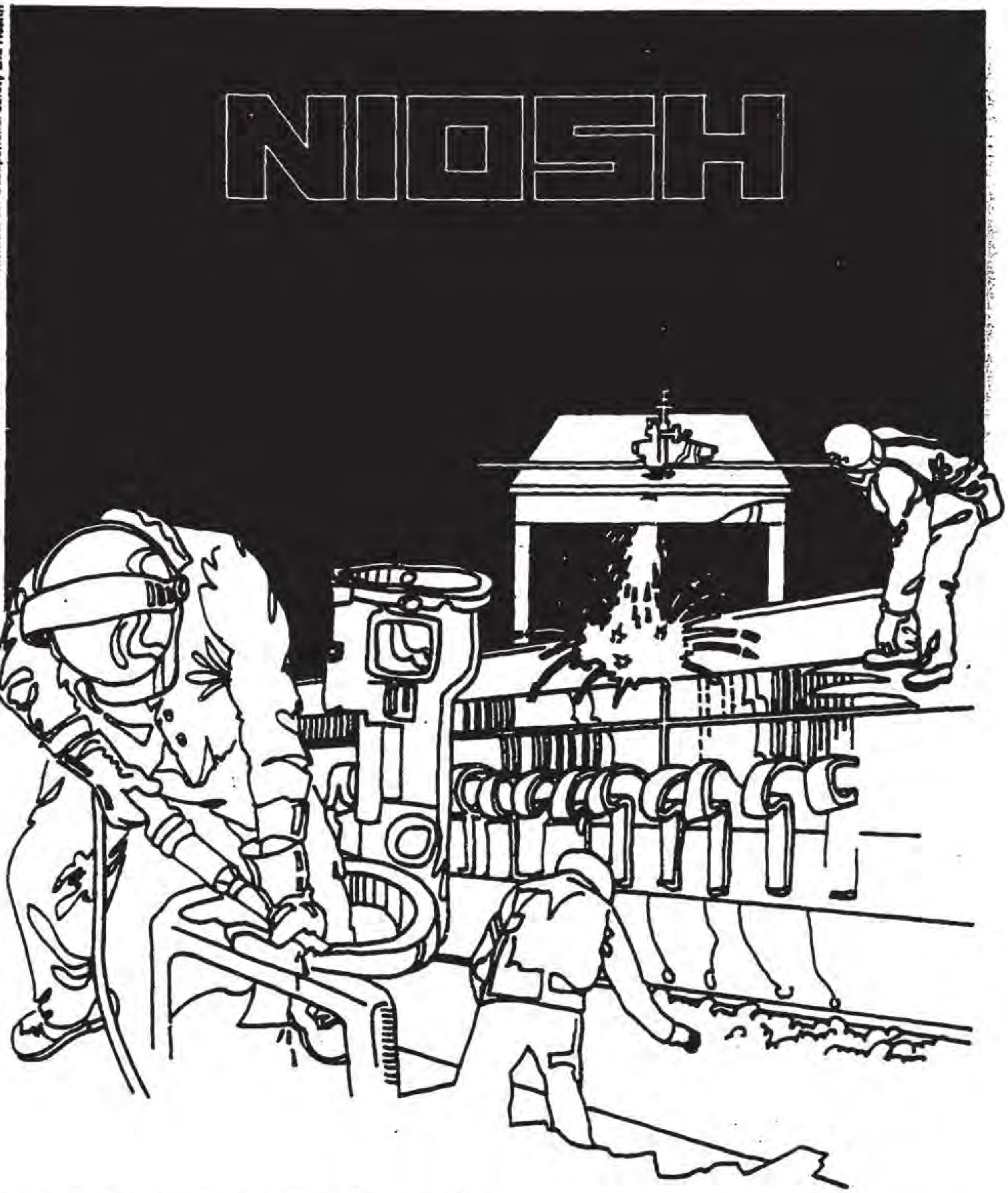
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 81-138-1563
FILLMORE DOLE MUSHROOMS,
CASTLE & COOKE FOODS
FILLMORE, UTAH

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 81-138-1563
JANUARY 1985
FILLMORE DOLE MUSHROOMS, CASTLE & COOKE FOODS
FILLMORE, UTAH

NIOSH INVESTIGATORS:
Bobby J. Gunter, Ph.D., CIH
Theodore W. Thoburn, M.D.
James E. Lockey, M.D.
Greg J. Kullman

I. SUMMARY

In January 1981, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate respiratory problems among workers exposed to fungal spores at the Fillmore Dole Mushroom Plant, Fillmore, Utah.

On June 23, 1981, environmental samples for measurement of bacteria and fungi and formaldehyde and 2,2-Dichlorovinyl dimethyl Phosphate (Vapona) were collected. Fourteen bacterial samples had a geometric mean of 132 colony forming units per cubic meter, CFU/M^3, with a standard deviation of 4.46. Sample colony counts ranged from a low of 18 CFU/M^3 to a high of 4100 CFU/M^3. The fungal samples showed higher mean concentrations than the bacterial samples. This group had a geometric mean of 2090 and a geometric standard devia- tion of 3.01. These samples ranged from a low of 367 CFU/M^3 to a high of 13,500 CFU/M^3.

Three formaldehyde samples were taken. Levels were 0.8 mg/M^3, 0.17 mg/M^3 and less than 0.008 mg/M^3. These samples were taken in the sterilization room immediately following sterilization. Three Vapona samples were taken in areas where it was used for fly control. Samples were below detection limits.

The workers' health was evaluated by questionnaire and measurement of serum precipitins to a number of bacteria and fungi. Because of language difficulties, the Southeast Asian workers were given a shorter questionnaire than were the English-speaking workers. The two groups also had separate comparison groups. In the English speaking groups, eight workers had symptoms compatible with acute or chronic hypersensitivity pneumonitis. Also respiratory illnesses, such as colds, were higher in the mushroom workers than in the comparison group. Precipitan results showed little difference between workers and comparison groups or between various job categories, although the inability to get a large enough Southeast Asian comparison group hampered evaluation of results in the Southeast Asian workers.

On the basis of the medical data, NIOSH concluded that a possible health hazard existed at the mushroom plant due to exposures to airborne fungi and bacteria. Environmental levels of formaldehyde and Vapona were not a hazard. Recommendations on eliminating possible hazards are included in this report.

KEYWORDS: SIC 2033, mushroom workers' lung, hypersensitivity pneumonitis formaldehyde, Vapona, fungi, bacteria

II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request in January, 1981 from workers at the Fillmore Dole Mushroom Plant in Fillmore, Utah to evaluate hypersensitivity pneumonitis among workers at this facility. Interim reports were sent to the plant in 1981, and 1982.

III. BACKGROUND

The Fillmore Dole Mushroom Plant has been in operation since 1976. The facility grows mushrooms for distribution to consumers in the intermountain area. The growing technique is common to that seen in other mushroom growing facilities. The mushroom compost is composed of raw straw, dry chicken manure, urea, cottonseed hulls, cottonseed meal, gypsum, soybean meal, and wheat bran. The initial phase of the agricultural process involves mixing these various materials every three to five days with water. Through organic decay the mixture is brought to 150-170 degrees Fahrenheit. After a total of 22 to 23 days, the compost is ready for phase two. During phase two, the compost undergoes selective pasturization after being transferred to large wooden growing trays. The trays are then taken to the spawning room, where mushroom spores on rye seeds are mechanically added. The trays are transferred to the spawn running room, where they are kept at 75 degrees F for 14 to 21 days. A layer of peat moss casing and lime is added to the top; then the trays are taken to the holding room where they are held for an additional nine days. In the holding room, the air temperature is approximately 70 degrees F to 80 degrees F. In this room the CO^2 and temperature are dropped and the spores change from a vegetative state in which they grow into the peat moss, to a fruiting state, in which the mushrooms are produced. The trays are then transferred to the picking room where they are held at 60 degrees F for approximately 35 days. The trays are harvested each day by hand for a total of five to six mushroom flushes. After approximately 35 days, the medium is transported to a sterilization room where it is sterilized by steam formaldehyde at 140-160 degrees F and then disposed of in a pile outside the plant.

At the time of the medical survey, the plant employed 118 persons: 57 were English-speaking; the remaining 61 were refugees from Southeast Asia and spoke limited or no English. The Southeast Asian refugee population consisted of Hmong, Vietnamese, Cambodians, Chinese, and Laotian. While the majority of the employees worked the morning (7 a.m. to 3 p.m.) or afternoon shifts (3 p.m. to 11 p.m.) there are a few employees that work from 11 p.m. to 7 a.m. monitoring the growing process.

Protective equipment: Respirators are not used by any employee directly involved in the mushroom growing process. Respiratory protection equipment and protective clothing were used by the environmental control personnel during the past vaporization of Vapona and Malathion for fly control within the growing rooms and yard. Currently, Vapona and Malathion are used only in the outside yard and a non-organophosphate is used within the growing rooms. The only insecticide used when the environmental study was done in January 1981 was Vapona.

IV. ENVIRONMENTAL DESIGN AND METHODS

A. Environmental

The Andersen biological sampler was used to measure airborne concentrations of thermophilic bacteria and fungi. The Andersen sampler is a primary reference instrument for this kind of aerobiological sampling.[1] Four sampling stations were established to collect environmental samples. Sampling station A was located in the tray mix room; samples were collected while tray preparation was in progress. Sampling station B was located in growing room number three; samples were taken while the workers were picking. Sampling station C was located in a large isleway outside of growing room number four. Sampling station D was located in the packing area. Formaldehyde samples were taken in the formaldehyde sterilization room and Vapona samples were taken in areas where it was used for fly control.

B. Medical

The work force was about equally divided between English speaking workers and Southeast Asians who spoke little or no English. Current job classification by linguistic group is given in Table I. These two groups had separate, non-exposed comparison groups as described below. Also, due to the language barrier, the Southeast Asians were asked a considerably abbreviated questionnaire. Fifty two (52) out of 57 (91.2%) of the English-speaking workers, and 59 out of 61 (96.7%) of the Southeast Asian workers participated in the study.

All participants had blood samples drawn to assess the prevalence of precipitating antibodies against a battery of micro organisms. The battery consisted of standard antigens known to be associated with hypersensitivity pneumonitis as well as the organisms cultured from the Fillmore Dole Mushroom Plant environment (see Table II and III). The standard antigens were those used at the Medical College of Wisconsin in the investigation of hypersensitivity pneumonitis. The environmental antigens were obtained by culturing the growing media from the Fillmore Dole Mushroom Plant for organisms. Crude Spawn Extract numbers 1 and 2 were phosphate-buffered saline extracts of this mushroom spawn. The second crude spawn extract was prepared in the same manner as the initial extract after the supply of the first was exhausted. Precipitin assays were done by an agar gel immunodiffusion technique in the laboratory of Jordan Fink, M.D., Chief of Allergy Section, Medical College of Wisconsin.

A modified American Thoracic Society respiratory questionnaire was administered to all English-speaking participants by trained interviewers. The questionnaire collected additional data relevant to symptoms suggestive of hypersensitivity pneumonitis and to non-work exposures that are known to cause hypersensitivity pneumonitis. The questionnaires for the Southeast Asians were shortened because of the difficulty of comparing five different ethnic and linguistic groups and the small size of the population. It was believed there was no adequate method to assess ethnic variations in meaning of chronic cough, chronic phlegm, etc. Permission requests were translated into the various languages of the Southeast Asian population and the questionnaires were administered by trained translators of the same ethnic background as the subject. These questionnaires documented data on environmental exposures known to be associated with hypersensitivity pneumonitis. No respiratory symptom data was obtained from the Southeast Asian population.

A comparison of the characteristics of the workers' groups and comparison groups are included in Table IV. The comparison group for the English-speaking workers was obtained in a small rural town (Parowan, Utah) similar in social and economic base to Fillmore, Utah. The English-speaking groups were matched by age, sex, and smoking history. The Southeast Asian comparison group was obtained from the Salt Lake City area. Efforts were made to match by age, sex, and ethnic background. Because of cultural differences, the Southeast Asian comparison group is only one-third as large as desired.

V. EVALUATION CRITERIA

A. Environmental

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH criteria documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8 to 10 hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Environmental Exposure Limits

8 Hour Time-Weighted Average (TWA)

		mg/M3	
	NIOSH	OSHA	ACGIH
2,2-Dichlorovinyl Dimethyl Phosphate (Vapona)	-	-	1
Formaldehyde	*	3.7	1

mg/M3 = milligrams of substance per cubic meter of air.
*Suspected carcinogen and should strive for the lowest possible level.

B. Medical

1. Respiratory Questionnaire - The definitions of symptom terms are as follows:

Chronic cough - cough four to six times per day, for three or more consecutive months per year, for at least two years.

Chronic phlegm - phlegm production from the chest at least twice a day, four or more days out of the week, for at least two years.
Chronic bronchitis - chronic cough and chronic phlegm.
Wheezing - wheezing most days or nights.
Breathlessness -
Grade I - shortness of breath when hurrying on the level or walking up a slight hill.
Grade II - walks slower than people of own age on the level because of breathlessness.
Grade III - has to stop for breath when walking at own pace on the level.
"Acute hypersensitivity pneumonitis" - symptoms compatible with this diagnosis, i.e., work related dry cough, fever /chills, shortness of breath, and malaise.
"Chronic hypersensitivity pneumonitis" - symptoms compatible with this diagnosis, i.e., chronic dry cough and breathlessness.
Serious chest cold or illness - chest illness in the last three years that kept subject off work, indoors, at home, or in bed.
Reported diagnoses - medical history from a physician confirmed bronchitis, pneumonia, chronic bronchitis, emphysema, asthma, or hay fever.

2. Precipitin Tests -

A wide range of environmental exposures have been associated with hypersensitivity pneumonitis and positive serum precipitins.[2] Many of the exposures are associated with thermophilic actinomyces: mushroom compost[3,4] moldy hay, sugar cane, and contaminated air conditioning and humidifying systems. Fungi have been implicated in exposures to malt, wood dust, cork dust, and in cheese manufacturing. Animal proteins can also be responsible, as with exposures to poultry or pigeons.[5] The questionnaires for both the English-speaking participants and the Southeast Asians sought information on such exposures.

Reactivity was judged subjectively into one of seven categories: negative, inconclusive, extremely weak, very weak, weak, positive, and strongly positive. Any result other than negative or inconclusive demonstrates the presence of precipitins. Positive precipitin reactions can help distinguish exposed from unexposed individuals, but cannot differentiate symptomatic from asymptomatic individuals among those who have positive reactions.

Precipitin results were analyzed in six different manners. In all cases, inconclusive results were excluded from the analysis. (1 & 2) Individual antigen results were classified as either negative or positive. Individual categorical measures looked at each antigen separately. The categorical combined measure was considered positive if any test was positive and negative only if all tests were negative. (3-6) A graded outcome measure was established for each antigen by assigning increasing integer values to increasing strengths of reactivity. Individual graded measures looked at each antigen separately. Graded measures were then combined into a combined graded thermophile measure, a combined graded fungal measure, and a combined overall graded measure.

Statistical associations between categorical measures were assessed by Chi^2 analysis or Fisher's exact test considering probabilities of chance of association 0.05 or less as being statistically significant. Associations between a categorical dichotomous variable (e.g., exposure, symptoms status) and a numerical discrete variable (e.g., work months, combined precipitin measures) were assessed by (a) point bi-serial correlation and (b) 2 x n, Mantel-Haenszel Chi-square with arbitrary categorization of the numerical discrete variable into n categories. Associations between two numerical discrete variables were assessed with correlation coefficients.

C. Toxicological

1. Hypersensitivity Pneumonitis

Exposure to various types of airborne organic material such as nonvirulent bacteria, fungi, and animal protein can cause a variety of health problems from dermatitis to lung disease. Exposure to certain bacteria and fungi are commonly associated with respiratory disorders involving non-IgE and cellular immunological pathways in the lung tissue.[6] These disorders are commonly identified as hypersensitivity pneumonitis. Farmers' lung, for instance, is a respiratory disorder resulting from exposures to thermophilic bacteria, (M. *faeni* and T. *vulgaris*) in moldy hay.[6,7] Cheese workers' lung results from exposure to *Penicillum* fungi from moldy cheese.[7,8] Malt workers can develop malt workers' lung from exposure to Aspergillus fungi growing in moldy barley.[6,7] Wood pulp workers' lung results from exposure to Alternaria fungal species from wood pulp.[6] Mushroom workers can develop mushroom workers' lung from frequent exposure to thermophilic bacteria from the compost.[6,7] There have also been reports of respiratory disorders from exposure to bacteria, fungi, and protozoa growing in contaminated air conditioning systems.[8] The primary risk associated with each of these lung disorders is the progression to fibrotic changes in the alveolar and bronchiolar wall result- ing in respiratory insufficiencies, defective gas transfer, and restrictive ventilatory changes.[6] Symptoms of acute hyper- sensitivity pneumonitis include a work related dry cough, fever/chills, shortness of breath, and malaise. Chronic hyper- sensitivity pneumonitis is characterized by a chronic dry cough and breathlessness.

2. Formaldehyde

Formaldehyde has a sharp odor which can be smelled at very low levels (less than 1 ppm). The first signs or symptoms noticed on exposure to formaldehyde at concentrations ranging from 0.12 to 6.0 mg/M^3 have been found to disturb sleep and to be irritating to a smaller number of people.[9] Higher exposures (12.3 to 24.5 mg/M^3) may produce coughing, tightness in the chest, a sense of pressure in the head, and palpitation of the heart.[10,11] Exposures of 61.3 to 122.6 mg/M^3 an above can cause serious injury such as collection of fluid in the lungs (pulmonary edema), inflammation of the lungs (pneumonitis), or death.[12]

Dermatitis due to formaldehyde solutions or formaldehyde containing resins is a well-recognized problem.[13] After a few days of exposure, a worker may develop a sudden inflammatory (eczematous) reaction of the skin of the eyelids, face, neck, scrotum, and flexor surfaces of the arms. An eczematous reaction also may appear on the fingers, back of the hands, wrists, forearms, and parts of the body that are exposed to the rubbing of clothing. Such rashes sometimes develop after years of asymptomatic exposure.

Formaldehyde has been shown in a study conducted by the Chemical Industry Institute of Toxicology[14] to induce squamous cell cancer of the nasal sinuses in both Fischer 344 rats and B6C3F1 mice. In a study by New York University, formaldehyde appears to have induced the same type of cancer in Sprague Dawley rats.[15] Although humans and animals may differ in their susceptibility to specific chemical compounds, any substance that produces cancer in experimental animals, particularly in more than one species, should be considered a cancer risk to humans. Formaldehyde also has demonstrated mutagenic activity in several test systems.[16]

Based on these results, NIOSH recommends that formaldehyde be handled in the workplace as a potential occupational carcinogen.[9] Safe levels of exposure to carcinogens have not been demonstrated, but the probability of developing cancer should be reduced by decreasing exposure. An estimate of the extent of the cancer risk to workers exposed to various levels of formaldehyde at or below the current 3 ppm Occupational Safety and Health Administration (OSHA) standard[17] has not yet been determined. Engineering controls and stringent work practices must be employed to reduce occupational exposure to the lowest feasible limit. The International Agency for Research on Cancer (IARC) concurs with these recommendations.[18]

VI. RESULTS

A. Environmental

In viewing the sampling data, geometric statistics were used because this body of data is represented well by log normal distribution.[19] The fourteen bacterial samples had a geometric mean of 132 colony forming units per cubic meter, CFU/M^3, and a geometric standard deviation of 4.46. (NOTE: These Andersen samples were incubated at 55 degrees C for thermophilic organism.) These samples ranged from a low of 18 CFU/M^3 to a high of 4100 CFU/M^3. Thermophilic bacterial colonies were found growing on all stages of the Andersen samples; this indicates that these particulates had an aerodynamic size range of approximately 0.65 microns to 7 microns. The twelve fungal samples showed higher mean concentration levels than the bacterial samples. This group of samples had a geometric mean of 2090 and a geometric standard deviation of 3.01. These samples ranged from a low of 367 CFU/M^3 to a high of 13,500 CFU/M^3. Fungal colonies were found growing on all stages of the Andersen samples; however, the majority of fungal growth was counted on stages three and four. This indicates that the majority of fungal particulates had an aerodynamic size range of about 1 to 5 microns. The size distribution of these samples indicates that both bacterial and fungal particulates were present in the respirable fraction at Dole Mushroom.

Mean concentration levels from Andersen sampling data are presented by area designation in Tables I and II. Sampling station A (the tray mix room) showed the highest levels of thermophilic bacteria with a geometric mean concentration of 1100 CFU/M^3. The other sampling stations showed much lower mean concentrations ranging from 63.1 CFU/M^3 to 94.8 CFU/M^3. Sampling station B (growing room #3) showed the highest levels of fungi with a geometric mean concentration of 5200 CFU/M^3. Sampling station C (outside of growing room) had the second highest fungal concentrations with a geometric mean of 1560 CFU/M^3. Sampling station D (packing area) showed the lowest fungal concentration at 1070 CFU/M^3.

Formaldehyde was found in 2 of 3 samples at levels of 0.18 and 0.17 mg/M^3. This is below the OSHA standard of 3.7 mg/M^3 and the ACGIH TLV of 1.0 mg/M^3. NIOSH recommends the lowest possible level. Due to the type of sampling and the inaccuracies of the method used, these levels do not pose a health hazard. Vapona was not found in the environmental samples.

B. Medical

Only two workers were identified who had changed jobs within the mushroom plant for health reasons. One had back pain resulting in a transfer to a less physically demanding position. The other had recurrent episodes of cough and wheezing thought to be related to formaldehyde and insecticide exposure.

Numbers of symptomatic persons in the English-speaking worker and comparison groups are given in Table V. Eight workers had symptoms compatible with acute or chronic hypersensitivity pneumonitis. There was no clustering by job category. There were none among the controls. The prevalence of chronic cough, chronic phlegm, wheezing, and serious chest colds or illness was higher in the mushroom workers than in the controls to a statistically significant level (25% vs. 2%; 13% vs. 0%; 27% vs. 0% and 38% vs. 17% respectively.) The prevalence rates of chronic bronchitis and symptoms compatible with acute or chronic hypersensitivity pneumonitis were also higher in the mushroom workers than in the controls, but failed to reach statistical significance with p=0.069 (Fisher's exact test) in each case when considered individually. However, if those with symptoms compatible with either acute or chronic hypersensitivity pneumonitis are combined, the difference is statistically significant (Fisher's exact p=0.004). Physician confirmed pneumonia was slightly less than twice as common in the workers as in the controls but this was not statistically significant. The controls had a statistically significant excess of reported of hay fever than did the mushroom workers (52% vs. 19%).

Despite the fact that the workers and controls were well matched for smoking exposure, the association between smoking status and symptoms of chronic sough, chronic phlegm, and symptoms compatible with acute and chronic hypersensitivity pneumonitis were assessed for the mushroom workers. Significant associations were found for chronic cough (chi^2=14.56, p 0.0001) chronic phlegm (chi^2=4.27, p 0.05) and chronic hypersensitivity pneumonitis (Fisher's exact p=0.007).

The questionnaire results are presented in Table VI. It covers exposures for all groups and associated acute symptoms for the English-speaking participants. There was a significantly higher number of English-speaking workers who used humidifiers or "swamp coolers" (evaporative coolers) than among their controls (63% vs. 38%). Among the Southeast Asians, the mushroom workers had significantly lower general farm exposure than their controls (36% vs. 67%), and significantly higher "swamp cooler" exposure (64% vs. 6%).

When comparing mushroom workers vs. controls, the only statistically significant differences in the precipitin results was for the penicillium from the mushroom farm (see Table VII). The individual categorical measure for the English-speaking mushroom workers showed 20% were positive whereas the controls showed only 4% positive (Chi^2=4.03, p§0.05). Using the same measure and comparing the Southeast Asian groups, no statistically significant associations were found. However, when the results with the crude spawn extract #2 were compared (22 positive, 25 negative for workers; 2 positive, 9 negative for controls), the Fisher's exact probability of chance was only 0.077 raising the possibility that the observed difference failed to reach significance because of the small number in the South East Asian comparison group. Neither the individual graded measures, nor any of the four aggregate measures showed any statistically significant differences between mushroom worker results and their comparison groups. However, when comparing English-speaking mushroom workers with Southeast Asian mushroom workers there was a statistically significant difference in the number positive to crude spawn extract #2, the Southeast Asians showing 22 positives and 25 negatives vs. 5 positives and 31 negatives (Chi^2=8.62, p 0.005). This may relate to the fact that 76% of the Southeast Asians were pickers whereas only 15% of the English-speaking workers were. For individual graded variables, crude spawn extract #2 correlated (poorly, r=0.24) with the picker job with p=0.01. There were even poorer negative correlations with the tray operator job (100% English-speaking, r = -0.17, p=0.05), and the packer job (64% English-speaking, r = -0.18, p=0.04). Although crude spawn extract #1 was produced in the same manner as #2, it evidently was more potent as a greater percentage of both worker groups reacted to it and there was no demonstrable difference between job categories. Both groups of mushroom workers showed many positives to crude spawn extract #1 (25 positives and 12 negatives for English-speakers, and 25 positives and 6 negatives for Southeast Asians), but the controls were not tested with this extract.

On the basis of industrial hygiene sampling, the tray operator job was determined to have high thermophile exposure. Eleven (11) workers had current or past experience in this job position. Compared to the remainder of the plant personnel, no significant associations were found between this job position and the six precipitin measures. There was no area in the plant that demonstrated excessively high fungal exposure relative to the remainder of the plant, so a corresponding high fungal exposure group could not be studied.

Work-months of exposure were calculated for each plant participant. Using individually graded measures, correlation coefficients were calculated. Only four antigen coefficients reached statistical significance but all lay between -0.27 and +0.22, considered very poor correlations. Partial correlation coefficients, controlled for age, were also calculated but the results were essentially unchanged. No meaningful association between duration of exposure and individual graded measures was found.

Several symptom complexes were more prevalent in the English speaking mushroom workers as compared to their matched controls: chronic cough, chronic phlegm, and symptoms compatible with acute and chronic hypersensitivity pneumonitis. Comparing symptomatic workers to the remainder of the English-speaking workers, none of the six precipitin measures showed a statistically significant association with any symptom category.

VII DISCUSSION AND CONCLUSIONS

There appears to be an increased prevalence of respiratory symptoms in the English-speaking workers at the Fillmore/Dole Mushroom farm when compared to age, sex, and smoking status matched controls. Since smoking status is also a statistically significant factor among the mushroom workers, it is probably a contributing factor. Unfortunately, data on symptoms is not available for the Southeast Asians. Industrial hygiene sampling from the plant showed the presence of airborne organisms known to be associated with hypersensitivity pneumonitis. These exposures may be responsible for some of the excess symptoms, but the precipitin data do not clearly support this. Other possible causes of symptoms include the use of formaldehyde, organophosphates, and nonorganophosphates insecticides within the mushroom facility. However, Formaldehyde and Vapona were not a problem during the January 1981 Evaluation. It is possible that unrecognized geographic or socioeconomic differences between the Fillmore worker group and the Parowan comparison group could account for the excess respiratory symptoms in the workers. For example, the Fillmore English-speaking workers had significantly more humidifiers and swamp cooler use than did the comparison group. However, no association was found between humidifier/ swamp cooler use and either precipitins or the symptoms complexes designated as "acute hypersensitivity pneumonitis", "chronic hypersensitivity pneumonitis", chronic cough, or chronic bronchitis. Also, the controls were volunteers, potentially introducing selection bias, but this seems unlikely.

Serum precipitin results did not differentiate between symptomatic and asymptomatic English-speaking workers, nor between workers with high thermophilic exposures and those with low thermophilic exposure. Differentiation between workers and controls was minimal. There was no significant association between duration of employment and serum precipitin results. Exposure to airborne micro organisms at the levels measured in the industrial hygiene study apparently does not cause significant antibody titers in comparison to a non-exposed control population. Lacey has suggested that the highest thermophile exposures occur on dumping of spent compost[20]. The Fillmore/Dole Mushroom Farm utilizes a technique of sterilizing the trays prior to dumping spent compost, thus possibly eliminating the potential for high antigen exposure in this particular process. Non-mushroom antigen exposures were common in the comparison groups and may diminish precipitin prevalence differences between worker and comparison groups.

VIII. RECOMMENDATIONS

1. The possible etiology for the increased respiratory symptoms in the English-speaking workers is not clear. The existence of hypersensitivity pneumonitis in this symptomatic population has not been excluded by this study, therefore, complete history and physical examinations, pulmonary function testing, chest x-rays, and possibly more intensive immunologic studies should be performed on this limited symptomatic group of workers. Also, efforts should be made to identify Southeast Asian workers with similar symptomatology and include them in the additional testing.

2. The Fillmore/Dole Mushroom Facility is relatively new (eight years); therefore, the duration of the exposure to the airborne microorganisms is relatively short in comparison with what is normally associated with the development of hypersensitivity pneumonitis. As the duration of exposure to these organisms may not ade-

quately reflect the induction period and antigen load needed for future development of hypersensitivity pneumonitis, the health survey should be repeated in about five years.

3. Although the current organophosphate, non-organophosphate, insecticide, and formaldehyde levels probably do not exceed OSHA standards, they should be monitored.

X. REFERENCES

1. Air Sampling Instruments Committee. Air Sampling Instruments, 5th ed. Cincinnati: American Conference of Governmental Industrial Hygienists, 1978.

2. Rubenstein E, Federman DD (Eds.) Scientific American Medicine, New York: Scientific American, Inc., 1983.

3. Bringhurst, LS, Byrne, RN, and Gershon-Cohen, J.: Respiratory disease of mushroom workers, J.A.M.A. 50:101 (1959).

4. Sakula, A.: Mushroom-worker's lung, Brit. Med. J. 3:708 (1967).

5. Stewart, C.J., and Pickering, C.A.C.: Mushroom worker's lung (letter), Lancet 1: 317 (1974).

6. Morgan K, Seaton, A Occupational Lung Diseases. Philadelphia: W. B. Saunders Co., 1975.

7. Occupational Diseases, U.S. Department of Health, Education, and Welfare, DHEW Publication No. (NIOSH) 77.171, 1978.

8. Fink, JN and others. "Interstitial Lung Disease Due to Contamination of Forced Air System." Annals of Internal Medicine, 84:406-413, April, 1976.

9. National Institute for Occupational Safety and Health. Formaldehyde: evidence of carcinogenicity. NIOSH Current Intelligence Bulletin 34. DHEW (NIOSH) Publication No. 81-111. April 15, 1981.

10. Committee on Toxicology: Formaldehyde--an assessment of its health effects. National Academy of Sciences, Washington, D.C., March 1980.

11. Kerfoot EJ, Mooney TF. Formaldehyde and paraformaldehyde study in funeral homes. Am Ind Hyg Assoc J 1975; 36:533--37.

12. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to formaldehyde. Cincinnati, Ohio: National Institute for Occupational Safety and Health. (DHEW publication no. (NIOSH) 77-126), 1977.

13. Proctor NH, Hughes JP. Chemical hazards of the workplace. Philadelphia: J.B. Lippencott Company, 1978.

14. Chemical Industry Institute of Toxicology. Statement concerning research findings, Docket No. 11109. CIIT, Research Triangle Park, North Carolina, October 8, 1979.

15. Nelson, N. Written communication from New York University Medical Center, Institute of Environmental Medicine to NIOSH, Rockville, Maryland, October 11, 1979.

16. International Agency for Research on Cancer. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Vol 29. Lyon: IARC, 1982:367-69.

17. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1980.

18. International Agency for Research on Cancer. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Vol. 29. Lyon: IARC, 1982.

19. Occupational Exposure Sampling Strategy Manual, U.S. Department of Health, Education & Welfare, DHEW Publication No. (NIOSH) 77-173, 1973.

20. Lacey, J.: Allergy in mushroom workers, Lancet 1:366 (1974).

XI. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared By:

Bobby J. Gunter, Ph.D.
Industrial Hygienist
NIOSH, Region VIII.
Denver, Colorado

Greg J. Kullman
Industrial Hygienist
Environmental Investigations Branch
NIOSH
Morgantown, West Virginia

William Sadler, M.D.
Occupational Medicine Resident
James E. Lockey, M.D.
Director, Occupational Medicine Residency Program
Rocky Mountain Center for Occupational and Environmental Health
University of Utah
Salt Lake City, Utah

Theodore W. Thoburn, M.D.
Medical Officer
NIOSH, Region VIII.
Denver, Colorado

Originating Office:	Hazard Evaluation and Technical Assistance Branch (HETAB) Division of Surveillance, Hazard, Evaluation, and Field Studies (DSHEFS) NIOSH, Cincinnati, Ohio
Acknowledgments:	C. DuWayne Schmidt, M.D. Howard Leaman, M.D. Medical Assistance Virginia Aldrich, PA-C Mary Powell Campbell Questionnaire administration Barbara Saffel Jackye Brooks Clerical and graphics Rocky Mountain Center for Occupational and Environmental Health University of Utah Salt Lake City, Utah
Report Typed By:	Loraine L. Emerson NIOSH, Region VIII

XII. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. Fillmore/Dole Mushroom Plant, Fillmore, Utah
2. U.S. Department of Labor/OSHA - Region VIII.
3. NIOSH - Region VIII.
4. Utah State Health Department
5. State Designated Agency.

For the purpose of informing affected employees, a copy of this report shall be posted in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I

Current Job Classification by Worker Groups

Fillmore/Dole Mushrooms
Fillmore, Utah

March 1983 - August 1983

Job Classification	English Speakers #	Southeast Asians #	Total Workers #	Total Workers %
Yard	9	2	11	10
Tray Operator	5	0	5	5
Waterer	2	4	6	5
Picker	8	45	53	48
Packer	7	4	11	10
Maintenance	13	1	14	14
Environmental Health Monitoring	2	0	2	2
Laboratory	0	0	0	0
Administration	6	3	9	8
Totals	52	59	111	100

TABLE II

Andersen Sampling Data - Tryptic Soy Agar (Thermophilic Bacteria)

Fillmore/Dole Mushrooms
Fillmore, Utah

Sample	Sampling Station	Concentration CFU/M^3	Organisms Identified in sample
A1	A	1980	Thermoactinomyces vulgaris
A2	A	162	T. vulgaris
A4	A	4100	T. vulgaris T. candidus T. intermedius
*B1	B	35.5	T. candidus
*B2	B	141	T. vulgaris T. candidus
B3	B	177	T. vulgaris
B4	B	18.0	T. candidus
C1	C	42.4	T. intermedius
*C2	C	212	T. vulgaris
D1	D	120	T. vulgaris T. candidus T. intermedius
D2-A	D	84.8	T. vulgaris T. candidus
D2-B	D	88.3	T. vulgaris T. candidus T. faeni
D3-A	D	31.8	T. candidus
D3-B	D	88.3	T. vulgaris T. candidus

*These samples contained broken or missing culture plates; their true concentrations could be greater than reported.

TABLE III

Andersen Sampling Data - Sabourud Dextrose Agar (Fungi)

Fillmore/Dole Mushrooms
Fillmore, Utah

Sample	Sampling Station	Concentration CFU/M3	Organisms Identified in sample
A1	A	919	Penicillium Paecilomyces Gymnoascus Diplosporium
A2	A	367	Penicillium Cladosporium Peziza Aspergillus fumigatus
A3	A	1520	Penicillium
A4	A	4510	Penicillium Cladosporium Peziza Aspergillus flavus
*B1	B	3550	Penicillium Cladosporium Peziza
*B2	B	13,500	Penicillium Cladosporium Peziza
B3	B	6290	Penicillium Cladosporium Gymnoascus
B4	B	2420	Penicillium Cladosporium Peziza
*C1	C	1120	Penicillium Cladosporium Peziza Gymnoascus

TABLE III (Continued)

Andersen Sampling Data - Sabourud Dextrose Agar (Fungi)

Fillmore/Dole Mushrooms
Fillmore, Utah

Sample	Sampling Station	Concentration CFU/M^3	Organisms Identified in sample
C2	C	6430	Penicillium Cladosporium Peziza Gymnoascus
*C3	C	530	Penicillium Cladosporium Peziza Gymnoascus
D1	D	1070	Penicillium Cladosporium Peziza Gymnoascus

*These samples had culture plates which were overgrown with spreader colonies; their true concentrations are greater than reported.

TABLE IV

Characterization of Worker and Comaprison Groups

Fillmore/Dole Mushrooms
Fillmore, Utah

March 1983 - March 1984

		English Speaking				Southeast Asian			
		Workers		Comparison		Workers		Comparison	
		#	%	#	%	#	%	#	%
Total Number		52		48		59		18	
Sex:	Male	41	78.8	39	81.3	38	64.4	11	61.1
	Female	11	21.2	9	18.8	21	35.6	7	38.9
Age:	Mean	35.9		35.4		47.9		33.7	
	Standard Deviation	+ 12.6		+ 13.5		+ 11.2		+ 11.0	
	Range	18 - 75		20 - 76		20 - 66		17 - 64	
Smoking Status:									
Current Smokers		16	30.8	14	29.2	20	33.9	7	38.9
Ever-smoked		24	46.2	23	47.9	24	40.7	8	44.4
Mean Pack-years		16.8		16.4		NA		NA	
	Standard Deviation	+ 16.3		+ 17.7					
Ethnic Background									
Caucasian		50	96.2	48	100				
American Indian		1	1.9						
Mexican American		1	1.9						
Cambodian						15	25.4	6	33.3
Chinese						12	20.3	0	0
Hmong						15	25.4	0	0
Laotian						13	22.0	10	55.6
Vietnamese						4	6.8	2	11.1

NA = Not Available

TABLE V

Symptoms/Reported Diagnoses for English Speaking Workers and Comparison Group

Fillmore/Dole Mushrooms
Fillmore, Utah

March 1983 - March 1984

Symptoms/Diagnoses	Mushroom Workers #	Mushroom Workers %	Comparison Group #	Comparison Group %	Statistical Probability	Significance Test
Total Number	52		48			
Symptoms:						
Chronic cough	13	25	1	2	0.01	Chi^2=9.07
Chronic phlegm	7	13	0	0	0.0084	Fisher's Exact
Chronic bronchitis	4	8	0	0	0.069	Fisher's Exact
Wheezing	14	27	0	0	0.001	Chi^2=12.87
Breathlessness	10	19	9	19	Not significant	
"Acute hypersensitivity pneumonitis"	4	8	0	0	0.069	Fisher's Exact
"Chronic hypersensitivity pneumonitis"	4	8	0	0	0.069	Fisher's Exact
Serious chest cold or illness	20	38	8	17	0.05	Chi^2=4.85
Reported Diagnoses:						
Bronchitis	14	27	9	19	Not significant	
Pneumonia	20	38	11	23	Not significant	
Hay Fever	10	19	25	52	0.01	Chi^2=10.44
Chronic bronchitis	1	2	1	2	Not significant	
Emphysema	1	2	0	0	Not significant	
Asthma	7	13	4	8	Not significant	

TABLE VI

Environmental Exposures of Worker and Comparison Groups with Associated Acute Symptoms for English Speaking Groups

Fillmore/Dole Mushrooms
Fillmore, Utah

March 1983 - March 1984

Environmental Exposure	English Speaking								Southeast Asian			
	Mushroom Workers				Comparison Group				Workers		Comparison	
	Exposed Number	% of Group	Symptomatic Number	Symptomatic % of Exposed	Exposed Number	% of Group	Symptomatic Number	Symptomatic % of Exposed	Exposed Number	% of Group	Exposed Number	% of Group
Total Number in Group		52				48				59		18
Mushroom Farm	52	100	11	21	0	0	0	0	59	100	0	0
Farm, in general	--	--	--	--	--	--	--	--	21 *	36	12 *	67
Grain Dust	30	58	7	23	29	60	7	24	--	--	--	--
Hay/Grain	19	37	6	32	19	40	4	21	--	--	--	--
Moldy Silage	20	38	1	5	14	29	1	7	--	--	--	--
Moldy Hay	--	--	--	--	--	--	--	--	1	2	1	6
Malt	--	--	--	--	--	--	--	--	1	2	1	6
Sugar Cane	4	8	0	0	1	2	0	0	1	2	2	11
Wood Dust	25	48	0	0	37	77	5	14	--	--	--	--
Cork	--	--	--	--	--	--	--	--	3	5	0	0
Molds	16	31	0	0	24	50	2	8	--	--	--	--
Enzymes	2	4	1	50	0	0	0	0	--	--	--	--
Cheese Making	5	10	0	0	6	13	0	0	--	--	--	--
Birds	NA	NA	2	NA	NA	NA	0	0	22	37	2	11
Pigeons	3	6			6	13						
Turkeys	0	0			1	2						
Chickens	11	21			7	15						
Pet Birds	5	10			6	13						
Thatched Roof House	--	--	--	--	--	--	--	--	29	49	11	61
Humidifier/Swamp Cooler	33 @	63	2	6	18 @	38	0	0	NA	NA	NA	NA
Humidifier	NA	NA	NA	NA	NA	NA	NA	NA	8	14	1	6
Swamp Cooler	NA	NA	NA	NA	NA	NA	NA	NA	38 #	64	1 #	6

NA = Not Available

Statistically Significant Differences
@ Chi^2=5.73, p 0.05 * Chi^2=4.24, p 0.05 # Chi^2=16 8, p 0.001

TABLE VII

Precipitin Results of Worker and Comparison Groups

Fillmore/Dole Mushrooms
Fillmore, Utah

March 1983 - March 1984

Antigens	English Speaking								Southeast Asian							
	Mushroom Workers				Comparison Group				Mushroom Workers				Comparison Group			
	Neg.	Inc.	Pos.	Ave. Pos.	Neg.	Inc.	Pos.	Ave. Pos.	Neg.	Inc.	Pos.	Ave. Pos.	Neg.	Inc.	Pos.	Ave. Pos.
Total Number in Group	52				48				59				18			
Environmental																
Crude spawn extract #1	12	15	25	2.4	--	--	--	--	6	28	25	1.7	--	--	--	--
Crude spawn extract #2	31	8	5	1.4	42	2	4	1.3	25	12	22	2.1	9	7	2	2.0
Aspergillus flavus	46	3	3	2.0	45	0	3	3.0	58	1	0	--	18	0	0	--
Aspergillus fumigatus	40	5	7	1.4	39	3	6	1.3	46	5	8	2.1	14	0	4	1.5
Cephalosporium	31	7	14	2.1	22	8	18	2.0	39	9	11	1.9	8	2	8	1.5
Chrysosporium	43	0	9	2.2	40	2	6	2.2	54	3	2	2.5	12	0	6	1.8
Mucor	18	18	16	2.4	20	9	19	2.4	29	9	21	2.0	8	2	8	1.9
Penicillium	39	3	10	1.9	43	3	2	2.5	43	7	9	1.6	15	2	1	1.0
Scopulariopsis	47	3	2	1.0	47	0	1	1.0	51	7	0	--	17	0	1	1.0
Thermoactinomyces candidus	27	8	17	2.1	34	4	10	2.5	18	18	23	1.9	4	5	9	1.8
Thermoactinomyces vulgaris	18	13	21	2.3	25	11	12	2.3	20	12	27	2.0	3	4	11	1.7
Standard																
Aspergillus fumigatus 507	52	0	0	--	47	1	0	--	59	0	0	--	18	0	0	--
Aspergillus fumigatus 515	44	3	5	2.0	43	1	4	2.3	59	0	0	--	18	0	0	--
Aspergillus fumigatus 534	51	0	1	4.0	47	0	1	4.0	59	0	0	--	16	1	1	3.0
Candida albicans	41	5	6	2.0	36	3	9	2.2	51	4	4	1.5	16	2	0	--
Micropolyspora facni	48	1	3	1.0	48	0	0	--	58	1	0	--	17	1	0	--
Green mucor	27	10	15	2.1	24	12	12	2.1	37	5	17	2.1	9	3	6	2.0
Penicillium notatum	50	2	0	--	46	0	2	2.5	57	1	1	1.0	18	0	0	--
Pigeon serum	51	1	0	--	46	0	2	2.0	59	0	0	--	18	0	0	--
Saccharomonospora viridis	34	11	7	2.0	38	8	2	2.5	47	2	10	2.1	12	1	5	2.0
Thermoactinomyces candidus	47	2	3	2.3	43	5	0	--	57	2	0	--	8	4	6	2.3
Thermoactinomyces intermedius	32	15	4	1.5	40	6	2	2.5	38	9	12	2.0	10	4	4	2.0
Thermoactinomyces vulgaris	45	4	3	1.0	40	5	3	1.7	56	1	2	1.5	14	2	2	1.5

Positives: 1=Extremely Weak 2=Very Weak 3=Weak 4=Positive 5=Strongly Positive (There were no 5s.)

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ROBERT A. TAFT LABORATORIES
4676 COLUMBIA PARKWAY, CINCINNATI, OHIO 45226

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

Third Class Mail

U.S. MAIL

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF HHS
HHS 396