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Keratinophilic fungi on various keratinous substrate: Hazardous to human and animal population

Jitendra Kumar and RKS Kushwaha

Abstract
Keratinophilic fungi were isolated from soil samples using human hair, cattle hair, human nail horn and feather as substrate. Thirty-two, 25, 25, 20, 26, 24 keratinophilic fungal genera were isolated from human hair, cattle hair, human nail, cow horn, and feather respectively. The frequency of *Chrysosporium* as recorded from various keratinous baits: human hair (24.48 %), cattle hair (20.81%), human nail (14.56 %), horn (32.90 %) and feather (18.03 %).

Keywords: Keratinophilic fungi, Dermatophytes, Medical Mycology

Introduction
Various keratinous substrates in the forms of hairs, nails, horns, hooves feathers, wool, and stratum corneum are abundantly present in nature as a waste. These substrates are mainly attacked by a specific group of microorganisms which have keratinolytic nature. The skill of dermatophytes and related fungi to invade and parasitize cornified tissue is closely associated with and depends on the utilization of keratin. The structure of keratin is like fibrous protein because it is also made up of folded polypeptide chains which lie parallel to one another along the axis of the fibre. The chains are cross-linked by hydrogen bonds, salt cross bridges, and disulphide bridges. All intermediate filament proteins have a structure consisting of a coiled-coil, α-helix rod domain (two polypeptide α-helixes wound around each other) that is interrupted by linkers and flanked by N-terminal head and C-terminal tail domains [1-2] stated that all keratinous structures contained insoluble calcium and other salts and classified all keratins in three groups based on their degree of mineralization Group I-keratins have < 0.1 % calcium and are highly keratinized e.g. hairs, quills, and feathers. The Group II-keratins are rigid like hooves, nails, claws and are much more highly calcified and much less keratinized. Group III-keratins i.e., beaks and baleen are still less keratinized and highly calcified with other salts. Indeed, feather protein is poorly digested by common digestive enzymes, such as trypsin and pepsin [3]. Hairs have a complex, heterogeneous structure. The distribution and organization of keratin's several parts are equally variable [4-11]. The hair cuticle forms efficient defence against injury from the environment. Its cell contains large amounts of amorphous keratin, especially in the thicker outer layer and an inner layer, both of which have high cystine content. Feather constitutes over 90% protein; the main component being β-keratin, a fibrous and insoluble structural protein extensively crossed linked by disulphide bonds. Hydrogen bonding and hydrophobic interactions among the polypeptide further confer mechanical strength and resistance to proteolytic enzymes [12]. The nail plate consists of a dorsal, an intermediate, and a ventral layer that differs in thickness and the compactness and type of bond between their cells [13]. Horn sheaths are living tissue that covers the bone core of horns etc. It is deciduous and composed of keratin, primarily. Hair and nails have nearly identical keratin fractions, according to nail keratin analysis[13]. Any microbe capable of producing an extra-cellular or surface located proteinase system is potentially keratinolytic, although its capacity to degrade keratin in nature or even in laboratory experiments may be negligible [14]. Several researchers have reported the presence of keratinophilic fungi in diverse habitats from India [15-22].
[23] reported four keratinophilic fungi *Aphanoascus stumoideus*, *Apinisia recovitzae*, *Biffdocarpus cubensis*, and *Crptumbellata terricola* from Pune and central India. The mechanism of sulphur oxidation and the use of sulphur oxidizing fungi were described by [24] while [25] isolated 154 fungi from 50 samples collected in Jaipur, Ajmer, Alwar, and Sikar. As a result of hygienic and ecological concerns, we observed frequency of isolation the keratinophilic fungi on human hair, cattle hair, human nail, horn, feather in soil.

This distribution and occurrence of keratinophilic fungi, could play a role in the industrial degradation of keratinous waste. Degraded keratinous waste can be used as a source of energy.

Materials and Methods

Isolation Methods

Isolation was done by the baiting method [26]. Ten to twenty gm of soil from each collected sample was taken in pre-sterilized Petri dishes and moistened with 10 ml of sterilized distilled water. These samples were baited by keratinous substrates. Human, horse, and buffalo hair, human nails, chicken feathers, and cow horns were used as keratinous substrate (Fig. 1-6). Human hair and cattle hair were washed and cut into pieces of 1-2 cm. Feathers were washed 2-3 times and cut into pieces of 1-2 cm. The human nail was collected and sterilized. Horn was used, these were broken into small pieces, sterilized for 15 min at 15 lbs pressure, and then buried in the soil. Fungal growth was observed on the bait and isolated on Potato dextrose agar and Sabouraud's dextrose agar and maintained as culture in a tube, water cultures, and dry herbarium are also maintained. For quantitative analysis, the following parameters were considered to estimate the fungal population.

$$\text{Distribution (\%)} = \frac{\text{Number of samples in which species occurred}}{\text{Total number of samples examined}} \times 100$$

$$\text{Frequency of isolation (\%)} = \frac{\text{Number of strains of a given species}}{\text{Total number of fungal strains}} \times 100$$

$$\text{L. index} = \frac{\text{Number of strains}}{\text{Number of Petri dishes prepared}}$$

Shannon index of general diversity (H)

$$\overline{H} = \frac{n1}{-\Sigma N} \log \frac{n1}{N}$$

Where n1 is many individuals of species and N is the total number of strains.

Results and Discussion

A total of one hundred twenty samples collected from six different habitats were examined for the occurrence of keratinophilic fungi on different keratinous baits like human hair, cattle hair, human nail, cow horn and feather (Table 1). Colonization of various keratin substrates like human hair, buffalo hair, horsehair, human nail, cow horn, and chicken feather by keratinophilic fungi was observed and results were given in Table 2. Twenty-nine genera belonging to 73 species were isolated on these five different baits. The maximum number of fungal species found on human hair (32) followed by cattle hair (29), human nail (24), chicken feather (25), and cow horn (24) (Fig. 1). Thirty-two, 25, 25, 20, 26, 24 keratinophilic genera were isolated from human hair, cattle hair, human nail, cow horn, and feather respectively. Human hair yielded maximum Hyphomycetous fungal genera followed by Ascomycetes, Zygomycetes, and Coelomycetes (Fig. 1).

The percent distribution and frequency of each fungal species on keratinous substrates were given in Tables 3 and 4. *Chrysosporium* is a cosmopolitan genus and found on all keratinous substrates. *Chrysosporium* showed 54.17, 41.67, 33.33, 54.17 and 33.34 percent distribution on human hair, cattle hair, human nail, horn and chicken feather respectively. The genus *Chrysosporium* showed maximum percent distribution (54.34) on the horn and human hair. Among *Chrysosporium* *Chrysosporium indicum* was recorded most frequently on all the keratinous substrates. Genus *Microsporum* was recorded from all substrates with maximum percent distribution (25.04) on cattle hair and minimum on human hair (08.34). *Malbranchea* was in its maximum occurrence on the human nail and showed a 31.77 percent distribution. *Ctenomyces* were capable of colonizing chicken feathers and human nail and showed (12.50), (4.17) percent distribution on the chicken feather and human nail respectively. *Aphanoascus* was recorded from all keratinous substrates except human nail and horn. *Eurotium* was limited in its isolation and confined to horn only. Genus *Trichophyton* showed 8.34, 20.83, 18.00, 20.84, and 16.67 percent distribution on human hair, cattle hair, human nail, cow horn and chicken feather respectively. The highest growth value of L index was recorded on human hair and the least was observed on the chicken feather. The frequency of *Chrysosporium* as recorded from various keratinous baits: human hair (24.48 %), cattle hair (20.81%), human nail (14.56 %), horn (32.90 %) and feather (18.03 %). The 2.04 percent frequency was showed by *Arthoderma*, *Curvularia*, *Epidermophyton*, *Mucor* and *Paecilomyces* on human hair (Table 4). A maximum percent frequency (32.90) was observed on the cow horn by *Chrysosporium*. Some Ascomycetous fungal genera like *Amauroascus*, *Auxarthron* and *Eurotium* were not isolated from feathers.

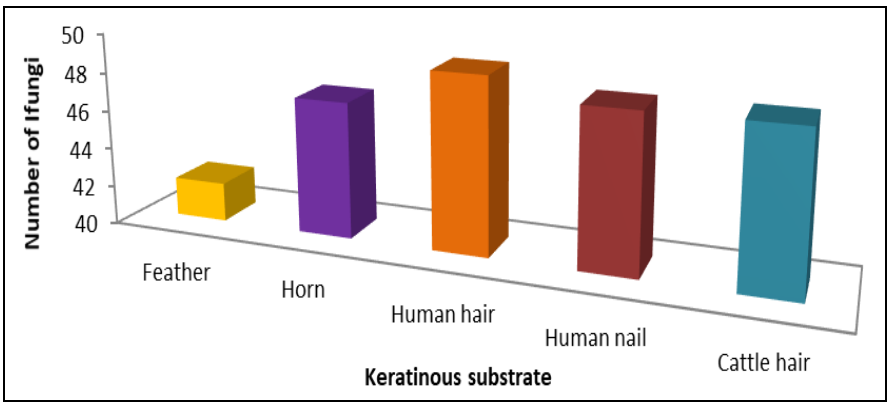

Fig 1: Number of fungi on the different substrate

Table 1: Keratinophilic fungi on keratinous substrates

S. No.	Keratinous Substrate	Total Sample	Total Fungi	Fungus
1	Feather	24	42	*Acremonium* sp., *Acremonium strictum*, *Alternaria alternata*, *Aphanoascus fulvescens*, *Aphanoascus terreus*, *Arthoderma simii*, *Aspergillus flavipes*, *Chaetomium globosum*, *Chrysosporium indicum*, *Chrysosporium pannicola*, *Chrysosporium tropicum*, *Ctenomyces serratus*, *Epidermophyton* sp., *Gymnoascus intermedius*, *Humicola grisea*, *Malbranchea pulchella*, *Microsporum canis*, *Microsporum fulvum*, *Mucor* sp., *Penicillium griseofulvum*, *Phoma humicola*, *Rhizomucor* sp., *Trichoderma viride*, *Trichophyton rubrum*, *Verticillium* sp.
2	Horn	24	45	*Amauroascus mutatus*, *Chrysosporium indicum*, *Chrysosporium keratinophilum*, *Chrysosporium merdarium*, *Chrysosporium* sp.2, *Chrysosporium tropicum*, *Curvularia geniculata*, *Epidermophyton* sp., *Eurotium repens*, *Geomyces pannorum*, *Gymnoascus reessii*, *Humicola grisea*, *Malbranchea pulchella*, *Microsporum canis*, *Microsporum cookie*, *Microsporum gypseum*, *Microsporum vanbreuseghemii*, *Myceliophthora vellerea*, *Paecilomyces javanicus*, *Phoma humicola*, *Trichoderma viride*, *Trichophyton ajelloi*, *Trichophyton mentagrophytes*, *Verticillium* sp.
3	Human hair	24	49	*Acremonium kiliense*, *Alternaria alternata*, *Aphanoascus keratinophilus*, *Aphanoascus terreus*, *Aspergillus sparsus*, *Aspergillus sydowii*, *Aspergillus terreus*, *Auxarthron conjugatum*, *Chrysosporium indicum*, *Chrysosporium queenslandicum*, *Chrysosporium* sp. 2, *Chrysosporium sulphureum*, *Chrysosporium tropicum*, *Chrysosporium zonatum*, *Curvularia lunata*, *Epidermophyton* sp., *Fusarium proliferatum*, *Fusarium oxysporum*, *Humicola grisea*, *Malbranchea flava*, *Malbranchea gypsea*, *Malbranchea pulchella*, *Malbranchea* sp., *Microsporum gypseum*, *Microsporum nanum*, *Mucor* sp., *Paecilomyces fusisporus*, *Penicillium chrysogenum*, *Penicillium griseofulvum*, *Penicillium pusillus*, *Trichophyton mentagrophytes*, *Trichophyton terrestre*
4	Human nail	24	48	*Acremonium recifei*, *Acremonium strictum*, *Alternaria alternata*, *Amauroascus mutatus*, *Arthoderma simii*, *Aspergillus ustus*, *Chrysosporium indicum*, *Chrysosporium keratinophilum*, *Chrysosporium merdarium*, *Chrysosporium pannicola*, *Chrysosporium tropicum*, *Ctenomyces serratus*, *Curvularia geniculata*, *Epidermophyton* sp., *Fusarium oxysporum*, *Fusarium proliferatum*, *Geomyces pannorum*, *Malbranchea aurantiaca*, *Malbranchea chrysosporoidea*, *Malbranchea flava*, *Malbranchea pulchella*, *Microsporum equinum*, *Microsporum fulvum*, *Paecilomyces javanicus*, *Trichophyton oryzae*, *Trichophyton rubrum*, *Trichophyton simii*, *Trichophyton terrestre*
5	Cattle hair	24	48	*Acremonium strictum*, *Amauroascus mutatus*, *Aphanoascus keratinophilus*, *Arthoderma simii*, *Aspergillus candidus*, *Aspergillus ustus*, *Auxarthron conjugatum*, *Chrysosporium indicum*, *Chrysosporium keratinophilum*, *Chrysosporium pannicola*, *Chrysosporium* sp., *Chrysosporium tropicum*, *Gymnoascus intermedius*, *Humicola grisea*, *Malbranchea aurantiaca*, *Microsporum canis*, *Microsporum fulvum*, *Microsporum gypseum*, *Myceliophthora fergusii*, *Paecilomyces javanicus*, *Paecilomyces crustaceus*, *Paecilomyces* sp., *Penicillium griseofulvum*, *Phoma humicola*, *Rhizopus Trichoderma viride*, *Trichophyton ajelloi*, *Trichophyton mentagrophytes*, *Trichophyton oryzae*

Table 2: Number of Fungal strains on keratinous substrates

Substrate	Number of samples	Number of positive samples	% Occurrence	Number of species	Number of strains	L. Index
Human hair	24	24	100	32	49	2.04
Cattle hair	24	24	100	29	48	2.00
Human nail	24	22	91.66	28	48	2.00
Horn	24	24	100	23	45	1.87
feather	24	24	100	25	42	1.75

Table 3: Distribution of keratinophilic fungi on different keratinous substrates

Sr. No	Fungus	Keratinous substrates				
		Human hair	**Cattle hair**	**Human Nail**	**Horn**	**Feather**
	Number of Samples	24	24	24	24	24
	Number of Positive Samples	24	24	22	24	24
	% Occurrence	100	100	91.66	100	100
1	*Acremonium kiliense*	12.50	0.00	0.00	0.00	0.00
2	*Acremonium recifei*	0.00	0.00	9.09	0.00	0.00
3	*Acremonium* sp.	0.00	0.00	0.00	0.00	4.17
4	*Acremonium strictum*	0.00	4.17	9.09	0.00	12.50
5	*Alternaria alternata*	4.17	0.00	13.63	0.00	8.33
6	*Amauroascus mutates*	0.00	8.33	9.09	8.33	0.00
7	*Aphanoascus fulvescens*	0.00	0.00	0.00	0.00	4.17
8	*Aphanoascus keratinophilus*	4.17	8.33	0.00	0.00	0.00
9	*Aphanoascus terreus*	4.17	0.00	0.00	0.00	4.17
10	*Arthoroderma simii*	0.00	4.17	4.54	0.00	4.17
11	*Aspergillus candidus*	0.00	4.17	0.00	0.00	0.00
12	*Aspergillus fumigates*	0.00	0.00	0.00	0.00	4.17
13	*Aspergillus sparsus*	12.50	0.00	0.00	0.00	0.00
14	*Aspergillus sydowii*	4.17	0.00	0.00	0.00	0.00
15	*Aspergillus terreus*	4.17	0.00	0.00	0.00	0.00
16	*Aspergillus ustus*	0.00	4.17	4.54	0.00	0.00
17	*Auxarthron conjugatum*	8.33	4.17	0.00	0.00	0.00
18	*Cheatomium globosum*	0.00	0.00	0.00	0.00	4.17
19	*Chrysosporium indicum*	20.83	20.83	9.09	29.16	12.50
20	*Chrysosporium keratinophilum*	0.00	4.17	4.54	8.33	0.00
21	*Chrysosporium merdarium*	0.00	0.00	9.09	4.17	0.00
22	*Chrysosporium pannicola*	0.00	4.17	4.54	0.00	4.17
23	*Chrysosporium queenslandicum*	12.50	0.00	0.00	0.00	0.00
24	*Chrysosporium* sp.1	0.00	0.00	0.00	0.00	0.00
25	*Chrysosporium* sp. 2	4.17	0.00	0.00	4.17	0.00
26	*Chrysosporium sulphureum*	4.17	0.00	0.00	0.00	0.00
27	*Chrysosporium tropicum*	4.17	8.33	9.09	16.67	16.67
28	*Chrysosporium zonatum*	8.33	0.00	0.00	0.00	0.00
29	*Ctenomyces serratus*	0.00	0.00	4.54	0.00	12.50
30	*Curvularia geniculata*	0.00	0.00	9.09	4.17	0.00
31	*Curvularia lunata*	4.17	0.00	0.00	0.00	0.00
32	*Epidermophyton* sp.	4.17	0.00	4.54	4.17	12.50
33	*Eurotium repens*	0.00	0.00	0.00	4.17	0.00
34	*Fusarium proliferatum*	4.17	0.00	9.09	0.00	0.00
35	*Fusarium oxysporum*	4.17	0.00	22.72	0.00	0.00
36	*Geomyces pannorum*	0.00	0.00	9.09	8.33	0.00
37	*Gymnoascus intermedius*	0.00	4.17	0.00	0.00	4.17
38	*Gymnoascus reessii*	0.00	0.00	0.00	12.5	0.00
39	*Humicola griesa*	12.50	12.50	0.00	8.33	4.17
40	*Malbranchea aurantiaca*	0.00	4.17	9.09	0.00	0.00
41	*Malbranchea chrysosporoidea*	0.00	0.00	4.54	0.00	0.00
42	*Malbranchea flava*	4.17	0.00	9.09	0.00	0.00
43	*Malbranchea gypsea*	4.17	0.00	0.00	0.00	0.00
44	*Malbranchea pulchella*	12.50	0.00	9.09	4.17	4.17
45	*Malbranchea* sp.	4.17	0.00	0.00	0.00	0.00
46	*Microsporum canis*	0.00	12.50	0.00	4.17	8.33
47	*Microsporum cookie*	0.00	0.00	0.00	4.17	0.00
48	*Microsporum equinum*	0.00	0.00	9.09	0.00	0.00
49	*Microsporum fulvum*	0.00	4.17	4.54	0.00	4.17
50	*Microsporum gypseum*	4.17	12.50	0.00	12.50	0.00
51	*Microsporum nanum*	4.17	8.33	0.00	0.00	0.00
52	*Microsporum vanbreuseghemii*	0.00	0.00	0.00	4.17	0.00
53	*Mucor* sp.	4.17	0.00	0.00	0.00	4.17
54	*Myceliophthora fergusii*	0.00	4.17	0.00	0.00	0.00
55	*Myceliophthora vellerea*	0.00	0.00	0.00	8.33	0.00
56	*Paecilomyces javanicus*	0.00	8.33	13.63	8.33	0.00
57	*Paecilomyces crustaceous*	0.00	8.33	0.00	0.00	0.00
58	*Paecilomyces fusisporus*	4.17	0.00	0.00	0.00	0.00
59	*Paecilomyces* sp.	0.00	4.17	0.00	0.00	0.00
60	*Penicillium chrysogenum*	4.17	0.00	0.00	0.00	0.00
61	*Penicillium griseofulvum*	8.33	8.33	0.00	0.00	12.50

62	*Penicillium pusillus*	4.17	0.00	0.00	0.00	0.00
63	*Phoma humicola*	0.00	4.17	0.00	12.5	4.17
64	*Rhizomucor* sp.	0.00	0.00	0.00	0.00	4.17
65	*Rhizopus* sp.	0.00	8.33	0.00	0.00	0.00
66	*Trichoderma viride*	0.00	4.17	0.00	4.17	8.33
67	*Trichophyton ajelloi*	0.00	8.33	0.00	4.17	0.00
68	*Trichophyton mentagrophytes*	4.17	4.17	0.00	12.5	0.00
69	*Trichophyton oryzae*	0.00	8.33	4.54	0.00	0.00
70	*Trichophyton rubrum*	0.00	0.00	4.54	0.00	8.33
71	*Trichophyton simii*	0.00	0.00	4.54	0.00	0.00
72	*Trichophyton terrestre*	4.17	0.00	4.54	0.00	0.00
73	*Verticillium* sp.	0.00	0.00	0.00	4.17	4.17
	Number of species isolated	32	29	28	23	25
	Number of strains	49	48	48	45	42
	L. index	2.04	2.00	2.00	1.87	1.75

Table 4: Frequency of keratinophilic fungi on different keratinous substrates

Sr. No.	Fungus	Keratinous substrates				
		Human hair	Horse hair	Human nail	Horn	Feather
1	*Acremonium kiliense*	6.12	0.00	0.00	0.00	0.00
2	*Acremonium recifei*	0.00	0.00	4.17	0.00	0.00
3	*Acremonium* sp.	0.00	0.00	0.00	0.00	2.38
4	*Acremonium strictum*	0.00	2.08	4.16	0.00	7.14
5	*Alternaria alternata*	2.04	0.0	6.25	0.0	4.76
6	*Amauroascus mutates*	0.00	4.16	4.16	4.25	0.00
7	*Aphanoascus fulvescens*	0.00	0.00	0.00	0.00	2.38
8	*Aphanoascus keratinophilus*	2.04	4.16	0.00	0.00	0.00
9	*Aphanoascus terreus*	2.04	0.00	0.00	0.00	2.38
10	*Arthoroderma simii*	2.04	2.08	0.00	0.00	2.38
11	*Aspergillus candidus*	0.00	2.08	0.00	0.00	0.00
12	*Aspergillus fumigates*	0.00	0.00	0.00	0.00	2.38
13	*Aspergillus sparsus*	6.12	0.00	0.00	0.00	0.00
14	*Aspergillus sydowii*	2.04	0.00	0.00	0.00	0.00
15	*Aspergillus terreus*	2.04	0.00	0.00	0.00	0.00
16	*Aspergillus ustus*	0.00	2.08	2.08	0.00	0.00
17	*Auxarthron conjugatum*	4.76	2.08	0.00	0.00	0.00
18	*Cheatomium globosum*	0.00	0.00	0.00	0.00	2.38
19	*Chrysosporium indicum*	10.20	10.41	4.16	14.89	7.14
20	*Chrysosporium keratinophilum*	2.04	2.08	0.00	4.25	0.00
21	*Chrysosporium merdarium*	0.00	0.00	4.16	2.12	0.00
22	*Chrysosporium pannicola*	0.00	2.08	2.08	0.00	2.38
23	*Chrysosporium queenslandicum*	6.12	0.00	0.00	0.00	0.00
24	*Chrysosporium* sp.1	0.00	2.08	0.00	0.00	0.00
25	*Chrysosporium* sp. 2	2.04	0.00	0.00	2.12	0.00
26	*Chrysosporium sulphureum*	2.04	0.00	0.00	0.00	0.00
27	*Chrysosporium tropicum*	2.04	4.16	4.16	9.52	8.51
28	*Chrysosporium zonatum*	4.76	0.00	0.00	0.00	0.00
29	*Ctenomyces serratus*	0.00	0.00	2.08	0.00	7.14
30	*Curvularia geniculata*	0.00	0.00	4.16	2.12	0.00
31	*Curvularia lunata*	2.04	0.00	0.00	0.00	0.00
32	*Epidermophyton* sp.	2.04	0.00	2.08	2.12	7.14
33	*Eurotium repens*	0.00	0.00	0.00	2.1	0.00
34	*Fusarium proliferatum*	2.04	0.00	4.16	0.00	0.00
35	*Fusarium oxysporum*	2.04	0.00	8.33	0.00	0.00
36	*Geomyces pannorum*	0.00	0.00	4.16	4.25	0.00
37	*Gymnoascus intermedius*	0.00	2.08	0.00	0.00	2.38
38	*Gymnoascus reessii*	0.00	0.00	0.00	6.38	0.00
39	*Humicola griesa*	6.12	6.25	0.00	4.25	2.38
40	*Malbranchea aurantiaca*	0.00	2.08	4.16	0.00	0.00
41	*Malbranchea chrysosporoidea*	0.00	0.00	2.08	0.00	0.00
42	*Malbranchea flava*	2.04	0.00	4.16	0.00	0.00
43	*Malbranchea gypsea*	2.04	0.00	0.00	0.00	0.00
44	*Malbranchea pulchella*	6.12	0.00	4.16	2.12	2.38
45	*Malbranchea* sp.	2.04	0.00	0.00	0.00	0.00
46	*Microsporum canis*	0.00	6.25	0.00	2.12	4.76
47	*Microsporum cookie*	0.00	0.00	0.00	2.12	0.00
48	*Microsporum equinum*	0.00	0.00	4.16	0.00	0.00

49	*Microsporum fulvum*	0.00	2.08	2.08	0.00	2.38
50	*Microsporum gypseum*	2.04	6.25	0.00	6.38	0.00
51	*Microsporum nanum*	2.04	0.00	0.00	0.00	0.00
52	*Microsporum vanbreuseghemii*	0.00	0.00	0.00	2.12	0.00
53	*Mucor* sp.	2.04	0.00	0.00	0.00	2.38
54	*Myceliophthora fergusii*	0.00	2.38	0.00	0.00	0.00
55	*Myceliophthora vellerea*	0.00	0.00	0.00	4.25	0.00
56	*Paecilomyces javanicus*	0.00	4.16	6.25	4.25	0.00
57	*Paecilomyces crustaceous*	0.00	4.16	0.00	0.00	0.00
58	*Paecilomyces fusisporus*	2.04	0.00	0.00	0.00	0.00
59	*Paecilomyces* sp.	0.00	2.08	0.00	0.00	0.00
60	*Penicillium chrysogenum*	2.04	0.00	0.00	0.00	0.00
61	*Penicillium griseofulvum*	4.08	4.16	0.00	0.00	7.14
62	*Penicillium pusillus*	2.04	0.00	0.00	0.00	0.00
63	*Phoma humicola*	0.00	2.08	0.00	6.38	2.38
64	*Rhizomucor* sp.	0.00	0.00	0.00	0.00	2.38
65	*Rhizopus* sp.	0.00	4.16	0.00	0.00	0.00
66	*Trichoderma viride*	0.00	2.08	0.00	2.12	4.76
67	*Trichophyton ajelloi*	0.00	4.16	0.00	2.12	0.00
68	*Trichophyton mentagrophytes*	2.04	2.08	0.00	6.38	0.00
69	*Trichophyton oryzae*	0.00	4.16	2.08	0.00	0.00
70	*Trichophyton rubrum*	0.00	0.00	2.08	0.00	4.76
71	*Trichophyton simii*	0.00	0.00	2.08	0.00	0.00
72	*Trichophyton terrestre*	2.04	0.00	2.08	0.00	0.00
73	*Verticillium* sp.	0.00	0.00	0.00	2.12	2.38

The distribution of keratinophilic fungi on keratinous substrates is because of the specific utilization of the substrate. Some genera of keratinophilic fungi showed only colonization of keratinous substrates due to their utilization of no keratinous substances present in the hair [27]. [28] found that keratinophilic fungi differ in their substrate preference for colonization. Capability to colonize hard keratin such as hooves, horns, and nails has been evidenced by [29]. During this study percent distribution of *Chrysosporium tropicum* was observed (16.67) on horn, (16.67) feather (8.33) human nail, (8.33) cattle hair, and (4.17) human hair. *Chrysosporium tropicum* was isolated from nails [29]. Later [30]observed during decomposition of wool in soil. Colonization and degradation of hair, nail, horn, feather and wool by *Microsporum* has been reported by [31-32]. *Trichophyton* occurred on all keratinous baits. These fungi can grow on keratin substrates such as wool, feathers, nails, human, animal hairs, and produce specific enzymes whose secretion appears to be induced by the presence of keratin in the substrate [33-34]. The potential of keratinophilic fungi to degrade human hair has been well known [35-36]. [37] reported that colonization of keratin baits by keratinophilic fungi may be due to their preferential nutritional requirements, availability of exposed surface of substrates to them and physical nature of the substrate. Presence of oil and fats in combination with keratin protein also determine the colonization of keratin substrates qualitatively and quantitatively [38]. Feathers have some easily assimilated compounds other than keratin [39]. [29, 40] reported substrate specificity that may be a result of the metabolic capacities of a fungus attributed to its specific enzymatic system or physical and chemical nature of keratin as it exists in several chemical forms. Keratin substances in the feathers of birds and hair of animals are known to be different in their biochemical composition e.g., content of nicotinic acid, cystine, arginine, and tryptophan [41]. Different fungi require different time for their appearance on keratinous baits[42]. Since the keratinophilic fungi mainly survive in soil and being final colonizers of keratinous substrates, there might be the possibility of interactions among themselves and other fungi. Hair baits contained a total of 66 species from 17 genera in the Onygenales order. Eleven taxa were discovered to be novel to science, the majority of which were uncommon because they were only found in one sample out of over 500 [43].

Conclusion

Present study indicates that keratinophilic fungi exist in our neighborhood habitats and occupy all kind of keratinous materials. *Chrysosporium*, *Microsporum*, *Trichophyton* genera occurs on all keratinous material. These fungi may be a major threat to human and animal health issue if keratinous waste materials not managed properly. Proper management of keratinous solid waste not only reduce the risk of dermatophytosis but also give valuable byproducts in the form of keratinase, amino acids, biofertilizers etc.

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