A Study of Athlete's Foot and Its Control, II*

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A vast amount of research has been carried on during the past quarter of a century, with a view toward finding a fungicide or a method capable of controlling dermatomycosis or dermatophytosis. These terms are commonly used interchangeably with epidermophytosis, epidermomycosis, trichophytosis, "ringworm" and "athlete's foot," all denoting any superficial fungus infection of the glabrous or intertriginous areas of skin.

It has been variously estimated that from 50% to 90% of the population of the United States are affected at some time during their lives, and Gilman (1) noted that of 390 new patients with diseases of the skin observed during a six months' period in the Student Health Service of the University of Pennsylvania, 145, or 37%, had a dermatophytic infection.

Legge, Bonar and Templeton (2) found that 53.3% of the men and 15.3% of the women of the 3100 freshmen in the University of California were infected, and at the end of the spring semester, 78.6% of the men and 17.3% of the women had a mycotic infection of the feet.

Prehn (3) found that 88% of 1500 men examined on eleven ships of the Navy in various parts of the world showed clinical evidence of a fungus infection of the feet.

Among the various chemicals recommended for the prevention and treatment of these fungus infections of the feet is sodium hypochlorite.

Gilman (1), Hadfield (5), and Vaughan and DeKay (6) all agree with Osborne and Hitchcock (4) that the fungus infection problem can be solved by control of exposure in swimming pools, showers, gymnasiums, etc., with foot baths containing 0.5% to 1.0% sodium hypochlorite solution.

Another series of workers, including Shaffer (7), Weirich (8), and Chiles (9) seem to disagree with the above-mentioned workers.

No species of fungi or technique has been generally accepted as a basis for comparative fungicidal tests. As a result, the literature on this subject is filled with apparent inconsistencies as to the comparative fungicidal powers of certain commonly used chemicals as well as methods for determining the fungicidal properties of these chemicals. The primary aim of this work was to continue the investigation started in 1940 (7) on the use of sodium hypochlorite solution.

EXPERIMENTAL

In this study five fungi, characteristic examples of the three main genera of Dermatophytes, were used. These five were chosen because of their common occurrence in the majority of cases of dermatophytosis. They were as follows: (1) *Trichophyton rosaceum*, (2) *Trichophyton interdigitale* 7190, (3) *Microsporon lanosum* 650, (4) *Achorion schoenleinii* 641 and 642, and (5) *Trichophyton gypseum asteroides* 7189. These five fungi were all grown successfully on Sabouraud's *A* culture medium in 8-ounce prescription bottles, and allowed to incubate at room temperature for three to four weeks to obtain maximum sporulation. A large quantity of inoculum was prepared at one time, consisting of a standardized number of spores (10,000/cc.) and finely comminuted mycelium suspended in normal saline solution almost completely freed from nutrient materials.

In testing, two 4-mm. loopfuls of the inoculum were placed in 5 ml. of the chemical and after proper time exposure, two 4-mm. loopfuls of this mixture were removed and introduced into 5 ml. of broth subculture. Slight amounts of the chemical being tested were carried over into the broth tubes, and in order to balance this, two loopfuls of the fungicide were added to each control tube in which the untreated spores were planted.

Samples of sodium hypochlorite foot baths were collected at the Purdue University field house, analyzed for their sodium hypochlorite content, and these samples tested for their relative fungicidal value using the five fungi heretofore mentioned.

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Samples analyzed at 0.215, 0.290, 0.508 and 0.701% of sodium hypochlorite were tested in this manner. In each case the inoculi were exposed to the sample for 10-, 20-, 30-, and 60-sec. intervals, and the subcultures observed for growth every 24 hrs. for twenty days. Table I shows the results.

TABLE I

NaOCl, %	0.215				0.290				0.508				0.701			
Time of exposure, min.	10	20	30	60	10	20	30	60	10	20	30	60	10	20	30	60
Fungus 1	+	+	−	−	+	+	−	−	−	−	−	−	−	−	−	−
2	+	+	−	−	+	+	−	−	−	−	−	−	−	−	−	−
3	+	+	−	−	+	+	+	−	−	−	−	−	−	−	−	−
4	+	+	−	−	+	+	−	−	−	−	−	−	−	−	−	−
5	+	+	−	−	+	+	−	−	−	−	−	−	−	−	−	−
Control	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

TABLE II

NaOCl, %	0.1			0.2			0.3			0.4			0.5			0.6		
Time of exposure, min.	10	30	60	10	30	60	10	30	60	10	30	60	10	30	60	10	30	60
Fungus 1	+	+	−	+	+	−	+	−	−	+	−	−	−	−	−	−	−	−
2	+	+	−	+	+	−	+	−	−	+	−	−	−	−	−	−	−	−
3	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
4	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
5	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

TABLE III

NaOCl, %	0.1			0.2			0.3			0.4			0.5			0.6		
Time of exposure, min.	10	30	60	10	30	60	10	30	60	10	30	60	10	30	60	10	30	60
Fungus 1	+	+	−	+	+	−	+	−	−	+	−	−	−	−	−	−	−	−
2	+	+	−	+	+	−	+	+	−	+	−	−	+	−	−	−	−	−
3	+	+	−	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−
4	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
5	+	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−

TABLE IV

NaOCl, %	0.1			0.2			0.3			0.4			0.5			0.6		
Time of exposure, min.	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
Fungus 1	+	+	−	+	+	−	+	−	−	+	−	−	−	−	−	−	−	−
2	+	+	−	+	+	−	+	+	−	+	+	−	+	−	−	−	−	−
3	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−
4	−	−	−															
5	−	−	−															

TABLE V

NaOCl, %	0.1			0.2			0.3			0.4			0.5			0.6		
Time of exposure, min.	10	30	60	10	30	60	10	30	60	10	30	60	10	30	60	10	30	60
Fungus 1	+	+	−	+	+	−	+	+	−	+	−	−	+	−	−	−	−	−
2	+	+	−	+	+	−	+	+	−	+	+	−	+	−	−	−	−	−
3	+	+	−	+	+	−	−	−	−									
4	+	−	−	−	−	−												
5	+	−	−	−	−	−												

The test for the efficiency of any fungicide is its ability to destroy or prevent the growth of organisms. The most reliable procedure would be to add definite amounts of fungi to the solutions being tested in order to be certain of the activity of the fungicide. In the second part of this study, foot-bath solutions of 500-ml. volume were prepared containing sodium hypochlorite in concentrations ranging from 0.2% to 0.6%.

Specific amounts of inoculi (1 ml. and 5 ml.) were added to these foot-bath solutions. The larger amount would contain more of the organism than a foot bath which had been in use for 24 hrs.

The baths were vigorously stirred from the time the inoculum was added until the end of the test. Two 4-mm. loopfuls of the solution were removed after 10, 30, and 60 seconds' exposure to the chemical, and placed in subcultures of beef broth, with the following results. Table II shows the results after adding 1 ml. of inoculum to each bath while Table III shows the results after adding 5 ml. of inoculum to each bath.

The third part of this experimentation was to determine the activity of the fungicide on foot baths containing definite percentages of sodium hypochlorite and known amounts of inoculum together with organic matter in the form of hide powder, thereby more nearly approaching the conditions of the foot bath which had been in use.

Foot baths were prepared containing sodium hypochlorite ranging from 0.1% to 0.6%. These baths also contained 1 ml. and 5 ml. of inoculum together with 0.5 Gm. of hide powder to each 500 cc. of solution. Table IV gives the results for 1 ml. of inoculum and Table V gives the results for 5 ml. of inoculum.

A study of Tables II to V, inclusive, shows that the amount of inoculum and the presence of organic matter do have a definite effect upon the activity of the fungicide.

SUMMARY

Foot baths containing 0.3% of sodium hypochlorite will prevent the growth of *Trichophyton rosaceum, Trichophyton interdigitale, Microsporon lanosum, Achorion shoenleinii* and *Trichophyton gypseum asteroides* after 30 seconds' exposure and baths containing 0.5% of sodium hypochlorite will prevent the growth of these fungi after 10 seconds' exposure.

REFERENCES

(1) Gilman, R. L., *J. Am. Med. Assoc.*, 100 (1933), 715.

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(5) Hadfield, W. A., *Soap*, 11 (1935), 121.

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(7) Shaffer, L. W., and Cary, W. H., *J. Mich. State Med. Soc.*, 32 (1933), 648.

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Book Reviews

Chemical Analysis. Volume II, Chromatographic Adsorption Analysis, by HAROLD H. STRAIN, Ph.D. Interscience Publishers, Inc., 215 Fourth Avenue, New York, 1941. x + 222 pp., 37 figs., 15 x 22.5 cm. Price, $3.75.

The aim of this book according to the preface, is to present a summary of the present knowledge concerning applications of the chromatographic adsorption method of analysis. Experimental procedures and applications of the method to problems involving the detection and isolation of natural products in a pure form are especially emphasized. Fundamental theories are also stressed. Different types of apparatus used in chromatographic adsorption methods are adequately described and clearly illustrated by means of diagrams, so that they may be readily assembled from apparatus at hand in any well-equipped laboratory. Information on adsorbents, solvents and eluants is unusually concise, but at the same time complete enough to serve as a guide to the research worker who is using the method for the first time.

The section on the chromatography of organic compounds is particularly interesting. It should serve as a stimulus to pharmaceutical chemists working with plant or animal material to attempt the application of chromatic adsorption methods where more conventional procedures have failed. A few of the topics covered are the applications of the method to the separation and isolation of hydrocarbons, acids, fats, amino acids, carbohydrates, terpenes, benzene derivatives, sterols and steroids, heterocyclic nitrogenous bases, vitamins, hormones, enzymes and plant pigments.

The book is excellently written and well documented throughout. The bibliography is quite extensive, but no claim to completeness is made by the