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MICROORGANISMS CAUSING DETERIORATION OF STORED GARLIC

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ABSTRACT

Samples of garlic in storage sheds in three northern Thai provinces were examined for fungi and other organisms causing deterioration. Twenty-three genera of fungi were found in 71 samples tested. *Aspergillus* spp. were found in nearly all samples. Other common fungi were *Penicillium* and *Curvularia*. Three field pathogens, namely *Fusarium, Colletotrichum* and *Alternaria,* were also found. Apparently normal looking cloves were often found to be contaminated inside. Bacterial infection was commonly found and resulted in rot. Rates of contamination by microorganisms were significantly reduced by surface desinfection. Several animal pests including insect larvae and mites occurred on the same deteriorating garlic.

INTRODUCTION

Garlic *(Allium sativum* Linn.*)*. a plant in the family Liliaceae, has been useful to mankind since ancient times. The Chinese people use the plant as a vegetable. They and people in other countries have admired garlic as a spice or herb for improving one's health, despite its strong odor, and its therapeutic value has recently been recognized (IKRAM, 1972; JAIN, 1977; BHUSHAN et al., 1979; BOULLIN, 1981). Therefore, the present consumption of garlic is increasing.

Garlic is economically important as a second crop after rice in northern Thailand. The bulbs are harvested in March and stored for use during the year (Fig.1). Deterioration occurs gradually during this period, reducing the quality as well as the quantity of the product. In certain years, the price soars a few months before the new crop is harvested due to the low supply.

In spite of the inhibitory effect of the allicin substance in garlic extract (CAVALLITO & BAILEY, 1944; KABELIK, 1970; IMWIDTHAYA et al., 1978), many microorganisms including fungi grow on stored garlic bulbs and thus damage the product (SMALLEY & HANSEN, 1962; GEOGIEVA & KOTEV, 1979). A number of Aspergilli and Penicillia have been reported to produce various kinds of aflatoxins on certain kinds of substrate (SHANK et al., 1972). Therefore, the objectives of our study were as follows:

1. To investigate the growth of microorganisms found on garlic from the North and to evaluate their significance in destroying stored garlic and/or spreading diseases if infected cloves are seeded.

2. To isolate fungi which are suspected of producing mycotoxin for further studies.

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METHODS

Samples of garlic bulbs were collected from six storages in the northern provinces of Chiang Mai, Lamphun and Lampang. Each month during the 1-year study period (July 1983 – June 1984), a sample of 1 kg was taken from each selected storage shed. A subsample of 100 g was taken from each 1-kg sample and was subdivided into two equal parts of 50 g. Each bulb in the first part was split into cloves and pretreated with 20% chlorox solution before being incubated on sterile moist blotters (Fig.2). The second part was incubated similarly without pretreatment. Samples were examined for microorganisms after 1 week of incubation.

The percentage of decayed cloves and percentage of cloves infected by each type of microorganism in each sample were recorded.

RESULTS

Fungi Encountered. Twenty-three genera of fungi were observed from 71 tested samples (Table 1). *Aspergillus* was most frequently found followed by *Penicillium, Curvularia* and *Fusarium;* the numbers of samples contaminated by these fungi were 70, 64, 33 and 29 respectively.

The Most Destructive Species. *A. niger* was found in almost all of the tested samples and in a much higher percentage than any other species. It thrived on the surface as well as inside the cloves. Normal looking bulbs sometimes contained fungal spoilage inside. Its growth characteristics on garlic and those of *A. flavus, Penicillium* sp., *Curvularia* sp., and *Fusarium* sp. are shown in Table 2 and Fig.3. Sometimes two or more types of fungi were present on the same clove (Fig.4). Bacterial infection associated with insect damage can also result in high percentage of garlic rot (Fig.5).

Pretreatment with Diluted Chlorox Solution. Samples receiving pretreatment of 20% chlorox solution showed a lower percentage of fungal and bacterial contamination (Table 3 and Fig. 6). This indicates that more microorganisms exist on the surface of the cloves than inside. Invasion into the cloves usually occurred through wounds made by insects, or by mite transmission.

Occurrence of Field Pathogens. *Alternaria* sp., *Colletotrichum* sp., and *Fusarium* sp., reported as causing garlic diseases in the field (BRANDAO & SOARES, 1943; GIATIGONG, 1980), were also encountered in our samples. The first two fungi occurred on a few samples, while *Fusarium* spp. were more common, especially from samples harvested from the infected field. Immature garlic showed a higher percentage of infection than did mature garlic. Newly harvested samples also gave higher percentages of *Fusarium* infection, which was gradually replaced by that of the storage fungi (*Aspergillus* spp.) during the time of storage (Table 4). Therefore, the chance of being the first inoculum in the field for the following planting season is low.

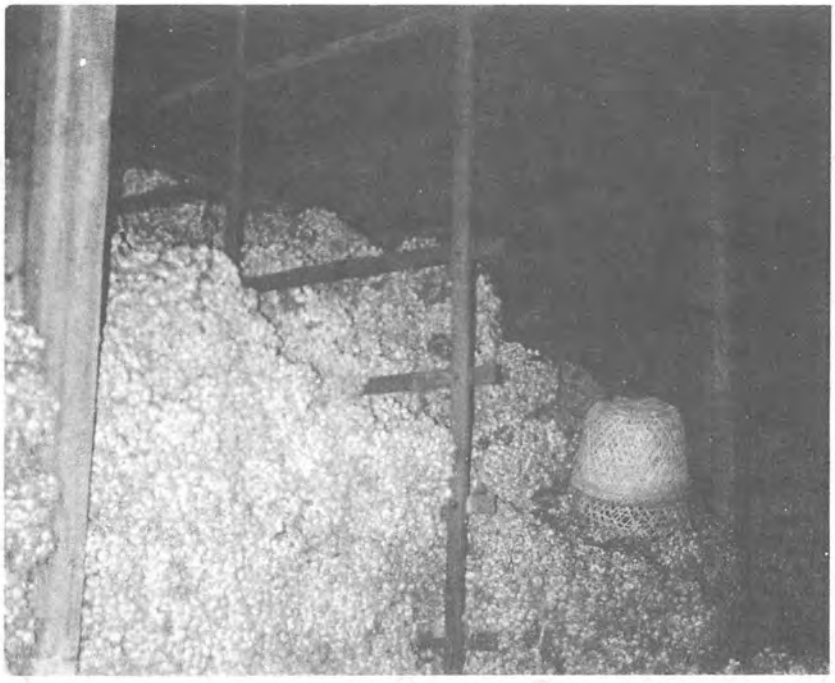

Figure 1. Garlic in storage.

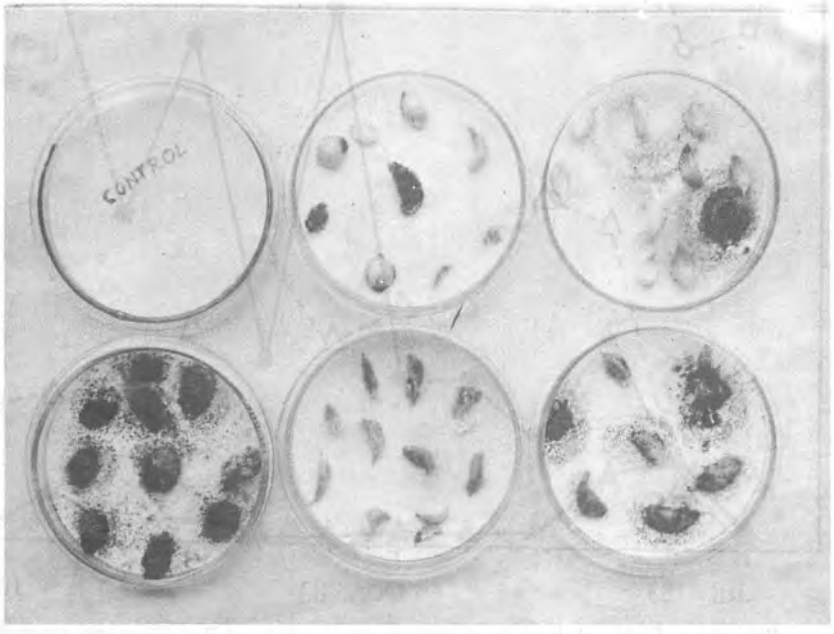

Figure 2. Incubation of tested garlic samples on sterile moist blotters.

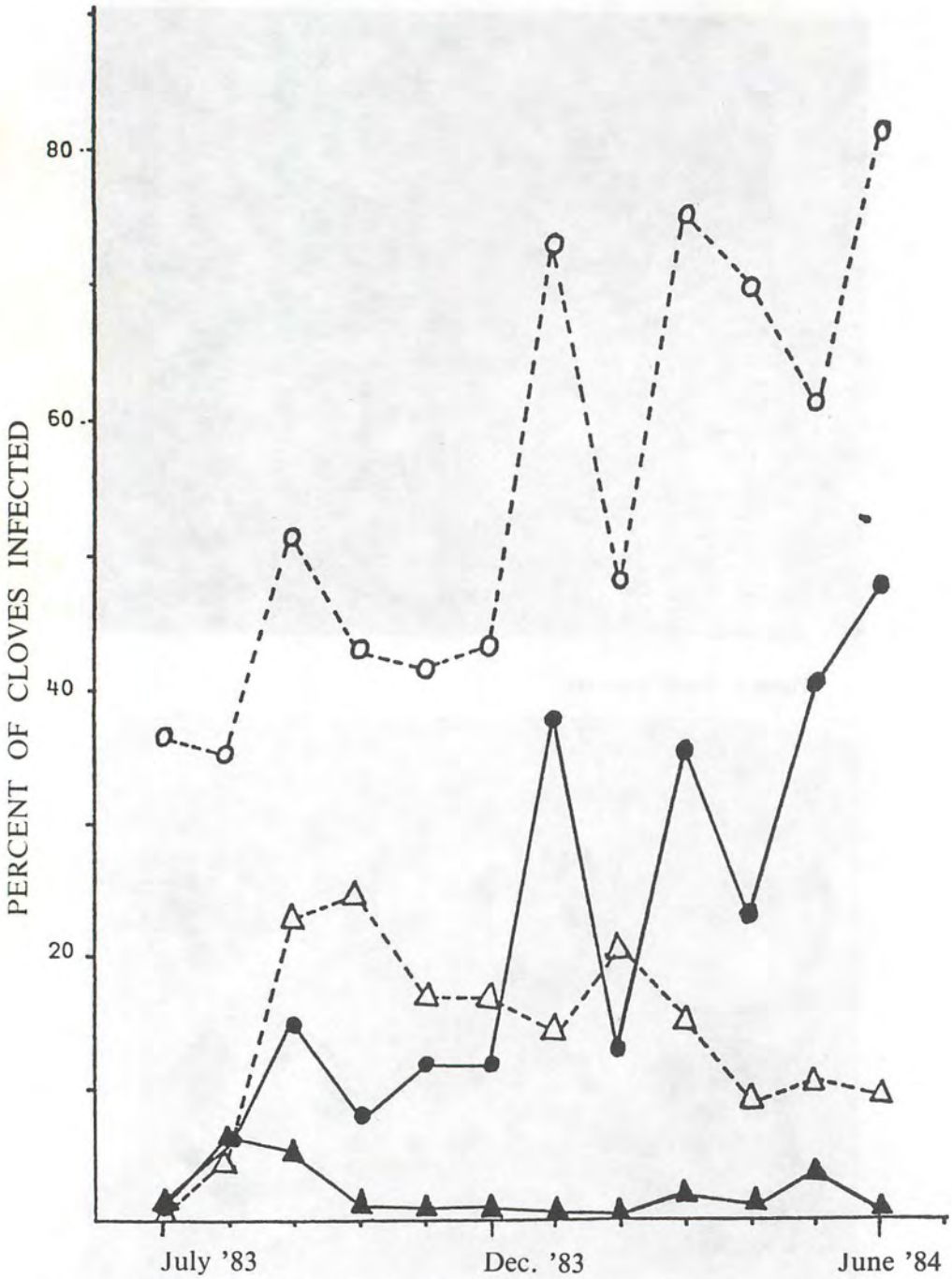

Figure 3. Percentage of infected cloves by *Aspergillus* spp. (circles) and *Penicillium* spp. (triangles) in each month during the study. Solid lines indicate surface disinfection treatment; dashed lines indicate no disinfection.

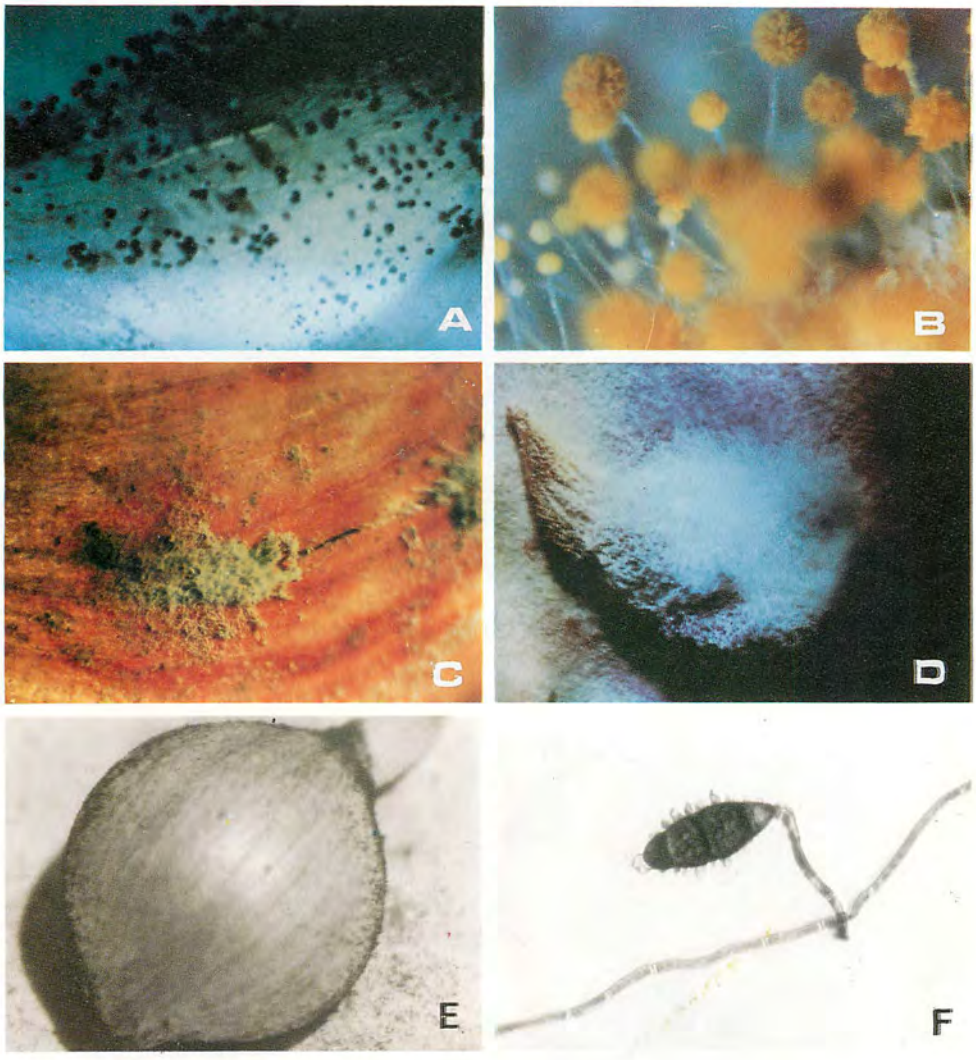

Figure 4. Growth of some fungi on garlic cloves. A, *Aspergillus niger;* B, *A. flavus;* C, *Penicillium funiculosum;* D, *Fusarium moniliforme;* E, *Curvularia tuberculata* and F, Conidium of *C. tuberculata.*

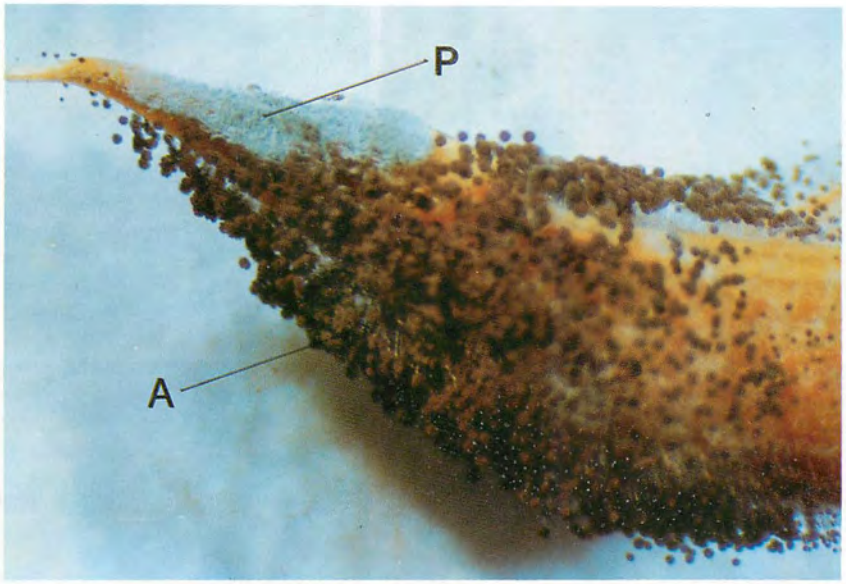

Figure 5. *Aspergillus niger* (A) and *Penicillium* sp. (P) on a garlic clove.

Figure 6. Bacterial infection resulting in garlic rot.

Deterioration by Other Pests. Besides fungi and bacteria, mites and insects also infested stored garlic. In the beginning of our investigation, spoilage of garlic due to mites was high, but was surpassed by spoilage due to microorganisms toward the end of the period of investigation.

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Table 1. Genera of fungi and percentages of infected garlic cloves.

	Genus	%
1.	*Alternaria*	0.03
2.	*Aspergillus*	55.09
3.	*Chaetomium*	0.48
4.	*Cladosporium*	0.68
5.	*Colletotrichum*	trace
6.	*Curvularia*	1.24
7.	*Fusarium*	1.17
8.	*Gliocladium*	trace
9.	*Helminthosporium*	trace
10.	*Mucor*	trace
11.	*Neurospora*	0.18
12.	*Nigrospora*	0.04
13.	*Ovularia*	trace
14.	*Penicillium*	14.04
15.	*Pulluraria*	0.06
16.	*Rhizoctonia*	0.10
17.	*Rhizopus*	0.47
18.	*Scopularia*	0.01
19.	*Spicaria*	trace
20.	*Syncephalastrum*	0.05
21.	*Thamidium*	trace
22.	*Trichoderma*	0.50
23.	*Verticillium*	trace

Table 2. Growth characteristics and symptoms produced on garlic cloves by some fungi.

Fungi	Growth characteristics	Symptoms
Aspergillus niger	Scattered colonies on surface or	Dry rot and heart rot,
A. flavus	occasionally under the clove's sheath	discoloration
Penicillium spp.	Dense colonies on surface	Dry rot, discoloration (*P. funiculosum* turned the sheath into pink)
Fusarium moniliforme	Pinkish white colony, sometimes covering the whole clove	Discoloration and decay of immature garlic
Curvularia tuberculata (*C. lunata* and *C. palescens* were more common)	Scanty mycelium, dark colonies with dark conidia on short conidiophore	Discoloration

Table 3. Percentages of infected cloves from each storage shed (averaged over 12 months).

Organisms	Without surface disinfection							With surface disinfection							
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean	L.S.D. for means
Aspergillus	65.3	60.0	40.3	44.3	43.0	73.6	54.42	26.6	25.5	20.8	16.7	17.2	28.2	22.55	8.21
Chaetomium	1.4	0.1	0.4	0.1	0.9	0.0	0.47	0.6	0.1	0.1	0.0	0.3	0.0	0.18	0.42
Curvularia	1.3	1.8	0.9	2.8	0.4	0.6	1.3	0.3	0.7	0.0	0.4	0.4	0.1	0.31	0.60
Fusarium	0.6	0.8	0.5	0.9	3.9	0.7	1.2	0.1	0.0	0.1	0.2	0.6	0.2	0.2	0.50
Penicillium	13.1	9.6	17.7	13.8	16.4	9.7	13.3	1.3	1.6	1.3	2.5	3.8	0.5	1.8	3.00
Trichoderma	1.4	0.7	0.6	0.3	0.0	0.4	0.6	3.5	0.7	0.02	1.6	4.5	0.3	1.7	1.00
Bacteria	14.5	17.4	9.8	15.4	20.4	13.9	15.2	3.4	7.7	4.7	8.7	10.1	7.2	6.9	4.02

Least Significant Difference (L.S.D.) between without and with surface disinfection for each storage :

Aspergillus	=	19.34	*Penicillium*	=	7.40
Curvularia	=	1.45	*Trichoderma*	=	2.35
Fusarium	=	1.07	*Bacteria*	=	9.97

Table 4. Percentage of cloves infected by *Fusarium* spp. and *Aspergillus* spp. (Samples of mature and immature garlic were taken from *Fusarium*-infected field).

Weeks after harvest	*Fusarium* infection		*Aspergillus* infection	
	Mature clove	Immature clove	Mature clove	Immature clove
2	13.0	44.0	0.0	1.0
15	3.3	17.1	8.7	3.4
36	0.0	4.1	15.7	22.3

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