FUNGAL INFECTION AND ITS EFFECT ON STORED SUN-DRIED AND KILN-DRIED COPRA

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ABSTRACT

Moisture content and meat surface cleanliness of stored copra influenced the occurrence, growth and abundance of fungi. *Aspergillus niger, A. oryzae, A. tamarii, A. flavus* **var.** *columnaris, Penicillium nigricans* **and** *P. bialoweinzense* **were found to infect sun-dried copra. Except for the absence of** *A. niger,* **the same species were found to infect the stored samples of kiln-dried copra. In addition to the aforementioned species,** *A. heteromorphus, A. tubigensis, A. flavus* **and** *Rhizopus nigricans* **were observed to infect copra collected from warehouses in Baybay, Leyte. The presence of fungi on copra attracted insect pests which caused additional damage such as holes in the meat and accumulation of copra "dust".**

The color of the oil obtained from infected sun-dried and kiln-dried copra was darker than that of oil obtained from uninfected copra indicating that the presence of fungi during storage might have affected the quality of the oil. The drying method had no effect on the quantity of oil extracted before storage as shown by the comparable amount of oil obtained from sun-dried and kiln-dried copra. Even after 3 months of storage, there was no significant difference in the quantity of oil extracted from infected and uninfected sun-dried and kiln-dried copra.

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KEY WORDS: Copra. Sun-dried. Kiln-dried. Moisture content. Oil content. Fungal infection.

INTRODUCTION

An essential requirement of copra making is the lowering of the moisture content of the wet meat from 50-55% to a commercially acceptable level of 5-7% (Child, 1974). Drying fresh kernels using a copra drier is commonly practiced in the Philippines except when there are few nuts to be dried and/or when there is continuous sunshine. Using a copra drier allows proper arrangement of the meat on the platform which results in good quality copra (Ly and Hinay, 1979).

Sun drying, on the other hand, has the disadvantage of exposing the meat to unfavorable elements. If drying is not done properly, the meat may be predisposed to infection by bacteria and fungi and to the attack of insect pests.

Copra deterioration is brought about by a number of factors. Careless preparation and inefficient drying cause bacterial action to set in at the initial stage of processing while long periods of storage with conditions allowing uptake of moisture enhance fungal infection and insect pest infestation (McFarlane, 1975). Once the copra is infected, high free fatty acid levels, rancidity and decrease in the amount of extractable oil result. Furthermore, the copra may yield an abnormally high quantity but inferior quality oil (Cooke, 1931). Aside from the low quality of oil extracted, the quantity of other components may be reduced and in some cases, toxic metabolites are produced (Ortega, 1976).

This study identified and compared the relative abundance of the different fungal organisms found on stored copra, ascertained the extent of infection on stored copra that was sun-dried and those dried using the ViSCA copra drier, and determined whether the quality of oil derived from fungi-infected and uninfected copra differed.

MATERIALS AND METHODS

Collection and Preparation of Copra Samples

Copra from mature nuts of the Baybay Tall coconut variety was used in this study. Half of the meat obtained was dried using a semi-direct modified kiln drier while the other half was sun-dried. Drying in both methods was continued until about 8% moisture level was attained. The dried halves of both treatments were divided into four parts after the drying period.

Copra from commercial warehouses in Baybay, Leyte was also collected to find out which among the fungal organisms present in the collected samples also infect copra prepared in ViSCA.

Determination of Oil and Moisture Contents

Immediately after all the copra samples were collected and dried to about 8% moisture level, oil and moisture contents were determined. Oil content was determined by extracting oil from copra using the Soxhlet apparatus of the NIDC Oil Mills in Tanauan, Leyte while moisture content was measured using the Direkto moisture meter.

Storage of Copra Samples

The prepared copra samples for each treatment were stored for 3 months in open shelves in a well-ventilated room at the Department of Plant Protection, ViSCA, Baybay, Leyte.

Culture of Fungal Organisms

Infected tissues of the prepared (both sun-dried and kiln-dried) and collected commercial copra with

distinct fungal growths were transplanted into petri plates containing potato dextrose agar (PDA).

Purification and Storage of Cultures

Small portions from the growing points of selected fungal colonies were transplanted into another set of plates and allowed to grow for 5 days. Purity was then checked by visual and microscopic examinations. Mixed cultures were further isolated using the same process and medium while pure cultures were stored in culture cabinets for subsequent identification.

Identification of Fungal Organisms

Specimens of different fungi from prepared and collected commercial copra were mounted on glass slides and observed under a compound microscope. Identification was done using taxonomic keys. The presence or absence of fungi on prepared and on collected commercial copra samples were noted.

RESULTS AND DISCUSSION

Physical Properties of Sun-dried and Kiln-dried Copra

Before Storage. Copra samples from both treatments were initially free of insect pests and fungi. The surfaces of kiln-dried copra had smooth texture with color varying from light to dark brown. The meat surfaces of sun-dried copra, on the other hand, had whitish color with slimy edges and rough surfaces due to adhering impurities (coir dust and sand). The differences in texture and color of the meat surfaces (Table 1) were attributed to the drying method used. Drying in a kiln drier produced uniformly dried copra (Ly and Hinay, 1979) while sun drying resulted in uneven drying. This uneven drying caused the appearance of some slime on the sun-dried copra. Slime observed on meat edges of sun-dried copra indicate the presence of bacteria which was also noted by Ward and Cooke (1932) but their identity was not determined in this study.

After Storage. Mycelial structures, colored patches and spore dusts were the only visible indications that fungal organisms infected the copra samples of both treatments. The meat surfaces underwent some changes in color. Kiln-dried copra changed from light or dark brown to dirty white, which may be due to the volatilization of the impurities that got incorporated in the meat surfaces during processing. The meat of sun-dried copra changed from white to yellowish white with black patches on the edges. These black patches were caused by the dried-up slime.

Perforations made by larvae of the foreign grain beetle, *Ahasverus advena,* were also seen but more were found in the sun-dried copra samples.

Fungal Population on the Stored Copra

Penicillium bialoweinzense Zaleski, observed as white pin heads

Table 1. Physical properties of copra obtained from the ViSCA copra drier and sun-dried copra before and after storage for 3 months.

Treatment	Before Storage			After Storage		
	Surface Color	**Surface Texture**	**Insect and Fungi**	**Surface Color**	**Surface Texture**	**Insect and Fungi**
Kiln-dried copra (T_A)	Light to dark brown	Smooth	Absent	Dirty white	Smooth to rough	Present, copra with holes
Unstored, uninfected T_A	Light to dark brown	Smooth	Absent	(Samples were not stored)		
Sun-dried copra (T_B)	White	Rough with sticky edges	Absent	Yellowish white with black patches	Rough	Present, copra with holes
Unstored, uninfected T_B	White	Rough with sticky edges	Absent	(Samples were not stored)		

on copra samples from both treatments, appeared on the second day of storage. After 1 month of storage, this species turned to light laurel green then to dark green. On the fourth day of storage, *Aspergillus flavus* var. *columnaris* growing from white mycelia with light yellow conidial heads having whitish tint, was noted on kiln-dried copra samples. They later became yellow and turned brown upon maturity. On sun-dried copra, *Aspergillus niger* van Tieghm was observed simultaneously with *A. flavus* var. *columnaris*. It was initially hard to differentiate the two species because both of them exhibited white conidial heads. On the third day following the first appearance of both species, conidial heads of *A. niger* turned to dark gray then to black when they matured. They grew fast during the first 2 weeks of storage but declined thereafter, thus remaining in small patches sparsely scattered on the meat edges. This decline in growth may have been due to the appearance of other fungal species which might have competed with the species for the moisture of the meat. Six to 8 days after storage, growth of *Aspergillus tamarii* Kita, *A. oryzae* (Ahlb.) Cohn and *Penicillium nigricans* (Bainier) Thom., were observed on both treatments. At initial stage of growth, the conidial heads of *A. oryzae* were somewhat lighter in color than those of *A. tamarii*. The colony of *A. tamarii* turned to deep yellow then dark brown when mature. *Aspergillus oryzae* changed from its original dirty white color to light green with age. The appearance and color of *A. oryzae* were similar to that of *A. niger* during the initial stage of development. *Penicillium nigricans* was observed to appear in patches of yellow orange with lighter shades at the center than at the periphery of the colony.

Among the fungal species infecting the prepared copra samples, *P. bialoweinzense* was observed to dominate other fungal growths in both treatments. However. *A. flavus* var. *columnaris* was found to be dominant in three replicates of the kiln-dried copra. On sun-dried copra, *A. niger* dominated other fungi in growth during the first 2 weeks but declined thereafter, thus remaining in patches on the edges of the meat. The other species noted, *A. tamarii, A. oryzae* and *P. nigricans* showed recessive characteristic growths on both treatments.

Comparison of Fungi Found on Sun-dried and Kiln-dried Copra and Those on Collected Commercial Copra

In addition to the fungal species found in the copra samples prepared in ViSCA, four more species were encountered in copra collected from commercial warehouses. These were *Rhizopus nigricans, Aspergillus heteromorphus* Batista and Maia, *A. flavus* Link and *A. tubigensis* (Schroeder) Mosseray (Table 2). The more varied fungal population on collected commercial copra was probably due to the varying moisture contents of the meat pieces comprising the samples which

Table 2. Characteristics of fungal organisms found in copra prepared and stored in ViSCA and in copra collected from commercial warehouses in Baybay when grown in different substrates.

Species [1]	Color of Colony		Conidial Heads	Shape of Spore Produced
	On Potato Dextrose Agar [2]	On Copra [3]		
Aspergillus flavus	Yellowish green to gray then black		One series of sterigmata loosely packed in the vesicle	Globose to ovoid
A. heteromorphus	Yellowish gray to dark olive then black		Sterigmata in two series compactly arranged in the vesicle, thinner than that of *A. tubigensis*	Globose to ovoid
A. tubigensis	Light green to gray then black		Sterigmata in two series compactly arranged in the vesicle	Globose
Rhizopus nigricans	Creamy white to light gray then black		Spores directly attached to conidiophore, compact	Globose
A. flavus var. *columnaris* [4]	Bright yellow to yellowish brown	Yellowish white to yellow then brown	Thick and short sterigmata in one series closely packed in the vesicle	Globose
A. niger [4]	Creamy white to light gray then black	Creamy white to dark gray then black	Closely packed sterigmata in two series	Globose

Table 2. Continued . . .

Species[1]	Color of Colony: On Potato Dextrose Agar[2]	Color of Colony: On Copra[3]	Conidial Heads	Shape of Spore Produced
A. oryzae[4]	Creamy white to yellowish green then green	Dirty white to light green then dark green	Hyaline sterigmata in one series closely packed in the vesicle	Globose to ovoid
Penicillium nigricans[4]	Light yellow orange at center with dull yellow periphery to yellowish green with yellow periphery	Light yellow orange at center to dark shades at periphery then yellow orange at center with darker shades at periphery	Three verticils of metulae arising from the conidiophore	Globose to ovoid
P. bialowein zense[4]	Light olive green to deep green	White light laurel green then dark green	Three verticils of metulae arising from the conidiophore	Globose to ovoid

[1] All species mentioned were found in the copra samples collected from commercial warehouses in Baybay, Leyte.

[2] Observations made for 2 weeks on PDA.

[3] Observations on the development of the fungi were done only on the copra that was prepared and stored in ViSCA because fungi found on copra collected from the warehouses were already mature and were directly cultured. The first four fungal species were not found in the samples dried in ViSCA.

[4] Found only on copra prepared and stored in ViSCA.

favored the growth of a greater variety of fungi. The growth of the fungal species on the collected copra was observed to be highly affected by the moisture content of the copra samples. Furthermore, infection might have taken place before the samples were collected and the places where these copra were processed might have had an effect on the species of fungi present. Copra samples in the warehouses were also exposed thus, fungi could have easily grown on them.

Color of Fungal Colonies When in Copra and When in a Synthetic Culture Medium

Fungal organisms cultured in PDA exhibited a slight change in the color of their colonies as compared with those found in copra (Table 2). The color of conidial heads, which were slightly darker or lighter than those found in copra, was attributed to the properties of the substrate on which they grew. The differences in pH, moisture content and nutrient components of the substrate might have caused the color variations as was observed by Ortega (1976).

Fungal Association with Insect Pests on Copra

Bacteria, fungi and insect pests are always associated with copra. Insects readily appear on copra when the cell structures have been broken down by bacteria and molds (Child, 1974). Generally, insects are attracted to copra with high moisture levels indicated by an abundant growth of fungi (Grimwood, 1975). Some insects, however, are attracted to the fungus itself. Examples are the foreign grain beetle *Ahasverus advena* and some *Carpophilus* spp. which are highly mycetophagous (Alpuerto, 1979).

Insects were found on the stored copra samples from both treatments. On sun-dried copra, a high population of mites was observed when *A. niger* was present. This was also true in collected commercial copra samples which had abundant growth of *A. niger*. Adults and larvae of *A. advena* as well as psocids of the family Liposcelidae were noted on sun-dried copra although more were found to infest the kiln-dried copra. These insect pests *(A. advena* and psocids), whose population was observed to be high after 2 months of storage, caused the decline of fungal growth, perforations on the meat, and accumulation of copra "dust".

Effect of Moisture Content and Molds on Oil Content

In the uninfected copra, the quantity of oil extracted was highly dependent upon the moisture content (Table 3). However when fungal organisms are present on copra for long periods, they cause biochemical changes resulting in high enzyme activity and a rise in free fatty acid levels (Child, 1974). This accounts for the inferior quality and reduced grade of oil extracted.

An inverse relationship was

Table 3. Average moisture and oil contents of copra before and after storage for 3 months.

Treatment	Moisture Content		Oil Extracted	
	Before Storage	After Storage	Before Storage	After Storage
Kiln-dried (T_A)	8.58	5.63	51.62	59.59
Unstored, uninfected T_A	8.72	6.37*	52.50	58.27*
Sun-dried (T_B)	8.42	5.73	51.53	59.20
Unstored, uninfected T_B	8.52	6.13*	52.23	58.63*

*Moisture content of unstored uninfected copra was adjusted to approximate that of the stored samples for the purpose of comparing oil contents as influenced by the moisture content.

found between the moisture content of copra and its oil content. When the moisture of copra was high, the amount of oil extracted was low but when the moisture content of the sample decreased, the amount of oil extracted was high. In kiln-dried copra, a decrease in moisture from 8.58% to 5.63% was noted after storage. The resulting moisture content of the meat increased the amount of extractable oil. Sun-dried copra was also observed to decrease its moisture content thus increasing the amount of oil extracted. The difference in the amount of oil extracted from sun-dried and kiln-dried copra might have been caused by the presence of more fungal species on the former.

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