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Ubiquinones as generic criteria in Eumycota

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Ubiquinone (= coenzyme Q) is an enzyme of the respiratory chain. It is nearly ubiquistically distributed in Procaryota and in Eumycota. In fungi, it occurs in 9 alternative types, distinguished by the configuration of the isoprenoid side chain: there may be 5 to 10 isoprene units, and one or two terminal units may be hydrogenated or not. The resulting types are called

ubiquinone Q-5, Q-6, Q-7, Q-8, Q-9, Q-10 and
ubiquinone Q-9(H_2), Q-10(H_2), Q-10(H_4).

In Q-10(H_2) two isomeres are possible, but they are indistinguishable in current analyses. The analysis of ubiquinone type is possible either by paper chromatography or by HPLC.

Several ubiquinone types may be demonstrated in the same organism. In such cases nearly always one of them (the "major ubiquinone") is prevalent by far. In rare cases two major ubiquinones are present in relations 1:1 or 2:1. Only the major ubiquinones seem to be of taxonomic relevance, while the "minor ubiquinones" can be understood as intermediates of current biosynthesis.

In recent years, the analysis of ubiquinone types has been shown to be of great taxonomic interest, beginning with a series of papers on yeast taxonomy (Yamada & Kondo 1971 ff.). It could be demonstrated that

— different strains of the same species have the same ubiquinone type, even if analyzed by different students and on different continents;

— anamorphic and teleomorphic states of the same species have the same ubiquinone type;

— closely related species have the same ubiquinone type;

— ubiquinones may be extracted from mycelial and yeast cultures, from fresh fruitbodies, and from exsiccata.

The most generally distributed type of ubiquinone is Q-9, which occurs in all investigated classes of fungi sensu lato (fig. 1); in several classes or subclasses of fungi it is the only type demonstrated as yet. The "shorter" ubiquinones Q-5, Q-6, Q-7, and Q-8 have been found only in yeasts and yeast-like (dimorphic) fungi. The hydrogenated types have been found only in Ascomycetes and in a few cases in Ustomycetes.

Ubiquinones in Fungi

Acrasiomycetes					9			
Oomycetes					9			
Zygomycetes					9			
Endomycetes	5	6	7	8	9	10		
Ascomycetes				8	9	10	$10(H_2)$	$10(H_4)$
Teliomycetes					9			
Ustomycetes				8	9	10	$10(H_2)$	
Basidiomycetes								
— Heterobasidiomycetidae			8	9	10			
— Hymenomycetidae					9			
— Gasteromycetidae					9			

Figure 1: Distribution of major ubiquinones in the classes of Fungi

In many cases ubiquinone types may serve as generic criteria. During the past 20 years nearly all cultivated species of yeasts and many yeast-like fungi have been analyzed - mainly by Japanes researchers -, and this has lead to a splitting of teleomorphic and anamorphic genera (table 1). With exception of the large artificial genus *Candida* and the so-called "black yeasts", the yeast genera in their actually accepted concepts are "ubiquinone-clean", as demonstrated in the proposed system of Von Arx & Van der Walt (1987); cf. Kreisel (1991) and tables 2 and 3.

In filamentous fungi - that is the great majority of fungi - the distribution of ubiquinones is often more complicated, particularly in many groups of Ascomycetes and related anamorphs. Their systematic analysis began only rather recently with a paper by Kuraishi et al. (1985). These authors demonstrated that several major genera of anamorphs are heterogeneous with regard to ubiquinone type, e.g. *Aspergillus, Paecilomyces,* and *Penicillium.* The same was found in *Sporothrix* by Suzuki & Nakase (1985) and in *Trichosporon* (Hara et al. 1989).

In *Sporothrix,* several researchers demonstrated that ubiquinone types could be correlated with cell wall carbohydrate patterns, with shape of septal pores and (if present) with the teleomorphs. That way it became evident that *Sporothrix* is a very heterogeneous anamorphic genus which includes anamorphs of *Endomycetes, Ascomycetes,* and *Basidiomycetes* (table 4; De Hoog et al. 1985, Wejman & De Hoog 1985, Smith & Batenburg-Van Der Vegte 1986, Suzuki & Nakase 1986, Traquair et al. 1989). The type species, *S. schenckii,* is ascomycetous and belongs to the teleomorphic genus *Ophiostoma* (De Hoog 1974).

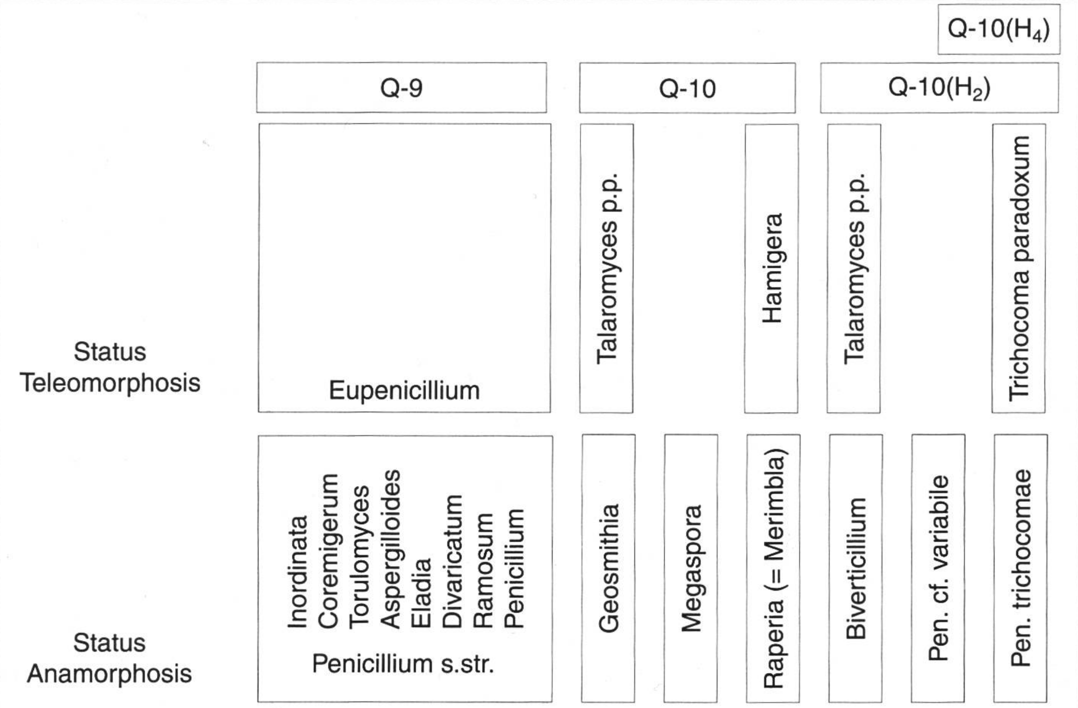

Figure 2: Distribution of major ubiquinones in the sections and segregates of *Penicillium* and the corresponding teleomorphs (Kuraishi et al. 1985, Schubert & Kreisel 1991)

A larger number of *Penicillium* species have been analyzed by Kreisel & Schubert (1990) and Schubert & Kreisel (1991 and unpublished data). *Penicillium* has two rather different teleomorphs, namely *Eupenicillium* and *Talaromyces*. We have demonstrated that all investigated species of *Eupenicillium* and of ralated *Penicillium* anamorphs have Q-9, while *Talaromyces* and related *Penicillium* anamorphs - corresponding to *Penicillium* sect. *Biverticillium* in the system of Stolk & Samson 1985 - have Q-10(H_2), a differentiation which is clearly supported by the deviating shape of phialides and morphology of conidiophores (see also Pitt 1979a).

Penicillium sect. *Geosmithia*, already segregated by Pitt(1979b) as a genus for its own, based on the shape of phialides and of conidia, has ubiquinone Q-10 supporting its generic independence. The same holds for the small segregated genus *Raperia* with its teleomorph *Hamigera*, which equally is characterized by ubiquinone Q-10 (fig. 2).

Aspergillus is an anamorphic genus, actually articulated in 18 sections (Gams et al. 1985), and correlated with no less than 10 genera of teleomorphs.

Table 1: YEAST GENERA segregated by means of ubiquinone types

1984	*Fellomyces* Yamada & Banno	Q-10	heterob.
	Sterigmatomyces Fell 1966	Q-9	heterob.
1985	*Waltomyces* Yamada & Nakase	Q-10	ascogen.
	Lipomyces Lodder & Kreger-van Rij 1952	Q-9	ascogen.
1986	*Holleya* Yamada	Q-9	ascogen.
	Nematospora Peglion 1897	Q-5, Q-6	ascogen.
1986	*Bensingtonia* Ingold	Q-9	(heterob.)
	Sporobolomyces Kluyver & van Niel 1924	Q-10	(heterob.)
	Bullera Derx 1930	Q-10	(heterob.)
1987	*Hasegawaea* Yamada & Banno	none	ascogen.
	Schizosaccharomyces Lindnere 1893	Q-10	ascogen.
	Octosporomyces Kudrjawzew 1960	Q-9	ascogen.
1987	*Saitoella* Goto & al.	Q-10	(ascogen.)
	Rhodotorula Harrison 1927	Q-9	(heterob.)
1987	*Mrakia* Yamada & Komagata	Q-8	heterob.
	Leucosporidium Fell & al. 1970	Q-9	heterob.
1988	*Erythrobasidium* Hamamoto & al.	Q-10(H2)	heterob.
	Rhodosporidium Banno 1967	Q-9	heterob.

Table 2: Ubiquinones of the Sporobolomycetaceae

Bensingtonia Ingold 1986	Anam. = *B. ciliata*	Q-9
Bullera Derx 1930	Anam. = *B. alba*	Q-10
Sporobolomyces Kluyver & van Niel 1924	Anam. = *S. roseus*	Q-10
Sporobolomyces p.p.	Anam. = *S. elongatus*	Q-10(H2)
Sporidiobolus Nyland 1949	Telem. = *S. johnsonii*	Q-10

Ref.: Nakase & Suzuki 1986, Nakase & Boekhout 1988

Table 3: Ubiquinones of the Filobasidiaceae

Filobasidiella neoformans Kwon-Chung (type)	Q-10
Filobasidium capsuligerum (Fell. & al.) Rodr. de Miranda	Q-10
Filobasidium floriforme Olive	Q-10
Filobasidium uniguttulatum Kwon-Chung	Q-9
Cystofilobasidium bisporidiis (Fell. & al.) Oberw.	Q-8
Cystofilobasidium capitatum Oberw. & Bandoni	Q-8
Cystofilobasidium infirmominiatum (Fell & al.) Hamamoto & al.	Q-8

Ubiquinones Q-9, Q-10 and Q-10(H_2) are the major ubiquinones found in *Aspergillus*. Kuraishi et al. (1990) investigated the distribution of ubiquinone types in the infrageneric units as established in the systems of Raper & Fennell (1965) and Gams et al. (1985). In both *Aspergillus* systems, not all of the

Table 4: *Sporothrix*

Sporothrix	sectio	group	carbohydrate pattern	septal pores	ubiquinone	teleomorph tax. position
catenata *foliorum* *fungorum* *guttuliformis*	Farinosa	A	Glu Man Gal	micropores simple or multiple	Q-9	*Stephanoascus* (Endomyc.)
ghanensis *insectorum* *ranii* *sclerotialis*	Farinosa	A	Glu Man Gal	simple with Woronin body	Q-10(H2)	unknown (Ascomyc.)
curviconis *inflata* *schenkii* TYPE	Sporothrix	B	Glu Man Gal Rha	simple with Woronin body	Q-10(H2)	*Ophiostoma* (Ascomyc.)
luteoalba *cyanescens*	Luteoalba	C	Glu Man Gal Xyl	dolipores	Q-10	unknown (Dacrymyc.)
Ref.:	1	2	2	3	4	various

1: Kreger van Rij 1984
2: Weijman & De Hoog 1985
3: Smith & Batenburg 1986
4: Suzuki & Nakase 1986

Table 5: *Aspergillus* - anamorphic species

	Q-9	Q-10	Q-10(H2)
Metulae absent (uniseriate):			
	1 Aspergillus	3 Fumigati	
	5 Restricti	3 Clavati	
	3 Cervini		(1 Cervini)
	1 Ornati	(1 Ornati)	(3 Ornati)
	<——— (1 Clavati) ———>		
Metulae present or absent (uni- /biseriate):			
	21 Nigri	(2 Flavi)	8 Flavi
	1 Cremei		1 Candidi
	2 Wentii		(3 Wentii)
	(1 Circumdati)	(2 Circumdati)	14 Circumdati
	(1 Sparsi)		4 Sparsi
Metulae present (biseriate):			1 Nidulantes
			9 Versicolores
			3 Usti
			3 Terrei
			3 Flavipedes

Reference: Kuraishi et al. 1990
( ) = type excluded
numbers = taxa investigated

Table 6: *Aspergillus* - holomorphic species

	Q-9	Q-10	Q-10(H2)
Metulae absent (uniseriate):	13 *Eurotium* Link:Fr. (Aspergillus)	9 *Neosartorya* Malloch & Cain (Fumigati)	
	1 *Edyuillia* Subram. (Aspergillus)	2 *Hemicarpenteles* Sarbhoy & E. (Ornati)	
	2 *Sclerocleista* Subram. (Ornati)	1 *Warcupiella* Subram. (Ornati)	
Metulae present or absent (uni- /biseriate):	4 *Chaetosartorya* Subram. (Cremei)	1 *Petromyces* Malloch & Cain (Circumdati)	
Metulae present (biseriate):			2 *Fennellia* Wiley & Si. (Flavipedes)
		<———————————	24 *Emericiella* Berk. & Br. (Nidulantes)

Reference: Kuraishi & al. 1990 numbers = taxa investigated

accepted sections are "ubiquinone-clean": in the system of Gams et al. four of the 18 sections appear to be heterogeneous, namely Sparsi, Circumdati, Wentii and Ornati, because 14 of the anamorphic taxa seem to be placed in a "wrong" section (table 5), but the 10 teleomorphs are "clean" (table 6). Moreover, it reveals that all sections and teleomorphs with constant metulae (i.e. the strictly biseriates) do have Q-10(H_2), although many Nidulantes resp. *Emericella* additionally have Q-10.

A serious problem still exists in *Trichosporon*, where even in the type species (*T. beigelii* = *T. cutaneum*) three different ubiquinones have been found in different strains (Yamada et al. 1982, Hara et al. 1989):

Q-10 in 14 strains, including the type strain, Q-9 in 29 strains, Q-8 in 1 strain, while 7 other investigated *Trichosporon* strains all have Q-9. On the other hand, there are large groups of fungi which seem to be quite uniform with regard to ubiquinone type. In Ascomycetes, e. g. all investigated taxa of Hypocreales, Clavicipitales, and Dothideales s. l. (i. e. the bitunicate Ascomycetes) and all their related anamorphs have ubiquinone Q-10(H_2) (Kuraishi et al. 1985). In Teliomycetes (Pucciniales) all investigated taxa have Q-9 (Sugiyama et al. 1988), and in Basidiomycetes all investigated Homobasidiomycetes (Hymenomycetidae and Gasteromycetidae) have Q-9 (Kuraishi et al. 1985, and our own results). That seems to be not promising for further attempts of ubiquinone chemotaxonomy in larger fungi. But facing the huge number of species still to be analyzed, surprising results cannot be excluded, and in some future ubiquinone analysis may also become interesting in the taxonomy of macromycetes.

References

v.Arx, J. A. & Van Der Walt, J. P. 1987. Ophiostomatales and Endomycetales. Studies in Mycology, Baarn, 30: 167 - 176.

Gams, W., Christensen, M., Onions A. H., Pitt, J. I. & Samson, R. A. 1985. Infrageneric taxa of *Aspergillus*. In: Samson, R.A. Pitt J. I. (eds.): Advances in *Penicillium* and *Aspergillus* systematics, pp. 55 - 62.

Hamamoto, M., Sugiyama & Komagata, K. 1988. Transfer of *Rhodosporidium infirmominiatum* to the genus *Cystofilobasidium* as *Cystofilobasidium infirmominiatum* comb. nov. J. Gen. Appl. Microbiol. 34: 271 - 278.

Hara, N., Tubota, Y., Saito, K. & Suto, T. 1989. Biochemical characteristics and ubiquinones of 44 strains of *Trichosporon beigelii* and related organisms. J. Gen. Appl. Microbiol. 35: 1 - 10.

De Hoog, G. S. 1974. The genera *Blastobotrys*, *Sporothrix*, *Calcarisporium* and *Calcarisporiella* gen. nov. Studies in Mycology 7: 1 - 84.

De Hoog, G. S., Rantio-Lehtimäkil, A. H. & Simith, M. T. 1985. *Blastobotrys*, *Sporothrix* and *Trichosporiella*: generic delimitation, new species, and a *Stephanoascus* teleomorph. Antonie van Leeuwenhoek 51: 79 - 109.

Kreisel, H. 1991. Neoteny in the phylogeny of Eumycota. In: Hawksworth, D.L. (ed.), Frontiers in Mycology, pp. 69 - 83. Kew.

Kreisel, H. & Schubert, M. 1990. Ubichinone in einigen filamentösen Pilzen. Zentralbl. Mikrobiol. 145: 91 - 94.

Kuraishi, H., Katayamata-Fujimura, Y., Sugiyama J. & Yokoyama, T. 1985. Ubiquinone systems in fungi. I. Distribution of ubiquinones in the major families of ascomycetes, basidiomycetes, and deuteromycetes, and their taxonomic implications. Trans. Myc. Soc. Japan 26: 383 - 396.

Kuraishi, H., Itoh, M., TsuzakiI, N., Katayama, Y., Yokoyama,T. & Sugiyama, J. 1990. The ubiquinone system as a taxonomic aid in *Aspergillus* and its teleomorphs. In: Samson, R. A. & Pitt, J. I. (eds.):, Modern Concepts in *Penicillium* and *Aspergillus* Classification, pp. 407 - 421. New York.

Kwon-Chung, K. J. 1987. Filobasidiaceae - a taxonomic survey. Studies in Mycology 30: 75 - 85.

Pitt J. I. 1979a. The genus *Penicillium* and its teleomorphic states *Eupenicillium* and *Talaromyces*. 634 pp. London etc.

Pitt, J. I. 1979b. *Geosmithia* gen. nov. for *Penicillium lavendulum* and related species. Can. J. Bot. 57: 2021 - 2030.

Raper, K. B. & Fennel, L, D. I. 1965. The genus *Aspergillus*. 686 pp. Baltimore.

Schubert, M., & Kreisel, H. 1991. Ubiquinones in selected species of *Penicillium* and related teleomorph genera. Persoonia 14: 341 - 346.

Smith, M. TH. & Batenburg-Van Der Vegte, W. H. 1986. Additional information on the ultrastructure in the genus *Sporothrix*. J. Gen. Appl. Microbiol. 32: 549 - 552.

Sugiyama, J., NagaiI, K. & Komagata, K. 1987. Ubiquinone systems in strains of species in the black yeast genera *Phaeococcomyces*, *Exophiala*, *Hortaea*, and *Rhinocladiella*. J. Gen. Appl. Microbiol 33: 197 - 204.

Sugiyama, J., Itoh, M., Katayama,Y., YamaokoY., Ando, K., Kakishima, M. & Kuraishi, J. 1988. Ubiquinone systems in fungi II. Distribution of ubiquinones in smut and rust fungi. Mycologia 80: 115-120.

Suzuki, M. & Nakase, T. 1986. Heterogeneity of ubiquinone systems in the genus *Sporothrix*. J. Gen. Appl. Microbiol. 32: 165-168.

Traquair, J. A., Shaw, L. A. & Jarvis, W. R. 1988. *Stephanoascus farinosus*, teleomorph of *Sporothrix fungorum*. Mycologia 80: 244 - 246.

Weijman A. C. M. & DE Hoog, G. S. 1985. Carbohydrate patterns of *Sporothrix* and *Blastobotrys*. Antonie van Leeuwenhoek 51: 111 - 120.

Yamada, Y. & Kondo, K. 1971. Taxonomic significance of coenzyme Q system in yeasts and yeast-like fungi (1). Proc. 1st Int. Symposium Yeasts, Smolenice, pp. 363 - 373.

Yamada, Y. & Kondo, K:. 1972a. Taxonomic signifinance of coenzyme Q system in yeasts and yeast-like fungi (2). Proc. 4th Int. Ferment. Symposium, Kyoto, pp. 781 - 784.

Yamada, Y. & Kondo, K. 1972b. Taxonomic significance of coenzyme Q system in yeasts and yeast-like fungi (3). Proc. 2nd Int. Spec. Symposium Yeasts, Tokyo, pp. 63 - 69.

Yamada, Y. & Banno, I., v. Arx, J. A., Van der Walt, J. P. 1987. Taxonomic significance of the coenzyme Q system in yeasts and yeast-like fungi. Studies in Mycology 30: 299 - 308.

Yamada, Y., Nakazawe, E. & Kondo, K. 1982. The coenzyme Q system in strains of *Trichosporon* species and related organisms. J. Gen. Appl. Microbiol. 28: 355 - 358.