

# FUNGI ENCOUNTERED ON FOOTWEAR AND DEFENCE ARTICLES

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A study of mycoflora on footwears and defence articles from Agra city was made. In all 38 fungi belonging to different genera were recorded. Out of these, 17 fungal species were isolated for the first time on these articles. A new variety i.e., *Aspergillus sydowii* var. *agraii* Sharma and Sharma was also created. Species of *Aspergillus*, *Penicillium*, *Paecilomyces*, *Drechslera*, *Alternaria*, *Fusarium* and *Trichoderma* were found to be dominant in all the cases. Maximum species were recorded from gents footwear and boots ankle in comparison to ladies footwear. All these fungi were grouped as (i) active (15 isolates), (ii) moderate (15 isolates) and (iii) slow leather deteriorogens (8 isolates) on the basis of screening.

Leather had most extensively been used by human beings from time immemorial to cover their bodies, footwear, military use and for other purposes. The leather and its products are usually attacked by large number of fungi, the heavy fungal growth renders them unsuitable for use by discolouring, developing cracks and spoiling the finish<sup>1, 2, 3</sup>. Mycobial deterioration is a world wide problem. The hot humid climate promotes the activity and causes deterioration of wide variety of materials. The extent of mycobial deterioration varies depending on the conditions of storage or usage and the nature of basic materials used in the processing of leathers. Fungal attack is widely encountered on outdoor exposed materials where fungal spores remain present in surrounding atmosphere (air and soil). The samples collected from different places have development of different types of fungi. The observations of many types of samples will give a large number of species which grow and infest the various leather articles and cause deterioration. With this view point in the present attempt the various types of fungi present in ladies and gents footwear and military articles from Agra city have been studied. A comparison has also been made with the ladies and gents footwear\*collected from different localities.

## MATERIALS AND METHOD

The various types of deteriorated footwears (ladies and gents) and defence articles viz; boot, belt, pistol case, gun and binocular cases were collected from different localities of Agra city and Central Ordnance Depot, Agra Cantt,

The fungi were isolated<sup>4</sup> by swabbing the samples with sterilized moist cotton which was shaken in 10 ml of sterilized distilled water in a culture tube. Dilutions, 1/10, 1/100, 1/1,000, and 1/10,000 were made. One ml of each of these dilutions was aseptically transferred to sterilized Petridishes. 20 ml of sterilized Czapek's medium was added to each dish. The Petridishes were incubated at 28±1° C and observed after 7 days for the fungal growth. The fungal isolates thus obtained were purified, maintained on agar slants, identified and got confirmed through the courtesy of Director, CMI, Kew, England.

The mycoflora isolated were screened to select the active (profusely growing) leather deteriorogens and to study their relative capacity for attacking different types (vegetables and chrome tanned) of leather following the method (ALCA, Procedure) developed by Physical Testing Committee of the American Leather Chemist's Association<sup>5</sup>.

## RESULTS AND DISCUSSION

The observations in the present investigation showed that various fungi appeared on different articles. In all 38 fungi were recorded. Out of these *Aspergillus awamorii*, *A. sydowii*, *A. sydowii* var. *agraii*, *Penicillium citrinum*, *P. cyaneum*, *P. variabile*, *P. expansum*, *P. simplicissimum*, *P. fellutanum*, *Curvularia senegalensis*, *Trichoderma harzianum*, *Cephalosporium* sp., *Drechslera papendorfii*, *Alternaria alternata*, *A. tenuissima*, *Fusarium solani* and *Cladosporium cladosporoides* were recorded for the first time in India on these articles (Table 1). Variable number of fungal species were found on

different articles viz., 38 each from gents footwear and boots ankle, 30 from ladies chappals and 35 from pistol cases. Similarly 36 species each were isolated from gun cases, belts and binocular cases respectively.

The observations on screening of mycoflora for the assessment of relative capacity for attacking different types of leather are shown in Table 2. A perusal of the results indicated that on the basis of visual examinations for relative amount and severity of growth on leather samples, the fungi were grouped into 3 categories viz., (i) active (ii) moderate, and (iii) slow deteriorogens,

The profusely developing mycoorganisms on all leather types i.e., ; *Aspergillus niger*, *A. flavus*, *A. flavus* (scl.), *A. fumigatus*, *A. tamaritii*, *A. sydowii*, *A. sydowii* var. *agrarii*, *Penicillium citrinum*, *P. funiculosum*, *P. purpurogenum*, *P. expansum*, *P. simplicissimum*, *P. fellutanum*, *Paecilomyces variotii* and *Trichoderma harzianum* were placed into first category (active deteriorogens). A few fungal isolates i.e., *Chaetomium globosum*, *Cephalosporium* sp., *Alternaria alternata*, *A. tenuissima*, *Fusarium solani*, *Cladosporium cladosporoides*, *Mucor* sp. and *Rhizopus* sp. which exhibited very poor growth were slow leather deteriorating species (III category). *Mycelia sterilia* could not grow except on vegetable sole and kattai leathers. Rest of the fungi were considered as moderately growing organisms (II category). Their growth pattern was moderate.

Variable number of fungal species on various articles did not seem to be more important but the high magnitude of their growth and infestation caused much deterioration. Literature on the subject revealed that types of species were also considered in the deterioration. The most dominant fungi recorded so far by various workers<sup>6,7,8,9</sup> from finished leathers, military equipments, footwears and shoemaking materials were the species of *Aspergillus*, *Penicillium*, *Paecilomyces*, *Trichoderma* and *Alternaria*. It is clear from the results (Table 1) that similar fungi were encountered in the present investigation.

It was observed in all the deteriorated samples that grain side was very much susceptible for fungal infestation than flesh side. It may be due to incorporation of leather finishes i.e., pigments, protein binders, casein, gelatin, egg albumins, waxes and other mucilaginous substances on this side. All

these substances serve as the best source in primary colonization of the mycoorganisms<sup>10, 11</sup>. In all the cases it was also noticed that articles made up of vegetable tanned leathers supported a luxuriant growth of fungi than the chrome tanned. This may be because of the fact that various oils, water soluble, vegetable tanning materials and extracts of barks are absorbed in higher quantities by the pelt fibres during vegetable tanning and fatliquoring which provide an enriched medium for fungal growth<sup>10, 11</sup>.

The results on isolations from footwears indicated that total number of mycoorganisms was higher on gents shoes than ladies chappals. This variation in development of maximum number of fungi may depend on the materials used in manufacture of footwear (inner and upper parts) and the environmental conditions in which the footwears were used. Table 1 showed that the footwears contained species of fungi that were also recorded either on shoemaking materials or on finished leathers. These fungi may come from both these sources to the footwear but the main role is played by the contamination from air and the surroundings. Particularly in closed type of footwears (shoe etc.) relative humidity and the moisture of the leather surface is considerably raised by the perspiration from foot skin. The temperature is also increased. These factors support the mycobial growth to the great extent in closed type of footwears.

Orlita<sup>12</sup> made similar observations regarding the mould growth in footwear during user conditions and stated that the inner space of the shoe becomes a tropical chamber in which there is an optimum temperature, humidity and sufficient amount of nutrients for the development of not only the leather deteriorating fungi but parasitic skin mildew also, which are dangerous for the health of foot skin and cause dermatomycosis, a foot skin disease. The observation fairly revealed that in closed type of footwear large number of fungi grow than those of open types, which are largely used by ladies in India as well as in other countries.

Furthermore, it was interesting to observe that fungal growth and deterioration was much higher in those samples which were collected from densely populated localities and labourers colonies. The improper drainage in such localities results in the formation of wet conditions which enhance the relative humidity in surroundings. Dirty heaps of

refuses comprised of various types of rotten organic materials provide suitable substrate for active multiplication and sporulation. Thus high inoculum is built-up in the atmosphere which ultimately colonize not only on leathers but other materials also.

It can be concluded from these observations that the indigenous finished leathers generally used for making the footwears, defence articles and other

various goods for daily use are highly susceptible for mycobial infestation. These are subjected to heavy fungal attack during storage and user conditions. The present investigation provide guidelines to develop certain control measures to make these articles free from infestation of micro fungi under the conditions of high relative humidity and temperature; the knowledge of specific fungal forms is the first stage in the solution of this problem.

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TABLE I  
FUNGI RECORDED FROM FOOTWEARS AND DEFENCE ARTICLES

Fungi	Various articles						
	1	2	3	4	5	6	
1. <i>Aspergillus niger</i>	+	+	+	+	+	+	+
2. <i>A. flavus</i>	+	+	+	+	+	+	+
3. <i>A. flavus</i> (scl.)	+	+	+	+	+	+	+
4. <i>A. fumigatus</i>	+	+	+	+	+	+	+
5. <i>A. terreus</i>	+	+	+	+	+	+	+
6. <i>A. sulphureus</i>	+	+	+	+	+	+	+
7. <i>A. tamaritii</i>	+	+	+	+	+	+	+
8. <i>A. nidulans</i>	+	+	+	+	+	+	+
9. <i>A. japonicus</i>	+	+	+	+	+	+	+
10. <i>A. luchuensis</i>	+	+	+	+	+	+	+
11. <i>A. chevalieri</i>	+	+	+	+	+	+	+
12. <i>A. amstelodami</i>	+	+	+	+	+	+	+
13. <i>A. awamori</i> *	+	+	+	+	+	+	+
14. <i>A. sydowii</i> *	+	+	+	+	+	+	+
15. <i>A. sydowii</i> var. <i>agraii</i> **	+	—	+	+	+	+	+
16. <i>Penicillium citrinum</i> *	+	+	+	+	+	+	+
17. <i>P. cyaneum</i> *	+	+	+	+	+	+	+
18. <i>P. oxalicum</i>	+	+	+	+	+	+	+
19. <i>P. variable</i> *	+	+	+	+	+	+	+
20. <i>P. purpurogenum</i>	+	+	+	+	+	+	+
21. <i>P. funiculosum</i>	+	+	+	+	+	+	+
22. <i>P. funiculosum</i> iso. 2	+	—	+	+	+	+	+
23. <i>P. expansum</i> *	+	+	+	+	+	+	+
24. <i>P. simplicissimum</i> *	+	+	+	+	+	+	+
25. <i>P. fellutanum</i> *	+	+	+	+	+	+	+
26. <i>Paecilomyces variotii</i>	+	+	+	+	+	+	+
27. <i>Curvularia senegalensis</i> *	+	+	+	+	+	—	—
28. <i>Trichoderma harzianum</i> *	+	—	+	+	+	+	+
29. <i>Cephalosporium</i> sp.*	+	—	+	+	+	+	+
30. <i>Drechslera papendorfii</i> *	+	+	+	+	+	+	+
31. <i>Alternaria alternata</i> *	+	+	+	+	+	+	+
32. <i>A. tenuissima</i> *	+	—	+	—	—	+	—
33. <i>Fusarium solani</i> *	+	+	+	+	+	—	+
34. <i>Cladosporium cladosporoides</i> *	+	+	+	—	—	+	+
35. <i>Chaetomium globosum</i>	+	—	+	+	+	+	+
36. <i>Mucor</i> sp.	+	—	+	+	+	+	+
37. <i>Rhizopus</i> sp.	+	—	+	+	+	+	+
38. <i>Mycelia sterilia</i>	+	—	+	—	+	+	+
Total Fungi	38	30	38	35	36	36	36

\* = Recorded for the first time in India from footwear and defence articles.

\*\* = New variety : 1. Gents shoes. 2. Ladies chappals, 3. boot, 4. pistol case, 5. gun case, 6. belt, 7. binocular case.

+ = Presence, — = Absence.

TABLE 2

SCREENING FOR RELATIVE CAPACITY OF ISOLATED FUNGI FOR ATTACKING DIFFERENT TYPES OF FINISHED LEATHER

Fungi	Duration 30 days							
	Temp. 28±1°C RH—90%							
ALCA Procedure	*Various leather types							
	1	2	3	4	5	6	7	8
1. <i>Aspergillus niger</i>	4	4	4	4	4	4	4	4
2. <i>A. flavus</i>	4	4	4	4	4	4	4	4
3. <i>A. flavus</i> (scl.)	4	4	4	4	4	4	4	4
4. <i>A. fumigatus</i>	4	4	4	4	4	4	4	4
5. <i>A. terreus</i>	3	3	3	3	3	3	3	3
6. <i>A. sulphureus</i>	3	3	3	3	3	3	3	3
7. <i>A. tamarii</i>	4	4	4	4	4	4	4	4
8. <i>A. nidulans</i>	4	4	4	4	4	4	4	4
9. <i>A. japonicus</i>	4	3	3	3	3	3	3	3
10. <i>A. luchuensis</i>	4	3	3	3	3	3	3	3
11. <i>A. chevalieri</i>	3	3	3	3	3	3	3	3
12. <i>A. amstelodami</i>	3	3	3	3	3	3	3	3
13. <i>A. awamorii</i>	3	3	3	3	3	3	3	3
14. <i>A. sydowii</i>	4	4	4	4	4	4	4	4
15. <i>A. sydowii</i> var. <i>agraii</i>	4	4	4	4	4	4	4	4
16. <i>Penicillium citrinum</i>	4	4	4	4	4	4	4	4
17. <i>P. cyaneum</i>	3	3	3	3	3	3	3	3
18. <i>P. oxalicum</i>	3	3	3	3	3	3	3	3
19. <i>P. variabile</i>	3	3	3	3	3	3	3	3
20. <i>P. purpurogenum</i>	4	4	4	4	4	4	4	4
21. <i>P. funiculosum</i>	4	4	4	4	4	4	4	4
22. <i>P. funiculosum</i> iso. 2	3	3	3	3	3	3	3	3
23. <i>P. expansum</i>	4	4	4	4	4	4	4	4
24. <i>P. simplicissimum</i>	4	4	4	4	4	4	4	4
25. <i>P. fellutanum</i>	4	4	4	4	4	3	3	3
26. <i>Paecilomyces variotii</i>	4	4	4	4	4	4	4	4
27. <i>Curvularia senegalensis</i>	3	3	2	2	3	3	2	2
28. <i>Trichoderma harzianum</i>	4	4	4	4	4	4	4	4
29. <i>Cephalosporium</i> sp.	2	2	2	2	2	2	2	2
30. <i>Drechslera papendorfii</i>	4	4	3	3	3	3	3	3
31. <i>Alternaria alternata</i>	2	2	2	2	2	2	2	2
32. <i>A. tenuissima</i>	2	2	2	2	2	2	2	2
33. <i>Fusarium solani</i>	3	2	2	2	2	2	2	2
34. <i>Cladosporium cladosporoides</i>	3	2	2	2	2	2	2	2
35. <i>Chaetomium globosum</i>	2	2	2	2	2	2	2	2
36. <i>Mucor</i> sp.	3	2	2	2	2	2	2	2
37. <i>Rhizopus</i> sp.	3	2	2	2	2	2	2	2
38. <i>Mycelia sterilia</i>	2	2	0	0	0	0	0	0

\*= 1. vegetable sole, 2. kattai, 3. zuggrain chrome, 4. chrome upper, 5. E.I. tanned, 6. semichrome  
7. chrome retan, 8. chrome belting.

4=Active, 3=Moderate, 2=Slow, 0=No growth

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