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Fungi of Coconut (*Cocos nucifera* L.)-Their Deteriorative Ability, Quality Stability and the Role of the Fungus-Eating Insects

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Abstract: Studies on the deteriorative ability and quality stability of coconut (*Cocos nucifera* L.) and the effect of the fungus-eating insects (*Necrobia rufipes*, *Alphitobius diaperinus*, *Crematogaster* sp. and *Tenebrio molitor*) were carried out in the Post Graduate Entomology and Plant Pathology Laboratories of the Department of Applied and Environmental Biology and also in Food Science Laboratory of the Rivers State University of Science and Technology, Port Harcourt. Results showed *Aspergillus niger* van Tieghem, *Rhizopus stolonifer* Lind and *Penicillium italiucum* Wehmer as the seed-borne fungi of coconut. Frequency of occurrence was 80% for *Aspergillus niger* and 100% for both *Rhizopus stolonifer* and *Penicillium italicum.* On storage stability, heat drying offered significantly higher protection to coconut copra. Percentage consumption of fungal hyphae by the fungus-eating insects varied with *Tenebrio molitor* consuming 100% of the three aforementioned fungi. *A. diaperinius* contributed up to 84.1% reduction of *A. niger* as against 80.3% reduction by *Necrobia rufipes* of *A. niger*, *Crematogaster* sp. offered the least reduction (64.2%).

Key words: Coconut, fungi, deterioration, quality stability, control, fungus-eating insects

INTRODUCTION

Coconut (*Cocos nucifera* L.) is one of the most extensively grown and used palms in Nigeria (Purseglove, 1977). It is widely grown in residences, parks, school premises and in all villages as ornamental and economic plants. It contributes significantly to the economy of Nigeria. Its chief product copra is the source of coconut oil, which used in the cosmetics industry. It can also be consumed as snacks in raw form, roasted or fried chips.

In Nigeria, Coconut copra is susceptible to fungal and insect attacks during storage. Most farmers who cultivate coconut palms stand at loss during harvest as fungi and insect infect the copra. A number of pests including scale insects, bruchids, aphids, spider mites, mealybugs, palm weevils and some caterpillars are occasionally found on coconut (Ogbalu, 2003; Onuegbu, 2002). *Rhizopus stolonifer* and *Pennicillium italicum* were associated with the rot of the kernel of *Irvingia gabonensis* var. *gabonensis* (Chuku *et al*., 2002). Onuegbu (1999) observed loss of coherence of green and normal cocoyam corm slices by cell wall-degrading enzyme product by *Botrydioplodia theorobromae* and *Fusarium* sp.

The reason for this study is that Nigeria exports coconut and since the copra needs to be preserved in good quality for storage/export purposes it is important to identify and check fungal growth which are associated with the deterioration of coconut copra and investigate possible control measures. Diseases of coconut palms are well-documented (Onuegbu, 2002) but little or no information is available on the fungi of copra and their deteriorative ability. Some Niger Delta plants have been discovered to possess some chemical properties that are pesticidal, antifungal and antibacterial in action (Asita and Etebu, 1997; Ogbalu *et al*., 2004). There is the need to extend research in this aspect in order to ascertain whether properties of some plants would also augment in fruit/seed preservation. This study therefore addresses the fungal agents associated with coconut copra, their deteriorative ability, quality stability and control using fungus-eating insects.

MATERIALS AND METHODS

Ten dry and mature freshly harvested coconut fruits were bought from a local market in Port Harcourt and the fruits were dehusked and stored in a jute bag in the Plant

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Pathology Laboratory in the Department of Applied and Environmental Biology of the Rivers State University of Science and Technology, Port Harcourt for further studies.

Two fruits were collected from the jute bag and the copra was extracted from the hard nut by cracking using a sterilized knife and the coconut water was also collected. Analyses of these products were carried out in Food Science and Technology Laboratory where their proximate composition was determined and recorded.

Ten grams of the copra were weighed using the triple beam balance and divided into four places and surface-sterilized in a 5% sodium hypochlorite. Four petri dishes were also surface-sterilized and Scottie tissues were damped using distilled water and placed in the Petri dishes. Each of the weighed copra was placed into four separate petri dishes and innoculated for 7 days. At the 7th day, the copra was covered by fungi in the petri dishes. In order to isolate these fungi into pure culture, Potato Dextrose Agar (PDA) was prepared and the fungi were inoculated onto the sterile PDA and incubated for 7 days at the end of which the fungi were identified based in their colour, spore morphology and mycelia growth using the light microscope.

Studies were also carried out to check if the isolated fungi were capable of causing rot on the copra. Ten grams of copra was weighed into four places and placed on Scottie tissue in sterile Petri dishes. A sterile scalpel was used to create wound in the copra and the isolated fungi were incubated into the wound separately, labeled and incubated for 7 days. At the end of the 7th day, the extent of rot caused by fungi was determined using the method as described by Kassim (1986):

$$\text{Rot } (\%) = \frac{A - a}{A} \times 100$$

Where:

A = Initial weight of copra.

a = Final weight of copra after the removal of the rotten portion.

Investigations were carried out to determine the effects of heat drying on the quality stability of copra. A fresh coconut was dehusked and coconut water was removed. The copra was placed in the oven at a low temperature (15°C for 6 h) for 1, 2 and 3 weeks, respectively. At the end of each week, the sample was taken to the laboratory for storage quality determination.

Preliminary observation showed that ants were feeding on the infected coconut copra. Infected coconut copra were therefore, exposed to three groups of fungus-eating insects including ants. Apart from ants, e.g., *Crematogaster* sp. that were isolated from infected copra, other insects; *Alphitobius diaperinius*, *Necrobia rufipes* and *Tenebrio molitor* were collected from the stock culture maintained on a mixture of palm kernal cake and sweet potato (*Ipomoea batatas*) in the Post Graduate Entomology Laboratory. Equal number (10) of each fungus-eating insects was introduced into petri dishes (placed on laboratory shelf) containing cultures of *A. niger*, *R. stolonifer* and *P. italicum* and they were allowed to feed for 48 h. A control was also set up without insects.

The experimental design was a complete randomized block design. Correlation analyses were used to investigate relationship between size (length in cm) of fungus-eating insects and percentage of food consumed having measured the area occupied by each of the fungi in the Petri dish. Mean separation was done using Duncan's Multiple Range Test at 5% level of significance after (ANOVA).

RESULTS

The frequency of occurrence of the seed-borne fungi of coconut and the percentage rot (Table 1). The results showed that *Pennicillium italicum*, *Rhizopus stolonifer* and *Aspergillus niger* were found to be seed-borne. However, there was 80% frequency of occurrence of *Pennicillium italicum* and 100% frequency of occurrence in both *Rhizopus stolonifer* and *Aspergillus niger*. All the isolated fungi were found to be pathogenic to the endosperm of coconut.

Table 2 shows the proximate composition and mineral analysis of freshly harvested and uninfected coconut endosperm (copra) and water. These parameters were used as standard for quality stability determination.

In Table 3, it was found that *Aspergillus niger* degraded the copra more as could be seen from the moisture content which increased from 36.1 to 38.5. Protein content reduced from 10.3 to 9.0 while carbohydrates contents reduced from 13.4 to 9.5. The mineral contents were also affected negatively. *Rhizopus stolonifer* also degraded the copra quality as was noted by the increase in moisture from 36.1 to 37.5. The protein and carbohydrate contents were equally affected. However, *Pennicillium italicum* appear to

Table 1: The incidence and rot of fungi of fungi coconut

Fungi	Incidence (%)	Rot (%)
Pennicillium italicum	80	35
Rhizopus stolonifer	100	30
Aspergillus niger	100	55

Table 2: Proximate composition and mineral analysis of uninfected coconut (copra) and water

	Proximate composition (%)						Mineral analysis				
Samples	Moisture	Ash	Lipid	Fiber	Protein	CHO	Calcium (mg)	Iron (mg)	Phosphorus (mg)	Sodium (%)	Potassium (%)
Coconut endosperm copra	36.1	1.7	35.500	3.6	10.3	13.40	24.5	0.25	75	0.84	0.20
Coconut water	99.6		0.005	0.2	3.5	0.02	3.5	0.22	35	0.02	0.05

Table 3: Effected of fungi on the biochemical composition of endosperm (copra)

	Moisture	Lipid	Fiber	Ash	Protein	CHO	Calcium	Iron	Phosphorus	Sodium	Potassium
Species	(%)						(mg)	(mg)	(mg)	(%)	(%)
Aspergillus niger	38.5	25.3	12.4	5.5	9.0	9.5	23.5	0.1	70	0.7	0.2
Rhizopus stolonifer	37.5	36.6	3.7	1.8	9.8	10.7	24.3	0.2	76	0.9	0.3
Penicillium italium	36.5	30.4	7.9	3.2	10.0	12.1	21.4	0.2	73	0.7	0.2

Table 4: Effect of heat-drying on the storage of coconut copra

	Proximate composition						Mineral analysis				
Storage	Moisture	Protein	Lipid	Ash	CHO	Fiber	Calcium (mg)	Fe^{2+} (%)	Phosphorus (mg)	Na^{+} (%)	K^{+} (%)
1 week of storage	26.51	11.75	30.50	2.37	25.25	3.56	24.60	0.12	85.5	0.67	0.36
2 weeks of drying	20.04	11.79	38.50	3.46	26.35	9.14	23.80	0.12	77.9	0.70	0.35
3 weeks	16.85	12.67	38.21	3.14	20.02	8.12	20.12	0.13	75.0	0.75	0.36

Table 5: Percentage consumption of fungi by four sets of fungus-eating insects (n = 10 insects per petri dish) at 78.7-82.5% Rh

	Fungi consumed (%)		
Fungus-eating insects	*A. niger*	*P. italicum*	*R. stolonifer*
Tenebrio molitor	100.0^{a}	100.0^{a}	100.0^{a}
Alphitobius diaperinius	84.1^{b}	82.3^{b}	78.2^{c}
Necrobia rufipes	78.6^{c}	72.8^{c}	80.1^{a}
Crematogaster sp.	64.2^{d}	50.8^{d}	61.8^{d}
Control (unconsumed %)	100.0^{a}	100.0^{a}	100.0^{a}

Figure used here were the maximum values in each case. Figures in the same column with different letter(s) are significantly different from each other

have preserved the copra quality better than the aforementioned fungi. The sample that was infected by *Pennicillium italicum* had a moisture content of 36.6%, protein content of 10.0 and carbohydrate content 12.1. The mineral components were equally not badly affected.

Drying reduced the moisture content and stabilized other mineral contents analyzed (Table 4). However, considering the proximate and mineral analysis of uninfected copra which was used as standard, the use of heat drying gave a better storage quality. The 1 and 2 week of drying produced a better result (stored better) but the best storage stability was from the 3 weeks of drying which reduced the moisture content of copra to 16.85. It was also reported that using direct heat such as smoking is the most basic and economic approach; the only disadvantage being that it is difficult to control or regulate the heat output.

Total reduction of the three fungi isolated from coconut copra was done by *T. molitor* (100.0% in 5 replicates out of 10) followed by *A. diaperinius* (84.1%), *N. rufipes* (80.1%) and *Crematogaster* sp. (4.2%) in that order (Table 5). Correlation analyses on the relationship between size of the fungus-feeding insects and amount of fungus consumed were position in all cases (*T. molitor*, $y = 0.16x + 98.28$, $r^2 = 0.45$; *A. diaperinius*, $y = 0.08x + 0.84$, $r^2 = 0.26$; *Crematogaster* sp., $y = 0.02x + 0.26$; $r^2 = 0.88$) but a much stronger relationship existed in *N. rufipes* ($y = 29.32x + 47.29$; $r^2 = 0.88$). Significantly higher differences existed in the consumption rate of *T. molitor* for all the fungi than others (Duncan Multiple Range Test at 5% of level of significance) (Table 5).

DISCUSSION

The results of this investigation showed that *Aspergillus niger*, *Rhizopus stolonifer* and *Pennicillium italicum* are seed-borne in coconut and that some insects such as *A. diaperinus*, *T. molitor*, *Crematogaster* sp. and *Necrobia rufipes* are effective in fungal control. The recent identification of the aforementioned pathogenic fungi associated with coconut disease and their control measures including the use of fungus-eating insects will help to reduce copra loss and increase commercial purchases of copra at all seasons in the Niger Delta region of Nigeria, a particularly humid tropic. Furthermore, the present findings of this study have proved that the drying of coconut in the oven at a regulated temperature should be adopted in order to reduce fungal growths and development before exportation. This work agrees with the finding of other researchers (Gabriel de Taffin, 1998; Asita and Etebu, 1997) on heat drying as a measure of preservation. Direct drying bring about uneven drying of the copra and the copra can be contaminated by toxic aromatic compounds present in smoke. The results also indicated that the aforementioned fungi reduced the nutritional and mineral compositions of the endosperm (copra of coconut which is an indicator of quality stability). Ihekoronye and Ngoddy (1985), also stated that peroxide value and free fatty acid of certain seeds are reduced by fungal isolated of the seeds. Free fatty acid and peroxide values have been described as measures of spoilage (Achinewhu, 1996). Ikeobi and Oti (1983), investigated the biochemical changes in *Dioscorea rotundata* Poir during storage but did not relate these changes to infection.

Onuegbu (1999) observed a loss of coherence of green and normal cocoyam, corn slices by cell wall-degrading enzymes produced by cocoyam isolates: *Botrydiplodia theobromae* Pat. *R. stolonifer*, *Pennicillium* sp., *A. flavus*, *Sclerotium rolfsii* and *Fusarium*. Chuku *et al*. (2002), also observed that *A. niger*, *P. italicum*, *R. stolonifer*, *A. tamarii* and *A. flavus* reduced the viscosity and storage stability of the seed of *Irvingia gabonensis*.

It has also been established that copra quality can be stabilized under heat drying at regulated temperature in the oven (Okaka, 1997), In other recent studies (Ogbalu *et al*., 2004) established the pesticidal potency of Niger Delta woods against some insects that attack fruits and vegetables.

Insects generally thrive best at optimum conditions for development (for most insects the ranges are between 10-100% RH and between 30-40°C e.g., *Callosobruchus maculatus* F. 30°C/70% RH) (Ogbalu, 2003). More than 100 species of fungi had caused deterioration (Okaka, 1997). Moisture has been identified as major precursor of fungal attack and deterioration of stored food products Hall (1970) and Ogbalu (2003) reported that most dipterans prefer moist surfaces for both alightment and oviposition. In this study the fungus-feeding insects contributed favorably in reducing the fungi growing on copra. The high moisture levels of the copra favoured their development. The moisture content range of 36.5-38.5 which favoured the growth of moulds was already outside the equilibrium value promoting the feeding and physiological activities of the insects. The insects ate up the hyphae and helped in checking deterioration and also contributed in storage stability of copra.

Generally speaking, copra extracted for household or industrial use in the Niger Delta region of Nigeria loses both its market and export values. However, with the present study enough proofs are now available to show that drying of copra and the use of fungus-eating insects if well managed will promote higher storage practices, shelf-life and increase higher demand of copra cakes. These facts notwithstanding, other serious threats to coconuts include the wind-borne pest, eriophyid mite which has affected a reasonable percentage of coconuts in some parts of the Niger Delta.

CONCLUSION

The three major fungi isolated from the endosperm of coconut are *A. niger*, *P. italicum* and *R. stolonifer*. The fungi were found to reduce quality and stability of coconut copra. Heat drying reduced the moisture contents of copra to a safe level and also, maintains the protein, carbohydrate and lipid quality of the copra. Heat drying is therefore recommended for better quality stability of coconut copra. Fungus-eating insects including ants (which have been identified in this study as a fungus feeder) contributed significantly in reducing the population of the fungi of copra.

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