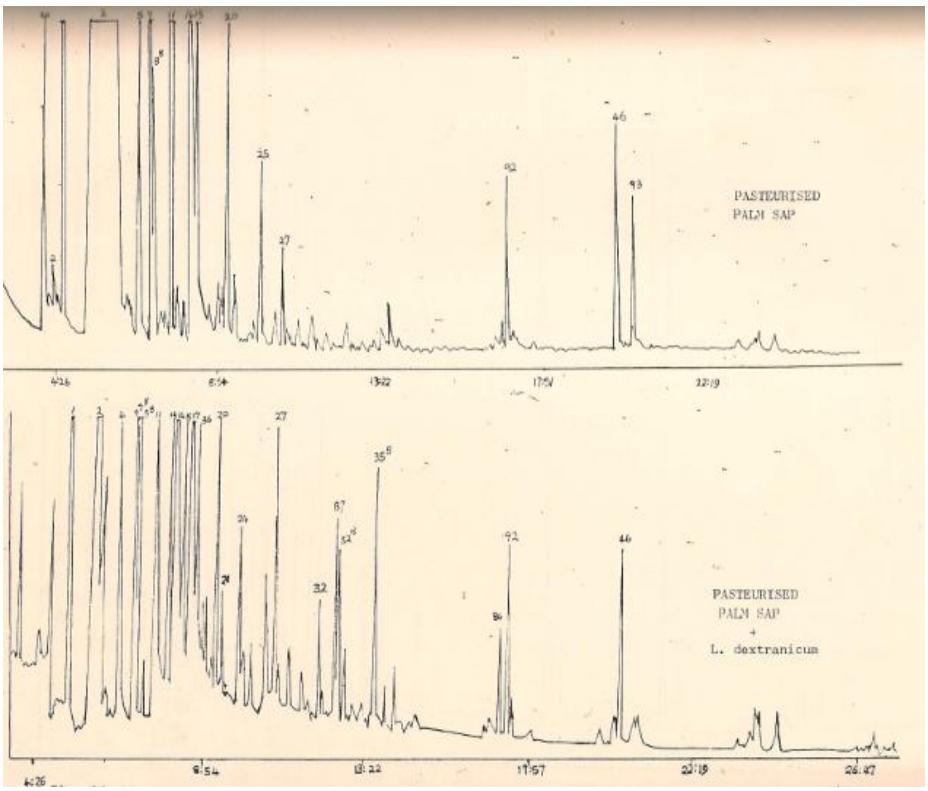

Fig 9: Gas chromatograms of the headspace volatiles of pasteurized palm sap fermented by *Leuconstoc dextranicum* (below) compared with that of pasteurized palm sap (above). Peak numbers correspond to those in Table 4.

Source: Mmegwa, (1987)

6.1.6 Palm wine flavor

Though the yeasts reproduced palm wine aroma, the lactic acid bacteria producing the bulk of the acid, would be necessary for balancing the taste. Based on these findings it was concluded that a combination of either *Leuconostoc mesenteroides* and *Leuconostoc dextranicum* with *S. cerevisiae* would reproduce palm wine aroma to give a formulated palm wine (Fig. 10)

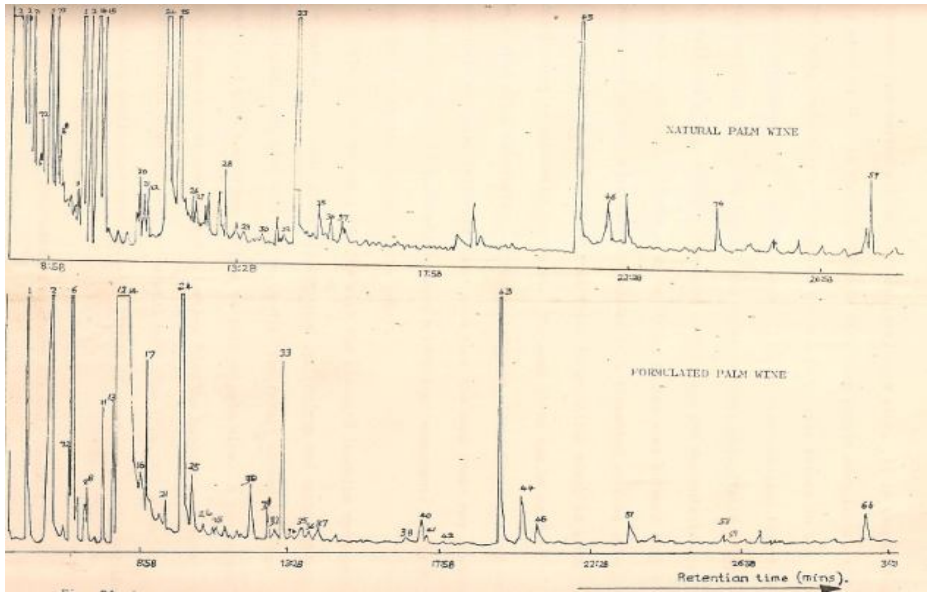

Fig. 10: Gas chromatograms of the headspace volatiles of natural palm wine (above), and formulated palm wine (below), both at the 9% sugar stage. Peak numbers correspond to those in Table 4.

Source: Mmegwa, (1987)

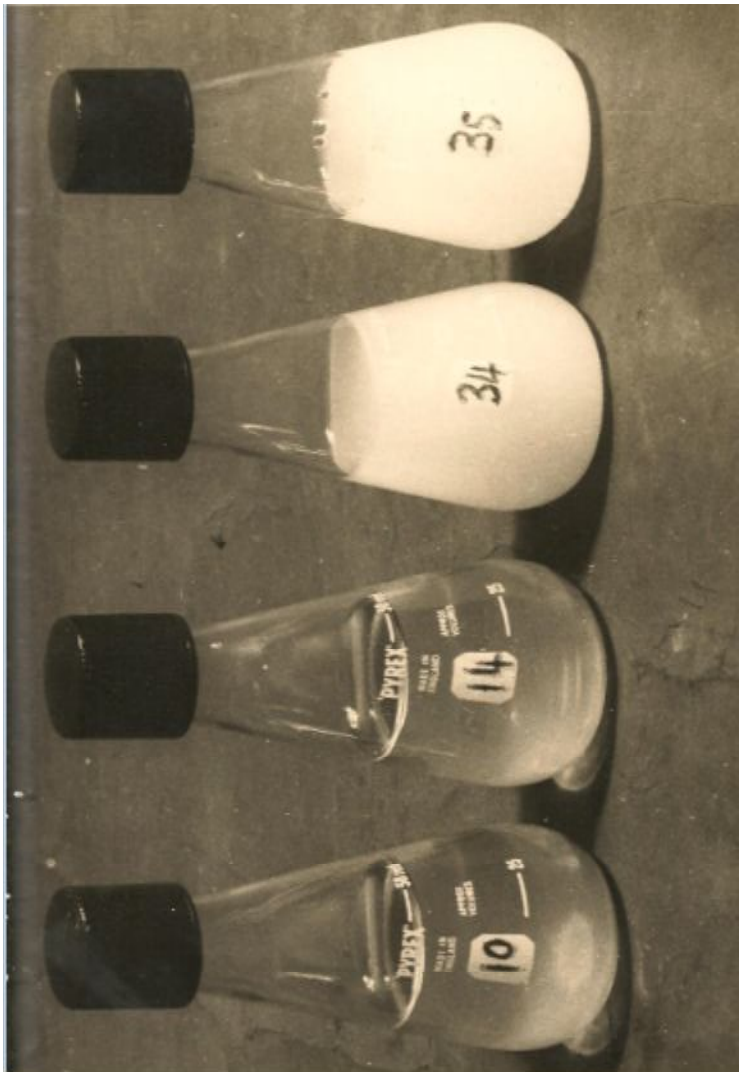

Plate 5: Palm sap after fermentation by *Saccharomyces cerevisiae* (10), *Saccharomyces chevalieri* (14) *Leuconostoc dextranicum* (34), and *Leuconostoc mesenteroides* (35)
Source: Uzochukwu et al., (1994)

with sufficient acid to balance the taste.

6.1.7 Nature of palm wine gums and the elaborating bacteria

The fermentations also showed that among the bacteria, *Leuconostoc spp,* one unidentified *Lactobaccilus spp* (AW), and an unidentified bacterium were involved in the production of the characteristic white colour and consistency of the beverage, while other bacteria present and the yeasts apparently played no role.

Analysis of the soluble white components produced by the lactic acid bacteria, by ethanol extraction and subsequent thin layer chromatography, showed those produced by the lactic acid bacteria (LAB) to be all glucose polymers or glucan gums . Those produced by the unidentified non-LAB gum-producers were found to be fructose polymers or fructans (Table 5) (Uzochukwu *et al*., 1994).

6.1.8 Structural analysis of gums

Structural analysis of the gums by ^{13}C nuclear magnetic resonance (^{13}C nmr) showed the types of linkages and degrees of linearity. Proton-decoupled ^{13}C nmr spectra were obtained at natural abundance. ^{13}C nmr shows only signals from the carbon atoms, unlike proton nmr, which shows signals from the hydrogen atoms, resulting in very complex profiles.

Table 5: Properties of gums extracted from palm wine, and gums elaborated in pure culture by palm wine bacteria

Gum producer/ Gum type	Grown in palm sap		Grown in sucrose solution		Nature of gum*	Solu-bility in water	Constitu-ent sugar
	Yield /100 mls	Viscosity of 10% solution (CPS)	Yield/ 100mls	Viscosity of 10% solution (CPS)			
PW50 (50% ethanol insoluble gum)	0.76	127	-	-	Short, crumbly	+	Glucose
PW60 (60% ethanol-insoluble gum)	0.22	1.9	-	-	Stringy	+	Fructose
Leuconostoc mesenteroides	1.77	585	2.50	1140	Sticky, cohesive	+	Glucose
Leuconostoc dextranicum	1.01	112	1.85	210	Short, cohesive	+	Glucose
Unidentified gum producer 2	0.21	2.1	0.24	2.5	Fluid	+	Fructose
Unidentified gum producer 3	0.25	1.8	0.30	1.9	Stringy	+	Fructose
Lactobacillus spp	1.86	-	2.7	-	Short, crumbly	+(-)	Glucose

+ = soluble, +(-) = sparingly soluble, * observed when precipitated from aqeous ethanol solution.

Source: Uzochukwu *et al*., (1994)

It was found that glucans produced by the bacteria in pure culture were composed exclusively of α-D-glucopyranosidic residues linked 1- 6, and branching at carbon 3 (Fig . 11). This confirmed them to be dextrans. Some samples also branched at carbons 2 or 4 in addition to the C3 branching. The pure culture fermentations showed that the dextrans produced by the different bacteria differed in the branch types additional to the common carbon 3 branching (Figs 12 and 13) . The Dextran from *Leuconostoc dextranicum* branched mainly $\alpha(1$-3), with minor $\alpha(1$-4) branching. It also had intra-chain $\alpha(1$-3) linkages. The *Leuconostoc mesenteroides* dextran branched $\alpha(1$-3), with strong $\alpha(1$-2)branching, while the dextran of the unidentified lactobacillus spp (AW) branched solely $\alpha(1$-3) (Fig. 11) (Uzochukwu et al., 2002). Experiments also showed that the bacteria would produce the same dextran in sucrose solution, as they produced in natural palm sap. The gums produced in sucrose solution were however more highly branched than the same dextran produced in palm sap, but this did not affect the viscosity of the gum. This meant that in a formulated sap or sucrose solution, they would produce the same gum they produced in palm wine, and impart the same colour and consistency effect.

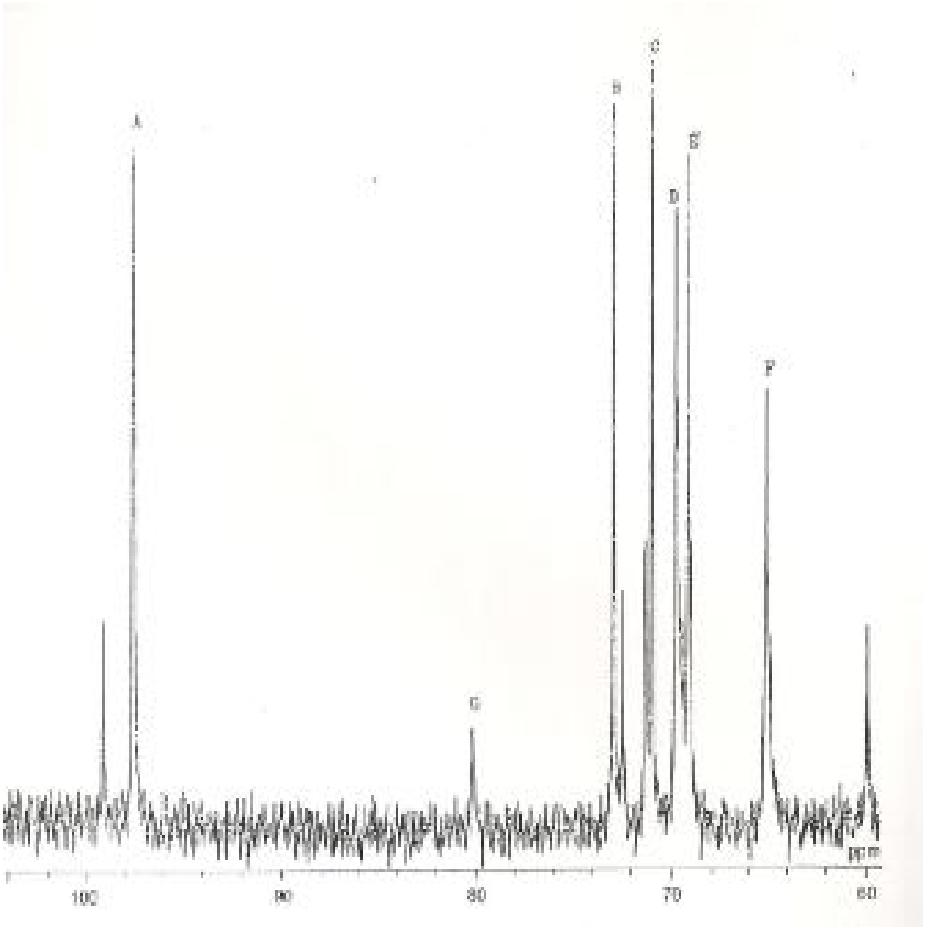

Fig. 11: ^{13}Cnmr spectrum of glucans produced by unidentified *Lactobacillus spp* (AW) in sterile palm sap. The letters A through F, refer to the major resonances of linear dextran

Source: Uzochukwu *et al.,* 1994

It was found that glucans in palm wine were composed also exclusively of α-D-glucopyranosidic residues linked 1- 6, and branching at carbon 3 (Fig. 13), confirming them also to be dextrans. In addition, all the branching signals found in the spectra of the palm wine bacteria gums produced in pure culture, were present in the palm wine glucan spectrum. This showed clearly, that these bacteria produced their various dextrans in palm wine at the same time. That palm wine dextran is a mixture, is shown clearly by the complexity of its NMR spectrum shown in Fig. 14. These experiments confirmed *Leuconostoc mesenteroides* as the LAB of choice to pair with *Saccharomyces cerevissiae* for formulated palm wine preparation. It was found superior to *Leuconostoc dextranicum* in formulated sap for formulated palm wine.

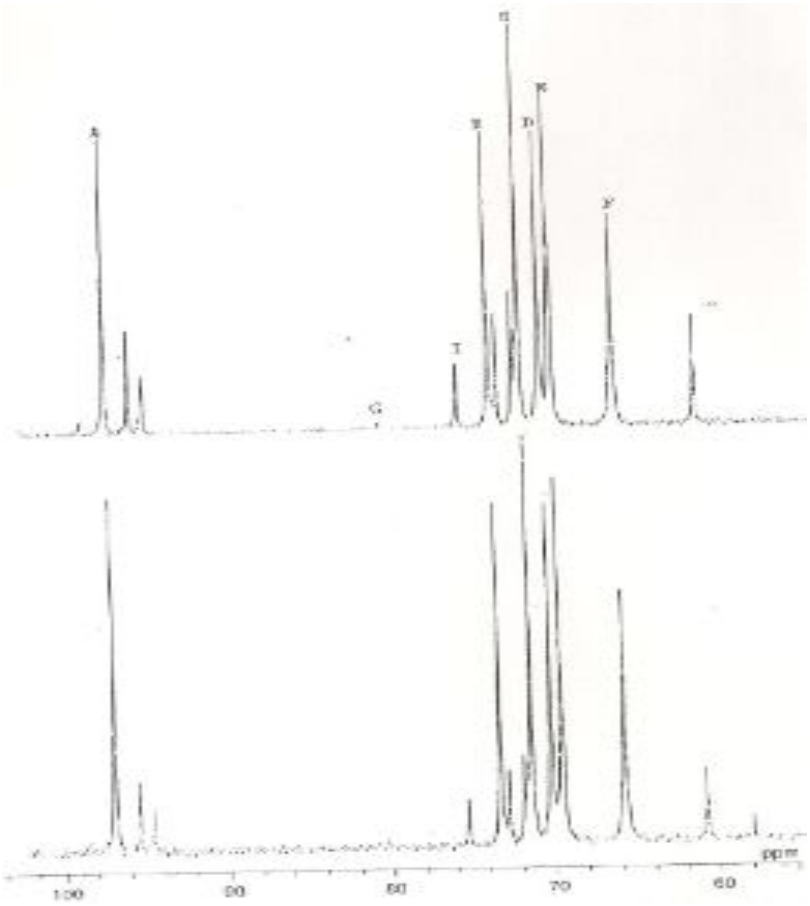

Fig 12: ^{13}Cnmr spectrum of glucans produced by *Leuconostoc mesenteroides* in sucrose broth (above) and in sterile palm sap (below). The letters A through F, refer to the major resonances of linear dextran

Source: Uzochukwu et al., 2001.

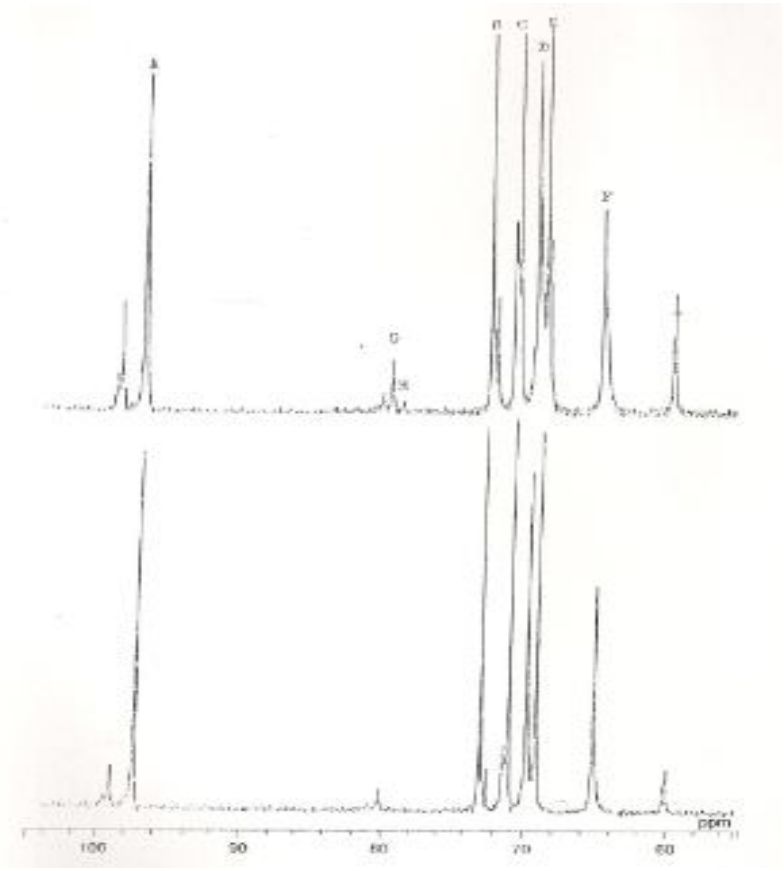

Fig. 13: ^{13}C NMR of spectrum glucans produced by *Leuconostoc dextranicum* in sucrose broth (above) and in sterile palm sap (below). The letters A through F, refer to the major resonances of linear dextran

Source: Uzochukwu *et al*., (1994)

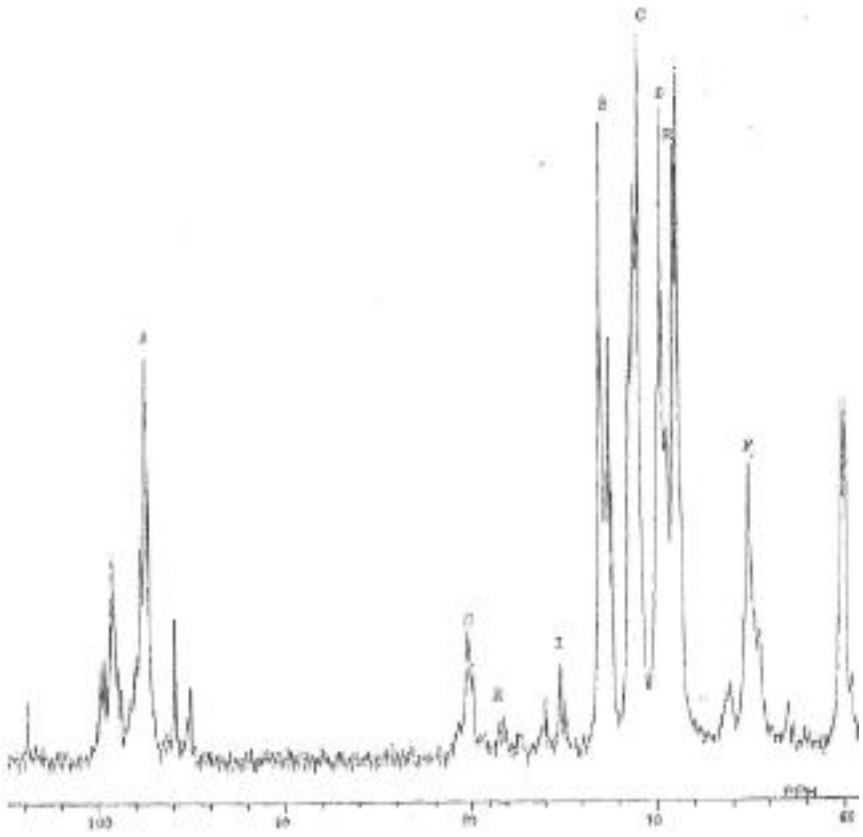

Fig. 14: ^{13}C NMR spectrum of 50%-insoluble glucan extracted from palm wine. The letters A through F, refer to the major resonances of linear dextran

Source: Uzochukwu *et al*., (2002)

6.1.9 Patents

From the results of these studies, it was possible to improve the formula for formulated and extended palm wine, in view of the perceived differences in colour and consistency observed in the initial formula. These adjustments resulted in three patents for : Formulated palm wine - Nigerian Patent No. Rp. 12612, a Non-Alcohlic palm drink - Nigerian patent No. 12613, and Palm table, sparkling and fortified wines - Nigerian Patent No. 12549, (Uzochukwu, 2004a, Uzochukwu, 2004b, Uzochukwu 1996).

6.1.10 Future palm wine research

In the area of palm wine research, we are at looking at genetically modifying the *Saccharomyces cerevisiae* yeast to breakdown bacteria gums as it ferments palm wine, resulting in table/sparkling/fortified wines, without the rigour involved in the patented procedure for making these beverages from palm wine.

6.2 Beans studies

Beans or edible legumes should be known as "healthy people's meat". Beans pack a surprisingly rich and varied array of substances that are vital for good health. Diets rich in beans lower cholesterol levels, improve diabetics' blood glucose control, reduce risk of many cancers, lower blood pressure, regulate functions of the colon, prevent and cure constipation, prevent

piles and other bowel problems. Also richly coloured dried beans offer a high degree of antioxidant protection. Isoflavones in beans may ease the symptoms of menopause, prevent some forms of cancer, reduce risk of heart disease and improve bone and prostate health, among other benefits. One of the reasons the health benefits of beans are so many is that they contain a lot of fibre. The fibre can actually mop up cholesterol from the intestine and whisk it out of the system. Beans are the new super foods and should be maximally exploited.

6.2.1 Tempeh: fermented Soybean and meat analogue

Many people fail to enjoy the health benefits of beans because they contain oligosaccharides which act as beneficial fibre, but also cause flatulence. In addition, some beans are so hard to cook that many people simply give up, so that they are eaten very rarely. Both problems can be alleviated by proper cooking methods, sprouting, or fermentation. Fermented legumes as healthier alternatives to meat and meat-based flavor enhancement has occupied the minds of many scientists including Nigerian Scientists. Tempeh, a fungus-fermented soybean meat analogue from Indonesia, has gained popularity in the United States of America (USA) in recent years. It has a firm texture and a nutty flavor. It is often used in burgers, instead of ham, and generally as a meat analogue in vegetarian cuisine by health conscious individuals. The fermenting fungus can

pre-digests hard-to-cook beans, making them more available for use. We looked at common Nigerian beans and hard-to-cook beans as substrates for Tempeh-making, since soy bean is still not a generally consumed bean in Nigeria. We surmised that Tempeh from other beans could play the same role of providing plant protein and calcium in fun-to-eat products such as burgers.

Tempeh with common local beans and hard-to-cook beans

Pigeon pea (*Cajanus cajan*), and the local white, and brown cowpeas (*Vigna unguiculata*), were evaluated for tempeh-making, with soybean tempeh as a control. The delicious but hard-to-cook beans bambara groundnut (*Vignia subterranean*), and African Yam bean (*Sphenostylis stenocarpa*) were also evaluated. Spores of a locally isolated *Rhizopus oligosporium* mould were employed as inoculum. This was seen as a way of getting more consumers to eat beans which have immense health benefits. It was also a way of bringing lesser-known beans of Nigeria into the general diet. Brown cowpea normally consumed in the West of Nigeria and bambara groundnuts popular in the East, were found suitable for tempeh-making but the white cowpea favoured in the East, as well as African yam bean, were found not to be suitable (Tables 6 and 7). Bambara groundnut tempeh, was actually considered superior to soy tempeh, by taste panelists. It had a distinct taste, light

texture, and aroma like fried palntain, which the taste panel loved. Both tempehs had a pleasant golden colour after frying. With half the oxalic acid content of soy bean (Ajayi *et al.,* 2009), bambara groundnut may then be a better choice for tempeh than soybean especially for people with kidney and gall bladder problems. High concentrations of oxalate in the blood could lead to crystallization and stone formation, with concomitant undesirable health consequences. It could also interfere with calcium absorption. The African yam bean tempeh was brown and heavy, with a poor aroma rating. The fried soy tempeh aroma was like that of roasted groundnut.

Table 6: Sensory evaluation results for fried tempeh made from Soybeans, Bambara groundnuts and African yam beans, scored on a 9-point hedonic scale

Tempeh Type	Taste	Colour	Aroma	Texture	General acceptability
Soy beans	5.6b*	5.7ab	5.6ab	5.3b	5.9b
Bambara groundnuts	6.4a	6.2a	5.9a	6.4a	6.5a
African yam beans	5.0b	5.0b	5.0b	5.1b	5.3c

*Means for each attribute not followed by the same letter, are significantly different at 5% level of significance.
Source: Uzochukwu *et al*., (2001)

Table 7: Sensory attributes of stews made from soybean tempeh, cowpea tempeh (local brown) Pigeon pea tempeh and meat, scored on a 9-point hedonic scale

Tempeh stews	Colour	Aroma	Texture	Taste	Overall activity
Soybean	5.1b*	5.5b	5.2b	4.9b	5.7b
Cowpea (brown)	6.1ab	6.1ab	5.8ab	5.9ab	6.3ab
Pigeon pea	5.0b	5.7ab	5.1b	4.8b	5.5b
Meat sauce	6.6a	6.6a	6.4a	6.5a	6.7a

*Means for the same attribute followed by the same letter are not significantly different at 5% level. Higher numbers indicate greater preference.
Source: Uzochukwu *et al.,* (1999).

Tempeh can be cubed and used for stews and soups, sliced for burgers or cut into fingers and fried, all in place of meat. Tempeh–making is a small scale industry waiting to be tapped in Nigeria. It requires very little capital to start, and can grow quite big in a short time, if good manufacturing practices are adhered to.

Benefit for FUNAAB

Tempeh-making is an ideal small scale industry for fresh graduates. Our 500 level students can start it during Youth Service and sell to fellow Corpers. They can then continue after service, having perfected their skill during service. The

University may wish to incorporate such skills into our Entrepreneurial scheme for students.

6.2.2 Iru, Ugba, Dawadawa: Fermented legumes and soup condiments

Another way we can enjoy legumes is by fermenting them with *Baccillus* species to give flavour enhancing condiments that increase the pleasure of eating, and decrease the flatulence factors in legumes. If food does not taste good, no matter the level of health-promoting substances in it, we will not want to eat it, therefore consumers will not get the required amounts of health-promoting nutrients into their bodies. Many of such indigenous condiments have been studied by Nigerian scientists and include Iru from African locust beans *Parkia bioglobosa* (Odunfa and Adewuyi, 1985), and *Okpehe* from *Prosopsis africana* (Sanni, 1993) to determine their microbial content and fermentation characteristics. Uzochukwu *et al*., (1997), attempted to optimize processing conditions for *Okpehe* and found that fermenting the seeds at 35^{o}C for 72h to attain a moisture content of 68 – 72% , gave a high quality product.

Many workers, have also investigated the microflora of these condiments with a view to determining the organisms responsible for the fermentations, so that standard inocula could be developed. Such workers in the past employed culture-

based methods. With the advent of advances in molecular biology, DNA-based methods have been found to be more accurate at detecting and identifying microorganisms. Uzochukwu, working with, Okpara and Adelekan (Okpara *et al*., 2013, Adelekan, 2012), sought to cross check the conclusions of previous Nigerian workers, on the microbial content of legume-based fermented condiments using the newer molecular methods now available. Using community DNA from *iru, dawadawa* and *ugba*, they were able to detect organisms present in the samples without the need to culture them, and to identify them by analysis of the highly conserved 16S ribosomal RNA (16S rRNA) genes of the bacteria, amplified by polymerase chain reaction (PCR). It was confirmed that the Bacillus group were the important group in Ugba and that *Bacillus subtilis* was the predominant bacteria.

It could not be confirmed however, that *Bacillus subtilis* was the species involved in *Iru* and *Dawadawa*. The results appeared to indicate that *Bacillus cereus* could be the important species for *Iru* (Adelekan, 2012), despite the fact that it is a species of public health importance for gastrointestinal disturbances. The *B. cereus* was absent in the aged product *Dawadawa*. The simple implication of this, is that any dish which includes locally prepared *iru* should be boiled before consumption.

Future condiment work

The observation about *B. cereus* in *Iru* gives room for concern and requires further research to confirm and reconfirm it. Ogiri does not appear to have this problem, probably because it is aged, like Dawadawa. This suggests that ageing these traditional condiments, as is traditionally done in the North and East of the country, improves their food safety status.

Table 8: Bacteria detected from *Ugba* – Fermenting oil bean seed Community DNA and identified by 16S rRNA gene analysis

Organism	No. (% abundance)	Gene Bank Accession number
Bacillus subtilis	17 (47.2)	AY833569
Bacillus spp VAN 22	2 (5.5)	AF286483
Staphylococcus spp	2 (5.5)	EM86592.1
Bacillus pumilus	9 (25)	AY456263
Bacillus licheniformis	4 (11.1)	AY017347
Bacillaceae bacterium	2 (5.5)	FM162988

Source: Opara *et al.* (2013)

Table 9: Bacteria in *Iru* and their variation with detection method and stage of fermentation, identified by 16S rRNA gene analysis, after amplification by PCR

Identity	Percentage abundance											
	Fermentation stage											
	Raw seed		Boiled 0hr		24hr		48hr		72hr		Dawadawa	
	C	T	C	T	C	T	C	T	C	T	C	T
Acetobacter pasteurianus	40*	NA	60	NA	10	75*	-	20	-	20	-	37.5
Acinetobacter baumannii	40	-	-	-	-	-	20	-	60	-	50	-
Bacillus algicola	-	-	10	-	-	-	-	-	10	-	-	12.5
Bacillus cereus	-	-	-	-	70	-	40	10	10	-	-	-
Bacillus clausii	-	-	10	-	-	-	-	60	10	80	-	50
Bacillus subtilis	-	-	-	-	10	25	10	-	-	-	-	-
Bacillus thuringiensis	-	-	-	-	10	-	30	-	-	-	-	-
Enterobacter hormaechei	-	-	-	-	-	-	-	-	-	-	28.6	-
Klebsiella oxytoca	-	-	-	-	-	-	-	-	-	-	7.1	-
Lysinibacillus sphaericus	-	-	-	-	-	-	-	-	10	-	7.1	-
Pectobacterium atrosepticum	20	-	-	-	-	-	-	10	-	-	7.1	-
Pseudomonas acephalitica	-	-	20	-	-	-	-	-	-	-	-	-

C = Cultured bacterial community T = Total bacterial community N.A. Not available
Source: Adelekan, (2012)

6.2.3 Bean paste

Another strategy for getting rid of much of the oligosaccharides in beans and making them easy to cook and digest, is to eat them in dishes that exclude the skin. Uzochukwu working with Henshaw and Bello (Henshaw *et al*., 2000), looked at how storage of such a product – cowpea paste, at fridge and freezer temperatures, would affect the sensory attributes of the fried paste (akara) prepared from it. The results showed that cowpea paste can still make good akara after freezer storage. The shelf life could be extended for up to 12 days if the paste is pre-blanced, and for 9 days if the paste is not blanched. This means that bulk production and storage of the paste for retail as a frozen product for akara-making is feasible – may there be electricity to do so.

Recipe for long life?

Everyone is urged to consume health-promoting beans, in any of these and other forms, regularly. Combine them with Sardines, mackerel (fote) or herrings (sabonde), and green vegetables, especially moringer leaves, and exercise regularly, to enjoy a long and healthy life. Green vegetables especially moringa leaves, are needed, because they are packed with antioxidants, which are needed to protect the heart - healthy unsaturated omega 3 fatty acids from the fish.

6.3 Cassava

Cassava is a Nigerian staple food and Nigeria is the largest producer in the world, though most of what is produced is for domestic use. It is our goal in the Department of Food Science and Technology, to help diversify the use of cassava, not only to improve nutrition, but also to increase its economic value to the rural farmers who are its main producers, and increase its foreign exchange earning power for the country. Our Department is now well known for work on, and promotion of, cassava bread through the efforts of the cassava group of Professor Oyewole, Professor Sanni and their team.

6.3.1 Cassava-soy weaning foods

Akinrele, (1966), pioneered research into the use of soyabean protein for the improvement of protein content of ogi (a popular traditional corn-based weaning food). Uzochukwu, working with Babajide (Babajide *et al*., 2001) formulated a weaning food with tapioca, and *abacha* – both cassava products, and soybeans. Weaning foods were prepared using these two cassava products with sprouted soybeans to prepare soy-cassava diets. The soy/cassava weaning food was well digested by rats and used effectively in the body (Table 10), and had no adverse effects on rat organs, (Table 11) The boiled cassava strip (*abacha*) was the cassava product of choice because of its low viscosity (Table 12) without added sprouted sorghum. This weaning food formulation is recommended for

use by rural women who can prepare them at home, or for entrepreneurs to produce at a commercial level.

Table 10: Weight gain in rats fed tapioca-soy, reference and basal diets respectively, through a period of 21 days[a]

Day/ Diet	TAP+SS	TAP + SS + MS	Cerelac	Basal
0	45.73 ± 0.24	47.67 ± 0.03	48.59 ± 0.16	49.44 ± 0.05
3	49.96 ± 0.09	52.96 ± 0.15	54.24 ± 0.32	51.07 ± 0.36
6	54.22 ± 0.22	58.31 ± 0.40	59.90 ± 0.21	52.71 ± 0.13
9	58.49 ± 0.18	64.34 ± 0.07	65.59 ± 0.08	54.35 ± 0.27
12	62.78 ± 0.12	68.44 ± 0.17	71.29 ± 0.44	56.02 ± 0.11
15	67.10 ± 0.33	74.51 ± 0.22	76.94 ± 0.34	57.69 ± 0.27
18	71.43 ± 0.16	79.95 ± 0.17	82.74 ± 0.16	59.38 ± 0.41
21	75.80 ± 0.11	85.42 ± 0.05	88.51 ± 0.33	61.08 ± 0.07

[a]n = 8, Mean ± SEM, TAP = Tapioca, SS = Sprouted soybeans, MS = Malted sorghum. Source: Babajide *et al.* (2001).

Table 11: Dry weight (percentage dry body weight) of various organs from rats fed tapioca-soy weaning food for 21 days, and reference weaning diets[a]

Organ/Diet	TAP + SS	TAP + SS + MS	Cerelac
Small intestine	1.61 ± 0.03	1.74 ± 0.03	1.79 ± 0.03
Pancreas	0.34 ± 0.01	0.37 ± 0.01	0.40 ± 0.01
Liver	3.09 ± 0.03	3.17 ± 0.03	3.26 ± 0.01
Heart	0.82 ± 0.03	0.90 ± 0.02	0.97 ± 0.01

[a]n = 8, Mean ± SEM, TAP = Tapioca, SS = Sprouted tapioca, MS = Malted sorghum. Source: Babajide *et al*., (2001)

Table 12: Amylograph pasting viscosity of processed cassava products, weaning food formulations and a reference commercial weaning food

Samples	Pasting Tempe apture (Tp) oC	Peak visco sity (Vp) B.U.*	Visco sity at 95oC B.U.	Visco sity after 30 mins holding at 95oC (Vr) B.U	Visco sity on cooling to 50oC (Vc) B.U.	Set Back Value (Vc-Vp) B.U.	Gelati nization Index (Vc-Vr) B.U.
Tapioca (TAP)	58	660	425	260	795	135	535
Boiled cassava (BC)	67	60	60	80	178	118	98
Fermented cassava (FC)	75	130	130	120	300	170	180
TAP + SS1	61	118	80	38	100	-18	62
BC + SS	68	10	10	20	40	30	20
FC + SS	78	35	35	38	85	50	47
TAP + SS + MS2	-	0	0	0	0	0	0
BC + SS + MS	-	0	0	0	0	0	0
FC + SS + MS	-	0	0	0	0	0	0
CR3	-	0	0	0	0	0	0

* B.U. Viscosity in Brabender units B.U., [1]SS = Sprouted Soy beans, [2]MS = Malted sorghum [3]CR = Cerelac (commercial weaning food). Source: Babajide *et al*., (2000).

6.3.2 Fu-fu and cassava shelf life

Cassava is commonly consumed in the south of Nigeria as a dough referred to as foo-foo. It is now a convenience food vended ready to eat and hawked in markets and residential areas. We set out to determine its shelf life by sensory evaluation and microbial count. It was found that the commodity would keep for a week at our ambient temperatures (30^{o} C), two weeks under refrigeration (4^{o} C) and a month in the freezer (-18^{o} C) (Uzochukwu *et al*., 2003). The team also sought to estimate the storage life of fresh cassava itself, which has a high rate of spoilage after harvest. Trench storage of cassava was estimated by sensory evaluation of gari and cassava made from the trench-stored product. It was found that cassava can be stored in trenches for up to 10 days and still give acceptable Fu-fu (Table 13), whereas, acceptable gari (Table 14) will not be obtained from trench-stored cassava, after 7 days storage (Uzochukwu *et al*, 2004). The variety of the cassava was found to affect these figures.

Table 13: Mean sensory scores for fu-fu prepared from TMS and MS6 cassava varieties stored in a covered trench in Nigeria

Age (days	Colour TMS	Colour MS6	Taste (TMS)	Taste MS6	Odour TMS	Odour MS6	Mould-ability TMS	Mould-ability MS6
1	8.3	8.3	7.5	8.2	8.0	8.2	7.7	8.0
7	6.5	7.1	6.4	6.8	6.5	6.9	6.6	6.8
14	4.7	4.4	4.3	3.8	4.4	3.6	4.5	3.9
21	3.2	3.3	2.5	3.0	2.8	2.7	3.1	2.9
28	1.8	1.9	1.5	1.9	1.6	1.3	2.0	2.0
35	1.1	1.1	1.4	1.1	1.1	1.2	1.3	1.2
Equation	Y=8.06-0.2145x	Y=8.22-0.2192x	Y=7.39-0.1955x	Y=7.88-0.2119x	Y=7.80-0.2112x	Y=7.85-0.2189x	Y=7.66-0.1963x	Y=7.76-0.2053x
S.E. of b	0.0158	0.0196	0.0239	0.0263	0.0197	0.0329	0.0156	0.0252
Signifi-cance	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Esti-mated storage life (Days)	9.58	10.1	7.09	8.50	8.51	8.45	8.45	8.60

Source: Uzochukwu *et al*. (2004)

Table 14: Mean sensory scores for gari prepared from TMS and MS6 cassava varieties stored in a covered trench in Nigeria

Age (days	Colour TMS	Colour MS6	Taste (TMS)	Taste MS6	Odour TMS	Odour MS6	Mould-ability TMS	Mould-ability MS6
1	7.8	8.0	7.7	7.7	7.8	7.5	8.0	8.0
7	4.9	5.6	6.3	5.0	6.0	5.1	6.5	5.7
14	3.3	2.9	3.8	4.0	3.2	2.9	3.2	3.3
21	2.6	2.2	3.0	2.5	2.1	1.9	3.1	3.2
28	1.2	1.5	1.8	1.3	1.6	1.2	2.1	1.8
35	1.1	1.1	1.5	1.2	1.2	1.1	1.7	1.2
Equa-tion	Y=6.79-0.1873x	Y=7.02-0.1965x	Y=7.34-0.1881x	Y=6.92-0.1868x	Y=7.11-0.1960x	Y=6.55-0.1849x	Y=7.38-0.1857x	Y=7.22-1897x
S.E. of b	0.03239	0.03761	0.0245	0.0274	0.0345	0.0353	0.0548	0.030
Signifi-cance	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Esti-mated storage life (Days)	3.7	5.19	7.12	4.83	5.68	2.97	7.44	7.12

Source: Uzochukwu *et al.,* (2004)

6.3.3 Cassava waste utilization

The cassava processing industry generates a lot of objectionable waste. The gari – processing industry waste is particularly an environmental nuisance. The possibility of converting some of this waste to useful components has been of interest.

6.3.3.1 Orange flavoured gin from cassava processing effluent

Uzochukwu *et al*., (2001c), gelatinized cassava waste effluent

by cooking, hydrolyzed it with commercial amylases, fermented it with palm wine yeasts, and distilled it into a gin, flavoured with dry orange peels in the rectifier. The cyanide content was by this treatment, reduced by 99.9%, to a level safe for human consumption (Table 15).

6.3.3.2 Bioprospecting in cassava waste

An environment such as the *gari* industry effluent, having a high cyanide content, is an extreme environment, and therefore a gold mine of some sort, for environmental microbiologists. Uzochukwu, working with Elijah, Atanda and Popoola (Elijah , 2013), investigated the microbial flora of this toxic environment and their plasmids, with a view to discovering microorganisms and genes of industrial importance.

Table 15: Changes in chemical constituents of gari industry effluent as it is processed to potable spirit

Parameter	Raw effluent	Cooked effluent	Hydrolyzed cooked effluent	Distilled fermented effluent
PH	4.2	4.3	4.3	7.5
Free fatty acids (as % acetic acid	1.52	1.65	0.03	0.01
Hydrogen cyanide (ppm)	9.001	0.037	0.035	0.003
Alcohol (%v/v)	N.D*	N.D.	7.01	50.11
Sugar (%w/v)	3.0	6.2	23.42	5.04
Starch (%w/v)	41.0	37.00	0.00	N.D
Conductivity μS/cm	N.D	N.D	N.D	130
Total Dissolved solids (ppm)	N.D.	N.D	N.D	90

*N.D.: Not Detected.
Source: Uzochukwu *et al*. (2001c)

Using analysis of the 16S ribosomal RNA genes from both isolates and community DNA, and sequencing and analyzing plasmid DNA of isolates, many useful genes were found, and the process of evaluating the gene products is still on. An environment such as this, could turn out to be a gold mine for a conscientious microbiologist. This study was made possible by our use of non-culture molecular methods which dispense with the need to culture organisms before it is possible to

study or exploit them. Table 16 shows clearly, that only a small percentage of microorganisms present in a sample are detected using culture methods. With the community-DNA approach, gene mining can be carried out on a sample, without ever isolating the organisms bearing the genes, by finding genes directly from sequenced community DNA, using tools of bioinformatics. Regarding this kind of studies, our environment has hardly been touched.

Table 16: Comparison of bacteria species identified by total bacteria community and isolates DNA analysis

Organism identity	Location 1				Location 2			
	Cassava peel		Cassava wastewater		Cassava peel		Cassava wastewater	
	Community DNA	Isolate DNA	Community DNA	Isolate DNA	Community DNA	Isolate DNA	Community DNA	Isolate DNA
Bacillus – Bacillales								
Bacillus substilis strain 22	+	+	+	-	+	+	+	-
Bacillus coagulans strain LCR24	+	+	-	-	+	-	-	-
Bacillus pumilus strain PSL-J7-2	+	+	-	-	+	+	+	-
Bacillus licheniformis strain S1	+	+	+	-	+	+	+	-
Bacillus circulans	+	-	-	-	+	+	-	-
Bacillus cereus	+	+	+	+	+	+	-	+
Staphylococcus xylosus	+	+	-	-	+	-	-	-
Staphylococcus aureus	-	-	+	-	-	-	+	-
Bacillus-Lactobacillales								
Lactobacillus plantarum	+	+	+	+	+	+	+	+
Lactobacillus fermentum	+	-	+	+	+	+	+	+
Lactobacillus pentosus	+	-	+	+	-	-	+	-
Lactobacillus manihotivorans	+	-	-	-	+	-	+	-
Lactobacillus delbrueckii	-	-	+	+	-	+	-	+
Lactobacillus brevis	+	+	+	-	+	-	-	+
Lactobacillus perolens	-	-	-	+	-	-	+	-
Lactobacillus sanfrancisco	-	-	+	-	-	-	+	-
Lactobacillus crispatus	-	-	+	-	-	-	+	-
Leuconostoc mesenteroides	+	+	+	+	+	+	+	+
Leuconostoc citreum	-	-	-	-	-	-	+	-
Leuconostoc cremoris	+	-	+	-	-	+	+	+
Leuconostoc lactic	-	-	+	-	-	-	+	-
Leuconostoc fallax	-	-	+	+	+	-	-	+
Pediococcus pentosaceus	+	-	+	-	-	+	-	+
Enterococcus faecalis	+	-	-	-	+	+	-	-
Enterococcus saccharolyticus	+	+	-	-	-	-	-	-
Gamma proteobacteria								
Pantoea agglomerans	+	-	+	-	-	-	-	-
Enterobacter aerogenes	+	-	-	-	+	-	-	-
Propionibacterium theonii	-	-	+	-	-	-	-	-
Azotobacter vinelandii	+	+	-	-	+	+	-	-
Acinetobacteria Actinomycetales								
Corynebacterium glutamicum	+	+	+	-	+	-	-	-
Beta proteobacteria								
Alcaligenes faecalis	-	-	+	-	-	-	+	-
Uncultured bacteria								
Uncultured bacterium clone ncd1462c07c1	-	-	+	-	+	-	-	-

+, detected; -, not detected
Source: Elijah, (2013)

I hereby urge students and scientists in the microbiology and related fields in the country, to embrace the new molecular methods in their research, because there is so much waiting to be discovered in our environment. Let us explore our environment (which includes our foods), using available cutting edge technology and discover what is there, before people from outside come and do so. Happily, the idea of employing advances in molecular biology in our research work, is catching on in FUNAAB, and spreading to all who come in contact with us. Some putative genes found on plasmids of bacteria isolated from cassava waste water are shown in Table 17.

6.4 Improvising molecular biology consumables

As we now employ modern molecular biology techniques in our research, we realize how expensive the consumables we use are, and we wonder if we cannot produce some of these ourselves here. Agarose is one of the basic but expensive reagents we require for our work. We therefore investigated some of our local gums as alternatives to agarose. Ideally, such an alternative must be neutral, in order not to interact with the massive negative charge on DNA, occasioned by the phosphate groups. So far, non of the food gums investigated have yielded a stable gel for DNA separation (Abdulsalaam, 2006). The search continues.

6.5 Biosafety Research

6.5.1 Evaluation of application for Field Trial of high carotene cassava and Bt. cowpea

In everything, safety is paramount. A lot of the food we eat are assumed to be safe because we have eaten them over the years without harm. Such foods are often refered to as Generally Regarded As Safe (GRAS) in food science parlance. For genetically engineered (GE) foods however, very stringent field and laboratory tests, are mandatorily carried out before the food can be released for general use. This is why it can take up to 8 to 10 years for a GE food to reach the consumer. As a member of the National Biosafety Committee (NBC), (2002—2010), I was priviledged to chair the sub-Committee which evaluated the safety dossier for Nigeria's first GM crop field trial – the high carotene cassava, and recommended its approval for trial to the NBC; as well as the second, the Bt cowpea (insect resistant cow pea). Both products have been in field trial for 3 – 4 years now.

Table 17: Putative genes and their products, deduced from nucleotide sequences of plasmids in some bacteria isolated from cassava waste water

Source	Gene name	ORF position (range)	Length (aa)	Best hit (Organism, Genbank accession number)	% identity	E-value	Proposed gene product identity
Lactobacillus plantarum	TanLpl	1 - 303	100	tannase (Lactobacillus plantarum, BAG68453.1)	95	$3e^{-38}$	Tannase
		1412-1612	66	Conserved hypothetical protein (Lactobacillus hilgardii ATCC 8290, ZP_03954203.1)	100	$3e^{-25}$	Hypothetical protein
Bacillus coagulans	bgl1E	1 - 249	82	beta-glucosidase (uncultured bacterium, ACM91556.1|)	89	$1e^{-36}$	Beta-glucosidase
	RepA	473 – 775	100	Replication protein (Lactobacillus plantarum, YP_002117539.1)	95	$2e^{-58}$	Replication protein
Lactobacillus brevis	HNL	26 - 850	274	(S)-hydroxynitrile lyase (Manihot esculenta, P52705.3)	99	0.0	Hydroxynitrile lyase
	abp118a	1005 – 1364	108	Abp118 bacteriocin alpha peptide (Lactobacillus salivarius UCC118, YP _536804.1)	100	$1e^{-35}$	Bacteriocin alpha peptide
Lactobacillus fermentum	HNL	77-922	281	A Chain A, Crystal Structure Of Hydroxynitrile Lyase From Manihot Esculenta In Complex With Substrates Acetone And Chloroacetone, 1DWO	100	0.0	Hydroxynitrile lyase
	Ptr	1157-1497	114	DNA-binding protein Ptr (Bacillus subtilis, NP_049444.1)	100	$4e^{-78}$	DNA-binding protein Ptr

Source: Elijah, (2013).

6.5.2 Survey on status of biotechnology and biosafety in sub-Saharan Africa

I was also priviledged to be involved in a study by the Biosafety Unit of the International Centre for Genetic Engineering and Biotechnology (ICGEB) in both Italy and South Africa, on the status of biosafety in sub-Saharan Africa (SSA). The study was an assessment of the current biosafety needs in SSA. It identified gaps in biosafety knowledge and expertise in the region and made proposals for appropriate interventions. The lack of biosafety information necessary for risk assessment to guide approval of GE food was one of the major gaps identified in the study. Table 18 shows some of the biosafety information which different SSA countries considered lacking for biosafety regulatory purposes in their countries. The study also found that Eastern and Southern Africa, appear to be ahead of, and to be more proactive than West Africa in adopting genetically modified foods, and in approving biosafety laws which will make it possible to grow and trade in, the products. These areas trade freely with South Africa who is a GM crop producer, and so are all already GMO consumers. We continue to pray that the Nigerian biosafety law which was passed by Senate, will soon receive presidential assent and be signed into law, so that other African countries do not leave Nigeria behind in the war against hunger and poverty. By international agreement, we cannot buy or sell or acquire GM foods without a biosafety law.

Table 18: Biosafety information identified as lacking by various countries in SSA

Specified information gaps	Countries (number of countries)
Effect on non-target organisms	GHA, KEN, Sierra Leone (SLE), ZAF, Sudan (SDN), UGA, Zambia (ZMB) (7)
Baseline agronomic data for major African crops	Burundi (BDI), ETH, KEN, NGA, ZAF, TZA (6)
Food safety data (allergenicity and toxicity)	GHA, KEN, MOZ, NGA, TZA, ZWE (6)
Gene flow parameter data	GHA, KEN, NGA, SLE, SDN, ZWE (6)
Molecular characterization data	Central African Republic (CAF), KEN, MOZ, TZA, UGA, ZWE (6)
Status and current spatial distribution of existing genetic diversity	ETH, KEN, Rwanda (RWA), SEN, SDN, ZWE (6)
Data on, and protocols for, the identification/detection/tracing of GMOs and products	CMR, Guinea Bissau (GNB), KEN, Madagascar (MDG), SEN (5)
Agricultural impact	Botswana (BWA)
Environmental impact (especially from previous African evaluations)	GHA, SEN, ZMB (3)
Pest resistance to GM crops	KEN, SLE, UGA (3)
Mitigation measures	MOZ (1)
Precise land use / land cover data	BFA (1)
Risk / benefit analysis	KEN (1)
Socio-cultural considerations	NGA (1)

NGA=Nigeria, KEN=Kenya, BFA=Burkina Faso, MOZ=Mozambique, UGA=Uganda, GHA=Ghana, SEN=Senegal, ZMB=Zambia, CMR=Cameroon, ZWE=Zimbabwe, SDN=Sudan, ETH=Ethiopia, TZA=Tanzania, ZAF=South Africa. Source: Obonyo *et al.* (2011)

6.6 Capacity Building

6.6.1 Capacity Building in Biotechnology

I spent the period 1999 – 2011 in capacity-building activities in biotechnology in Nigeria, and to a lesser extent in sub-Saharan Africa. My friends and colleagues have heard many times, how the UNAAB Summer Courses in Biotechnology resulted from my realization of the high level of my ignorance in the face of the new molecular techniques that form the basis of modern biotechnology. It was in my efforts to get rid of my ignorance by trying to go abroad to learn the new techniques, that the idea of organizing training courses in Nigeria in the subject matter, to re-train trainers like myself, was suggested by my friend Dr. Joan Campbell-Tofte, in 1999, and we started working on it. What we thought would be a one-off thing, became an annual or biannual event, and brought national and international fame and recognition to FUNAAB. The training courses led to the establishment of a Biotechnology Centre, and to the erection of a beautiful and befitting Biotechnology Centre building. Between 2000 and 2009, together with other collaborators and the FUNAAB team we had assembled, we organized 14 training courses, as well as seminars and symposia. About 500 Nigerian researchers and university lecturers were trained, as well as 30 final year undergraduates for whom a special course was organized.

The training courses of the UNAAB Biotechnology Centre,

were carried out as a service to the nation in building up core competence in molecular biology to jump-start the integration of Nigerian scientists and Nigeria, into the biotechnology whirlwind.

The very successful model curriculum and format developed from these training courses, has been presented at international conferences and have been adopted by other institutions all over Nigeria, and by other developing countries for building capacity in biotechnology and biosafety.

The training courses were designed to pay for themselves, but not to be used for revenue generation. As much as possible, we sourced grants to pay for the training courses, and when fees had to be charged, they were minimized to just enough to cover costs. I still do not believe capacity building efforts in Nigeria for biotechnology should be used to make money. When money-making becomes the priority beyond covering costs, the most important group of people – the post graduate students, (who are always broke), and the young Ph.D. holders, would be unable to afford to attend, and they are the ones who need it most. These young people are the ones who drive research and innovation everywhere in the world.

The Biotechnology Centre which resulted from these biotechnology capacity-building activities, is one of the foot prints it

has pleased God to make it possible for me to leave in FUNAAB.

6.6.2 Capacity Building in Biosafety

I was also involved in capacity-building in biosafety under the Bill and Melinda Gates ICGEB Biosafety Project for sub-Saharan Africa. We organized Biosafety Risk Assessment training courses for African Biotechnology Regulators in Hermanus, South Africa; Nairobi, Kenya; and Accra, Ghana, all in 2010. About 100 regulators were trained on how to evaluate applications for field trial of genetically modified crops, and on risk assessment of application dossiers for general release of genetically modified crops.

7.0 EXTENSION

The mandate of the university is tri podal: Teaching, Research and Extension. How have I carried out extension as a food specialist?

7.1 Palm wine factory

UNAAB held a fair in 1998 as part of the celebrations for her 10th anniversary. I exhibited bottled palm wine, having learnt the procedure from my first employer, NIFOR, Benin, and having carried out my post graduate research on palm wine. University Management became interested in it and mandated me to continue production. I began to produce

what I called UNAAB palm wine, in my kitchen, for 8 years, before I was finally given approval to establish a factory for the University, at the University farms. Apart from its commercial value, the factory now serves as a training centre for rural people who may want to acquire the bottling technology, and as a practice factory for students of Food Science and Technology. The factory is another foot print which God has made it possible for me to leave on the soil of FUNAAB. Long live FUNAAB palm wine, Long live FUNAAB.

8.0 SOME RECOMMENDATIONS

8.1 For the leaders of our great country Nigeria

8.1.1 Human Capacity building in Universities and Research Institutes

The tenacious capacity building policy that used to sponsor graduate assistants and trainee researchers for post graduate work to doctoral level, in universities and research institutes, should be returned to the system and pursued vigorously, if the country is not to be left behind by the rest of the world in science and technology.

8.1.2 Human and infrastructural capacity in agricultural biotechnology needs to be urgently built up

Massive funding of science and technology R&D, especially agricultural biotechnology R&D, is vital, in order to build

core competence in agricultural biotechnology, so that Nigeria will not be a hungry, beggar nation in 20 years' time.

8.1.3 National examination for post graduate work

The Unified Tertiary Matriculation Examination (UTME) is an excellent concept and it would be a mistake to scrap it. Rather, we should have a post graduate version of it similar to the GRE of the United States of America. After such an examination, accepted doctoral students should be paid a stipend for 4 years. They are the foot soldiers of research, everywhere.

8.2 For our Universities

8.2.1 Agricultural students should be practically taught mechanized farming

Students of agriculture, should be taught modern mechanized agriculture with scientific and technological inputs. Knife and hoe farming cannot feed any nation today.

8.3 For Vice Chancellors, the leaders of Universities in Nigeria

8.3.1 Grants and grant management

All great universities are built on research grants. FUNAAB is already being counted, and shall continue to be counted among their numbers. For the growth and progress of our universities and for peaceful co-existence within the academic

community, the procedure for managing research grants, should be well spelt out in each university, and the document widely disseminated among researchers. This will help ensure that researchers' grants are not usurped, and squandered, by Grant Administrators and Procurement Officers, with resultant frustration of researchers.

8.3.2 Research projects and proposals, and intellectual property

An idea is an intellectual property, and can be patented. A research proposal is a cascade of ideas. Thus a research project conceived, developed and articulated into a research proposal, is the intellectual property of the researcher who conceived and developed it. Whether the project wins a grant or not, it is like a publication, the author cannot be changed, even if the person no longer lives. Nigerian universities need to pay greater attention to the concept of intellectual property, as is now required by international best practices. Research projects though undertaken for the university, remain the intellectual properties of the researcher/s who conceived and developed them.

8.4 For Postgraduate students

Sometimes the research life can be a lonely one. So, postgraduate students, I have one advice for you: marry yourselves, so you can keep each other company. If you are em-

barking on an important journey, it is wise to take a travel companion who is heading the same way.

9.0 ACKNOWLEDGEMENTS

9.1 Almighty God

I am most grateful to Almighty God, the father of the orphan, the husband of the widow, the everlasting rock of ages, for His grace, which has made it possible for me to give this Inaugural Lecture. I thank Jesus Christ in the Blessed Sacrament, my wonder-worker, my friend and confidant, for always being there for me. I am grateful to the Holy Spirit, the Spirit of Life, the comforter of the afflicted, who proceeds from the Father and the Son, for sustaining me. I thank the Most Blessed Virgin Mary, Mother Most pure, Mother Most Chaste, Mother most inviolate, the Queen of heaven, whose prayers and intercessions have won for me, uncountable favours.

9.2 My loving father

I am grateful to my loving father Barrister James B. C. Mmegwa - Iduu Dara Nnabuenyi, who made all this possible by giving me education. He rushed back from Britain to take us from his parents in the village at Ihiala, to Lagos in 1964. He could have stayed back to continue enjoying the luxuries of the white man's land, but he returned to care for us, with excruciating school runs, involving morning and afternoon sessions for different children. I was the one on afternoon ses-

sion, the one who complicated his life most. All through my education, he has been my greatest fan, always cheering me on. My joy is that God has been so kind as to keep him long for us, such that now, he fully appreciates just how much we love and appreciate him. May God continue to grant him health of mind and body, to continue to enjoy life. I am grateful to my father for teaching me the value of honesty, by example. He taught me that the problems that dishonest people can create for others, are nothing, compared to the problems they eventually create for themselves. May God continue to shower him with immeasurable blessings.

9.3 FUNAAB Authorities

I am grateful to the Vice Chancellor Professor Olusola Oyewole and his Management Team, for making it possible for me to give this lecture, and for the work they have been doing looking after us all. I thank all the past Vice Chancellors: Prof. Nurudeen Adedipe, Prof. Julius Okojie, Prof. Israel Adu, Prof. Isola Adamson, and Professor Olaiya Balogun. I was priviledged to serve them all as Acting Director or Director of the Biotechnology Centre, except Prof. Adedipe, who employed me. I thank them all for the opportunities they gave me to be of some service to this great University.

I thank my Dean, Professor Folake Henshaw, and the entire College Board of the College of Food Science and Human

Ecology (COLFHEC), the administrative and technical staff, the cleaners and security personnel, for their support and their love. I am grateful to God for making me part of the history of COLFHEC. I can say, it is also one of the foot-prints God has made it possible for me to leave in FUNAAB.

In the same way I thank my academic nuclear family in FU-NAAB, the Department of Food Science and Technology, ably headed by Prof. Lateef Sanni, for their love , care, friend-ship, warmth, and ever-present support. It has been a delight working with you these many years.

We used to be in the College of Agricultural Management, Rural Development and Consumer Studies (COLAMRUCS). I thank all our Colleagues there with whom we fraternized for so many years, and where I served as Deputy Dean. I thank specially, the former Dean of that College Professor Bola Okuneye, who was my boss, and has remained my Mentor ever since.

9.4 NIFOR my first employer

I remain indebted to my first employer, the Nigerian Institute for Oil Palm Research (NIFOR), Benin, who employed me after my youth service in 1980, and sponsored my graduate studies on a full salary till I got a Ph.D. in 1987. The invest-ment the Federal Government made in my life through

NIFOR, including paying for my trip abroad to analyze my samples, is the reason I am a chronic patriot today.

9.5 My supervisors for Masters and Doctoral studies

I thank specially today, Professor Patrick Ngoddy who supervised my Masters and Ph.D. research and has remained my Academic Father and Mentor. I am grateful to him and all the staff of the Department of Food Science and Technology of the University of Nigeria, Nsukka, for making me what I am today, and for continuing to support me till this moment. I am grateful also to my second supervisor Professor Esther Balogh who was of the Department of Food Science and Technology, of the University of Ife, now Obafemi Awolowo University (OAU). I am grateful to her and to that Department, for the very supportive and accommodating role they played in my post graduate studies, at the instance of Prof. Ngoddy who used to be one of them. Unfortunately, I cannot call on Prof. Balogh today to take a bow, because after preparing her own Inaugural Lecture in 2000, she took ill and died, and could not present it. I dedicate this lecture to her memory. Please indulge me today, by rising for one minute's silence in her honour... I thank also post humously, her late husband Professor Zoltan Bozomenyi who always took his wife's students also as his students. He taught me a lot of the biochemistry I use for teaching my students today.

9.6 My benefactors for analytical facilities

I am grateful to Dr Anthony Williams and Dr. Owen Tucknott of the Food Research Institute, Reading, United Kingdom (U.K.), who provided the facilities for my GC-MS and NMR studies during my doctoral work, at no charge, both at the Food Research Institute, Long Ashton, Bristol, and the Food Research Institute, Norwich, both in the U.K., and made the successful completion of my Ph.D. possible.

9.7 My First Degree Department and my secondary schools

I thank my lecturers at the Department of Plant Biotechnology (then Department of Botany), of the University of Nigeria, Nsukka, for my basic degree, especially my academic adviser Professor Maduewesi, and my Project Supervisor, Dr. Vivian Okonkwo. I will not forget my secondary school teachers at Queen's School Enugu, who moulded me into a passable human being. I learnt virtually every basic thing I know today from that most wonderful of schools. I am grateful also to my teachers at Federal Government College Enugu, where I went for the Higher School Certificate course, as well as my teachers at Mary Wood Primary School Ebute Metta, Lagos, and Ndiezike Primary School Ihiala, Anambara State.

9.8 My collaborators

I must use this opportunity to thank specially the great patri-

ots who worked with me for biotechnology in FUNAAB. I thank Dr. Joan Campbell-Tofte, the originator of the FUNAAB Summer Courses in Biotechnology – the basic molecular biology short courses for which FUNAAB has come to be so well known, and which gave birth to the FUNAAB Biotechnology Centre. She was joined later by Dr. Alexander Ochem of the International Centre for Genetic Engineering and Biotechnolgy (ICGEB), Italy and Dr. Nwadiuto Esiobu of Florida Atlantic University, Davie, Florida, USA. They sourced grants, bought equipment, taught the courses for FUNAAB, and helped to supervise and mentor our post graduate students. Sometimes they provided research facilities and consumables in their home laboratories, for our graduate students who want to use molecular tools, all at no charge. They are three great patriotic Nigerians in the Diaspora, who put in so much for capacity building in Biotechnology in Nigeria, through FUNAAB. I thank Dr. Campbell-Tofte's husband, Dr. Mads Tofte, Vice Chancellor of the IT University of Denmark, who developed the first website for the FUNAAB Summer course series and managed it free of charge, for many years. I thank the Biotechnology Deveoplment Agency (NABDA) who introduced Dr. Esiobu and Dr. Ochem to me, for purposes of assisting with our biotechnology activities in FUNAAB, especially the Director-General Prof. Bandele Solomon, and the NABDA Biosafety Director, Dr. Christy Onyia.

I am grateful to the following organizations from whom the three patriots mentioned above, and myself, received grants for the FUNAAB Summer Courses in Biotechnology and for equipping the Biotechnology Centre, when I was in charge of the Centre: The Plasmid Foundation of Denmark, the Society for General Microbiology (SGM), U.K., the United States Agency for International Development (USAID) through the National Agricultural Research Project (NARP), the American Society for Microbiology (ASM), the Academy of Sciences for the Developing World (TWAS), the International Centre for Genetic Engineering and Biotechnology (ICGEB), and the Science and Technology Education – Post Basic program of the World Bank. I also thank, the International Institute for Tropical Agriculture and its plant biotechnology scientists – Dr. Paul Keese, Dr. Ivan Inglebrecht, Dr. Machuka and many others, who responded positively each time I called, for their strong role in helping the FUNAAB Summer Courses to survive, and for helping us in developing the Biotechnology Centre of FUNAAB. I thank our own FUNAAB colleagues who were guest lecturers for the courses especially Prof. Steve Afolami and Prof. Adetiloye. I am grateful to the College of Animal Science and Livestock Production (COLANIM) who graciously housed the Courses and the Centre for the first few years, and Prof. Segun Osinowo whose laboratory we used for the first few courses. I thank the Agricultural Media Resources

Centre (AMREC) who also accommodated the courses and the Centre for some years, especially its Directors at different points at the time, Prof. Omotayo and Prof. Salako, respectively.

I acknowledge with gratitude, the former Biotechnology Group of UNAAB, led by Prof. Isola Adamson, under whose auspices we organized the first two training courses in biotechnology. They forfeited their year 2000 grant of N100,000, to support the first course. Prof. Adamson later became the first Director of the Biotechnology Centre, and my Boss as Associate Director. A man of great vision, Prof. Adamson saw the great potentials of the workshops when I didn't, and encouraged me. I thank him most sincerely for his foresight, sincerity, and support, as well as his many pieces of advice which I continue to treasure.

I thank the Associate Scientists of the Biotechnology Centre, whom I drew from all the life-science Colleges, to work with me: Prof. Mobolaji Olufunmilayo Bankole, Dr. Yinka Edema, Dr. Iyabo Kehinde, Dr. Akin Popoola, Dr. Emily Ayo-John, Dr. Emmanuel Idehen, Dr. Martha Bemji, Dr. Tumi Adebambo, Dr. Toyin Opeolu, Dr. Andrew Agbon, Dr. Olusegun Atanda, Dr. Gbenga Akintokun, Mr. Lere Oyewunmi; the ever hard working staff - Mr Ibiwunmi Oloye, Mr. Aliu, Mr. Ganiu Adekunle, Mrs Obembe, Mrs. Florence Alabi, Miss Bukola

Adeyemi (now Mrs. Seriki) and Miss Sola Shoyemi. You were a self-sacrificing, industrious but joyous lot. The Lord himself shall reward you all. My love for you will live with me forever. I thank also, our senior adviser, Prof. Olufunmilayo Adebambo. I am grateful to the Alumni of the FUNAAB Summer courses in Biotechnology for their kind words and thoughts towards us. They have continued to keep in touch, and are very highly appreciated.

I am grateful to the Agricultural Research Council of Nigeria (ARCN), for a grant, which was meant to build modern biosafety capacity in my department, Department of Food Science and Technology. I thank the ASM, for an International Educator Award, in 2009, and the ICGEB for a 1-year Biosafety Fellowship in 2010.

I thank all other groups I have worked with in the university especially, those with whom I worked in the Ceremonials Committee of the University for 9 years. We all became special friends to each other, and so shall it always remain. I thank the present CERECOM for all the hard work they have put in, to organize this Inaugural Lecture, and the Publications Committee for their painstaking review, editorial comments and suggestions and final publication of the manuscript.

9.9 My Students

I thank my students at all levels. You are the ones who make it all worth it. I thank specially, my graduate students for their diligence, their resilience, and emotional support. Please bear with me, on recent trends in our lives. If we build but remain homeless, and we sow and others gather the harvest, it is because that is the will of God. Give Him thanks in all situations, and He Himself will organize your own harvests.

9.10 My Church

I am sustained in my life by the support and prayers of the Catholic Church. I therefore specially thank the Priests and Parishioners of St Anne Catholic Parish, Ibara, Abeokuta, past and present, for their prayers, emotional support and stabilizing influence over the years. I thank other priests, pastors, and lay faithful everywhere who have positively impacted on my life. May God continue to bless you all.

9.11 My sisters and co-wives in IWA

The Imo Welfare Association (IWA) (Women's wing), Abeokuta, is another stabilizing group in my life, whose comradeship I have enjoyed over the years. I am grateful to them for their love, friendship and support, and for their confidence in me. I thank also, the men's wing, our husbands, for their ever present support and love.

9.12 My friends, Colleagues and Associates

I thank my friends and colleagues everywhere, far too numerous to mention by name, who have made my life so far an enjoyable experience, those who were able to make it here and those who could not. May God bless you all. I am grateful to all who were able to come here today, for the sacrifice they made to make it possible. May the angels of God lead everyone safely home.

My different Families

I appreciate the Mmegwa family, especially my brother Mr. Chukwugozie Mmegwa – Dara Akunwafor, and my sister Mrs. Patricia Mmegwa-Secke for their long-standing and long suffering love for me. I thank our brothers Mr. Chukwueloka Mmegwa and Mr. Ntomchukwu Mmegwa, and our sister Mrs Milliecent Ohaechesi, and all the members of my father's family, the Mmegwa and Ebegworo families, of Ihiala, Anambara State for their love and care all my life. May God bless you all.

I thank my late mother, Mrs. Esther Ifeatu Mmegwa (a.k.a "Miss Nigeria")and my mother's family, the Okechukwu family of Enugwu-Ukwu, Anambara State, for their ever-faithful love. I want them to know I love them too.

I am grateful to all members of the Uzochukwu family of Nkwere, Imo State, for their support, their love and their care,

over the years. May God continue to bless them. I thank especially, the tall, dark and handsome member, who brought me to the family, Engr. Ikechukwu Benjamin Uzochukwu.

God blessed us with two angels to keep me company in this world. The first is Chukwumaobim (God knows my heart), who my grandfather named Ihekibie (the thing that is greater than other things) – an allusion to his contention that at last, after all the big big degrees, I have brought the most important thing – a child. By the time the second angel arrived two years later, my grandfather had joined his ancestors, so there was no funny name for her. We called her Oluchukwu (the handwork of God) – an allusion again, this time to the fact that, were it not for the grace of God, both herself and myself, would have joined my grandfather, in the great beyond, when she was born. The two angels have been my joy, my life, and my sustenance.

I thank other members of my household who have also been my children over the years, for the countless joys they brought to my home at different times and for coping with me at all times – Mary-Ann Mmegwa, Judith Onuoha, Christopher (Mazi) Mmegwa, Osagie Ighodaro, Sonia Ogbonna, Chude Chike-Obi, Sunday Mmegwa, and many others.

10.0 CONCLUSION

Mr. Vice-Chancellor Sir, Ladies and Gentlemen, in my 21 years of service to FUNAAB, God blessed me with many things, especially three things: The Palm wine bottling factory, The Biotechnology Centre, and the College of Food Science and Human Ecology. They are, by the grace of God, apart from my students, my most enduring achievements in FUNAAB. May His name be glorified for ever and ever, Amen.

Mr. Vice-Chancellor, Sir, We have all worked to build FUNAAB, and indeed, it is a beauty to behold. It is now time for some of us to move on, to help in building other places. Following the footsteps of my supervisors and mentors, I humbly, most respectfully offer this account of my academic journey so far, with a **Subject Prize for the Best Undergraduate Student in Food Biotechnology, in the Department of Food Science and Technology**, of our great University. To God be the glory.

Ladies and Gentlemen, I thank you all for leaving everything you had to do today, to honour FUNAAB's invitation to come here to listen to one of her Professors. Thank you, for your patience and for listening. May God shower His blessings upon you. Please let us raise our voices together to plead for the showers of Blessings.

There shall be showers of blessings
This is the promise of love
There shall be seasons refreshing
Sent from the Saviour above
Showers of Blessings
Showers of Blessings we need
Mercy drops round us we see
But for the showers we plead.

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