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DRYING FOR WEALTH, FOOD SECURITY AND NATION BUILDING

By

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Distinguished Academic and Professional Colleagues in FUNAAB and from other Universities;
My Academic Mentors;
President, Nigerian Institute of Food Science and Technology;
Director-Generals,
My Lord Spiritual and Temporal;
Members of my Immediate and Extended Families,
Gentlemen of the Press
Distinguished Ladies and Gentlemen
Great FUNAABITES!

Preamble:

All praise is due to ALLAH, Al-Latif (the subtle) and the protector for His guidance and protection over me throughout.

Mr Vice-Chancellor, Sir,
I feel very happy to be given this singular honour to deliver my inaugural lecture to mark my Golden Jubilee on earth. An inaugural lecture serves as a Town-Gown platform to celebrate the birth of a 'new' Professor. It is an obligation required of a new Professor in the course of his/her academic career in the University. Also, it is a privilege because for various reasons, not all qualified Professors will have such an opportunity to deliver the lecture.

In all, I consider myself very lucky. This is the FIRST inaugural lecture by an alumnus of this great University. To Allah be the grace to be agile to present my inaugural lecture to this audience.

This inaugural lecture is the fifth in the Department of Food Science and Technology. The first was given by my foundation research mentor, the current Vice Chancellor, Professor O.B. Oyewole, followed by my academic father, Professor Engineer S.O. Awonorin, followed by my inspirational mother, Professor (Mrs) S.V.A. Uzochukwu while the fourth was by my dynamic mother, Professor (Mrs.) F.O. Henshaw. This is however the first to be given by an alumnus of the University. To God be the glory.

Challenges we all face is poverty, hunger and malnutrition of large populations. However, achieving food availability, accessibility and affordability should be able to address these problems.

In recent years, there have been a lot of discussions on food security issues. Topics like poor post harvest handling, losses, shelf stability, retention, quality, economic value, are topical issues, which have all been brought about by heavy postharvest losses of agricultural commodities. We have a duty to ensure safe and abundant food for all to ensure wealth creation and stable livelihood as individual, community and corporate entity called Nigeria.

Aligning myself to the wisdom and knowledge of Prophet Yusuf ("Place me (in authority) over the treasures of the land, Surely, I am a good keeper, knowing well" Q12: 55) on preservation.

Vice-Chancellor Sir, distinguished audience, please permit me to present my outputs emanating from over two decades of drying research in this **49th** FUNAAB Inaugural Lecture, the

fifth from the Department of Food Science and Technology and the **Third** from the College of Food Science and Human Ecology with the title "**Drying for Wealth, Food Security and Nation Building**"**.**

1.0 INTRODUCTION
1.1 Food Security

Food is the most basic of human needs and is central to the concept of human rights and social development. Food problems, with regard to quantity and quality, are major characteristics of developing countries such as Nigeria. Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2002). If food security involves access at all times to enough and appropriate foods, then "food insecurity" reflects uncertain access to enough and appropriate foods.

From this definition, four main dimensions of food security can be identified:

1. **Physical Availability:** Food availability addresses the supply side of food security and is determined by the level of food production, stock level and net trade.
2. **Economic and Physical Access to Food:** An adequate

supply of food at the national or international level does in itself guarantee household level food security. Concerns about insufficient food access have resulted in a greater policy focus on incomes, expenditure, markets and prices in achieving food security objectives.

3. **Food Utilization**: Utilization is commonly understood as the way body makes the most of various nutrients in the food, sufficient energy and nutrient intake by individuals is the result of good care and feeding practices, food preparation, diversity of the diet and intra-household distribution of food. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals.
4. **Stability of the other Three Dimensions**: Even if your food intake is adequate, you are still considered to be food insecure if you have inadequate access to food periodically, risking deterioration of your nutritional status. Adverse weather conditions, political instability, or economic factors (unemployment, rising food prices) may have an impact on your food security status.

The concept of seasonal food security falls between chronic and transitory food insecurity. It is similar to chronic food insecurity as it is usually predictable and follows a sequence of known events. However, as seasonal food insecurity is of limited duration it can also be seen as recurrent, transitory food insecurity. It occurs when there is a cyclical pattern of inadequate availability and access to food. This is associated with seasonal fluctuations in the climate, cropping patterns, work opportunities (labour demand) and disease.

A nation experiences food insecurity when no measures are taken to cushion the effects of production and price variation on consumption. In fact, food production variations have always been the primary cause of food insecurity in many developing countries like Nigeria. This situation of food insecurity can also be attributed to the low current growth rates of crop and livestock production of one percent and 0.75% respectively, which are insufficient to cope with the higher overall population demand growing at 3.5% per annum. As a result, the gap between demand and supply has continued to widen as production of food fail to meet the demand both in quantity and quality.

Agriculture has suffered from years of mismanagement, neglect, inconsistent and poorly conceived government policies and the lack of basic infrastructure. Agriculture has failed to keep pace with Nigeria's rapid population growth, so that the country, which once exported food, now relies on import to sustain itself. Per capital food production in Nigeria remains virtually stagnant, suggesting that the food security situation in the country is still a matter of concern, because a nation that cannot feed her citizens cannot have national stability and economic development. Nevertheless, traditional agriculture still remains the major avenue of expanded food production in Nigeria today. Small farms ranging from 0.01 to 5.99 hectares constitute about 80% of the farm holding in the country and contribute about 98% of the food produced in this nation. There is no doubt that lack of capital and technical know-how imposes serious limitations on the level of production in traditional farming systems. Also, Nigeria, which was once the biggest poultry producer in Africa, has had the corporate poultry output slashed from 40 million birds annually to about 18 million. Import constraints limit the availability of many agricultural and food processing inputs for poultry production and other sectors.

1.2 Wealth / Wealth Creation

Wealth is the abundance of valuable resources or materials possession (Njoku, 2001). An individual, community, region or countries that possess an abundance of such possessions or resources is known to be wealthy. Wealth is principally generated in agro-industrial and/or manufacturing sector of an economy. The principle of wealth creation by manufacturing is the basis of many large fortunes. The word industrialist originally referred to someone who creates wealth through manufacturing for a nation. To successfully contribute to wealth creation though manufacturing, it is critical to find a valuable and well-demanded product and market it uniquely. If a society is going to have a net increase in wealth, it must control the products manufacture and the steps that could lead to its value addition.

The role of agriculture and agro-based industries in Nigeria cannot be over emphasized. Agriculture is a source of food for consumption by man, foods for animals and raw material for the agro-based industries. Agriculture contributes to the growth of the economy and also provides employment opportunities for the teaming population and eradicates poverty in the economy. An articulated agricultural revolution and increased value addition activities in the downstream agro-processing sub-sector present a potential platform for effective wealth generation and consequently, sustainable poverty eradication. Nigeria has a huge potential of wealth creation through agribusiness via the manufacture of value added agro-products provided the production of prolific breeds of livestock and cultivation of high yielding crops resulting in sustainable profit, better environmental management and sustainable economic growth and development.

1.3 Nation Building

To understand the concept of nation-building, one needs to have a definition of what a nation is. Early conceptions of nation defined it *as a group or race of people who shared history, tradi-*

tions, and culture, sometimes religion, and usually language. The people of a nation generally share a common national identity, and part of nation building is the building of that common identity. Nation building can then be described as the process of politically socialising the people into becoming good citizens of the political order and making the citizens feel they have a stake in the community worth fighting for (Ndolo, 2005). Obasi and Erondu (2000) posited that nation building is a process of mobilising available resources (human, materials and financial) for socio-economic and political developments of a given nation state. It is worth mentioning that it was the desire to establish and build the Nigerian nation that led to the nationalist struggle. Nation building therefore involves the transformation of existing structures through the collective efforts of the citizens of state (country). Nation building entails strategies designed to bring about long term political stability, rapid economic development and visible social justice. However, I would like to emphasize the fact that nations just don't happen by historical accident; rather men and women with vision and resolve build them.

Agriculture helps contribute to nation building by providing food for the teeming population of the country. When output increases, the incomes of the farmers increase thereby leading to an increase in the standard of living. Similarly, agricultural development is of vital importance to nation building due to the fact that a rise in rural purchasing power as a result of the increase in the agricultural surplus is a great stimulus to industrial development and expansion in the size of the market. The market size for manufactured goods in Nigeria is very small because a large proportion of the population is poverty ridden.

Furthermore, agriculture creates employment opportunities in rural areas. As agricultural productivity and farm income increase, non-farm rural employment expands and diversifies. An increase in rural income as a result of the agricultural surplus tends to improve rural welfare. The rural people build better houses fitted with modern amenities like electricity, furniture, radio farm, etc. They also receive direct satisfaction from schools, health centers, irrigation, banking, transport, and communication facilities, which forestall rural-urban migration thus contributing to sustainable nation building. This is the change Nigerian populace is expecting.

1.4 Post Harvest Losses

The most recent estimates from FAO highlight that 842 million people in the world do not eat enough to be healthy. This implies that one in every eight people on earth goes to bed hungry each night (FAO 2013; Anon, 2013). Current world population is expected to reach 10.5 billion by 2050 (United Nations, 2013), thereby adding to global food security concerns. This increase translates into 33% more human mouths to feed, with the greatest demand growth in the poor communities of the world especially in Sub-Saharan Africa. According to Alexandratos and Bruinsma (2012), food supplies would need to increase by 60% (estimated at 2005 food production levels) in order to meet the food demand in 2050. Production, improving distribution, and reducing the losses can increase food availability and accessibility (Kader, 2005). Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security.

Postharvest food loss (PHL) could also be any measurable loss in quantity (such as physical weight losses) and quality (loss in edibility, nutritional quality, caloric value, consumer acceptability) that occurs between the time of harvest and the time it reaches the consumer (Buzby and Jeffrey, 2011).

Postharvest losses of fruit and vegetables are more serious in developing countries than those in well-developed countries. An additional constraint to improving this situation is that in most developing countries, the number of scientists concerned with post-harvest food losses is significantly lower than those involved in production research. Similarly, more research attention and resources have been devoted to increase food production. About 95% of the research investments during the past 30 years were reported to have focused on increasing productivity and only 5% directed towards reducing losses (APHLIS, 2013).

According to FAO (2013) on a global basis, an annual food loss along the production chain is put at a whooping figure of 1.3 billion tonnes. The pattern of post-harvest losses varies in different parts of the globe based on the type of food commodities and stages in the production chain. Food losses in developed countries are lower in the middle stages of the supply chain because of better infrastructure and efficient processing and preservation facilities. In contrast, a large proportion of production never gets to the consumption stage in developing countries. Ineffective or inappropriate processing technologies, poor or non-existent infrastructure, poor post-harvest handling and lack of efficient value - addition chain are the major contributing factors to high food losses (Aworh, 2008).

Losses after harvest of both quantity (weight losses) and quality deprive farmers of the full benefits of their labour. Food losses do not merely reduce food available for human consumption but also increases costs of waste management, greenhouse gas production, and wastage of scarce resources used in agricultural production (FAO, 2011). Postharvest food losses significantly endanger the livelihoods of stakeholders across the value chain by reducing valuable incomes and profitability. The benefits to consumers from reducing losses include lower prices and improved food security. In addition, postharvest activities such as processing and marketing can create employment.

1.5 The post harvest system

One aspect of food supply that has received little attention to date is the fate of food crops in developing countries like Nigeria from the time it is ready for harvest to the point where it reaches the consumer's table. What happens here is a whole series of events that, taken together, constitute- a post-harvest system (Figure 1).

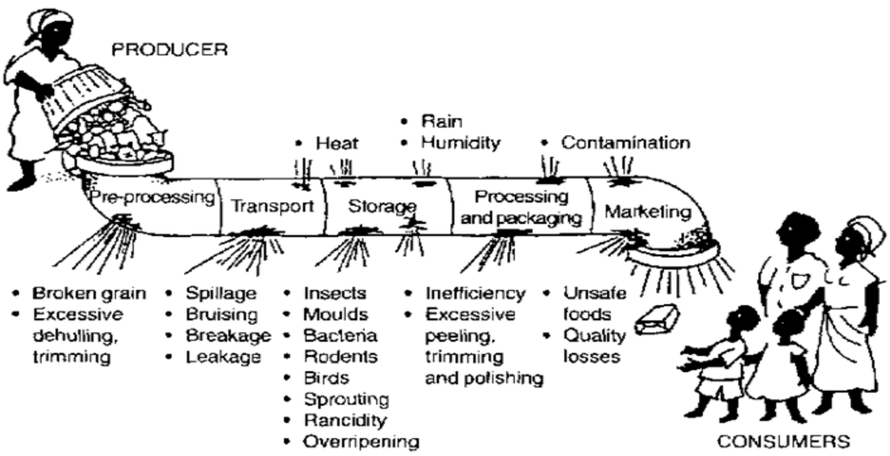


Figure 1: Total Post harvest system (food pipelines) (Source: Paris (1987) as reported by FAO)

Nigerian agricultural system is characterized by large amount of postharvest losses caused by inefficient harvesting and drying methods, delays in harvesting, poor processing techniques, inadequate method of storage and distribution, and even at the consumer end (Sanni, 1999). Therefore, efforts must be made to address these postharvest issues if Nigerian agricultural system must be transformed to that which can catalyze the much-desired economic development. It will also be an opportunity to improve our resources (Hodges et al., 2011).

1.6 Drying

Drying usually refers to the removal of water from materials, in most cases at temperature below boiling points (Sanni, 1999; Karim *et al.*, 2008). Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. Water content of properly dried food varies from 5 to 25% depending on the food. When drying foods, the key objective is to remove moisture as quickly as possible at a temperature that does not seriously affect the nutritional composition, flavour, texture and colour of the food. Two basic phenomena are involved in the drying process, namely: the evaporation of moisture from the surface of the materials and the migration of moisture from the interior of a material to the surface (Sanni, 2000).

There are four major modes of moisture transfer viz:

1. liquid movement caused by capillary forces;
2. liquid diffusion resulting from concentration gradient;
3. vapour diffusion due to partial pressure gradients; and
4. diffusion in liquid layers absorbed at solid interfaces

Drying reduces water activity sufficiently to prevent or delay bacterial growth(Sanni *et al.*, 1999). This in turn extends shelf life and ensures microbial safety of perishable roots and tubers. Drying also reduces weight, making food more portable and easily packaged for onward transport from one place to the other. Hence, postharvest losses can be curtailed through sustainable drying and value addition.

Different kinds of drying systems have been and are still widely used by processors in African countries, some common ones include open air or sun drying, cabinet drying while recently emerging ones are flash dryer, rotary dryer, tunnel dryer, solar cabinet dryers, and a combination of solar and indirect heating of the drying room, which can be described as a hybrid drying system. The traditional drying systems in Africa are characterized by drudgery and high processing losses. Sun drying still remains the dominant forms of drying in Africa.Unfortunately, sun drying has a lot of limitations and drawbacks due to its reliance on nature. This results in products with varied qualities. There are also concerns of contamination and mould growth leading to mycotoxin production.

Exposing food commodity directly to sun for drying is referred to as 'sun drying'. If the commodity is placed in a structure that enhances the effects of the sun's energy, the term 'solar drying' is used. If a controllable source of energy is used to dry, the drying is referred to as artificial or mechanical drying. The drying at rural or domestic level cannot be done artificially because of the high capital investment in equipment and energy required and hence open sun drying is done (Plate 1).

Roadways sun drying **Raised pole** **Blackened surface**

Plate 1: Sun Drying System in Nigeria

Sun drying is beset by several inherent drawbacks such as susceptibility to damage due to inclement weather, slow drying rates and contamination of products. Because of these limitations and the high cost and low utilization of more efficient traditional dryers, advancing practicable and commercial oriented drying systems in Africa becomes a tipping point for intervention.

2.0 RESEARCH CONTRIBUTIONS

2.1 Research Focus

The field of my research is Food Science and Technology at B.Sc. Degree (1990) and Food Technology at M. Sc. and Ph.D. degrees, respectively (1993 and 1999) with a focus on development of appropriate processing, storage and quality regimes for upgrading of traditional local foods in Nigeria. I had worked on commodities such as cassava, yam, okra, plantain, catfish, soybean, locust bean, sweet potato, tomato, etc.

2.2. Solar Drying Research

I started with the design, fabrication and test performance of flat bed solar dryer using okra and yam chips. A forced air-convection solar cabinet dryer (Plate 2) was designed, fabricated and used to study the dehydration characteristics of sulphited and parboiled cassava chips of various thicknesses. Drying kinetics of dried cassava chips are presented in Figure 2. The average rates of drying over the total period were higher for solar dried cassava chips than their corresponding sun dried samples. The fastest drying was observed in the samples dried in the solar dryer with 'fan on' (0.25-0.26 kg/ m^2h). The average temperature readings obtained during solar drying process of cassava chips with 'fan on and off' and the corresponding ambient shows that there is an average difference of 19-29°C between the ambient and chamber temperature during drying of cassava chips.

Plate 2: Forced Convection Solar Cabinet Dryer
Source: Sanni (1993)

Temperatures of 68-72°C (Solar dryer) and 35-37°C (ambient temperature) were recorded. The lower maximum chamber temperature for solar dryer of cassava chips with 'fan on' shows the effectiveness of heat distribution during drying as the fan blows hot air across the product surface almost quickly. Moisture contents reached minimal levels faster for forced convection solar dried samples. Generally, falling rate periods were founds.

Faster drying rates were observed for solar dried samples than the natural types. Also comparing the drying rate of the pre-treated samples, drying rates of those samples that were dipped in 2% sodium metabishulphite solution before drying gave the highest drying rates while parboiled cassava chips formed hard coat during drying-a case hardening and this would surely impede drying. Drying rate was affected in chemically and parboiled treated samples with 9 mm chemically treated cassava chips as the best. The diffusivity of dried cassava chips (Table 1) ranged from 0.60 to 2.64 x 10^{-7} m^2/h and 0.39 to 1.13 x 10^{-7} m^2/h for convective solar dried samples and natural convective solar dried samples, indicating higher rate of moisture removal for the solar dried samples.

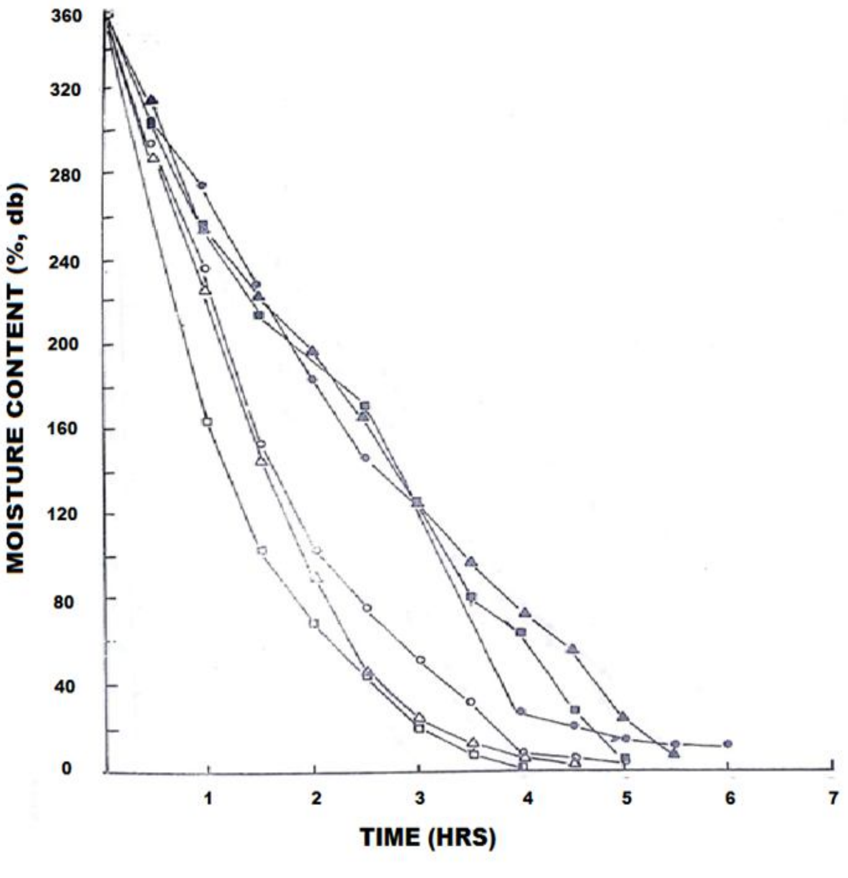


Figure 2: Drying Kinetics of Cassava Chips using solar cabinet dryer
Source: Sanni *et al*. (1998)

Table 1: Diffusivity for dried cassava chips

Thickness (mm)	Without Blower		With blower	
	Solar	Ambient	Solar	Ambient
10	2.16	0.60	2.64	1.13
9	0.90	0.49	2.48	0.82
8	0.60	0.39	2.30	0.69

Source: Sanni et al. (1998)

2.3 Effect of different drying methods on *Lafun* (fermented cassava flour)

Lafun is a fine powder prepared from dried fermented cassava root. It is usually made into stiff dough in boiling water before consumption. Authors such as Oyewole and Odunfa (1988) reported several pre-drying options to improve the quality of *lafun*. Sanni, *et al.* (1998) researched into the effects of solar, oven and sun drying on the composition and sensory qualities of *lafun*. Irrespective of the drying method there were no significant differences in the proximate composition or acidity of *lafun* (Table 2). Sun-dried samples had the lowest cyanide content (Tables 3) and lowest peak viscosity, but highest retrogradation (set-back) value (Table 4). The oven-dried *lafun* had significantly lower water binding capacity and it was highly rated by sensory panellists.

Table 2: Proximate Composition (db) of *lafun* dried by different methods

Parameter	Solar-dried	Oven-dried	Sun-dried
Protein	1.69±0.01	1.65±0.02	1.65±0.02
Carbohydrate	82.30±0.05	82.00±0.01	82.20±0.01
Ash	1.58±0.00	1.58±0.01	1.58±0.01
Fat	0.47±0.01	0.47±0.01	0.46±0.02
Crude fibre	1.58±0.01	1.59±0.01	1.58±0.01
Moisture	12.40±0.01	12.60±0.02	12.50±0.00
Energy	340.19	338.83	338.74

Source: Sanni *et al.* (1998)

Table 3: Chemical properties of *lafun* dried by different methods

Samples	pH	Titratable Acidity (%)	HCN (mg /100g)	Water binding Capacity (%)	Amylose content (%, db)
Fresh roots	7.06 (0.03)	0.07 (0.02)	12.82 (0.10)	115.2 (0.00)	14.78 (0.01)
Oven-dried *lafun*	4. 84 (0.01)	0.27 (0.00)	0.08 (0.02)	127.8 (0.04)	17.13 (0.02)
Solar-dried *lafun*	4. 84 (0.01)	0.26 (0.01)	0.03 (0.03)	136.2 (0.02)	17.13 (0.03)
Sun-dried *lafun*	4. 86 (0.01)	0.29 (0.03)	0.01 (0.01)	135.8 (0.03)	17.76 (0.00)

Source: Sanni *et al.* (1998)

Table 4: Pasting characteristics of *lafun* dried by different methods

Parameter	Solar-dried	Oven-dried	Sun-dried
Pasting temperature (°C)	69	72	70
Gelatinization time (min)	22	26	25
Temperature at peak viscosity (°C)	93	91	84
Peak viscosity (Vp) BU	885	810	700
Time to reach Vpi Mn (min)	40	38	36
Viscosity at 95°C BU	840	700	620
30 min hold at 95°C (Vr) BU	335	208	360
Cooled to 50°C (Ve) BU	400	495	670
Ease of cooking (Mn-Mg) min	18	12	11
Hot paste stability (Vp-Vr) BU	550	602	320
Setback (Ve-Vp) BU	-485	-415	-30
Gel index (Ve-Vr) BU	65	290	310

Source: Sanni *et al.* (1998)

2.4 Effect of drying methods on the chemical and sensory qualities of *Iru*

'*Iru*' is a fermented product of African locust bean. The product is given three names in Nigeria-*Iru* in the South West, '*Dawadawa*' in the North and '*Ogiri-gala*' in the South East. It is widely acceptable for its flavoring characteristics as a condiment. *Iru* is highly perishable product owing to its high moisture and protein content that can support microbial growth. The effect of microwave, cabinet and sun drying methods on the chemical and sensory qualities of *iru* was investigated in Sanni and Francis, 1999. As shown in Table 5, moisture of microwave dried samples had lower value of 6.5% compared to cabinet (7.5%) and sun dried samples (15.1%). In terms of overall acceptability, microwave dried *iru* had the highest rating (7.1%) followed by cabinet dried *iru* samples (7.0) and sun dried *iru* samples (6.7) (Sanni and Francis, 1999).

Table 5: Chemical and sensory qualities of *iru*

Properties	Fresh Iru	Microwave dried (15 min, 135°C, 350W)	Cabinet Dried Iru (2 days, 70°C)	Sun Dried Iru (3 days, 25±3°C)
Proximate composition				
Crude protein (%)	42.2	39.9	40.3	40.2
Fat (%)	34.4	31.3	32.3	31.4
Ash (%)	4.1	3.9	4.0	3.9
Moisture (%)	54.4	6.5	7.5	15.1
Free Fatty Acid (%)	0.12	0.03	0.04	0.05
pH	8.2	7.9	8.1	8.1
Sensory Qualities				
Colour	8.8a	7.0a	5.6b	8.0a
Odour	8.1a	6.7a	6.7b	6.2b
Texture	8.0a	7.8a	7.8a	7.8a
Taste	8.4a	6.6b	6.8b	6.5b
Overall acceptability	8.3a	7.1a	7.0a	6.7a

Source: Sanni and Francis, (1999).

2.5 Solar Drying of Soybean

Soybean (*Glycine max. (L.) Merill*) received a lot of research attention n the nineties in Nigeria, because of its high protein content (40%) and potential to solve the protein-calorie malnutrition of the ever expanding population in the country (IITA, 1989). Soybean is often converted into some other products before consumption and the sequence of these processes have been documented (IITA, 1989). Some of the conversion processes involve blanching and drying. The drying at rural or domestic level cannot be done artificially because of the high capital investment in equipment and energy required and hence open sun drying is done. The grain is spread on different surfaces, such as rocks, tarred roads, cement floors or cement floors covered with black polythene films, which absorbs solar energy and enhances drying (Sanni, 1999). Sun drying of soybean is beset by several inherent drawbacks such s susceptibility to damage due to inclement weather, slow drying rates, and contamination. Because of these limitations, the adoption of a modified sun drying process called solar drying has been considered for the drying of low volume materials in the rural areas. A study was therefore conducted to determine the effect of sun and solar drying on the drying temperatures, heat fluxes, proximate composition and functional properties of soybean (Sanni *et al.*, 2000). A forced-air convection mixed mode solar dryer previously constructed in the Department of Food Science Technology, University of Agriculture Abeokuta, Nigeria was used (Plate 3). It consists of the glazed solar collector (0.04×0.04×0.5m) and drying chamber (maximum drying area of 0.43m^2) connected together by an insulated polyvinyl pipe 0.1m diameter with a suction fan (3,300 rpm.) located at right hand side of the drying chamber.

Plate 3. Indirect forced convection solar dryer
Source: Sanni *et al.* (2000)

As in Figure 3, temperature ranges from 30-35°C, 64-78 RH, 481-510 WM^{-2} for ambient compared with solar temperature of 44-63°C, 49-62 RH and 524-718 Wm^{-2}.

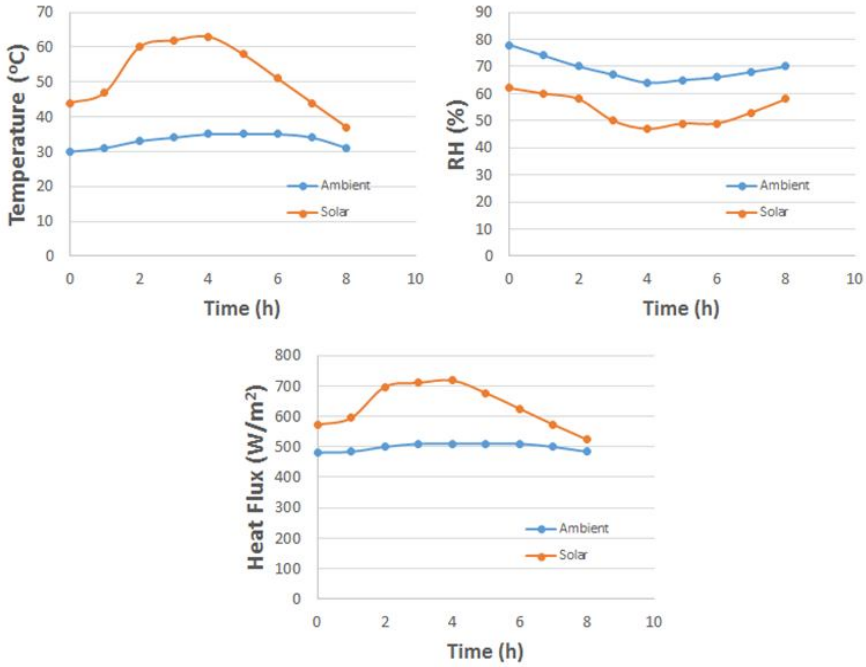


Figure 3: Air temperature and relative humidity variations in the solar dryer cabinet compared with the ambient during soybean drying experiment (Source: Sanni *et al.*, 2000)

Table 6 shows the proximate compositions of sun and solar dried soybean. The moisture removal was greater for solar dried samples (from initial moisture content of 180.0% dry basis to 7.3% dry basis) after 2 days of elapsed drying time while sun dried samples took 3 days of elapsed drying time before reaching constant moisture content of 11.0% from 180.0% dry basis. From Table 6, crude protein content (N×6.25) of the solar dried samples (47.0%) was higher than that of the sun dried sample (45.0%). Except for variation in moisture content and protein values of dried soybean samples, other proximate values were not appreciably different from each other.

Table 6: Proximate Composition (%) of dried soybean

Proximate	Uncontrolled solar dried	Controlled solar dried
Moisture	11.00 ± 0.2	7.00 ± 0.2
Protein	45.00 ± 0.5	47.00 ± 0.5
Fat	23.00 ± 0.1	23.00 ± 0.1
Ash	4.70 ± 0.1	4.70 ± 0.1
Crude fibre	2.10 ± 0.2	2.10 ± 0.2
Carbohydrate (by Difference)	14.20 ± 0.0	15.20 ± 0.0

± Standard deviation from mean. Source: Sanni *et al.*(2000).

As in Table 7, solar-dried samples had higher gelation capacity, foam stability, water and oil absorption capacity but lower foaming capacity, emulsification capacity, nitrogen solubility and bulk density than the sun dried samples. Since water absorption capacity is related to initial water content of samples, the lower value of moisture content (7.30±0.20% dry basis) for solar dried sample indicates that solar dried sample will absorb moisture content better than, sun-dried sample (11.00±0.20% dry basis). Solar dried soy flour samples had lower bulk density values (0.60±0.10) than the sun dried samples (0.66±0.10).

Table 7:Functional properties of dried soyflour

Properties	Uncontrolled solar dried	Controlled solar dried
Gelation capacity (%)	14.00±0.10	16.00±0.10
Water absorption capacity (g/g)	3.00±0.10	3.98±0.00
Fat absorption capacity (g/g)	1.58±0.30	1.74±0.30
Foam capacity (%)	9.00±0.30	7.50±0.20
Foam capacity after 13 minutes (%)	94.44±0.20	93.33±0.10
Emulsification capacity (ml/g protein)	5.00±0.30	0.60±0.40
Nitrogen solubility (%)	28.00±0.20	24.00±0.10
Bulk density (g/cm^3) protein	0.66±0.10	0.60±0.10

Standard Deviation for replicates determinations
Source: Sanni *et al.*(2000)

2.6 Modelling drying kinetics of leafy vegetables under open sun

Open sun drying experiments in thin layers of crain-crain (CC), fever (FV) and bitter (BT) leaves grown in Abeokuta, Nigeria were conducted (Sobukola *et al.*, 2007). The drying process took place in the falling rate period and no constant rate period was observed from the drying curves (Figure 4). Eight thin layer mathematical drying models were compared using the multiple determination coefficients (R^2), reduced chi-square (χ^2) and root mean square error (RMSE) between the observed and predicted moisture ratios. Accordingly, Midilli *et al.* model satisfactorily described the drying curves of the three leaves with R^2 of 0.9980, χ^2 of 2.0×10^{-4} and RMSE of 1.09×10^{2} for CC leaves; R^2 of 0.9999, χ^2 of 2×10^{-6} and RMSE of 1.11×10^{-3} for FV leaves; and R^2 of 0.9998, χ^2 of 1.9×10^{-5} and RMSE of 3.3×10^{-3} for BT leaves. The effective diffusivity was found to be 52.91×10^{-10}, 48.72×10^{-10} and $43.42\times10^{-10} m^2/s$ for CC, BT and FV leaves, respectively.

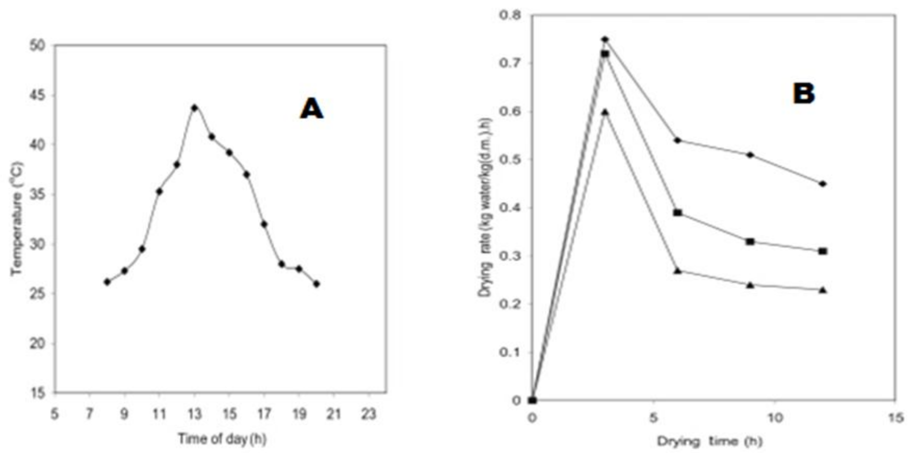


Figure 4: Variation of ambient temperature (a) and drying rate of leafy vegetables versus drying time (b) during open sun drying of leafy vegetables [(w) CC leaf, (n) FV leaf, (▲) BT leaf] in October 2005
(Source: Sobukola *et al.*, 2007)

2.7 Optimization of pre-fry drying of yam slices using response surface methodology

The effect of convective hot-air drying pre-treatment and frying time at a frying temperature of 170ºC on moisture and oil contents, breaking force (crispness) and colour parameters of yam chips was investigated (Sobukola *et al.*, 2007). Response surface methodology technique was used to develop models for the responses as a result of variation in levels of drying temperature (60-80ºC), drying time (1-5 min) and frying time

(2-6min). Drying pre-treatment had a significant effect on oil and moisture contents, breaking force and colour parameters of yam chips, with water removal exhibiting a typical drying profile. Response surface regression analysis shows that responses were significantly ($P < 0.05$) correlated with drying temperature and time and frying time. The optimum pre-fry drying condition observed was a drying temperature of 70-75ºC for about 3–4 min while frying for 4–5 min (Figure 5).

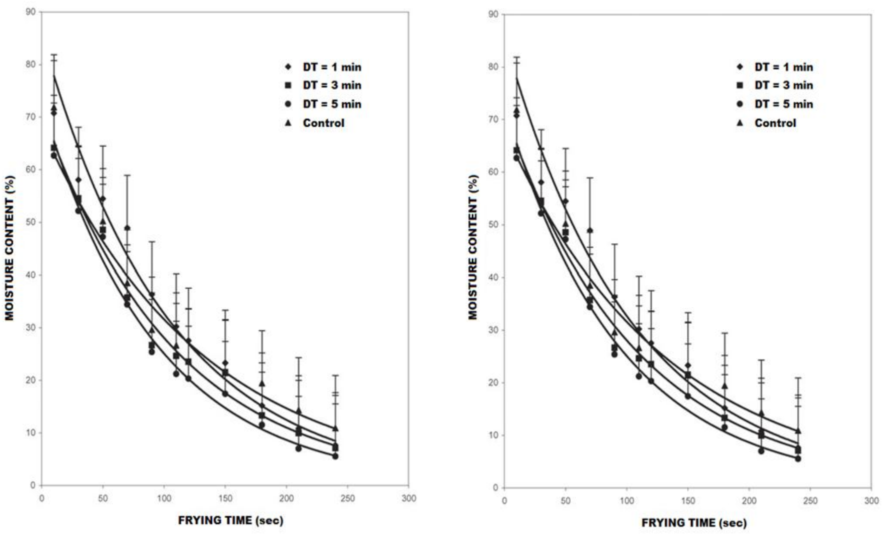


Figure5: Effects of (A) pre-fry drying time (DT) at 70°C on moisture content versus frying time of yam chips fried at 170°C, and (B) pre-fry drying temperature (DTm) on moisture content versus frying time of yam chips fried at 170°C. Source: Sobukola *et al.*, 2007

2.8 Nutrient retention and sensory characteristics of dried leafy vegetables

Drying is a major way of reducing losses of vegetables due to their high moisture content. But conventional dryers are too expensive for peasant farmers, who are the predominant growers of vegetables. Solar dryers have advantages of being cheaper than conventional dryers and are more efficient than sun drying. Vegetables are important for their high mineral and vitamin contents. The effect of sun (30°C), solar (55°C) and oven (60°C) drying on two Nigerian leafy vegetables (*Corchorus olitorius* and *Solanum macrocarpon*) were investigated (Shittu *et al.*, 1999). Oven drying took place most rapidly giving the least moisture contents of dried samples. The more severe drying conditions (higher temperature and forced air flow) in the oven dryer caused higher losses of ascorbic acid (44.60-46.30%) and characteristic colour (67.50-83.33%). Sun dried samples were inferior in term of appearance and colour, which might be due to mouldiness. There was no significant difference in the sliminess of dried *Corchorus olitorius* samples. Sun and solar drying retained more ascorbic acid compared to oven-dried samples (Table 8).

Table 8. Drying characteristics and sensory qualities of dried leafy vegetables using three drying methods

Parameter	*Corchorous olitorius*			*Solanum macrocarpon*		
	Sun	**Solar**	**Oven**	**Sun**	**Solar**	**Oven**
Drying Characteristics:						
Drying time (h)	4.25	3.00	1.25	4.00	3.00	0.80
*Drying rate (h^{-1})	29.12	32.22	66.20	28.90	48.33	75.20
Final moisture (%, d.b.)	14.47	3.46	2.19	15.74	3.84	3.10
% loss in ascorbic acid	35.60^{a}	39.55a	46.30^{b}	32.16^{a}	37.02^{a}	44.02^{b}
% Colour loss	45.00^{a}	43.25a	67.50^{a}	33.40^{a}	61.67^{b}	83.33^{c}
Sensory properties:						
Appearance^{A}	2.00^{a}	2.17^{a}	1.80^{a}	2.10^{a}	2.56^{b}	2.36^{b}
Appearance^{B}	2.38^{a}	2.50^{a}	2.10^{a}	2.14^{a}	2.40^{b}	2.52^{b}
Odour^{A}	2.27^{a}	2.10^{a}	2.00^{a}	2.36^{a}	2.36^{a}	2.40^{a}
Odour^{B}	1.96^{a}	2.34^{a}	2.40^{b}	2.32^{a}	2.66b	2.70^{b}
Sliminess	2.13^{a}	2.38^{a}	2.26^{a}	ND	ND	ND
Overall acceptability	2.12^{a}	2.49^{a}	2.12^{a}	2.26^{a}	2.50^{b}	2.50^{b}

Values followed by the same letter within same row are significantly different by Turkey's LSD (P = 0.05).
A-uncooked sample B-Cooked sample. ND- Not determined * Rate of moisture loss.
Source: Shittu*et al.*(1999).

2.9 Chemical and sensory qualities of pre-treated dried Nigerian Catfish (*Clarias gariepinus*)

Fish is highly perishable, hence, the need for its preservation immediately after harvest. Wet curing, drying and smoking had been reported to be good preservative techniques for fresh fish. A study conducted by Sanni and Ojelade (1999) on the effect of drying methods on the chemical and sensory qualities of salted and unsalted Nigerian catfish showed that the drying time for oven dried samples were 11 h compared to 18 h recorded for solar dried cat fish. Salted dried fish recorded the lowest fat content with salted solar dried sample giving the least value of 18%. Salting was found to generally result in dried catfish of lower protein and lipid values probably as a result of the oxidizing effect of salts on fish lipids (Tables 9).

Drying of salted catfish affected the values of TVB-N and TBA significantly ($p<0.05$) with solar dried catfish recording the highest values. The TVB-N is an indicator of nucleotide breakdown in fish where the bacteria enzymes convert Trimethylamine oxide into trimethlamine and decompose the amino acids and proteins forming ammonia, hydrogen sulphide and other volatile bases. From the results, salted oven dried catfish would keep better the other dried samples. The TBA measured mg malonaldehyde per kg fish. Malonadehyde is a product of lipid oxidation. There were no significant differences in the colour, flavor and texture of unsalted catfish.

In terms of taste and overall acceptability, there were significant differences ($p<0.05$) between dried catfish samples, with unsalted oven-dried fish samples rated best followed by the salted oven-dried fish samples. Salted solar-dried samples were the least acceptable. This may be due to the fluctuations of heat energy from the sun drying. Since fish is a consumer product, oven drying of catfish was recommended for com-

Table 9: Chemical and sensory qualities of pre-treated dried catfish

Properties	Unsalted		Salted	
	Solar	**Oven**	**Solar**	**Oven**
Proximate composition:				
Moisture (%, db)	8.9[a]	8.3[a]	9.1[a]	8.4[a]
Protein (%)	71.2[a]	73.1[a]	65.7[a]	68.3[a]
Fat (%)	20.7[a]	23.2[a]	18.0a	18.9[a]
TVB-N (mg/100g)	20.2[a]	17.1[b]	18.9a	17.0[b]
TBA (mgmol/kg)	2.7[a]	2.3[a]	2.9a	2.4[b]
Sensory Qualities:				
Colour	6.1[a]	6.7[a]	5.2[b]	5.6[a]
Flavour	5.9[a]	6.9[a]	4.8[b]	5.1[b]
Texture	6.0[a]	6.4[a]	5.6[b]	6.2[a]
Taste	5.5[a]	7.1[a]	3.9[c]	7.1[a]
Overall acceptability	5.6[a]	6.9[a]	4.5[c]	5.7[a]

Means of each attribute followed the same letter are not significantly different at 5% level. Collector temperature: 41-32°C. Drying chamber temperature: 352-32°C; Relative humidity: 64-55%; Carcass temperature: 45-32°C; Ambient temperature: 39-32C. Drying time for samples solar and oven-dried catfish were 18 and 11 h respectively. Source: Sanni*et al.*, (1999).

2.10 Foam-Mat Dried Tomato Powder

Tomato (*lycopersicum esculentum*) have become one of the most popularly and widely grown vegetables in the World. Fresh ripe tomatoes are refreshing and appetizing and its consumption has contributes immensely to the vitamins and mineral content of human diet. A large proportion of the crop is used in the sauces and other products. Being a highly perishable fruit, large amount of it is greatly loss annually resulting from poor postharvest handling. Drying is the commonest method of preserving tomatoes. It might involve use of sun, drum, vacuum, and spray drying methods. Drum, vacuum and spray drying technologies are generally useful to produce high quality tomato powder at commercial scale but they are capital intensive and not suitable for small-scale operation, especially in developing countries like Nigeria. Hence, foam-mat drying- as a les an alternative to spray drying are employed. Foam-mat drying involves drying a thin-layer food concentrate presented as foam in a heated chamber with air at atmospheric temperature and has been described to be efficient and inexpensive (Sanni *et al.*, 1999).

Two varieties of Nigerian tomato samples were foam-mat dried at 71°C using glyceryl monostearate as foam stabilizer and subjected to storage conditions of ambient (30 ± 2°C), refrigeration and desiccation for six weeks. From Table 10, moisture content loss from the two samples was about 90%

during drying. Vitamin C content of the tomato samples reduced with percentage loss of 71-72%. Higher reducing sugar value were obtained after concentration of the juice but reduced slightly after foam mat drying. Vitamin C losses were attributed to oxidative changes instituted by elevated temperature during drying. Sensory panellists rated freshly prepared tomato powder and refrigerated stored samples higher in terms of colour, taste and overall acceptability (Table 11).

Table 10: Chemical composition of raw tomato, tomato paste and foam-mat dried tomato powders

Samples	Moisture content (%)	Vitamin C (mg/100g)	Reducing sugar (%)
Raw Tomato:			
Local	95.60 ± 0.01	21.50 ± 0.00	12.00 ± 0.05
Hausa	93.70 ± 0.03	23.70 ± 0.00	15.50 ± 0.08
Tomato paste:			
Local	26.90 ± 0.01	11.70 ± 0.00	18.70 ± 0.10
Hausa	25.40 ± 0.04	13.56 ± 0.03	24.60 ± 0.08
Foam-mat dried tomato powder:			
Local	9.34 ± 0.0	5.99 ± 0.02	15.10 ± 0.01
Hausa	9.27 ± 0.01	6.77 ± 0.01	17.80 ± 0.00

± Standard error. Source: Sanni *et al*. (1999).

Table 11: Mean sensory scores of foam-mat dried tomato powder stored under different storage conditions

Tomato samples	Colour	Taste	Aroma	Overall acceptability
Local variety				
Fresh powder	7.00a	6.10a	6.30a	7.20a
Stored under:				
Ambient condition	5.10b	4.40c	6.30a	4.60c
Desiccation condition	5.10b	4.20c	5.50a	4.50c
Refrigeration condition	5.20b	5.10b	5.90a	5.60a
Hausa variety				
Fresh powder	7.90a	7.00a	7.20a	7.70a
Stored under:				
Ambient condition	6.80b	6.30b	6.40a	6.50a
Desiccation condition	6.60b	5.90b	6.50a	6.70a
Refrigeration condition	6.63b	5.00b	6.50a	6.00a

Source: Sanni *et al.* (1999).

2.11 Fufu Drying

Fufu -a fermented cassava (*Manihot esculenta* Crantz) product is traditionally sold in the wet form (moisture: about 50 %), which renders it highly perishable (Sanni *et al.*, 1998). During fermentation of foods, several compounds are formed and several intermediate products are fermented (Doetsch and Cook, 1973). Some of the organic acids produced during cassava fermentation have been identified as the sources of the characteristic odours of fermented products (Ohochuku and Balantine, 1983). As shown in Table 12, the acids identified are butanoic acid, propionic acid and acetic acid (Ohochucku and Balantine, 1983; Blanshard, 1994). Efforts to reduce or remove these odours, which make some fermented cassava products objectionable to many, include the use of hydrogen peroxide treatments (Ohochukwu, 1985), and aeration, with citric acid treatment (Okechukwu *et al.*, 1984). The drying of fufu paste caused a reduction in the acidity (0.28 - 0.48 (g / kg, lactic acid) that was reflected in increased pH values (Table 12).

Table 12: Acidity and Volatile Compounds (µg /20g *fufu* weight) of wet *fufu*

Volatile component	Retention time (min)	Concentration (µg/g solid *fufu*)
1- Butanol	8.56	1.12 ± 0.1
Formamide N, N-Dimethyl	12.63	8.04 ± 1.4
Acetic acid	17.60	2.24 ± 0.1
2 ethyl- 1-hexanol	18.98	0.03 ± 0.0
Propionic acid	20.75	0.08 ± 0.0
Butanoic acid	23.71	46.56 ± 0.0
pH	n.a.	3.64 ± 0.0
Titratable acidity (Lactic acid, g/kg)	n.a.	0.65 ± 0.0

± Standard deviations for two determinations. n.a.- not applicable.
Source: Sanni *et al*. (2000).

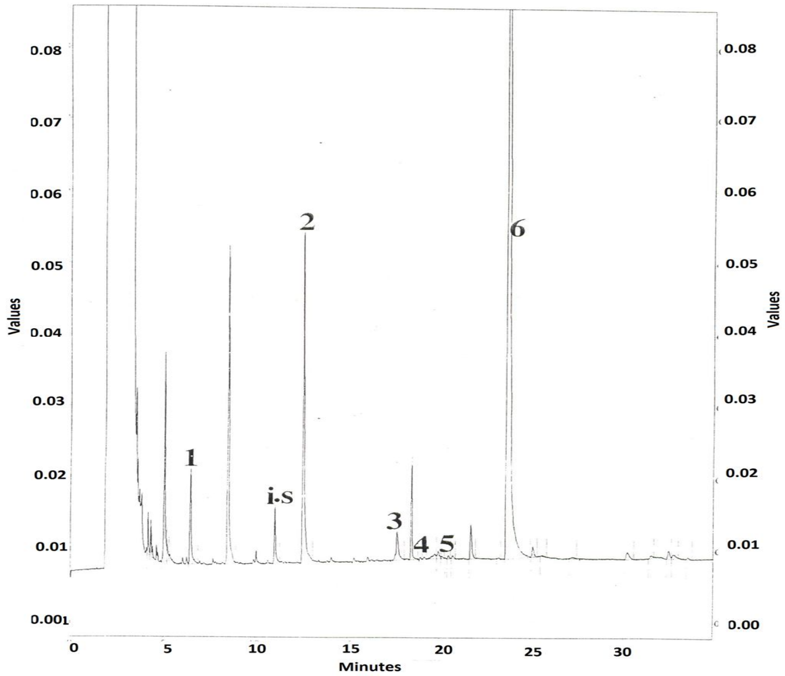


Figure 6: A typical volatile chromatogram of *fufu*

Source: Sanni *et al*. (2000)

A practical approach to improving the shelf life and marketability of *fufu* is by converting wet *fufu* paste to a dried product. Okpokiri *et al.* (1985) reported that good quality dried *fufu* was produced when wet *fufu* was dried in the oven at 55ºC for the first 8 hours and thereafter increasing the drying temperature to 80ºC. Drying of *fufu* in an oven at 60ºC for 48 hours reduced the strong odour of *fufu* but the product was sticky, bland and unacceptable compared to wet *fufu* (Akingbala *et al.*, 1991). A system of controlled drying that would retain the desirable qualities of *fufu* is required. This section summarizes studies to optimize drying variables, such as temperatures, air velocity and air moisture content, using as indices desirable *fufu* quality parameters.

2.11.1 Falling rate phenomenon observed in fufu drying

The kinetic curves in Figure6 shows the drying rates versus drying time and drying rates versus moisture content, of dried *fufu* at different combinations of drying conditions. *Fufu* exhibited the characteristic drying curves known for biological materials. The drying rate initially increased with time initially but later fell. Highest drying rates (49-52 kg / kg h) were observed for samples dried at higher temperatures with elapsed drying time in the range of 5-7.2 hour. At higher drying temperature (65^{o}C) the *fufu* dried faster. Drying process of *fufu* is characterized mostly by diffusive transfer of moisture to the evaporation surface. The moisture content was reduced from between 145-156 % (dry basis) to between 6-19 % (dry basis), with the exception of the sample dried at 45^{o}C, air velocity of 2 m/s and relative humidity of 60% which had 30 % moisture content dry basis even after 11 hours of drying.

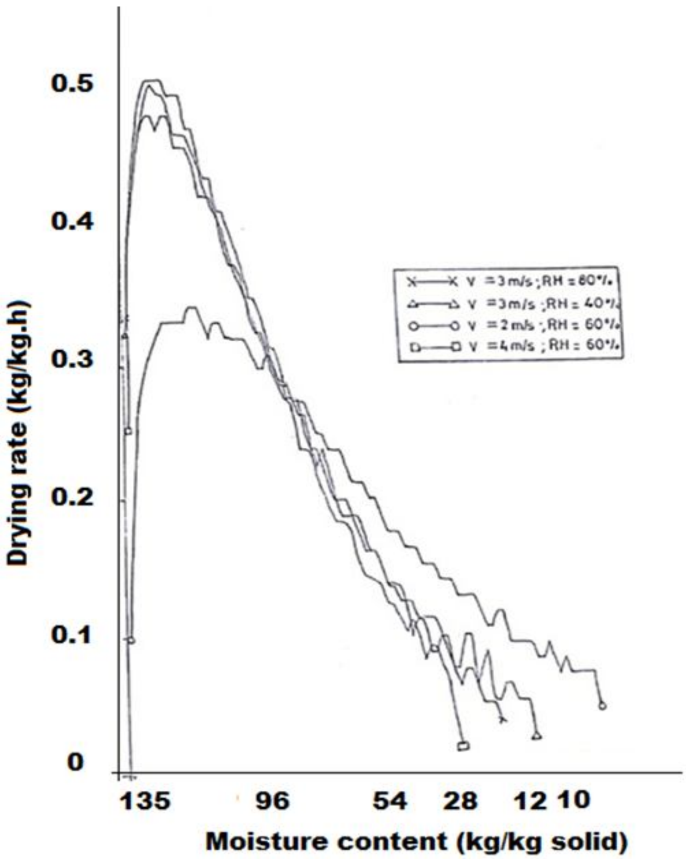


Figure 7: Drying rate curves of wet *fufu* paste at different air speed and temperature
Source: Sanni (1999)

During drying of *fufu* samples in this study, a dry impermeable light brown skin hindering moisture transfer was observed on the material surface of all the samples dried between 45-65°C. Phenomena such as shrinkage and case hardening have been reported to be dependent on drying conditions (Sanni, 1999). However, the depth of the surface hardening was generally too thin to cause any damage to the product.

The higher drying rate observed for dried *fufu* is an indication of effective heat transfer. The analysis showed that for the most critical parameter, K, the optimal values of temperature, velocity and air moisture subject to constraint that they are within the range used in the experiment are: Temperature, T = 65°C, Velocity, V = 4 m / s, Relative Humidity (RH) = 40% (i.e. temperature set at the maximum value tested, velocity set at the maximum value tested, and air moisture set at the minimum value tested). This is because the best model relating K to temperature, velocity and air moisture was found to be:

$$K = 1.2091 + 0.006992*T - 0.06454*V + 6.54*RH \quad (R^2 = 94.1\%)$$

$$B = 428 + 32020*RH + 8.91*T + 533*T*RH + 54.90*V - 9.95*V^2 \quad (R^2 = 57.1\%)$$

The model fitted the data very well, explaining 94.10 % of the variation (R^2) in K. The equations fitted for the other parameters were:

$$A = -22.999 + 4.562*V \quad (R^2 = 20.1\%)$$

The equation for the optimal values of temperature, velocity and air moisture relating moisture loss with respect to drying time is given by:

$$Y = -4.75 + 102.76^{t}$$

This equation is valid for time between 0.5 - 11.00 hours of drying.

2.11.2 Acidity and Volatile components of dried fufu

Drying generally resulted in major losses of volatile gases (Table 13). For example, Butanoic acid reduced from 46.61μg/g dry matter of *fufu* to between 0.01 and 0.12 μg/g dry matter of *fufu* at the end of the drying process. This is a desirable effect, as butanoic acid, propionic acid acetic acid are thought to be responsible for the offensive odour in wet *fufu* (Ohochukwu, 1985). Efforts to reduce or remove these odours in *fufu*, which make the product objectionable to the consumers, include the use of hydrogen peroxide treatment (Ohochukwu, 1985) and aeration, with citric acid treatment (Okechukwu et. al. 1984). This study shows the adequacy of controlled drying as a good method of reducing the suspected volatile components responsible for the offensive odour in *fufu*. Apart from reducing some volatile components such as butanoic acid, drying conditions enhanced retention some desirable volatile components in dried *fufu* samples. This may eventually promotes consumer acceptability of dried *fufu* compared to the wet *fufu.*

The optimum drying conditions for each variable measured during *fufu* drying are presented in Table 14. Temperature had significant effect on pH while titratable acidity was affected by the three drying conditions. Storage days of wet *fufu* before drying were also observed to have strong influence on the titratable acidity. There was very strong evidence of an interaction between temperature and velocity for butanoic acid (R^2 = 90.5 %) followed by dimethyl formamide (52.8%) and acetic acid (37.3%). For butanol, the response was not linear and was affected by the level of air moisture (R^2 = 44.9%).

Since the objective was to reduce the unpleasant smell of *fufu*, the best air drying conditions to achieve this are temperature of 65°C, an air velocity of 5 m/s and relative humidity of 40% RH.

Table 13: Effect of drying conditions on acidity and volatile compounds of dried *fufu*

Drying conditions	Acidity		Volatile components (µg/g dry matter *fufu* weight)					
	pH	TTA	A	B	C	D	E	F
65°C 3m/s 80%RH	3.9	0.4	1.4	1.96	0.8	1.4	0.2	0.3
65°C 4m/s 60%RH	3.8	0.5	2.3	21.8	0.5	0.0	0.0	0.2
65°C 2m/s 60%RH	3.8	0.4	1.1	19.5	1.0	1.8	0.0	1.8
65°C 3m/s 40%RH	3.9	0.4	1.2	19.8	1.0	0.0	0.0	0.0
55°C 4m/s 80%RH	4.3	0.4	1.3	20.8	1.0	0.2	0.0	0.1
55°C 4m/s 40%RH	4.3	0.3	1.1	19.0	1.1	0.0	0.0	0.2
55°C 2m/s 80%RH	4.2	0.4	1.0	20.2	0.9	0.1	0.0	0.4
55°C 2m/s 40%RH	4.3	0.3	1.1	20.8	0.9	0.1	0.0	0.0
45°C 3m/s 80%RH	4.5	0.3	1.0	19.4	1.6	0.1	0.0	0.8
45°C 2m/s 60%RH	4.2	0.4	1.2	21.4	0.9	0.0	0.0	0.2
45°C 4m/s 60%RH	5.4	0.3	1.6	20.1	0.9	0.1	0.0	2.2
45°C 3m/s 60%RH	4.0	0.4	2.2	20.6	1.2	0.1	0.1	0.1
55°C 3m/s 60%RH	3.9	0.4	1.3	20.3	1.2	0.2	0.1	1.0

TTA - Titratable acidity (g/kg lactic acid). A: Butanol;B: Dimethyl formamide; C: Acetic acid;
D: 2-ethyl-1-hexanol; E: Propionic acid;F: Butanoic acid.
Source: Sanni *et al* (2000).

Table 14: Regression models and optimum drying conditions for acidity and volatile components of *fufu*

Model Expression	R^2	Objective	Optimum conditions T (°C)	V (m/s)	RH (%)
$pH = 6.109 - 0.0353 * T$	37	Maximize	65		
$TA = 2.185 - 0.0464 * T + 0.0472 * S - 0.0058 * S^2 - 143.3 * RH + 2.447 * T * RH - 0.2082 * V + 0.003696 * T * V$	90.4	Maximize	65	4	80
$\text{Butanol} = 23.83 + 0.241 * V - 0.619 * T + 0.0037 * T^2 - 723 * RH + 12.37 * T * RH$	44.90	Maximise	45	4	40
$DMF = 2.3 - 0.285 * T + 4144 * RH - 124800\ RH^2\ 3.04 * V + 0.0912 * T * V$	330	Minimize	45	2	60
$\text{Acetic acid} = 6.87 + 2.030 * V - 0.342 * V^2 + 0.206 * T - 0.00202 * T^2$	52.80	Maximize	51	3	-
$2\text{-}ethyl\ 1\text{-hexanol} = 2.036 - 0.0401 * S$		-	-	-	-
$\text{Butanoic acid} = 9.79 + 1819 * RH - 53063 * RH^2 - 0.333 * T + 0.00539 * T^2 + 2.595 * V + 0.409 * V^2 - 0.0913 * V * T$	90.5	Minimize	65	4	40
		Maximize	45	4	49

R^2: Coefficient of determination; Op: Optimum drying conditions; T:Temperature; V:Velocity; RH-Relative humidity; S: Dummy variable representing the effect of storage days before drying.
Source: Sanni *et al.* (2000).

2.11.3 Pasting properties of dried fufu

From Tables 15, Dried *fufu* exhibited higher peak viscosity (500-950 BU) compared to wet *fufu* (280 BU) showing higher starch disruption by drying. The viscosity at 50°C of dried *fufu* ranged between 630 and 860 BU compared to 900 BU for wet *fufu*. This is an indication of high retrogradation tendencies in dried *fufu* samples compare to the wet product. The wet *fufu* exhibited a good level of cold paste stability when held at 50°C for 30 minutes. Similar degrees of paste stabilities were obtained for samples dried at 65°C, 3 m/s or 4 m/s and relative humidity of 80% or 60%. *Fufu* dried under different combinations had a much lower level of cold paste stability and this would result in a less firm product, which is likely not to appeal to consumers.

As shown in Table 16, the percentage of association for peak viscosity was very low at 28.7%. The three-dimensional diagram for the peak viscosity against drying conditions of dried *fufu* (Figure 6) highlights the stronger influence of relative humidity compared to other conditions. There is strong evidence ($p < 0.05$) that temperature, air moisture and storage period before drying (as a dummy variable) affected the value of viscosity at 50°C (R^2 = 80.3%). There was also evidence that only temperature and storage period affected viscosity at 50°C for 30 minutes. Retaining firmness of cooked dried *fufu*, which is desirable to consumers, as measured by viscosity on cooling at

50°C, requires control of air drying temperature and relative humidity of the dryer, and of course, the freshness of wet *fufu* before drying.

Table 15: Effect of drying conditions on the pasting properties of *fufu*

Drying conditions	Pasting temp (°C)	Peak viscosity (BU)	Viscosity at 95°C (BU)	Viscosity at 95°C for 20 min (BU)	Viscosity at 50°C (BU)	Viscosity at 50°C for 30 min (BU)
Fresh wet *fufu*	71 (0.0)	280 (21.22)	260 (21.2)	350 (0.0)	900 (63.6)	880 (28.3)
65°C 3m/s 80%RH	70 90.0)	785 (63.6)	750 (14.1)	565 (35.4)	630 (42.4)	595 (35.4))
65°C 4m/s 60%RH	76 (1.4)	740 (28.3)	740 (28.3)	585 (7.1)	655 (7.1)	620 (0.0)
65°C 2m/s 60%RH	70 (0.0)	770 (42.4)	770 (42.4)	615 (14.1)	700 (14.1)	650 (14.1)
65°C 3m/s 40%RH	70 (0.4)	950 (70.7)	950 (70.7)	690 (14.1)	770 (14.1)	710 (14.1)
55°C 4m/s 80%RH	71 (0.2)	810 (14.1)	810 (14.1)	680 (0.0)	800 (0.0)	740 (0.0)
55°C 4m/s 40%RH	81 (0.0)	780 (0.0)	780 (0.0)	640 (0.0)	780 (0.0)	700 (28.3)
55°C 2m/s 80%RH	69 (2.0)	890 (14.1)	890 (14.1)	730 (14.1)	860 (0.0)	730 (14.1)
55°C 2m/s 40%RH	70 (0.4)	860 (0.0)	860 (0.0)	745 (7.1)	820 (0.0)	700 (0.0)
45°C 3m/s 80%RH	71 (0.9)	755 (7.1)	755 (7.1)	700 (0.0)	830 (14.1)	700 (0.0)
45°C 2m/s 60%RH	71 (1.3)	800 (0.0)	800 (0.0)	720 (0.0)	790 (14.1)	695 (7.1)
45°C 4m/s 60%RH	80 (0.3)	500 (0.0)	500 (0.0)	480 (0.0)	700 (0.0)	635 (7.1)
45°C 3m/s 60%RH	70 (0.0)	810 (14.1)	810 (14.1)	710 (14.1)	770 (14.1)	690 (14.1)
55°C 3m/s 60%RH	70 (0.0)	820 (0.0)	820 (0.0)	700 (28.3)	770 (14.1)	700 (0.0)

Source: Sanni *et al* (2000).

Table 16: Optimum-drying conditions for each pasting property measured in dried *fufu*

Model	Objective	R^2 %	Optimum drying conditions		
			T (°C)	V (m/s)	RH (%)
$PT = 59.4 - 4.72*V + 3.56*V^2 + 1892*RH - 789*RH*V$	Maximize	76.8		4	40
$PV = 4243 - 61.2*V + 391088*RH + 11500000*RH^2$	Maximize	38.6		2	40
$\text{Viscosity at } 95^{o}\text{C} = 947 - 61.2*\text{V}$	Minimize			2	
$\text{Viscosity at } 95^{o}\text{C for 20 min} = -264 - 342*\text{V} + 58.6*\text{T} - 0.694*\text{T}^2 + 5.25*T*V$	Minimize	56.9	45	2	
$\text{Viscosity at } 50^{o}\text{C} = 904 + 5.80*\text{T} - 298681*\text{RH} + 9372292*\text{RH}^2 + 80.4*S - 0.828*S^2$	Maximize	80.3	65		80
$\text{Viscosity at } 50^{o}\text{C for 30 min} = -1354 + 51.80*\text{T} - 0.470*\text{T}^2 - 0.47*\text{T}^2 + 29.5*S - 0.330*S^2$	Maximize	57.4	55.1		

R^2: Coefficient of determination; Op: Optimum drying conditions; T:Temperature; V:Velocity; RH-Relative humidity; S: Dummy variable representing the effect of storage days before drying.
Source: Sanni *et al.* (2000).

2.11.4 Sensory acceptability ofdried *fufu*

Based on the findings from the chemical and pasting results above, sensory analyses were conducted on selected dried *fufu* samples. Wet *fufu* made in Nigeria from a low cyanogen cassava was assessed along with selected *fufu* samples made in the UK. The mean sensory scores of wet and dried *fufu* products in the form of paste are presented in Table 17. Generally, there were significant differences for wet and dried *fufu* samples in terms of all the sensory qualities assessed ($P<0.05$). Panelists preferred dried *fufu* samples to the wet *fufu* sample. Reasons for these differences may be due to differences in drying conditions or differences in the raw material. However, informal discussions with panelists indicated that this was due to the reduction in the level of offensive odour in the dried product. This was corroborated by the instrumental results that indicated a reduction in volatiles. There were also significant differences among the dried *fufu* samples. From the results, *fufu* samples dried at temperature of 65°C, air velocity of 2 m/s and relative humidity of 60% had the highest mean scores for all the sensory attributes except texture. In general, there is a good relationship between the sensory characteristics and the other variables measured for dried *fufu.* Particularly, the data showed that the colour of dried *fufu* flour had the highest correlation with its overall acceptability ($r=0.948$, $p<0.05$). This implies that appearance of fufu powder can affect its commercial success. Also, any drying method applied in producing *fufu* flour must not affect its appearance negatively.

Table 17: Mean Scores for sensory evaluation of dried *fufu*

Drying conditions	Drying time (h)	Sensory parameters				
		Colour	Taste	Odour	Texture	Accept-ability
Freshly prepared wet *fufu*	ND	3.89^{c}	4.33^{c}	4.67^{c}	4.67^{c}	4.11^{c}
$65^{o}C$ 4m/s 60%RH	5.0	5.89^{b}	5.33_{c}	5.78^{b}	5.89^{b}	5.22^{b}
$65^{o}C$ 2m/s 60%RH	7.15	7.22_{a}	6.44_{a}	6.89^{a}	6.56^{a}	7.22^{a}
$55^{o}C$ 3m/s 60%RH	7.06	6.56_{b}	5.11_{b}	5.78^{b}	6.78^{a}	6.67^{b}
$55^{o}C$ 2m/s 80%RH	9.82	5.67_{b}	4.89_{c}	5.33^{b}	5.33^{b}	5.89^{b}
$45^{o}C$ 4m/s 60%RH	9.30	5.56_{b}	6.00_{a}	5.67^{b}	5.44^{a}	5.44^{b}
$45^{o}C$ 2m/s 60%RH	10.68	5.11^{b}	6.11^{a}	5.56^{b}	6.44^{a}	5.44^{b}

Mean scores followed by the same letters are not significantly different ($P < 0.05$). ND- Not determined. Source: Sanni (1999).

2.11.5 Effect of drying methods on the yield, moisture contents and acidity of dried *fufu*

Fufu was dried using rotary drier, cabinet dryer and sun drying. The effects on the physical, chemical and sensory properties of *fufu* by the different drying methods were evaluated (Sanni and Akingbala, 2000). The drying methods did not significantly affect the yield, proximate composition or acidity of *fufu*flour (Tables 18-20), but affected the cold paste viscosity, which is well related to products' firmness. Panellists rated the rotary dried *fufu* best (Table 21).

Table 18: Effect of drying method on the yield, moisture contents and acidity of dried *fufu*

Parameter	Rotary	Cabinet	Sun
Drying time (h)	0.5	7.0	11.0
Yield (%)	58.1±0.2	53.2±0.2	50.6±0.1
Final moisture	8.10±0.1	10.2±0.1	11.4±0.1
pH	3.9±9.2	3.8±0.1	3.8±0.3
TTA (% Lactic acid)	0.2±0.0	0.3±0.1	0.3±0.1

± Standard Deviation for three replicates; Moisture content for wet f*ufu* = 40%. Source: Sanni and Akingbala (2000)

Table 19: Proximate composition (dry basis) of fufu dried by different drying methods

Parameters	Rotary	Cabinet	Sun
Protein	1.3±0.1	1.3±0.1	1.3±0.2
Carbohydrate	87.8±0.1	86.2±0.1	85.0±0.1.
Ash	0.5±0.1	0.5±0.2	0.5±0.2
Fat	0.5±0.1	0.5±0.2	0.5±0.2
Crude fibre	1.6±0.1	1.6±0.1	1.6±0.1

± Standard deviation. Source: Sanni and Akingbala (2000).

Table 20: Pasting characteristics of *fufu* dried by different drying methods

Parameters	Rotary	Cabinet	Sun
Pasting temperature (°C)	71	83	72
Gelatinization time (Min)	23	35	26
Temp at peak viscosity (°C)	91	95	95
Peak viscosity (Vp) BU	300	162	250
Time to reach Vp (min)	36	48	40
Viscosity at 95°C (BU)	240	145	248
30 min hold at 95°C(BU)	110	140	90

Source: Sanni and Akingbala (2000).

Table 21: Mean sensory scores of *fufu* dried by different drying method

Parameters	Rotary	Cabinet	Sun
Colour	6.8	6.7	6.5
Texture	6.8	6.5	6.0
Aroma	5.6	5.5	5.5
Taste	6.8	6.7	6.5
Overall acceptability	7.8	7.6	6.7

Mean scores in a column followed by the same letters are not significantly different ($P < 0.05$).

Source: Sanni and Akingbala (2000).

2.11.6 Quality of flash and rotary dried *fufu*

According to Sanni *et al* (2006), *fufu* flour was produced from locally fabricated flash and rotary dryer (Plate 4). The functional, chemical and pasting properties of the *fufu* flour were investigated. The *fufu* flours were also cooked into ready to eat *fufu* paste and subjected to sensory evaluation. There were significant differences in the functional, chemical and pasting properties of the *fufu* flours (Table 22). Sensory panelists rated cooked *fufu* from rotary dryer closer to market *fufu* (Table 23). However, it is recommended that further investigation be carried out on these drying methods to improve on the odour and colour of *fufu* flour so that the end product would have characteristic qualities close to traditional wet *fufu* relished by many *fufu* eaters.

Plate 4: Rotary (A) and Flash (B) Dryers
Source: Sanni *et al.* (2006)

Table 22: Functional, Chemical and pasting properties of rotary and flash dried *fufu* flour

Properties	**Flash dried *fufu***	**Rotary dried *fufu***
Water absorption	48.79±0.77a	96.45±1.09b
Dispersibility	61.00±.41b	56.00±1.41ab
Bulk density	0.85±0.03a	0.97±0.11b
Least gelation concentration (LGC)	5.50±0.71	5.50±0.71
pH	6.50±0.0b	4.18±0.14a
Starch damage	12.60±0.85a	25.90±0.14b
Moisture content	9.90±0.09[a]	9.29±0.24[ab]
Amylose content	21.26±0.72[a]	20.96±1.33[a]
Starch damage	12.60±0.85[a]	25.90±0.14[b]
Peak viscosity	340.16± 0.11[a]	507.51±3.52[c]
Trough	183.13±0.30	186.15±2.14
Breakdown	156.94±0.33[b]	174.00±2.47[c]
Final viscosity	9.87±0.99[a]	431.94±0.50[c]
Setback	136.77±0.74[c]	93.96±0.05[b]
Peak time	4.68±0.07[a]	4.78±0.09[b]
Pasting temperature	63.77±0.03[a]	65.11±0.03[b]

Mean scores followed by the same letters are not significantly different ($P < 0.05$).
Source: Sanni *et al.* (2006)

Table 23: Sensory acceptability of rotary and flash dried *fufu* flour

Samples	Odour	Colour	Texture	Taste	Overall acceptability
Flash dryer	5.80	5.36a	5.83[a]	5.00[a]	5.36[a]
Rotary dryer	5.26	6.00[ab]	5.56[a]	5.53[a]	5.93[ab]
Commercial *fufu*	6.26	6.36[c]	7.46[b]	7.00[b]	7.50[c]

Mean scores followed by the same letters are not significantly different ($P < 0.05$).
Source: Sanni *et al.* (2006)

2.12 Enhancement of texture of ready-to-eat *fufu* from *fufu* flour

2.12.1 The influence of palm oil and chemical modifications on the pasting and sensory properties of *fufu* flour

Fufu has also been dried using different methods likes sun drying, rotary, and cabinet drying. Drying method did not appreciably affect the properties tested but affected the pasting properties. There was an element of stickiness in the dried *fufu*. To complete the strategy of producing acceptable and wholesome *fufu* ,there is the need to improve the stickiness of dried-*fufu*. This project aims to investigate the effects of the addition of palm oil and certain chemicals (citric acid/sodium hydroxide) on the pasting and sensory properties of dried *fufu* flour.

As reported by Sanni *et al.* (2004), there was significant ($p<0.05$) effect of addition of palmoil, citric acid, or NaOH to wet *fufu* on the pasting characteristic of dried *fufu* flour. The pasting characteristics of the samples showed significant differences at the cooling stage. *Fufu* samplewith0.06MNaOH and *fufu* sample with 0.1M citric acid were more stable followed by *fufu* sample with 0.05M citric acid. There were significant differences ($P<0.05$)in the sensory qualities for taste, colour, odour, texture, and overall acceptability of *fufu* with and without addition of palmoil. Sensory evaluation shows that *fufu* sample containing 0.1 and 0.5% palmoil to be the most acceptable in the overall general acceptability ($p<0.05$). The sensory qualities of *fufu* samples modified with acid also vary with the panellists preferring both samples made from wet slurry and *fufu* samples with 0.05M citric acid (Table 24). There exist a negative correlation between sensory texture and peak viscosity starch stability, while a positive correlation exists between sensory texture and setback value for the *fufu* samples.

Table24: Sensory qualities of dried *fufu* with and without palm oil, citric acid, or NaOH

		Palmoil			Citric acid		NaOH	
Properties	Control	0.1%	0.5%	2.5%	0.01M	0.05M	0.01M	0.05M
Taste	6.4a	6.4a	6.1a	5.8b	6.2b	6.7ab	3.6d	4.3cd
Colour	7.7a	7.0a	5.7b	2.6c	6.1c	6.7bc	4.0d	4.7d
Texture	6.2c	6.8b	7.2a	7.4a	6.6b	6.4b	3.3cd	4.0c
Odour	8.0a	7.7a	6.9a	6.0b	6.7b	6.4b	4.2d	4.7d
Overall acceptability	7.7a	8.0a	7.8a	6.7b	6.0b	7.2ab	4.6c	4.8c

Mean scores within the same row followed by the same superscript are not significantly different ($P<0.05$).Source: Sanni *et al.* (2004)

2.12.2 Effect of texture modifiers on the physicochemical and sensory properties of dried *fufu*

Adebowale *et al*. (2005) determined the effect soft exture-modifiers on the physicochemical and sensory properties of dried *fufu*. Glycerol monostearate (GMS) and monoglyceride phosphate (MGP) were added to*fufu*flouratdifferentlevels(0.5%, 1.0%and1.5%) in hydrated and powdered form. The study shown that addition of hydrated GMS or MGP increased the internal stability of starch granules, resulting in reduced swelling and decreased amylose solubility during heating. The relatively high dispersibility and the fact that there is no significant difference (p> 0.05) in the values of dispersibility indicate that the addition of GMS or MGP does not affect reconstitutability negatively (Table 25).The study equally proved that the addition of the hydrated form of GMS or MGP increases stability of cooked *fufu* samples as shown by high values of viscosity after 30 min holding at 95 °C and viscosity on cooling to 50°C as well as values of starch stability which are indicative of the low retrogradation tendency of the cooked *fufu* samples. Addition of GMS or MGP imparts a thickening effect on the samples as shown in the low value of LGC with samples mixed with GMS or MGP compared to the value of the control (Table 26).

Results of sensory evaluation shows that the cooked *fufu* samples treated with GMS or MGP are relatively more acceptable than cooked *fufu* samples prepared without adding emulsifiers. Addition of 0.5% texture modifier to dried *fufu* is economically feasible stemming from the net profit obtained from the cost analysis (Table 27). However, regardless of its profitability, consumer acceptance is a determinant of its overall success. Hence, the results of physicochemical analysis, sensory evaluation and OQI support addition of 0.5% hydrated GMS to dried *fufu*. Given the adequate and favourable business climate and awareness, addition of 0.5% GMS to dried *fufu* gives *fufu* dough that possesses nearly similar textural properties to *fufu* dough from wet *fufu* paste. This in turn is capable of bringing more positive dimension towards *fufu* consumption in Nigeria.

Table 25: Effect of texture modifier on the functional properties of *fufu* flour

Emulsifier Type	Concen-tration (%)	Dispersi-bility* (%)	WAI (%)	WAC (%)	Solubility Index (%)	LGC (%)	Swelling Power			
							70°C	80°C	90°C	100°C
None	0	69. 7	47.7a	119.3a	21.2g	8.7c	16.7e	20.7f	35.1d	45.6cd
GMS (powder)	0.5	70.3	54.4g	136.3g	23.2h	6.7ab	16.9ef	20.8f	35.9d	63.4f
	1	69.6	52.8f	132.3f	26.7j	5.3ab	18.7g	25.4g	42.1e	66.9fg
	1.5	70.1	52.0ef	131.0ef	31.7k	4.7a	20.1h	30.4i	47.0f	69.7g
MGP (powder)	0.5	69.3	50.4c	126.3c	22.4h	6.7ab	17.4f	25.9g	43.5e	56.6e
	1	69.2	49.3b	126.0c	25.1i	6.0ab	18.2g	28.6h	47.9f	58.3e
	1.5	70.2	48.0a	120.0a	30.7k	5.3ab	20.1h	33.5j	50.5g	63.3f
GMS (hydrated)	0.5	69.7	51.7de	129.3de	12.7f	7.3bc	15.5d	19.0e	34.2cd	45.2bcd
	1	69.2	49.2b	123.0b	10.4d	6.0ab	13.1b	15.8c	32.8c	40.7ab
	1.5	69.1	48.9b	121.7ab	6.9b	4.7a	10.4a	14.2b	29.8h	38.0a
MGP (hydrated)	0.5	69.8	52.5ef	131.3ef	11.4e	7.3bc	14.6c	16.5d	32.7c	48.6d
	1	69	51.1cd	127.0cd	7.9c	5.3ab	13.3b	14.3b	28.9b	45.2bcd
	1.5	69.2	49.3b	124.3bc	5.3a	4.7a	10.3a	11.5a	25.6a	41.6abc

Table 26: Effect of texture modifier on the pasting properties of *fufu* flour

Emulsifier Type	Concen-tration (%)	Gelatini-zation Time (min)	Ease of cooking (min)	Pasting Tempera-ture (oC)	Peak viscosity (BU)	Viscosity at 95oC (BU)	Viscosity after 30 minutes holding at 95oC (BU)	Viscosity on cooling to 50oC (BU)	Starch stability (BU)	Set Back Value (BU)	Gelatiniza-tion Index (BU)
None	0	24.5cde	16.5b	68.5ab	440.5a	390.0b	185.5b	475.5c	255.5a	35.5cd	290.5c
GMS (powder)	0.5	24.5cde	8.5a	72.0d	638.0f	400.5c	160.5a	360.5a	499.0j	-279.0a	200.5b
	1	23.5bcd	17.0bc	71.5d	640.0f	557.5f	340.5l	795.5k	300.5b	155.5g	455.5i
	1.5	25.0de	8.2a	71.0d	630.0e	328.0a	220.5d	600.5e	410.0h	-30.0b	380.0e
MGP (powder)	0.5	25.7e	15.7b	71.0d	590.5c	575.0g	248.5e	640.5f	342.0c	45.0d	392.5g
	1	24.2cde	18.5d	70.5cd	720.5i	660.0i	380.5k	797.5k	340.0c	75.0e	415.5h
	1.5	23.2bc	18.0cd	68.5ab	660.0g	632.5j	287.5g	700.5i	375.5e	35.0cd	415.5h
GMS (hydrated)	0.5	24.5cde	17.0bc	70.5cd	625.0e	580.5h	240.5e	580.5d	380.5f	-30.0b	340.0d
	1	24.5cde	16.5b	67.0a	762.5j	640.0k	360.5j	862.5l	402.5g	95.0ef	500.0j
	1.5	24.0bcd	16.5b	67.5ab	662.5g	500.5e	210.5c	382.5b	455.5l	-272.5a	170.0a
MGP (hydrated)	0.5	23.2b	18.5d	68.5ab	565.0b	480.5d	260.5f	675.5h	300.0b	115.0f	415.0h
	1	23.7bcd	18.0cd	69.5bc	692.5h	692.5m	320.5h	710.0j	375.0e	15.0c	390.0f
	1.5	17.5a	18.0cd	67.5ab	605.5d	605.0i	262.5f	652.5g	345.0d	45.0d	390.5f

Source: Adebowale *et al*. (2005)

Table 27: Cost and returns of modified dried *fufu* flour production

Cost	N
Capital and fixed cost	1,018,550
Tax	7,500
TOTAL FIXED COST	1,026,050
VARIABLE COST:	
Salary of Manager/year (at N6,000/month)	72,000
Salary of technicians(2)/year (at N3,000/month)	72,000
Labour wage rate for 10 people (at N5,000/month)	60,000
Electricity	15,000
Maintenance & Repairs	10,000
Cost of polyethylene sheets for packaging	10,500
Purchase of cassava roots (at N10/kg)*	250,000
Purchase of texture modifier (at N1,500/kg)**	195,000
Waste management	1,500
TOTAL VARIABLE COST	686,000
TOTAL COST	1,712,050
RETURNS	
Annual sales of dried *fufu* (at 20% yield) 25 tonnes/ year (N100/kg)***	2,500,000
Cassava peels	5,500
Cassava fibre	2,000
TOTAL REVENUE	2,507,500
NET PROFIT	795,450

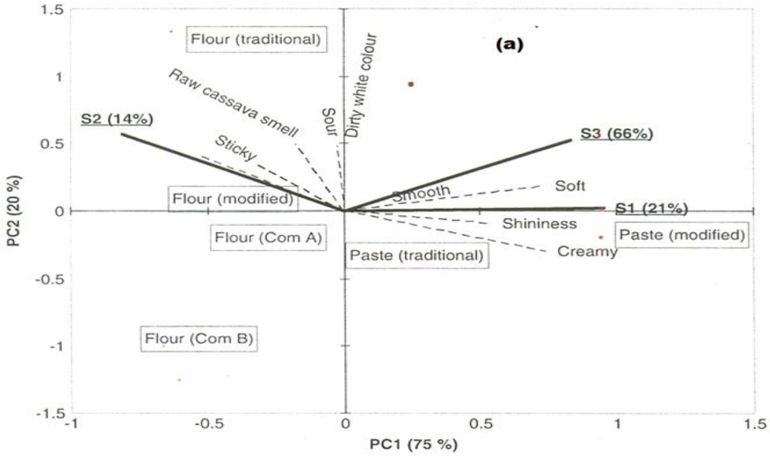
* 2.5 ton cassava roots/week = 125 ton/year (50 weeks per annum)
** At 0.5% Addition of modifier we need 125kg modifier
*** 20% yield of 125 ton = 25 ton *fufu* flour/year
Source: Adebowale *et al.* (2005)

In another study by Sanni and Ayinde (2003), on consumer acceptance and economic feasibility of dried *fufu* production in Nigeria revealed a positive disposition of potential of consumers towards dried *fufu* consumption and a strong willingness to purchase the dried *fufu* when available in the market. The study also revealed that large scale dried *fufu* production is a profitable venture with a positive net present value and a cost-benefit ratio of 0.81 as well as an internal rate of return of 43 percent. It was concluded that dried *fufu* production on a large scale is a profitable venture and it offers a veritable opportunity for investors in the food industry; while there is a ready market for it among the *fufu* consumers in the urban area.

2.13 Consumer acceptability and sensory evaluation of a fermented cassava product (Nigerian *fufu*)

The sensory profile and acceptability of six types of *fufu* (a fermented cassava product) produced by different processes using sensory evaluation and consumer acceptability testing was investigated by Tomlins *et al*. (2007). *Fufu* samples were selected from processors and marketers in Oyo, Ogun and Lagos States to evaluate the acceptability of dried *fufu* flours, which are increasingly being consumed, and compare with a traditional paste and a newly developed paste that produces less environmental waste. Descriptive sensory profiles of the selected samples demonstrated distinct differences in sensory profiles. They were evaluated for consumer acceptance at three demographic locations; Lagos (*n* = 91), Ibadan (*n* = 121) and Abeokuta (*n* = 99), Nigeria. *Fufu* made from a paste that produced less environmental waste had the highest acceptance scores, followed by flour and paste made by the traditional method and finally the remaining flours. Average consumer liking between the three locations did not differ (Figure 8a).

As shown in Figure 8b, three distinct consumer segments were identified and the number of consumers in these segments differed between the locations. Consumers differentiated *fufu* made from pastes and from flour. Internal preference mapping indicated that consumers associated the flours with sensory attributes such as sticky texture and raw cassava odour, while pastes were associated with soft texture, and shiny and creamy appearance. *Fufu* acceptance varied widely among consumers and was related to preferences for distinct *fufu* flavour profiles. Correlations between consumer acceptance scores and sensory scores appeared to be non-linear for many attributes but a larger sample size of *fufu* samples would be necessary to confirm this. The implications of these finding are discussed.



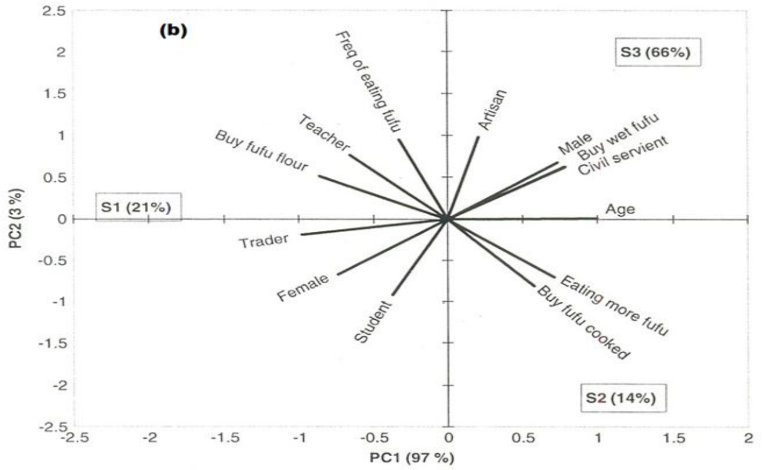


Figure 8: Internal preference (a) and principal component (b) of consumer acceptability and socio-economic profile of *fufu* consumer. Source: Tomlins *et al*. (2007).

2.16 Hybrid Solar House Research for multi-product drying

The performance of a solar hybrid dryer (Plate 5) developed by IITA-CFC was adapted for drying cassava wet cassava cake by our research team (Adedibu *et al*., 2014) at FUNAAB's Industrial Park Unit. The dryer uses agricultural waste as the second source of heat. In our first experiment, the use of agricultural wastes as the second source of energy resulted in faster drying rate when compared with use of solar energy only (Figure 9). The thermal efficiency with the use of cashew nut shell as the second source of heat was the highest followed by use of sawdust. The moisture diffusivity values increased significantly by about 22-1500% with use of the agricultural waste as fuel compared to use of solar energy only (Table 28). The highest drying rate was observed in February while the rate progressively reduced as the experiment moved into May and August. This could have been due to the increasing humidity of ambient air.

Plate5: FUNAAB Solar Hybrid Dryer
Source: Adedibu *et al.* (2014)

It can be concluded that, using a solar dryer that uses the combustion of cassava peel or saw dust as it second source of heat is more suitable in rural setting if the house is closer to the farm, this have the potential to increase the productivity and resultant economic viability of small and medium-scale enterprises producing and processing agricultural produce in tropical countries. This also opens up the possibility of addressing the problem of environmental pollution caused by agricultural wastes generated as well as generating extra income from wastes.

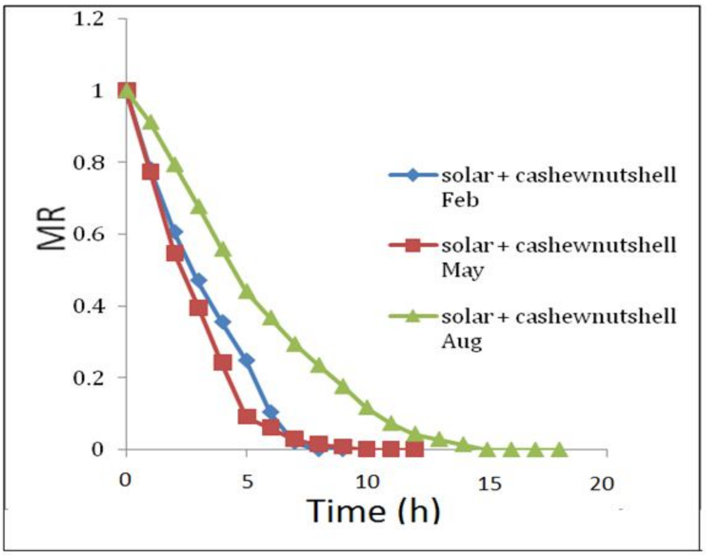


Figure 9: Moisture Ratio of cassava pulp during the three sections of drying using cashew nut shell combustion + solar drying. Source: Adedibu *et al.* (2014)

Table 28: Effective moisture diffusivity of wet cassava cake drying at different time of year

Drying Method	Moisture Diffusivity (m^2/s)		
	February 2014	May 2014	August 2014
Solar	5.00×10^{-6}	2.44×10^{-6}	8.23×10^{-7}
Solar + cassava peel combustion	1.06×10^{-5}	3.24×10^{-6}	1.11×10^{-6}
Solar + sawdust combustion	1.01×10^{-5}	3.54×10^{-6}	8.56×10^{-7}
Solar + cashew nut shell combustion	7.47×10^{-5}	3.62×10^{-6}	1.86×10^{-6}

Source: Adedibu *et al.* (2014).

2.14 Storage Stability

Predictions of storage properties for dried local food products have been established (Sanni *et al.*, 1997). Experimental moisture content values obtained for *fufu* dried using three different drying methods at three different temperatures. In all cases at least three experimental moisture content values were used. The curves show that *fufu* dried using rotary dryer has the highest equilibrium moisture content at all the water activity and temperatures. The sun-dried *fufu* has the lowest moisture content. The difference between the moisture contents of sun dried and cabinet dried *fufu* decreases with increasing temperature. However the rotary dried *fufu* has the lowest initial moisture content (8.6% db) and hence can absorb more water at any given water activity. The initial moisture contents for the other products are 10.2% and 11.4% for cabinet dried and sun dried *fufu*. Other investigators, who observed that the sorption characteristics of dried products are dependent on drying methods, have reported similar results. The GAB model fit the data very well, thus confirming the high correlation coefficients in Table 29.The monolayer values were 3.9-4.4, 4.4-5.4 and 5.0-5.2 (g water/100 g solids) for sun, rotary and cabinet dried *fufu* samples. These values generally increased as temperature of storage increased from 25-45°C.

For most dehydrated food products, monolayer value in the range of 5.4-7.0 (g water / 100 g solids) is suitable for storage

(Sanni, 1999). Thus, the calculated monolayer values of 3.9-5.4 (g water / 100 g solids) obtained for dried *fufu* samples in this work were within the expected levels for storage stability.

Table 29: Comparison of Different models for Rotary Dried *Fufu* at Various Temperatures

Model	C_1	C_2	M_o	Av. Dev	Max Dev	Cor Coef	Nd
At 25°C							
GAB	61.794	0.6643	5.4373	3.148	-0.5084	0.9828	11.11
Chung-	37879	0.3865		3.858	-0.8285	0.98629	33.33
Pfost	-13.91	0.6866		3.969	7.434	-0.98629	33.33
Bradley	7.9198	0.221		4.674	-9.498	0.98528	44.44
Oswin							
At 32°C	84.232	0.6864	4.8997	1.966	-4.03	0.99003	0
GAB	33154	0.3934		2.819	7.029	0.99248	22.22
Chung-	-12.441	0.6787		3.028	6.664	-0.99248	22.22
Pfost	7.387	0.2282		3.492	8.372	0.99104	33.33
Bradley							
Oswin							
At 45°C	44.538	0.7138	4.387	2.21	5.377	0.98262	22.22
GAB	23480	0.3795		3.21	7.429	0.99364	11.11
Chung-	-	0.6875		3.284	7.095	-0.99364	11.11
Pfost	8.5577	0.2599		3.85	9.039	0.99202	22.22
Bradley	6.5826						
Oswin							

C_1, C_2 = Coefficients in the equations. M_o = Monolayer moisture content (kg water/kg solid).
Source: Sanni *et al*. (1997)

2.14.1 Effect of roasting methods on sorption isotherm of tapioca grits

Adebowale *et al.*(2006) reported the sorption characteristics of tapioca grits produced from three varieties of cassava using two roasting methods at temperatures of 25, 32 and 45°C. The roasting methods evaluated were the traditional and rotary methods. The results showed that sorption isotherms of tapioca grits were affected by the roasting method used (Figure 10). At 5% error level, the sorption data were significantly different from each other except for the data for Odongbo variety at 25°C. Similar observations were made by Sanni *et al.* (1997, 1999) and Adebowale *et al.* (2006). Also, for a given temperature, cassava variety and water activity, the equilibrium moisture content for tapioca grits obtained from the two roasting methods were significantly different ($P<0.01$). At 45°C, it would appear that the equilibrium moisture content for the traditionally roasted tapioca is higher.

2.14.2 Moisture Adsorption Isotherm of Yellow-fleshed Cassava Root Starches

Awoyale *et al*. (2014) reported the moisture adsorption isotherm of three yellow-fleshed cassava root starches (YfCRS) at temperatures of 27 °C, 37 °C and 42 °C and water activities level of between 0.10 and 0.80. Data obtained were fitted to four sorption models (Peleg, GAB, Oswin and Langmuir). The model fit was evaluated using the coefficient of determination (R^2), root mean square error (RMSE) and mean percentage deviation (%E). The results showed that Peleg model gave the best fit for predicting the moisture adsorption data of the starches (R^2=0.99, RMSE=0.00, %E=0.00). TMS 06/1630 YfCRS had the highest monolayer moisture (M_o) while that of TMS 01/1368 had the lowest (Table 30). The high β-carotene content of TMS 01/1368 YfCRS could be responsible for its low M_o (r = -0.96), irrespective of the storage temperatures. However, all the YfCRS might be stored for longer periods at all the temperatures since their M_o fall within limit for storage stability.

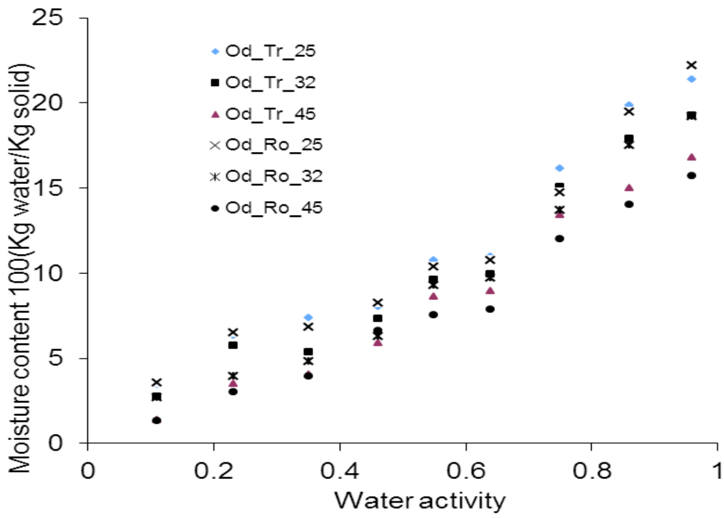


Figure 10: Effect of roasting method on the sorption isotherm of tapioca grits from Odongbo cassava (Od). Tr: Traditional drying; Ro: Rotary drying; Figures represents temperature (ºC). Source: *Adebowale et al. (2006)*

Table 30: GAB monolayer moisture content (M_o) at different temperatures (T) and total b-carotene content of Yellow-fleshed Cassava Root Starches (YfCRS)

Samples	T (°C)	M_o (g H_2O/100 g solid)	Mean M_o (gH_2O/100 g solid)	F -Cal	Total β -carotene content
TMS01/1371YfCRS	42	8.74		1973.69	0.1700(0.00)c
	37	8.84	8.62	3667.64	
	27	8.29		5084.14	
TMS01/1368 YfCRS	42	5.76		1375.45	0.2150(0.01)a
	37	6.74	6.64	2497.43	
	27	7.41		2913.6	
27 TMS06/1630 YfCRS	42	9.6		2725.08	0.1800(0.00)b
	37	8.47	8.75	4621.72	
	27	8.17		2830.39	

Awoyale *et al*. (2014)

2.15 Drying for Wealth: Significant improvements to Rotary and flash dryer for high quality cassava flour

Apart from the Pilot drying facility at FIIRO since late 60s, the development of a indigenous rotary dryer started with ADDIS Engineering, Isolo, Lagos, Nigeria, in the 1980s. The company started with a hand operated rotary dryer (<1 kg daily capacity) fuelled by charcoal. Next came a locally fabricated rotary dryer that could be fired by charcoal or gas and rotated by a 2 hp gear motor/1hp blower electric motor. The rotary dryer was used by Top Rank Foods, Ile-Ife to produce *fufu* flour, maize-cassava blend, pounded yam flour, etc.

The University of Agriculture, Abeokuta, in collaboration with the Natural Resources Institute, Chatham Maritime, Kent, UK, used the rotary dryer at pilot level to commercialize *fufu* flour (popularly known as UNAAB *FUFU*) since 2001. The commencement of ICP in 2004 hosted by IITA spurred the development of a diesel- operated rotary dryer powered by a 6–8 Hp diesel engine by Starron Engineering Ltd, Isolo, Lagos, who installed more than 25 driers in various processing centers in Nigeria. The dryer consists of an insulated drying chamber (drum-like). It has production capacity of 300 kg/ day of flour (Sanni *et al*., 2006).

The commencement of Integrated Cassava project of IITA in 2004 hosted by IITA provided needed opportunity for myself to secure sabbatical leave from UNAAB to serve as the Post-harvest Specialist. In collaboration with colleagues at IITA, local fabricators, electrical/diesel-operated rotary dryers (300 kg/8h) were fabricated and deployed to Niger Delta.

A flash dryer is a pneumatic type dryer, with high temperature (150- 250°C), fuel usage (around 15 L/h) and short residence time (5 s). The flash dryers have power consumption rate of 12-13KW each. The main component parts of the flash dryer are as follows: fuel tank, combustible material reservoir; burner, initiates and sustains combustion; heat exchanger, combustion chamber; suction line, heat path to the pulverizer; pulverizer, breaks the clods of material into wet powder; drying duct, drying tunnel with embedded dampers; cyclone, separates the drying air from the drying product; suction fan, exerts the main suction material and hot air pull; exhaust line, conveys moistened spent air out via the suction fan. The flash dryer has been reported to dry cassava starch, *fufu* flour, cassava flour, cornstarch, poundo yam and any other slurry. Outcome of a brainstorming session (Sanni *et al*., 2007) with Peak Product at IITA Onne, Port Harcourt in 2004 produced a new version of locally fabricated flash dryer with product contact surface made of stainless steel that could produce *fufu* flour, High quality cassava flour (Plate 6).

Plate 6: Peak product Flash Dryer

Our team- *IITA- Cassava Enterprise Development Project (CEDP)* assisted SMEs with 33 flash dryers in the Niger Delta region over a period of five years (2004/05 – 2008/09). Peak products Nigeria exported flash dryers to IITA- Common Fund for Commodity Cassava Project in East Africa (Tanzania, Zambia and Madagascar) in 2005. This serves as impetus to technology developers like myself (Sanni *et al*., 2007).

Also due to the high demand, other fabricators such as Nijilucas, Idimu, Lagos, installed well over 18 flash dryers for the IITA project in different locations in Nigeria (Plate 7).

Plate 7: Nijilucas Flash Dryer

Ladies and gentlemen, on achievement of CEDP, Tarawali and Okarter (2010) reported that project beneficiaries and other stake holders realized income worth $3.2m with over 22,370 gainfully employed and 700 sustainable producer associations strengthened. It should be noted that all SMEs were supported with equipment (**flash dryer inclusive**), installation and capacity building by IITA-USAID-SPDC projects. Most of the processing equipment was multi-product and functional.

Vice-Chancellor, Sir, the 2014 UK times higher education and 2015 UK Guardian award project (Plate 8) for the Natural Resources Institute of the Greenwich University, UK, the Cassava: Adding Value for Africa (C: AVA) carried out tests on some of the traditional flash dryers in 2009.

The test flash dryers consumed between 122 litres and 324 litres of diesel to produce between 709kg and 1074kg of flour/8hours of operation (Sanni and Siwoku, 2014).

The greatest success story in C: AVA's intervention in the development of improved flash dryers in Nigeria is the mentoring of a Nigerian fabricator to produce a flash dryer that meets international standards. The improved versions use only 28 litres of diesel to deliver 1700 kg of HQCF in 8 hours of operation. At an average of about N150/litre of diesel, this is a saving of between N9, 570 to N25, 050 per 8 hours operation. The main elements of C: AVA support included the development of engineering drawings; incorporation of parts that can be easily dismantled by bolting various parts instead of the traditional practice of welding; inclusion of installation, training and operations & maintenance manuals for each set of equipment and general tailoring of flash dryer fabrication to meet international standards.

Plate 8: NRI-C:AVA Awards

By 2010 a new four Cyclone Flash Dryer was assessed and adjudged to have attained 49% efficiency compared to 11% measured in the existing one (Plate 9).

Plate 9: Andrew Marchant analysing the 4-cyclone Flash Dryer at NOBEX Limited

Source: Sanni and Siwoku (2014).

A 6-cyclone FD was installed in another commercial factory in Ekiti in April, 2013 (Plate 10) and FUNAAB just acquired one for *fufu* factory courtesy EU-Cassava Growth Market of NRI-Greenwich University, UK. By 2013, with mentoring, Nobex fabricated 4-cyclone flash dryer with improved fan and heat exchanger. Old dryers used 199 litres of diesel per ton HQCF, newly designed Nobex 4-cyclone flash dryer uses 86 litre/ton (49% efficient) with cost reduction ca. $130/t- 50% fuel cost reduction (Graffham *et al*., 2013).Through the support of the C: AVA project, one of this more efficient 4-cyclone flash dryer has been purchased by a cassava-processing factory was in Malawi for commercial operations starting in February 2013.By March 2014, the Bank of Industry through the Cassava Transformation Agenda commissioned Nobextech with 28 flash dryers for SMEs in Nigeria.

Plate 10: NOBEX Flash Dryer in Oamsal SME, Ayede Ekiti, Nigeria
Source: Sanni and Siwoku (2014).

As a technology developer, Thai Farm (Plate 11) provided necessary impetus for me as a Game Changer. The factory has 60t production capacity with flash dryer from Thailand. The factory is based at Ososa and readily available to supply high quality cassava flour. My team have been working with the company to ensure sustainable production. I had once recommended we need at least 10 of Thai Farms in our regions to transform our drying systems for nation building.

Plate 11: Thai Farm with 60t capacity Flash Dryer at Ososa

There is strong demand for optimizing small and medium scale dryers while keeping the capital and running costs at an acceptable level (RTB, 2014). While the technology used by large HQCF processors will not be adopted by small and medium enterprises, CIAT, CIRAD, IITA and NRI RTB team is carrying out a benchmarking exercise with large enterprises, as the information gained could further guide improvements to the small-scale drying technologies. As opined by RTB, improvements, such as energy optimization and alternative fuel types, could contribute to increasing production capacity, lowering processing costs, and raising the profitability of High quality cassava flour production.

2.15.1 Policy Advocacy

With some advocacy campaigns through annual stakeholders' forum held with relevant stakeholder; practical demonstration of the use of HQCF in various products and the organisation of several stakeholders' forum (Plate 12) to discuss the problem facing the cassava sub-sector in the country, there was a positive shift in the situation as some flour millers are now beginning to purchase HQCF for their use.

Plate 12: Engr. Ayo Olubori, CEO, Peak Products Nigeria Limited & President of NICAPMA addressing the Stakeholders' Forum
,
Source: Sanni and Siwoku (2014)

The aftermath of the several advocacy activities by C: AVA project along with other players has resulted in The Honourable Minister of Agriculture in January 2014 putting his weight behind the HQCF inclusion in composite flour production in the country and has met with all key stakeholders to officially present 10-20% inclusion policy to the Legislature. Also, it created visibility for the project which made many organisations and projects wanting to collaborate with the C: AVA project in the area of value chain development and soliciting for C: AVA project's wealth of experience in identifying stakeholders and markets for their beneficiary groups. Based on data from the Cassava Transformation Program's SME Audit Report Government signed MoU with Bank of Industry to loan 35 SME's money with at least N10m each and working capital. This action will increase daily production of high quality cassava flour from around 20,000 to 44,250 t, generating N3.39b to processors and N13.56b to cassava farmers.

2.17 Nation Building: Case Study of Presidential Initiative on High Quality Cassava Flour using Flash dryer

2.17.1 University-Industry Linkages

My stint as the PostHarvest Specialists at the International Institute of Tropical Agriculture, Ibadan provided multi-stakeholder solutions to market led problems. Cassava flash dryer project was a case study. Assembly team of Engineers, investors, industrialists and fabricators led to strong alliance with Godilogo Farm Ltd, Cross Rivers State, Nigeria. Godilogo, IITA, UNIPORT, UI, SEDI, EDO ADP, FIIRO for the designed and fabricated cassava flash dryer producing 250kg/h. The Raw Materials Research Development Council (RMRDC) funded the official commissioning of the hybrid flash dryer on August 19, 2008 (Plate 13).

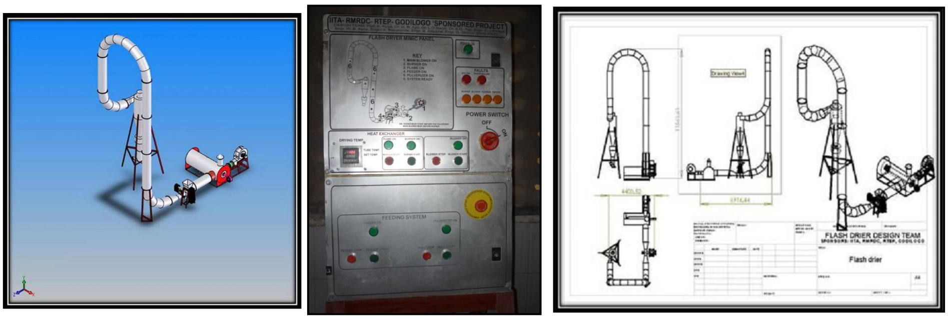


Plate 13: Newly fabricated flash dryer
Source: Kuye *et al*.(2008)

This validated the workability of Public-private Partnership in Agricultural Development in Africa. This innovation also demonstrated impact of government policy through the Presidential Initiative on Cassava and government support via RMRDC. This is an example of better ways for government to act as a mediator or catalysts for UIL and innovation (Juma, 2011).

The most interesting news is that Cassava: Adding Value for Africa (2008 to date) had significantly improved the efficiency of Nigerian made flash dryer. Following the findings of the national Audit of cassava processing SMEs (Plate 14) coordinated by C: AVA Nigeria in FUNAAB, it is imperative to retrofit some additional SMEs as most processing factories are pulling away from the production of HQCF as a result of high production costs and the price at which the end users are willing to buy the HQCF.

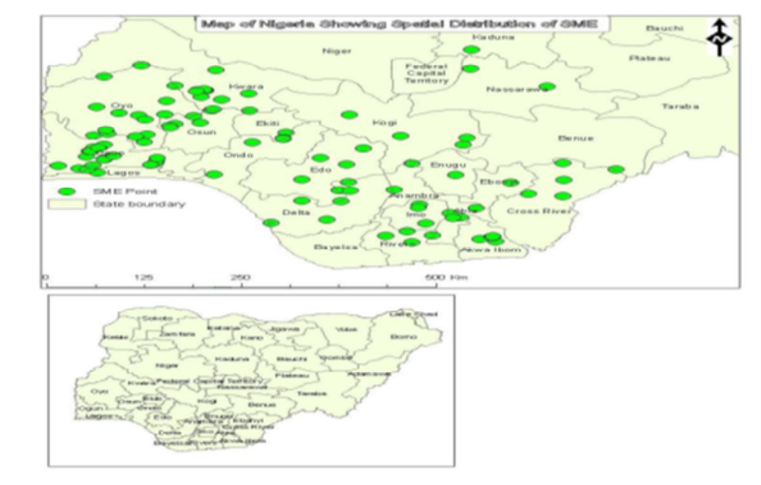


Plate 14: SMEs using Flash Dryers in Nigeria Source: Sanni *et al.* (2012)

With effective knowledge flows and feedbacks, I have engendered positive University-Regulatory-Industry linkages. I have served as Chairman Technical Committee for the Standard Organisation of Nigeria in 2006 as PostHarvest Scientists with IITA between 2004 and 2006 and 2014 as Country Manager, Cassava: Adding Value for Africa. Cassava Standards released in 2006 were revised in 2014. The affected standards were those for High Quality Cassava Flour; Cassava-Wheat Composite Bread; Cassava and Cassava Products-Determination of total Cyanogens as well as Code of Practice for Cassava Products.

These Nigerian Industrial standards were elaborated by the Technical Committee on Cassava and Cassava Products to ensure quality, safety and fair trade practices in the production and sales of roots, products and composite cassava-wheat while maintaining highest level of good manufacturing practices. Please note that in elaborating these standards, references were made to data from research institutes, National and International publications and to data obtained from relevant stakeholders all of which are hereby acknowledged.

3.0 CONTRIBUTIONS TO CAPACITY BUILDING

Mr. Vice Chancellor Sir, my sojourn as a student and staff of this great citadel of learning positioned me for global relevance. I have passed through rudiments of local, national and international tutelage. Through sound scholarship and academic leadership from you and other erudite professors, FUNAAB had produced a world-class professor and leader of sustainable development in agriculture in Africa. I won the 2008 Consultative Group of International Agricultural Research (CGIAR) Award Regional Technology Development in Sub Saharan Africa (http://www.cgiar.org/newsroom/scientific.html) (Plate 15)

Plate 15: Sanni receiving CGIAR AWARD in Maputo, 2008

FUNAAB opened the gate for total learning. I have received academic awards from the World Bank, International Foundation of Science, Sweden, Natural Resources Institute through Department for International Development, UK, European Union, Bill and Melinda Gates Foundation, and IITA through USAID, SPDC, and FGN to actualize my research focus. I have worked as consultant to various National and International bodies on food processing, packaging, storage, quality control, establishment of processing centres in Nine States of Nigeria and other African countries.

I have been actively involved in the promotion of cassava processing and utilization for food, industrial and livestock through extensive train the trainers programs in African countries. I provided necessary technical support on the use of innovative drying systems to kick start the sensitization of High Quality Cassava Flour in 28 States of the Federation in 2005 and some West African countries on cassava development as a Post Harvest Scientist with the Integrated Cassava Project of IITA.

Serving as a mentor to five young Nigerian scholars and 1 Zambian under the African Women in Agricultural Research and Development (AWARD) enhanced my listening, people, network and scientific skills (Plate 16).

Plate 16: Some Global Partnership

I have been a **Resource Person** in the EUACP trainings of Early Career Scientists on research proposal, research methodologies and intellectual property rights on tropical roots in Uganda, Nigeria, Barbados, Fiji, and Lusaka (Plate 17).

Plate 17: Capacity Building pictures

On the completion of the EUACP project, the training modules have been used for FUNAAB Alumni Research Mentoring Laboratory for Post Graduate Students of FUNAAB, ISTRC Early Career Scientists in University of Science and Technology, Hanoi, Vietnam, and CTCRI, Thiruvananthapuram, India.

Industry actors were also led on study tour to Cassava Industry in Vietnam and Bangkok in 2013. Graduate students benefitted from the AAU-DFID Sponsored West African Regional Training Workshop on Food Fortification and Entrepreneurship hosted by the Institute of Food Technologist, Dakar, Senegal.

4.0 RECOMMENDATIONS

Drying is no doubt an appropriate and sustainable preservation method. Industrial drying revolution seems promising in Nigeria, however, further work need to be done on the following;

- Rehabilitation of existing 153 flash drying facilities stimulated by the Presidential Initiative on Cassava is very critical to effect regional change of food insecurity.
- Development of more environmentally and rural friendly drying systems for both food and non-food uses to stimulate national, regional and international markets.
- Improvement of existing investment on flash drying of cassava and the creation of incentives to the private sectors to enhance greater competitiveness of our agri-business.
- Government should block leaking pipes. Government should serve as catalyst or facilitator in agricultural development. Private sectors must be allowed to lead agricultural initiatives.
- We all know that Nigeria is well endowed to ensure effective post harvest system. We need a designated Ministry of Post harvest or strengthen the dynamics of Food security unit of the Presidency in active collaboration with Agriculture, trade and investment, and science and technology ministries.
- The time has come for harmonization of agricultural based

project interventions with institutions, NGOs and developmental partners. This would enable innovations and research development.

- Let us nourish the talent pipeline in African Drying Systems through integrated capacity building for students, fabricators, processors and trainers (North-South interaction).

5.0 CONCLUSION

Vice-Chancellor, Sir, appropriate drying is a tool of changing and developing the Nigerian economy. I have been privileged to be part of the technical hubs for the Presidential Initiative on Cassava while I was a Post-harvest specialist with IITA and Cassava Transformational Agenda as Country Manager, Cassava: Adding Value for Africa pushing sustainable drying technology to the realization of our nation's aspirations for greater economic productivity. Leadership instability is a bane to sustainable postharvest system in Nigeria. There seems to be a serious disconnect from those initiatives. We need to sustain our collective resolve to solve agricultural problems.

A major intervention to reduce post harvest losses of agricultural commodities is drying. This inaugural lecture has shown us possible options in drying of agricultural commodities. Appropriate drying systems will ensure efficient and profitable food value chain. We need to encourage pragmatic investment on adoption of those drying options for farm gate processing and storage system. This will ensure positive engagement of youth, women, and other value chain actors at the rural level. As exemplified by other Nations like Brazil, China and Singapore, we would thus be able to create more wealth, stable food security and rural-urban development. I am therefore, proposing that our agenda for Nigeria should focus on **sustainable food security through efficient and appropriate drying. Let us Act Now!**

6.0 ACKNOWLEDGEMENTS

To God be the Glory. I hereby acknowledge and thank Allah, the Subtle for His succour over me. I give praise to Him for allowing me to see this day. I am indeed very grateful to the Publication committee under the able-leadership of Prof. Oguntuase.

I wish to thank Him for all the people He blessed me with, who have been major or even minor actors in my success story.

MY PARENTS: The two conjugal partners my late father (Mr. Rufai Sanni) and mother (Mrs. Raliat Iyabode Sanni) are absent here today. I lost my father in 1983 while writing my West African School Certificate Examinations (WASCE) and my mother in 1990 during my ONE-month service training. I thank you for the dedication, love and passion extended to my

upbringing. Also, my immediate senior brother, late Mr Ismail Aderemi Sanni, late Moshood Adesupo Makinde and Late Muritala Makinde contributed to my success in life. I thank you and pray to Allah to count you amongst the inmates of paradise.

I appreciate the love and support of my uncle Engineer Alhaji Ahmed Bimbola Makinde, Madam Risqaut Owolabi (Nee Makinde), Pa. Bashiru Sanni, Balogun Ganiyu Sanni, Mr. Dauda Sanni, Sister-Adijat Azeez, Sister Rasheedat-Iya Molade, Bro. Asimiyu Sanni, Kazeem Sanni, Amudalat Gbolagade and Saudat Azeez. God bless you all. I appreciate your support and care for me and my family.

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MY EMPLOYER: I assumed duty in February 1993 as Assistant Lecturer being one of the few Alumni being employed as staff of the Federal University of Technology Abeokuta, (FUTAB).As a young energetic, pro-active and fast pace leading figure in food research, FUNAAB had been good for me.
I appreciate the current Vice Chancellor, Prof. Olusola Bamdele Oyewole for giving me the privilege to present my Inaugural Lecture as a Birthday gift. May the divine power of the Almighty strengthen his quest for academic excellence and global relevance for our University.

I wish to place on record the great contributions of the foundation Vice Chancellor of FUNAAB, Prof. Nurudeen Olorun -Nimbe Adedipe to what this University has become today. Papa remains an embodiment of success, excellence, integrity, and faith. I must thank Prof. Julius A. Okojie, who despite activities as ASUU Secretary, understood my passion for greater heights. He stood by me during my early career development and positioned me for today as a future champion.

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