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ORIGINAL ARTICLE

Fungal Nail Infections amongst Cassava Farmers and Processors in Southwest Nigeria

Infections Fongiques des Ongles chez les Producteurs et les Transformateurs de Manioc dans le Sud-Ouest du Nigeria

[1]*O. O. Ayanlowo, [2]R. O. Oladele

ABSTRACT

INTRODUCTION: Onychomycosis has been documented as an occupational dermatosis and dermatophyte infection of the nail is the most common infection amongst farmers. This study aims to determine the prevalence of fungal nail infections amongst cassava farmers and processors and identify causative organisms.

METHODS: Consenting individuals engaged in the processing of raw cassava into 'garri' meal in Odogbolu local government area of Ogun State were included. Questionnaires contained demographic details, clinical descriptions, classification, and the presence of fungal infections in other parts of the body. Nail clippings were collected for direct microscopy using 40% Potassium hydroxide solution to break down nail keratin. Specimens were inoculated onto Sabouraud's dextrose agar with chloramphenicol and gentamicin incorporated, and incubated at 26°C and 35°C.

RESULTS: Clinical features of onychomycosis were found in 119 (68.4%) participants. Distal subungual onychomycosis (68–57.1%) was the most common clinical type, followed by total dystrophic onychomycosis (49–41.2%), candida onychomycosis (34–28.6%), proximal subungual onychomycosis (14–11.8%) and superficial white onychomycosis (9–7.6%). One hundred and one (84.9%) respondents with clinically described onychomycosis had positive results in mycology studies. The non-dermatophyte molds (*Aspergillus* and *Penicillium* spp.) were found in 130 samples (78.8%); dermatophytes in 31 (18.8%) and yeast in 7 (4.2%).

CONCLUSION: Non-dermatophyte molds, traditionally thought to be contaminants of nail cultures, were the main causative agents of primary fungal nail infections. Garri processors will benefit from public health intervention geared towards automation of some of these processes to minimize contact with soil and water, and health education on the use of protective materials. **WAJM 2022; 39(11): 1127–1133.**

Keywords: Onychomycosis, 'garri', cassava processors, non-dermatophyte molds, dermatophytes, yeasts.

RÉSUMÉ

INTRODUCTION: L'onychomycose a été documentée comme une dermatose professionnelle, et l'infection dermatophyte de l'ongle était l'infection la plus courante chez les agriculteurs. Cette étude vise à déterminer la prévalence des infections fongiques des ongles chez les cultivateurs et les transformateurs de manioc et à identifier les organismes responsables.

MÉTHODES: Des individus consentants engagés dans la transformation du manioc brut en farine de 'garri' dans la zone de gouvernement local d'Odogbolu de l'Etat d'Ogun ont été inclus. Les questionnaires contenaient des détails démographiques, des descriptions cliniques, une classification et la présence d'infections fongiques dans d'autres parties du corps. Des coupures d'ongles ont été prélevées pour une microscopie directe en utilisant une solution d'hydroxyde de potassium à 40% pour décomposer la kératine de l'ongle. Les spécimens ont été inoculés sur de la gélose dextrose de Sabouraud avec du chloramphénicol et de la gentamicine incorporés, et incubés à 26°C et 35°C.

RÉSULTATS: Des caractéristiques cliniques d'onychomycose ont été trouvées chez 119 (68,4%) participants. L'onychomycose sous-unguéale distale (68–57,1 %) était le type clinique le plus fréquent, suivie par l'onychomycose dystrophique totale (49 à 41,2 %), l'onychomycose à candida (34 à 28,6 %), l'onychomycose sous-unguéale proximale (14 à 11,8 %) et l'onychomycose blanche superficielle (9 à 7,6 %). Cent un (84,9 %) répondants présentant une onychomycose décrite cliniquement ont eu des résultats positifs dans les études mycologiques. Les moisissures non dermatophytes (Aspergillus et Penicillium spp.) ont été trouvées dans 130 échantillons (78,8%) ; les dermatophytes dans 31 (18,8%) et les levures dans 7 (4,2%).

CONCLUSION: Les moisissures non dermatophytes, traditionnellement considérées comme des contaminants des cultures d'ongles, étaient les principaux agents causaux des infections fongiques primaires des ongles. Les transformateurs de garri bénéficieront d'une intervention de santé publique axée sur l'automatisation de certains de ces processus afin de minimiser le contact avec le sol et l'eau, et d'une éducation sanitaire sur l'utilisation de matériaux de protection. **WAJM 2022; 39(11): 1127–1133.**

Mots clés: Onychomycose, 'garri', transformateurs de manioc, moisissures non dermatophytes, dermatophytes, levures.

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INTRODUCTION

Onychomycosis has been documented as an occupational, and dermatophyte infection of the nail is the most common infection amongst farmers.[1] Farming is the predominant occupation amongst the rural dwellers in Southwest Nigeria. It is non-mechanized with the use of the traditional hoe and cutlass, which exposes their hands and feet to trauma and infections.[2] Cassava meals are a staple diet in Nigeria. Dumping cassava peels in the farm environment, removal of heaps of cassava tuber peelings, soaking of cassava and clearing of ditches have been identified to be potentially harmful to farmers.[3] The processing of cassava is a major post-harvest activity in communities in Ogun State, Southwest of Nigeria.[4] These processes are done with bare hands and exposes the skin to soil, cassava plants, cassava peels and water (during washing and soaking) which are nidus of fungal infections.

Onychomycosis is a word used to describe fungal nail infections which can affect both the fingernails and the toenails.[5] It can affect the entire nail unit, the nail matrix, the nail bed and the nail plate. The infection can be caused by a dermatophyte, yeast or non-dermatophyte mold species.[5] Onychomycosis caused by dermatophytes is often referred to as tinea unguium.[5,6] Factors predisposing to onychomycosis include age over 50 years, frequent contact with water, associated tinea pedis, family history of onychomycosis, immune suppression, other nail pathologies such as psoriasis and occupation that involves regular wetting of hands such as hair dressing and catering.[5,6]

In a survey in India, the incidence of onychomycosis was highest amongst farmers and gardeners.[7] Some of the factors noted to facilitate the spread of infections amongst farmers include overcrowded living environment, sharing of facilities, keeping of pets, and non-wearing of protective foot and hand wears.[7,8] The organisms frequently noted to cause onychomycosis include *Trichophyton rubrum* (dermatophyte), *Candida albicans* (yeast) and *Aspergillus* species (non-dermatophyte mold).[9]

Apart from the cosmetic significance, onychomycosis is regarded as a public health issue in view of the pain, discomfort, disfigurement and its effect on the activities of daily living.[5,10] It is hoped that this study will inform the need for public health intervention and health education on fungal nail infections amongst cassava farmers and processors in Nigeria.

This study aims to determine the prevalence of onychomycosis amongst cassava (Garri) farmers and processors and identify causative organisms.

MATERIALS AND METHODS

This is a cross sectional study conducted amongst farmers in four towns in Odogbolu local government of Ogun State, Southwest, Nigeria. Farming is the predominant occupation amongst the rural dwellers and the cassava meal called 'garri' is the most frequently eaten staple food by the Ijebu tribe of Ogun State. The processes involved in the production of 'garri' meal start from planting cassava, to harvesting, peeling, washing, grinding, drying, sieving, frying and bagging. Individuals (males and females) engaged in farming and processing raw cassava into 'garri' using the traditional processors, who gave their consent, were included in the study. People who processed cassava into 'elubo' powder and 'fufu', which are other types of cassava meal and those who did not give their consent were excluded. Minimum sample size was calculated using $n= Z^2pq/D^2$ (7.79% prevalence was used)[8] = 110 with 10% attrition, resulting in a value of 121.

Ethical approval was obtained from the Health and Research Ethics Committee of Lagos University Teaching Hospital, Idi-Araba (assigned number: *ADM/DCST/HREC/980)*.

Four wards out of the fifteen wards in Odogbolu LGA were selected by a simple random sampling (balloting). The selected wards were Odogbolu, Ijesha, Okun-owa and Araromi. A rapid census survey was conducted to identify and enumerate all the garri processing plants in the four wards. Then all the workers in the plants were approached for recruitment into the study.

Three research assistants, fluent in Yoruba, were trained to administer the demographic aspect of the questionnaire, while one of them, a microbiologist was trained to collect the nail samples. The researchers examined the nails and documented the examination findings.

The data were collected over a period of four weeks in July 2014. The questionnaire obtained demographic details, clinical descriptions of fungal nail infections, clinical classification, and the presence of fungal infections in other parts of the body. The clinical types of onychomycoses include distal subungual onychomycosis (DSO), proximal subungual onychomycosis (PSO), superficial white onychomycosis (SWO), total dystrophic onychomycosis (TDO), and candida onychomycosis which is often associated with chronic paronychia (yeast infection of the proximal and lateral nail folds).[9,11]

Nail clippings and skin scrapings were taken from individuals with clinical features suggestive of fungal nail and skin infections after cleaning with 70% ethanol. All nails were scraped with a blunt scalpel from the proximal to the distal end of the nail. The first 4–5 scrapings were discarded (to reduce contaminants and get to viable tissue). Participants with suspicious skin lesions also had skin scrapings following established protocol. All samples were transported in a folded square of black paper and transported to the microbiology laboratory of the Lagos University Teaching Hospital. Moulds were observed growing on the wet bagged up cassava undergoing fermentation and samples were collected for culture.

The specimen was divided into two parts. Potassium hydroxide solution (40% w/v) was added to the first part of the specimen for 2 hours to break down the nail keratin and release fungal elements for observation by direct microscopy. Fungal elements seen and identified as hyphae or yeast cells were documented. The second part of the specimen collected was inoculated onto Sabouraud's dextrose agar (SDA) with chloramphenicol and gentamicin incorporated; plates were sealed with paraffin wax tape and incubated as duplicate cultures at 26°C and 35°C

respectively. Yeasts were identified within 48 hours using microscopy; germ tube test was used for the presumptive diagnosis of *C. albicans*. Other *Candida spp*. were documented as non-*C. albicans* spp. Cultures were maintained for 4 weeks for dermatophytes and other molds. However, they were reviewed twice weekly for growth and colonial morphology, pigmentation and consistency were documented. Identification and speciation of fungal organisms was done using colonial morphology, pigmentation of both front and reverse of plate and microscopy. Criteria for diagnosis of non-dermatophyte mold as a pathogenic organism include clinical nail disease, positive KOH with hyphae, growth of the mold in duplicate cultures, absence of a dermatophyte and yeast and characteristic morphology.

The data was entered on an excel spreadsheet and analysis was done using the IBM SPSS Statistics 20 (SPSS Inc., Chicago, IL., USA). Absolute and relative frequencies were calculated for qualitative variables and means and standard deviation for quantitative variables.

RESULTS

One hundred and seventy-four cassava 'garri' processors were recruited during the study, 160 females (92%) and 14 males (8%), giving a male to female ratio of 1:11.4. The mean age of the respondents was 40.01 $\pm$ 14.9 years. The cassava 'garri' processors were from all age groups, ranging from 13 to 80 years. The individuals in the pediatric age group were either introduced to the business by their parents or helping their mothers in what is seen as family business. Details of the demographics are shown in Table 1. Table 2 shows the frequency of participants' involvement in different processes of cassava meal (garri) production from planting to bagging.

Clinical features suggestive of onychomycosis were found in 119 (68.4%) participants. All the five clinical types of onychomycoses were documented amongst the cassava 'garri' processors. Figures 1 and 2 show the clinical types and morphology of the nails in participants who have fungal nail infections. Distal subungual onychomycosis was the most common type (68–57.1%). One hundred and one (84.9%) of the 119 respondents with clinically described onychomycoses had positive microscopy and/or culture results. Table 3 shows clinically nail diseases (onychomycoses) by age groups. Participants in the middle age group were the most affected relatively.

Two hundred and seven samples were taken from the respondents with clinical features of onychomycoses: 116 (56.3%) from the toenails, 84 (40.4%) from the fingernails, 3 (1.4%) from associated tinea manum (hand infection) and 4 (1.9%) from tinea corporis (trunk). Positive microscopy was documented in 105 samples (50.5%): hyphae in 83/105 (79.0%) samples, yeasts in 8/105 (7.6%) samples and spores in 14/105 (13.3%) samples. Positive culture results were documented in 164 nail samples (79.3%). Table 4 shows the culture results. The non-dermatophyte molds (*Aspergillus spp.)* were the most common organisms

Table 1: Demographic Data of Study Participants

Parameters		Data
Total Respondents		174
Sex Distribution	Males	14 (8.1)
	Females	160 (91.9)
Male : Female Ratio		1 : 11.4
	Mean Age	40.01 + 14.9
	Age range	13 to 70 years
Age Distribution	Paediatric age (0–16 years)	8 (4.6)
	Young Adults (17–25 years)	25 (14.4)
	Older Adults (26-44 years)	73 (41.9)
	Middle age (45–64 years)	44 (25.3)
	Elderly (>65 years)	9 (5.2)
	Unknown	15 (8.6)
Educational Level of Respondents	No Formal Education	53 (30.5)
	Primary	52 (29.9)
	Secondary	37 (21.3)
	Post secondary	2 (1.1)
	No response	30 (17.2)
Marital Status of Respondent	Married	114 (65.5)
	Single	5 (8.6)
	Widowed	19 (10.9)
	Divorced	2 (1.1)
	Separated	5 (2.9)
	Cohabiting	2 (1.1%)
	No response	18 (10.3)
Ethnic Groups (Nigeria)	Southwest	40 (23.0)
	North Central	57 (32.8)
	Southeast	50 (28.7)
	South-South	2 (1.1)
	Non-Nigerians	6 (3.4)
	No response	17(9.8)

Table 2: Involvement of Participants in Various Processes of Garri Production

Processes	Frequency (n)	Percentage (%)
Planting	106	60.9
Harvesting	83	47.7
Peeling	137	78.7
Washing	126	72.4
Grinding	28	16.1
Drying	96	55.2
Sieving	107	61.5
Frying	141	81.0
Bagging	123	70.7

Participants were involved in more than one process in the production.

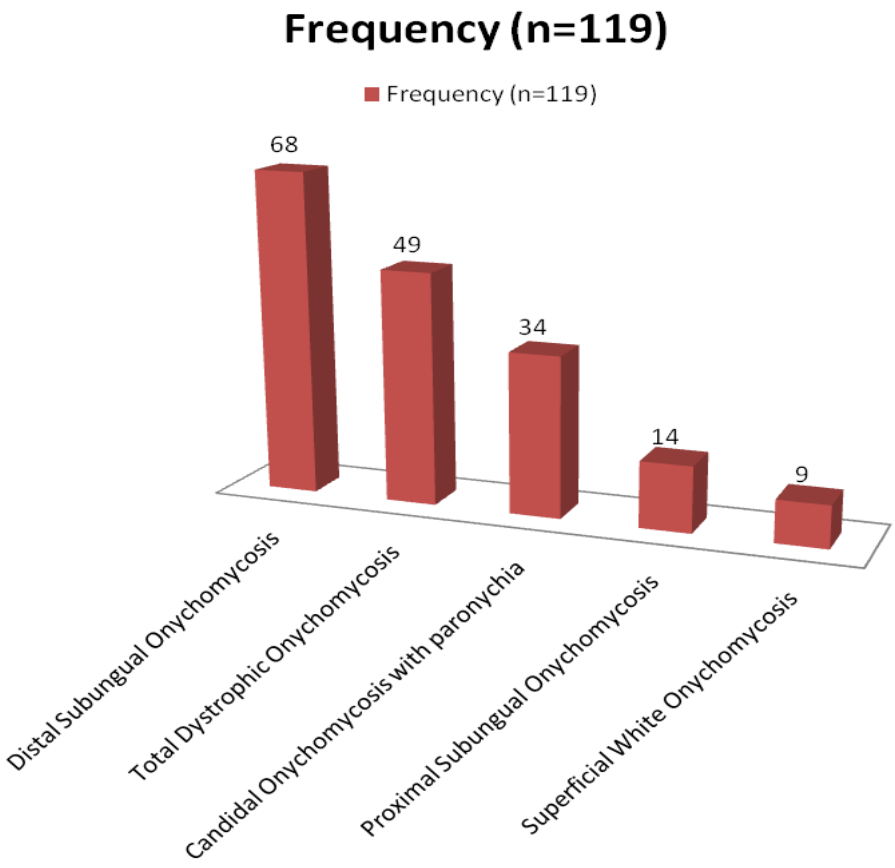

Fig. 1: Frequency of the Clinical Classes of Onychomycosis.

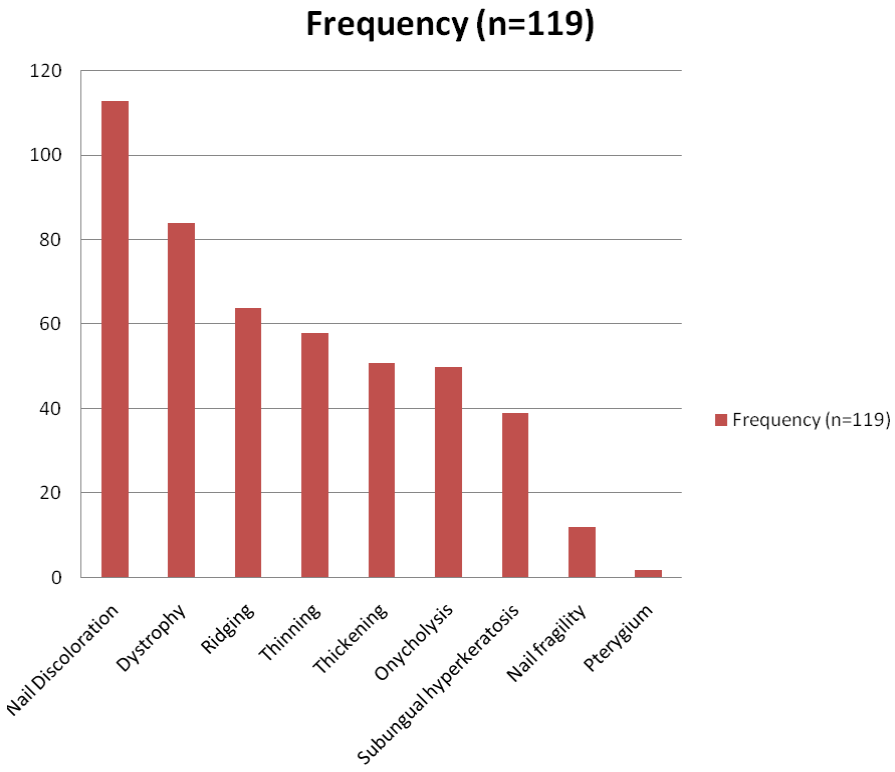

Fig. 2: Morphology of Onychomycosis amongst Respondents.

in the cultures done amongst the study participants, in 119 samples (72.6%). Samples collected from the wet bagged garri grew predominantly *Aspergillus flavus*. Some cultures grew more than one organisms (Table 4).

DISCUSSION

Food processing and farming, like many other occupations, predispose workers to various dermatoses including infections. This study shows that fungal nail infections are an important occupational dermatosis amongst cassava farmers and processors (garri) affecting more than 68% of workers. Fungal nail infections have been documented in other farmers including rice and cassava processors in Nigeria and other parts of the world.[1,2,7,8] Cassava 'garri' production involves several processes such as planting, harvesting, peeling, washing, grinding, sieving, and frying (Table 2), which involves contact of the hands and feet with soil and water. These processes facilitate the transmission of dermatophytes, yeasts and molds which are often pathogenic.

Farming in other climes has become more mechanized with improving technology, but, farming and food processing in Nigeria remains largely manual, often without the use of protective equipment such as gloves, aprons, and boots. This predisposes cassava 'garri' processors to micro-trauma, which is a major risk factor for fungal nail infections.[1–3] Farmers in industrialized countries report trauma predominantly from the use of machinery, biologic hazards, psychological stress, exposure to farm chemicals, deafness from heavy machinery, while in less developed countries, fungal infections top the list of occupational hazards.[1–3,12] This study shows that cassava 'garri' processing is a predominantly female occupation in the region of study, and these women are involved at all stages, from planting to bagging. This agrees with a previous study amongst farmers in Southwest Nigeria which noted that while men were involved with clearing and planting, women do the harvesting, processing, and selling of food products.[2] Our study noted that these women were predominantly of child-

Table 3: Frequency of Clinical Onychomycosis by Age Group

Age Groups	Total Participants (%)	Participants with Nail Diseases (%)	Percentage within Age Group
Paediatric age (0–16 years)	8 (4.6)	6 (5.0)	75
Young Adults (17–25 years)	25 (14.4)	13 (10.9)	52
Older Adults (26–44 years)	73 (41.9)	49 (41.2)	67.1
Middle age (45–64 years)	44 (25.3)	37 (31.1)	84.1
Elderly (>65 years)	9 (5.2)	6 (5.0)	66.7
Unknown	15 (8.6)	8 (6.7)	53.3
Total	**174 (100)**	**119 (100)**	**68.4**

Table 4: Organisms Cultured in Samples Collected from the Garri Processors

Organisms	Frequency (n=164)	Percentage (%)
Non dermatophyte moulds	**119**	**72.6**
Aspergillus niger	71	46.7
Aspergillus fumigates	26	18.2
Aspergillus flavus	15	9.1
Penicillum spp.	7	4.8
Dermatophytes	**30**	**18.3**
Trichophyton rubrum	19	13.9
Trichophyton tonsurans	4	2.4
Trichophyton violaceum	3	1.8
Trichophyton verrucosum	1	0.6
Micosporum canis	1	0.6
Micosporum nanum	2	1.2
Yeast Infection	**6**	**3.6**
Candida albicans	6	4.2
Combined mould/Yeast Infections	**9**	**5.5**
Trichophyton rubrum/ Aspergillus niger	3	1.8
Aspergillus niger/ Aspergillus fumigates	3	1.2
Trichophyton rubrum/ A. fumigates	1	0.6
Aspergillus niger/ penicillum	1	0.6
Aspergillus niger/ A. fumigates/candida	1	0.6

bearing age and middle age and involved with housekeeping and other wet works which further increased their likelihood of having onychomycosis. Although onychomycosis has low mortality and morbidity, it has been found to be of great cosmetic concern particularly amongst women and has a large effect on the quality of life and psychosocial and emotional wellbeing from the disfigurement.[10]

Respondents in the paediatric age group were involved as part of the family business or assist their parents after school and during the holidays. This study revealed a low educational background amongst cassava 'garri' processors, with approximately two-thirds of respondents having only primary education or no formal education at all. Studies on fungal infections in Nigeria have identified socio-economic status evidenced by low educational levels, low income, and poor hygiene as predisposing factors to fungal infections in rural communities in Nigeria.[13,14]

All clinical types of onychomycoses were documented by this study, although the most common type was distal subungual onychomycosis. Cultures of samples revealed the presence of dermatophytes, yeasts, and non-dermatophyte molds (NDM) as the causative agents of onychomycosis. Non-dermatophyte molds (*Aspergillus niger*, *Aspergillus fumigates, Aspergillus flavus and Penicillium spp.)* were the most prevalent organisms cultured in this study. *Aspergillus spp* was also cultured on several wet bagged up garri. Globally, studies done in temperate countries, urban centres and dermatology clinics often document low prevalence of NDM, while studies done amongst the rural dwellers and farmers document a higher prevalence of NDM than dermatophytes.[2,8,12,15,16] Our findings are similar to that found in a study done at the dermatology clinic of a hospital in a predominantly farming community of Sri Lanka amongst farmers and manual labourers in paddy fields and tea plantations.[12] They found more NDM than dermatophytes as causative agents for onychomycosis.[12]

The increasing prevalence of NDM has been attributed to occupationally-related trauma such as may be the case in our cohort who are cassava farmers and processors, immune suppression and increasing use of broad-spectrum antibiotics.[17] Other high-risk occupations found with NDM include butchers and housewives.[17] Non dermatophyte molds are no longer regarded as contaminants of nail cultures but are causes of fungal nail infections.[18,19] They are found principally in the soil; predisposing factors noted for NDM in the study from Sri Lanka included walking barefooted or using open slippers, frequent immersion in water, low economic status, close contact with soil and hot humid environment.[12]

Clinically NDM are not distinguishable from dermatophytes and can present with any of the known clinical types of onychomycoses. They can be considered as a cause of false negative results when cultured on dermatophyte-specific medium and of non-response to routine antifungals.[19] They may be primary onychomycosis or secondary infections in a previously diseased nail. A study amongst patients with nail abnormalities and previously culture negative results with medium containing cyclohexidine showed 68% positivity for NDM, when cyclohexidine was excluded.[17] Molecular methods such as the use of Polymerase chain reaction are more sensitive to detect NDM in previously microscopy and culture negative samples.[20]

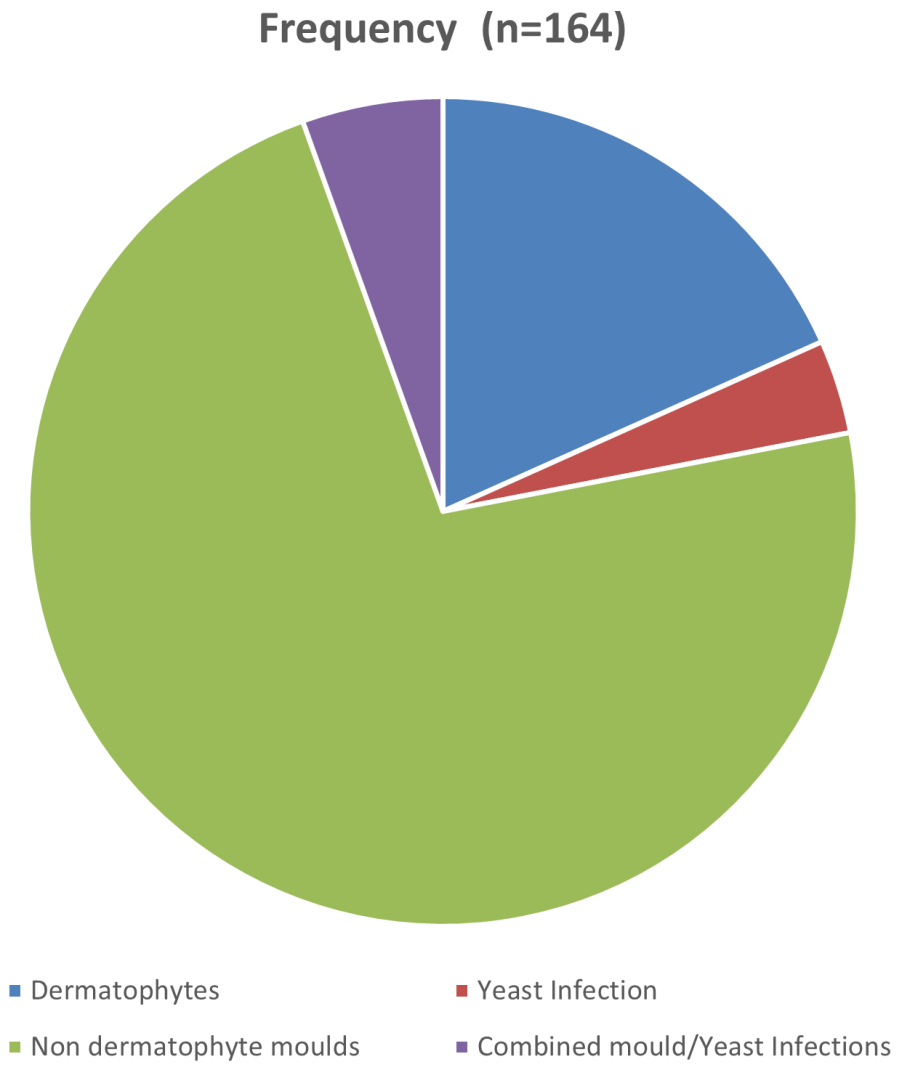

Fig. 3: Distribution of Classes of Organisms.

Trichophyton rubrum was the most frequently cultured dermatophyte in this study, second to *aspergillus niger and flavus*. It represented 74.2% of the total burden of dermatophytes and 13.9% of all organisms seen in this study.[2] This is comparable to findings from another study amongst farmers, mostly males and rice workers in Nigeria, which also documented *Trichophyton rubrum* as the most prevalent dermatophyte infection.[8,16] The higher prevalence of Aspergillus specie in this study compared to other studies in Nigeria amongst farmers may be related to the fact that the participants in this study are also involved with cassava processing which involves very frequent immersion of hands in water. Clinic-based studies as well as community work have shown high prevalence of *Trichophyton rubrum* in dermatophyte infections of the nails, skin, and hair.[2,12,16,21]

The limitations of this study include the fact that the community is rural with resource limitations, and this is non-funded research, hence the researchers were not able to provide antifungals for treatment and follow up on the management of the nail infection. We, however, provided education on measures to prevent fungal nail infections and gave prescriptions to those with fungal nail infections. We did not do histology for the individuals with clinical features suggestive of onychomycoses but negative fungal studies revealed negative mycology results or possible differentials of onychomycosis such as nail psoriasis.

In conclusion, this study found a high prevalence of onychomycosis which is mainly due to NDM amongst garri processors and farmers. Factors noted to predispose them to this were exposure to soil and water because of the various processes of Garri production. Garri processors will benefit from public health intervention geared towards automation of some of these processes to minimize contact with soil and water and health education on the use of protective materials to prevent onychomycosis.

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Conflict of Interest

None.

Sponsorship obtained

None.

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