

A survey of warning colours of pesticides

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Abstract Pesticides are used to protect plants all over the world. Their increasing specificity has been due to utilization of differences in biochemical processes, and has been accompanied by lower human toxicity. Nevertheless cases of poisoning are still observed. While certain toxic substances are provided with characteristic dyes or pigments to facilitate easy identification, no overview of pesticide colors exists. The lack of available product information prompted us to explore the colors and dyes of pesticides registered in Germany, most of which are commercially available worldwide. A compilation of the colors and odors of 207 pesticide products is presented. While some of the substances can be identified by their physical characteristics, in other cases, the range of possibilities can be narrowed by their nature and color.

Keywords Forensic science · Pesticides · Warning colors · Dyes · Odor · Poisoning

Introduction

Pesticides are used all over the world, in large agricultural centers as well as in private households. They are easily available and procurable. Plant protecting products are defined by the US Environmental Protection Agency as agents that protect plants and plant products against animals, plants and micro-organisms (<http://www.epa.gov/>

pesticides). In a broader sense, substances that kill plants, regulate growth or inhibit germination are also counted among plant protecting agents.

The risk of human toxicity and the resulting forensic interest in these substances is especially related to agents used against animals. Agents used against other pests make use of the differences in metabolic pathways between humans and non-mammals resulting in a lower human toxicity [1].

Schmoldt divided insecticides into three groups: halogenated hydrocarbons, pyrethroids and inhibitors of acetylcholinesterase [2]. The former have been prohibited to a large extent and play only a minor role at the present time. The most known substance in this group is DDT (Dichlorodiphenyl-trichloroethane). The pyrethroids decelerate the closing of voltage-gated sodium channels of the nervous system of insects and are highly selective for this class [3]. In humans, toxic effects are seen only after intravenous injection and long-lasting and intensive inhalation [4]. There are mainly two classes of acetylcholinesterase inhibitors: organophosphates and carbamates. Whereas inhibition by organophosphates is of an irreversible nature, carbamates cause a reversible enzyme inhibition [2]. Due to their lipophilic character the inhibitors are well absorbed enterally, and percutaneous absorption is moderate [5]. The inhibition of acetylcholinesterase by phosphorylation of serine in the active centre of the enzyme in the synaptic gap inhibits the inactivation of acetylcholine [2]. Therefore, parasympathomimetic effects determine the clinical response, and poisoning is frequently fatal. Symptoms depend on the degree of intoxication: First miosis, lacrimation, hypersecretion of the mucous membranes, hypersalivation, nausea, emesis and diarrhoea occur; critical stages are accompanied by dyspnea, agitation, convulsions, muscular disorders, unconsciousness and respiratory

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Table 1 Form, colors and odors of products of solid consistency

Form	Color	Trade name	Active ingredient	Odor		
Granulate	White/whitish	Dantop	Clothianidin			
		Provado 5 WG	Imidacloprid			
	Beige	Provado 5 WG Universalspritzmittel	Imidacloprid			
		Yellow to brownish	Nemathorin 10G	Fosthiazate		
	Plenum 50 WG		Pymetrozine			
	Brown		Confidor WG 70	Imidacloprid		
		Asulfa Jet	Sulphur			
		Steward	Indoxacarb	Wood-like		
		Sufran Jet	Sulphur			
		Thiovit Jet	Sulphur			
		Dun	Kumulus WG	Sulphur		
			Insegar	Fenoxycarb		
	Compo-Mehltau-frei Kumulus WG		Sulphur			
	Netzschwefel WG		Sulphur			
	Grey		Schädlingsfrei Careo Combi-Granulat	Acetamiprid	Sharp	
		Lizetan Combigranulat	Imidacloprid			
	Green-blue	Pirimor Granulat	Pirimicarb			
	Blue	COMPO Schneckenkorn	Metaldehyde	Aromatic		
		Glanzit Schneckenkorn	Metaldehyde	Aromatic		
		FCS Schneckenkorn	Metaldehyde	Aromatic		
		Delu Schneckenkorn	Metaldehyde	Aromatic		
		Detia Schneckenkorn	Metaldehyde	Aromatic		
		Ferramol Schneckenkorn	Fe-III-phosphate			
		Metarex	Metaldehyde			
		Schneckenkorn Spiess-Urania	Metaldehyde			
		Clartex blau	Metaldehyde			
		Pro Limax	Metaldehyde	Aromatic		
		Crystalline	Red	Garten-Loxiran	Chlorpyrifos	
			Lentil-like	Delicia Schnecken-Linsen	Metaldehyde	
		Etisso Schnecken-Linsen Power-Packs		Metaldehyde		
Pressed	Grey	Detia Pflanzenschutz-Stäbchen	Dimethoate			
		Gabi-Combi-Pflanzenschutz-Düngestäbchen	Dimethoate			
	Grey-green	Detia-Gas-Ex B	Aluminiumphosphide	Garlic-like		
		Detia-Gas-Ex P	Aluminiumphosphide	Garlic-like		
		Detia-Gas-Ex T	Aluminiumphosphide	Garlic-like		
		Detia-Magphos	Magnesiumphosphide	Garlic-like		
		Phostoxin Pellets	Aluminiumphosphide	Garlic-like		
		Phostoxin Tabletten	Aluminiumphosphide	Garlic-like		
		Delicia-Gastoxin-Pellets	Aluminiumphosphide	Garlic-like		
		Delicia-Gastoxin-Tabletten	Aluminiumphosphide	Garlic-like		
Powder	Whitish	Ordoval	Hexythiazox			
	Beige	Masai	Tebufenpyrade			
		Insekten-Streumittel Nexion Neu	Chlorpyrifos			
	Yellow	Netz-Schwefelit WG	Sulphur	Sharp		
	Brown	Cruiser 70 WS	Thiamethoxam			
	Blue	Mospilan	Acetamiprid			
	Grey	Degesch-Magtoxin Granular	Magnesiumphosphide	Garlic-like		

Table 1 continued

Form	Color	Trade name	Active ingredient	Odor
Sticks	White	Etisso Blattlaus-Sticks	Dimethoate	
		Etisso Combi-Sticks	Dimethoate	
		Combi-Sticks Insektan	Dimethoate	
		Schädlings-Sticks Insektan	Dimethoate	
	Yellow	Compo Axoris Insekten-frei Quick-Granulat	Thiamethoxam	
		Compo Axoris Insekten-frei Quick-Sticks	Thiamethoxam	
	Grey	Lizetan Combistäbchen	Imidacloprid	
		Combi-Stäbchen Hortex-D	Dimethoate	
		Schädlingsfrei Careo Combi-Stäbchen	Acetamiprid	Sharp
	Grey-brown	Bi 58 Combi-Stäbchen	Dimethoate	
Compo Bi 58 Combi-Stäbchen		Dimethoate		
Unspecific	Brown	Pflanzenschutz-Zäpfchen	Dimethoate	
	Whitish	Dimilin 80 WG	Diflubenzuron	
	Grey-green	Degesch-Magtoxin Tabletten	Magnesiumphosphide	Garlic-like
	Blue	Mesurool Schneckenkorn	Methiocarb	
		Karate WG forst	Lambda-Cyhalothrin	
		Trafo WG	Lambda-Cyhalothrin	
	Brown	Dr. Stähler Tandem-Stäbchen plus	Dimethoate	

Missing indication of odor stands for uncharacteristic

paralysis [2]. Recently developed insecticides like imidacloprid or tebufenozide show a high specificity for insects and are barely toxic for humans; nevertheless, fatal cases have, however, been reported for imidacloprid [6, 7].

It is well recognized that toxic substances are frequently provided with characteristic dyes or pigments, such as blue colored paraquat and parathion. The use of warning colors is not a recent new occurrence, even at the end of the 19th century, leach that was used as a detergent was supplemented with ultramarine [8]. However, our enquiry into pesticides in the scientific literature, safety data sheets, and manufacturers' and other internet sites did not reveal an overview of commercial substances and their colors and this has prompted us to explore the colors and dyes of pesticides that are registered and in use in Germany.

For descriptions of colors (dyes, pigments) standardized tables or normalized color systems can be used. Color tables are based on different standardized systems, for example, BS381C, BS5252, RAL840 h and Pantone 1000 can easily be found on the internet. It must be recognized that variations of visible color depend on the quality of the monitor TFT (thin film transistor) display. However, these standardized systems can be used for the description of colors. Another method is to use standardized systems such as the CIEL*a*b* color system, which has already been applied for forensic purposes [9–12]. The CIEL*a*b*

system is an objective method to determine the brightness, the hue and the saturation of a color.

Materials and methods

The safety data sheets of the substances that are registered in Germany were collected and the active ingredients, the color, the form and the odor were compiled. This survey includes insecticides, molluscicides, nematocides and miticides. Rodenticides and avicides were not dealt with. In Germany, according to the Federal Office of Consumer Protection and Food Safety, the number of registered substances in these categories was 299 in September 2007 (www.bvl.bund.de). Mainly due to multiple citations and because of the non-availability of some safety data sheets our compilation includes 207 trade products.

In five pesticide preparations color measurements were performed with a diode array spectrophotometer MCS 400 (Carl-Zeiss-Jena GmbH, Jena, Germany) with a halogen bulb as the light source (standard illuminant D65). The measuring head allowed recording of the directed surface reflection of a 5 mm wide measuring spot (measuring geometry 45°/45°). Compressed barium sulphate was used as a white standard according to DIN 5033. The measurements were controlled and evaluated with the help of a personal computer. The software (MCSCol 2.11,

Table 2 Colors and odors of liquid products

Color	Trade name	Active ingredient	Odor
White	Pflanzenspray Hortex Neu	Pyrethrin	
	Schädlingsfrei Spray	Pyrethrin	
	Substral Pflanzenspray	Pyrethrin	
	Bayer Garten Gießmittel gegen Schädlinge	Thiaclopride	
	Bayer Garten Kombi-Schädlingsfrei	Thiaclopride	
	Alverde	Metaflumizone	Aromatic
	Fastac Forst	Alpha-Cypermethrin	
	Compo Austrieb-Spritzmittel	Mineral oil	
	Nomolt	Teflubenzuron	
	Mimic	Tebufenozide	Mouldy
	Promanal AF Neu Schild- und Wollausfrei	Mineral oil	
	Promanal Neu	Mineral oil	
	Promanal Neu Schild- und Wollausfrei	Mineral oil	
	Austrieb-Spritzmittel Weißöl	Mineral oil	
	CEL 265 43 AE	Acetamiprid	
	Celaflor Austriebs-Spritzmittel	Rape oil	
	Celaflor Blattlausfrei	Rape oil	
	Celaflor Schildlausfrei	Rape oil	
	Schädlingsfrei Careo Konzentrat	Acetamiprid	
	Schädlingsfrei Careo	Acetamiprid	
	Schädlingsfrei Careo Rosenspray	Acetamiprid	
	Schädlingsfrei Careo Spray	Acetamiprid	
	Schädlingsfrei Hortex	Rape oil	
	Chrysal Pflanzenspray	Pyrethrin	
	Micula	Rape oil	
	Austrieb-Spritzmittel Eftol-Öl	Mineral oil	
	Para Sommer	Mineral oil	
	Para Sommer S	Mineral oil	
	Applaud	Buprofezine	
	Force 20 CS	Tefluthrin	
	Biscaya	Thiaclopride	
	Chinook	Beta-Cyfluthrin + Imidacloprid	
	Elado	Beta-Cyfluthrin + Clothianidine	
Janus	Beta-Cyfluthrin + Clothianidine		
Poncho Beta	Beta-Cyfluthrin + Clothianidine		
Kiron	Fenpyroximate		
Fastac SC Super Contact	Alpha-Cypermethrin		
Bayer Garten Oliocin Austriebsspritzmittel	Mineral oil		
Whitish	Envidor	Spirodiclofen	
	Raptol AF Rosen-Schädlingsfrei	Pyrethrin + Rape oil	
	Pflanzenspray Hortex N	Pyrethrin + Rape oil	
Beige	Spruzit AF Schädlingsfrei	Pyrethrin + Rape oil	
	Calypso	Thiaclopride	
	Karate mit Zeon Technologie	Lambda-Cyhalothrine	Aromatic
	Contur plus	Beta-Cyfluthrin	
	Magister 200 SC	Fenazaquine	
Cruiser 600 FS	Thiamethoxam		
Magister 200 SC	Fenazaquine		

Table 2 continued

Color	Trade name	Active ingredient	Odor
Yellow	Aco.sol PY-Z	Pyrethrin	
	Sumicidin Alpha EC	Esfenvalerate	
	Decis flüssig	Deltamethrine	Aromatic
	Bayer Garten Obst- und Gemüse-Schädlingsfrei	Pyrethrin + Rape oil	
	Compo Schädlings-frei plus	Pyrethrin + Rape oil	
	Bulldock	Beta-Cyfluthrin + Imidacloprid	Aromatic
	Neudosan Neu	Potassic placer	Alcoholic
	Neudosan Neu Blattlausfrei	Potassic placer	Alcoholic
	Promanal Neu Austriebsspritzmittel	Mineral oil	
	Spruzit Neu	Pyrethrin + Rape oil	
	Spruzit Käfer-&Raupenfrei	Pyrethrin + Rape oil	
	Spruzit Käferfrei	Pyrethrin + Rape oil	
	Spruzit Schädlingsfrei	Pyrethrin + Rape oil	
	Schädlingsfrei Parexan Plus	Pyrethrin + Rape oil	
	Milbeknock	Milbemectine	Aromatic
	Rogor 40 L	Dimethoat	Mercaptane-like
	Rogor 40 LC	Dimethoat	
	Schädlingsfrei Eftol	Pyrethrin + Rape oil	
	Kanemite SC	Acequinocyl	
	Pyreth Natur-Insektizid	Pyrethrin + Rape oil	
	Promanal Austriebsspritzmittel	Rape oil	
	Kanemite SC	Acequinocyl	
	Yellowish	Neudosan AF Neu Blattlausfrei	Potassic placer
Raptol Schädlingspray		Pyrethrin + Rape oil	Aromatic
Vertimec		Abamectin	Aromatic
Celaflor Schädlingsfrei		Rape oil	
Schädlingsfrei Naturen		Rape oil	
Substral Schädlingsfrei		Rape oil	
Micula		Rape oil	
Apricot-coloured	Appeal	Cyfluthrin	
	Danadim Progress	Dimethoat	
Pink	Apollo	Clofentezine	
Red	Monceren G	Pencycuron + Imidacloprid	
	Poncho	Clothianidine	
	Cruiser 350 FS	Thiamethoxam	
	Gaucho 600 FS	Imidacloprid	
	Manta Plus	Fuberidazole + Imazalil + Triadimenol + Imidacloprid	
	Mesuroil flüssig	Methiocarb	
	Smaragd	Clothianidine	
	Blue	Perfekthion Insektenvernichter	Dimethoat
Bi 58		Dimethoat	Malodorous
Perfekthion		Dimethoat	Malodorous
Tamaron		Methamidophos	
Insekten Spritzmittel Roxion D		Dimethoat	Malodorous
Insekten-Spritzmittel Roxion		Dimethoat	Malodorous
Cruiser osr		Fludixonil + MetalaxyI-M + Thiamethoxam	

Table 2 continued

Color	Trade name	Active ingredient	Odor
Brown	Naturen Schädlingsfrei Neem	Azadirachtin (Neem)	
	NeemAzal-T/S	Azadirachtin (Neem)	
	Actellic 50	Pirimiphos-methyl	Aromatic
	Fury 10 EW	Zeta-Cypermethrin	Sharp
Brownish	SpinTor	Spinosad	
	Conserve	Spinosad	
	Runner	Methoxyfenozide	
	Schädlingsfrei Neem	Azadirachtin (Neem)	
Colourless	Bayer Garten Spinnmilbenfrei	Acequinocyl	
	Bayer Garten Spinnmilbenspray	Methiocarb + Imidacloprid	
	Lizetan Plus Zierpflanzen-spray	Methiocarb + Imidacloprid	
	Provado Gartenspray	Methiocarb + Imidacloprid	
	Bi 58 Spray	Dimethoat	Acetone-like
	Compo Zierpflanzen-Spray Bi 58	Dimethoat	Acetone-like
	Etisso Blattlaus-Spray	Pyrethrin	
	Spruzit Zimmerpflanzen-spray	Pyrethrin	
	Spruzit Gartenspray	Pyrethrin	
	Gartenspray Hortex	Pyrethrin	
	Bio-Insektenfrei Gartenspray	Pyrethrin	
	Blattlaus-frei Spiess-Urania	Dimethoat	Acetone-like
	Blattlaus-Spray Dimeton	Dimethoat	Acetone-like
	Zierpflanzen-spray Pyreth	Pyrethrin	

Missing indication of odor stands for uncharacteristic

Carl-Zeiss-Jena GmbH, Germany) automatically calculated the color measures CIE-L*a*b* from the spectral reflectance curves in the visible light spectrum.

Results

With the aid of the safety data sheets available, the colors and odors of the substances were sorted. These products contain 55 different active ingredients. As a result of multiple combinations, lack of human toxicity of single active ingredients did not lead to their exclusion from the compilation. The preparations had 17 different colors.

According to German and European regulations, admixed additives have to be specified under certain circumstances only, therefore, detailed chemical information could not be gained from the safety data sheets, neither for the dyes nor for the odors. Furthermore, the description of the perceptible characteristics has little detail, so that the subdivision in shades of colors is limited (Tables 1, 2).

The information on the odor of a pesticide preparation given in the respective safety data sheet of most substances is “nonspecific”, and in our compilation of products (Tables 1, 2) information about the odor is only provided

Table 3 Calculated CIEL*a*b color measures

	L	a	b
Pirimor granulät	4.28	-3.38	-1.3
Technoate	1.53	6.93	-16.03
Hostaquide	0.98	0.19	0.61
Confirm	88.26	0.54	9.29
Mesurool	37.98	34.23	12.78

when it was characteristic. Individual differences in the perception of odors also has to be taken into account.

The results of the color measurements are shown in Table 3.

Discussion

Accidental and suicidal intoxications are a frequent occurrence, and due to their ready availability pesticides are still among the most often ingested toxic substances. In many cases of intoxication, the symptoms are nonspecific and reflect underlying pathophysiological mechanisms, e.g. inhibition of acetylcholinesterase. On the basis

of the clinical symptoms, the specific toxic agent can hardly be identified. Therefore, deductions based on the perceptible characteristics of a toxic agent are of particular interest and possible benefit. The rapid identification of an ingested substance by its color and odor could significantly reduce the effort put into diagnostic testing and thereby save time not only in post-mortem toxicology, but also in the acute poisoning of living patients.

Our survey is limited to products that are available on the German market, but an internet search revealed that to a great extent these products are traded internationally—mostly under the same or a similar product designation.

Products are of liquid and solid consistency. Preparations of solid consistency can be identified more easily than liquids, although reliable identification of a specific product on the basis of its characteristic is often only partly successful. The range of possible products can clearly be narrowed by their nature and color. For liquid preparations the type of the product can only to some extent be deduced from the color and the odor.

For accurate color identification we suggest the use of remission spectrometry as well as the use of standardized color models and color tables that are available on the internet.

Key points

1. Even modern pesticides carry an inherent risk of human toxicity.
2. Toxic substances are frequently provided with characteristic warning colors.
3. A register of the colors of commercial pesticides could not be found.
4. The safety data sheets of insecticides, molluscicides, nematocides and miticides were assembled and the

active ingredients, colors, forms and odors were compiled.

5. Some of the substances can be identified by their physical characteristics, for other products the number of possible preparations can be reduced by examining their color and odor.

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