ESSENTIAL OILS – SOURCE OF USEFUL PRESERVATIVES ?

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INTRODUCTION

Essential oils and preservatives are used both in many products to be intended for human utilization, e.g. food, cosmetics, medicinal preparations, technical products. The antimicrobial properties of preservatives are essentially for the stabilization of such products, and therefore, a comparison of antimicrobial properties of compounds occurring in essential oils with preservatives is near by hand.

METHOD

Antimicrobial data of essential oil components and preservatives were collected from literature in a common database (1). To enable a comparison of data their outlining parameters were generally standardized, such as inhibitory data (all concentrations given in ppm), compound names and compound types [mono-, sesqui-, diterpenoids, aromatic and aliphatic substances], microorganism names and microorganism types [gram-negative (Bac-), gram-positive bacteria (Bac+), fungi and yeast].

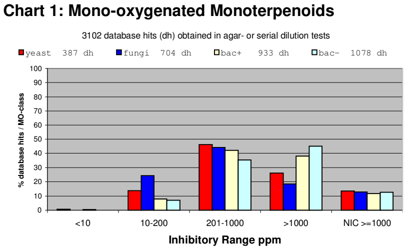
Sub-classification was done if necessary, e.g. mono-oxygenated mono- and mono-oxygenated sesquiterpenoids. Among different types of inhibitory data only MIC- (minimal inhibitory concentration) and MMC- data (minimal microbicidal concentration) were selected, which are results of agar dilution (ADIT) or serial dilution tests (SDT).

For comparison of inhibitory data, the inhibitory concentrations of selected compound groups or individual compounds were divided in 5 sections. The section 10-200 ppm represents the amount of butylated hydroxy anisole (BHA) and butylated hydroxy toluene (BHT) allowed to be added to food and the section 201-1000 ppm represents the amount propylparaben tolerated in food in the United States (2). Results of tests without inhibition are listed among NIC (= non-inhibitory concentration).

RESULTS

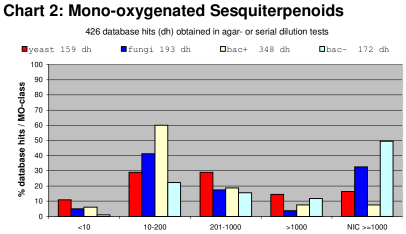
The inhibitory properties of different compound classes or individual compounds towards different types of microorganisms are shown in the charts 1 to 8.

Chart 1: Mono-oxygenated Monoterpenoids



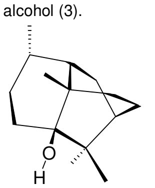
Mono-oxygenated monoterpenoids exhibit antimicrobial effects against all microorganism types examined, however, most of such compounds are not active at low concentrations.

Chart 2: Mono-oxygenated Sesquiterpenoids



Mono-oxygenated sesquiterpenoids are strong inhibitors of gram-positive bacteria, yeast and some fungi, while gram-negative bacteria are more resistant.

One example of a selected compound of this group is given in Table 1, which schedules the inhibitory data of patchouli alcohol (3).

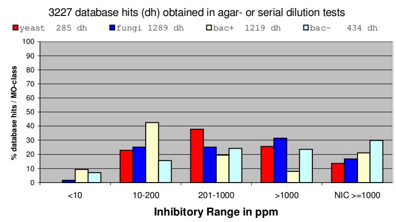


Unlike other sesquiterpene alcohols, this compound was very active against gram-negative bacteria. Interestingly, results obtained with two *Eikenella corrodens* strains are contradictory.

Table 1: Inhibitory Data of Patchouli Alcohol (in ppm)

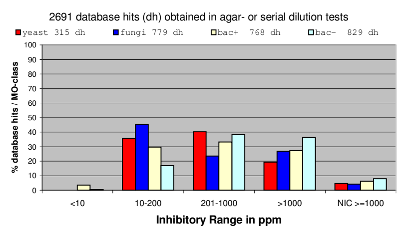
Type	Microorganism Strain	MIC	NIC
Bac-	Prevotella melaninogenica ATCC 25845	39	
Bac-	Prevotella intermedia ATCC 33563	78	
Bac-	Eikenella corrodens FDC 375	78	
Bac-	Prevotella denticola ATCC 33185	78	
Bac-	Prevotella intermedia ATCC 25611	78	
Bac-	Porphyromonas gingivalis FDC 381	78	
Bac+	Streptococcus sanguinis ATCC 10558	156	
Bac+	Actinomyces viscosus ATCC 15987	156	
Bac+	Propionibacterium acnes ATCC 11827	156	
Bac+	Streptococcus mutans Ingbritt	156	
Bac+	Streptococcus mutans JC-2	156	
Bac+	Streptococcus salivarius ATCC 9759	156	
Bac-	Fusobacterium nucleatum ATCC 25586	156	
Bac+	Streptococcus pyogenes ATCC 10398	313	
Bac-	Capnocytophaga ochracea ATCC 33596	313	
Bac-	Capnocytophaga sputigena ATCC 33624	313	
Bac-	Porphyromonas gingivalis ATCC 33277	313	
Bac+	Actinomyces naeslundii ATCC 12104	313	
Bac+	Actinomyces israelii ATCC 12102	313	
Bac-	Actinobacillus actinomycetemcomitans Y4	1250	
Bac+	Streptococcus pyogenes ADP	1250	
Bac-	Actinobacillus actinomycetemcomitans I		2500
Bac-	Actinobacillus actinomycetemcomitans II		2500
Bac+	Actinomyces viscosus T14V		2500
Bac-	Eikenella corrodens FDC 1073		2500

Chart 3: Fatty Acids

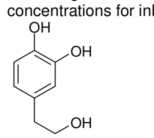


Among fatty acids a greater number of tests resulted in strong inhibition of gram-positive bacteria. Gram-negative bacteria are more resistant than other microorganism types tested.

Chart 4: Phenols (others than in charts 5 to 8)



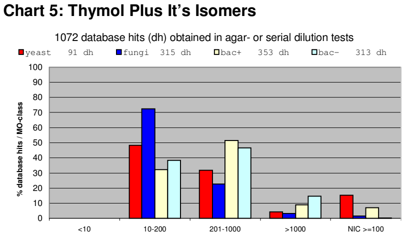
Phenols cause growth inhibition of all microorganism types. Gram-negative bacteria require somewhat higher compound concentrations for inhibition than other microorganisms.



4-(2-Hydroxy-ethyl)-benzene-1,2-diol

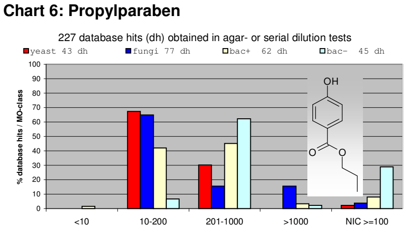
One very active example of this group is 4-(2-hydroxy-ethyl)-benzene-1,2-diol (4). This compound inhibited growth of the gram-negative bacterium *Shigella flexneri* (MIC = 6,25 ppm) in the serial dilution test, however, it is untested against other microorganism.

Chart 5: Thymol Plus It's Isomers



Thymol plus it's isomers inhibits almost all microorganisms below 1000 ppm. Especially, fungi (dermatophytes, *Aspergillus* sp.) and yeast (*Candida albicans*) are very sensitive.

Chart 6: Propylparaben

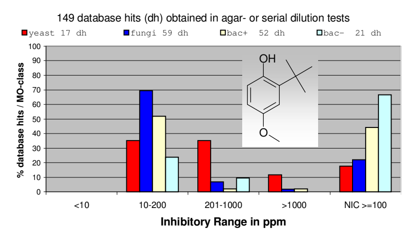


Propylparaben has a strong inhibitory activity towards fungi and yeast. Among bacteria especially such of gram-negative type require high compound concentrations for growth inhibition (Table 2).

Table 2: Inhibition of Gram-Negative Bacteria by Propylparaben

Microorganism Strain	Method	MIC	MMC	NIC	Ref-Nr
Achromobacter sp.	SDT	<100-<1000			6
Alcaligenes faecalis	ADIT	400			7
Alcaligenes faecalis B170	ADIT	400			8
Alcaligenes viscolactis	SDT			600	9
Enterobacter aerogenes ATCC 13048	SDT			250	10
Eschericia coli 500009	SDT		180		11
Eschericia coli	SDT		360		5
Eschericia coli ATCC 9637	ADIT	1000			12
Eschericia coli DC2 (envelope mutant)	ADIT	200			13
Eschericia coli	SDT	300-1000			6
Eschericia coli	ADIT	400			7
Eschericia coli ML30	ADIT	400			8
Eschericia coli ATCC 9637	SDT	420			14
Eschericia coli DCO	ADIT	450			13
Klebsiella pneumoniae ATCC 8308	ADIT	1000			12
Klebsiella pneumoniae ATCC 10031	ADIT	250			12
Klebsiella pneumoniae	SDT	300-1000			6
Proteus vulgaris	SDT	<400-1000			6
Proteus vulgaris ATCC 8427	ADIT	500			12
Pseudomonas aeruginosa 799	ADIT			400	13
Pseudomonas aeruginosa 799/69	ADIT			400	13
Pseudomonas aeruginosa 111	ADIT			500	8
Pseudomonas aeruginosa ATCC 9027	ADIT			2000	12
Pseudomonas aeruginosa	SDT		600		5
Pseudomonas aeruginosa	SDT	<400-<1000			6
Pseudomonas aeruginosa	SDT	400			5
Pseudomonas aeruginosa	SDT	5000			6
Pseudomonas effusa	SDT	<400-<1000			6
Pseudomonas fluorescens	SDT			250	15
Pseudomonas fluorescens	SDT			250	10
Pseudomonas fluorescens ATCC 9721	ADIT			2000	12
Pseudomonas fluorescens	SDT	<400-<1000			6
Pseudomonas fragi (resistant isolate)	SDT			600	16
Pseudomonas fragi	SDT		600		16
Pseudomonas putida	SDT	<400-<1000			6
Salmonella paratyphi	SDT	330-700			6
Salmonella paratyphi B	SDT	330-700			6
Salmonella paratyphi B	ADIT	500			12
Salmonella typhi	SDT	330-700			6
Salmonella typhi	ADIT	417			17
Salmonella typhi	ADIT	1000			12
Salmonella typhimurium 3-4	SDT			300	18
Salmonella typhimurium Tm1	ADIT			500	8
Serratia marcescens	ADIT			500	8

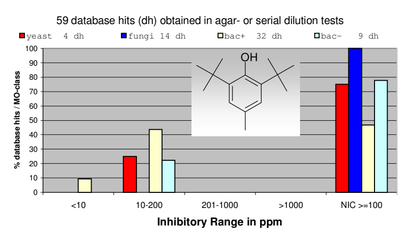
Chart 7: BHA



BHA strongly inhibits growth of fungi, gram-positive bacteria and some yeast. It was inactive against gram-negative bacteria in many tests.

Chart 8: BHT

The few inhibitory data of BHT indicate a failure of antifungal activity. Also other microorganisms are not strongly inhibited, exceptionally some gram-positive bacteria.



SUMMARY

The inhibition of microorganisms by selected compound groups or individual compounds below 201 ppm are compared below:

	Bac-	Bac+	Fungi	Yeast	dh <201 ppm
1. O_1-Monoterpenes	+	+	++	++	377
2. O_1-Sesquiterpenes	++	++++	+++	+++	214
3. Fatty acids	++	++++	+++	++	1136
4. Phenols (not 5-8)	++	+++	+++	+++	866
5. Thymol + isomers	+++	+++	++++	+++	506
6. Propylparaben	+	+++	++++	++++	109
7. BHA	++	++++	++++	+++	79
8. BHT	++	++++	—	++	20

— = no, + = very weak, ++ = weak, +++ moderate, ++++ strong inhibitory activity

The results indicate that compounds of the groups mono-oxygenated sesquiterpenoids, phenols, thymol plus it's isomers and fatty acids exhibit similar antimicrobial activity as selected preservatives. A greater number of resistant species exists towards all selected groups of compounds or individual compounds among gram-negative bacteria.

DISCUSSION

Although compounds occurring in essential oils are capable to produce similar antimicrobial effects as selected preservatives, the usability of essential oil compounds as preservatives in industrial products, however, depends on additional factors, such as taste, odor, stability or physical properties.

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