Evaluation of Cocoyam Corms Processing and Storage in Nigeria

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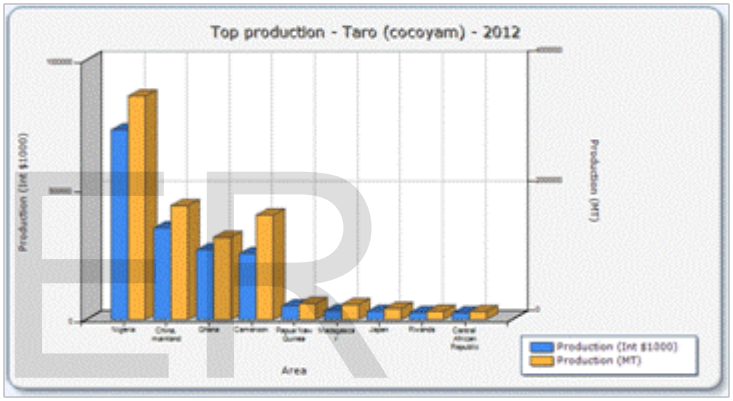
Abstract— Cocoyam is a crop valued for its tubers and leaves in West Africa and beyond. In recent times, there is an increase in demand and consumption of 'local' food in Nigeria. This rise is as a result of the widely held belief that these local delicacies are natural and hence obviate fear of contamination from consumption of processed or artificial food. Nigeria is the world leading producer of cocoyam, however, the prevalence traditional methods of cocoyam production, processing, and storage has hampered its utilisation and farmers' access to export market for profit optimization. It then becomes necessary to evaluate the present postharvest operations of cocoyam with a view to ascertain their adequacy and shortcomings, and highlights the areas that need research focus to drive revolutionary approach in cocoyam study and guarantee value addition to cocoyam food chain. Thus, this work reviews efforts in cocoyam research so far and propose ways to meet up with future demands.

Index Terms— Cocoyam, production, processing, storage, taro, tannia, postharvest

1 Introduction

Cocoyam is a perennial crop grown in Nigeria mainly for its edible roots. It ranks third in importance after cassava and yam, among the root and tuber crop cultivated and consumed in Nigeria [1], and it is nutritionally superior to cassava and yam [1]. It belongs to the Araceae family. Colocasisa esculenta, otherwise known as taro is more popular in Nigeria than Xanthosoma sagittaifolium, also known as tannia [2]. Cocoyam is used as source of food for man and livestock. Cocoyam can be processed and consumed as soup thickner, fufu, roasted achicha, and boiled. Also, it is sliced into chips and dried, and the dried chips are rehydrated and made into porridge with vegetables, palm oil and oil bean. Cocoyam can be used for the production of alcohol, medicines, flour and starch [2]. Nine cultivars of cocoyam that are resistance to disease and have high yield capacity have been identified, and they include NX5001, NX5002, NX5003, NX5004, NCE002, NCE003, NCE004, NCE005 and NCE006 [1]. Nigeria is the highest producer of cocoyam in the world, with about 3450000 metric tones [3], accounting for over 40% of world production and over 70% of production in West Africa [4]. Market supply is declining, and cropped-area has maintained a downward trend, but production is gradually picking up [5]. It is evident from Table 1 that cocoyam is highly nutritious. It contains about 2.0g of protein, 31g of carbohydrate, 1.0g of fibre, 20mg of calcium, among other nutritive and vitamins [6]. Those on dietary prescription requiring low starchy food prefer cocoyam to cassava. The starch is also more readily digested compared to cassava and yam starch [1]. The possibility of making a living through cocoyam farming among rural farmers is hampered by limited farm size and lack of fund [7]. But, the major set back is deterioration of the corms and the factors responsible for the loss in quality have been identified to include are mechanical, physiological, pathogenic, fungi, insect infestation, rodents and birds [see Table 4].



Source: [3]
Fig. 1: Top production – Taro, 2012

2 Advances in Cocoyam Research

The sorption isotherm, particle size, chemical and physical properties of cocoyam corm flours to enhance the storage and application in food formulation were studied [8]. Three cocoyam corms, namely; ede cocoindia, ede ofe, ede uhie and ede ocha were processed into flour and investigated. The moisture isotherm obtained reveals a type II isotherm. The gelling temperatures were 63.8°C, 96.8°C, 65°C and 73.8°C respectively. This result implies that lesser amount of energy will be spent in cooking cocoa-india than other corms. The mean water absorption capacities were 2.19g/g, 2.410g/g, 2.178g/g and 2.0082g/g respectively. They recommended cocoyam flour as composite material for bread making, biscuits, pasta, binder in sausage, among other potential uses in confectionary industry. The proximate composition, rheology and sensory qualities of corn-cocoyam salad cream were evaluated and compared with that of commercial Heinz salad cream [9]. It was observed that as the percentage of cocoyam starch in the salad cream increased, the carbohydrate content gradually increased, while the fat and ash contents reduced gradually. Also, replacement of corn starch with cocoyam starch up to the level of 50% in salad cream will not negatively affect the rheology and senso-

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ry attributes of salad cream. Again, the researchers found that varied quantities corn-cocoyam starch in salad cream did not affect the moisture and protein contents of the cream compared to Heinz salad cream which varied from 48.80 - 49.79% and 2.62 - 3.28%, respectively. A study on how to improve the yield of cocoyam using sawdust mulch and NPK 20:10:10 fertilizer rate in the humid forest zone of Nigeria was undertaken [10] to ascertain the veracity of the claim that one of the major reasons why commercialization of cocoyam is at its low ebbs is the low yield. So, these researchers worked on improving the yield of cocoyam production. They observed that combining sawdust mulch with any fertilizer rate resulted in significant (p=0.05) higher yield than when the rate of fertilizer rate was solely applied. A combination of sawdust mulch and fertilizer applied at 200, 300 and 400 kg/ha produced higher yields by 3.4ton/ha (34%), 3.7 tons/ha (29%), and 3.7tons/ha (19%) than the corresponding sole fertilizer rate. They concluded that joint application of sawdust mulch and fertilizer is beneficial to cocoyam and farmers should combine 20 t/ha sawdust mulch with 400 kg/ha NPK fertilizer for high and sustainable productivity of cocoyam in the rain forest zone of Southeastern Nigeria.

Table 1: Nutritional values of cocoyam per 100g edible portion

	Taro (*Colocasia esculenta*)			Tania (*Xanthosoma saggittifolium*)		
	Corms	Corms	Leaf Stalks	Corms	Leaves	Shoots
Major Nutrients						
Water	73	75	93	65	89	89
Calories	102	94	24	133	34	33
Protein (g)	1.8	202	0.5	2.0	2.5	3.1
Fat (g)	0.1	0.4	0.2	0.3	1.6	0.6
Carbohydrate (g)	23	21	6	31	5	5
Fibre (g)	1.0	0.8	0.9	1.0	2.1	3.2
Calcium (mg)	51	34	49	20	95	49
Phosphorous (mg)	88	62	25	47	388	80
Iron (mg)	1.2	1.2	0.9	1.0	2.0	0.3
Vitamins						
β-carotene equivalent (µg)	Trace	Trace	180	Trace	3300	-
Thiamine (mg)	0.10	0.12	0.02	0.10	-	-
Riboflavin (mg)	0.03	0.04	0.04	0.03	-	-
Niacin (mg)	0.8	1.0	0.4	0.5	-	-
Ascorbic acid (mg)	8	8	13	10	37	82

Source: [6]

The possibility of making a living through cocoyam farming among rural farmers was investigated [7]. It was found that the gross neglect of cocoyam production by policy makers in agricultural and food sector is responsible to low productivity of the product in Nigeria. A study on non-ruminants use of cocoyam and its by-product, among other root crops was carried out [11]. The researchers used processing techniques – fermentation, soaking, boiling, ensiling and sun-drying to remove deleterious substances and the adverse effects on animals. They also said that to achieve increase in the use of these roots crops and their by-products for maize replacement in intensive non-ruminant production systems, adequate supplementation and proper processing are essential. To help rural women farmer, a descriptive survey in studying the competency needs of women in agriculture (WIA) in processing cocoyam into flour and chips, in using a target population of 362 women processors in South Eastern, Nigeria was done [12]. It was observed that women processors need improved competency in planning, processing cocoyam into flour and chips, and marketing of cocoyam. The survey is important for Agricultural Extension officers and other community developers in satisfying the needs of these rural farmers to ensure boost in cocoyam postharvest operations. Pure isolates of five storage rot causing fungi of cocoyam (Colocasia esculenta) corms for their potency in causing rots of the corms during preservation were assessed [13]. The isolates used were Sclerotium rolfsii Sacc., Botryodiplodia theobromae Pat., Fusarium solanii (Mart) Sac., Fusarium SP. and Rhizopus stolonifer (Ehren ex. Fr) Lind. Cocoyams free from blemish were inoculated with each of the fungal orgamisms and left for 14 days, after which their extent of rot was observed. They reported that S. rolfsii and B. theobromae proved most potent in causing rot with mean percentage volume of 14.50cm^3 and 10.14cm^3 respectively. Effects of fermentation on physicochemical properties and oxalate content of cocoyam (Colocasia esculenta) flour was the focus of some researchers [14]. They found that fermentation bring about a significant reduction in oxalate level (58 to 65%) depending on the fermentation duration. Again, they found that amylase content was higher in 48h (55.52%) fermentation than in 24h (54.55%). Lastly, pasting (gelatinization) temperature decreased, and water absorption capacity increased markedly due to fermentation. They recommended work on longer period of fermentation (72-96h) as well as microorganism associated with the fermentation. The efficacy of botanical protectants in the storage of cocoyam (Colocasia esculenta (L) Schott) was investigated by some researchers [15]. They used aqueous extracts from Ocimium basilium L., Veronia amygdalina Del., Azadirachita indica L. and Carica papaya L. 150g/l and 300g/l concentrations to study their effects on corm fresh weight loss, rotting, and sprouting of two varieties of Colocasia esculenta. They found that all the aqueous extracts at both concentrations reduced fresh weight loss and rotting of corms in both varieties; however, Ocimium basilium was promising than others since it significantly, at both concentrations, reduced fresh weight loss and rotting of corms when compared to other extracts.

3 PROBLEM STATEMENT

It is evident that researchers have not done any tangible work on postharvest operations of the crop, and this has hampered mechanisation and improved postharvest techniques of cocoyam in Nigeria. Besides, despite ranking number one in world cocoyam production, with an estimated quantity of 3450000 metric tonnes [3], Nigeria is lagging behind in adding value to cocoyam production. Egypt, occupied Palestinian territory, Cyprus, Lebanon and Solomon's Island, in descending order, are the leading countries delivering the five highest yields over the last two decades. Again, Japan, Ivory Coast, Egypt, Philippines and Gabon, also in descending order, are the world's top five cocoyam seed producers [3]. Many losses encountered by local farmers as a result of poor processing techniques and improper storage have militated against advances in cocoyam production in Nigeria. Mechanization of cocoyam production and improving the postharvest operations and storage of cocoyam, which this work highlights, will remove many problems, increase the value of the product for farmers in both local and international market and ultimately encourage production and consumption of corms.

4 POSTHARVEST OPERATIONS AND PROCESSING OF COCOYAM CORM

Cocoyam corms are harvested by pulling the shoot; and the remaining ones are dug out using rod harvester. Harvest starts around November when the temperature is usually high with low relative humidity in Southeastern Nigeria. The ambient conditions are unfavourable for natural storage widely practised by rural farmers. Again, in order to achieve better storage using regulated temperature, the cost of power comes into play.

4.1 Corm quality measurement

There are many possible ways of determining the quality of corms, and they include [16]:

- Size of corm, weight and length to circumference, including specific gravity
- Skin thickness and ease of removal
- Freedom from disease and injury
- Corm storagability
- Corm flesh color
- Corm flesh starch content and starch type
- Corm flesh free sugar, mucilage and phenol content
- Corm texture when boiled
- Chip texture, color and taste

Apart from these, the thickening quality of corms' paste in soup preparation is a major quality among the people of SouthEastern Nigeria.

4.2 Cleaning of corms

Cleaning of corms consist in careful removal of sands, debris and roots, and washing with water. This type of cleaning usually precedes cooking with or without peeling. Traditionally, cleaning is usually not carried out before storage, except when wooden platforms are used for storage.

4.2 Storage

Traditional methods of storage have prevailed till date [17], and these include heaping the corms under a shade or covering them with leaves, storing inside a pit and covering them with leaves and soil. Alternatively, only corms that are needed for consumption or corms that will be taken to the market are harvested while the rest are left un-harvested in the farm till when they are needed or till the next planting season. Other traditional techniques used for storing cocoyam (*Colocasia* sp and *Xanthosama* sp.) in Nigeria to have been reported [18] to include (i) storage on wooden platforms with corms arranged in irregular rows and covered with dry grass to allow air circulation and (ii) using trenches made in dry and shaded areas to store corms, which are covered with dry grass and subsequently covered with soil. They reported no modern method of extending the shelf life of cocoyam in Nigeria. These traditional methods are inefficient, and they make the corms susceptible to postharvest loss, which in turn to great loss to the farmers.

Table 2. Recommended storage conditions for taro

Temperature (°C)	Relative humidity (%)	Length of storage
4.4	-	3.5mo
6.1-7.2	80	-
7.2	85-90	120-150d
7-10	85-90	4-5mo
10	-	6mo
11.1-12.8	85-90	21wk
11-13	85-90	5mo
12	90	5mo
13.3	85-90	42-120d
20	60	2-4wk

Source [6]

Various temperatures and relative humidity for extending shelf life of taro and tannia are given in Tables 1 and 2. Cocoyam stores best in a cool, dry and well ventilated environment. At the temperature of 10°C, taro can be stored for 6 months [6], and this appears to be the best condition for longest shelf life of taro corms. At the temperature range of 7-10°C and relative humidity of 80%, tannia can be stored for up to 20weeks. These remain the optimum storage conditions for taro and tannia. At higher ambient temperatures (25° to 30°C), cocoyam will store only for periods of 4 to 6 weeks without serious losses [19]. The average ambient temperature in Nigeria is around 30°C. In the South Pacific, corms are often harvested with about 25cm of the basal petiole attached, tied into bundles and suspended in the shade for storage [20]

Table 3. Recommended storage conditions for tannia

Temperature (°C)	Relative humidity (%)	Length of storage
7	80	17.1-18.6wk
7.2	80	18wk
7-10	80	16-20wk
15	85	5-6wk

Source: [6]

The cost and management of controlled environment required for storage of cocoyam is a great challenge to local farmers. Therefore, alternative methods that will be better than traditional methods and requiring lesser skill and low energy consumption will benefit the local farmers and boost production.
The factors responsible for corms deterioration of cocoyam corms were identified [19].

4.3 Processing and utilisation

The processing of cocoyam in Nigeria is hampered by unavailability of machines and equipment to carryout various processing tasks. The enginnering properties of cocoyam corm are yet to be properly evaluated, and as such there is no empirical data to develop required processing equipments. It has been observed that the need to determine the engineering properties to enhance postharvest operations of root crops is important [21] and it cannot be over-emphasized [22]. The cocoyam rebirth for food security and empowerment programme under National Root Crops Research Institute

Umudike have identified various value-added products of cocoyam to include; cocoyam crisps, high quality flour for confectionaries, soup thickner, cocoyam fufu flour, achicha, chin chin, cocoyam queen cake, doughnut and chips [5]. The value addition will increase consumption by different categories of people, increase production and reduce spoilage in storage [5]. It can be used in making bread [23]. Cocoyam corms can also be used for industrial purposes [24]. About 97% of respondant in a research conducted in Southwest Nigeria have cocoyam as part of their family menu [25]. Apart from human consumption, cocoyam corma can be utlized as feed for animals [11]

Table 4. Factors responsible for loss in cocoyam corms and their resulting effects

Factor	Mechanism	Stage Affected	Resulting Loss
Mechanical	Rupture, crushing, Bruising	Harvest,transport, storage	Moisture loss, total loss, access to pests and diseases
Physiological	Transpiration, respiration, sun scorch, chilling, greening, inversion of starch	All stages before processing, in field after lifting, cold storage, end of dormancy	Water loss, dry matter loss, tissue degradation, loss of palatability, increased transpiration and respiration
Pathogenic and fungi	Sprouting, nicrosis and tissue degradation	Storage and preharvest	Partial to complete loss
Insect infestation	Boring and chewing	Storage, preharvest,	Downgrading, partial loss, access for decay organisms
Rodents and birds	Chewing, pecking	Pre-harvest, storage	Partial loss, access for decay organisms

Adapted from [21]

6 Conclusion

It is evident that even though a lot has been reported on cocoyam corms, very little attention has been given to postharvest operations. To start the revolutionary study on postharvest of cocoyam, comprehensive research on the engineering properties of the corms should come first. This is because design and development of machines and equipments for cocoyam postharvest handling and operation cannot be done without the knowledge of these properties. Then, an alternative to the prevalent traditional storage systems should be developed to encourage farmers to produce more. Handling and processing techniques need to be researched further to widen value-addition in cocoyam food chain.

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