Studies on Pyrethroidal Compounds Part VII. Factors Influencing the Vaporization of Allethrin from Burning Mosquito Coils.

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7. ピレスロイド系化合物の研究（第7報）燃焼蚊取線香からのアレスリンの揮散に影響をおよぼす要因

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燃焼蚊取線香からのアレスリンの揮散に影響を与える種々の要因について調査した．空気流量を変えて燃焼速度を変えた場合，燃焼速度の速い方が揮散率が高くなる傾向が認められた．線香組成を変えて燃焼速度を変えた場合も，燃焼速度の速い方が揮散率は高くなった．後者の場合，線香基材の性質による空隙性が関係しているものと考えられた．

線香中に酸化防止剤（B. H. T.）を加えると，アレスリンの揮散率および殺虫効力は，わずかに増加した．6種類のピレスロイド用シネルギストの添加による影響を調査したところ，アレスリンの揮散率にはほとんど変化が認められなかった．効力試験では，致死効力はわずかに高くなるものもあったが，ノックダウン効力はむしろ低下するものが見出された．

線香へアレスリンを塗布した線香からの揮散率は，通常の練込み線香より約10%高い値を与えた．練込み線香でも，ほぼ同じ断面積を有する線香での比較では，丸型より長方形の断面線香の方が，アレスリンの揮散率が3～7%高かった．丸型断面線香の直径と揮散率の関係では，直径が大きくなるに従って揮散率は低下すること，そしてその低下は有効断面積の低下に比例していることが明らかとなった．また，このことからおのおの，0.30%および0.60%アレスリン線香では，線香の表面から0.24 cm 以内および 0.21 cm 以内の深さに存在しているアレスリンが，燃焼中に揮散していることが示唆された．従って，蚊取線香の適性直径は 0.42cm 以下であることが明らかとなった．

In the preceding paper[1], the authors reported a simple, rapid and highly accurate method to determine vaporization ratios of active ingredient from burning mosquito coil. And vaporization ratios of various pyrethroids were described.

This paper deals with burning rate, composition of mosquito coil, additives, surface coating technique and shape of mosquito coil, which are some of the factors influencing vaporization of insecticides from burning mosquito coils. Allethrin was used in this experiment, which is the most useful insecticide for mosquito coil in the world.

Materials and Methods

Collection of mosquito coil smoke. The method was reported in detail in the preceding paper[1]. Air flow rate in the apparatus was regulated by controlling suction. Burning rate was obtained by dividing weight of burned

Table 1. GLC Conditions for the determination of synergists in mosquito coil smoke.

Condition		P. Butoxide	Synepirin-500	S-421	MGK-264
Liquid phase*1		2% XE-60	2% XE-60	2% XE-60	5% DC-200+10% QF-1
Column temperature*2		200°C	190°C	150°C	180°C
Injection temperature		240°C	230°C	180°C	220°C
Internal standard (IS)		Tetramethrin	Tetramethrin	Allethrin	Di-*n*-hexyl sebacate
Retention time (min)	Synergist	4.1	4.5	5.0	5.8
	IS	9.0	13.5	11.5	11.5

*1; Each liquid phase was coated on acid-washed and silanized Chromosorb W (60-80 mesh). Stainless steel column (1.5m × 3mmø) was used.

*2; Apparatus: Yanagimoto GCG-550F (FID detector). Gas flow rate; carrier (N_2) 25ml/min, hydrogen 30ml/min and air 0.9 liter/min.

Table 2. Effect of composition of mosquito coil on vaporization ratio.

		A	B	C	D	E
Composition	Pyrethrum marc	18.9 wt %	48.9 wt %	68.9 wt %	58.9 wt %	38.9 wt %
	Tabu powder	30.	30.	20.	30.	50.
	Wood flour	50.	20.	10.	10.	10.
	Allethrin*	0.60	0.60	0.60	0.60	0.60
	Malachite green, Sodium dehydroacetate	0.5	0.5	0.5	0.5	0.5
Property	Burning time (hr/13g)	4.3	6.2	6.6	7.5	8.4
	Apparent density (g/cm^3)	0.50	0.71	0.77	0.79	0.81
	Vaporization ratio (%)	64.1	62.7	60.6	56.7	41.7

* (+)-*cis, trans*-Allethrin

mosquito coil by the time taken to burn out in the apparatus.

Analysis. The determination of pyrethroid in mosquito coil smoke was performed by gaschromatography (GLC). GLC conditions for allethrin were described in the paper[1]. GLC conditions to determine synergists are shown in Table 1.

Mosquito coil. (a) Blending technique: Unless otherwise noted, mosquito coils used were prepared by the blending technique in our laboratory. Composition of the coil was mentioned in the preceding paper[1].

(b) Dipping technique: Blank coils were prepared according to the composition similar to that shown in Table 2. Pyrethroid was added to them by pipetting the appropriate volume of acetone solution as evenly as possible onto a side of the coil which was then air-dried.

Apparent density of mosquito coil. Cross section, length and weight of a piece of mosquito coil (*ca.* 7-8cm in length) were accurately measured. Apparent density was calculated according to the following equation. The measurement was repeated 9 times. The mean was obtained as apparent density.

$$\text{Apparent density } (g/cm^3) = \frac{\text{Weight (g)}}{\text{Cross section } (cm^2) \times \text{Length (cm)}}$$

Biological test of mosquito coil. Mosquito coil (0.3-0.5g) was fixed on a stand in a glass chamber (70cm cube) and ignited at the both ends. After the coil was burnt out, *ca.* 20 adult mosquitoes (*Culex pipiens pallens*) were released into the chamber. Knockdown mosquitoes were counted at indicated intervals up to 17 min. The knockdown insects were collected and mortality was observed after 24 hr in a fresh air.

Results and Discussion

Effect of burning rate on vaporization There are 2 methods to regulate burning rate of mosquito coil. One is obtained by changing composition of mosquito coil, the other is by changing air flow rate during combustion. According to the former, the effect of burning rate is not clearly distinguishable from the effect of basic materials for mosquito coil. Mosquito coils of the same composition were therefore burned and burning rate was regulated by the latter method.

Burning rate varied from 0.91 to 1.11 mg/sec by changing air flow rate from 2.1 to 9.0 liters/min. This burning rate corresponds to 6.5-8.0 hr taken a coil (13g) to burn.

Vaporization ratios were determined under various burning rates with mosquito coil containing 0.60% of (±)-*cis, trans*-allethrin. A linear relationship was found to exist between them as shown in Fig. 1, and the straight line gives a following equation:

$$Y = 25.51X + 34.47$$
$$(r = 0.61)$$

where Y: vaporization ratio (%)
X: burning rate (mg/sec)
r: correlation coefficient

From the result of testing of correlation, the correlation coefficient is significant at the 1% level. The similar result was given with (+)-

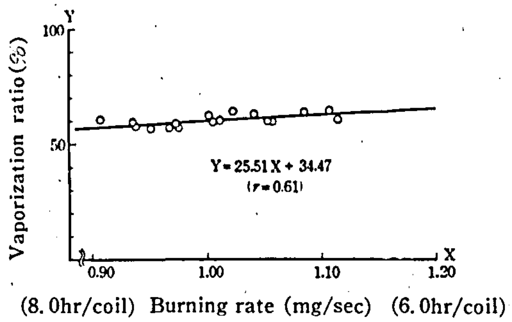


Fig. 1. Effect of burning rate on vaporization ratio of allethrin from burning mosquito coil (0.60% of (±)-*cis, trans*-allethrin)

cis, trans-allethrin coil (0.30%) and (±)-*cis, trans*-furamethrin coil (0.60%). It is presumable that an increasing of burning rate may likely cause a rise of burning temperature of mosquito coil and thus an acceleration of the thermal decomposition of allethrin. But the result of Fig. 1 shows that the increasing of burning rate by high air flow rate raised vaporization ratio of allethrin. This fact may be explained as follows: Vaporization ratio would be independent of a rise of the temperature of the glowing tip in the coil because the insecticide appears to be volatilized at the zone of much lower temperatures behind the tip[2,3]. And the increasing of air flow rate would probably accelerate the evaporation of allethrin.

Effect of composition of mosquito coil on vaporization of allethrin

Composition of mosquito coils used and their physical properties are shown in Table 2. Burning rate became small with a decrease of wood flour and an increase of pyrethrum marc and tabu powder. The reduction in burning time was paralleled by a decrease in apparent density of mosquito coils. Vaporization was accelerated by an increase of burning rate. This finding is in accord with the above result obtained by regulating the burning rate by changing the air flow rate. Apparent density is closely related to porosity of mosquito coil. The increase of the porosity might enhance burning rate and also vaporization ratio.

Effect of additives to mosquito coil on vaporization of (±)-*cis, trans*-allethrin

Addition of B. H. T. (anti-oxidant) at 2.5 wt % showed some protection against thermal decomposition and raised slightly vaporization ratio of allethrin (Table 3). It contributed slightly to a knockdown effect in the biological test too (Table 4). Several pyrethroid synergists were added to mosquito coil at 5 times percent as much as that of allethrin. Vaporization ratio of allethrin was little affected by the addition of 6 kinds of synergist (Table 3). Addition of synergists, however, retarded knockdown time, like the cases of piperonyl butoxide, Synepirin-500 and MGK-264. Mortality was found to be raised slightly (Table 4). Only S-421* showed improved knockdown and mortal effects. It may come from the fact that this compound itself had appreciable insecticidal activity (Table 5). Fujimoto *et al.* found that piperonyl butoxide was remarkably synergistic with pyrethroid in aerosol formulation[4]. But in our experiment of mosquito coil, synergistic effect was not so significant as in the case of aerosol and oil spray (Table 4). Hayashi reported the same biological result with some of these synergists[5].

In this respect, it might be expected that

Table 3. Vaporization ratio of (±)-*cis, trans*-allethrin in the presence of additive from burning mosquito coil.

Allethrin		+Additive		Vaporization ratio (%)
Allethrin	0.30%			58.0
〃	0.50			57.3
〃	0.70			57.6
〃	0.50	+B. H. T.	2.50%	58.6
〃	〃	+P. Butoxide	〃	58.2
〃	〃	+Synepirin 500	〃	55.9
〃	〃	+S-421	〃	53.9
〃	〃	+MGK-264	〃	57.5
〃	〃	+MGK-5026	〃	58.1
〃	〃	+Tropital	〃	56.5

B. H. T.: Dibutyl hydroxy toluene
P. Butoxide: Piperonyl butoxide
Synepirin 500: N-(2-Ethylhexyl)-1-isopropyl-4-methylbicyclo (2.2.2)-5-octene-2,3-dicarboximide
S-421: Octachlorodipropyl ether
MGK-264: N-(2-Ethylhexyl)bicyclo (2.2.1)-5-heptane-2,3-dicarboximide

*Octachlorodipropyl ether

Table 4. Effectiveness of mosquito coils containing (±)-*cis, trans*-allethrin and additive against mosquitoes (*Culex pipiens pallens*).

Compound in mosquito coil*1		Percent knockdown in minutes								KT_{50} (min'sec")	Mortality after 24hr
		1'30"	2'08"	3'00"	4'15"	6'00"	8'30"	12'	17'		
Allethrin*2 0.70%		2.1	6.4	16.0	31.9	69.1	91.5	97.9	100	4'50"	24.5%
〃 0.50%		1.1	4.3	14.0	37.6	60.2	89.2	96.8	100	5'05"	18.3
〃 0.30%		2.1	5.2	6.2	16.5	46.4	73.2	91.8	100	6'25"	9.3
All. 0.50%+B.H.T.	2.50%	4.3	5.4	15.1	37.6	67.7	92.5	98.9	100	4'45"	12.9
〃 +P. Butoxide	〃	0	1.1	5.3	13.8	42.6	75.5	91.5	100	6'20"	23.4
〃 +Synepirin 500	〃	1.1	2.2	6.5	17.4	52.2	81.5	92.4	100	5'55"	15.2
〃 +S-421	〃	8.3	16.7	29.2	39.6	69.8	87.5	97.9	100	4'25"	20.8
〃 +MGK-264	〃	2.0	4.1	8.2	21.4	48.0	79.6	95.9	100	6'10"	21.4
〃 +MGK-5026	〃	0	5.4	11.8	30.1	69.9	84.9	96.8	98.9	5'10"	22.6
〃 +Tropital	〃	0	3.1	13.3	32.7	62.2	92.9	98.0	99.0	5'00"	27.6

*1; Three hundred miligram of mosquito coil was burned in the glass chamber.
*2; (±)-*cis, trans*-Allethrin.

additives would depress the vaporization of pyrethroid or low vaporization of synergists occured. But synergist was certainly present in the smoke from a burning mosquito coil and vaporization ratios of them were nearly similar to those of pyrethroids (Table 5). Nagasawa *et al.* described that the extreme susceptibility of adult mosquitoes to pyrethrins and their apparent inability to detoxify them to any great extent might cause no measurable synergism with piperonyl butoxide in pyrethrum mosquito coils[6]. Maciver also observed no significant influence on kill attributable to the presence of piperonyl butoxide, because of the high rate of kill obtained with the coil containing only pyrethrins[7]. It is considered that synergists could enhance mortal effect by inhibiting oxidative detoxification with mixed-function oxidase[8]. Thus, it may be of importance to pay attention to differences of entry of active ingredients into the active site between the penetration through the integument (aerosol and oil spray) and the absorption through the tracheae (mosquito coil) of insects.

Vaporization ratios of allethrin from dipped coils

It is believed that pyrethroids in the center of a coil have more chance of thermal decomposition and less opportunity for release than those present on the surface[2]. It was reported that a mosquito coil prepared by dipping technique was

Table 5. Effectiveness of mosquito coils containing synergists alone (3.0%) against mosquitoes (*Culex pipiens pallens*) and vaporization ratio of synergists from burning mosquito coils.

Compound in mosquito coil		Percent knockdown in minutes*1								KT_{50} (min'sec")	Mortality after 24hr (%)	Vaporization ratio (%)
		1'30"	2'08"	3'00"	4'15"	6'00"	8'30"	12'	17'			
P. Butoxide	3.0%	0	0	0	0	0	0	0	29.3	*	24.1	54.4
Synepirin 500	〃	0	0	0	0	0	0	0	28.3	*	3.3	54.9
S-421	〃	0	0	0	1.7	11.7	71.7	96.7	100	7'40"	53.3	32.2
MGK-264	〃	0	0	0	0	0	0	5.0	39.0	*	13.6	33.1
Blank	0.	0	0	1.7	1.7	3.3	1.7	8.3	36.7	*	15.0	—
Allethrin*2	0.60%	8.3	25.0	51.0	77.1	90.6	100	100	100	3'00"	54.2	57.5

* Non-calculable.
*1; Half a gram of mosquito coil was burned in the glass chamber.
*2; (±)-*cis, trans*-Allethrin.

more effective against mosquitoes than a coil by blending technique[9]. According to a report by Webley[10], the vaporization ratio of pyrethrins ranged from 50 to 60% with dipped coils, and 30 to 40% with blended coils.

Vaporization ratios of (+)-*cis, trans*-allethrin from dipped coils were determined, and they were 10% or more higher than that of the blended coils (Table 6). There was not so large difference with allethrin as with pyrethrins. This may be ascribed to larger stability of allethrin to heat than that of pyrethrins.

Table 6. Vaporization ratios of (+)-*cis, trans*-allethrin from burning mosquito coils prepared by dipping technique.

Content of allethrin in mosquito coil (%)	Vaporization ratio (%)
0.15	70.5
0.30	71.5
0.60	72.0
1.50	74.9

Geometry as a factor in vaporization of pyrethroids

Vaporization ratio of 3 pyrethroids from burning mosquito coil with rectangular and circular section was measured (Table 7). Vaporization ratios with rectangular section coils were 3-7% higher with each pyrethroid than those with circular section coils of nearly similar cross section. Maciver said that the coil of circular section should present the greater opportunity for release of pyrethrins than the rectangular coil section of similar thickness[2]. Mosquito coils of similar cross section or weight should be, however, compared from a practical point of view because similar weight of coil would contain similar weight of pyrethroid and show similar burning time.

Vaporization should be related to circumference and area of mosquito coil section because pyrethroids appear to be vollatilized in the partly carbonized zone (*ca.* 2mm long) behind the burning tip[2]. It is described previously that increase of porosity would cause a rise of vaporization. It appears, therefore, worthwhile to consider geometry coefficient (the ratio of circumference to apparent density × cross section) in order to analyze the relationship between vaporization of pyrethroid and the geometry of coils. The relation of these physical properties and geometric situations are shown in Table 7.

Relation of the diameter of circular section coils to the vaporization of pyrethroid is referred to in the following. Mosquito coils of various diameter were prepared, which had the same composition of basic materials and 0.72-0.77g/cm³ of apparent density. Vaporization ratios of (+)-*cis, trans*-allethrin from those coils were measured. From the result shown in Fig. 2, vaporization ratio in 0.30% allethrin coil was higher than that in 0.60% allethrin coil. The

Table 7. Vaporization ratio of pyrethroids from burning mosquito coil with rectangular and circular section.

Pyrethroid content in mosquito coil		Geometry of coil section		Rectangular / Circular
		Rectangular	Circular	
(+)-*cis, trans*-Allethrin	0.30%	60.5%	55.0%	1.10
Pyrethrins	0.30	41.5	34.6	1.20
(+)-*cis, trans*-Furamethrin	0.30	46.2	42.6	1.08
Geometric property: Circumference (cm)		1.98	1.73	1.14
Geometric property: Apparent density (g/cm³)		0.707	0.736	1/1.04
Geometric property: Cross section (cm²)		0.223	0.237	1/1.06
Geometric property: Geometric coefficient* (cm²/g)		12.56	9.92	1.27

$$* \text{ Geometric coefficient } (cm^2/g) = \frac{\text{Circumference (cm)}}{\text{Apparent density } (g/cm^3) \times \text{Cross section } (cm^2)}$$

difference was more remarkable in the larger diameter. Relationship between the vaporization ratio and the content of pyrethroid was not so outstanding in the preceding paper[1] because allethrin is comparatively stable to heat and coil section used in the preceding paper was small, equaling that of commercial one. But the tendency that the higher content of pyrethroid gives the smaller vaporization ratio appears a fundamental nature of mosquito coils.

Vaporization ratio from mosquito coils with small diameter was almost same even if content of allethrin in the coils was different. But the vaporization ratio decreased with the increase of the diameter beyond *ca.* 0.45cm. The decrease began at *ca.* 0.42 cm of diameter in 0.60% allethrin coil and at *ca.* 0.48cm in 0.30% allethrin coil.

It is believed that pyrethroids in the center of a coil (S′ in Fig. 2) have more chance of damage and less opportunity for release than those present on the surface[2]. This theory forms the basis of a surface coating technique. It was confirmed that a dipped coil gave a higher vaporization ratio than a coil prepared by blending technique. The fact that the vaporization ratio of allethrin decreased with increase of the diameter of coils can be rationalized by considering that area (S′) of the center in coil becomes large with increase of the diameter. This idea leads to the conception of effective cross section (the ratio of vaporizing area to cross section).

$$\text{Effective cross section (E. C. S.)} = \frac{S-S'}{S}$$

where S : cross section of coil

S′: area in the center of coil

The reduce of E.C.S. would mean reduce of vaporization ratio. When depth from surface of coil where pyrethroids can be volatilized is called an effective depth (X in Fig. 2), the curves of E.C.S. at X = 0.24 cm and 0.21 cm are closely paralleled by the curves of vaporization ratio in 0.30% and 0.60% allethrin coils, respectively. This fact supports the conception of E.C.S., suggesting that allethrin present in less than 0.24cm and 0.21cm of depth from coil surface can vaporize in 0.30% and 0.60% allethrin coils, respectively. This indicates that the higher vaporization ratio of the lower content of pyrethroid in mosquito coil would arise from its larger effective depth (X).

Constancy of vaporization ratio below *ca.* 0.45 cm of diameter would be probably result from presence of all pyrethroid in vaporizing area of coil (*i.e.* S′=0), therefore, becoming E.C.S.=1. Thermal decomposition of pyrethroid during the burning of a coil might be the reason that vaporization ratio can not arrive at 100% even at the region of S′=0. From the fact mentioned above, effective depths would be found 0.24cm and 0.21cm in 0.30% and 0.60% allethrin coils, respectively. Thus, the optimum diameter of coils is below 0.42cm on the basis of vaporization ratio of allethrin. The thickness of commercial mosquito coils were 0.36-0.42cm (7 blands of sample), and it could be therefore said that they are kept in the range of optimum diameter.

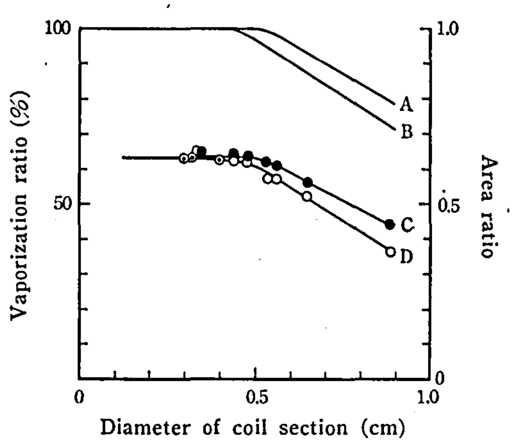
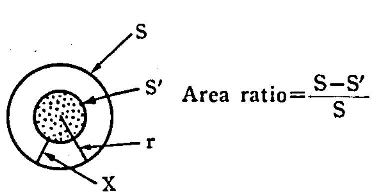


Fig. 2. Relation of diameter of coil section to vaporization of (+)-*cis*, *trans*-allethrin.



A: Area ratio at X=0.24cm

B: Area ratio at X=0.21cm

C: Vaporization ratio in 0.30% allethrin coil

D: Vaporization ratio in 0.60% allethrin coil

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References

1) Abe, Y. and Y. Fujita: *Botyu-Kagaku*, 41, ○ (1975).
2) Maciver, D. R.: *Pyrethrum Post*, 7, 15 (1964).
3) Murayama, H., K. Kyogoku, T. Iguchi and S. Kobayashi : *Nippon Nogeikagaku Kaishi*, 44, 77 (1970).
4) Fujimoto, K., T. Kadota, Y. Fujita, Y. Okuno and H. Koda: International Aerosol Congress in Tokyo, Sept. (1970).
5) Hayashi, A.: *Botyu-Kagaku*, 34, 189 (1969).
6) Nagasawa, S., M. Ohno and Y. Katsuda: *Botyu-Kagaku*, 17, 47 (1952).
7) Maciver, D. R.: *Pyrethrum Post*, 7, 7 (1964).
8) Casida, J. E.: *J. Agr. Food Chem.*, 18, 753 (1970).
9) Nagasawa, S., Y. Katsuda, A. Okamoto and M. Ohno: *Botyu-Kagaku*, 16, 176 (1951).
10) Webley, D. J.: *Pyrethrum Post*, 9, 4 (1968).

抄　録

ミツバチの *N*-アセチルトランスフェラーゼ

Enzymatic *N*-Acetylation of Indolalkylamines by Homogenates of the Honeybee, Apis mellifera. Philip H. Evans, P. Michael Fox, *J. Insect Physiol.*, 21, 343-353 (1975). Comparison of Various Biogenic Amines as Substrates for Acetyl Transferase from Apis mellifera (L.) CNS. P. H. Evans, P. M. Fox, *Comp. Biochem. Physiol.*, 51C, 139-141 (1975).

ミツバチの脳から *N*-アセチルトランスフェラーゼ活性が見つかり，その性質が調べられた．ミツバチの脳のホモジネートを酵素標品とし，アセチル基供与体としてはアセチル-CoA を用いた．チラミンを基質とした場合，K_m は 5.0×10^{-7}M，最適温度，最適pHは，それぞれ 33°C，pH 7.0であった．またドーパミンはチラミンと同程度のよい基質であったが，セロトニンはチラミンに比べてアセチル化を受けにくく，ノルエピネフリンではアセチル化が見られなかった．

昆虫の外皮の硬化にドーパミンの *N*-アセチル化反応が関与していることが知られており，今回見い出された *N*-アセチルトランスフェラーゼが硬化に関係した酵素と同一であるかどうかが一つの問題点となろう．

また殺虫剤として知られるクロルディメホルムは，モノアミンオキシダーゼ (MAO) の作用を阻害することによって殺虫効果を示すと考えられていたが，最近になって，MAO の作用と考えられていたのは，実は *N*-アセチルトランスフェラーゼによる *N*-アセチル化反応であることが明らかにされた．したがってクロルディメホルムの作用機作という点からも，本研究は興味あるものと思われる．　(田江泰彦)

培養細胞を用いた薬物代謝の研究

Tsu H. Lin, Hanson H. North and Robert E. Menzer

(1) Metabolism of Carbaryl (1-Naphthyl *N*-methylcarbamate) in Human Embryonic Lung Cell Cultures. *J. Agr. Food Chem.*, 23, 253 (1975).
(2) The Metabolism of Chlodimeform in Human Embryonic Lung Cell Cultures. *J. Agr. Food Chem.*, 23, 257 (1975).

Carbaryl の代謝がヒト胎児肺の初代培養細胞を用いて調べられた．^{14}C-Carbaryl を培地中に加え，細胞とともにインキュベートした後培地から代謝物をエーテルにより抽出した．72時間のインキュベートではエーテル層に約70%，水層に約30%の放射能があり，与えた放射能の99%が回収された．そして1-Naphthol, 1,4-Naphthalene-diol 1,5-Naphthalene-diol, 5-Hydroxycarbaryl, 4-Hydroxycarbaryl, 5,6-Dihydro-5,6-dihydroxycarbaryl が代謝物として確認された．また水層を β-glucuronidase 処理した後エーテル抽出を行なったが，エーテル中に放射能は検出されなかった．したがって代謝生成物中には glucuronic acid 抱接化合物は含まれていない．Carbaryl を超音波処理した細胞，UDPG，その他の補助因子とともにインキュベートしても水層中の放射能は増加しなかった．これらのことからこの細胞の代謝系の中に *o*-glucuronidation の系が存在しないものと考えられた．また chlordimeform の代謝も同様の方法で検討され，*N*-formyl-4-chloro-*o*-toluidine, 4-chloro-*o*-toluine *N*-demethylchlordimeform が代謝物として同定された．このように薬物代謝の研究にも培養細胞が利用されはじめている．培養細胞は器官のような複雑性を全くもたないので薬物と細胞との直接的な作用を研究してゆく有力な武器になっていくものと思われる．

(吉田正徳)