The Powers At The Roots: Food And Its Microbial Allies

By

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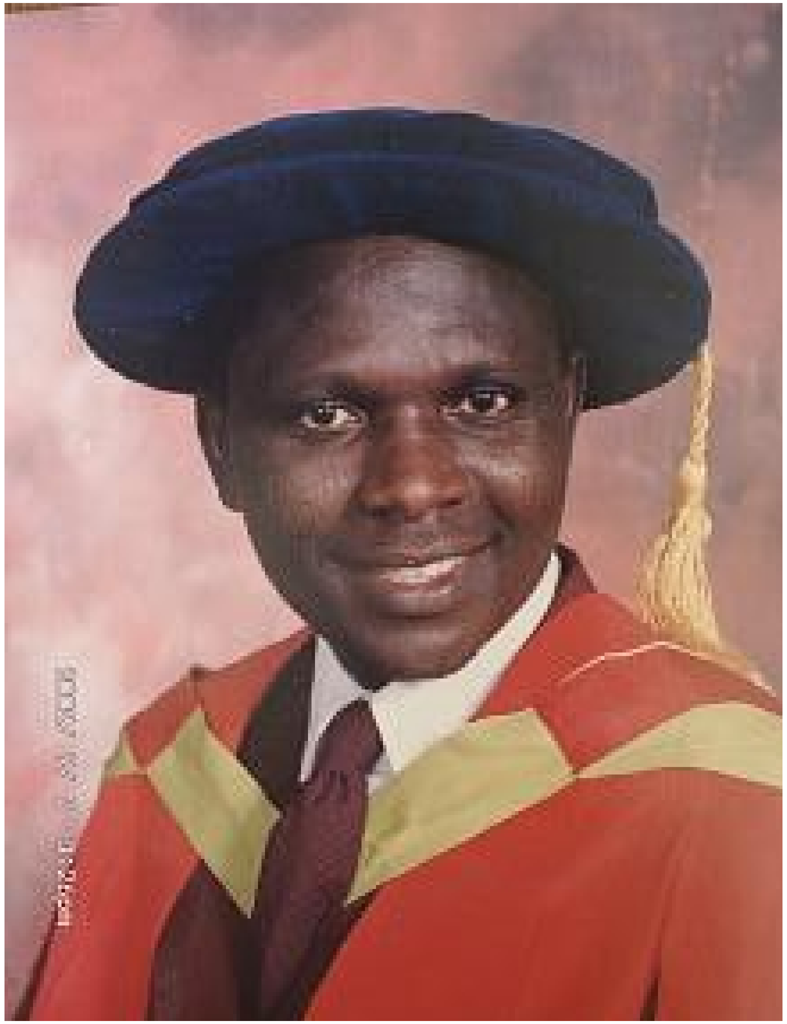

Professor Olusola B. Oyewole

Olusola Bandele, Oyewole

Olusola Bandele Oyewole is a Professor of Food Science and Technology (Microbiology and Biotechnology) at the University of Agriculture, Abeokuta. Nigeria.

Olusola Oyewole started his educational career in Lagos where he attended the Lagos Street African Church Primary School, Ebute Metta. Between 1969 and 1973, he attended Odo Otin Grammar School at Okuku via Osogbo for his secondary education. He spent a one year stint at the Federal School of Science, Victoria Island in Lagos before proceeding for his University education. He studied General Microbiology at the University of Ife (Now, Obafemi Awolowo University), Ile Ife, Nigeria from 1977 to 1981. He furthered his studies into the area of Food Microbiology for his M.Sc and Ph.D programmes at the University of Ibadan, Ibadan, Nigeria. His M.Sc and Ph.D research works were carried out under the supervision of Professor Sunday Ayo Odunfa. His thesis on the Microbiological fermentation of Cassava for 'lafun' and 'fufu' production was defended in 1990.

Oyewole started his lecturing career as an Assistant Lecturer (Food Technology and Microbiology) at the then University of Lagos, Abeokuta Campus on May 23, 1985. He has progressed along the line with his research and teaching career becoming a Senior lecturer in 1993. He was promoted to the position of Professor of Food Science and Technology(Food Microbiology and Biotechnology) on October 01, 2001.

Professor Oyewole has focussed his research work on the science and technology of cassava processing and products. In 1986, the International Foundation for science (IFS), Sweden awarded him a research grant to carry out some studies on cassava fermentation. This grant has attracted other funds into his work to make him an international expert in Food Microbiology and Biotechnology. He has studied the fermentation of cassava, Locust bean and Soya bean. One of the major goals of his research work was to reduce the tedium involved in the fermentation of cassava. He has studied the optimum conditions for good quality fermented

cassava products. The new processing techniques that emanated from his work is now being promoted among local processors of 'lafun' and 'fufu' in Nigeria. When Oyewole started his work on cassava in 1986, 'fufu' and 'lafun' were local household localised names. Today, through his research work, fufu is now an export commodity in Nigeria. Following the success of his first IFS supported research, his work on 'fufu' has been able to attract other supports in Nigeria and overseas.He is currently collaborating with scientists outside Nigeria on the commercialization of 'fufu'. The goal of this furthered work, which also involves economists, social scientists and extensionist agents, is to empower local 'fufu' processors to industrialize the processing of the product.

Professor Oyewole has won some International awards for his research efforts. In December, 1992, Oyewole won the IFS / King Baudouin Award for report of exceptional merit among IFS funded researches. In 1999, at the termination of his IFS project, Oyewole also won the IFS / Danida Award which was given to honour researchers from Sub-Saharan Africa who have made noteworthy achievements clearly associated with research work supported fully or in part by the International Foundation for Science.

Today, Professor Oyewole is a scientific adviser to the International Foundation of Science, Sweden. His cassava processing group has also attracted research supports from the United Kingdom Department for International Development (DFID) and the European Union. Professor Oyewole has had the honour of chairing a World Health Organisation meeting on Fermentation Technology which was held in Pretoria, South Africa in 1995. He has attended many international Conferences and has made scientific presentations in Sweden, South Korea, South Africa, Ghana, Burkina Faso, Senegal, Tanzania, Brazil, Morocco among others.

Professor Oyewole is a man of many parts. Apart from his academic activities, he is also highly involved in Christian ministerial works. He is a Pastor and the Regional Overseer of the Mountain of Fire and Miracles Ministries in Ogun State. Professor Oyewole is married to Bolanle Oyewole and they both have four children.

THE POWERS AT THE ROOTS: FOOD AND ITS MICROBIAL ALLIES

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Prologue:

Seventeen years ago when I was assuming duty as an Assistant Lecturer, in the then Department of Food Technology, University of Lagos, Abeokuta Campus, which became the University of Agriculture, Abeokuta in 1988, little did I realise that I will be the first Professor of Food Science and Technology in the Department of Food Science and Technology to present an inaugural lecture. Today, I know why this is so. It is because at the root of my life is the Almighty God. The power of the Almighty God is the greatest power that you can have at the root. Before, I continue with this lecture, I therefore want to appreciate the faithfulness of the Almighty God, who is the power at the root of my Life.

CHAPTER ONE

INTRODUCTION:

1.1 The Root:

The word: 'ROOT' connotes different things to different people. The common 'root' is usually connected with a plant, The root of a plant is that part of the plant axis that is typically found beneath the surface of the soil, where its primary function is to help in absorbing water and nutrients from the soil into the plant. In many cases the roots serve as the structures that help to anchor the standing plant to the ground or when aerial, projecting above the ground into the air or into the trunks of other plants and decaying materials where it helps in obtaining some essential nutrients for the growth of the plant. Without the root, many plants will not survive because it is the root that helps in conducting nutrients to other parts of the plant as well as helping in storing required nutrients for the plant. To the plant, the root therefore is a 'power house'.

Outside the plant, the human life too has 'roots'. The root of a human being is his or her foundation or the quality of the early parts of the persons life. Many lives had been destroyed at the root because of the powers that reside there.

Inanimate things also possess 'roots'. The 'root' of a thing is the beginning of that thing. The designs and preparations that are necessary before things are constructed constitute the roots of such things. Buildings have roots. They are composed in the blocks buried in the ground as the foundation of the building. While the foundation of many building remains hidden after the completion of the building, the strength of the building however depends on its foundation which is its 'root'.

Problems and life's challenges have 'roots'. Situations such as poverty, underdevelopment, sickness and food insecurity have roots. The best solution to these challenges of life is to go to the Roots.

There is however a group of 'ROOTS' that is important to many Africans. These roots have helped to sustain many lives in situations of droughts, poor soils, wars and famine. These 'roots' are natural plant materials which serve as food to man and animals. These ROOTS had served as security crop in many parts of the developing world and future development of these ROOTS have been recognized as a key to sustainability in the African continent.

It is my intention to use the opportunity of this inaugural lecture to share our efforts and experiences in working with African roots and tuber crops and to discuss the roles of some microorgansms ('microbial powers') in food production.

1.2 Root And Tubers Crops:

Root and tuber crops constitute the major food crops consumed in Africa. It is estimated that root and tuber crops are responsible for meeting the dietary energy needs of about 700 million people. The major root and tuber crops in Africa include Cassava (*Manihot esculenta* Crantz), Yam (*Dioscorea* spp.), Sweet Potato (*Ipomea batatas* (L.) Lam.

These root and tuber crops have survived in Africa because of their agronomical advantages and their low input requirements for cultivation. Cassava, which is an important root crop of Africa is known to survive in poor soils, with a high yield of carbohydrates and has good resistance to pest infestations, diseases and drought. Table 1 shows that African countries are the leading world producers of cassava and yam.

Table 1: African and World Production of some major root and tuber crops (Mt)

	Total African Production	Total World Production
Cassava	92,119,233	168,054,531
Yam	35,467,255	36,939,489
Sweet potato	9,333,492	135,194,481

Source: FAO(1999)

Apart from being the leading producers of these crops, Africans depend on them for survival. Cock (1985) estimated that cassava was a staple crop for millions of people.

In order to contribute to the well being of Africans, it is necessary for African scientists to commit themselves to the improvement in the quality and processing of foods consumed by African. Early in my career, I chose the Cassava root as my challenge (Figure 1).

Figure 1 : Harvested Cassava Roots

1.3 The Cassava Crop:

Cassava (*Manihot esculenta* Crantz) is one of the most important food crops grown in Africa (Brujin and Fresco, 1989). It provides a major source of calories for about 500 million people globally (Cock, 1985) and has been instrumental in alleviating the food crises in many war-torn and drought ravaged parts of Africa (Hahn and Keyser, 1985).

Cassava is grown for use as food in more than thirty nine African countries (Hahn and Keyser, 1985). Cassava production in Africa is projected to grow at about 3 % per year in the next 20 years. FAO (2002) had estimated that cassava production will increase to about 114 million tones by 2005 and continue into 2020 when the production is estimated to double the current level .

The main cassava producing countries of Africa include Nigeria, Benin, Kenya, Zambia, Tanzania, Uganda, Ghana, Zimbabwe, Democratic Republic of Congo and Mozambique. Various other countries in Africa produce cassava and process it to a diversity of food and industrial products.

The cassava plant has become food not only to man but to various animals. Apart from the root, cassava leaves are consumed as a green vegetable in some parts of Africa. Cassava leaves have been found to be a good source of protein and vitamins A and B. The peel of the cassava root is used as a component of animal feed, while starch derived from the root finds wide industrial applications.

Despite its importance, cassava has some peculiar limitations. Its bulkiness due to its high moisture contents makes transportation of the crop very difficult. The Cassava root has a very short post-harvest shelf life and undergoes

spoilage within three days of harvest (Nweke, 1994).

Apart from these limitations, some 'myths' have been wrongly attached to the cassava crop. Many have wrongly referred to cassava as an 'inferior food crop' (Kwatia, 1986; Hahn *et al.,* 1987); as a 'poor peoples crop' or as a 'dangerous crop' (Hahn and Keyser, 1985). Those who refer to cassava as an 'inferior crop' alleged this because of its low protein content. They have failed to realize that cassava is an 'energy' crop which has survived in difficult situations and soils where many 'protein' crops cannot stand. Many people in situations of war and famine have survived because cassava was available.

Among all the myths associated with cassava, the one that is of greatest concern is the reference to cassava as a 'dangerous crop' that contains cyanide. Cassava does not contain cyanide. What people wrongly refer to as 'cyanide' in cassava are some complex molecules which consist of a glucose ring combined with a cyanohydrin, which has a cyanide group and hydroxyl group attached to the same carbon. Such molecules are called 'cyanogenic glucosides'. Cyanogenic glucosides can be found in many plant materials including apple seeds, bamboo, pear seeds, sorghum, lima beans, bitter almonds, linen seeds among others. Two cyanogenic glucosides which are represented in cassava are linamarin and lotaustralin. Processing of cassava has been found to be efficient in breaking away the cyanogenic glucoside thus releasing the cyanogens component and consequently making the root safe for consumption. Inadequate and improper processing is the cause of the problems associated with cassava. The powers involved in making our cassava food to be safe are the focus of this lecture – the living organisms which cannot be seen with the naked eyes, usually called the Microorganisms.

Microorganisms have been found to be an important ally with cassava in making the cassava root to be safe for human consumption. Today, cassava has been found to be a 'security' crop in the continent of Africa. When other crops fail, cassava had survived. It is therefore no surprise that cassava is processed to a wide variety of food products which are consumed in Africa (Table 2).

My research work on the cassava roots had been focused on some of these traditional cassava foods and the microorganism which powers were able to transform the cassava roots to various types of products and make them safe for human consumption.

Table 2 **Fermented Cassava Products of Africa**

Product Name	Other names given to the product
1. Gari	'koko-Gari'; 'Eba"; 'Agbelima','Kapok Pogari".
2. Fufu	'foufou'; 'foofoo';'fulful';foutou';'baton du manioc';'akpu'; 'udep utim;'pupuru'; 'pukuru'; 'Farine';"Yakayeke''agbalima'; 'water-fufu'.
3. Lafun	'bombo'; 'makessa'; 'luku'; 'cossettes'; 'nshima'; 'exidzi'; 'makak'; 'kanyanga';'mapanga' 'maphumu'.
4. Attieke	'Atieke'
5. Kokonte	'crueira'; 'Alebo"
6. Chikwangue	'Ntuka'; 'bugali''kmonmogo','chawada';'bobolo'; 'myondo';'mboung'; 'mangbele'; 'cassava bread'.
7. Placani	'Placani'
8. Mould fermented flour	'Tapioca flour'
9. Cassava beer.	'enguii'; 'panvu'; 'banuu; 'Uala'
10. Fermented boiled roots	'Meduame –M Bong'

Oyewole (2000)

CHAPTER TWO

RESEARCH ON THE CASSAVA ROOT

2.1 Preamble:

The food of people varies with their culture and territories. It is important to find out the type of foods that Africans eat. One of our earliest observations is that Africans consume a large quantity of root and tuber crops and cereals. One way of helping the Africans is to help in improving the quality and quantity of the type of foods that Africans eat.

It is unfortunate that until recently, Africans still employ age old traditional food processes and crude utensils for the production of their foods. The underlying motivations behind my research work were to improve our traditional food processing technologies. The best approach to this is to first understand the traditional activities before introducing modern innovations. (I should confess that when I was about to embark on my work on traditional cassava processing at the University of Ibadan, one of the earlier discouraging advices that I got was that all works had been concluded on cassava processing. I am happy that I did not oblige myself to such discouraging opinions that no new thing can be done on a subject matter.)

2.2 Studies into the Traditional Cassava Processing:

The major unit operations involved in traditional processing of cassava are shown in Figure 2. These include : peeling and size reduction, fermentation, sieving and dehydration before cooking.

The major steps involved in the processing of cassava to three popular cassava products of Nigeria namely ‘gari’, ‘fufu’ and ‘lafun’, are shown in Figure 3.

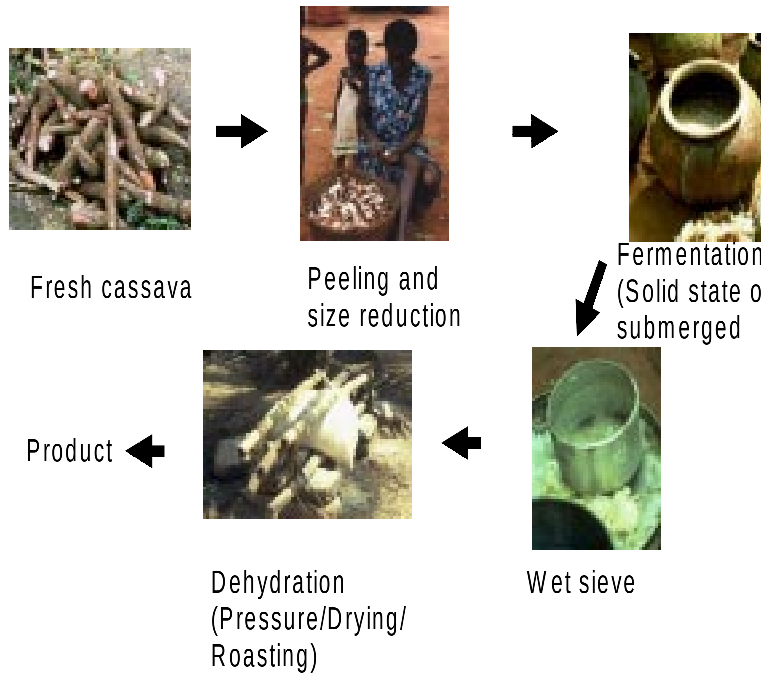


Photo courtesy: Prof. Andrew Westby.

Figure 2 : Major Unit Operations Involved in Cassava processing (Oyewole et. al.,2001)

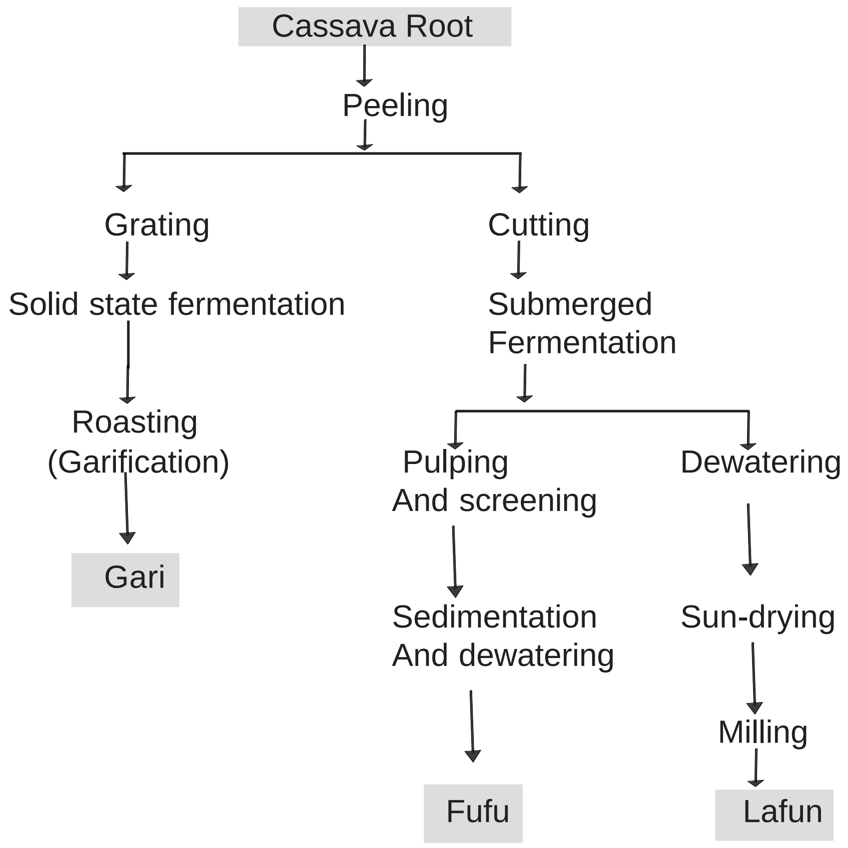


Figure 3: Village processing of cassava to 'gari', 'fufu' and 'lafun'. (Oyewole and Sanni, 1995).

The first stage of our research was a survey carried out among local cassava processor in Ogun state. This was done to understand the art behind the processing and find out the constraints facing the local processors to which scientific investigations were directed. Results of this survey are presented in Table 3.

Table 3 : Constraints in the traditional processing of cassava to 'fufu'

Identified Constraints	% of affirmative processors
Peeling is time-consuming	90
Peeling is tedious	64
Fermentation is too long	93
Fermentation odour not liked by neighbours	56
Colour of soak water disdainful	34
Some cassava roots do not ferment readily	90
Newly introduced cultivars are not good for 'fufu'	54

(Oyewole and Sanni, 1995)

All the processors recognized the need to ferment cassava before consumption. Reasons given for fermentation include prevention of spoilage of fresh cassava root, observance of traditional techniques and the need to have a wide range of cassava products. General constraints identified by the processors in the processing of cassava include long un-economic period of processing, uncontrolled fermentation process, non-suitability of some cassava cultivars for their desired characteristic product and the variations in the quality of the product at different weather conditions and with different batches of production.. our scientific works were geared towards overcoming these constraints.

It was quite interesting to know that even local processors recognize the importance of fermentation in cassava processing. Many of them were aware a long time before science confirms it of the dangers of consuming unprocessed raw foods and the fact that fermentation helps in making cassava safe for human consumption. What is however not clear to them are the powers behind the day to day operations that brings food to the table of many people.

2.3 <u>Our Research Approach:</u>

Our approach on cassava processing research is divided into four broad stages:

These include:

(a) Investigating the science of the traditional process
(b) Studies on the Microbial powers at the roots
(c) Optimization of the processing through process controls
(d) Industrialization and Commercialization

2.3.1 Investigating the science of the traditional process:

When an African woman soaks peeled cassava roots in water and leaves it there for four days, she was sure of the nature of the products that would result. However, she may not know about the details of the biochemical and microbiological activities that take place during this process.

This process is known as **Fermentation.**

Africans consume a large number of fermented foods. Some details of these can be found in the latter part of this presentation. However what we found with traditional cassava fermentation process appears to be common to other fermented products of Africa. Many of these fermented products are well acceptable in their regions of consumptions. Fermented cassava products is not only rich in carbohydrate (energy source), it is a good source of calcium, magnesium and potassium (Oyewole and Odunfa, 1989).

Age old methods and traditional equipment are still being used for the processing. There is little or no process controls involved as fermentation is left to chance inoculations from the environment. The traditional packaging is poor and the products are produced under unhygienic conditions. The keeping qualities of the products are usually poor.

Our goal is to advance traditional fermentation processing from their arts to their sciences. An understanding of the powers behind the fermentation processes was found to be essential in doing this.

2.3.2 The Microbial Powers at the roots:

The early goal of my work was to find out the powers behind the transformations that take place at the root of the cassava crop during fermentation. There are powers that rule in the world and quite often they are big. However at the root of cassava are some mighty powers that cannot be seen with the naked eyes. These powers are wielded by minute microscopic organisms called Microorganisms. They are the powers at the root of the cassava crop.

The microorganisms involved in the submerged fermentation of cassava for ‘fufu’ and ‘lafun’ production include: *Bacillus subtilis , klebsiella* species, *Candida tropicalis, Candida* *krusei, Leuconostoc mesenteroides*, *Lactobacillus plantarum*. Figures 4a-4d show the photomicrographs of some microorganisms involved in cassava fermentation. Each of these microorganisms possess some inate powers that make cassava safe and good for human consumption. The major ones include :

(a) ***Bacillus* species : (Figure. 4a)**

In our studies on cassava fermentation, we found a succession trend among the microorganisms. Many microorganisms, including bacteria and fungi, usually exist at the beginning of the process depending on the environment or the nature of the containers being used as fermenters. One of the notable organisms isolated at the beginning of fermentation is the Bacillus strains (Oyewole and Odunfa, 1988). These Bacillus strains are rod-shaped, Gram positive, Catalase positive bacteria.

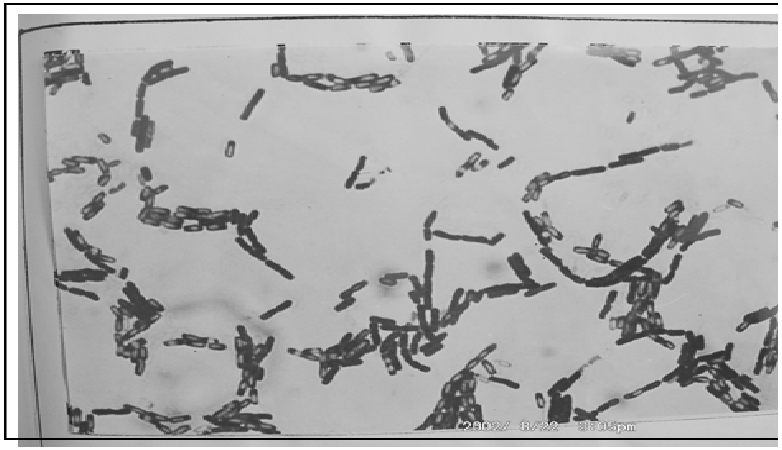


Figure 4a : *Bacillus subtilis* from fermenting cassava (Oyewole,1990a)

One important power possessed by Bacillus strains isolated from fermenting cassava is their ability to produce amylase enzyme.(Amund and Ogunsua, 1987;Oyewole and Odunfa, 1992a,b). The amylases are involved in the initial breakdown of cassava starch into simple sugars, which are required by other actors in the power play. While Oyewole (1992b) reported that in the submerged cassava fermentation for ‘fufu’ and ‘lafun’, the Bacillus species which appear at the beginning of the fermentation became extinct towards the end of the process, Amoa-Awua and Jakobsen (1995) reporting on the solid state fermentation of cassava to ‘agbelima’ in Ghana, showed that Bacillus species occurred in high numbers and persisted throughout the fermentation process.

(b) The Yeasts: (Figure 4b)

Yeasts have been identified as another important microbial power implicated in the fermentation of cassava roots. Oyewole (1997) reported that the yeasts survived through out the cassava fermentation process.

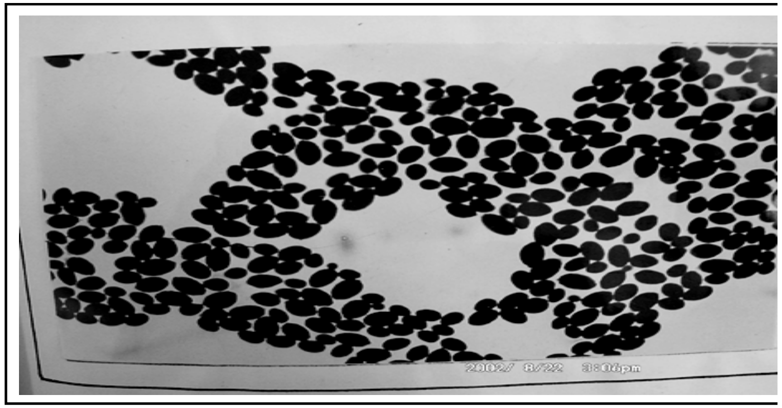


Figure 4b : Candida krusei isolated from fermenting cassava (Oyewole, 1990a)

Oyewole (1990a,b) in studies carried out on the roles of the individual microorganisms involved in cassava fermentation reported that *Candida krusei* (a yeast) effected the highest characteristic odour found in 'fufu'. Amoa-Awua et al., (1997) implicated many yeasts including *Candida krusei, C. tropicalis* and *Zygosaccharomyces* in the fermentation of cassava to produce 'agbelima'.

Oyewole (2001) investigated the characteristics and significance of yeasts in cassava fermentation for 'fufu' production. Six different strains of yeasts were reported including *Candida krusei, C. tropicalis, Pichia saitol, Saccharomyces cerevisiae, P. anomala* and *Zygosaccharomyces bailii.* The enzymatic activities of the isolated yeasts are shown in Table 4.

Table 4 : Enzymatic characteristics of predominant yeasts isolated from fermenting cassava

Yeasts	Amylase	Linamarase	Cellulase	Polygala-cturonase
Candida. krusei	+ve	+ve	-ve	+ve
C. tropicalis	+ve	-ve	-ve	+ve
Pichia.anomala	+ve	-ve	-ve	+ve
P. saitoi	+ve	-ve	-ve	+ve
Zygosaccharomyces	±ve	-ve	-ve	-ve
***Saccharomyces** spp*	.±ve	-ve	-ve	+ve

Oyewole(2001)

The latter part of the fermentation was dorminated by three strains of yeasts namely *C. krusei, C. tropicalis* and *Z. bailii*. All the yeasts exhibited amylolytic capabilities but none was

able to produce cellulase. All the strains except *Zygosaccharomyces* spp. exhibited polygalacturonase activities but only C. krusei was able to produce linamarase.

Oyewole (2001) also reported that there is an inter-relationship between the yeasts and the lactic acid bacteria, both of which dominate the latter part of the cassava fermentation process.

(c) The lactic acid bacteria : (Figure 4c and 4d)

Following our observation on the predominance of the lactic acid bacteria during cassava fermentation, we investigated the characteristics and distributions of this group of microorganisms in fermenting cassava root (Oyewole and Odunfa, 1990a,b). Members of this group are Gram positive , Catalase negative cocci (Figure 4c) and rod-like (Figure 4d) bacteria which acts on carbohydrate to produce lactic acid among others.

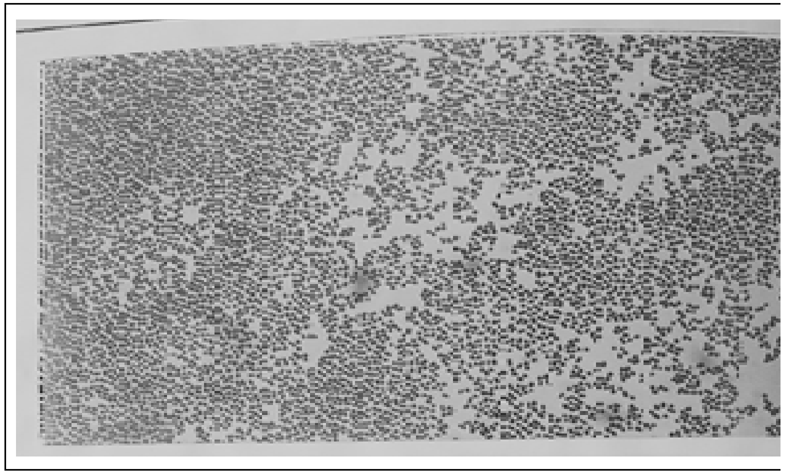


Figure 4c : *Leuconostoc mesenteroides from fermenting cassava. (*Oyewole, *1990a)*

About one hundred and thirty strains of lactic acid bacteria were screened. The spectrum and proportion of the strains include *Lactobacillus plantarum* (81%); *Leuconostoc mesenteroides* (16%); *Lactobacillus cellobiosus* (15%); *Lactobacillus brevis* (9%); *Lactobacillus coprophilus* (5%); *Lactobacillus lactis* (4%); *Leuconostoc lactis* (3%) and *Lactobacillus bulgaricus* (1%).. This work established the fact that *Lactobacillus plantarum* is the major lactic acid bacteria involved in cassava production.

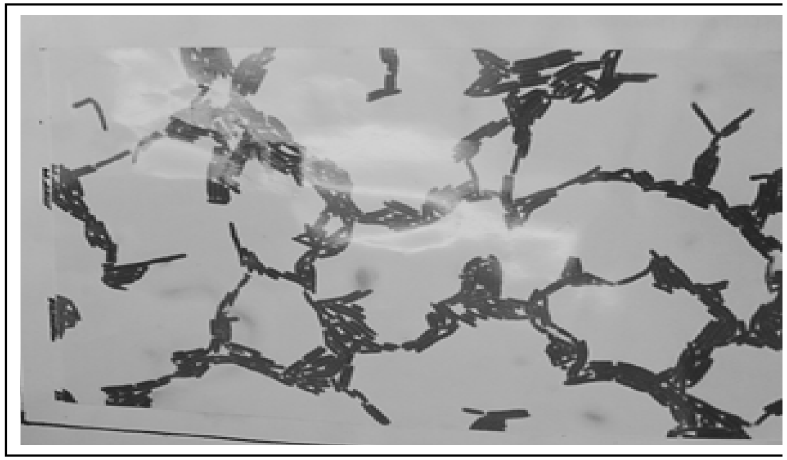


Figure 4d : *Lactobacillus plantarum* isolated from fermenting cassava roots. *(*Oyewole, *1990a)*

These lactic acid bacteria play important roles in the fermentation process. They act on the sugars produced and convert them to organic acids. The organic acids have been found to be inhibitory to some pathogenic and spoilage organisms. The lactic acid bacteria therefore serve protective roles to the food and the consumers. Many of the lactic acid bacteria isolated from cassava have been found to produce

linamarase enzyme which help in detoxifying the potential toxicity of cassava.

There are many African foods produced through the fermentation activities of lactic acid bacteria. Oyewole (1997) reviewed the lactic acid fermented foods of Africa and noted that lactic acid fermentation technology has the following benefits:

(a) It serves as a household technology for improving food safety in Africa.

(b) It serves as a low-cost method of food preservation in Africa.

(c) It contributes to the improvement of the nutritional value and digestibility of food raw materials in Africa.

Our interest on the microorganisms is not just to identify them but to be able to tap their potentials for optimum activities or even re-engineer them for other applications.

2.3.4 Process Optimization:

Cassava processors found that the quality of their products were not stable as they vary from season to season and from one processor to another. This made us to investigate the processing conditions for optimizing the fermentation process. Peeling and non peeling of the cassava roots and the sizes to which the roots are cut all contribute to the quality of the fermented products (Oyewole, 1990b). We found that the temperature range of 30^0C to 35^0C, with a soaking period of 48 to 60 hours were optimal for the submerged fermentation production of ‘lafun’ and ‘fufu’. Some other researchers have found a different situation with the production of ‘gari’. It has been found that the simple process of grating cassava in ‘gari’ production releases enough linamarase from the plant cells such that fermentation may not be necessary for the detoxification (Vasconcelos et al., 1990). However, our studies confirm that fermentation performs other roles than detoxification even in 'gari' production. The microorganisms have some special roles to play in the characteristic flavour of gari as well as help in preserving the products.

One major problem with 'fufu' is the characteristic odour which is disdainful to many. Our work has shown that by ordinary changing of the fermenting water daily after the second day of fermentation till the end help in yielding low odour 'fufu'.

2.3.5 Product Improvement and Industrialization prospects:

If cassava had been a product of the western world, the status of the crop would had been enhanced more than what it is today in Africa. There are many fermented African foods waiting to be industrialized and commercialized (Sanni 1993).

The need to commercialize and industrialize Africa's traditional and fermented food would not be appreciated if two dangerous problems in the continent is not focused. These are the problems of food insecurity and poverty which constitute the discussion in the next section.

CHAPTER THREE

FOOD AND ITS MICROBIAL ALLIES IN FOOD SECURITY

3.1 Preamble:

One of the salient reasons for the establishment of the Universities of Agriculture is to gear the country towards overcoming the problems of food insecurity, and poverty. Many research workers have come to recognize cassava as Africa's food security crop (Babaleye, 2002). A scientist once comented that "Cassava is to the African peasant farmer what rice is to the Asian farmers, or what wheat and potato are to the European farmers". In order to understand the role of cassava in food security, it is necessary to understand the concept and know the state of our nation, Nigeria.

3.2 Profiles on Nigeria:

Every year, the World Bank provides statistics on the profile of different countries. It will be relevant to provide some statistics on one of the recent profiles on Nigeria (Table 5).

These statistics show that poverty is prevalent in Nigeria. Indeed, Nigeria has been categorized among the 25 poorest countries in the world, in a list largely occupied by many African countries. The hidden secrets behind this dismay statistics is the lack of **Food Security** in the country. Indeed, a 'Yoruba'

Table 5 : Country Profiles on Nigeria (Extracts)

▪ Population	126.9 million
▪ Population growth	2.4% annually
▪ Life Expectancy at birth	46.8 years.
▪ Fertility Rate (Total birth per woman)	5.3 children
▪ Mortality rate , infants (per 1000 live birth)	84.4 children
▪ Mortality rate , under 5 years (per 1000 births)	153 children
▪ Malnutrition (% children under 5 years)	27.3%
▪ Illiteracy rates . Adult males(15yrs. +)	27.6%
▪ Illiteracy rates . Adult females (15 yrs +)	44.3%
▪ Population under poverty	66%
▪ Maternal Mortality (per 10000 births)	10%

Source: ***World Development Indicators database*, (World Bank, 2002)**

proverb says : ‘ Where there is food security, poverty is terminated’. (“Bi ebi ba ti kuro ninu ise, ise buse”) (Yoruba)

3.3 Food Security:

The World Food Summit (1996) stated that 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.

Three major components therefore constitute food security. These are:

(a) Production or availability of nutritionally adequate and safe food

(b) Access or capacity to acquire nutritionally adequate and safe food

(c) Utilization of food in proper proportion for an active and healthy living.

Situation where the above is not available is a situation of food insecurity.

Five years ago, the World Health Organization presented the following data which appears to be growing worse after they were released :

- 50 million people suffer from acute hunger as a result of disaster, war, civil unrest and economic crises.
- Half of more than 10 million deaths among children under five every year are associated with malnutrition.
- 170 million children are underweight.
- 208 million children are stunted.
- 49 million children are wasted.
- 50 million people suffer from brain damage due to iodine deficiency.
- 3 million children are at the increased risks of infection , blindness and death due to Vitamin A deficiency.
- 200 million people are suffering from iron deficiency and anaemia

It is paradoxical to note that while the world food production continues to increase year in year out, there are countries, regions, households and individuals that do not have required or enough food to eat.

It has been reported that over 800 million people, mostly in the developing countries remain chronically hungry. Today, about 20% of the people in the developing countries are chronically undernourished.

In Africa, many cases of child and mothers mortality, mental deficiency, growth retardation, blindness and deaths occur because of lack of access to required nutrients and adequate food.

There are different approaches to solving the problems of food insecurity. Maternal and child health and nutrition need to be improved. Food supplementation and increased agricultural activities need to be promoted.

One other approach is to improve the quality and quantity of food that the Africans currently consume. Improving the foods that are culturally acceptable to the Africans will be an important way of helping to solve the food problems.

A large percentage of the foods consumed by Africans are fermented. These fermented foods are the outcome of the beneficial association of microorganisms with some natural food products.

3.4 Fermented Foods for Food Security in Africa:

Fermented foods constitute an important components of the diets of Africans (Odunfa and Oyewole, 1997). Some of these fermented foods are consumed as the main course meal while others are used as condiments in the preparation of soups and food ingredients. The fermented foods can be categorized using their raw material base into fermented products of grain legumes, seeds and nuts; fermented products of non-grain starchy staples; and fermented animal products . Tables 6-8 show some of the major fermented foods of Africa and the levels of their scientific developments.

There are several reasons why fermented foods became popular in Africa. Firstly, fermentation modifies the raw material physically, nutritionally and sensorily [Aidoo, 1986] yielding products of better qualities than the raw materials. Secondly, fermentation helps to remove or reduce

some anti-nutritional factors present in some of these raw materials thus making them to be safe for human consumption. For example, most raw legumes, seeds and nuts contain substances such as trypsin inhibitors which reduce digestibility of proteins and low-molecular weight carbohydrate fractions which have been found to be responsible for flatulence after ingestion, which are removed or reduced to safe levels through the process of fermentation. [Odunfa,1983]. Thirdly, fermentation improves the appearance, texture and nutritional quality of some raw materials. (Dirar, 1993).

In Africa, the problem of food security is not just that of inadequacy of food but it is also a problem of loss of food due to **spoilage**. Lack of adequate food preservation methods is a major problem contributing to food insecurity in Africa. The high costs and infrastructural requirements of many advanced food preservation methods such as refrigeration, freezing, canning and irradiation, have greatly reduced their applications in the developing world (Cooke et al., 1987). Microorganisms which are involved in food fermentation have been known to help foods in combating their kinds and other agents that work to spoil foods. *Lactobacillus plantarum* involved in cassava fermentation (Oyewole, 1990); maize fermentation for Nigerian ‘ogi’ and Kenyan ‘Uji’ (Akinrele, 1970; Mbugua, 1981) and North African ‘Ayib’ and ‘kawal’ (Dirar, 1975) have been found to be effective against many spoilage agents. Fermentation has been identified as a low cost preservation method (Oyewole, 1997). Promoting fermentation in Africa is a means of promoting food security.

Malnutrition is a food security problem in Africa. While malnutrition is partly due to non-availability of food, it is also due to low energy and nutrient density and low bioavailability of nutrients in the available foods (Ljungqvist et al., 1981). The presence of some antinutritional factors such as phytic acid, tannins and polyphenols in some cereals used as weaning foods is known to be responsible for the low availability of proteins (Maclean et al., 1980) and iron (Gilooly et al., 1984). Traditional fermentation of foods as found in Africa has been found to effectively reduce the amount of phytic acid, polyphenols and tannins and improve protein availability in sorghum (Chavan et al., 1988) and millet (Khetarpaul and Chauhan, 1990). Fermentation due to the activities of microorganisms have led to improved iron availability in many foods (Svanberg and Sandberg, 1988). Today, there are vitamin and amino acid synthesizing microorganisms which had been isolated from some of our local fermented foods. Microorganisms involved in the fermentation of African fermented foods are allies with food and man in destroying agents that hinder man from getting the best from the food he consumes.

Food is dangerous if it will cause you **diseases**. Consumption of pathogen contaminated foods will promote health and nutritional insecurity. Microorganisms involved in fermentation have for a long time been involved in protecting man against their kinds that can cause diseases. Some fermented foods are now being promoted for their therapeutic properties. Yogurt and some other fermented milk products have been reported to be effective in the treatment of a variety of disorders, including colitis, constipation and diarrhea (Sanders, 1993). In Europe today, 'Acidophilus milk' which contains live *Lactobacillus acidophilus*, is now being promoted as a therapeutic food for the treatments of *Escherichia and Shigella* mediated diarrhea and dysenteries in infants (Alms, 1983). Our African fermented foods can do the same. Odugbemi et al., (1991) confirmed that enteropathogenic *Escherichia coli, Salmonella typhii* and *Salmonella paratyphi*

were inhibited in fermented 'ogi'. Mbugua and Njenga (1991) reported the inhibition of the growth of *Staphylococcus aureus*, *Salmonella typhii* and *Shigella dysenteriae* in Kenyan 'uji'. Mensah et al. (1991) simulated an unhygienic condition as available in some developing countries by inoculating some pathogens in Ghanaian fermented maize dough and found that the pathogens were inhibited. Studies carried out by Olukoya et al., (1993) and Olasupo et al., (1994) in Nigeria have confirmed that various lactic acid bacteria isolated from fermented African foods produce some antimicrobial chemicals called bacteriocins which make these fermented foods safe for human consumption. In other parts of the world, these beneficial microorganisms are packaged into products called probiotics. The term **'probiotic'** refers to a product containing mono or mixed cultures of live microorganisms which when applied to animals or man will improve the health status and or affect beneficially the host by its microbial balance (Oyewole, 1997). Through our fermented foods, there are microorganisms which will help Africans to improve their nutritional status.

Unfortunately the state of development of the various traditional and fermented foods of Africa is still low as shown in Tables 6 – 8.

The **major problems associated with African fermented foods** and many of our traditional foods are the following:

- Age old traditional methods are still being used which limits scaling up.
- Processing equipment and utensils are crude.
- Poor quality standards and controls causing variability in products.

- Poor packaging.
- Low demands and status when compared to imported foods of lower nutritional qualities.
- Limited scientific interests - Research grants for African traditional foods are grossly inadequate.

One of the urgent needs of these fermented foods is to improve their qualities, industrialize their products and commercialize them. This goal forms our current focus in our cassava research which is discussed in the concluding section.

Table 6 : FERMENTED NON-GRAIN STARCHY STAPLES OF AFRICA

RAW MATERIAL CATEGORIES	FERMENTED PRODUCT NAME	COUNTRY/REGION OF CONSUMPTION	LEVEL OF DEVE*
Cassava [a]	Gari [a]	Africa	1,2,5,7,8,
	Fufu [a]	West Africa	1,2,5,6
	Lafun / Kokonte [a]	West Africa	1,2,5,6
	Chikawangue [a]	Zaire	1,2,.7
	Cingwada [a]	East & C/ Africa	1,2
	Attieke	West Africa	1
	Placani	West Africa	1
	Cassava beer.	E/South Africa	0
Ensette (b)	Kocho [b]	East Africa	1,2
Carrot	Carrot beer	N/East Africa	0
Yam	Elubo	West Africa	7
Cocoyam	Kokobele	Central Africa	0
Ginger	Ginger beer	Africa	7,8
Breadfruit	Brefu	Africa	1
Banana	Mbege	Central Africa	1
Plantain	Agadagidi drink	West Africa	1,2

***Key to the level of advancements*:**

0 : Little or no scientific information on the fermentation

1 : Microorganisms involved known

2 : Roles of individual microorganisms known

3 : Genetic improvement carried on organisms.

4 : Starter cultures available for the fermentation

5 : Varieties of raw materials that are best for the product known

6 : Improved technology available and adopted

7 : Pilot Plant production

8 : Industrial Plant production

[(a),(b)]: products with the same superscripts as the raw material can be produced from that raw material

(Source : Oyewole, 1997)

TABLE 7: FERMENTED CEREALS OF AFRICA

RAW MATERIAL CATEGORIES	FERMENTED PRODUCT NAME	COUNTRY/REGION OF CONSUMPTION	LEVEL OF DEVE*
[A] Gruels and Beverages			
Maize (a)	Ogi (a)(b)(c)	Nigeria / West Africa	1,2,3,4,5,,7
Sorghum (b)	Abreh (b)	Sudan	1,2
Millet (c)	Uji (a)(b)(c)	Kenya / East Africa	1,2
Rice (d)	Kenkey (a)	Ghana	1,2
Wheat (e)	Mahewu / Magou	South Africa	1,2,7
Tef (*Eragrotis tef*)(f)	Humulur (b)	Sudan	1,2
Mawe (a)		Benin / west Africa	1,2,3
[B] ALCOHOLIC BEVERAGES			
	Busa (a)(b)(c)(d)	Kenya/ East Africa	1,2,7
	Mbege (c)	Tanzania	1,2
	Bouza (e)	Egypt	1,
	Merisa (b)(c)	Sudan	1,2
	Kaffir / Kefir (a)(b)	North Africa	
	Leting / Joala (a)(b)	South Africa	
	Utshival amqomboti (b)	South Africa	
	Burukutu (b)	West Africa	1,2
	Pito (b)(c)	West Africa	1,2
	Malawa (a)	East and Soth Africa	
[C] OTHERS			
Palm	Palm Wine	West Africa	1,2,7
[D] ACID-LEAVENED BREAD/ PANCAKES			
	Kisra (b)(c)	Sudan	
	Enjera / Tef Injera (f)	Ethiopia	
	Kishj (e)	Egypt	
	Laban zeer	Morocco	

***Key to the level of advancements*:

0 : Little or no scientific information on the fermentation
1 : Microorganisms involved known
2 : Roles of individual microorganisms known
3 : Genetic improvement carried on organisms.
4 : Starter cultures available for the fermentation
5 : Varieties of raw materials that are best for the product known
6 : Improved technology available and adopted
7 : Pilot Plant production
8 : Industrial Plant production
(a),(b): products with the same superscripts as the raw material can be produced from that raw material
(Source: Oyewole, 1997)

Table 8: COMMON FERMENTED LEGUMES, NUTS AND ANIMAL PRODUCTS OF AFRICA.

RAW MATERIAL	FERMENTED PRODUCT NAME	COUNTRY/REGION OF CONSUMPTION	LEVEL OF DEVE*
Locust bean	Dawadawa	West Africa	1,2,3,6,7
[*Parkia* spp.,]	Daddawa; Iru;		
Soybean	Kal, Chu,		
[*Glycine max*]	Etchum	Soumbara	1,2,3,6,7
African oil bean	Ugba; Ukpaka	West Africa	1,2
[*Pentaclethra macrophylla*]	Central Africa		
Melon seeds	Ogiri/ Ogili	West Africa	1
[*Citrullus vulgaris*]	Ogiri-egusi	East Africa	
Castor oil seed	Ogiri-igbo	West Africa	1
[*Ricinus communis*]	Ogiri-isi		
Pumpkin bean	Ogiri-ugu	West Africa	1
[*Telferia occidentalis*]	East Africa		
Sesame	Ogiri-saro	West Africa	1
[*Sesamum indicum*]			
Cotton seed	Owoh	West Africa	1
[*Gossypium hirsutum*]			
Bambara Groundnut	Bara Nut	West Africa	0
[*Vigna subterranea*]		North Africa	
Prosopis africana	Okpehe/Okpiye	West Africa	1
Cassia obtusifolia	Kawal leaf	North Africa	1,2
[B] ANIMAL PRODUCTS			
Goat Milk (c)	Ayib (c)	E/Central Africa	1,2
Cow Milk (d)	Leben/Lben (d)	N/E/Central Africa	1,2,3
Sheep Milk(e)	Leban rayeb	N/E/Central Africa	1,2
	Jben (e)	North Africa	1
	Yogurt/Zabadi	North Africa	1,2,7
	Nono (d)(e)	West Africa	1,2,7

***Key to the level of advancements*:
0 Little or no on the fermentation
1 Microorganisms involved known
2 Roles of individual microorganisms known
3 Genetic improvement carried on organisms.
4 Starter cultures available for the fermentation
5 Varieties of raw materials that are best for the product known
6 Improved technology available and adopted
7 Pilot Plant production
8 Industrial Plant production
(a), (b), (c), (d), (e): products with the same superscripts as the raw material can be produced from that raw material
(Source: Oyewole, 2001)

CHAPTER FOUR

INDUSTRIALIZATION AND COMMERCIALIZATION OF AFRICAN FERMENTED FOODS

(CASSAVA AS A MODEL)

4.1 The Scheme:

In order to industrialize the traditional fermented foods of Africa, a five step scheme, which we are following in our work on cassava , is being recommended. These include:

(a) Process Standardization and Controls :

One of the requirements of industrial products is that the quality remains stable with different processing batches. For this to be applied to traditional fermented foods, there is need to investigate the optimum conditions for the fermentation processes. Similar works had been done for the fermentation of locust bean, 'iru'. (Odunfa and Adewuyi, 1985a,b) and in the case of cassava products (Oyewole and Odunfa, 1992b). Some varieties of cassava are not good for processing to some particular products. We have screened different cassava varieties to find out those that are best for some particular products (Oyewole and Afolami,2001.). As part of efforts at standardization, we have studied the effect of length of fermentation on the functional characteristics of some cassava products (Oyewole and Ogundele, 2001).

(b) Process Mechanization:

The traditional processing of cassava has been found to be tedious and time consuming (Oyewole and Sanni,1995). This has implications for the scale of processing. In the industrialization of cassava processing where the scale of processing will need to be increased, the use of appropriate machineries will be essential.

Among cassava traditional fermented products, 'the processing of 'gari' has been highly mechanized (Igbeka et al., 1992). Indeed, gari processing has assumed an industrial process a long time before now. This is largely due to the mechanization of its unit operations. The first fully integrated pilot plant for the mechanized production of gari in Nigeria was started at the Federal Institute of Industrial Research , Oshodi, Nigeria (FIIRO) in 1962 (Odunfa, 1998). Machines are now available for cassava peeling, grating, dewatering, and frying (garification). In order to industrialize the processing of other cassava products, the Federal Institute of Industrial Research at Oshodi, Nigeria have demonstrated that machinery used for 'gari' production can be adapted in most situations for the production of 'fufu' and 'lafun'. However, some of the available machinery still need improvements. The mechanical peeling system is still less efficient than the manual peeling process. Fermenters with control parameters are yet to be developed for the fermentation process and an efficient drier still needs to be developed for non- 'gari' products.

(c) Development of new food products

New fermented foods can still be developed from the many yet to be tapped raw materials which are available in Africa. Onabolu et al (1998) has documented new food materials from cassava flour. These products range from cassava bread, cassava pies, cakes, cookies, biscuits, flakes, etc.

The International Institute for Tropical Agriculture (IITA) has been promoting the production of high quality cassava flour (HQCF) which is used increasingly as substitute for wheat in biscuit (5-25%); bread-making (5-20%); puff-puff (12.5%); fish pie (12.5%); chinchin (25 – 100% and noddles (10%) (Abass et al., 1998). These newer uses of cassava are said to be generating more income for local cassava processors (Abass et al., 1998).

In the industrialization of cassava processing, the new products must offer benefits that are not found in the traditional products. Cassava –based foods have the potentials of serving as carriers of essential nutrients needed in the diet of our people. In Nigeria, we now have vitamin D-enriched ‘gari’ in the market and it is hope that very soon we shall have iodine supplemented cassava products.

In assessing the future prospect of cassava utilization in Africa, Henry et al., (1999) suggested the need to develop more convenient forms of traditional food products. This concept will need to be adopted for the industrialization process. There are various ways by which the current traditional cassava food products could be made to be more convenient and more nutritious. Possible interventions to achieve these include protein enrichment of the products. An effort in this direction was made when we developed a method for producing a protein enriched product through the co-fermentation of cassava with soya bean or cowpea (Oyewole and Aibor, 1992). Figure 5 shows the production scheme that was developed for this processing.

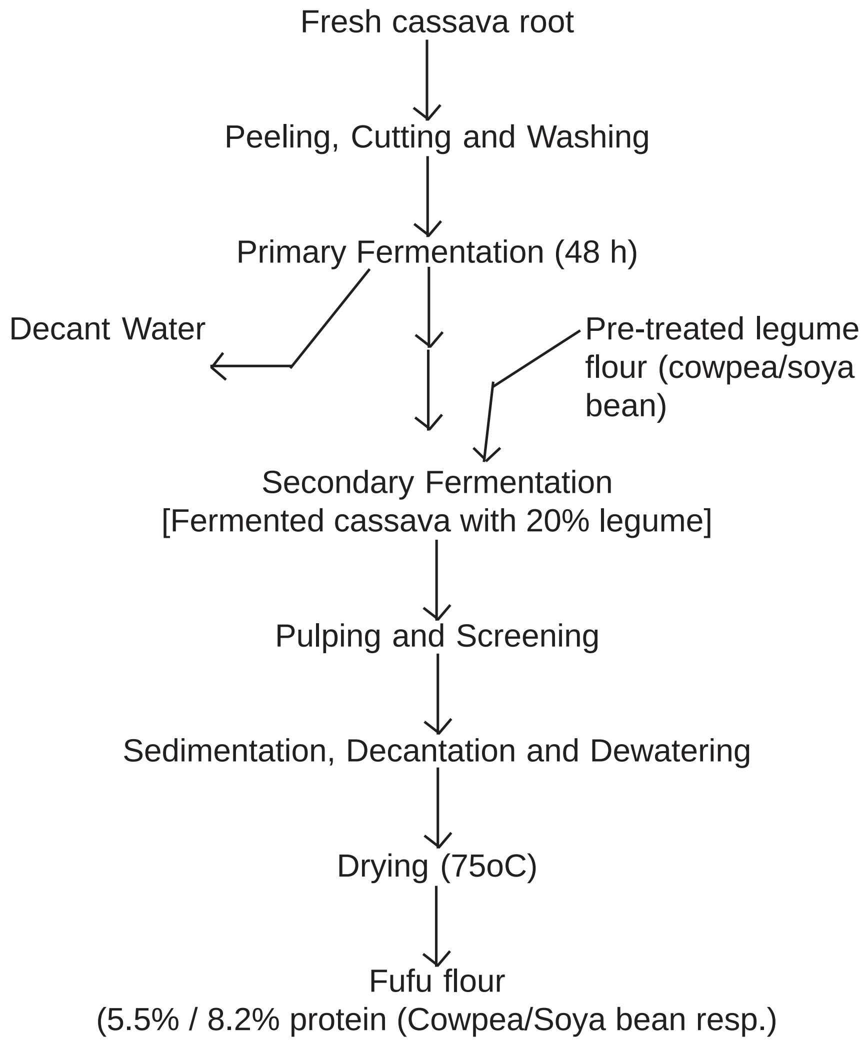


Figure 5 : Scheme for the co-fermentation of cassava with legumes to produce enriched ‘fufu’. (Oyewole and Aibor, 1992)

One traditional cassava product which appears to be neglected is 'Tapioca' flakes. Information on the science of the traditional production has also attracted our studies (Oyewole and Obieze. 1995). It is hoped that one day, tapioca will take the place of the currently imported carbohydrate products which are consumed as breakfast foods.

Similar to the efforts of the researchers at the International Institute of Tropical Agriculture, we have also investigated the use of cassava flour for biscuits and bread production. Cassava biscuits produced in this University of Agriculture (UNAAB CASSAVA BISCUITS) has been found to be of good and acceptable qualities to the consumers (Oyewole et al.1996).

I am happy to note that our research efforts are not confined to the corners of our laboratory buildings alone. As part of our mandate for training and extension, our research team 'floated' a 'pseudo-business' called CHALLENGE FOODS' to market our products. The managers and workers of CHALLENGE FOODS were students of the Department of Food Science and Technology who saw the project as a business incubator. Challenge Foods was an industrial/ business stimulation within the University. Challenge Foods was so named to challenge our young graduates for the future. Challenge Foods was not just involved in the production of cassava products, but was popular on the campus of this University as the manufacturer of Cashew Juice. With the Cashew Processing factory under construction in our University now, I am sure that the visions of Challenge Foods will be actualized.

(d) <u>Improved Packaging</u>

In industrializing traditional fermented products, there is need to improve the packaging and presentations of some of the traditional products. Modern packaging materials will need to be adopted. Consumers expect some of the products which are currently marketed in the wet form (e.g. 'fufu') to be presented in the dry flour form. There will be need to develop new ready to serve cassava food products to meet the challenges of the future.

(e) <u>Management of wastes</u>

Issues of disposal of wastes and environmental pollution associated with cassava fermentation are yet to be addressed. These are issues that industrializatio will demand answers to. Unfortunately, not much has been done on the last two steps of this model. However, cassava peels and some other wastes are finding use as local feeds for livestocks and in the production of single cell proteins.

4.2 <u>Our Fufu Commercialization Project</u>:

4.2.1 <u>Background</u>:

This inaugural lecture will not be complete if I fail to mention our on-going research which is titled: "**Identification of an approach to the commercialization of cassava for 'fufu' processing in West Africa that maximizes benefits to sustainable rural livelihoods**'.

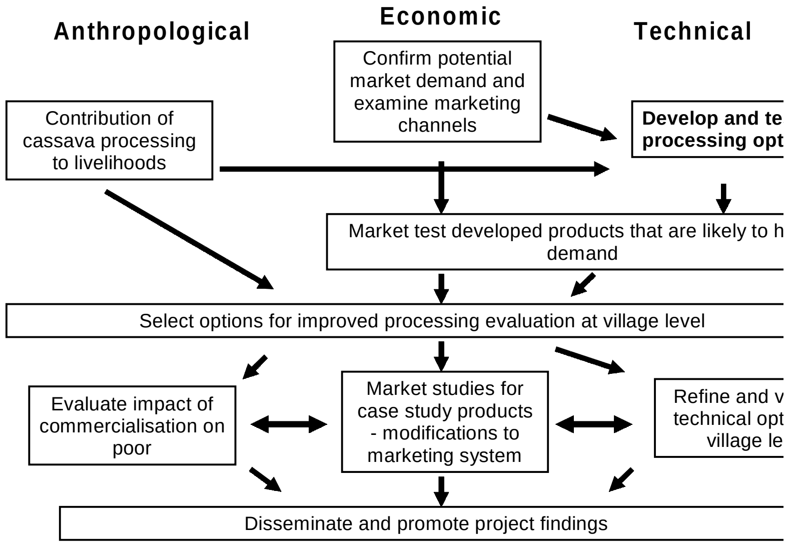
Research has shown that widespread processing of *fufu* takes place in rural areas in this country (Henry *et* *al,*.1999). The processing of cassava to 'fufu; is very popular in many villages of West Africa. The widespread importance of cassava (roots, leaves and processed products) to poor rural farmers, processors, and both rural and urban consumers means that investments in the processing of the crop are likely to have a positive impact on both urban and rural livelihoods.

With the current high levels of urbanization in Nigeria, consumers are demanding foods that are more convenient, are readily available, and are competitively priced. This market segment can be filled by imported goods, but it would be more beneficial to the Nigerian economy and to rural livelihoods if domestic products were available at similar prices and with similar characteristics and quality levels. We felt that dried *fufu* could be one of such products that could be introduced to consumers.

It was our belief that the commercialization of traditional processed products from cassava, such as *fufu*, will potentially offer new opportunities to rural households – either through sale of fresh roots or through processing and marketing.

4.2.2 <u>Our Commercialization Research Approach</u>

One important feature of the approach adopted by us in this project, is the collaboration of researchers from different orientations in working together as shown in Figure 6, In this research project Economists, Rural Extensionists, Food Microbiologists, Food Technologists and Engineers collaborated. Our experiences in this work confirm the need to encourage similar collaborations among scientists and workers from various disciplines.



(Prepared by: Prof. Andrew Westby)

Figure 6 : Our 'Fufu' Commercialization Research Project Approach

4.2.3 What has been achieved:

i. We have confirmed that cassava processing contributes to the livelihoods of many rural dwellers. We have carried out analysis of the existing contribution of traditional cassava processing to rural livelihoods.

ii. We have studied the marketing chains and market potentials for wet and dried fufu flour in south west Nigeria and in the export market.

iii. Extensive studies had been carried out on the technical options that are available for the improvement of 'fufu' processing in south west Nigeria.

iv. We have developed a processing technology for the village level production of dried ‘fufu’ flour using a simple drier that can operate in areas with or without electricity (Figure 7). The drier can be operated with wood or charcoal while a large capacity model is also available that can be operated with electricity.There are local ‘fufu’ exporters who are currently using similar technologies.

v. We have interacted with local ‘fufu’ producers in many towns across Ogun, Lagos and Oyo state with open demonstrations of our improved ‘fufu’ technology

vi. We have confirmed the emergence of an urban and export demand for cassava ‘fufu’.

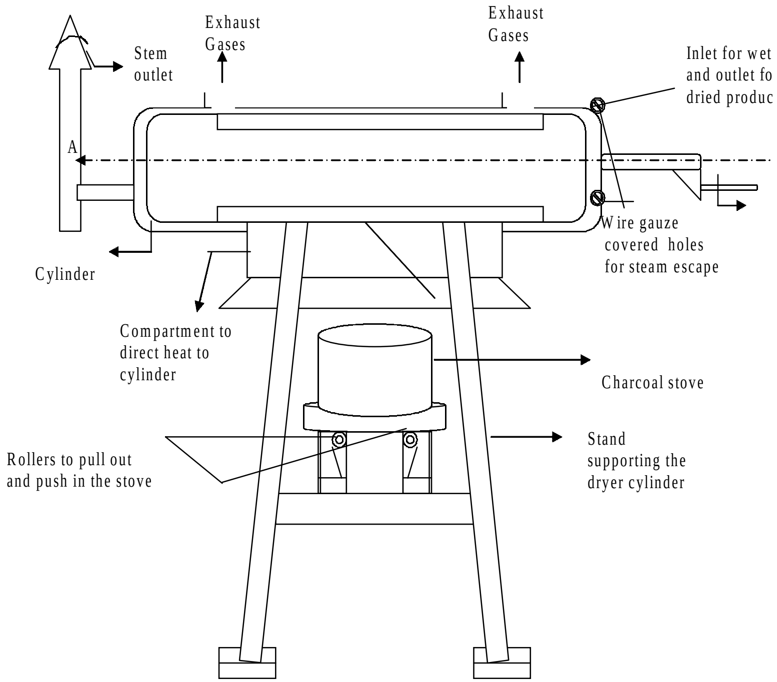


Fig. 7: UNAAB Fufu Rotary Drier

Today, ‘fufu’ flour is one of the export commodities of Nigeria. Our goal is to empower the rural ‘fufu’ producers to benefit from these developments. Our goal is also to encourage the development of small and medium scale enterprises involved in the production of cassava based products to meet these emerging urban and export demands. These will help us to achieve the maximum benefits of the powers at the roots.

Let me end with the words of Winston Churchill that: “This is not the end, it is not even the beginning of the end“ but it is one of the many celebrations of the exploits in a life that has God at the root. Greater glories lie ahead in the name of Jesus Christ, Amen.

ACKNOWLEDGEMENTS

Firstly, I want to thank my supervisors at the University of Ife (Now Obafemi Awolowo University) - Professor O.O. Shonukan and University of Ibadan – Professor S.A. Odunfa. They introduced me to and encouraged me to investigate the minute super powers. I give God the glory for opportunities to work in Universitate Kaiserslautern in Germany with Professor Roland Plapp under the DAAD programme.

I cannot but appreciate a small foundation with a great mission which has contributed immensely to my career. – Between 1986, I have been able to attract three different grants from the International Foundation for Science (IFS). The IFS has taken me from the cradle of my research career to the Professorship. I have also been blessed of God to receive awards form the same Organisation in the course of doing my research work.

I started my academic job career as an Assistant Lecturer at the University of Lagos, Abeokuta Campus (ULAB), which later became the then College of Science and Technology, University of Lagos (COSTAB) which finally got transformed to this University of Agriculture. Professor Lekan Oyebande was the then Campus Director. I will always appreciate the lead support he gave to my career and those early encouragements.

Our University has been blessed with good leadership. I have been tutored under two past Vice Chancellors of this University. Professor Nurudeen Adedipe was the foundation Vice Chancellor. His penchant for excellence was high. He was succeeded by Professor Julius Okojie. I thank them all for their great supports. I am highly indebted to the current

Vice Chancellor , Professor Israel Folorunso, Adu, for his Christian support and good leadership. I am grateful sir.

When I was employed in the University in 1985, Dr. Kofi Agyeman was the Acting Head of our then Department of Food Technology. I have had opportunities to work under other Heads of Department, including Dr. N.N. Nkpa and Dr. Ogunmoyela. It was after Dr. Ogunmoyela that I got the challenge of serving firstly as Departmental Coordinator and later as Acting Head of the Department of Food Science and Technology from 1992 to 1999. I want to thank the Head of my Department and all the members of our Department of Food Science and Technology. They have all helped me to know how to survive by praying.

The past Deans of our College have been very marvellous. They include Late Professor Folu Akinbode, Prof. Okuneye. I thank my current Dean, Professor Adenike Addo. I will keep on appreciating you, ma. I want to express gratitute to Prof. Oguntona for his useful suggestions on the draft manuscript.

No professor is self-made. Firstly, you are what you are by the special grace of God Almighty. Secondly, one is a product of the students and others researchers with whom you have collaborated. I want to acknowledge the supports of Dr. L.O. Sanni of the Department of Food Science and Technology and the other ‘fufu commercialisation team including Dr. Wale Dipeolu, Mr. A.O.Adebayo and Mr. K. Ayinde. I am also indebted to our UK associates led by Professor Andrew Westby, Mr. Keith Tomlins , Ms. Joanna White of Natural resources Institute, University of Greenwich, UK. It has been a pleasure and challenge working with them all.

I appreciate the support of the Oyewole family of Abeokuta and the Adekunle family of Ogbomoso in my up-bringing. I am happy that my life has demostrated that with Jesus Christ at the root, you can fulfill your divine destiny.

My life will not be complete without God and the people of God. I have had opportunities of serving God at the Mountain of Fire and Miracles Ministries. I thank the General Overseer of the Church, Dr. D.K. Olukoya and every member of our congregation. I cannot but show my appreciation to Pastor Oluwole Ebofin and his wife. He has been a great partner in the service of God. I believe that without my service and commitment to God in the Church, I would either had been 'cut' down or hindered from making the progress of my destiny.

My University career and one important aspect of my destiny commenced in the same week. Few days after I resumed as an assistant lecturer in the University, I got married in the Church to my wife; Mrs. Bolanle Oyewole. My stride through the academic world was because she remained a formidable power in my life. I thank my wife for her loving partnership. She has remained a faithful daughter of the Almighty God and a very faithful, responsible and holy wife. With her together, we have been blessed with four God-given children namely Oluwatofunmi (God is sufficient for me); Oluwatodimu (God is enough to be held on to); Oluwatomisin (God is enough for me to serve); Oluwatoni (God is enough to have). The names that we had given to our children are testimonies that the most reliable and greatest power that you can put at the root of your life is Jesus Christ.

I will want to end this lecture with a song that was rendered on my wedding day and I do this to tell you that God is the power at my root. The song is 'O Lord, my God..

O Lord my God

1 O Lord my God,
When I in awesome wonders
Consider all the work thy hand has made
I see the stars
I hear the roaring thunder
Thy power throughout the Universe display
Chorus:
Then sing my soul, my Saviour God to Thee
How great Thou art, how great Thou art
Then sing my soul, my Saviour God to Thee
How great Thou art, how Great Thou art

2. When through the woods and forest glades
I wander
And hear the birds sing sweatly in the trees
When I look down from lofty mountain grandeur
And hear the brook and feel the gentle breeze
Chrous:

3. And when I think that God His Son not spearing
Sent Him to die, I scarce can take it in
That on the cross, my burdens gladly bearing
He bled and died to take away my sins.
Chrous:

4. When Christ shall come with shouts of acclamation
And take me home, what joy shall fill my heart
Then I shall bow in humble adoration
And there proclaim my God how great thou hath
Chrous:

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