Journal of Advances in Biology & Biotechnology
11(3): 1-7, 2017; Article no.JABB.31035
ISSN: 2394-1081

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Effects of Different Drying Methods on the Mycoflora Associated with Cocoyam (*Colocasia esculenta* (L) Schott) Chips (Achicha) in Storage

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JABB/2017/31035
Editor(s):
(1) Fernando José Cebola Lidon, Universidade Nova de Lisboa, Campus da Caparica, Portugal.
(2) James W. Lee, Department of Chemistry and Biochemistry, Old Dominion University, USA.
Reviewers:
(1) Opeyemi Uwangbaoje Lawal, Evangel University Akaeze, Nigeria.
(2) Prabhakara Rao Pamidighantam, CSIR CFTRI Resource Centre, Hyderabad, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/17833

Original Research Article

Received 16th December 2016
Accepted 31st January 2017
Published 14th February 2017

ABSTRACT

Cocoyam (*Colocasia esculenta* (L) Schott) corms were processed into chips (Achicha) by drying to increase storage life and availability. During this drying process, microorganisms often settle on the exposed surface causing deterioration. In this study, the effect of different drying methods on mycoflora associated with cocoyam chips in storage was evaluated. The corms were washed under flowing tap water, parboiled for 10 minutes, peeled, slice and divided into three equal portions for drying. Three drying methods were used (A = Ambient, O = Oven and S = Sun drying). Dried chips were stored in airtight containers at room temperature (30 ± 2℃) for 3-months period. Observed mycoflora were isolated on agar plates and identified. A total of 961 colonies comprising of 15 species of fungi were recorded including *Aspergillus flavus, A. fumigates, A. niger, Botryodiplodia theobromae, Curvalaria lunata, Fusarium solani, Mucor mucedo* and *Rhizopus stolonifer* among others. *A. niger* occurred most, followed by *M. mucedo, F. solani* and *B. theobromae* throughout the period of storage irrespective of drying method employed. Mycoflora occurred in the order of S>A>O while number of fungal colonies increased as the storage period increased with August>July>June. Thus, oven drying cocoyam chips is recommended as this reduced exposure to fungal colonization compared to sun and ambient drying. Since various traditionally processed food including cocoyam chips are consumed in Nigeria, drying in more confined environment with enhanced facilities are needed to improve quality of product, good health and food security for the local populace.

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Keywords: Drying methods; cocoyam chips; mycoflora; storage period.

1. INTRODUCTION

Taro cocoyam (*Colocasia esculenta* (L) Schott) (Plate 1a) belonging to the family Araceae is one of the five important root crops in Nigeria alongside yam, cassava, Irish potato and sweet potato [1]. The production of cocoyam in Nigeria is affected by diseases in the field [2-4] and in storage [5,6]. This is worsened with the fact that cocoyam is often called "women crop" [7,8], since it is cultivated by women who do not have control over land, labour and capital as in some communities in South-eastern Nigeria [6]. The crop is valued for its edible corms, carmels and flower spadix (Opi-ede) [4] as well as other traditional uses.

Cocoyam corms and camels (Plate 1b) can be consumed in various forms especially in South-eastern and South-western Nigeria [1,9,10]. In Ora-Eri for instance, boiled cocoyam can be eaten with red oil sauce locally called "ncha" or with vegetables and "ukpaka" (sliced and fermented seeds of oil bean tree = *Pentaclethra macrophylla*) in form of porridge. It could be pounded alone or together with boiled unripe plantain and eaten with soup, a diet for the elderly and diabetic patients. The carmels are used in thickening soup popularly called Ofe-ede using either washed bitterleaf (*Vernonia amygdalina*) or "Oha" (*Pterocarpus soyauxii*) leaves as a vegetable.

Post-harvest loss of cocoyam has been a very serious problem to farmers because they are easily infected by rot causing microorganisms [6, 11]. Due to the difficulties in storage, cocoyams are usually consumed shortly after harvest. In order to increase the shelf-life and period of availability, the farmers have to process them by drying into chips popularly known as "Achicha ede" (Plate 1c) which provides food all year round especially during the lean planting season [8]. The chips are pound into tiny piece, boiled with fresh corn and eaten with vegetables or boiled with beans as porridge.

Nevertheless, during the drying process, microorganisms often settle on the exposed surface of these chips as pointed out by [12-14]. Consequently, these organisms may deteriorate the chips thereby reducing their nutritive quality and market values [15-19]. Besides, the danger of toxin production by some of these organisms and subsequent deleterious health effects on humans when consumed has been reported [20-22]. Fungal contamination can also lead to discolouration of the chips giving rise to moldy taste and produce off odours [23,24].

In this study therefore, the effect of different drying methods on the mycoflora associated with cocoyam chips in storage was evaluated. It is hoped that the study will recommend the best drying method that will improve quality, good health and food security for the local populace.

2. MATERIALS AND METHODS

2.1 Collection of Samples

The fresh cocoyam corms (*Colocasia esculenta*) (Plate 1b) were purchased from Oye market in Ora-Eri, Aguata Local Government Area of Anambra State, collected in polyethylene bags and taken to Delta State University, Abraka for the study.

2.2 Drying Process

Cocoyam corms were washed in flowing tap water, parboiled for 10 mins at 100℃, allowed to cool, peeled and sliced into flat sheets. The method of [14] was adopted for drying the cocoyam slices. Three drying methods were used which included Ambient, Oven and Sun drying. The boiled cocoyam slices were divided into three portions and tagged A, O and S. Sample A was dried at ambient (room) temperature (30±2℃) for two weeks; sample O was oven dried for 6hours, while sample S was spread on sterilized tray and placed on 60cm high stool in the open field for eight hours daily (9.00am – 5.00pm) for one week. Care was taken to avoid rain or dew wetting the slices for this period by taking the tray to a shade during rainfall. The dried samples (Plate 1c) were then used for the study.

2.3 Storage of Samples

The cocoyam chips (Ambient, Oven and Sun dried) were stored separately in air-tight containers at room temperature (30 ± 2℃). They were observed on monthly basis for the period of three months (June to August).

2.4 Isolation and Identification of Fungi

The method of [13] was adopted. Potato dextrose agar (PDA) was prepared according to

manufacturer's specification and dispensed into sterile petri-dishes for inoculation. The chips were broken into small (5 mm by 5 mm) pieces and placed on PDA in three replicates. The inoculated petri-dishes were sealed with paraffin to prevent contamination, incubated in the laboratory at 30±2°C for 5 days and examined daily for fungal growth. When growth established, sub-culture were prepared using inoculum from different organisms in the mixed cultures as obtained. The resulting pure cultures were used for characterization and identification of the fungal isolates using a compound microscope and mycological guides by [25,26] and other mycological literature [27]. Percentage frequency of isolation (PFI) of all fungi was calculated by the method of [4].

$$PFI = \frac{Number\ of\ times\ a\ fungi\ is\ encountered}{Total\ number\ of\ times\ all\ fungus\ was\ encountered} \times \frac{100}{1}$$

3. RESULTS

A total number of 961 colonies with 10 genera and 15 species were isolated from the dried cocoyam chips studied (Table 1). The results revealed that *Aspergillus niger, Aspergillus flavus, Aspergillus glaucus, Aspergillus funigatus, Aspergillus ochraceous, Aspergillus tamarii, Absidia corymbifera, Botryodiploda theobramae, Candida* spp. *Curvularia lunata, Fusarium solani, Mucor* spp, *Neurospora sitophila, Penicillium digitatum* and *Rhizopus stolonifer* were found to be associated with cocoyam chips in storage. *Aspergillus niger* had the highest number of occurrence with a total colony of 136 (14.15%) followed by *Mucor* mucedo, *Fusarium solani* and *Botryodiplodia theobramae* with total number of 114 (11.86%), 109 (11.34%) and 102 (10.61%) respectively. These four species were isolated from all the chips irrespective of the drying method employed.

Aspergillus ochraceous, Aspergillus tamarii, Curvularia lunata and *Penicillium digitatum* made appearance in the second (July) and third (August) months. These species were also totally absent in the oven and ambient dried chips except *Aspergillus ochraceous* which was isolated both in the ambient and sun dried chips but totally absent in the oven dried chips. *Neurospora sitophila, Curvularia lunata, Absidia corymbifera, Aspergillus tamarii, Aspergillus ochraceous* and *Aspergillus glaucus* were totally absent in the oven dried chips throughout the months of study. *Aspergillus tamarii* were least isolated with a total number of 11 (1.14%), followed by *Penicillium digitatum* and *Curvalaria lunata* with a total number of 14 (1.46%) and 20 (2.08%) respectively through the period of the study.

For each organism, the number of colonies increased as the period of storage increased. Nevertheless, *A. ochraceous, A. tamari, Curvalaria lunata* and *Penicillum digitata* were totally absent in the month of June (Table 2). With respect to the drying method used, chips dried in the sun harboured more fungi than those dried under the Ambient temperature which in turn harboured more fungi than those from Oven dried method (Fig. 1). In the monthly study, more fungi were isolated in the month of August, followed by July and lastly the month of June (Fig. 2). *Aspergillus* species accounted for a total of 365 (37.98%) occurrence among all the fungal species encountered in the study. Among these species, *A. niger, A. flavus* and *A. fumigates* were 37.26, 23.56 and 18.36% respectively.

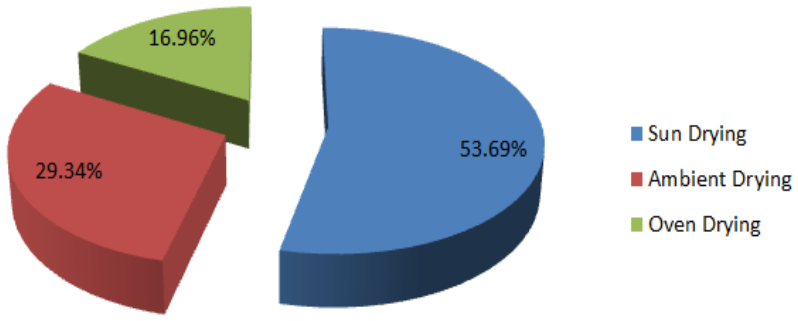

Fig. 1. Percentage occurrence of fungi in different drying methods

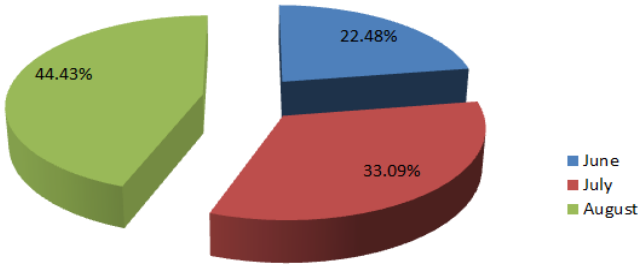

Fig. 2. Percentage occurrence of fungi in different months

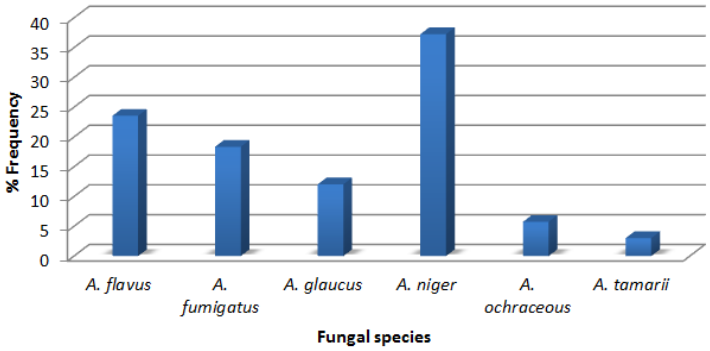

Fig. 3. Percentage occurrence of *Aspergillus* spp in the study

(a) **(c)**

(b)

Plate 1. Healthy cocoyam: (a) farm (b) corms and (c) chips

Table 1. Summary of fungi isolated with their frequency of occurrence in the study

S/N	Fungi	June			July			August			Total	%
		A	O	S	A	O	S	A	O	S		occurrence
1	*Aspergillus flavus*	6	-	12	8	4	16	8	8	24	86	8.95
2	*Aspergillus fumigatus*	9	-	6	10	-	10	13	2	17	67	6.97
3	*Aspergillus glaucus*	4	-	6	7	-	9	11	-	7	44	4.58
4	*Aspergillus niger*	10	9	14	14	12	19	17	16	25	136	14.15
5	*Aspergillus ochraceous*	-	-	-	2	-	6	5	-	8	21	2.19
6	*Aspergillus tamari*	-	-	-	-	-	4	-	-	7	11	1.14
7	*Absidia corymbifera*	-	-	6	6	-	10	4	-	15	41	4.27
8	*Botryodiplodia theobromae*	8	6	10	10	10	15	12	10	21	102	10.61
9	*Candida* spp.	-	4	8	-	6	8	3	10	14	53	5.52
10	*Curvularia lunata*	-	-	-	-	-	8	-	-	12	20	2.08
11	*Fusarium solani*	10	6	14	12	7	18	12	9	21	109	11.34
12	*Mucor mucedo*	8	8	12	12	8	17	13	10	26	114	11.86
13	*Neorospora sitophila*	7	-	9	7	-	12	8	-	14	57	5.93
14	*Penicillium digitatum*	-	-	-	-	-	4	-	-	10	14	1.46
15	*Rhizopus stolonifer*	8	6	10	8	6	13	10	6	19	86	8.95
	Total	70	39	107	96	53	169	116	71	240	961	100

Key: A = ambient drying; O = Oven Drying; S = Sun drying

Table 2. Total fungi isolated from cocoyam chips in different months

S/N	Fungi	June	July	August	Total	% occurrence
1	*Aspergillus flavus*	18	28	40	86	8.95
2	*Aspergillus fumigatus*	15	20	32	67	6.97
3	*Aspergillus glaucus*	10	16	18	44	4.58
4	*Aspergillus niger*	33	45	58	136	14.15
5	*Aspergillus ochraceous*	0	8	13	21	2.19
6	*Aspergillus tamari*	0	4	7	11	1.14
7	*Absidia corymbifera*	6	16	19	41	4.27
8	*Botryodiplodia theobromae*	24	35	43	102	10.61
9	*Candida* spp.	12	14	27	53	5.52
10	*Curvularia lunata*	0	8	12	20	2.08
11	*Fusarium solani*	30	37	42	109	11.34
12	*Mucor mucedo*	28	37	49	114	11.86
13	*Neorospora sitophila*	16	19	22	57	5.93
14	*Penicillium digitatum*	0	4	10	14	1.46
15	*Rhizopus stolonifer*	24	13	35	86	8.95
	Total	216	318	427	961	100

4. DISCUSSION

In this study, several fungi with varied frequency of occurrence were isolated from dried cocoyam chips in storage. Some of these fungi have been reported previously to cause spoilage of food and have been isolated from different food products such as onions [22], sweet potato [14], cassava [12], plantain [22], yams [27-29,17,13]. These reports suggest that these fungi are general contaminants as they have been previously isolated from different food products.

The observation that sundried chips harboured more fungi than the other drying methods is in consonance with the works of [14,22,19] whose earlier reports indicated a progressive increase in fungal species in sundried sweet potato, plantain and cocoyam chips respectively. Increased number of fungal colonies encountered in the sundried chips suggested that the fungi must have been present in the atmosphere in form of spores and easily contaminate the exposed chips. Parboiling of the cocoyam during the processing of the chips made the nutrients available which encouraged the germination and colonization of these fungi. Invasion of these mycoflora on the cocoyam chips can cause nutrient depletion which can affect the quality and quantity of the product, their market value as well as making the consumers especially immune-compromised individuals vulnerable to microbial infection. Similar observation was made by [27,15,21,22].

The occurrence of different species of fungi in food is of major public health concern. This is because different strains of these organisms vary tremendously in their ability to produce aflatoxins [21] have detected various levels of aflatoxins B_1 content in fungi (especially five species of *Aspergillus* and *Alternaria alternata* from onion bulbs. Other researchers such as [28,24,20,18] have similarly reported aflatoxin detection in other stored foods. Therefore, prolong intake of these contaminated food materials can constitute a health risk thereby reducing the population growth rate significantly. Although mycotoxin detection is not reported in this study, many of the fungi identified to be associated with cocoyam chips in storage have the potential for toxin production.

5. CONCLUSION

This study revealed the various fungi associated with dried cocoyam chips in storage. The use of oven drying method should be encouraged as this will reduce exposure to fungi and their subsequent colonization usually encountered during the sun dry. Since a lot of traditionally processed food including cocoyam chips are consumed in Nigeria, drying in a more confined environment with enhanced facilities are needed to improve quality of product, good health and food security for the local populace

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/17833