Climate Change and Cassava Processing in Southeast Nigeria

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Summary

Climate change is perhaps the most serious environmental threat to whom African agriculture is confronted today, essentially because of its impact on pre- and post-harvest agricultural productivity. Available literature shows that most of the recent studies on climate change and agriculture were mainly focused on pre-harvest, with little or no emphasis on post-harvest issues. This study aims to provide empirical information on the effect of climate change on cassava processing and on the cost-effectiveness of indigenous adaptation practices relative thereto. The study was conducted in two randomly selected states of southeast Nigeria and in four randomly selected agricultural zones, two from each state. The data were collected using a well-structured questionnaire administered to 320 randomly selected cassava processors. The result of the analysis shows that the respondents were predominantly women who, in addition to cassava processing, also grow cassava. Virtually all of them were, not only aware of climate change, but also aware that it will have effects on cassava post-harvest operations. The respondents suggest that as a result of climate change, the length of time cassava tubers can stay in the soil without spoiling has been decreasing while the water content of cassava tubers has been increasing. In addition, the storage quality of all the products has been deteriorating, just as the growth of spoilage moulds in the products during storage has been increasing. Moreover, the fermentation period for akpu *and* alibo *has been increasing while there has been a general decline in the quantity of product yield after processing for all the products. Some of the adaptation measures used by the processors include increased use of water, palm oil, hired labour and wood fuel, increased harvesting of cassava earlier than usual, processing of more adaptive varieties of cassava, shifts in the timing of processing as the weather also shifts and increased fermentation in the open spaces. There were also some relatively new adaptation practices such as the use of detergents, nails, beans and bitter leaf to aid fermentation, especially for the production of* akpu *and* alibo*. In terms of profitability, the four adaptation practices with high profitability indices were, in order of decreasing importance, increased use of sun-drying, water, hired labor and palm oil. The study therefore recommends that breeding of improved varieties of cassava should begin to target those that are tolerant to excessive and extreme fluctuations of rainfall, heat and flood. In addition, the adaptation practices with high profitability indices should be vigorously disseminated. Also, further studies, especially on the chemistry of the observed relatively new adaptation practices should be explored.*

Résumé

Changement climatique et traitement du manioc dans le sud – Nigeria

Le changement climatique est peut-être la menace la plus grave pour l'environnement à laquelle fait face l'agriculture africaine aujourd'hui, essentiellement en raison de son impact sur la productivité agricole avant et après la récolte. La littérature disponible montre que la plupart des études récentes sur le changement climatique et l'agriculture ont tendance à se concentrer sur les opérations qui précèdent la récolte, avec peu d'accent sur ce qui se passe après la récolte. Cette étude vise à fournir des informations empiriques sur l'effet du changement climatique sur la transformation du manioc et du rapport coût-efficacité des pratiques d'adaptation indigènes vis-à-vis de celui-ci. L'étude a été menée dans deux états choisis de façon aléatoire au sud-est du Nigeria et dans quatre zones agricoles choisies au hasard, deux de chaque État. Les données ont été recueillies à l'aide d'un questionnaire bien structuré administré à 320 transformateurs de manioc choisis au hasard. Le résultat de l'analyse montre que les répondants étaient en majorité des femmes qui, en plus de la transformation du manioc le cultivent aussi. La quasi-totalité d'entre eux étaient non seulement conscients des changements

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*climatiques, mais aussi conscients que cela aura des effets sur ce qui se passe après la recolte manioc. Les répondants suggèrent que, en raison du changement climatique, la longueur de la période de maintien des tubercules de manioc dans le sol sans nuire à leur qualité a diminué tandis que la teneur en eau des tubercules de manioc a augmenté. En outre, la qualité du stockage de tous les produits se détériore, tout comme la croissance des champignons dans les produits au cours du stockage a augmenté. En outre, la période de fermentation de l'*akpu *et de l'*alibo *n'a cessé d'augmenter alors qu'il y a eu une baisse générale des rendements de tous les types de transformation des racines tubérisées. Certaines des mesures d'adaptation utilisées par les transformateurs comprennent l'utilisation accrue d'eau, d'huile de palme, du travail salarié et du bois de chauffage, la réalisation plus fréquente d'une récolte précoce, le traitement de plus de variétés de manioc adaptées, des changements dans le calendrier de traitement ainsi que des temps de fermentation accrus dans les espaces ouverts. Il y avait aussi des pratiques d'adaptations relativement nouvelles comme l'utilisation de détergents, de clous, de haricots et de feuilles amères pour favoriser la fermentation, en particulier pour la production d'*akpu *et d'*alibo*. En termes de rentabilité, les quatre pratiques d'adaptation les plus rentables sont par ordre d'importance décroissante, l'utilisation accrue du séchage solaire, d'eau, du travail salarié et de l'huile de palme. L'étude recommande la sélection de variétés améliorées de manioc qui sont tolérantes à des fluctuations excessives et extrêmes des précipitations, de la chaleur et des inondations. En outre, les pratiques d'adaptation avec des indices élevés de rentabilité devraient être vigoureusement diffusées. En outre, d'autres études, en particulier sur la chimie des pratiques observées d'adaptation relativement nouvelles doivent être examinées.*

Introduction

As the planet warms, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent (41), farmers in Africa, particularly, battle with the challenge of poor and unpredictable yields/post-harvest losses, thereby making them even more vulnerable (40). They (who constitute the bulk of the poor in Africa), face prospects of tragic crop failures, reduced agricultural productivity, increased post-harvest losses, increased hunger, malnutrition and diseases (41). As the people of Africa strive to overcome poverty and advance economic growth, this phenomenon threatens to deepen vulnerabilities, erode hard-won gains and seriously undermine prospects for development (21).

Cassava (Manihot spp) is Africa's second most important staple, after maize, in terms of calories consumed, with Nigeria as the World leading producer (33). A recent study on cassava shows that it accounts for about 70% of the total calorie intake of more than half of Nigerians (35). In addition, approximately 16% of cassava root production is utilized as industrial raw materials (37) and it is a major source of income for producing/processing households. It is therefore, not only capable of, providing food security (24) but also reducing poverty through enhanced income, especially for vulnerable groups in Nigeria, because it is relatively cheap to produce. Moreover, one of the aims of the Nigerian Presidential Initiative on cassava production was to assist the country realize an income of US$5.0 billion pa from the export of its products. Because of its hardy nature, cassava has also become increasingly dominant with the advent of climate change (15); being tolerant to extreme weather conditions.

Cassava fresh roots are however, very bulky to transport, extremely perishable and for some varieties, contain poisonous cyanogenic compounds (18). Hence, bulkiness and high perishability of harvested roots make immediate processing of the roots necessary. Processing makes cassava roots easier to transport, gives them longer shelf-life, removes the cyanogenic compound and improves their palatability (31). Despite the capacity of cassava in providing financial and food security (24), its production and processing is challenged by many factors, of which climate related variables are among the major ones. This is because, temperature, sunlight, water, relative humidity do not only constitute the main drivers of crop growth and yield (2) but also influence their processing and storage. For instance, cassava roots deteriorate within three to four days after harvesting depending on heat intensity and thus are either consumed immediately or processed into a form with better storage qualities (20). Enete *et al.* (15) have shown that climate change has brought about increased heat intensity in Nigeria. In addition, heavy rainfall could prevent the drying of cassava bread; and may increase product perishability and seasonal inadequacy of food supplies. One of the variables identified to be on the increase as a result of climate change is heavy rainfall (15). The heat effect of climate change on processing of agricultural products include the growth and development of spoilage moulds which affect products in storage by causing adverse quality changes, heat-damage, dull appearance, musty odours, visible moulds, production of toxins and allergens (11). Unfavourable environmental condition is one of the major causes of post harvest losses in the world with special emphases on developing countries such as Nigeria (20). Thus, the potential impact of climate change also threatens the post-harvest of food systems.

The relevant questions that agitate the minds are - what is the nature of climate change impacts [such as types of effects and for which cassava product(s)] on cassava processing and products? Are there some cassava products that are more vulnerable to climate change effects? What are the indigenous climate change adaptation strategies practiced by cassava processors? What are the cost implications of these measures?

This paper therefore attempts to provide answers to these questions. Although, there are numerous recent regional and national studies on socio-economic aspects of climate change and agriculture in Africa (e.g., 22; 28; 29, and 11), there has been little or no focus on post-harvest activities of small-holder farmers such as agricultural food processing. Millions of people are at risk of hunger and poverty if these processors do not get support in coping with climate change. Moreover, investigating the effects of climate change on post-harvest will help in providing a more complete picture of climate change and agriculture, and hence broaden policy formulations towards tackling the challenge of climate change.

Methodology

Area of Study: Southeast Nigeria is located within Longitudes 5°30' & 9°30' E and Latitudes 4°30' & 7° 00' N. It occupies a land area of 75,488Km^2 and comprises nine states namely Abia, Akwa Ibom, Anambra, Bayelsa, Cross River, Ebonyi, Enugu, Imo, and Rivers. These states fall into two geopolitical zones in Nigeria namely the south-south and southeast. While, Akwa Ibom, Bayelsa, Rivers and Cross River are in the south-south, Abia, Anambra, Ebonyi, Enugu and Imo are in the southeast.

The region has a total population of 31,371,941 and an average population density of 416 persons per square kilometer. This average however conceals the true picture of population pressure in the region. About 21 years ago, Okafor (36) noted that a prima facie evidence of population pressure has been established and that the region stands out prominently on maps of Sub- Saharan Africa showing population distribution and high crude densities. Also, Madu (26) demonstrated that population pressure is the most important problem of rural development in the region. The effects of population pressure in the area have been recognized in a broad spectrum of livelihood activities such as intensive agriculture, engagement in non-farm activities and migration.

Sampling: For logistic reasons, the study was restricted to the southeast geo-political zone. It was conducted in two phases. Phase one involved a Rapid Rural Appraisal (RRA) of the study area. Two states were randomly selected from the five states of the zone namely Enugu and Imo states. Each state in Nigeria is usually made up of three agricultural zones. In each selected state therefore, two agricultural zones were randomly selected making four agricultural zones for the study. In Enugu, Nsukka and Awgu agricultural zones were selected while in Imo, Okigwe and Owerri agricultural zones were selected. The pilot survey was however restricted to Okigwe in Imo state and Nsukka in Enugu state and in each of the two agricultural zones, with the assistance of the Extension Services Department (ESD), male and female cassava processors with a wide age range were constituted (50 in Okigwe and 40 in Nsukka) and interviewed, first collectively in a focus group discussion, and then individually with a structured instrument. The purpose was to have baseline information regarding the current situation on climate change and cassava processing in the area and help validate the survey instrument. This was conducted in October, 2011. The duty of the ESD officials was just to assist in assembling the processors. They did not take part in the administration of the survey instrument.

The second phase involved detailed processor to processor visit of the respondents. The two states already visited during RRA were still used for this part of the study. In each of the four agricultural zones and with the assistance of ESD, cassava farming communities (which invariably were also processing communities) were compiled, from which two communities were randomly selected making a total of eight communities for the study. These were Ogugu and Mgbowo in Agwu agricultural zone; Umualumo in Okigwe and Okwe in Onuimo, all in Okigwe agricultural zone; Opanda and Nkpologu, in Nsukka agricultural zone; Amaigbo and Okpuala in Owerri agricultural zone.

In each community, a list of cassava processors was compiled, also with the assistance of the ESD. Forty processors were randomly selected from each of them, to make a total of 320 processors for the study. This was done in November/December 2011.

Background[1]

The cassava processing methods and products are presented here to provide the necessary background for the discussion of the results. Cassava processing involves a combination of activities which are performed in stages. Such activities are (i) peeling; (ii) chipping, milling, slicing, grating; (iii) dehydration by pressing, decanting, drying in the sun or over a hearth, frying; (iv) fermenting by soaking in water; (v) sedimentation; (vi) sieving; and (vi) cooking, boiling, steaming. The number of steps required and the sequence varies with the product being made. This sequence of activities also generates a wide range of intermediate products, which can either be sold or stored until the need arises. Hence, it is not always easy to distinguish between intermediate and end products of processed cassava. In addition, some of the processed products are ready to eat without further cooking while others require some extra preparation.

Processed products

The following discussion is based on end products as those which enter the marketing system. This will include some intermediate products such as cassava flour.

Cassava pastes: Cassava pastes are called *akpu* in the study area. To make them, whole roots are immersed in water (streams, puddles or water in a container) for 3-5 days, while they soften and ferment. They are taken out of the water and peeled. Fibers are removed from the pulp by sieving in water using a basket, fiber bag or perforated metal bowl. The mash is squeezed in a fiber bag to reduce water content. The product is balled and steamed. Sometimes peeling is done before soaking, which improves the attractiveness of the end product but makes it more expensive because fresh roots are harder to peel than soaked ones. The product is ready to eat without further cooking. Uncooked paste is made in a similar way to steamed paste but without cooking, and so it must be steamed before it can be eaten. Just as in the case of steamed paste, the fermentation step is intensive in its use of water, but fuel is not required although it will be needed at the meal preparation stage (Figure 1).

Figure 1: Cassava Pastes in the market.

Cassava flour: This is called *alibo* in the study area. Flour is often made at home from cassava chips. Chips and flour are made by a wide range of traditional methods. Soaked roots can be converted into chips by sun- or smoke-drying either directly after peeling or after crushing, sieving, pressing and rolling into balls. Alternatively, chips are made directly from fresh roots by sun- or smoke-drying of peeled fresh roots. The peeled chips may be fermented before drying by piling them in heaps covered with leaves for a few days. Chips made by any of these methods can be milled into flour (Figure 2).

Figure 2: An example of Cassava Flour being displayed in the market.

Toasted granules: These are called *gari* in the study area. Fresh roots are peeled and grated; the grated pulp is put in sacks and the sacks are placed under heavy objects for 3 or 4 days to drain excess liquid from the pulp while it is fermenting. The dewatered and fermented lumps of pulp are sieved and the resulting fine pulp is roasted in a pan. Palm

[1]*Adapted from Nweke and Enete (34)*

oil is sometimes added during roasting, which changes the colour of *gari* from white to yellow (Figure 3).

Figure 3: *Gari* in the market.

Abacha: The production of *abacha* (its local name) involves boiling peeled roots and slicing the boiled roots into small flat pieces, using knives or perforated metal. The sliced pieces are soaked overnight to make wet *abacha*, and may then be sun-dried to make dry *abacha* (Figure 4).

Figure 4: *Abacha*, ready for market.

Results and Discussion

Awareness of Climate Change

The respondents were asked whether they have heard of climate change before. About 99% of them responded in the affirmative (Table 1). This suggests a high level of awareness of the subject matter in the area. The awareness of climate problems and the potential benefits of taking action is an important determinant of adoption of agricultural technologies (22). Maddison (25) argued that farmer awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making. For example, Araya and Adjaye (8) and Anim (6) reported that farmers awareness and perceptions of soil erosion problem as a result of changes in climate, positively and significantly affect their decisions to adopt soil conservation measures. On the source of information, majority (67%) of the respondents indicated that they heard from friends, about 27% of them heard from farmers' cooperatives, 23% from personal observation, 21% from radio/television, 10% from extension personnel, 7% from other farmers, 5% from newspapers, while 2% of the respondents heard it from researchers (Table 2). On the question of whether climate change has or will have anything to do with cassava processing, all (100%) the respondents said yes. Most governments in Nigeria already have agencies charged with environmental issues including climate change and they most often sensitize the people through the radio, television, cooperatives, posters, handbills etc. This may explain the high level of awareness of the respondents.

Patterns of Climate Change Impact on Cassava Processing and processed products

The respondents were asked to indicate the direction of change (increasing, decreasing or no-change) in the last ten years, for some hypothesized variables regarding climate change effects on cassava post-harvest. The information collated from the survey show (Table 2) that almost all (92%) the respondents agree that the length of time cassava tubers can stay in the soil without spoiling has been decreasing in the last ten years.

Table 1
Percentage distribution of respondents by awareness of climate change and sources of information.

Questions on awareness of climate change		Yes*	No
Have heard of climate change before now?		99	1
Source of information**:			
(i)	Friends	67	
(ii)	Extension workers	10	
(iii)	Farmers cooperatives	27	
(iv)	Newspapers	5	
(v)	Radio/Television	21	
(vi)	Researchers	2	
(vii)	Other farmers	7	
(viii)	Personal observation	23	
Do you think climate change will have any effect on cassava processing?		97	3

Note: * Number of respondents is 320, ** Multiple responses

Table 2
Percentage distribution of respondents by direction of climate change impact on cassava processing.

	Phenomena you think have been changing over the past ten years	Product	Increasing (%)	Decreasing (%)	N° change (%)	Mean extent of contribution of climate change
(i)	Spoilage of cassava tubers after harvest	Fresh roots	94	6	0	3.759
(ii)	Length of time cassava tubers can stay in the soil without spoiling	Fresh roots	4	92	4	3.870
(iii)	Water content of cassava tubers	Fresh roots	66	23	11	3.981
(iv)	Cooking quality of cassava products	*Garri*	4	38	58	2.850
		Akpu	20	30	50	1.261
		Alibo	26	32	42	1.278
		Abacha	5	27	68	2.453
(v)	Storage quality of cassava products	*Garri*	4	88	8	3.996
		Akpu	20	72	8	3.707
		Alibo	5	88	7	3.854
		Abacha	5	73	22	3.522
(vi)	Fermentation period of cassava products	*Garri*	2	33	66	2.190
		Akpu	66	34	0	3.700
		Alibo	63	37	0	3.955
		Abacha	36	4	60	1.433
(vii)	Labour use in cassava processing	*Garri*	49	23	28	3.851
		Akpu	53	21	26	3.205
		Alibo	49	25	26	3.726
		Abacha	71	6	23	3.202
(viii)	Growth of spoilage moulds in processed and stored cassava products	*Garri*	87	4	9	4.032
		Akpu	91	5	4	4.007
		Alibo	92	5	3	3.694
		Abacha	93	1	6	3.947
(ix)	General spoilage of processed cassava products	*Garri*	92	4	4	3.543
		Akpu	91	5	4	3.724
		Alibo	91	5	4	4.055
		Abacha	90	6	4	3.910
(x)	Taste of processed cassava products	*Garri*	25	36	39	2.386
		Akpu	26	33	41	2.217
		Alibo	31	32	37	1.899
		Abacha	32	30	38	1.976
(xi)	Aroma of processed cassava products	*Garri*	17	40	43	2.131
		Akpu	1	35	64	2.216
		Alibo	5	33	62	2.069
		Abacha	4	32	64	2.097
(xii)	Colour of processed cassava products	*Garri*	4	23	73	2.178
		Akpu	13	17	70	2.247
		Alibo	21	10	69	1.884
		Abacha	4	11	85	2.003
(xiii)	Quantity of product from cassava after processing	*Garri*	5	89	6	3.752
		Akpu	3	92	5	3.887
		Alibo	6	89	5	3.740
		Abacha	3	90	7	3.900

Cut off = 3

This is particularly worrisome because cassava has often been referred to as a famine reserve crop as it can be stored in the soil and milked by families as need arises. This may also further impoverish the farmers because they may no longer have the possibility of storing their cassava in the soil until market prices are favorable. A majority (66%) of the respondents report that the water content of cassava tubers has also been on the increase. This may also mean poor product yield from processing since it (processing) generally involves dewatering. In addition, almost all (94%) the respondents reported that spoilage of cassava tubers after harvest has been increasing. This is consistent with the above observations on increasing water content of cassava tubers and reduced length of time it could be stored in the soil without spoiling.

Table 3

Percentage distribution of respondents by whether or not they use suggested adaptation measures.

S/N	Adaptive measures	Use (%)	Not use (%)
1	Increased use of water in cassava processing	71	29
2	Increased use of hired labour to avoid spoilage of harvested tubers	57	43
3	Increased use of wood fuel in drying cassava products	49	51
4	Increased use of sun-drying in cassava processing	27	73
5	Harvesting cassava earlier than usual to avoid its decaying in the soil	53	47
6	Increased spacing of cassava in the farm to enhance aeration, which reduces its decay in the soil	34	66
7	Exit from processing cassava to other farm products	3	97
8	Use of more adaptive varieties of cassava	44	56
9	Increased fermentation of cassava in open spaces.	43	57
10	Increase in the quantity of cassava processed	13	87
11	Increased fermentation of cassava in closed spaces (inside the house for instance)	8	92
12	Increased use of oil in cassava processing	59	41
13	Increased use of other additives to cassava products (e.g. mixing yam and cassava flour)	10	90
13	Shifts in the timing of cassava processing as the weather also shifts	42	58
14	Change from processing to production	1	99
15	Change from processing to marketing	2	98
16	Combining cassava processing with other farm produce processing	10	90
17	Change in the type of cassava products processed	11	89
19	Increased use of mechanized processing	10	90
21	Use of detergents in the fermentation of cassava products	24	76
22	Use of nails or other metal objects in the fermentation of cassava products	19	81
23	Use of beans in the fermentation of cassava products	24	76
24	Use of bitter leaf in the fermentation of cassava products	25	75

The cooking quality of all the major processed cassava products in the area namely *gari*, *akpu*, *alibo* and *abacha* have generally not changed in the past ten years as indicated by majority of the respondents (Table 2). However, a majority of them suggest that the storage quality of all the products has been decreasing (Table 2). This agrees with their observation below that the growth of spoilage moulds in these products has been increasing. The respondents indicate that the fermentation period for *gari* and *abacha* has not changed while that of *alibo* and *akpu* has been increasing. This is to be expected because smooth paste is not required for *abacha* after fermentation as it is just boiled, sliced, washed and sun- dried. *Gari*, on the other hand, is crushed into a smooth paste, with a grater, before fermentation. However, *alibo* and *akpu* require making into a smooth paste after fermentation which necessitates that they must ferment well (the whole tuber must be completely softened while fermentation takes place). Their fermentation could therefore be generally more sensitive to weather conditions than *gari* and *abacha*. Labour use in the processing of all the cassava products have been increasing. This is consistent with their responses to first three questions. Processors now have shorter time to process cassava tubers before they spoil and the tubers contain more water in them which needs to be extracted. Almost all the respondents agree that the growth of spoilage moulds in all the cassava products while in storage has been increasing. This may be because of the rising extreme fluctuations of temperature and hence humidity associated with climate change in the region (38). It is also in line with the above observation regarding their deteriorating storage quality. In addition, there has been increased general spoilage of all the products as indicated by almost all the respondents (Table 3). Majority of them reported that taste, colour and aroma have generally not changed for all the processed cassava products. They however reported that the quantity of product after processing has been declining for all the products. This may be because of increasing water content and spoilage of cassava tubers as reported above.

The respondents were asked to indicate the extent to which they think climate change was responsible for the changes in the variables above. Their responses (Table 2) show that all the changes discussed above such as length of time cassava tubers can stay in the soil without spoiling, water content of cassava tubers, general spoilage of cassava tubers after harvest, storage quality of the products, fermentation period of *alibo* and *akpu*, growth of moulds in the products and quantity of product after fermentation, have all to do with climate change. These changes may have affected the fortunes of the processors greatly. For instance, almost all (92%) the respondents indicated that their income from cassava processing has been decreasing in the last ten years. They were then asked to rank, for each of the products, the extent to which their income had been decreasing on a five point scale (5= to a very great extent, 4= to a great extent, 3= to some extent, 2= to a little extent and 1= to no extent). The average response for each of the products were 4.28 for *gari*, 4.33 for *akpu*, 3.56 for *alibo* and 4.16 for *abacha*, all of which imply to great extent.

Indigenous Climate Change Adaptation Practices

Climate change adaptation is taken here to mean modifications and/or improvements on (or intensification of) existing agricultural practices with the aim of ameliorating the effect of climate change on food systems. Some of the popular adaptation practices used by the processors include increased use of water in cassava processing as indicated by 71% of the respondents (Table 3). This was followed by increased use of hired labour (intensified use of hired labour, aimed at countering the effect of climate change on cassava post-harvest is considered an adaptation strategy) in cassava processing (about 57% of the respondents). This may have been necessitated by increased general spoilage of cassava tubers after harvest and their increased water content. The next adaptive measure reported by about 59% of the respondents was increased use of oil in cassava processing. This was particularly more pronounced in the cases of *gari*, *akpu* and *alibo*. Its use in *gari* was particularly to add colour and taste in addition to aiding preservation for longer period. An example of *gari* being processed with oil is seen in the figure 5.

Figure 5: *Gari* being processed with oil.

For *akpu* and *alibo*, the use of oil was to aid fermentation, we had earlier noted that the fermentation periods of these products have increased as a result of climate change. Many of the respondents in some of the villages did indicate that they have completely changed the processing methods for *alibo* as a result of the difficulties encountered in its fermentation. Instead of the usual submerging of whole fresh roots in water and leaving it to ferment for some days, they have now resorted to peeling the fresh roots, grating them into smooth pastes and sun- or smoke drying. This method has also changed the texture of *alibo* in ready to eat form. Instead of its usual smooth and velvety texture, those prepared in this form now looks like the figure 6.

Figure 6: An example of *alibo* prepared through grating.

Increased harvesting of cassava, earlier than usual, was reported by about 53% of the respondents as an adaptive measure. This may be because of the reported decreases in the length of time cassava tubers can stay in the soil without spoiling. About 44% of the respondents indicated increased use of more adaptive varieties of cassava as an adaptation measure.

The next adaptation measures were increased fermentation of cassava in open spaces (43%) and shifts in the timing of cassava processing as the weather also shifts (42%). Some of the relatively new adaptation practices reported by the respondents were the use of detergents, nails, beans, biter leaf and jatropha leaves to aid fermentation in the cases of *akpu* and *alibo*. The figure 7 illustrates the case of Jatropha leaves:

Although the chemistry of these is unclear, one is concerned that the use of detergents may have some residual effects in the final products which may be borne by the final consumer. The foregoing suggests that there is increasing fermentation

Table 4
Mean and standard deviation of the responses of the respondents in Imo and Enugu states on climate change adaptation cost.

s/n	Adaptation measures	Cost/kg of product		Revenue/kg of product		PI	
		Mean	SD	Mean	SD	Mean	SD
i.	Increased use of water in cassava processing	10.88 (68)	11.39	7.07(67)	5.69	1.53 (67)	1.13
ii.	Increased use of hired labour	6.44(18)	3.13	9.83 (18)	5.95	1.51 (18)	0.48
iii.	Increased use of wood fuel in drying cassava products	7.87(47)	4.36	10.32 (47)	6.63	1.34 (47)	0.49
iv.	Increased use of sun drying	4.06 (17)	1.74	7.41 (17)	4.08	2.52 (17)	2.90
v.	Increased use of palm oil in cassava processing	56.60(62)	81.77	104.22(62)	162.82	1.51 (62)	0.39
vi.	Increased use of mechanized processing	8.89(19)	5.68	11.58 (19)	6.88	1.41 (19)	0.50
vii.	Increased used of other additives like mixing yam and cassava flour	15.91 (17)	8.41	21.21 (17)	12.63	1.35 (17)	0.54

Note: Figures in parentheses are no of observations.

Figure 7: The use of Jatropha leaves to aid fermentation

difficulty being faced by cassava processors as a result of climate change.

In terms of profitability, the farmers were asked to estimate the average costs and added returns per kilogram of cassava product for each of the adaptation practices using a partial budgeting framework. Using this information, an index of profitability (returns per Nigerian naira invested) was calculated for the practices. The result of the analysis (Table 4) shows that increased use of sun-drying had the highest index (mean=2.5). This is not surprising because sun-drying relatively had the least average cost per kilogram of product and most of the costs in the practice come from labor, which may have been largely supplied by the family. The next adaptive measures in terms of the index were increased use of water, hired labor and oil in cassava processing (mean = 1.5 each). Increased use of mechanized processing had an average index of 1.4 while that of wood fuel and other additives, each had a mean of 1.34. There was no information in this regard for other adaptation practices, perhaps because of the skepticism respondents always had in divulging information regarding their finances to researchers. The foregoing suggests ingenious attempts by the processors to device ways of countering the effects of climate change. It will be worthwhile for experts to work with them in order to fine-tune and hence broaden the impact of these adaptive measures.

Conclusion

The respondents in this study were mostly women who, in addition to cassava processing, also grow cassava. Virtually all of them were, not only aware of climate change, but also aware that it will have effects on cassava post-harvest activities. The predominant source of such information was their friends. The respondents suggest that as a result of climate change, the length of time cassava tubers can stay in the soil without spoiling has been decreasing while the water content of cassava tubers has been increasing. In addition, the storage quality of all the processed products has been deteriorating, just as the growth of spoilage moulds in the products during storage has been increasing.

Moreover, the fermentation period for *akpu* and *alibo* has been increasing while there has been a general decline in the quantity of product yield after processing for all the products. Some of the adaptation measures practiced by the processors include increased use of water, palm oil, hired labour and wood fuel in cassava processing, increased harvesting of cassava earlier than usual to avoid decay in the soil, use of more adaptive varieties of cassava for processing, shifts in the timing of processing as the weather also shifts and increased fermentation of cassava in the open spaces. There were also some relatively new adaptation practices such as the use of detergents, nails, beans and bitter leaf to aid fermentation, especially for the production of *akpu* and *alibo*. In terms of profitability, the four adaptation practices with high profitability indices were, in order of decreasing importance, increased use of sun-drying, water, hired labor and oil in cassava processing. In the light of the foregoing, the study recommends that breeding of improved varieties of cassava should begin to target those that are tolerant to excessive and extreme fluctuations of rainfall, heat and flood. In addition, the adaptation practices, particularly those with high profitability indices, should be vigorously disseminated by extension agents to cassava processors. Also, further studies, especially on the chemistry of the observed relatively new adaptation practices should be explored.

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