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condition that a particular solution of a Riccati differential equation or a 2nd order linear differential equation can be found.

2. THE MAIN RESULTS

It is known that a curve with $\kappa(s)=0$, $s\in I\subseteq R+$, is a straight line.

Hence we assume that the curve we discuss has $\kappa(s)>0$, and let

$$\frac{\tau(s)}{\kappa(s)}=\nu(s), \quad s\in I. \tag{2}$$

Put

$$t=\int_0^s \kappa(u)du, \quad s\in I, \quad t(I)=J. \tag{3}$$

This allowable change of parameter from s to t is due to the fact that $\frac{dt}{ds}=\kappa(s)>0$. Applying (2), we get a new form for the Frenet formulas as follows.

Lemma. Let a curve $\sigma(s)$ have continuous functions $\kappa(s)(>0)$, $\tau(s)$, s being the arc length measured from 0, $s\in I$. For a differentiable function $t=\int_0^s \kappa(u)du$, $t(I)=J$, and the new Frenet frame $T=\boldsymbol{t}(s)$, $N=\boldsymbol{n}(s)$, $B=\boldsymbol{b}(s)$, the Frenet formulas (1) become

$$\frac{dT}{dt}=N, \quad \frac{dN}{dt}=-T+cB, \quad \frac{dB}{dt}=-cN \tag{4}$$

where $c=\nu(s)$.

We will solve the new Frenet equations (4) under the given initial frame $\{\boldsymbol{r}_0;\ T_0, N_0, B_0\}$ at $t=0\ (\in J)$, $\boldsymbol{r}(t)=\sigma(s(t))$.

Consider a vector field

$$V=T+\lambda N+\mu B \tag{5}$$

with parameter functions $\lambda,\ \mu\in C^1(J)$.

Differentiating (5) with respect to t, we have

$$\begin{aligned} V' &= T'+\lambda N'+\mu B'+\lambda' N+\mu' B \\ &= -\lambda V+(\lambda'+1+\lambda^2-c\mu)N+(\mu'+c\lambda+\lambda\mu)B \end{aligned} \tag{6}$$

by (4) and (5).

Let λ, μ satisfy the simultaneous differential equations

$$\begin{cases}\lambda' = c\mu - (1+\lambda^2), \\ \mu' = -\lambda(c+\mu), \end{cases} \tag{7}$$

then (6) and (7) imply that

$$V' + \lambda V = 0. \tag{8}$$

For a pair of particular solutions $\lambda(t)$, $\mu(t)$ of (7), integrating (8), we get

$$V = T + \lambda N + \mu B = V_0 e^{-\int_0^t \lambda(u)\,du}, \quad t \in J, \tag{9}$$

where $V_0 = T_0 + \lambda(0)\, N_0 + \mu(0)\, B_0$.

Hence three sets of different values of $\lambda(t)$, $\mu(t)$ enable us to find the vectors T, N, B satisfying (4). Then r can be obtained by integrating T once or N twice.

Now we will solve the simultaneous DEs (7):

Multiplying the first equation of (7) by λ, the second equation of (7) by μ and adding the two equations, we get

$$\lambda\lambda' + \mu\mu' + (1+\lambda^2+\mu^2)\,\lambda = 0, \tag{10}$$

a differential equation which has a general solution

$$1 + \lambda^2 + \mu^2 = A\, e^{-\int 2\lambda(t)\,dt}, \quad A: \text{an arbitray constant} \geq 0. \tag{11}$$

Take $A=0$ in (11) for brevity. Then

$$1 + \lambda^2 + \mu^2 = 0 \tag{12}$$

is an integral of (7). We find the other integral of (7) by squaring the latter equation of (7) and substituting (12) into it to obtain

$$\mu'^2 + (c+\mu)^2(1+\mu^2) = 0, \tag{13}$$

a binomial DE of degree 2.

Consider a substitution of μ by y such that

$$y^2 = \frac{\mu + i}{\mu - i}, \tag{14}$$

then (13) becomes

$$\frac{-4y^2}{(y^2-1)^4}\left[4y'^2+\{(y^2+1)\,i+(y^2-1)\,c\}^2\right]=0,$$

or

$$y'=\frac{\pm i}{2}\{(i+c)y^2+(i-c)\}\ [4], \tag{15}$$

a Riccati DE which can be easily solved in the case where one of its particular solutions is found. When c is a constant, (15) becomes a separable differential equation, y can be solved, and μ is found by (14).

There is another way to solve (15): when c is differentiable and does not equal to $-i$, then a substitution

$$y=\frac{+2z'}{(ci-1)\,z}\ [5] \tag{16}$$

into (15) yields a linear differential equation of 2nd order

$$z''-\frac{c'i}{ci-1}\,z'+\frac{(c^2+1)}{4}\,z=0, \tag{17}$$

which can be solved as a series of z.

A particular solution of y from (15) or (16) gives the value of μ by (14). For such μ, when $\mu^2+1\neq 0$, we get two values of λ by (12). Let them be

$$\lambda_1=i\sqrt{1+\mu^2}\ ,\quad \lambda_2=-i\sqrt{1+\mu^2}\ . \tag{18}$$

Put $\lambda=\lambda_i$ in (8) and intergrating $\mathrm{V}'+\lambda_i\,\mathrm{V}=0$, $i=1, 2$, we have

$$\mathrm{V}_i=\mathrm{V}_{i0}\,e^{-\int_0^t\lambda_i(u)\,du},\quad \mathrm{V}_{i0}=\mathrm{T}_0+\lambda_i(0)\,\mathrm{N}_0+\mu(0)\,\mathrm{B}_0,\quad i=1, 2, \tag{19}$$

or

$$\mathrm{T}+\lambda_1\,\mathrm{N}+\mu\mathrm{B}=\mathrm{V}_{10}\,e^{-\int_0^t\lambda_1(u)\,du}, \tag{20}$$

$$\mathrm{T}+\lambda_2\,\mathrm{N}+\mu\mathrm{B}=\mathrm{V}_{20}\,e^{-\int_0^t\lambda_2(u)\,du}, \tag{21}$$

substracting (21) from (20) we obtain

$$\mathrm{N}(t)=\frac{1}{\lambda_1(t)-\lambda_2(t)}\left(\mathrm{V}_{10}\,e^{-\int_0^t\lambda_1(u)\,du}-\mathrm{V}_{20}\,e^{-\int_0^t\lambda_2(u)\,du}\right),\quad t\in\mathrm{J}. \tag{22}$$

Intergration of (22) reduces to

$$T(t)=\int_0^t \frac{1}{\lambda_1(v)-\lambda_2(v)}(V_{10}e^{-\int_0^v \lambda_1(u)du}-V_{20}e^{-\int_0^v \lambda_2(u)du})dv+T_0,$$
$$t\in J, \qquad (23)$$

and the required vector equation of the curve is found as

$$r(t)=\int_0^t \frac{1}{k(w)}\left\{\int_0^w \frac{1}{\lambda_1(v)-\lambda_2(v)}(V_{10}e^{-\int_0^v \lambda_1(u)du}\right.$$
$$\left.-V_{20}e^{-\int_0^v \lambda_2(u)du})\,dv+T_0\right\}dw+r_0, \quad t\in J. \qquad (24)$$

In the case c=constant, applying (12) to (7), and by investigation of (7), we get an integral of (7) other than (12) to be

$$\mu=-c. \qquad (25)$$

We discuss some values for constant c:

If $c\neq\pm i$, then (12) and (25) give $\lambda_1=i\sqrt{1+c^2}$, $\lambda_2=-i\sqrt{1+c^2}$. Thus, from (23)

$$T(t)=\int_0^t \frac{1}{2i\sqrt{1+c^2}}(V_{10}e^{-i\sqrt{1+c^2}v}-V_{20}e^{i\sqrt{1+c^2}v})\,dv+T_0$$
$$=\frac{1}{(1+c^2)}V_{10}(e^{-i\sqrt{1+c^2}t}-1)+V_{20}(e^{i\sqrt{1+c^2}t}-1)+T_0$$
$$=\frac{c^2+\cos\sqrt{1+c^2}t}{1+c^2}T_0+\frac{\sin\sqrt{1+c^2}t}{\sqrt{1+c^2}}N_0$$
$$+\frac{c(1-\cos\sqrt{1+c^2}t)}{1+c^2}B_0, \quad t\in J. \qquad (26)$$

Integrating (26), we obtain

$$r(t)=\int_0^t \frac{1}{k(w)}\left(\frac{c^2+\cos\sqrt{1+c^2}w}{1+c^2}T_0+\frac{\sin\sqrt{1+c^2}w}{\sqrt{1+c^2}}N_0\right.$$
$$\left.+\frac{c(1-\cos\sqrt{1+c^2}w)}{1+c^2}B_0\right)dw+r_0, \quad t\in J. \qquad (27)$$

For a constant unit vector $a=\frac{1}{\sqrt{1+c^2}}(cT_0+B_0)$, $T(t)\cdot a=\frac{c}{\sqrt{1+c^2}}$, a constant $\forall t\in J$, hence the curve in (27) is a cylindrical helix [6].

If $c=0$, then $\mu=0$, $\lambda_1=i$, and $\lambda_2=-i$. A direct computation

of (20) and (21) yields

$$\mathrm{T}(t)=(\cos t)\,\mathrm{T}_0+(\sin t)\,\mathrm{N}_0,\quad t\in\mathrm{J}. \tag{28}$$

integrating (28), we have

$$\boldsymbol{r}(t)=\Big(\int_0^t\frac{\cos w}{k(w)}dw\Big)\,\mathrm{T}_0+\Big(\int_0^t\frac{\sin w}{k(w)}dw\Big)\,\mathrm{N}_0+\boldsymbol{r}_0,\quad t\in\mathrm{J}, \tag{29}$$

a plane curve. The result in (29) can be obtained from (24) or (27) also.

If $c=-\mu=\pm i$, then $\lambda=0$, and (19) becomes

$$\mathrm{T}-i\mathrm{B}=\mathrm{T}_0-i\mathrm{B}_0, \tag{30}$$

$$\mathrm{T}+i\mathrm{B}=\mathrm{T}_0+i\mathrm{B}_0, \tag{31}$$

adding (30) and (31), and integrating, we get

$$\sigma(s)=\mathrm{T}_0\,s+\boldsymbol{r}_0,\quad s\in\mathrm{I}, \tag{32}$$

a straight line, which is the case $\kappa=0$ we have excluded. Thus we obtain a theorem such as:

Theorem. Let a curve $\sigma(s)$ have differentiable curvature $k(s)(>0)$ and torsion $\tau(s)$, s being the arc length of the curve measured from 0, $s\in\mathrm{I}$. For a parameter $t=\int_0^s k(u)du$, $t(\mathrm{I})=\mathrm{J}$, let $\sigma(s(t))=\boldsymbol{r}(t)$, $\boldsymbol{t}(s(t))=\mathrm{T}(t)$, $\boldsymbol{n}(s(t))=\mathrm{N}(t)$, $\boldsymbol{b}(s(t))=\mathrm{B}(t)$ and $c(t)=\nu(s(t))$. Then for an initial frame $\{\boldsymbol{r}_0, \mathrm{T}_0, \mathrm{N}_0, \mathrm{B}_0\}$ given at $t=0$, the Frenet equations in (4) can be solved as in (24), where λ_i and V_{i_0}, $i=1, 2$, are given in (18) and (19) respectively.

For the special cases of (24), we have the cylindrical helix as in (27) and a plane curve as in (29).

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關於空間曲線的存在定理

數學系

顏　一　清

摘　要

空間曲線的存在定理謂：給定二連續函數 $\kappa(s)(>0)$, $\tau(s)$, $s\in I\subseteq R+$，則存在一曲線在 $I'(\subseteq I)$ 間，以 κ 和 τ 爲它的曲率與撓率，但實際運作則困難重重。

在這裏我給它一個新的簡明求式方法。

ČECH COHOMOLOGY THEORY OF FINITE GROUP ACTIONS

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ABSTRACT

We study the Čech cohomology theory of paracompact space with finite group action. First, we consider some special coverings of the space. Then Čech cohomology groups are defined, along with a discussion of properties.

We also consider the finitistic space with the action of cyclic group of prime order p. Take Z_p as coefficient group, the Čech cohomology groups then defined are vector spaces over Z_p. Thus there arise the problem of dimension of these Čech groups. Finally, we give an application of above discussion.

§ 1. COVERING AXIOMS AND ČECH COHOMOLOGY

In this section, X is taken to be a paracompact G-space, G finite and $A \subset X$ is a closed invariant subspace.

We call an invariant open covering $\mathcal{U}$ ($g\mathcal{U}=\mathcal{U}$ for all g) a G-covering if the nerve $K(\mathcal{U})$ of $\mathcal{U}$ [the simplical complex with vertices the members $U \neq \emptyset$ of $\mathcal{U}$ and simplices $(U_0, \ldots, U_n)$ where $U_0 \cap \ldots \cap U_n \neq \emptyset$] satisfies the following condition: If $U \in \mathcal{U}$ and $g \in G$ with $U \cap gU \neq \emptyset$, then $U = gU$.

We call a G-covering $\mathcal{U}$ regular if $K(\mathcal{U})$ satisfies the following condition for each subgroup H of G: If $(U_0, \ldots, U_n) \in K(\mathcal{U})$ and $(h_0U_0, \ldots, h_nU_n) \in K(\mathcal{U})$ where $h_0, \ldots, h_n$ are in H, then there is an element $h \in H$ such that $hU_i = h_iU_i$ for each i.

1.1 *Theorem.* Let X be a paracompact G-space, G finite. Then the locally finite, regular G-coverings of X are cofinal in the set of all coverings of X.

Proof. Let $\mathcal{U}$ be any open covering of X, then $\mathcal{V} = \bigcap_{g \in G} g\mathcal{U}$ is an invariant cover refining $\mathcal{U}$. Since X is paracompact, there exists a locally finite invariant covering $\mathcal{W}$ which refines $\mathcal{V}$.

Let $f=\{f_{\mathrm{W}}\,|\,w\in\mathrm{W}\}$ be a partition of unity subordinate to $\mathcal{W}$. We define f' by putting $f'_{\mathrm{W}}(x)=1/|\mathrm{G}|\sum_g f_{g\mathrm{W}}(gx)$. Then

$$\sum_{\mathrm{W}} f'_{\mathrm{W}}(x)=\frac{1}{|\mathrm{G}|}\sum_g\sum_{\mathrm{W}} f_{g\mathrm{W}}(gx)=\frac{1}{|\mathrm{G}|}\sum_g 1=1,$$

$$f'_{h\mathrm{W}}(hx)=\frac{1}{|\mathrm{G}|}\sum_g f_{gh\mathrm{W}}(ghx)=\frac{1}{|\mathrm{G}|}\sum_{g'} f_{g'\mathrm{W}}(g'x)=f'_{\mathrm{W}}(x),\quad (h\in\mathrm{G}),$$

and the the support of f'_{W}:

$$\overline{\{x\in\mathrm{X}\,|\,f'_{\mathrm{W}}(x)\neq 0\}}=\bigcup_g\overline{\{x\,|\,f_{g\mathrm{W}}(gx)\neq 0\}}$$
$$=\bigcup_g g^{-1}\overline{\{y\,|\,f_{g\mathrm{W}}(y)\neq 0\}}\subset\bigcup_g g^{-1}g\mathrm{W}=\mathrm{W}.$$

Thus $f'=\{f'_{\mathrm{W}}\,|\,\mathrm{W}\in\mathcal{W}\}$ forms a G-partition of unity subordinate to $\mathcal{W}$.

Let $\bar{f}:\mathrm{X}\to|\mathrm{K}(\mathcal{W})|$ be the associated map with $\bar{f}(x)=\sum_{\mathrm{W}} f'_{\mathrm{W}}(x)\mathrm{W}$, then $\bar{f}$ is equivariant, since

$$\bar{f}(gx)=\sum_{\mathrm{W}} f'_{\mathrm{W}}(gx)\mathrm{W}=\sum_{\mathrm{W}} f'_{g\mathrm{W}}(gx)g\mathrm{W}=\sum_{\mathrm{W}} f'_{\mathrm{W}}(x)g\mathrm{W}$$
$$=g\sum_{\mathrm{W}} f'_{\mathrm{W}}(x)\mathrm{W}=g\bar{f}(x).$$

Let $\bar{f}^{-1}\mathrm{K}(\mathcal{W})$ denote the covering of X by the inverse image of open vertex stars of $|\mathrm{K}(\mathcal{W})|$. In fact, it is the covering by the open sets: $f^{-1}(st\mathrm{W})=\{x\,|\,f'_{\mathrm{W}}(x)\neq 0\}\subset\mathrm{W}$ which refines $\mathcal{W}$.

We take a simplicial complex K′ which vertices are simplices of $\mathrm{K}(\mathcal{W})$ and whose simplices are the sets $(s_0,\ldots,s_n)$ where s_i are simplices of $\mathrm{K}(\mathcal{W})$ such that s_i is a face of s_{i+1}, that is K′ is the barycentric subdivision of $\mathrm{K}(\mathcal{W})$, then there is a canonical homeomorphism $|\mathrm{K}'|\cong|\mathrm{K}(\mathcal{W})|$. We claim that the induced G-action on K′ satisfies:

> If s is a vertex of K′, and if s and gs belong to the same simplex of K′, then $s=gs$. (*)

This can be seen, by the construction of K′, since then s is a face of gs or vice versa. But the G-action preserves the dimensions of simplices, so that $s=gs$.

Let K″ be the barycentric subdivision of K′ as in the above paragraph. We shall prove that K″ satisfies the following

condition for each subgroup H of G by induction on n:

> If $(s_0, \ldots, s_n)$ and $(h_0 s_0, \ldots, h_n s_n)$ both are simplices of K'' where h_i are in H, then there exists an element h in H such that $h_i s_i = h s_i$ for all i (**)

By inductive assumption, there is an element h in H with $hs_i = h_i s_i$ for $0 \leqslant i < n$. Operation on $(h_0 s_0, \ldots, h_n s_n)$ by h^{-1} shows that $(s_0, \ldots, s_{n-1}, h^{-1}h_n s_n)$ is a simplex of K'' and then $s_0 \subset s_1 \subset \ldots \subset s_{n-1} \subset h^{-1}h_n s_n$. Thus $s_{n-1} \subset s_n \cap h^{-1}h_n s_n$, which impies $h^{-1}h_n$ acts trivially on s_{n-1}, hence trivially on s_i for $i < n$. That is $h_n s_i = h s_i$ for $i < n$. Thus $h_n s_i = h_i s_i$ for all i. Moreover, K'' also satisfies the condition (*), since if s and gs belong to some simplex of K'', then (s, s) and (s, gs) are simplices of K'', whence for some h, $s = hs$, $hs = gs$. Thus $s = gs$.

Returning to the map $\bar{f}: X \to |K(\mathcal{W})| \cong |K''|$. Then $\bar{f}^{-1}K''$ is an invariant covering, since $\bar{f}$ is equivariant. If s is a vertex of K'' and if $\bar{f}^{-1}(sts) \cap g\bar{f}^{-1}(st\,s) \neq \emptyset$, then there is a point x in X such that $\bar{f}(x)(s) \neq 0$ and $\bar{f}(x)(gs) \neq 0$, thus s and gs belong to the same simplex of K''. By the condition (*), we have that $s = gs$. Hence $\bar{f}^{-1}(st\,s) = \bar{f}^{-1}(st\,gs) = g\bar{f}^{-1}(st\,s)$. Thus we have shown that $\bar{f}^{-1}K''$ is a G-covering. Finally, one can easily show that $\bar{f}^{-1}K''$ is a regular covering by using the condition (**). Q. E. D.

From now on, let $\mathcal{U}$ be a regular covering of X, and let $K(\mathcal{U}/A)$ denote the subcomplex of $K(\mathcal{U})$ consisting of those simplices $(U_0, \ldots, U_n)$ with $U_0 \cap \ldots \cap U_n \cap A \neq \emptyset$, $\bar{K}(\mathcal{U}/A)$ denotes the subcomplex consisting of those simplices $(U_0, \ldots, U_n)$ such that $U_0 \cap \ldots \cap U_n \neq \emptyset$ and each $U_i \cap A \neq \emptyset$. For simplicity, write $K = K(\mathcal{U})$, $L = K(\mathcal{U}/A)$. Let C(K) be the oriented chain complex of K. [see ref. 2, p. 159]. Then C(K) inherits an action of G by putting $g[U_0, \ldots, U_n] = [gU_0, \ldots, gU_n]$ and hence is a module over the group ring ZG of G.

We let $\alpha = \Sigma_{g \in G} g$, then $\alpha C(K)$ is a subcomplex of C(K). Since L is an invariant subcomplex, then G acts on $C(K, L) = C(K)/C(L)$ and $\alpha C(K, L)$ is a subcomplex of C(K,L). Let π:

$K \to K/G$ be the canonical simplicial map. [K/G is the simplicial complex with vertices, the orbits $U^*=\{gU \mid g\in G\}$ of the action of G on the vertices U of K and simplices of the form $(U_0^*, \ldots, U_n^*)$ where $(U_0, \ldots, U_n)$ is a simplex of K.] We also use π to deonte the chain map $\pi : C(K, L) \to C(K/G, L/G)$.

1.2. *Theorem.*

$$\ker \{\pi : C(K, L) \longrightarrow C(K/G, L/G)\} = \ker \{\alpha : C(K, L) \longrightarrow C(K, L)\}$$

Proof. Let s be any simplex of K/G, let $s_1, \ldots, s_n$ be the simplices of K over s. Since $\mathcal{U}$ is regular, there exists $g_i \in G$ such that $s_i = g_i s_1$ for $i>1$. Thus we may orient the s_i and s so that π: $s_i \to s$ preserves those orientations. Thus it suffices to consider chains of the form $c=\Sigma n_i s_i$. Then $\pi c = (\Sigma n_i)\, s$, so that $\pi c=0$ iff $\Sigma n_i=0$.

On the other hand, since G permutes the s_i transitively and $g\alpha(c)=\alpha(c)$, thus we have $\alpha(c)=m \Sigma s_i$ for some integer m. By adding the coefficients on both sides of this equation, we see that $|G|\Sigma n_i = mn = m|G|/|Gs_1|$ where $|Gs_1|$ denotes the order of the isotropy subgroup of G at s_1. Consequently, $m=|Gs_1|(\Sigma n_i)$. Thus $\alpha c=0$ iff $\Sigma n_i=0$. Q. E. D.

By 1.2, we have the chain isomorphism:

$$\alpha C(K, L) \cong C(K, L)/\ker \alpha = C(K, L)/\ker \pi \cong C(K/G, L/G).$$

In fact, the map $\alpha C(K, L) \to C(K/G, L/G)$ by $\alpha c \to \pi c$ is this isomorphism. Let σ be the composition $C(K/G, L/G) \to \alpha C(K, L) \subset C(K, L)$ given by $\pi c \to \alpha c$.

Now we consider cohomology groups with any coefficient group Γ. Then σ induces a cochian map

$$\mathrm{Hom}(\sigma, 1) : \mathrm{Hom}(C(K, L); \Gamma) \longrightarrow \mathrm{Hom}(C(K/G, L/G); \Gamma)$$

and hence a homomorphism in cohomology $\sigma^* : H^*(K, L; \Gamma) \to H^*(K/G, L/G; \Gamma)$. Also note that π induces the map π^*: $H^*(K/G, L/G; \Gamma) \to H^*(K, L; \Gamma)$.

Since if $c^*=\pi c$, then $\pi\sigma(c^*)=\pi\alpha(c)=|G|\pi(c)=|G|\, c^*$. Also $\sigma\pi(c)=\alpha(c)$. It follows that:

$$\sigma^*\pi^* = (\pi\sigma)^* = |G| : H^*(K/G, L/G; \Gamma) \longrightarrow H^*(K/G, L/G; \Gamma) \quad (1.3)$$

$$\pi^*\sigma^* = (\sigma\pi)^* = \alpha^* = \Sigma g^* : H^*(K, L; \Gamma) \longrightarrow H^*(K, L; \Gamma) \quad (1.4)$$

Let us generalize the above discussion by considering a subgroup H of G and the diagram

$$\begin{array}{ccc} & K & \\ {\scriptstyle \pi_H}\swarrow & & \searrow{\scriptstyle \pi_G} \\ K/H & \xrightarrow[\pi_{G/H}]{} & K/G \end{array}$$

of simplicial maps. As before we use π_G, π_H and $\pi_{G/H}$ to stand for the induced chain maps. Also let $\alpha_H = \Sigma_{h\in H} h$, $\alpha_G = \Sigma_{g\in G} g$. We define a chain map

$$\sigma_{G/H} : C(K/G, L/G) \longrightarrow C(K/H, L/H)$$

by composing

$$\begin{array}{l} C(K/G, L/G) \cong \alpha_G(C(K, L)) \underset{\text{inclusion}}{\longrightarrow} \alpha_H C(K, L) \cong C(K/H, L/H) \\ \pi_G(c) \longmapsto \alpha_G(c) \overset{=}{\longrightarrow} \alpha_H(c') \longmapsto \pi_H(c'), \end{array}$$

where $c' = \Sigma g_i c$, $\{g_i\}$ being any system of representatives of the right cosets of H in G.

Since

$$\pi_{G/H}\sigma_{G/H}(\pi_G(c)) = \pi_{G/H}(\pi_H(c')) = \pi_G(c') = (|G|/|H|)\,\pi_G(c),$$

thus we have a homomorphism

$$(\sigma_{G/H})^* : H^*(K/H, L/H; \Gamma) \longrightarrow H^*(K/G, L/G; \Gamma)$$

such that

$$\begin{array}{l} (\sigma_{G/H})^*(\pi_{G/H})^* = |G|/H| : H^*(K/G, L/G; \Gamma) \\ \qquad\qquad \longrightarrow H^*(K/G, L/G; \Gamma). \end{array} \quad (1.5)$$

If $\mathscr{V}$ is a regular G-covering refining $\mathscr{U}$, then there exists an equivariant projection $p : \mathscr{V} \to \mathscr{U}$, that is $V \subset p(V)$ and $p(gV) = gp(V)$. To see this, simply choose a representative out of each orbit of G on $\mathscr{V}$ and define p arbitrarily on these representatives so that $V \subset p(V)$ (since $\mathscr{V}$ refines $\mathscr{U}$). If $gV = g'V$, where V is

one of these representatives, then $g^{-1}g'p(V) \cap p(V) \supset g^{-1}g'V \cap V = V \neq \emptyset$. This implies that $g^{-1}g'p(V)=p(V)$ for $\mathcal{U}$ is a G-covering. That is $g'p(V)=gp(V)$. Thus we can extend the definition by putting $p(gV)=gp(V)$.

Of course, an equivariant refinement projection $p : \mathcal{V} \to \mathcal{U}$ defines a simplicial map $\bar{p} : K(\mathcal{V}) \to K(\mathcal{U})$ which is equivariant. And any two such maps $p, p' : \mathcal{V} \to \mathcal{U}$ define contiguous simplicies maps $\bar{p}, \bar{p}'$, which means that for each simplex $(V_0, ..., V_n)$ in $K(\mathcal{V})$, $\bar{p}(V_0, ..., V_n)$ and $\bar{p}'(V_0, ..., V_n)$ belong to the same simplex of $K(\mathcal{U})$. This can be seen, since $\bar{p}(V_0, ..., V_n)=(p(V_0), ..., p(V_n))$ and $\bar{p}'(V_0, ..., V_n)=(p'(V_0), ..., p'(V_n))$, thus

$$p(V_0) \cap ... \cap p(V_n) \cap p'(V_0) \cap ... \cap p'(V_n) \supset V_0 \cap ... \cap V_n \neq \emptyset.$$

Returning to the map σ corresponding to two regular coverings $\mathcal{U}$, $\mathcal{V}$ with $\mathcal{V}$ being a refinement of $\mathcal{U}$ and let $p : \mathcal{V} \to \mathcal{U}$ be any equivariant projection, then we have the induced commutative diagram:

$$\begin{array}{ccc} H^*(K(\mathcal{U}), K(\mathcal{U}/A); \Gamma) & \xrightarrow{\sigma^*} & H^*(K(\mathcal{U})/G, K(\mathcal{U}/A)/G; \Gamma) \\ \downarrow & & \downarrow \\ H^*(K(\mathcal{V}), K(\mathcal{V}/A); \Gamma) & \xrightarrow{\sigma^*} & H^*(K(\mathcal{V})/G, K(\mathcal{V}/A)/G; \Gamma) \end{array}$$

by naturality of the map σ. The vertical maps are independent of the choice of p since contiguous equivariant simplicial maps $K(\mathcal{V}) \to K(\mathcal{U})$ induce contiguous maps on $K(\mathcal{V})/G \to K(\mathcal{U})/G$. Also see ref. 1, p. 164. Passage to the direct limit gives: $\sigma^* : \check{H}^*(X, A; \Gamma) \to \check{H}^*(X/G, A/G; \Gamma)$, where $\check{H}^*(X, A; \Gamma)$ denotes the Čech cohomology of (X, A) over Γ.

In the above discussions, one can use $\bar{K}$ rather K to produce the same groups [see ref. 1, p. 249]

From (1.3) and (1.4), we derive:

$$\sigma^*\pi^* = |G| : \check{H}^*(X/G, AG; \Gamma) \longrightarrow \check{H}(X/G, A/G; \Gamma) \tag{1.6}$$

$$\pi^*\sigma^* = \alpha^* = \Sigma g^* : \check{H}^*(X, A; \Gamma) \longrightarrow \check{H}^*(X, A; \Gamma) \tag{1.7}$$

In the general case, we have:

$$(\sigma_{G/H})^*; \check{H}^*(X/H, A/H; \Gamma) \longrightarrow \check{H}^*(X/G, A/G; \Gamma)$$

with

$$(\sigma_{G/H})^*(\pi_{G/H})^* = |G|/|H| : \check{H}^*(X/G, A/G; \Gamma) \longrightarrow \check{H}^*(X/G, A/G; \Gamma). \tag{1.8}$$

§ 2. SPECIAL ČECH COHOMOLOGY

Through out this section, X will be a finitistic G-space (every open covering has a finite-dimensional refinement), G is cyclic group of prime order p and A is a closed invariant subspace of X. We shall study cohomology with coefficient in Z_p. First note that by 1.1, we have that the finite-dimensional (the dimension of a covering is the dimension of its nerve.) regular coverings of X are cofinal in the set of all coverings of X.

Let $\mathcal{U}$ be any finite-dimensional regular covering of X. As before, let $K=K(\mathcal{U})$, $L=K(\mathcal{U}/A)$. Let g be a fixed generator of G and put $\beta=1+g+\cdots+g^{p-1}$, $\gamma=1-g$ in the group ring $Z_p G$. Since $g^p=1$ and since we are working over Z_p, thus $\beta\gamma=\gamma\beta=0$, and since $(-1)^i\binom{p-1}{i} \equiv 1 (\mathrm{mod}\, p)$ we have that $\beta=\gamma^{p-1}$. If $\eta=\gamma^q$, we put $\bar{\eta}=\gamma^{p-q}$. Thus $\bar{\beta}=\eta$ and $\bar{\gamma}=\beta$. Consider the chain subcomplex $\eta C(K, L; Z_p)$ of $C(K, L; Z_p)$ for $\eta=\gamma^q$, $1 \leqslant q < p$.

2.1 *Theorem.*

$$0 \longrightarrow \eta C(K, L; Z_p) \oplus C(K^G, L^G; Z_p) \xrightarrow{j} C(K, L; Z_p) \xrightarrow{\bar{\eta}} \bar{\eta} C(K, L; Z_p) \longrightarrow 0$$

is an exact sequence of the chain complex, where j is the sum of inclusions.

Proof. It suffices to consider n-chains in the orbits of s for n-simplex s of K not in L, and there are two cases, depending on whether s is in K^G or not. If s is in K^G, then $\gamma s=0$, so that $\eta s=0=\bar{\eta} s$, and the sequence restricted to this case is exact. (K^G is the subcomplex of fixed points of G on K.)

If s is not in K^G, an n-chain in $G(s)$ has the form $\Sigma n_i g^i s$,

$n_i \in Z_p$, and corresponding to the unique element $\Sigma n_i g^i$ of the group ring $\Lambda = Z_p G$. Thus the sequence reduces to

$$0 \longrightarrow \eta\Lambda \xrightarrow{j} \Lambda \xrightarrow{\bar{\eta}} \bar{\eta}\Lambda \longrightarrow 0.$$

We now investigate the exactness of this. Since these are vector space over Z_p and j is injective and η is surjective, it suffices to show that $\dim \eta\Lambda + \dim \bar{\eta}\Lambda = \dim \Lambda = p$. The kernel of $\gamma : \Lambda \to \Lambda$ consists of the elements with constant coefficients and hence 1-dimensional, generated by β. It follows that $\dim \gamma\Lambda = \dim \Lambda - 1$. However $\ker \gamma = Z_p \beta \subset \gamma^i \Lambda$ for each $1 \leqslant i < p$, since $\beta = \gamma^{p-1} = \gamma^i \gamma^{p-i-1}$. By induction, $\dim \gamma^{i+1}\Lambda = \dim \gamma(\gamma^i \Lambda) = \dim \gamma^i \Lambda - 1 = p - i - 1$. Thus $\dim \gamma^q \Lambda = p - q$. Q. E. D.

Let $H_\eta^*(K, L; Z_p) = H^*(\eta C(K, L; Z_p); Z_p)$, that is the homology of the cochain complex $\mathrm{Hom}(\eta C(K, L; Z_p); Z_p)$. For the same reasons as in section 1, we can define:

$$\check{H}_\eta^*(X, A; Z_p) = \varinjlim \check{H}_\eta^*(K(\mathscr{U}), K(\mathscr{U}/A); Z_p)$$

and

$$\check{H}^*(X^G, A^G; Z_p) = \varinjlim H^*(K(\mathscr{U}/X^G), K(\mathscr{U}/A^G); Z_p),$$

where $\mathscr{U}$ ranges over the finite-dimensional regular converings of X.

2.2 *Proposition.* Let D be a direct set and let $\{A_\alpha, f_{\alpha,\beta}\}$ and $\{B_\alpha, g_{\alpha,\beta}\}$ be direct systems of abelian groups based on D. Let $\{\theta_\alpha : B_\alpha \to A_\alpha\}$ be a homomorphism of directed systems $(\theta_\beta g_{\alpha,\beta} = f_{\alpha,\beta}\theta_\alpha)$. Assume that for each α, there exists an index $\beta > \alpha$ and a homomorphism $h_{\alpha,\beta} : A_\alpha \to B_\beta$ such that the diagram

$$\begin{array}{ccc} B_\alpha & \xrightarrow{\theta_\alpha} & A_\alpha \\ {\scriptstyle g_{\alpha,\beta}}\downarrow & \swarrow {\scriptstyle h_{\alpha,\beta}} & \downarrow {\scriptstyle f_{\alpha,\beta}} \\ B_\beta & \xrightarrow[\theta_\beta]{} & A_\beta \end{array}$$

commutes. Then the induced map $\theta : \varinjlim B_\alpha \to \varinjlim A_\alpha$ is an isomorphism.

Proof. Let $K_\alpha=\ker\theta_\alpha$, $C_\alpha=A_\alpha/\mathrm{Im}\,\theta_\alpha$, thus $0\to K_\alpha\to B_\alpha\to A_\alpha\to C_\alpha\to 0$ is exact for each α. If $\beta>\alpha$ is such $h_{\alpha,\beta}$ exists, then from the diagram:

$$\begin{array}{ccccccccc} 0 & \longrightarrow & K_\alpha & \longrightarrow & B_\alpha & \longrightarrow & A_\alpha & \longrightarrow & C_\alpha & \longrightarrow & 0 \\ & & \downarrow & & \downarrow & \swarrow{\scriptstyle h_{\alpha,\beta}} & \downarrow & & \downarrow & & \\ 0 & \longrightarrow & K_\beta & \longrightarrow & B_\beta & \longrightarrow & A_\beta & \longrightarrow & C_\beta & \longrightarrow & 0 \end{array}$$

the induced maps $K_\alpha\to K_\beta$ and $C_\alpha\to C_\beta$ must be zero. Thus $\varinjlim K_\alpha=\varinjlim C_\alpha=0$. This implies the result immediately, since the direct limit is an exact functor. Q. E. D.

2.3 *Proposition.* If $\mathscr{U}$ is a covering of a space Y and if $\mathscr{V}$ is a star refinement of $\mathscr{U}$ [see ref. 3, p. 167] with a refinement projection $p:\mathscr{V}\to\mathscr{U}$ such that $V'\cap V\neq\emptyset$ implies that $V'\subset p(V)$. Then for any subset E of Y, the image under the induced map $\bar{p}$ of $\bar{K}(\mathscr{V}/E)$ in $\bar{K}(\mathscr{U}/E)$ is contained in $K(\mathscr{U}/E)$. Moreover, if Y is a paracompact G-space and $\mathscr{U}$ is a G-covering, then there exists a G-covering $\mathscr{V}$ which is a star refinement of $\mathscr{U}$ and an equivariant projection $p:\mathscr{V}\to\mathscr{U}$ with the property: If $V'\cap V\neq\emptyset$, then $V'\subset p(V)$.

Proof. If $(V_0,\ldots,V_n)$ is a simplex of $\bar{K}(\mathscr{V}/E)$, i. e., $V_0\cap\ldots\cap V_n\neq\emptyset$ and $V_i\cap E\neq\emptyset$, then $V_0\subset p(V_i)$ for all i. Thus $p(V_0)\cap\ldots\cap p(V_n)\supset V_0\supset V_0\cap E\neq\emptyset$, so that $(p(V_0),\ldots,p(V_n))$ is a simplex of $K(\mathscr{U}/E)$.

For the last statement, we may assume that $\mathscr{U}$ is locally finite, since Y is paracompact. Let f be a G-partition of unity subordinate to $\mathscr{U}$ (see the proof of 1.1), and $\bar{f}:X\to|K(\mathscr{U})|$ be the associated equivariant map, then if L is the second barycentric subdivision of $K(\mathscr{U})$, and if we let $\mathscr{V}=\bar{f}^{-1}L$, then $\mathscr{V}$ is a G-covering and is a star refinement of $\mathscr{U}$ [see ref. 3, p. 171-173]. Finally we choose p arbitrary on representatives V for the orbits of G on $\mathscr{V}$ such that $V'\subset p(V)$ for $V'\cap V\neq\emptyset$, and then extend p by putting $p(gV)=gp(V)$. Q. E. D.

2.4 *Proposition.* Let $\mathscr{U}$ be a G-covering of a G-space Y and $E\subset Y$

be a closed invariant subspace. Then there exists a G-covering $\mathscr{V}$ refining $\mathscr{U}$ such that:

$$K(\mathscr{V}/E^G) \subset K(\mathscr{V}/E)^G \subset \bar{K}(\mathscr{V}/E^G)$$

and

$$K(\mathscr{V}/Y^G) \subset K(\mathscr{V})^G = \bar{K}(\mathscr{V}/Y^G).$$

Proof. The first inclusion means that if $V \cap E^G \neq \emptyset$ (where V is in $\mathscr{V}$), then $gV = V$ for all g, and this always holds for a G-covering. The second inclusion means that if $V \cap E \neq \emptyset$ and $gV = V$ for all g, then $V \cap E^G \neq \emptyset$. The equality means that $gV = V$ for all g iff $V \cap Y^G \neq \emptyset$. We take the following three cases:

(i) If $y \in Y - Y^G$, let V_h (which is contained in some U of $\mathscr{U}$), U_h be disjoint open sets containing y, hy respectively for each $h \notin G_y$, then take $W = \bigcap_{h \notin G_y} (V_h \cap h^{-1}U_h)$, and thus $V_y = \bigcap_{g \in G_y} g[W \cap (Y - Y^G)]$ is an open set containing y which is invariant under the action of G_y and is such that $hV_y \cap V_y = \emptyset$ for each $h \notin G_y$.

(ii) If $y \in Y^G \cap E = E^G$, then $y \in U$ for some U of $\mathscr{U}$. Thus the set $V_y = \bigcap_{g \in G} gU$ is an invariant open set containing y.

(iii) If $y \in Y^G - E$, then $y \in U$ for some U of $\mathscr{U}$. Thus the set $V_y = \bigcap_{g \in G} g[U \cap (Y - E)]$ is an invariant open set containing y.

It is clear that all the V_y and their translates by G have provided the desired G-covering. Q. E. D.

It follows from 2.2-2.4 that the inclusion of pairs

$$(K(\mathscr{U}/X^G), K(\mathscr{U}/A^G)) \longrightarrow (K(\mathscr{U})^G, K(\mathscr{U}/A)^G)$$

induces isomorphism:

$$\varinjlim H^*(K(\mathscr{U}/X^G), K(\mathscr{U}/A^G); Z_p) \cong \varinjlim H^*(K(\mathscr{U})^G, K(\mathscr{U}/A)^G; Z_p)$$

where $\mathscr{U}$ ranges over the G-converings of X, hence we may restrict the coverings to be finite-dimensional regular covering when X is finitistic.

Thus

$$\check{H}(X^G, A^G; Z_p) \cong \varinjlim H^*(K(\mathscr{U})^G, K(\mathscr{U}/A)^G; Z_p),$$

where $\mathscr{U}$ ranges over the finite-dimensional regular coverings of X. Hence from 2.1, we have an exact sequence:

$$\cdots \longrightarrow \check{H}^i(X, A; Z_p) \xrightarrow{j^*} \check{H}^i_\eta(X, A; Z_p) \oplus \check{H}^i(X^G, A^G; Z_p) \xrightarrow{\delta^*} \check{H}^{i+1}_{\bar{\eta}}(X, A; Z_p) \xrightarrow{\bar{\eta}^*} \check{H}^{i+1}(X, A; Z_p) \longrightarrow \cdots \qquad (2.5)$$

2.6 *Theorem.*

$$\dim \check{H}^n_\eta(X, A; Z_p) + \sum_{i \geq n} \dim \check{H}^i(X^G, A^G; Z_p) \leq \sum_{i \geq n} \dim \check{H}^i(X, A; Z_p),$$

where X, A, G are described as in the begining of this section, and $\dim \check{H}^i$ denotes the dimension of $\check{H}^i$ over Z_p.

Proof. If $\Sigma_{i \geq n} \dim \check{H}^i(X, A; Z_p)$ is infinite, then there is nothing to prove. Thus we assume that $\dim \check{H}^i(X, A; Z_p) < \infty$ for $i \geq n$. Since X is finitistic, there exists an integer N such that $\check{H}^i(X, A; Z_p) = 0$ for $i \geq N$.

First, we claim then that $\check{H}^i_\eta(X, A; Z_p) = 0 = \check{H}^i(X^G, A^G; Z_p)$ for $i \geq N$. [One can show that $\check{H}^i_{\bar{\eta}}(X, A; Z_p) = 0 = \check{H}^i(X^G, A^G; Z_p)$ for $i \geq N$ in the same way.] Suppose this is not the case, then there exists a finite-dimensional regular covering $\mathscr{U}$ of X so fine that, with $K = K(\mathscr{U})$, $L = K(\mathscr{U}/A)$, so that

$$H^i_\eta(K, L; Z_p) \oplus H^i(K^G, L^G; Z_p) \longrightarrow \check{H}^i_\eta(X, A; Z_p) \oplus \check{H}^i(X^G, A^G; Z_p)$$

is nonzero for some such $i \geq N$. Consider the commutative diagram:

$$\begin{array}{ccccc} H^i_\eta(K, K; Z_p) \oplus H^i(K^G, L^G; Z_p) & \xrightarrow{\delta^*} & H^{i+1}_{\bar{\eta}}(K, L; Z_p) & \longrightarrow & H^m_\eta(K, L; Z_p) = 0 \\ \downarrow & & \downarrow & & \downarrow \\ \check{H}^i_\eta(X, A; Z_p) \oplus \check{H}^i(X^G, A^G; Z_p) & \xrightarrow{\delta^*} & \check{H}^{i+1}_{\bar{\eta}}(X, A; Z_p) & \longrightarrow & \check{H}^m_\eta(X, A; Z_p) \end{array}$$

where the horizontal maps are compositions of the maps δ^*: $H^j_\eta \oplus H^j \to H^{j+1}_{\bar{\eta}}$ and those with η, $\bar{\eta}$ interchanged alternating, and here $m > \dim K$. Since $\check{H}^j(X, A; Z_p) = 0$ for $j \geq N$, then by using 2.5 again, we have the bottom row of this diagram consisting of monomorphisms, this contradicts the nontriviality of the

left-hand vertical map.

The exact sequence of 2.5:

$$\check{H}^i(X, A; Z_p) \longrightarrow \check{H}^i_\eta(X, A; Z_p) \oplus \check{H}^i(X^G, A^G; Z_p) \longrightarrow \check{H}^{i+1}_{\bar{\eta}}(X, A; Z_p)$$

shows that

$$\dim \check{H}^i_\eta(X, A; Z_p) + \dim \check{H}^i(X^G, A^G; Z_p) \leqslant \dim \check{H}^{i+1}_{\bar{\eta}}(X, A; Z_p) + \dim \check{H}^i(X, A; Z_p) \quad \text{for } i \geqslant n.$$

Let

$$a_i = \dim \check{H}^i_\eta(X, A; Z_p),$$

$$b_i = \dim \check{H}^i(X^G, A^G; Z_p),$$

$$\bar{a}_i = \dim \check{H}^i_{\bar{\eta}}(X, A; Z_p)$$

and

$$c_i = \dim \check{H}^i(X, A; Z_p).$$

Thus we have

$$a_n + b_n \leqslant \bar{a}_{n+1} + c_n$$

$$\bar{a}_{n+1} + b_{n+1} \leqslant a_{n+2} + c_{n+1}$$

$$\vdots$$

$$\bar{a}_{n+2k-1} + b_{n+2k-1} \leqslant a_{n+2k} + c_{n+2k-1}$$

$$a_{n+2k} + b_{n+2k} \leqslant \bar{a}_{n+2k+1} + c_{n+2k},$$

until $n+2k+1 \geqslant N$.

The last inequality shows that both sides are finite. Then, the next to the last inequality has both sides finite, and so on. Thus every term in the above is finite. Adding these inequalities and canceling gives $a_n + \Sigma_{i \geq n} b_i \leqslant \Sigma_{i \geq n} c_i$ as claimed. Q. E. D.

Note that the map $\beta = 1 + g + \ldots + g^{p-1} : C(K, L; Z_p) \to C(K, L; Z_p)$ has the same kernel as does the composition

$$C(K, L; Z_p) \longrightarrow C(K, L \cup K^G; Z_p) \longrightarrow C(K/G, L/G \cup K^G/G; Z_p).$$

This follows from that if s is a simplex of K not in L, then

$$\beta(\Sigma n_i g^i s) = (\Sigma n_i)\beta(s) = 0 \quad \text{iff } \Sigma n_i = 0 \text{ or } s \in K^G.$$

Thus

$$\beta C(K, L; Z_p) \cong C(K/G, L/G \cup K^G; Z_p)$$

and in cohomology we have

$$H^*_\beta(K, L; Z_p) \cong H^*(K/G, L/G \cup K^G/G; Z_p) \tag{2.7}$$

2.8 *Proposition.* Let $\mathcal{U}$ be a regular covering of a space Y and let $\mathcal{U}_G$ denote the covering of Y/G by the sets $\tilde{U}=G(U)/G$ with indexed by $\mathcal{U}/G$ ($\mathcal{U}/G$ denotes the set of orbits of G on $\mathcal{U}$). Then the assignment $U^*=\{gU \mid g\in G\} \xrightarrow{\varphi} \tilde{U}=G(U)/G$ gives an isomorphism of the simplicial complexes $K(\mathcal{U})/G \cong K(\mathcal{U}_G)$.

Proof. If $\tilde{U}=\tilde{V}$, then $U=gV$ for some $g\in G$ since $\mathcal{U}_G$ is indexed by the sets $\mathcal{U}/G$. This implies $U^*=V^*$. Thus φ is 1-1 between vertices of $K(\mathcal{U})/G$ and $K(\mathcal{U}_G)$. Also φ is onto between vertices.

If $(U_0, \ldots, U_n)$ is a simplex of $K(\mathcal{U})$, i. e., $U_0 \cap \ldots \cap U_n \neq \emptyset$, then $\tilde{U}_0 \cap \ldots \cap \tilde{U}_n \neq \emptyset$. This proves that φ is a simplicial map. Conversely, every simplex of $K(\mathcal{U}_G)$ has the form $(\tilde{U}_0, \ldots \tilde{U}_n)$ with $\tilde{U}_0 \cap \ldots \cap \tilde{U}_n \neq \emptyset$. Then $g_0U_0 \cap \ldots \cap g_nU_n \neq \emptyset$ for some g_i in G, and $\varphi^{-1}((\tilde{U}_0, \ldots, \tilde{U}_n)) = ((g_0U_0)^*, \ldots, (g_nU_n)^*) = (U_0^*, \ldots, U_n^*)$. Thus φ^{-1} is also a simplicial map. Therefore, φ is an isomorphism. Q. E. D.

In the above proposition, we see that every covering $\mathcal{V}$ of Y/G is produced in this way since $(\pi^{-1}\mathcal{V})_G = \mathcal{V}$. And since an indexed covering and the associated self-indexed covering are refinements of one another, this will not effect the Čech cohomology.

From 2.2-2.4, and 2.8, we have

$$\begin{aligned}\check{H}^*(X/G, A/G \cup X^G/G; Z_p) &= \varinjlim H^*(K(\mathcal{U}_G), K(\mathcal{U}_G/A \cup X^G); Z_p) \\ &\cong \varinjlim H^*(K(\mathcal{U})/G, K(\mathcal{U}/A \cup X^G)/G; Z_p) \\ &\cong \varinjlim H^*(K(\mathcal{U}/G, K(\mathcal{U}/A)/G \cup K(\mathcal{U})^G/G; Z_p)\end{aligned}$$

where $\mathcal{U}$ ranges over the finite-dimensional regular coverings of X. By 2.7, we have

$$\check{H}^*_\beta(X, A; Z_p) \cong \check{H}^*(X/G, A/G \cup X^G/G; Z_p) \tag{2.9}$$

§ 3. APPLICATION

3.1 *Proposition.* Let G be a finite group acting on a fintistic space X, and $A \subset X$ be closed and invariant. Suppose that $\check{H}^i(X, A; Z)=0$ for $i>n$, then $\check{H}^i(X/G, A/G; Z)=0$ for $i>n$.

Proof. First, we shall show that $\check{H}^i(X/G, A/G; Z)=0$ for $i>n$, when G is a cyclic group of prime order p. Also we consider, for the present, the case of a p-group G. Since a p-group is solvable, there is a nontrivial normal subgroup G′ [see ref. p. 24-25]. Since $K/G \cong (K/G')/(G/G')$ (where K denotes the nerve of the covering), an induction on the order of G reduces this case to the case in which G is cyclic of order of p.

From the exact sequence $0 \to Z \xrightarrow{p} Z \to Z_p \to 0$, there is an exact sequence

$$\cdots \longrightarrow \check{H}^i(X, A; Z) \longrightarrow \check{H}^i(X, A; Z) \longrightarrow \check{H}^i(X, A; Z_p) \longrightarrow \check{H}^{i+1}(X, A; Z) \longrightarrow \cdots$$

By hypothesis, $\check{H}^i(X, A; Z)=0$ for $i>n$. Thus $\check{H}^i(X, A; Z_p)=0$ for $i>n$. From 2.6, we have

$$\dim \check{H}^i_\beta(X, A; Z_p) + \sum_{j \geq i} \dim \check{H}^j(X^G, A^G; Z_p) \leqslant \sum_{j \geq i} \dim \check{H}^j(X, A; Z_p) \quad \text{for } i>n.$$

Hence

$$\check{H}^i_\beta(X, A; Z_p) = 0 = \check{H}^i(X^G, A^G; Z_p) \quad \text{for } i>n.$$

Thus by using 2.9, we also have

$$\check{H}^i(X/G, A/G \cup X^G/G; Z_p)=0 \quad \text{for } i>n.$$

We consider the exact sequence of the triple $(X/G, A/G \cup X^G/G, A/G)$ and then use the Nother isomorphism theorem of modules [see ref. 5, p. 13]. Thus we have the long exact sequence

$$\cdots \longrightarrow \check{H}^i(X/G, A/G \cup X^G/G; Z_p) \longrightarrow \check{H}^i(X/G, A/G; Z_p) \longrightarrow \check{H}^i(X^G, A^G; Z_p) \longrightarrow \check{H}^{i+1}(X/G, A/G \cup X^G/G; Z_p) \longrightarrow \cdots$$

Thus

$$\dim \check{H}^i(X/G, A/G; Z_p) \leqslant \dim \check{H}^i(X/G, A/G \cup X^G/G; Z_p) + \dim \check{H}^i(X^G, A^G; Z_p)=0 \quad \text{for } i>n.$$

Therefore,

$$\check{H}^i(X/G, A/G; Z_p)=0 \quad \text{for } i>n.$$

Using $0\to Z\to Z\to Z_p\to 0$ again, we have the exact sequence

$$\cdots\longrightarrow\check{H}^i(X/G, A/G; Z)\longrightarrow\check{H}^i(X/G, A/G; Z)\longrightarrow \check{H}^i(X/G, A/G; Z_p)\longrightarrow\cdots \quad (i>n).$$
$$\|$$
$$0$$

This means that $\check{H}^i(X/G, A/G; Z)$ is divisible by p for $i>n$ [see ref. 5, p. 93]. By 1.6, the composition

$$\check{H}^i(X/G, A/G; Z)\xrightarrow{\pi^*}\check{H}^i(X, A; Z)\xrightarrow{\sigma^*}\check{H}^iX/G, A/G; Z)$$

is multiplication by $|G|=p$ through 0. Hence $\check{H}^i(X/G, A/G; Z)=0$ for $i>n$.

Now for the case of a general finite group G, let H be a Sylow p-group in G. By 1.8, there are homomorphisms

$$\check{H}^i(X/G, A/G; Z_p)\xrightarrow{(\pi_{G/H})^*}\check{H}^i(X/H, A/H; Z_p)\xrightarrow{(\sigma_{G/H})^*}\check{H}^i(X/G, A/G; Z_p)$$

whose composition is multiplication by $|G|/|H|$. Since $|G|/|H|$ is prime to p and $\check{H}^i(X/H, A/H; Z_p)=0$ for $i>n$ in above processes. Thus $\check{H}^i(X/G, A/G; Z_p)=0$, for $i>n$.

The exact sequence

$$\check{H}^i(X/G, A/G; Z)\longrightarrow\check{H}^i(X/G, A/G; Z)\longrightarrow\check{H}^i(X/G, A/G; Z_p)=0$$

$(i>n)$ shows that $\check{H}^i(X/G, A/G; Z)$ is divisible by each prime p of the factors of $|G|$, and hence is divisible by $|G|$. The composition.

$$\check{H}^i(X/G, A/G; Z)\longrightarrow\check{H}^i(X, A; Z)\longrightarrow\check{H}^i(X/G, A/G; Z)$$

is multiplication by $|G|$ through 0 $(i>n)$. Therefore, $\check{H}_i(X/G, A/G; Z)=0$ for $i>n$, where G is a finite group. Q. E. D.

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有限羣作用之 Čech 上同調理論

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摘 要

我們研究有有限羣作用其上的仿緊空間的 Čech 上同調理論。首先先考慮空間上的特殊覆蓋，然後定出 Čech 上同調羣以及討論它們的一些性質。

我們也考慮有 p 階循環羣作用的有窮論空間。並以 Z_p 爲係數，所造出的 Čech 上同調羣成爲在 Z_p 上的向量空間。以致引發維維度的問題。最後針對以上的討論給予一應用。

IRON TRANSPORT STUDIED BY DOUBLE-LABELLED RADIOACTIVE TRACER TECHNIQUE

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ABSTRACT

The basic physiological function of three protiens: ferritin, transferrin and hemoglobin for iron transport is introduced The evidence of transferrin-reticulocyte interaction for heme synthesis, in the immature blood cell was studied by double-labelled radioactive iron and the results are presented in this work.

INTRODUCTION

Iron is not only a passive substrate in haem synthesis but also participates in the control of this process. Understanding the mechanisms of iron uptake, delivery, storage and entrance into erythroid cells, reaching the haem molecule and ready for haemoglobin synthesis, is essential under both normal and pathological conditions. In this paper I will briefly introduce three protiens: ferritin, transferrin and haemoglobin which play key roles in this process and also present results of my study on iron transport by radioactive tracing technique.

Ferritin is widely distributed throughout the various organs of mammals, with particularly high concentrations being found in the liver spleen, and bone marrow. Dietary iron, after reducing to Fe^{+2} in the upper part of the intestine, is absorbed by the mucosal cells and transferred to ferritin. Once the mucosal ferritin is saturated, no further iron is taken up. Ferritin consists of a shell of protein subunits surrounding a

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core of ferric hydroxyphosphate. The principal function of ferritin is to act as a soluble storage form for ferric iron, in which it can be mobilized. For the maintenance of the ferric hydroxyphosphate micelle in a soluble form, the stability of the subunit structure of the protein is of obvious importance. Models[1] have been proposed and a generally agreed feature is that apoferritin (the protein part of ferritin) contains 24 subunits (polypeptide chain of molecular weight 18,500.) and properly has 5 tyrosin residues per subunit which are at the subunit-subunit interface; a tryptophan residue in the vicinity of the interface acts as a signal, changing its position in the interior of the protien for the solvent just before dissociation occurs; and that the subunit-subuit interface contains at least 3 carboxyl groups of rather low pK (2.16 to 3.25). Iron complexes mobilize in and out of ferritin through the channel formed between the subunits' interface and its mechanism of mobilization is still under exploration. Mazur *et al.*[2] first demonstrated the transfer of iron between ferritin and transferrin and that only the ferrous ion of ferritin was transferred. Both Bielig[3] and Mazur's lab[4] later found that transport iron via a semipermeable membrane demains ascorbic acid from ferritin to transferrin and ATP from transferrin to ferritin. Perkins[5] in 1969 did a detailed analysis of iron transport between ferritin and transferrin and found it to be a passive process, which was unaffected by the iron moving against a concentration gradient. A reducing agent was required for transfer, of those used ascorbate was the best. The transfer reaction is pH dependent, with an optimum pH at 7.3, and transfer is dependent on the iron content of transferrin and ferritin. The results can be expressed by the scheme,

$$\begin{array}{ccc} \mathrm{Fe^{+3}\text{-}Transferrin} + \mathrm{chelate} & \overset{\text{reducing agent}}{\rightleftharpoons} & \mathrm{Fe^{+2}\text{-}chelate} \\ & & \Big\downarrow\Big\uparrow \\ \mathrm{Fe^{+3}\text{-}ferritin} & \overset{O_2}{\rightleftharpoons} & \mathrm{Fe^{+2}\text{-}ferritin} \end{array}$$

The above description was again deduced from semipermeable

transport experiment. When we consider the transfer of iron between ferritin and transferrin *in vivo.* much less is known. Only one fact at present is certain, that iron must be presented to ferritin in the Fe^{+2} form and must be mobilized in this form. Further progress in this area must await advances in our knowledge of the transport of iron across cell membranes and the interaction of tranferrin, ferritin with the receptor molecules on the outer and inner surface of the cell membrane.

Tranferrin is a β-globulin found in plasma. The molecule contains 676 residues[6] yielding a molecular weight of about 81,000. It possesses two binding sites for metal ions the isoelectric point for apotransferrin (ATf) is 5.6, for diferric transferrin (Fe_2-Tf) it is 5. The binding of each Fe (III) to transferrin (Tf) is acompanied by the simultaneous binding of an anion, such as bicarbonate or carbonate, and the release of three protons into solution. The protein sequence has been determined but only at relatively low resolution (6 angstroms). X-ray crystallographic results are available[8].

The kinetics of iron-binding to transferrin is an area where controversial reports constantly arise. Warner and Weber (1953) measured the thermodynamic properties and claimed that iron bound to transferrin co-operatively, in a pairwise fashion. Aasa (1963) using classical equilibrium dialysis adduced evidence that the binding sites of human transferrin are equivalent and independent in their affinities for iron. Aisen (1978) *et al.,* followed the above groups procedure and reanalysed the experiment. They claimed that a two-sited protein like transferrin must have four rather than two intrinsic or site constants, since the binding of iron to each distinguishable site has its own equilibrium. These exciting studies and arguements are not directly relavent to the theme of this paper, even it is a very important fact. Those interested in the details of this kinetic study may refer to reference 9.

Iron (III) ion with unpaired 3-d electrons, possesses good properties for a protein complexation study. Fe (III)-Tf-HCO_3

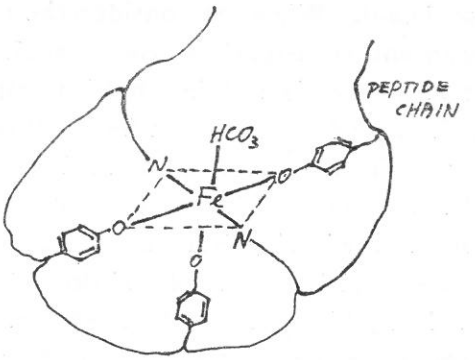

Fig. 1. Diagrammatic representation of the ferric ion, bicarbonate chelate of transferrin. (Transaction, New York Academy of Sciences 16, 182 [1953]).

Fe-O tyrosine binding to Fe (III)
Fe-N imidazoles liganded to Fe (III)

(salmon pink color) displays a strong absorption band near 465 nm, which presumably is due to the 3-d electron in Fe (III) allowed ligand-metal charge transfer transition. Because of the sensitivity of ligand field about a para-magnetic metal ion, electron spin resonance (ESR) spectroscopy has proven particularly valuble in the study of the transferrins. In frozen solution, Fe(III)-Tf displays two signals. A strong resonance occurs at a g value of 4.3 (1,500G). The associated weaker signal downfield at g around 9.5 (700 G) is found for many nonheme iron protiens and iron chelates having high spin Fe^{+3} in a rhombic crystal field enviroment. The detailed feature in the g=4.3 region of Fig. 2 are unique to transferrin. Uncomplexed Fe(III) at physiological pH exists as polymeric hydroxide which is difficult to detect by ESR. ESR studies employing other metal ions to probe for differences in the sites of transferrin have met with various success.[10]

The two sites of iron binding to transferrin are equivalent kinetically or spectroscopically certaintly endowed with great challenge in protein chemistry. But most important, and hence most studied, is the role of serium transferrin in the transport

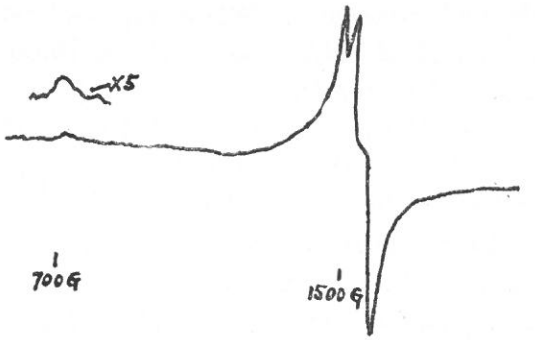

Fig. 2. Characteristic frozen (77K) solution X-band ESR spectrum of 0.5 mM diferric transferrin in 0.01 M $NaHCO_3$, pH 8.5. (Coordination Chemistry Reviews, 22,9 [1977])

of iron among sites of absorption, storage, utilization and excretion. Transferrin, a true carrier molecule, has no known enzymatic function of its own and is conserved for many cycles of iron transport in its interaction with target tissues. Its function as a source of haem synthesis by erythroid cell can not be replaced by synthetic iron chelators. The accessibility of the reticulocyte in the pheripheral circulation has made it the model for most studies of transferrin-cell interactions in which protien functions as an iron donor. In this paper, the interaction between Ferritin; a storage site, transferrin; a transport molecule and reticulocyte; target tissue for haem synthesis will be the theme of presentation.

HAEMGLOBIN AND HAEM IN RETICULOCYTE

Formation of blood cells occurs principally in the bone marrow of the axial skeleton, ribs, and sternum. In early stages of devolopment, the immature cell contains a large nucleus, maturation proceeds by cell division and differentiation. During the process the nucleus becomes progressively smaller. At this time of their entry into the circulation, newly formed erythrocytes do not have a nucleus but usually do contain

mitochondria and ribosomes. When appropriately stained, a reticulum composed of RNA is seen within these young cells (reticulocyte). They constitute about 1% of the red cells of a normal person. Mature red blood cell lack of mitocndria and RNA, therefore is incapable of protein synthesis.

Among all three blood proteins mentioned in this paper, haemglobin (Hb) structure is the only one that has been determined by high resolution (2.8 Angstroms) 3-dimensional X-ray. It's deoxy and liganded tertiary structure forms are similar but the quaternary structure of deoxy Hb differs from that of liganded Hb. It has been shown that co-operativity is associated with the quaternary structure change that takes place during ligation. [for a review article see[11]]. With the aid of X-ray results and because of its important role as an oxygen carrier, extensive studies on this protein have been done.[12]

Haemglobin is a tetramer of four chains α_2 β_2 with a molecular weight about 64 K. Each subunit has a haem group (Fig. 3) located in a pocket formed by the folded protein. The iron (III) in the haem group possess a octahedron crystal field configuration. Five nitrogen atoms (four from prophyrin and one from histidine) attached to iron (III) and the sixth ligand position normally being occupied by oxygen atom which is from either oxygen molecule or monocarboxide. Cyanide ion (CN^-) possesses even higher affinity to iron in prophyrin than the oxygen molecule and hence is a very toxic substance. Haem is synthesized in mitocondria and cytoplasm but the uptake of iron (II) to form heme is achieved in mitocondria. How and

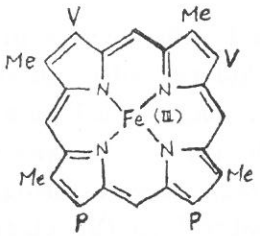

Fig. 3. The Haem group.

where the iron ion releases from its carrier transferrin to haem is still uncertain. Since 1964 Katz and Jandl[13] assumed that iron was removed from transferrin at the surface of erythroid cell, cytoplasmic carriers exist which obtain iron from Tf and donate it to the site of haem synthesis. In 1969, Morgan and Appleton[14] provided evidence that the transferrin molecules enter the interior of erythoid cell and this internalization idea obtained great support. In 1972, Shulman and Martinez-Medellin[15] thought it is possible that transferrin transports iron to the mitochondria without the intermediacy of another intracellular carrier. At any rate, during the past decade, the intracellular transport of iron from the plasma membrane to the mitochondria still reveals many gaps in our understanding and controversy exists at all stages in the process. In this paper, I will introduce double-incubation method of Fe_2-Tf and present some results of the study of transferrin interaction with reticulocyte in order to reveal the mission of iron transprot for haem synthesis.

EXPERIMENT

Physical Measurement Methods The magnetic resonance techniques involved in the Fe_2-Tf-ATP study made use of the E-4 ESR spectrometer. ^{31}P NMR were done on a JOEL-100 and a NIC-300 FTNMR spectrometer. The isotope counting was done on a Beckman LS-230 Liquid Scintillation counter. We then used the PDP 8 Focal Program to carry out the data analysis obtained from the scintillation counter.

Human Transferrin (electrophoretic purity 98-99%) was bought from Behring Diagnostics and further purification was done by dissolving 1 gram of Tf in 50ml glass distilled water. Dialysis three times in 0.1 M citrate; acetate mixture (1:1) at pH 4.5, followed up 3 times dialysis against H_2O. Then dialysis against 0.1 M sodium perchlorate and three times water to remove perchlorate anion binding with transferrin Most of the time the dialysis bag was attached on a rotary, stirred and left

in refergerator (4℃) for 3 to 4 hours for each change of dialysis solution. If a rotary dialyzer is not used, then 8 to 12 hours of each dialyzing is needed. The concentration of Tf is determined by A_{280} measurement and Fe_2 Tf was prepared by putting Tf in a test tube, then adjusting pH values higher than 7.5 with bicarbonate. $FeCl_3$ was then added to Tf with an amount of two equevalent weights. Bicarbonate was then used to bring up the pH value to 7-8. This solution by now is 90% saturated transferrin, after dialysing against salin buffer overnight, the Fe_2 Tf is ready for use. For the tracing study, then the coresponding hot iron isotope ^{59}Fe or ^{55}Fe is used for making Fe_2 Tf (half life for ^{59}Fe is 49 days and ^{55}Fe is 2.5 years).

Preparation of Reticulocyte Cell is achieved by injecting 0.6% APH (1-Acetyl-2-Phenydrazine) 0.9% NaCl solution in rabbit for two days and 1.2% APH 0.9% NaCl for another two days. Then wait for two days before bleeding. At the moment of bleeding, xylene was first used to rub the rabbit ear and irritate the artery. Then a disposable hypodermeric needle (20G sterile) was pierced into the artery and fresh blood ejected out like a stream. Blood was collected in a 60 ml plastic bottle with HEPARIN (1ml/30ml blood) To prevent blood clotering, HEPARIN was made by (1 mg/ml) dissolving in dithizone extracted salin buffer (0.13 M NaCl, 0.005 M KCl, 0.0074 M $MgCl_2$, 0.01 M Hepes, pH=7.4). The collected blood was stored at 0℃ until use (within one day). In order to have RBC only, blood was washed with phosphate salin buffer (0.005 M Na_3PO_4, 0.15 M NaCl pH=7.4). The ratio of salin buffer vs. red blood cell is around four to one by volume to assure efficient washing. After centrifuge, we sucked out the supernatant and buffy coat with an aspirator. The procedure was repeated four times in a cold room and was then ready for incubation.

To packed cells, cold salin buffer was added to make 50% hematocraft. Then 1 mg/ml glucose and 320μl $^{59}Fe_2$ Tf (1.34 μg) in 1 ml of RBC was added and then incubated at 37℃ for 30 min. Continuous shaking was done by putting the incubation sink on

a shaker. Then the cells weve washed again 4 times in a cold room. Afterward 80 μl (1.38 μg) of $^{55}Fe_2$ Tf and glucose were added, then incubated at 37°C. The first aliquot (1/2 ml) was taken out after a few min of incubation and the second aliquot (1/2 ml) was again removed after another interval of time. This was repeated at several intervals to pace out the time development of iron distribution and transport in the reticulocyte. The aliquot RBC was washed with phosphate salin buffer 4 times and lysed with 15 mmos (2 ml) phosphate buffer and allowed to stand for 30 min. Constant stirring was done to assure good lysing. It was centrifuged (Sorvall Superspeed RC-2B centrifuge, Rotor model *ss*-34 *r*=4. 25″, and 10 K r. e. m. speed was used) at 0°C for 30 min. and the supernatant transferred to a tube and put 1.5 ml on ACA 44 column with a flow rate of 8 sec./drop. A calibration run was done to obtain an elution profile before hand and known that three peaks were observed on the O. D. (280nm) vs tube number plot. The buffer used in this elution was HEPES (0.1 M KCl, 0.01 M HEPES, pH= 7.5) on a ACA 44 ultragel column. The elution profile was confirmed by comparing with Morgan's work[16], i. e. the first peak is ferritin and the second peak is hemoglobin. A small peak/shoulder before hemoglobin was assumed to be transferrin. The last peak is a low molecular weight unknown compound. After fractional collection was done on the elution, a Beckman LS-230 Liquid Scintillation counter was used to obtain the hot iron distribution profile This is based on the assumption we made that the first peak is ferritin (colorless) and the second peak hemoglobin (red) and low molecular peak (colorless). With different molecular weight of protien and color, we were forced to treat the first two peaks differently (The third peak was ignored due to its low level count). A blank sample was prepared corespondingly to each method of treatment.

The ferritin peak portion was treated with conc. (12 M) HCl (100 μl per 800 μl of ferritin solution) and allowed to stand more than 3 hours to degrade the protein. We then added 100 μl

20 mM EDTA, 300 μl saturated NaAc and 10 ml aqusol. Then put this ferritin sample along with a blank scintillation counting vial for measurement.

The second peak hemolysate 1 ml is treated with 0.2 ml of clorox (5.25% NaOCl) and was allowed to stand for one hour at room temperature. The red color faded. A freshly prepared 0.2 ml of ascorbic acid solution (120 g/l) was added to reduce unreacted clorox. Then 10 ml of aqusol was added and a count made of the sample along with a blank in liquid scintillation counter.

In this series of counting, the quenching problem had to be considered and calibration was done by comparing a pair of ^{59}Fe and ^{55}Fe hemolysate samples. The factor of this quenching calibration was used for later samples. Elution profiles of two incubations, both the O. D. and counting results are displayed in Fig. 4. The average recovery of Fe^{+3} in each step is around 70–78%. Counts were also taken after throughly washing the cell and before adding ^{55}Fe. The uptake of ^{59}Fe thus calculated is about 0.14 nmol of iron/mg of protein/30 min.

After all the counts were obtained from the scintillation counter, a PDP 8 Focal program was used to solve the following simultaneous equations.

$$\text{Channel A} = a_1(^{55}Fe) + a_2(^{59}Fe)$$
$$\text{Channel B} = b_1(^{55}Fe) + b_2(^{59}Fe)$$

and the ratio of ^{55}Fe and ^{59}Fe were obtained.

CONCLUSION

This experiment has been repeated three times, and all indicate that regardless of the incubation time interval, The counting ratio at Hb peak for $^{59}Fe/^{55}Fe$ is around 20 to 1. The counting elution profile for ^{55}Fe is not shown in Fig. 4 mainly because it's low level of counting. The uptake of ^{55}Fe by ferritin at its maximal counting is just bearly above the backgraound reading. The consistancy of the ^{59}Fe and ^{55}Fe ratio

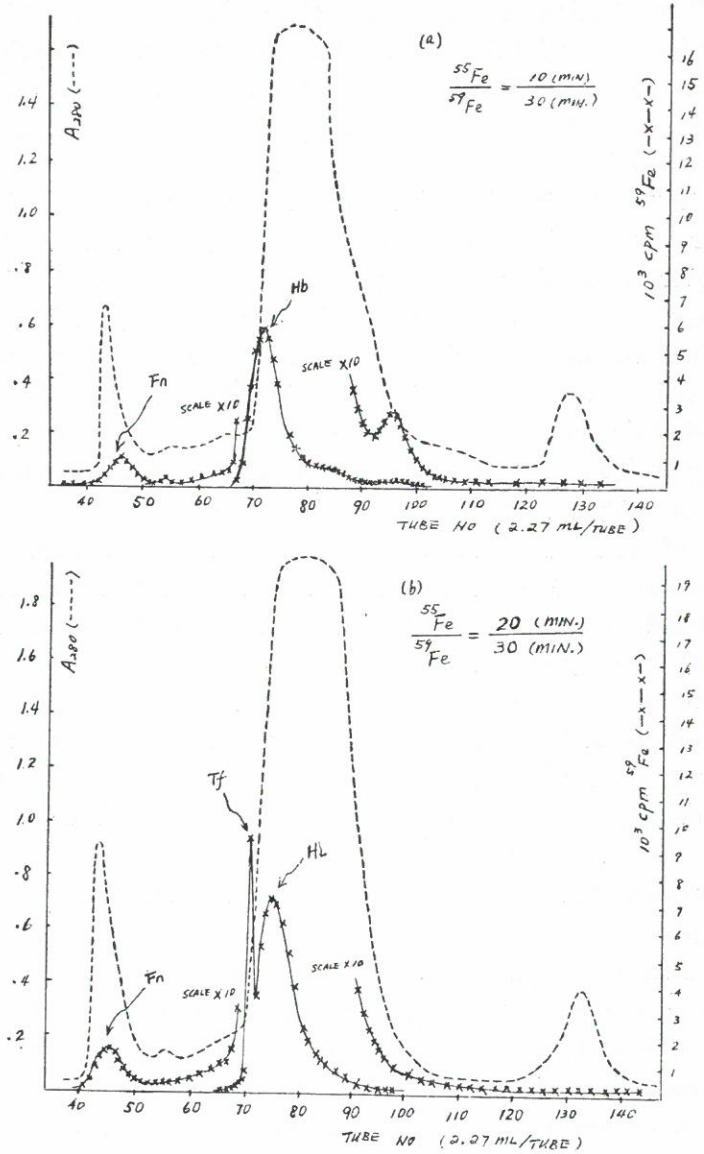

Fig. 4. Utragel ACA 44 elution profile (O. D. 280 nm) of lysate from reticulocyte cell. The column was equilibrated and elution with 0.01 M HEPES buffer pH=7.5, 0.1 M KCl. (a) lysate obtained from 30 min $^{59}Fe_2$ Tf incubation and followed by 10 min.'s $^{55}Fe_2$ Tf incubation. (b) lysate obtained from 30 min.'s $^{55}Fe_2$ Tf incubation and followed by 20 min.'s $^{55}Fe_2$ Tf incubation.

for all incubation intervals may indicate the equivalency in iron donating ability for A and B sites of transferrin. Comparing the (a)and (d) elution profiles of Fig. 4, the results indicate at the shorter incubation time, 40 min., the counting ratio (1:52) at the maximal point for ferritin (Fn) to hemoglobin (Hb) is higher than its for 50 min. (1:46) incubation. Another striking different feature observed in this comparison is (a) has a small hump/ shoulder right after Hb peak yet there is no sign of Tf. For (b) the small hump after Hb peak disappears and a Tf peak is seen before the Hb peak. All these facts confirm the previous reported result, such as internalization of Tf to the reticulocyte. Cytoplasmic intermedia chelator may exist and its binding ability to iron may be equal or better then Tf. Ferritin may serve as only an storage site instead of also being an intermediacy of iron transport to mitochondria. In this work we added glucose during incubation without added extra ATP because we found by ESR and ^{31}P NMR study that ATP will not attack Fe(III) directly in Tf. at pH=7.4[17]. Comparing with the iron uptake study reported by Konopka and Turska[18], they found ^{59}Fe uptake of ^{59}Fe-transferrin by rat mitochondria membrane pellet of approximately 0.2 nmol iron/mg protein/30 min at pH 7.4, 2 mmol/1 ATP and 37℃ The uptake proceeded linearly for 45-60min and about 55% of ^{59}Fe was recovered in the inner membrane. From our study and the results contributed by Konopka's group, no conclusive physiological significance can be drawn at this moment. It is known that ATP does influence the iron uptake in the cell, then if ATP does not directly attach to iron, how does ATP helped iron release from transferrin? Is it possible that ATP interacts with transferrin and produces local microenviromental pH fluctuations which change the conformation of transferrin and make Fe(III) more exposed to the outer enviroment for reducing to Fe(II) and hence expelled by transferrin? In this double incubated work we showed that human transferrin interacts with rabbit reticulocyte and may perform a kinetically equivalent iron donation. For the iron

transport pathway in the cell, it seems some other complimentary technique is needed to gain unequivocal evidence.

ACKNOWLEDGEMENTS

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血液蛋白中鐵質元素傳輸現象之研究

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摘　要

探討三種血液蛋白質：Ferritin, Transferrin 及 Hemoglobin 在鐵質輸送生理學上的基本作用，同時介紹數種物理化學試驗方法。在本研究中，以放射性鐵質元素追踪法所得之結果，作爲總結。

由愛玉瘦果抽製低甲氧基果膠粉之研究

食品營養研究所

陳　雪　娥

摘　要

愛玉瘦果含有豐富的高甲氧基果膠 (High Methoxyl Pectin, HMP) 及高活性的果膠酯酶 (Pectin esterase, PE)，經殺菁抑制 PE 活性，所萃取出的果膠屬於 HMP。影響愛玉 HMP 之萃取因子有萃取溫度，用水量及萃取時間；最適合愛玉 HMP 萃取的條件是 75 倍用水量在室溫下，萃取10分鐘，可得到82.82%之果膠萃取率。以未殺菁的愛玉瘦果，萃取 HMP 時，其果膠萃取率及高甲氧基含量都比殺菁者低。利用愛玉瘦果的 PE，對 HMP 行脫甲基作用轉爲低甲氧基果膠 (Low Methoxyl Pectin, LMP)，其萃取最適當之溶劑爲 0.02 M trisodium citrate，萃取時間愈長，pH 值愈低，果膠萃取率也愈高，而果膠之甲氧基其含量愈低。至 2 小時，甲氧基含量可降至 4.5%。以甲氧基含量爲 5.06%之果膠作凝膠試驗，結果以 0.4% LMP，0.15% adipic acid(已二酸)及 40 ppm Ca 之凝膠强度最接近市售之愛玉凍。

前　言

果膠是以半乳糖醛酸 (D-galacturonic acid) 爲單位，經 α-1.4 鍵結而成的膠性多醣類，其半乳糖醛酸的羧基(Carboxyl group)可以與 methanol 結合成 ester，這種酯化的程度決定果膠的各種重要性質。當羧基完全酯化時，即 DE 值 (Degree of Esterification) 爲100%而甲氧基含量爲 16.32%；一般稱甲氧基含量在 7 %以上者爲高甲氧基果膠 (High Methoxy Pectin, HMP)，反之在 7 %以下者稱爲低甲氧基果膠 (Low Methoxy Pectin, LMP)[8]。高低甲氧基果膠之凝膠機制差異很大，前者最適凝膠條件爲 pH 2.0～3.5，糖分60～65%，後者凝膠之 pH 值範圍較大，在 pH 2.5～6.5，不須糖分即能凝膠，但須有兩價金屬離子存在方可[11]。

愛玉瘦果含有豐富的 HMP[1]，HMP 可經由攪拌過程溶於水中，並藉存在瘦果中且同時溶出的果膠酯酶 (Pectinesterase, PE) 的作用，將 HMP 經脫甲基作用 (demethylation)，轉變成 LMP，使愛玉瘦果溶出液不受糖酸限制而凝膠[8]。Speirs 等人[9] 將柑桔皮及蕃茄皮在 pH 8.5 緩衝溶液下處理，其果膠受本身 PE 作用，使柑桔皮果膠之 DE 值由 64.5%降爲10.5%，蕃茄的果膠由22.2%降爲5.6%。King 等人[5] 以 pH 8.5 緩衝溶液(？)處理檸檬皮渣，使其果膠之 DE 值由60%減爲17%。Tuerena 等人[10] 同樣利用柑桔皮本

身 PE 的作用，使 DE 值由61.9%降至5.5%。Michel 等人[7] 於萃取甜菜果膠時發現，萃取時間愈長，果膠產率愈高，而 DE 值愈低。本研究擬探討愛玉瘦果於殺青抑制 PE 後，HMP 萃取的最適條件，及利用瘦果本身之 PE，進行脫甲基作用後，萃取 LMP，並探討所得之 LMP 的凝膠條件。

材料與方法

材料：本研究所使用原料購自臺北零售商店的乾燥愛玉瘦果。

方法：

1. 高甲氧基果膠之萃取

愛玉瘦果經 80℃ 眞空乾燥（殺青）8 小時，以研磨機磨碎後，於室溫下加入10～100 倍水，攪拌 10～60 分鐘，用玻璃棉過濾，濾液加入95%酒精，使果膠沈澱，以 Whatman No. 4 濾紙過濾，除去酒精，於 30℃ 下眞空乾燥48小時。

2. 低甲氧基果膠之萃取

愛玉瘦果加入 50 倍之 0.02 M 檸檬酸鈉溶液 (trisodium citrate) pH 8.36，經果汁機打碎 1 分鐘後，攪拌至 pH 爲 6.7、6.6、6.5、6.4、6.3、6.25 時以玻璃棉過濾，濾液加入 95 %酒精，使果膠沈澱，以 Whatman No. 4 濾紙過濾，除去酒精，於 30℃ 下眞空乾燥48小時。

$$\text{果膠萃取率}(\%)=\frac{\text{萃取產品重}(g)\times\text{產品果膠含量}(\%)}{\text{愛玉瘦果重}(g)\times\text{愛玉瘦果果膠含量}(\%)}\times 100\%$$

3. 果膠含量測定

採用 Kintner 和 Van Buren[6] 於1982年發表之 m-Hydroxydiphenyl 的修正方法，首先將酒精不溶物溶於水，並稀釋至每毫升含 galacturonic acid 5～75 μg，取 1 ml 稀釋液，於 ice-water bath 中，加入 6 ml H_2SO_4/tetraborate 溶液，混合均勻，然後放入 100℃ 沸水中加熱 5 分鐘，立即放入ice-water bath 中冷却，加入 0.1 ml 0.15% *m*-hydroxydiphenol 溶液 (in 0.5% NaOH)，混合均勻，靜置20分鐘以去氣泡，再以分光光度計 (Hitachi 220s, Japan) 於 520 nm 下測吸光度，果膠含量以 anhydrogalacturonic acid 表示，另以 anhydrogalacturonic acid (Sigma, USA) 當標品，製作定量曲線。

4. 愛玉瘦果果膠含量測定

取愛玉瘦果約 5 g 加入85% alcohol 150 ml，加熱至 80℃ 廻流30 min，以 Whatman No. 4 濾紙過濾，在 30℃ 眞空乾燥48小時，於 4℃ 儲存備用。此酒精不溶物再依 3.之方法測定果膠量。以此方法測得本研究所使用愛玉瘦果果膠含量爲 6.67%。

5. 甲氧基含量測定

取 100 mg 果膠溶於 40 ml 沸水中，冷却至室溫，以 0.05 N NaOH 滴定至 pH 7.0，加入 10 ml 0.5 N NaOH 靜置30分鐘，以 0.05 N NaOH 滴定至 pH 7.0，假設用去 x ml NaOH，而空白試驗用去 y ml，則

$$\text{甲氧基含量}(\%)=(y-x)\times 0.05\times 31/100\times \text{pectin content}\times 100\%^{(4)}$$

6. L. M. P 凝膠質地之測定

L. M. P 及 $CaHPO_4$，adipic acid（已二酸）溶於水後倒入 100 ml 之燒瓶中，2小時後以物性測定儀 (Rheometer, NRM-2020J-CW Fudoh Kogyo Co. Ltd. Japan.) 測其膠性，測定條件如下：

力 (force): 200g

套頭 (adapter): No. 6，直徑 5 mm

載物臺速度：30 cm/min

記錄紙速度：30 cm/min

結 果 與 討 論

一、高甲氧基果膠之萃取

愛玉瘦果經80℃之眞空乾燥，其 PE 已被抑制，因此萃取果膠不被 PE 作用，應屬於 HMP，傳統萃取果膠所用的溶劑均爲 HCl 或 HNO_3 水溶液，酸在萃取過程中會使果膠行脫甲基作用而降低 DE 值[7]。吾人曾利用0.5% HNO_3

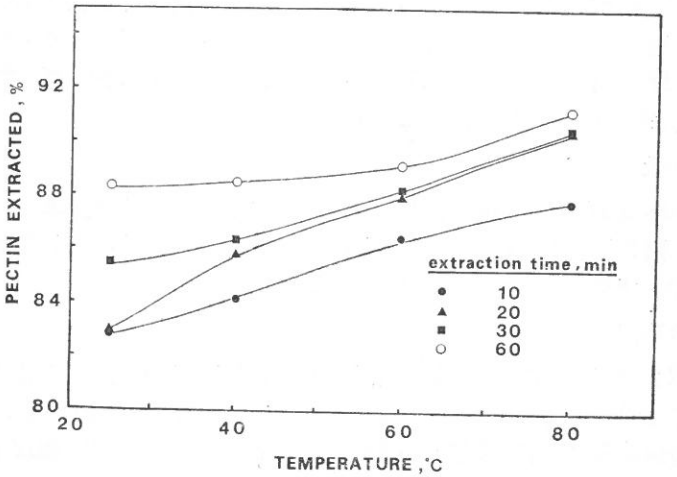

Fig. 1. Effect of the extraction temperature on the extraction rate of pectin from sycone of Akeotsang.

Table 1. Effect of extraction temperature on the methoxyl content of pectin* from sycone of Awkeotsang

Extraction Temp. ℃	Extraction Time (min)			
	10	20	30	60
	Methoxyl Content (%)			
25	11.28	11.23	11.18	11.14
40	11.37	11.32	11.23	11.24
60	11.35	11.33	11.35	11.24
80	11.40	11.39	11.38	11.37

* Pectin was extracted with 75 times weight of distilled water.

當溶劑，萃取愛玉瘦果果膠，結果在萃取過程很容易凝膠，因 HMP 經酸作用轉變爲 LMP 又在低 pH 值下，所以容易凝膠。以水當溶劑，於萃取過程並未凝膠，因此決定以水當溶劑萃取 HMP 以探討萃取溫度，用水量及萃取時間對果膠抽取率及甲氧基含量的影響。

1. 萃取溫度

以75倍水於室溫及 40℃，60℃，80℃ 恒溫水浴中攪拌 10，30，60 分鐘，所得果膠萃取率如圖1所示。由圖1知加溫可提高果膠萃取率，以80℃處理60分鐘所得 91.28 %的萃取率最高。但25℃處理60分鐘，其萃取率亦高達 88.35 %，不同萃取溫度下所得果膠甲氧基含量如表1所示，果膠甲氧基含量並未受溫度影響，因此雖然加溫可提高果膠萃取率，但並不顯著，爲節省能源，吾人認爲室溫(25℃）較適合作愛玉 HMP 之萃取。

2. 用水量

以 10～100 倍水在室溫下萃取 10，20，30，60 分鐘，其果膠萃取率如圖2所示，由圖2知果膠萃取率隨着用水量的增加而上升，至75倍水量時達到平衡，因此75倍用水量最適合愛玉 HMP 之萃取。

3. 萃取時間

由圖2亦可看出萃取時間愈長，果膠萃取率愈高，但增加的百分比並不顯著；以75倍用水量爲例，於室溫萃取10分鐘時已達 82.82%而60分鐘爲 88.35%，因此在10分鐘時幾已達平衡狀態。表2爲不同用水量及萃取時間下之果膠甲氧基含量，甲氧基含量與萃取用水量並無明顯關係，而隨萃取時間增加有降低的趨勢，但因 PE 已被抑制，因此其降低量並不明顯。

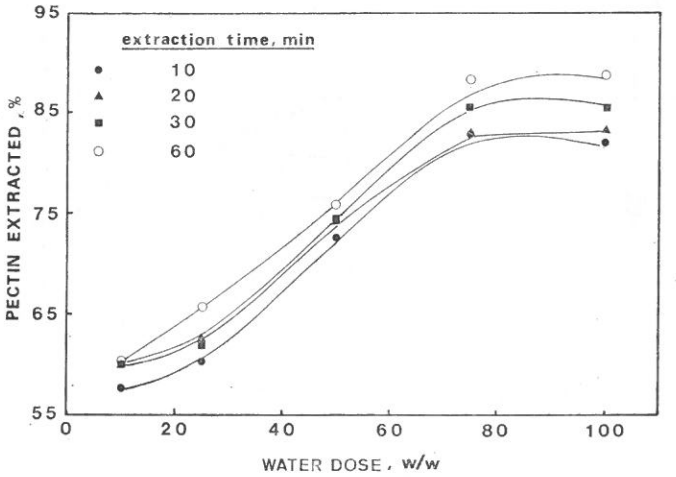

Fig. 2. Fffect of water dose on the extraction rate of pectin from sycone of Akeotsang.

Table 2. Effect of water dose on the methoxyl content of pectin* from sycone of Awkeotsang

Water dose (w/w)	Extraction Time (min)			
	10	20	30	60
	Methoxyl Content (%)			
10	11.42	11.34	11.28	11.08
25	11.45	11.20	11.24	11.12
50	11.39	11.22	11.20	11.07
75	11.28	11.23	11.18	11.14
100	11.36	11.31	11.18	—

* Pectin was extracted at room temperature.

4. 以未殺菁愛玉瘦果萃取果膠

未經殺菁的愛玉瘦果研磨後，以75倍水萃取果膠，與殺菁者比較，結果如圖3所示。未殺菁者，果膠萃取率與甲氧基含量均較殺菁者低，因未經殺菁之愛玉瘦果之 PE 仍具活性，於果膠萃取過程中，對 HMP 進行脫甲基作用，使甲氧基含量降低；而在研磨過程，可能因磨擦生熱，使部分 PE 失去活性，因此甲氧基含量降低有限，仍屬於 HMP。又由於其他酵素，如果膠分解酶的活性仍存在，可能使果膠分解成小分子，無法被酒精沈澱，因此未殺菁愛玉瘦果之果膠萃取率較殺菁者低。

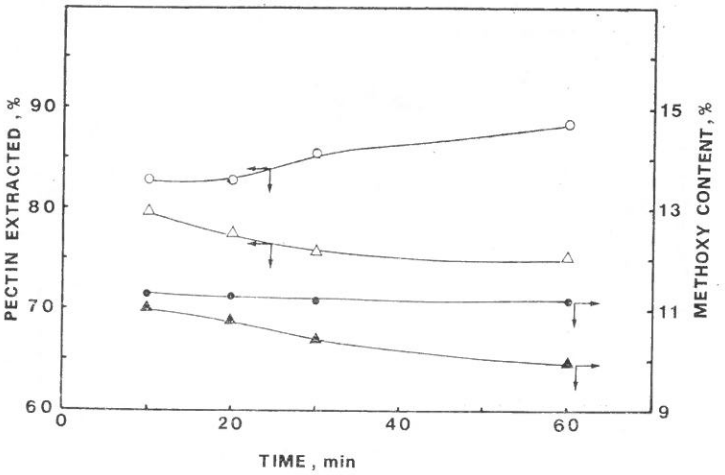

Fig. 3. Effect of blanching on the extraction rate and methoxyl content of HMP from sycone of Akeotsang.
△, ▲, unblanching; ○, ●, blanching.

二、低甲氧基果膠萃取

愛玉瘦果的果膠屬於 HMP，而瘦果本身亦含有高活性的 PE [1]，因此本研究希望藉愛玉瘦果本身的 PE 將 HMP 脫甲基生成 LMP。由於低甲氧基果膠凝膠後，若將膠體破壞，則無法再凝膠，而 LMP 在 pH 6.5 以下即有可能凝膠，因此 LMP 的萃取過程，溶液之 pH 值須維持在6.5以上，以防止凝膠。而且愛玉瘦果之 PE 最適作用 pH 值在 7 左右 [1]，因此溶液 pE 值維持在 6.5 以上亦有助於 PE 之活性，提高脫甲基的速率。本實驗以水，sodium hydrogen phosphate buffer，及 trisodium citrate 進行 LMP 萃取，當溶劑與愛玉瘦果比爲50：1 時，以水當溶劑，攪拌20分鐘即有凝膠現象產生，pH 值由6.71降爲4.20，以 sodium hydrogen phosphate buffer 0.02M pH 7.50 當溶劑時，攪拌 2 小時後 pH 爲 6.93，且未凝膠，但加入 citric acid 使降至 4.0，則無法凝膠，因 buffer 中的 Na^+ 會妨礙凝膠作用[2]。以 0.02 M pH 8.36 trisodium citrate 當溶劑，在攪拌 2 小時後仍未凝膠，其 pH 由 8.36 降到 6.25，當加入 citric acid 使 pH 降到 4.0 時凝膠現象很快就產生，由以上結果顯示 0.02 M pH 8.36 之 trisodium citrate 應適用於 LMP 萃取。

以 0.02 M trisodium citrate 當萃取溶劑，使用50倍溶劑用量萃取 LMP，所得結果如圖 4 所示，隨着萃取時間增長，pH 值與甲氧基含量逐漸降低，因爲 HMP 受 PE 作用脫去甲基，同時放出 H^+ 使 pH 降低，由圖 4 可知 pH

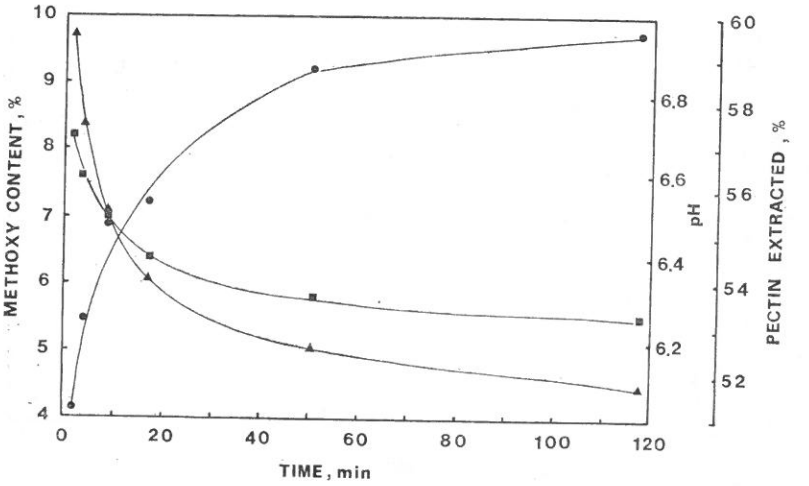

Fig. 4. Effect of extraction time on the extraction rate and methoxyl content of LMP and pH value of extracted solution.
●, pectin extracted; ■, pH value; ▲, methoxy content.

值與甲氧基含量的降低速率，於萃取前20分鐘最快，因愛玉 PE 之最適 pH 值在7左右，所以在 LMP 萃取初期 PE 活性最高，pH 值及甲氧基含量的降低速率也最快，萃取時間愈長，果膠萃取率愈高，至50分鐘時幾已達平衡。

以50倍溶劑(0.02 M trisodium citrate)萃取愛玉瘦果50分鐘，得到甲氧基含量爲 5.06%之果膠粉，以之作凝膠試驗，結果如圖 5 所示。愛玉瘦果加入50

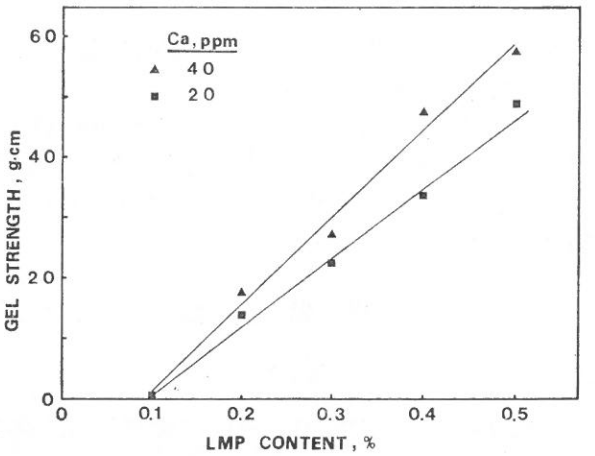

Fig. 5. Relationship between the LMP content and gel strength.

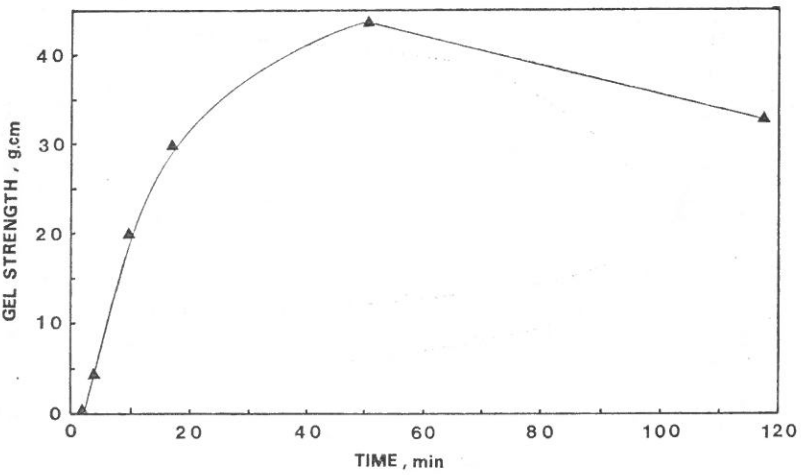

Fig. 6. Effect of extraction time on the gel strength of LMP from sycone of Akeotsang.

倍水打碎 2 分鐘後過濾，濾液靜置 2 小時，當對照組，對照組的 gel strength 爲45 g·cm，由圖 5 可知，以0.4% LMP+0.15% adipic acid+40 ppmCa^{++} 三組合，其凝膠强度最接近對照組，亦卽此配方之凝膠最接近市售愛玉凍。以此配方試驗不同時間所萃取出之 LMP 凝膠强度結果如圖 6 所示，由圖 6 知萃取 50分鐘之 LMP 凝膠强度最强。

結　　論

1. 高甲氧基果膠萃取之最佳條件爲乾燥愛玉瘦果在室溫下，以75倍用水量萃取10分鐘，其果膠萃取率可達 82.82%。

2. 低甲氧基果膠萃取係以50倍量的 0.02 M trisodium citrate 當溶劑，萃取50分鐘時，pH 值爲 6.30，甲氧基含量5.05%，此時有最大之凝膠强度。

3. 以 0.4% LMP, 0.15% adipic acid 及 40 ppm Ca^{++} 配方所得之凝膠，其凝膠强度與市售之愛玉凍相同。

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Studies on the Preparation of Low Methoxyl Pectin Powder from the Sycone of Awkeotsang

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ABSTRACT

The Sycone of Awkeotsang (*Ficus Awkeotsang* Makino) contains high concentrations of methoxyl pectin (HMP) and high activity pectin esterase. The extracted pectin from the blanched sycone belongs to HMP. The factors which affect the extraction of the HMP from the sycone of Awkeotsang are the extraction temperature, the water dose and the length of extraction time. The best condition for the extraction of HMP was to use water in a 75 to 1 ratio at room temperature. After ten minutes the extraction rate reached 82.82% of the total pectin. The blanching treatment affects the extraction rate and the methoxyl content of HMP.

By using the internal pectin esterase of sycone, the HMP can be converted to low methoxyl pectin (LMP) through the demethylation reaction. The most appropriate extraction solvent was 0.02 M trisodium citrate. The extraction rate and the methoxyl content of LMP and the pH of the extracted solution were affected by the length of the extraction time. As the reaction continued for two hours, the methoxyl content decreased to 4.5%. The result obtained from the gelling test with a solution containing 0.4% extracted LMP (5.06% of methoxyl content), 0.15 adipic acid and 40 ppm Ca^{++} is very similar to that of the sycone gel on the market.

都市婦女冷凍食品消費行為之研究

生活應用科學系

黃　韶　顏

摘　要

本研究以臺北、臺中、高雄3,804名婦女爲研究對象，採問卷調查方式，研究目的在於探討都市婦女冷凍食品知識、態度、購買行爲正確性及使用現況；不同地區婦女冷凍食品知識、態度、購買行爲正確性，使用頻率、滿意程度之差異性；冷凍食品知識、態度、購買行爲正確性的相關及重要影響因素；不同變項對冷凍食品知識、態度、購買行爲正確性之相關及不同使用羣的人對冷凍食品知識、態度、購買行爲正確性的差異。

本研究採用次數百分比、重覆量數單因子變異數分析、單因子變異數分析、皮爾遜積差相關、集羣分析、單因子變異數分析、進行各項考驗，結果發現：

1. 都市婦女冷凍食品知識偏低，但對冷凍食品態度與購買行爲正確性尚可。
2. 不同地區婦女對冷凍食品知識、態度、購買行爲正確性、使用頻率、滿意程度有差異性。
3. 都市婦女冷凍食品知識、態度、購買行爲正確性有顯著正相關。
4. 不同變項對冷凍食品知識、態度、購買行爲正確性、使用頻率有顯著的相關。
5. 不同使用羣在冷凍食品態度無顯著的差異，但在冷凍食品知識以中使用羣優於低使用羣，購買行爲正確性以中使用羣優於低使用羣，高使用羣優於低使用羣。

壹、緒　言

隨着生產技術的提昇，臺灣區農產品生產的數量與種類每年有增加的趨勢，由於新鮮材料極易腐敗必須藉由食品加工方法將過剩的農產品經過適當的加工方可延長保存期限，十九世紀初期人們發明了冷凍設備將新鮮材料經適當處理後經低溫凍結，因此冷凍食品具有長期貯存對於安定農村經濟有很大貢獻。

歐美各先進國家在飲食生活力求速簡，冷凍食品已普偏爲其國人所接納，我國對冷凍食品的發展已有二十多年歷史，大多以外銷爲主，現今國人所得逐年增加，家中冰箱普偏化及超級市場逐年增加，對冷凍食品的發展有很大潛力，爲了解國人對冷凍食品的認識、接納力與使用現況而作此研究。

人類社會由自給自足演變至生產導向，生產者以自己的利益爲依歸，現今社會因產品種類多進入了銷售導向，生產者不能只靠促銷來達到目的，而是要了解消費者的需求，消費行爲的研究便成了重要的課題，由於冷凍食品必須在具有冷

凍櫃的超級市場或青年商店才可買到，在吳恪元（民70）指出國內超級市場以臺北、臺中、高雄最普徧因此本研究以臺北、臺中、高雄婦女爲研究對象，研究目的如下：

一、了解都市婦女冷凍食品知識、態度與購買行爲的正確性。

二、比較臺北、臺中、高雄三區婦女在冷凍食品知識、態度、購買行爲正確性，使用頻率及滿意程度之差異。

三、了解都市婦女冷凍食品的使用現況。

四、探討都市婦女冷凍食品知識、態度與購買行爲的相關。

五、探討不同變項如年齡，家中共同生活人口數、收入、職業有無、社經地位等對冷凍食品知識、態度、購買行爲正確性與使用頻率之相關。

六、探討影響都市婦女冷凍食品知識、態度、購買行爲正確性與使用頻率之重要因素。

七、探討冷凍食品不同使用羣對冷凍食品知識、態度與購買行爲正確性的差異。

貳、研究方法

一、研究對象

本研究採用叢集抽樣法，由臺北、臺中、高雄三市抽取國小、國中、高中各一校，各校各抽一班，問卷由老師交給學生帶回給家中主要負責買菜的婦女填答，共發出 4,500份問卷，三星期後收回 4,018份，回收率 89.3%，經剔除填答不全者有效問卷 3,804份占總回收之 94.6%。

二、研究工具及步驟

本研究採用問卷調查法收集資料，所用的工具包括自編之 1. 冷凍食品知識測驗量表 2. 冷凍食品態度量表 3. 冷凍食品購買行爲正確性量表 4. 冷凍食品使用現況調查表 5. 個人基本資料調查表。

首先參考國內外學者編製出問卷大綱，再由十八位專家學者進行問卷內容效度處理，進行預試後作建構效度及信度分析，了解受試者填答情況，再進行實際施測，現將問卷經預試後所作的分析與結果列於表1。

三、資料處理

有效樣本收齊全之後，在師大電子計算中心利用社會科學統計系統之電腦程式（Statistical Package for the Social Science 簡稱爲 SPSS^x）爲工具進行資料分析工作。本研究採用的統計方法包括二次數百分比，皮爾遜積差相關，多元逐步迴歸分析、集羣分析、重覆量數單因子變異數分析、卡方考驗、單因子共變數分析，其分析架構如圖1所示：

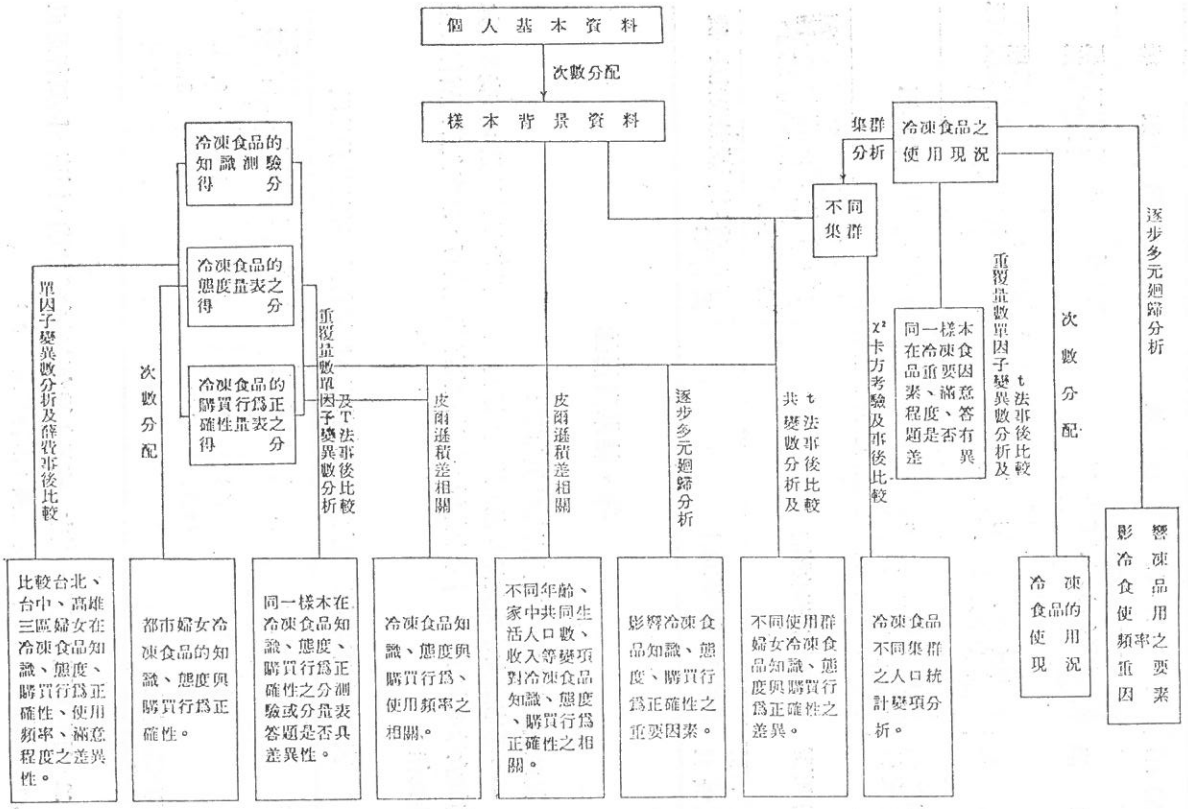

圖1. 本研究之資料分析圖

表1. 預試後問卷之分析與結果

問卷內容	項目分析	信度	效度	問卷架構
知識	取 鑑別指數(D)>0.2 難度(P)在 0.4～0.8之間的題目	KR−20 =0.87		共20題：定義3題，加工4題 選購4題，貯存6題 使用3題
態度	取 鑑別度(DP)>0 臨界比(CR)>3 之題目	α 係數 =0.789	由因素分析求建構效度萃取出4個因素	共18題：品質與利用價值6題 冷凍與新鮮食品比較5題 使用者特性5題 方便性2題
購買行爲正確性	取 鑑別度(DP)>0 臨界比(CR)>3 之題目	α 係數 =0.9.5	由因素分析求建構效度萃取出2個因素	共15題：選購與使用12題 貯存3題
使用現況	視填答情形修改題目			內容包括：使用頻率、消息來源、每月花費金錢、購買季節、滿意程度、購買原因、不買原因、積極改進項目
個人基本資料	視填答情形修改題目			內容包括：個人背景資料及一般購買行爲

參、結果與討論

爲達研究目的，本研究所得結果如下：

一、都市婦女冷凍食品知識、態度、購買行爲正確性得分結果：由表2可知都市婦女冷凍食品知識得分十分低，對冷凍食品態度尙可，冷凍食品購買行爲正確性尙佳。

表2. 都市婦女冷凍食品知識、態度、購買行爲正確性得分結果

統計量數 / 量表	人數	平均數	標準差	滿分	每題滿分	平均每題平均數
知識	3,804	58.38	0.696	20	1	0.292
態度	3,804	57.82	6.771	90	5	3.21
購買行爲正確性	3,804	58.94	1.374	75	5	3.929

二、不同地區（臺北、臺中、高雄）婦女冷凍食品知識、態度、購買行爲正確性、使用頻率、滿意程度之差異，所得結果如下：

㈠冷凍食品知識

由表3結果可見臺北、臺中、高雄三區婦女在冷凍食品知識得分未達顯著差異。

表3. 不同地區婦女在「冷凍食品知識」之單因子變異數分析摘要表

地 區	人 數	平均數	標準差	變異來源	自由度	離均差平方和	均 方	F 值
A臺北	1,355	5.87	1.4712	組 間	2	6.1830	3.0915	1.4391
B臺中	1,226	5.86	1.4424	組 內	3801	8165.4707	2.1482	
C高雄	1,223	5.78	1.4826	全 體	3803	8171.6538		

㈡冷凍食品態度

由表4可見臺北婦女對冷凍食品態度優於高雄婦女；臺中婦女對冷凍食品態度優於高雄婦女但臺北與臺中婦女在冷凍食品態度則不具顯著差異。

表4. 不同地區婦女在「冷凍食品態度」之單因子變異數分析摘要表

地 區	人數	平均數	標準差	變異來源	自由度	離均差平方和	均 方	F 值	薛費法事後比較
A臺北	1,355	58.0686	5.9507	組 間	2	484.001	242.0055	6.9015*	
B臺中	1,226	58.0636	5.8693	組 內	3801	133283.7166	35.0654		A＞C
C高雄	1,223	57.3025	5.9415	全 體	3803	133767.7277			B＞C

* $P<0.01$

㈢冷凍食品購買行爲正確性

由表5可見臺北、臺中、高雄三區婦女對冷凍食品購買行爲正確性沒有顯著差異。

表5. 不同地區婦女「冷凍食品購買行爲正確性」之單因子變異數分析摘要表

地 區	人 數	平均數	標準差	變異來源	自由度	離均差平方和	均 方	F 值
A臺北	1,355	58.9018	8.4241	組 內	2	41.6444	20.8222	0.2653
B臺中	1,226	58.8499	9.0883	組 間	3801	298342.9453	78.4906	
C高雄	1,223	59.0965	9.0945	全 體	3803			

㈣冷凍食品使用頻率

由表6可見臺中婦女冷凍食品使用頻率高於高雄婦女；臺北婦女的使用頻率亦高於高雄婦女，但臺北與臺中婦女則未達顯著差異。

表6. 不同地區婦女「冷凍食品使用頻率」之單因子變異數分析摘要表

地區	人數	平均數	標準差	變異來源	自由度	離均差平方和	均方	F值	薛費法事後比較
A臺北	1,355	11.3100	2.6222	組內	2	281.1716	140.5858	18.9801*	
B臺中	1,226	11.1166	2.8817	組間	3801	28153.9921	7.4070		A>C
C高雄	1,223	11.0392	2.6639	全體	3803	28435.1638			B>C

* P<0.001

(五)冷凍食品滿意程度

由表7可見僅臺中婦女對冷凍食品的滿意程度高於高雄婦女，其他地區如（臺中、臺北）；（臺北、高雄）婦女對冷凍食品的滿意程度均未達顯著差異。

表7. 不同地區婦女「冷凍食品滿意程度」之單因子變異數分析摘要表

地區	人數	平均數	標準差	變異來源	自由度	離均差平方和	均方	F值	薛費法事後比較
A臺北	1,355	12.9550	1.9560	組內	2	38.2795	19.1393	4.4881*	
B臺中	1,226	13.1036	2.1916	組間	3801	16209.4816	4.2645		B>C
C高雄	1,223	12.8553	2.0520	全體	3803	16247.7610			

* P<0.05

三、都市婦女冷凍食品的使用現況

使用場合以沒特定時候最多，其次是晚餐及忙碌時；消息來源主要由親友處得知，其次爲電視、報紙，其他來源甚少；每月花費以100～800元最多；購買時認爲重要的因素主要爲新鮮度、製造日期、品質、營養價值，認爲最不重要的爲新奇、他人推薦、價格；冷凍食品的使用頻率以冷凍調理食品最多，其次冷凍畜產、冷凍水產及冷凍蔬菜；購買季節以認爲四季無差異最多；對冷凍食品的滿意程度以對冷凍調理食品最滿意，每題滿分爲5分時，冷凍調理食品滿意度平均得分爲3.579，其次爲冷凍畜產，平均每題得分爲3.402；購買主要原因爲使用方便，結果分別認爲冷凍調理食品方便者占47.9%，冷凍畜產方便者占45%，冷凍水產占28.9%，冷凍蔬菜占23.1%；不買主要原因認爲冷凍食品不新鮮認爲各類冷凍食品不新鮮所得百分比爲冷凍水產占18.3%，冷凍畜產占11.2%，冷凍蔬菜占18.8%，冷凍調理食品占10.6%；認爲應積極改進的項目以政府及廠商對冷凍食品的品質管理最重要占53.7%，其次爲建立優良標示，加强民衆對冷凍食品的宣導工作。

四、都市婦女冷凍食品知識、態度與購買行爲正確性呈顯著的正相關，即冷

凍食品知識得分越高，對冷凍食品的態度愈好，購買行爲亦越正確，結果如表8所示。

表8. 都市婦女冷凍食品知識、態度與購買行爲正確性的相關矩陣

變項 \ 統計量數	知識	態度	購買行爲正確性
知識	1.0000		
態度	0.0949*	1.0000	
購買行爲正確性	0.1143*	0.1651*	1.0000

* $P<0.001$

五、不同變項對冷凍食品知識、態度、購買行爲正確性與使用頻率之相關，結果如表9所示，在表中顯示不同變項與冷凍食品知識、態度、購買行爲正確性之相關係數均很小，僅冷凍食品態度與使用頻率、滿意程度之相關係數較具有意義，且僅滿意程度與使用頻率之相關性較大，其餘相關性不大，現分述於下：

表9. 不同變項與冷凍食品知識、態度、購買行爲正確性與使用頻率之相關矩陣

變數 \ 統計量數	冷凍食品知識	冷凍食品態度	冷凍食品購買行爲正確性	冷凍食品使用頻率
年齡	−0.0032	0.0370*	0.1300***	−0.0397*
家中共同生活人口數	−0.0343*	−0.0313	−0.0333	−0.0987***
全家收入	0.0404*	0.0205	0.0729***	0.0813***
主婦職業有無	−0.0409*	−0.0066	−0.9409*	−0.0656***
社經地位	0.0248	0.0465**	0.0563***	0.0265
超級市場有無	0.0179	−0.0013	−0.0419*	−0.1052***
買菜頻率	−0.0526**	−0.0523**	0.0074	−0.0945***
冷凍食品使用頻率	0.0895***	0.1819***	0.0959***	1.000
冷凍食品滿意程度	0.0947***	0.2469***	0.1267***	0.4103***

* $P<0.05$ ** $P<0.01$ *** $P<0.001$

㈠年齡：受試者年齡與冷凍食品知識無顯著相關，但與冷凍食品態度、購買行爲正確性有顯著正相關；占冷凍食品使用頻率有顯著負相關。

㈡家中共同生活人口數：顯示家中人口數與冷凍食品態度、購買行爲正確性無顯著相關，但與冷凍食品知識、使用頻率有顯著（$P<0.05$）負相關，即家中人口數愈多，對冷凍食品的知識愈差，使用頻率愈低。

㈢全家收入：表3顯示全家收入與冷凍食品知識、購買行爲正確性、使用頻率呈顯著正相關，但與冷凍食品態度無顯著相關，即收入愈高者，冷凍食品知識越好，購買行爲越正確，使用頻率越高。

㈣主婦職業有無：研究結果顯示主婦職業之有無對冷凍食品知識、購買行爲正確性、使用頻率有顯著負相關，即職業婦女冷凍食品知識、購買行爲正確性、使用頻率較家庭主婦好，但與冷凍食品態度無關。

㈤社經地位：研究結果顯示社經地位與冷凍食品態度、購買行爲正確性呈顯著（$P<0.01$）的正相關，但與冷凍食品知識、使用頻率無顯著相關，即社經地位愈高，對冷凍食品態度愈好且購買行爲愈正確。

㈥家中附近超級市場之有無：結果顯示家中附近有超級市場者，冷凍食品的使用頻率越高亦愈正確。

㈦買菜頻率：買菜頻率越高者冷凍食品知識得分越低、態度愈差、使用頻率越低。

㈧冷凍食品的使用頻率：冷凍食品使用頻率越高者對冷凍食品的知識愈好、態度亦愈好、購買行爲愈正確。

六、影響冷凍食品知識、態度、購買行爲正確性、使用頻率之重要因素，其結果如下：

㈠影響冷凍食品知識之逐步多元迴歸分析結果以冷凍食品購買行爲正確性最具影響力，其次爲冷凍調理使用頻率、冷凍畜產滿意程度、冷凍食品態度、冷凍畜產使用頻率、冷凍水產使用頻率。

㈡影響冷凍食品態度之逐步多元迴歸分析結果以冷凍調理滿意程度最具影響力，其次依序爲冷凍食品購買行爲正確性、冷凍水產滿意程度、冷凍畜產滿意程度、冷凍食品知識、年齡、冷凍調理使用頻率、冷凍蔬菜滿意程度。

㈢影響冷凍食品購買行爲正確性結果以對冷凍食品態度最具預測力，其次社階地位，冷凍畜產滿意程度、冷凍食品知識、全家收入、冷凍調理使用頻率、冷凍蔬菜使用頻率、冷凍水產使用頻率、同堂代數。

㈣影響冷凍食品使用頻率之因素以冷凍蔬菜滿意程度最具影響力，其次爲冷凍畜產滿意程度、冷凍水產滿意程度、社經地位、冷凍調理滿意程度、家庭生活週期、冷凍食品知識。

七、不同使用羣婦女在冷凍食品知識、態度、購買行爲正確性之差異結果顯示冷凍食品中使用羣冷凍知識優於低使用羣，態度上則不具差異性，但在購買行爲正確性以中使用羣優於低使用羣，且高使用羣優於低使用羣。

肆、建　　議

一、對行政上的建議

㈠研究結果顯示都市婦女對冷凍食品知識、態度、購買行爲正確性得分不高，應將冷凍食品有關知識列入學校課程內，並編印認識冷凍食品手冊及食譜給消費者。

㈡消費者十分重視品質，儘速讓消費者知道政府已於77年6月訂立優良冷凍食品標誌，政府應加强冷凍食品品管督導工作；協助冷凍業及超市人員的訓練，以利於冷凍食品品管工作之進行。

二、對廠商之建議

㈠研究開發適合不同場合如早餐、午餐、便當等、宴客等所用之冷凍食品。

㈡藉由不同管道及傳播媒體廣作宣導。

㈢廠商應加强品管工作，發展精製、小包裝之冷凍食品。

㈣增設大型超級市場或青年商店以利於消費者採買之需要。

㈤每隔一段時間作市場調查，以了解消費者之需要。

㈥舉辦優良產品展售，使消費者認識其品質，選購及重調利用。

三、對未來研究之議建

㈠研究對象：可作較大規模之抽樣，或比較家政從業人員與一般主婦之差異或比較都市與鄉村婦女在冷凍食品消費行爲上的差異。

㈡研究工具：繼續修訂研究工具，使更具有效度。

㈢研究內容：對於影響消費行爲的變因如參考羣體、生活型態、購買動機作更深入之探討。

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Study of Women's Consumption Behavior of Frozen Food In Urban Areas

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ABSTRACT

This study was conducted using a questionnaire survey with a sample of 3,804 women living in Taipei, Taichung and Kaohsiung cities. The objectives of this study were to determine urban women's knowledge, attitudes, and accuracy in purchase and the present usage of frozen foods; the differentiation of urban women's frozen foods' knowledge, attitudes, accuracy in purchase, frequency of usage and degree of satisfaction in different areas; the main factors that influence the knowledge, attitude and accuracy in purchase of frozen food; the correlations between different variables that influence the knowledge, attitude, accuracy in purchase and frequency of usage of frozen food; and the differentiation between different consumer group's knowledge, attitudes and accuracy of purchase of frozen food.

The statistical methods used in this study were frequency, repeated measure one way ANOVA, one way ANOVA, Pearson Correlation, quick cluster analysis and ANCOVA. After analysis of the data, we found that:

A. Urban women do not have an adequate knowledge of frozen food, but are fairly good in their attitude and accuracy in purchase of frozen food.
B. In different areas of Taiwan, women's knowledge of frozen foods, attitude, accuracy of buying behavior, frequency of use and degree of satisfaction are different.
C. There existed positive correlations among urban women's knowledge, attitude and accuracy in purchase of frozen

food.

D. There existed apparent correlations between different variables that influence the knowledge, attitude, accuracy in purchase and frequency of usage of frozen food.

E. The attitude of different kinds of user groups toward frozen food is very much the same, but the knowledge of medium frequency groups about frozen food is better than the lower frequency user. The medium frequency user is also better than the lower frequency user in terms of the correct buying behavior. The highest frequency user of frozen food is also better than the lowest frequency user.

學前障礙幼兒與一般正常幼兒混合就讀之效果

—二個個案研究—

生活應用科學系

蘇 雪 玉

摘 要

為了找出安置學前障礙幼兒與一般正常幼兒混合就讀篩檢時的依據及指引，一名輕度障礙幼兒與一名中度障礙幼兒被安置於正常幼兒學前教育機構。

自然行為觀察法和學齡前兒童發展量表及嬰幼兒發展測驗作為研究工具。

經過一年混合就讀的結果，發現輕度障礙幼兒的發展有顯著的進步，反之中度障礙幼兒則未見進展，且因干擾性行為的增加而轉介到特教機構。

混合就讀計劃對輕度障礙幼兒有顯現的良好教育效果。

壹、動機與目的

現今人民生活富裕，社會生活層面提高，接受教育不再屬於某些特權幼兒，而是屬於所有的幼兒；不分貧富，正常或殘障，尤其特殊教育法在民國七十三年通過，規定學前教育需兼顧各類兒童身心發展，我們在學前階段不僅要教育身心正常幼兒，也要及早啓發幫助障礙幼兒。其中發展遲緩或是輕度智能不足幼兒當盡量安置於較正常的學習環境成為未來必然的趨勢。

自鄧恩（Dunn, 1968）首次提出將輕度障礙兒童回歸到普通教室，以便兒童發揮他們較大的潛力，在教育界引起一連串的連鎖反應，「回歸主流」至今仍成為被探討的主題。

柯克與蓋勒佛（Kirk & Gallagher, 1979）指出「回歸主流」是指將特殊兒童(1)與正常兒童安置在一起；(2)在普通班同時接受特殊教育服務；(3)在最少限制的環境中，儘可能和正常同儕有社會性交往（互動），此即混合就讀計劃(integrated plan)，亦即將障礙幼兒在普通班中接受教育，却有特殊教育專業人員從旁協助或課餘輔導。

回歸主流有用嗎？如何建立一個成功的回歸主流教育模式？

由教育心理學觀點來看，我們必須提供幼兒最少限制的環境(least restrictive environment)，儘可能將障礙幼兒安置於較正常的教學環境；而由社會及道德觀來看，混合就讀(integrated plan)可提供障礙兒童正常的社會經驗，同時殘障幼兒的存在對於一般幼兒也是一種態度與觀念的教育，有益於其對

特殊兒童的瞭解及消除對障礙可能的觀念偏差。

但混合就讀並非無計劃的將障礙幼兒隨意的安置於幼兒課室中，如何將診斷和評量特殊兒童的方法，幼兒安置、教學方法、課程設計、師資訓練、課餘輔導及服務設施做有系統和小心的計劃成爲一個主要的課題。

多數對學齡前，小學及中學的兒童有關的研究及調查(Kirk, 1958; Spollen and Ballif, 1971; Allen, Benning and Drummond, 1972; Devoney, Guralnick and Rubin, 1974)，已經證明回歸主流的積極結果，並顯示出回歸主流在對輕度或臨界的障礙兒童而言是有效的。雖然這些研究調查對回歸主流提出正面積極的效果及各種建議，但至今對於究竟何種幼兒適合混合就讀却缺乏共識的標準；對於接納或拒絕的依據也十分籠統。一般均指出經過審愼的觀察及評估，其中重度及具干擾性的幼兒將不被接納於混合班（回歸主流的教育裏）；但對何謂重度或具干擾性的定義也十分含糊，其間各持的差異也大。

本研究係就兩名被安置於輔幼的障礙幼兒，作初步的探討以達到下列研究的目的：

一、經由個案研究，發現在混合制下，障礙幼兒於生活自理，大肌肉動作、精細動作、認知與學業，語言及社會等學習領域成長的模式；

二、發現出這兩名障礙幼兒的遊戲行爲及社會化的過程；

三、探討障礙幼兒適合混合就讀與否的決定性因素以作爲安置幼兒混合就讀篩檢時的依據及參考；

四、驗證混合就讀對輕度障礙或臨界幼兒是可行和有效益的。

貳、研究方法

一、幼兒描述：

㈠幼兒甲：年齡三歲十一個月，發展程度爲中重度障礙幼兒。出生時患有點頭抽筋症，及癲癇波出現，進入輔幼時仍有癲癇，乃以藥物（中藥）控制之，癲癇發作次數極少，但發作時則呈現不能控制的笑聲及眼淚。沒有語言，僅有些許肢體語言，如：手勢附加一些聲響，並出現刻板行爲如：喜歡旋轉盤子、喜歡「洞」，對所有發聲的物體及地方均感到興趣。

㈡幼兒乙：年齡三歲三個月，發展程度爲輕度障礙幼兒。溝通表達嚴重缺乏（很少說話），很少與其他幼兒互動；入學時適應能力很差，緊跟住一位大人（老師），與父母分開有極大困難，情緒不安、容易哭，很沒有安全感。

二、幼兒安置及教學環境

兩名幼兒分別安置於輔大家政系附設托兒所（簡稱輔幼）。幼兒甲安置於小小班（2足歲至3足歲幼兒，比幼兒甲年齡小一歲）與其他19名正常幼兒混合就讀，並有教師一位及助理教師一位。幼兒乙被安置於小班（3足歲至4足歲）與其他29名正常幼兒混合就讀，並有教師一位及助理教師一位。

輔幼是角落教室佈置，分成不同的學習角落，包括：娃娃家、益智角、科學角、圖書角、積木角等。學習活動包含各種結構性及非結構性活動，課程設計採取大單元設計，教學法採用啓發式教學。

三、研究工具及實施過程

㈠測量工具及實施過程：

1. 測量工具：

⑴學齡前兒童行爲發展量表（臺大心衞中心，第四次修訂版）：

民國64年改編自 M. C. D. I. (Minnesota Child Development Inventory)以適合我國使用，且其信度令人滿意。其項目分爲粗動作，精細動作、溝通表達、概念理解、環境理解、身邊處理、人際社會行爲和一般發展八大項。

⑵嬰幼兒發展測驗：

主要是參考美國科羅拉多州丹佛城所作的試驗「丹佛兒童發展量表」(DDST)。此嬰幼兒發展測驗包括四部分：粗動作、精細動作及適應能力、語言、身邊處理及社會性四大項。

2. 實施過程：

由入學開始起施測，每隔三個月分別由家長和教師填寫學齡前兒童行爲發展記錄及施測。

3. 發展遲緩評定方式：

經由學齡前兒童發展量表 (M. C. D. I.) 及嬰幼兒發展測驗 (DDST) 的二種測驗結果，按公式：$\frac{\text{年齡}-\text{發展年齡}}{\text{年齡}}\times 100\%$，計算出發展遲緩百分比。本研究將幼兒發展程度依據前鋒計劃 (Head Start) 所訂定智能發展等級規列如下：

發展遲緩百分比	幼兒發展程度
21～30%	臨　界
31～50%	輕　度
51～70%	中　度
71～90%	重　度

㈡觀察方法及實施過程：

1. 觀察方法：

⑴攝影記錄

⑵個案觀察記錄（自然行爲觀察法）

2. 實施過程：

⑴攝影記錄：每星期攝影一次，包括：

i. 幼兒全天活動作息。

ii. 教室內自由角落時間及戶外活動時間，每次以10分鐘爲限。

3. 評定方式：

自由活動時間，由2名觀察員利用30秒時間抽樣及事件抽樣二種方式一同觀看錄影帶而記錄之。記錄表上所包括的遊戲行爲項目是依據巴頓（Parten, 1932）的六種社會性遊戲範圍，而採用其中前五項分別爲游動行爲(Unoccupied behavior)，旁觀行爲(Onlooker behavior)，單一遊戲(Solitary play)，平行遊戲(Parallel play)和聯合遊戲(Associative play)。

⑵個案觀察記錄：

在觀察廊由觀察員做自然觀察記錄，以作爲進一步了解幼兒行爲時的參考每星期實施一次，項目包括幼兒全天活動。

四、結果與討論

㈠幼兒甲與幼兒乙在生活自理、粗動作、精細動作、認知與學業、語言及社會學習領域的成長模式：

1. 學齡前兒童行爲發展量表（改編自 M. C. D. I.）

⑴由表（4-1、4-2）看出二名幼兒之發展在入學時即有中重度及輕度之別，同時也看出在八個項目中兩名幼兒在精細動作，粗動作之能力較强，而溝通表達及概念理解爲他們在發展上共同的最弱的一環。

⑵一年之後，幼兒甲與幼兒乙在成長上產生顯著差異。幼兒甲大部分項目均仍停留在中度程度（表4-1）（圖4-1）。其中溝通表達有依年齡增長反而落回重度的傾向。反觀幼兒乙多項進步十分明顯（表4-2）（圖4-2）。唯粗動作和精細動作是落後的項目。

2. 嬰幼兒發展測驗（DDST）：

⑴由表（4-3、4-4）看出幼兒甲與幼兒乙在初入學時，在粗動作、精細動作、及適應能力、語言及身邊處理及社會性四大項發展程度均在中重度之間，並沒有差異。此結果與「學齡前兒童行爲發展量表」入學時二名幼兒之間中重及輕度的差異明顯不同。分析其原因可能由於：

表 4-1 幼兒甲發展程度分析表（學齡前兒童發展量表）

項目 ＼ 發展程度	入學時			一年後		
	輕	中	重	輕	中	重
發展遲緩百分比	31-50	51-70	71-90	31-50	51-70	71-90
粗動作	44.2				52.5	
精細動作	44.2				50.8	
溝通表達		68.4				80.3
概念理解		60.5			65.9	
環境理解		51.2			52.5	
身邊處理		55.8			52.5	
人際社會	50				62.3	
一般發展		51.6			59	

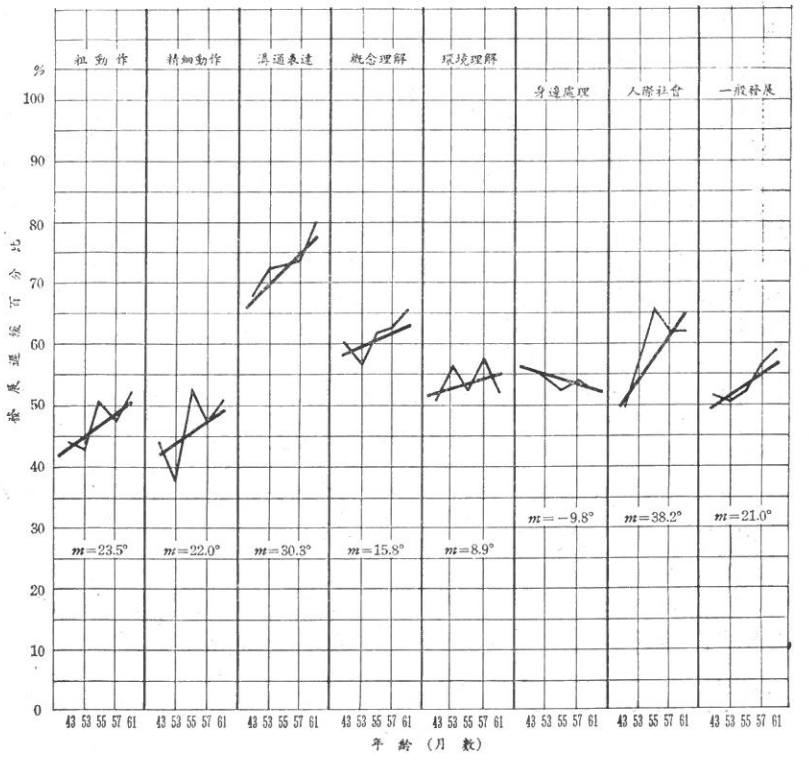

圖 4-1 幼兒甲發展遲緩百分比圖（學齡前兒童發展量表）

表 4-2 幼兒乙發展程度分析表（學齡前兒童發展量表）

項目 ＼ 發展程度 ＼ 發展遲緩百分比	入學時 正常	入學時 臨界 21-30	入學時 輕 31-50	入學時 中 51-70	一年後 正常	一年後 臨界 21-30	一年後 輕 31-50	一年後 中 51-70
粗動作	13.2						34.6	
精細動作	18.4					25		
溝通表達				56.6			38.5	
概念理解				55.3			30.8	
環境理解			42.1			28.8		
身邊處理			36.8			26.9		
人際社會			47.4				34.6	
一般發展			39.5			26.9		

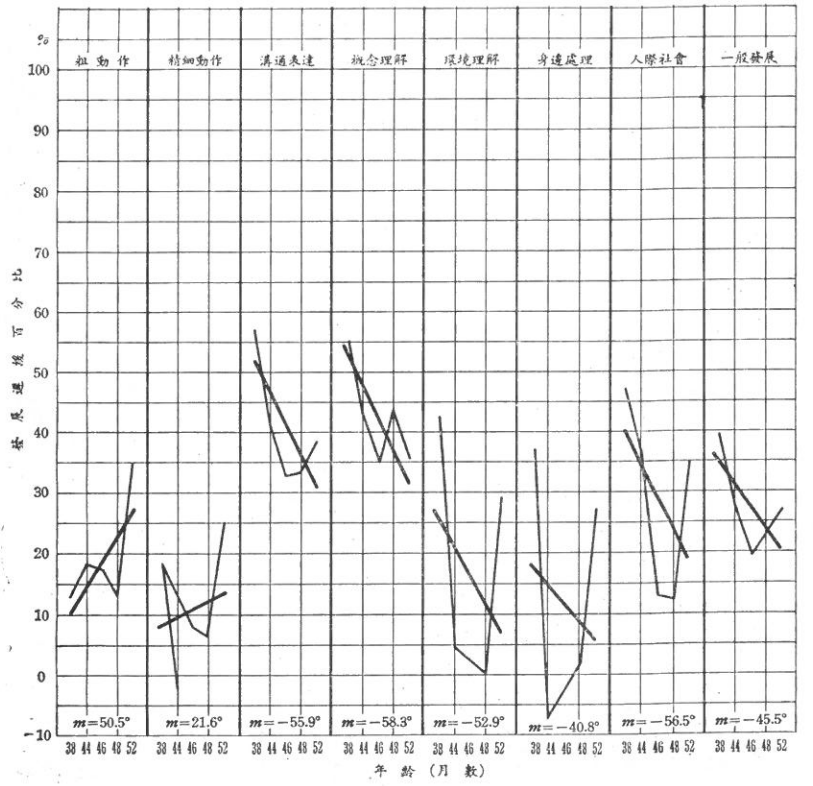

圖 4-2 幼兒乙發展遲緩百分比圖（學齡前兒童發展量表）

表 4-3 幼兒甲發展程度分析表（嬰幼兒發展測驗）

項目 ＼ 發展程度	入學時			一年後		
	輕	中	重	輕	中	重
發展遲緩百分比	31-50	51-70	71-90	31-50	51-70	71-90
粗動作			70.2		67.2	
精細動作及適應能力		69.2				70.7
語言			88.3			89.2
身邊處理及社會性			96			89.5

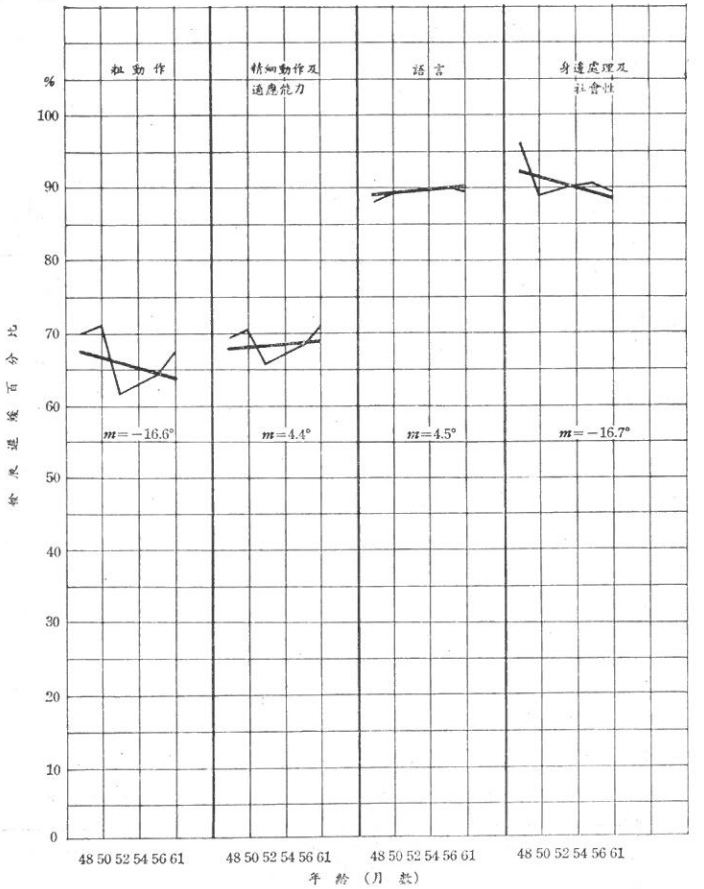

圖 4-3 幼兒甲發展遲緩百分比圖（嬰幼兒發展測驗 DDST）

表 4-4 幼兒乙發展程度分析表（嬰幼兒發展測驗）

項目 ＼ 發展程度	入學時			一年後			
發展遲緩百分比	輕	中	重	臨界	輕	中	重
	31-50	51-70	71-90	21-30	31-50	51-70	71-90
粗動作			71		36.6		
精細動作及適應能力			84.8	24.5			
語言			86			61.7	
身邊處理			95.3			56.6	

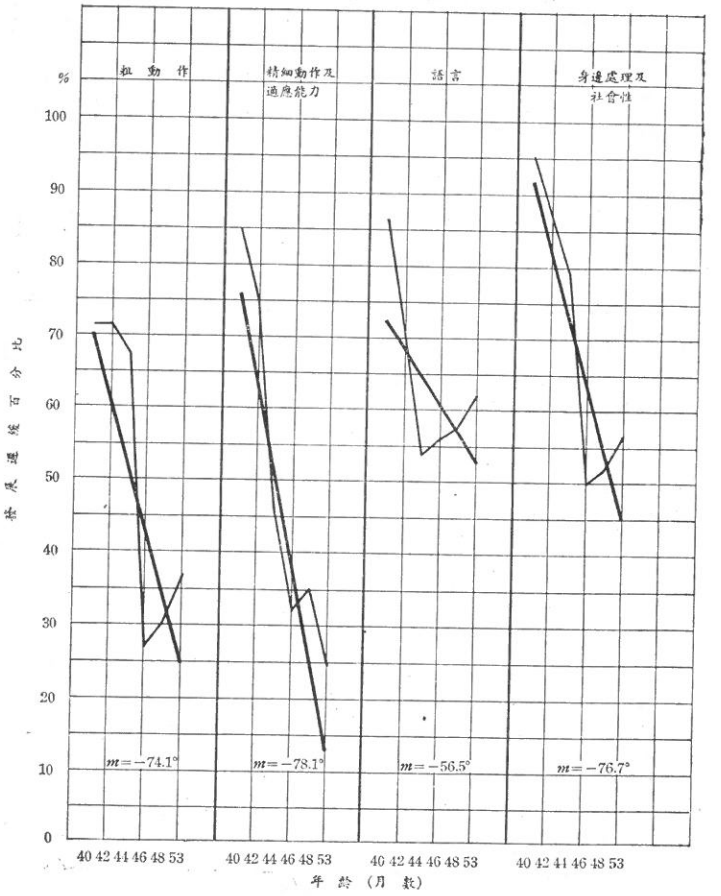

圖 4-4 幼兒乙發展遲緩百分比圖（嬰幼兒發展測驗 DDST）

表 4-5 幼兒乙發展遲緩百分比表（嬰幼兒發展測驗）

項目 / 年齡(月份)	粗動作	精細動作及適應能力	語言	身邊處理
40	71	84.8	86	95.3
42	71.2	74.5	69.5	87.1
44	67.5	45.9	53.9	79.3
46	27	32.2	55.9	50
48	30	35	57.7	52
53	36.6	24.5	61.7	56.6

「學齡前兒童行爲發展量表」是由父母填寫，而「嬰幼兒發展測驗」是需要老師與幼兒一對一的施測；而施測員與幼兒關係在起初未建立，加上此二名幼兒均有溝通表達上的困難，因此產生測驗結果與實際能力上的差異。但在四個月之後，亦即第三次施測起（見表 4-5），即看出幼兒甲與幼兒乙明顯之差異。

⑵一年之後，幼兒甲與幼兒乙在發展上則產生顯著差異。由（圖 4-3）雖顯示出幼兒甲在粗動作及身邊處理及社會性有輕微進步，但仍維持在中重度（表 4-3）；反之，幼兒乙則有明顯的進步（圖 4-4）（表 4-4），語言及身邊處理及社會性進步至中度，而粗動作由重度進展至輕度，精細動作及適應能力則進步最爲顯著，由重度到臨界。

由以上對二種發展量表上分析所得結果得知：在混合就讀一年之後，幼兒甲與幼兒乙在發展模式上有顯著差異；幼兒甲仍停留在中度，而幼兒乙則進入臨界與輕度之間。顯然混合就讀對幼兒乙的成長是具有正面效果的。

㈡遊戲行爲及社會化情形：

採自幼兒自由活動時間，其中大部分是教室內的自由角落時間，部分戶外自由活動時間，分別由時間抽樣及事件抽樣作記錄分析。分析結果如下：

1. 由表（4-6）看出，兩名幼兒所呈現的主要遊戲行爲，依出現頻率由高至低，幼兒甲依序爲單一遊戲，聯合遊戲，游動行爲；而幼兒乙則爲聯合遊戲、單一遊戲，平行遊戲。二名幼兒最大差異即幼兒乙在前三項中出現頻率最高的行爲中並無游動行爲，且其中聯合遊戲及平行遊戲均爲社會化行爲，而幼兒甲則以非社會化行爲：單一行爲及游動行爲爲主。幼兒甲與幼兒乙在游動行爲和平行遊戲上有顯著差異。（游動行爲，$X^2=4.16$, $P<0.05$; 平行遊戲，$X^2=7.14$, $P<0.01$）。
2. 雖然幼兒甲和幼兒乙中的聯合遊戲出現率均列前三名中，但仔細分析二名幼兒在聯合遊戲中，幼兒與老師（大人）之間的互動，則可發現（表

4-7) 幼兒甲60%時間均由老師或大人主動開始而產生互動，且由表(4-8)，又可看出其中互動大部分是由於幼兒甲不斷出現負向干擾行爲而引發老師事先阻止。例如：走過去將壁報紙撕下，動不動推倒椅子，將牆

表 4-6 幼兒甲（乙）遊戲行爲情況表

遊戲行爲類別	幼兒甲		幼兒乙		
	N	%	N	%	
U	41	20	17	9	$X^2=4.16^{**}$
S	89	43	65	34	$X^2=1.04$
O	16	8	13	7	$X^2=0.06$
P	4	2	23	12	$X^2=7.14^{*}$
A	57	28	76	39	$X^2=1.80$
合計	207		194		

**P<0.05 *P<0.01

U：游動行爲 P：平行遊戲 A：聯合遊戲 S：單一遊戲 O：旁觀行爲

表 4-7 幼兒甲（乙）聯合遊戲之互動狀況分析表

起始者	幼兒甲		幼兒乙		
	N	%	N	%	
老師	32	60	17	24	$X^2=15.42^{**}$
一般幼兒	9	17	28	40	$X^2=9.28^{*}$
幼兒甲（乙）	12	23	25	36	$X^2=2.86$
合計	53	100	70	100	

**P<0.001 *P<0.01

表 4-8 幼兒甲（乙）聯合遊戲之正負向行爲分析表

	幼兒甲		幼兒乙		
	N	%	N	%	
正向行爲	19	38	40	100	$X^2=27.86^{**}$
負向行爲	31	62	0	0	$X^2=62^{*}$
合計	50	100	40	100	

**P<0.001 *P<0.001

表 4-9 幼兒甲聯合遊戲中正負向行爲的發展過程

年齡(月數) \ 次數 / 百分比	正向行爲		負向行爲	
	N	%	N	%
50	7	87.5	1	12.5
51	2	50	2	50
54	3	30	7	70
55	2	22	7	78
56	5	56	4	44
57	0	0	10	100

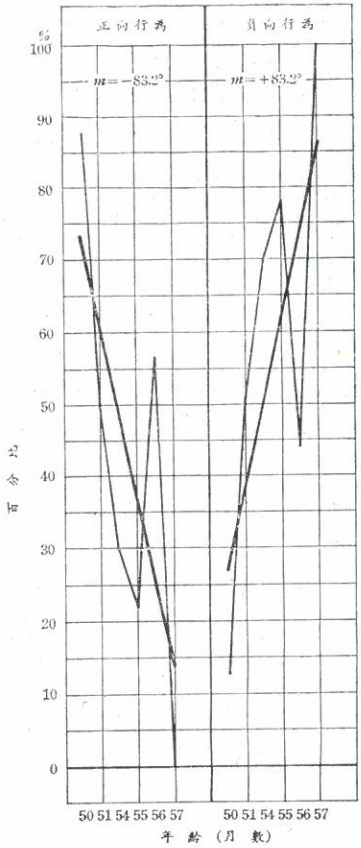

圖 4-5 幼兒甲聯合遊戲正、負向行爲發展過程圖

表 4-10 幼兒甲乙聯合遊戲中幼兒溝通方式

溝通方式 \ 次數 / 百分比	幼兒甲		幼兒乙	
	N	%	N	%
肢體語言、手勢	34	92	53	98
聲音	3	8	0	0
語言	0	0	1	2
合計	37	100	54	100

上鐵子用力搖晃，開水龍頭讓水沖流不停，突然跑出教室外，推倒窗臺上花瓶等需要老師額外注意力的負向行爲。同時由（表4-9）（圖4-5）也看出幼兒甲與老師（大人）之間負向行爲有顯著增加的傾向。另一方面，幼兒乙的聯合遊戲中，以幼兒乙及一般幼兒爲主要起始者表 (4-7)，並且幼兒乙與老師或其他一般幼兒互動均爲能被接納的正向，積極行爲（表 4-8）。幼兒甲與幼兒乙在聯合遊戲中，以老師爲起始者及以一般幼兒爲起始者上有顯著差異。（老師爲起始者，$X^2=15.42$, $P<0.001$；一般幼兒爲起始者，$X^2=9.28$, $P<0.01$）幼兒甲與幼兒乙在聯合遊戲中，在出現正向行爲及負向行爲上也有顯著差異。（正向行爲，$X^2=27.86$, $P<0.001$；負向行爲，$X^2=62$, $P<0.001$）

3. 由（表4-10）看出，幼兒甲與幼兒乙在社會互動中，語言表達均十分落後，以肢體、手勢語言爲主，溝通能力與他們在發展量表上情形吻合。
4. 一年之內，二名幼兒社會化進展情形來看，幼兒甲與幼兒乙在社會互動中，並無顯著進步。由（圖 4-6）顯示出幼兒甲的游動行爲減少，但單一遊戲及與老師的負向行爲則增加，雖然巴頓主張單一遊戲是所有遊戲中最不成熟的，但摩爾（Moore, 1974）却視單一遊戲含有主動、積極、有目標導向的活動。此一論調似乎可以用來解釋幼兒甲減少游動行爲而增加單一遊戲，對他自身發展上是正面的，只是與老師（大人）之間的負向行爲構成他參與普通教室活動中的一大障礙。幼兒乙則除在平行遊戲行爲顯著增加外，游動行爲和單一遊戲些微增加，聯合遊戲下降，但看不出其他明顯社會化互動上的成長。

叁、結論與建議

一、結論

兩名幼兒入學時在發展上即有輕度及中重度之區別。在遊戲行爲上，幼兒甲與幼兒乙也有顯著差異；幼兒甲負向、干擾性行爲居多，困擾其他幼兒及教學活

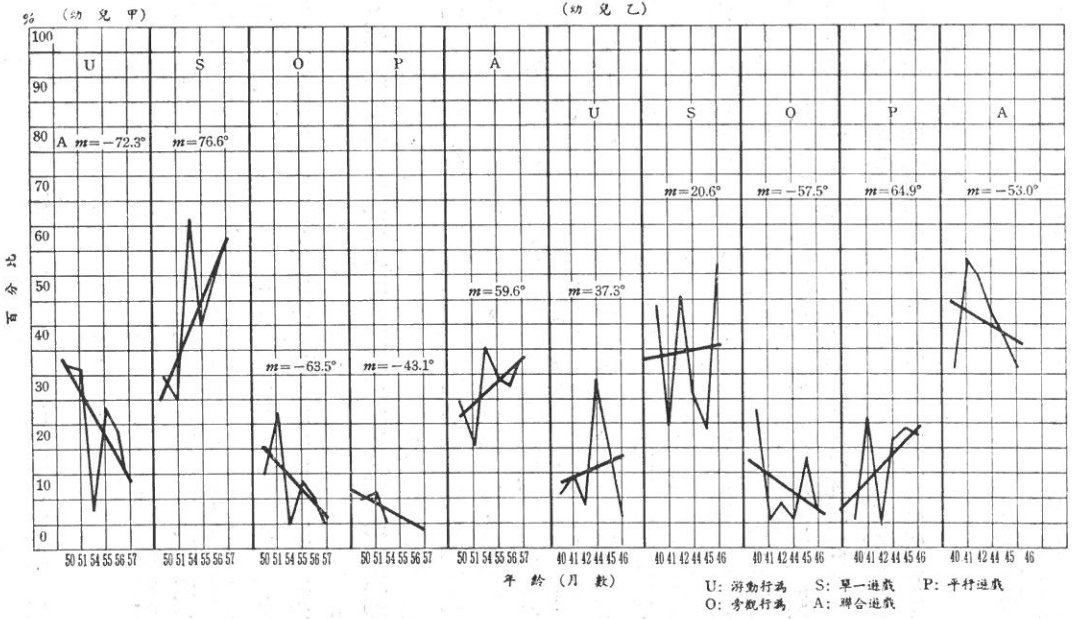

圖 4-6 幼兒甲（乙）遊戲行爲分析圖

動的進行；幼兒乙除溝通表達能力差以外，大都能參與團體活動中，其表現行爲仍都屬正向能接納的。在一年之內，二名幼兒在成長上更顯出極大差異，幼兒甲仍停留在中重度而且負向行爲仍未見減少，幼兒乙則有重大進步，遊戲行爲所呈現大部分均以社會化行爲居多。

二、建議

㈠經過一年在輔幼混合就讀後，幼兒甲因其發展未見進步及干擾行爲而被轉介到特教機構，而幼兒乙仍留輔幼繼續與一般正常幼兒混合就讀。由這兩名幼兒的個案來探討幼兒適宜混合就讀的要素，至少可包括下列：

1. 在除課外輔導外教室內完全無特殊教師的情況下，幼兒發展程度應以輕度爲宜，中重度以上則適宜加重個別化教學及小組教學。
2. 如果幼兒單只適應不良，情緒不穩定，仍無大礙，可以慢慢適應；但如幼兒大部分時間在游走，無法參與團體活動或無法跟隨老師的指引、指導，再加上太多干擾性行爲，甚或破壞行爲，需要借助老師額外的注意力，因而干擾教學及其他幼兒學習情緒，此幼兒則將成爲混合就讀的障礙而需要結構性的教學環境，並且加强小組教學，甚至一對一教學。

因此，研究的初步結果至少可以應用推廣在與輔幼教學環境類似，較爲開放的學前機構。平時教室中就是沒有特教老師，但只要有專業老師做課外輔導，則一般輕度或臨界程度的幼兒似可以安置於一般教室中，也可達到在最少限制中學習的良效。

㈡本研究之發展程度之訂定方式最好能進一步找另一標準化工具，以做效度研究。

㈢對輔幼與二名障礙幼兒同齡之正常幼兒進行同樣的遊戲行爲觀察分析，以便能將二名障礙幼兒所表現的遊戲行爲與輔幼同齡正常幼兒作比較。

㈣增加每星期觀察次數。理由是：一星期中前三天及後三天幼兒情緒表現有顯著差異；同時在一天之中早上和下午幼兒行爲表現也極爲不同。故增加觀察次數可以對幼兒行爲表現做客觀的評估。

肆、謝　　誌

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The Integration of Preschool Handicapped and Non-handicapped Children

—The Case Study of Two Children—

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ABSTRACT

For the purpose of determining placement guidance to integrate handicapped with non-handicapped children, one mildly handicapped child and one moderately handicapped child were placed in a normal preschool setting.

The Chinese Child Development Inventory, Revised Denver Developmental Screening Test and the natural observation method were used to evaluate the children's growth and social interaction.

After one year, results indicated an increasing developmental rate for the mildly handicapped child but not for the moderately handicapped child. Due to increasing disruptive behavior, the moderately handicapped child was referred to a special school.

It was concluded that the integrated plan has good educational effects on the child with a mild handicap and prosocial behavior.

輔大理工學院教學評鑑調查研究

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摘 要

教學包括『教』與『學』兩方面，是師生共同參與而產生交互影響的動態過程。運用科學方法和技術，蒐集有關學生學習行爲及意見，予以分析、研究，透過此評鑑的方式將結果提供教師作爲改善教學上的參考，期能達到『教學相長』的目標。

前 言

輔大自在臺復校以來，一直在穩定中發展，尤其對學生在生活學習活動上的重視更是不遺餘力，此乃因大學實爲作育英才之所在，而其主要功能是以教學、研究和服務爲主。因此現在大學莫不以提高教學品質，增進人類知識與社會福祉爲其努力目標。欲達此目標校方除了積極延聘學有專長的師資、鼓勵教師進修加强學生輔導及訂定完善的升等制度以提升教學品質外，『教學評鑑』亦不失爲一改善教學績效方法。此一途徑乃透過師生共同參與之另一溝通方式，以期達到「教學相長」之目標，此項工作主要用途旨在提供教師改進教學的參考。

理工學院針對此一目標，自民國七十六年四月院務會議中決議實施教學評鑑，隨即成立評鑑小組，遂於七十五學年度第二學期期末首創在本校實施教學評鑑工作，而於同年的十月二十九日校務會議通過全校實施教學評鑑，各學院自行負責。自第一次評鑑工作完成後，接獲不少教師們的反應，將問卷作適度的修訂，截至77年6月底止，理工學院已實施三次「教學評鑑」。爲評估教學成效乃從㈠教師的個人特質、㈡教學技巧、㈢教材安排、㈣師生關係、㈤教學評量與回饋等方面加以評量。

無可諱言地，實施評鑑工作亦遭遇不少困難，如許多教師仍未瞭解評鑑之意義及功能，以至未能有效運用其結果，因而降低了評鑑之成效，所以針對此項缺憾，乃著手研究此三學期中理工學院學生對各課程教學反應作一探討，俾供改進教學的重點參考。

一、研究對象及程序

本研究之對象爲修理工學院除實驗課程外之所有課程的學生，此三學期之課程增減互見。實施方式是於每學期期末考前二～三週，請各系助教至各班，採普查方式實地作問卷，回收後採讀卡方式將資料輸入電腦並進行統計分析工作。

二、研究工具

本研究之調查工具爲輔仁大學理工學院「教學意見調查表」。七十五學年度第二學期之問卷共有 30 題，除第 26 至 30 題爲基本資料外其餘分爲——個人特質 (1～3題)，教學目標 (4～6題)，教學技巧(7～10題)，教材安排(11～13題)，師生關係 (14～16題)，評量與回應 (17～20題) 等六個向度及學生的學習行爲，自第一次評鑑後經教師們的反應，將問卷修改精簡爲 5 個向度（取消教學目標），第二次問卷成爲25題，第三次問卷增加一題學生對教材難度的反應，第一次參加評鑑的科目有 158 科(6,852人次)，第二次參加者有 250 科(11,042人次)，第三次 230 科 (8,377 人次)。

三、研究結果

就七十五學年度第一次評鑑結果而言見（附表１），以教師在各向度所獲分數排列次序，發現各向度之等級相關性相當顯著，都達 0.95以上，表示學生給予老師們在各向度的表現，並非任性、不加思索的，而七十六學年度的兩次評鑑結果顯示見（附表２、３），等級相關係數更達 0.96 以上，若以實際獲得分數觀其各向度間的相關係數：第一次評鑑顯示達 0.72 以上，第二次評鑑顯示達 0.79 以上，第三次評鑑顯示達 0.82 以上。

就三次評鑑而言，師生關係與教學技巧相關性最強，其相關係數分別爲 0.9002，0.9342，0.9284，此即顯示師生關係良好與否與老師在教學上是否善於引導學生學習興趣與思考或鼓舞其發問相發密切。

從第二、三次評鑑知道，學生學習行爲的表現與師生關係教學技巧亦有高度相關，此說明學生對課程興趣及能否與老師充分配合教學活動，是否師生關係，教學技巧是受到肯定有高度的相關性。而學習行爲的表現倒是與教材安排的滿意程度相關性較弱，至於學習行爲的表現與教師個人特質被肯定與否兩者相關性所呈現算是最弱，此即顯示大學生的學習行爲重實質的收益。

就第一次評鑑而言，教學目標的達成程度與教材安排有最高的相關，其次是學生對教師的評量方式是否能眞正測出程度亦與教材安排得當有次第相關。

就年級而言，在三次評鑑中發現無論那一年級，教學技巧與師生關係兩向度的相關性最強，其次是教材安排與教學目標，此即顯示學生非常重視良好氣氛的學習環境及充分溝通，端賴教師技巧的引導，此種看法的學生是普遍性的。

附表 1. 七十五學年度第二學期各向度分數或等級的相關矩陣

向度 1 "個人特質" 向度 2 "教學目標"
向度 3 "教學技巧" 向度 4 "教材安排"
向度 5 "師生關係" 向度 6 "評量與回應"

(a) 所有科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.7718				
3	0.7385	0.8316			
4	0.7285	0.9018	0.8560		
5	0.7851	0.8345	0.9002	0.8394	
6	0.7219	0.8669	0.8312	0.8777	0.8655

(a') 所有科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9622				
3	0.9526	0.9690			
4	0.9525	0.9824	0.9746		
5	0.9620	0.9667	0.9812	0.9693	
6	0.9517	0.9732	0.9667	0.9764	0.9745

(b) 一年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.7484				
3	0.7132	0.9158			
4	0.7241	0.9212	0.8670		
5	0.7403	0.9014	0.9088	0.9033	
6	0.7370	0.8847	0.8370	0.9030	0.9024

(b') 一年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9978				
3	0.9975	0.9971			
4	0.9953	0.9935	0.9916		
5	0.9958	0.9985	0.9950	0.9905	
6	0.9950	0.9932	0.9973	0.9886	0.9917

(c) 二年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.7729				
3	0.7229	0.8523			
4	0.6821	0.8842	0.8774		
5	0.7801	0.8594	0.9139	0.8616	
6	0.6806	0.8887	0.8107	0.8978	0.8659

(c') 二年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9993				
3	0.9984	0.9976			
4	0.9990	0.9996	0.9967		
5	0.9992	0.9996	0.9973	0.9997	
6	0.9977	0.9968	0.9993	0.9956	0.9960

(d) 三年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.7884				
3	0.7694	0.7707			
4	0.7634	0.9043	0.8297		
5	0.8297	0.7733	0.8870	0.7876	
6	0.7440	0.8378	0.8426	0.8502	0.8401

(d') 三年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9972				
3	0.9958	0.9911			
4	0.9984	0.9978	0.9955		
5	0.9967	0.9905	0.9966	0.9964	
6	0.9966	0.9915	0.9990	0.9962	0.9973

附表 2. 七十六學年度第一學期各向度分數或等級的相關矩陣

向度 1 "個人特質" 向度 2 "教學技巧"
向度 3 "教材安排" 向度 4 "師生關係"
向度 5 "評量與回應" 向度 6 "學習行為"

(a) 所有科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.8924				
3	0.8448	0.8667			
4	0.8852	0.9342	0.8506		
5	0.8207	0.8702	0.8597	0.8641	
6	0.8206	0.9141	0.7985	0.8731	0.8382

(a') 所有科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9808				
3	0.9781	0.9768			
4	0.9802	0.9882	0.9762		
5	0.9710	0.9762	0.9748	0.9768	
6	0.9668	0.9844	0.9664	0.9772	0.9724

(b) 一年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.8773				
3	0.8108	0.9165			
4	0.7939	0.9424	0.8575		
5	0.7847	0.8329	0.8671	0.8300	
6	0.7688	0.9122	0.8208	0.9078	0.7902

(b') 一年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9965				
3	0.9987	0.9963			
4	0.9967	0.9973	0.9974		
5	0.9965	0.9969	0.9976	0.9996	
6	0.9898	0.9962	0.9881	0.9871	0.9858

(c) 二年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.9027				
3	0.9175	0.9159			
4	0.9466	0.9578	0.9153		
5	0.8730	0.9274	0.8962	0.9226	
6	0.8243	0.9202	0.8286	0.8923	0.8736

(c') 二年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9929				
3	0.9929	0.9943			
4	0.9991	0.9917	0.9918		
5	0.9987	0.9918	0.9928	0.9994	
6	0.9702	0.9717	0.9687	0.9720	0.9719

(d) 三年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.8934				
3	0.8488	0.8497			
4	0.8857	0.9323	0.8616		
5	0.8451	0.8920	0.8551	0.8965	
6	0.8396	0.9496	0.7969	0.8752	0.8681

(d') 三年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9990				
3	0.9994	0.9990			
4	0.9996	0.9991	0.9998		
5	0.9991	0.9988	0.9990	0.9995	
6	0.9951	0.9981	0.9946	0.9951	0.9958

(e) 四年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.8875				
3	0.7984	0.8278			
4	0.8861	0.9096	0.7830		
5	0.7609	0.7914	0.8331	0.7730	
6	0.8262	0.8547	0.7773	0.8304	0.7716

(e') 四年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9978				
3	0.9987	0.9976			
4	0.9988	0.9970	0.9987		
5	0.9992	0.9972	0.9994	0.9995	
6	0.9908	0.9952	0.9883	0.9869	0.9872

附表 3. 七十六學年度第二學期各向度分數或等級的相關矩陣

向度 1 "個人特質" 向度 2 "教學技巧"
向度 3 "教材安排" 向度 4 "師生關係"
向度 5 "評量與回應" 向度 6 "學習行爲"

(a) 所有科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.8728				
3	0.8969	0.8669			
4	0.8920	0.9284	0.9007		
5	0.8428	0.8586	0.8807	0.8911	
6	0.8236	0.8883	0.8533	0.8900	0.8623

(a') 所有科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9757				
3	0.9820	0.9743			
4	0.9818	0.9871	0.9818		
5	0.9728	0.9740	0.9770	0.9809	
6	0.9693	0.9797	0.9749	0.9802	0.9751

(b) 一年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.8322				
3	0.8893	0.8095			
4	0.8529	0.9036	0.8442		
5	0.8497	0.8624	0.8929	0.8722	
6	0.8371	0.8694	0.8451	0.8693	0.8012

(b') 一年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9994				
3	0.9958	0.9929			
4	0.9997	0.9998	0.9942		
5	0.9997	0.9998	0.9937	0.9998	
6	0.9730	0.9669	0.9884	0.9696	0.9681

(c) 二年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.8705				
3	0.8778	0.8663			
4	0.9006	0.9433	0.9189		
5	0.8558	0.8584	0.8810	0.9114	
6	0.8071	0.8831	0.8560	0.9013	0.8403

(c') 二年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9995				
3	0.9970	0.9945			
4	0.9988	0.9985	0.9962		
5	0.9964	0.9959	0.9945	0.9991	
6	0.9838	0.9792	0.9933	0.9833	0.9827

(d) 三年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.8722				
3	0.8885	0.8597			
4	0.8933	0.9192	0.9058		
5	0.8647	0.8656	0.8533	0.8904	
6	0.8238	0.8740	0.8476	0.8989	0.8725

(d') 三年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9996				
3	0.9976	0.9960			
4	0.9979	0.9998	0.9972		
5	0.9996	0.9998	0.9967	0.9999	
6	0.9809	0.9767	0.9896	0.9791	0.9779

(e) 四年級科目各向度分數的相關矩陣

向度	1	2	3	4	5
2	0.9025				
3	0.9235	0.8945			
4	0.9158	0.9370	0.9089		
5	0.8416	0.8615	0.9086	0.8851	
6	0.8506	0.9086	0.8686	0.8755	0.8879

(e') 四年級科目各向度按得分等級的相關矩陣

向度	1	2	3	4	5
2	0.9987				
3	0.9965	0.9960			
4	0.9982	0.9984	0.9973		
5	0.9978	0.9991	0.9971	0.9994	
6	0.9865	0.9839	0.9932	0.9840	0.9837

就一年級言：第一次評鑑結果（見附表1(b)、(b')），評量與回應對教材安排師生關係，教學目標三向度之相關程度較高，依次爲 0.903，0.9024，0.8847。

師生關係與教學技巧，教材安排及教學目標三向度相關程度較高，依次爲 0.9088，0.9033，0.9014。

教材安排與教學目標相關程度最高爲 0.9212。

而教學技巧亦與教學目標有高度相關爲 0.9158。

第二次評鑑結果發現（見附表2(b)、(b')），學生學習行爲反應與教師的教學技巧，及師生關係有較高的相關性，依次爲 0.9121，0.9078。

師生關係與教學技巧有最高的相關性達 0.9424。

教材安排與教學技巧亦有高的相關性達 0.9165。

第三次評鑑結果發現（見附表3(d)、(d')，學生學習行爲反應與教師的教學技巧及師生關係有較高的相關性，依次爲 0.8694，0.8693。

而評量與回應與教材安排及師生關係亦具較高的相關性，依次爲 0.8929，0.8722。

師生關係與教學技巧具有最高的相關係數爲 0.9036。

就二年級言：第一次評鑑結果發現（見附表1(c)、(c')），評量與回應與教材安排及教學目標有較高的相關係數分別爲 0.8978，0.8887。

師生關係與教學技巧有最高的相關係數 0.9139。

教材安排與教學目標及教學技巧亦有高的相關，依次爲 0.8842，0.8774。

第二次評鑑結果發現（見附表2(c)、(c')），學習行爲與教學技巧有高度相關爲 0.9202。

評量與回應與教學技巧及師生關係亦有高的相關性，依次爲 0.9274，0.9226。

而師生關係與教學技巧及個人特質具有最高的相關性，依次爲 0.9578，0.9466。

第三次評鑑結果顯示（見附表3(c)、(c')），學習行爲與師生關係有高的相關性爲 0.9013。

評量與回應與師生關係有高的相關性爲 0.9114。

而師生關係與教學技巧及教材安排具最高的相關性，依次爲 0.9433，0.9189。

就三年級言：第一次評鑑結果顯示（見附表1(d)(d')），師生關係與教學技巧有

高度相關 0.887。

教材安排與教學目標具有最高相關 0.9043。

第二次評鑑結果顯示（見附表 2 (d)、(d')），學習行爲與教學技巧有最高的相關 0.9496。

評量與回應與師生關係及教學技巧亦具高度相關，依次爲 0.8965，0.8920。

師生關係與教學技巧亦具高的相關達 0.9323。

第三次評鑑結果顯示（見附表 3 (d)、(d')），學習行爲與師生關係有高度相關 0.8989。

評量回應亦與師生關係有高度相關 0.8904。

然師生關係與教學技巧及教材安排具最高的相關，依次爲 0.9192，0.9038。

就四年級言：第一次評鑑的時間是在畢業考以後，沒作問卷調查。第二次評鑑結果顯示（見附表 2 (e)、(e')），僅師生關係與教學技巧的相關性達 0.9096 以上。

第三次評鑑結果顯示（見附表 3 (e)、(e')），學習行爲與教學技巧有高的相關 0.9086。

評量回應與教材安排具有高的相關係數 0.9086。

而師生關係與教學技巧具有最高的相關係數 0.937。

問卷內容見附表 4 。

四、結論與建議

從研究資料結果顯示：就各向度所得分得等級的相關矩陣所顯示的高度相關，不論其課程的難易如何，所表示學生的作答是相當理性的。

又由各向度分數相關矩陣，顯示師生關係與教學技巧的高度相關及教材安排與教學目標的達成亦有高度相關，此乃說明欲改進教學績效，實應在教材內容安排與其目標實現上下點功夫，還有在培養良好的師生關係上盡量著重於如何引導學生發問、思考，引發其學習興趣，如此每次評鑑工作能得到教師們的合作及肯定，與學生們分享，進而得到學生們更確實的配合，對於「教學相長」目標是不難實現。

五、後　　誌

最後感謝評鑑小組召集人化學系主任周善行教授的充分支持，外語實習所所長郭爲夏神父的協助，評鑑小組委員：生物系主任劉寶瑋教授及家政系林惠雅教授熱心參與及建議，使本小組的工作得以順利完成。

附表 4. 輔仁大學理工學院教學意見調查表

填答說明：(1)本調查在評量上分成 A, B, C, D 四種不同的尺度，分別表示「非常同意」、「同意」、「不同意」、「非常不同意」。

(2)作答時請逐題閱讀，並按實際情況將答案以2B軟心鉛筆劃記於電腦卡片上。

(3)若有其他意見，請書寫於答案卡之背面（鋼筆、原子筆）

A非常同意　B同意　C不同意　D非常不同意

我對任課老師的感受：

1.態度認眞。
2.音量適中。
3.表達清晰。
4.善於引發學習興趣。
5.善於激發學生思考。
6.善於鼓勵學生發問。
7.能明示本課程目標，並進行教學。
8.能有系統的安排教材。
9.所用教材內容充實。
10.上課準備充實。
11.深受學生愛戴與尊重。
12.能與學生充分溝通。
13.能維持課堂的良好氣氛。
14.所用評分方式合理。
15.對考卷與作業能有效的批閱或檢討。
16.考試題目能測量學生眞正程度（沒有考試之科目不必填）。

我對課程：

17.很有興趣。
18.能按教師指導方式認眞學習。
19.能充分了解。
20.總覺得收穫豐富。
21.我對本科目之教學總評爲

A：上等　B：中上　C：尙可　D：待改進

22.我認爲教材難度

A：很艱深　B：艱深　C：適中　D：容易

基本資料：

23.我的性別是A：男；B：女。
24.我是A：本系學生；B：外系學生。
25.本科之作業我A：全做；B：做大部分；C：做一半；D：做小部分；E：不做。
26.我上課出席率約爲 A：90%以上； B：75%～90%； C：60%～75%； D：50%～60%；E：50%以下。

參 考 文 獻

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The Teaching Evaluation in the College of Science and Engineering

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Dept. of Mathematics

HRUNG-YAHN LIN

Dept. of Computer Science and Information Engineering

ABSTRACT

Teaching and learning are two parts of a dynamic process through which teachers and students study together and influence each other.

We have used scientific methods and techniques to collect the opnions of students and the characteristics of the learning of students. We have studied and analyzed the data. We hope that the results of our research can give some valuable suggestions to teachers to improve their teaching and the learning of the students.

ABSTRACTS OF PAPERS BY FACULTY OF THE COLLEGE OF SCIENCE AND ENGINEERING THAT APPEARED IN OTHER REFEREED JOURNALS DURING THE 1987 ACADEMIC YEAR

Preconditioned Conjugate Gradient Algorithms and Software for Solving Large Sparse Linear Systems

DAVID M. YOUNG*, KANG C. JEA, and TSUN-ZEE MAI*

Linear Algebra In Signals, Systems, and Control
edited by B. N. Datta et al., SIAM,
Philadelphia, 1988. P. 260-283.

The classical form of the conjugate gradient method (CG method), developed by Hestenes and Stiefel, for solving the linear system $Au=b$ is applicable when the coefficient matrix A is symmetric and positive definite (SPD). In this paper we consider various alternative forms of the CG method as well as generalizations to cases where A is not necessarily SPD. This analysis includes the "preconditioned conjugate gradient method" which is equivalent to conujgate gradient acceleration of a basic iterative method corresponding to a preconditioned system. Both the symmetrizable case and the nonsymmetrizable case are considered. For the nonsymmetrizable case there are very few useful theoretical results available. A package of programs, known as ITPACK, has been developed as a tool for carrying out experimental studies on various algorithms. Preliminary conclusions based on experimental results are given.

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Rhodium Catalyzed Reductive Esterification Reactions

IVAN J. B. LIN, HAYDER A. ZAHALKA,* and HOWARD ALPER*

Tetrahedron Letters, Vol. 29, No. 15, pp 1759-1762, 1988

Reductive esterification occurs when unsaturated acids are treated with hydrogen in alcohol using either rhodium trichloride or the dimer of chloro(1,5-hexadiene) rhodium(I) as the catalyst. Saturated acids containing appropriate functional groups are also esterified under the same conditions.

* Department of Chemistry, University of Ottawa, Ontario, Canada K1N 9B4

Regio-and Stereoselective Synthesis of Substituted 2-(Phenylthio)-1,3-butadienes

SHANG-SHING P. CHOU, SHYH-YEON LIOU, CHUNG-YING TSAI, and AE-JUNE WANG

J. Org. Chem. 1987, 52, 4468-4471

Sulfur-substituted 1,3-butadienes are useful reagents in organic synthesis. We now report two general methods for the regio-and stereoselective synthesis of substituted 2-(phenylthio)-1,3-butadienes 4 and 5. 3-(Phenylthio)-3-sulfolenes 2 can be specifically alkylated at C5 under basic conditions. Extrusion of sulfur dioxide by lithium aluminum hydride then gives the dienes 4. On the other hand 2-substituted 3-sulfolenes 11 can be converted to the 3-phenylthio derivatives 9, which upon heating give the dienes 5.

Potassium Bifluoride-Catalyzed Group Transfer Polymerization of Acrylates

SHANG-SHING P. CHOU and CHAO-WEN NIU

MRL bull. res. dev., Vol. 1, No. 2(1987)pp. (33-40)

A convenient catalyst system-potassium bifluoride/18-crown-6 ether has been developed for the group transfer polymerization of acrylates. Factors affecting polymerization such as moisture, monomer concentration, the amount of potassium bifluoride and crown ether, reaction time and temperature have also been studied. Functional polymers can be prepared by using special initiators, monomers and reactive end group techniques. All these polymerizations proceed at room temperature with high conversion and give polymers of narrow molecular weight distributions.

Preparation of 2,3-Dihetero-Substituted 1,3-Dienes from Brominated 2-Sulfolenes

TA-SHUE CHOU,* SHWU-JIUAN LEE,*
MAN-LI PENG,** DER-JEN SUN, and
SHANG-SHING PETER CHOU

J. Org. Chem. 1988, 53, 3027-3031

A general procedure for the preparation of 2,3-dihetero-substituted 1,3-butadienes is described. These dienes are obtained from the thermolysis of the corresponding 3,4-disubstituted 3-sulfolenes, which can be prepared by nucleophilic substitution reactions from 4-brominated 2-sulfolenes.

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On the *Plistophora* Infection in Eel

I. Histopathology, Ultrastructure, and Development of *Plistophora anguillarum* in Eel, *Anguilla japonica*

WEN-HUEI T'SUI and CHUNG-HSIUNG WANG

Bull. Inst. Zool., Academia Sinica 27(3): 159-166 (1988)

The Micro-spora, *Plistophora anguillarum* was known to be the causative agent of "beko" disease of Japanese eel, *Anguilla*

japonica. This protozoa parasitized mainly in the skeletal muscle of the eel. The infection of *P. anguillarum* caused the necrosis of the muscle resulting the various degree of the body curvature. Mainly, harm done to the eel was by mechanical damage in early infections.

In addition to the histopathology, the ultrastructure and the development of *P. anguillarum* were investigated with the light and the electron microscopes. Several distinct developmental stages of *P. anguillarum* observed in the infected muscle were also described in present study.

Functional Morphology of Sex-pheromone Glands in Female Moths

CHUNG-HSIUNG WANG

R. O. C. symposium on Insect Biochemistry and Physiology 95-101 (1988)

It has been known for nearly four decades that sex pheromone plays an essential role in sexual behavior of insect, especially in that of notuid moths. Sex pheromones are released by female moths that effect the physiology and behavior of male moths of the same species. A great deal of interest in insect sex pheromones is not only because of their role in insect physiology or behavior but also because of their potential for use in pest control. Recently many successful instants have shown that the synthetic sex phero-mones or relative compounds are applied in the field with an excitable result by so called sex-pheromone traps or disruption methods.

Using bioassay with male moths to determine the present relative amount and optimal releasing condition of sex pheromone have shown that (1) sex pheromones are pratically existing in female moth; (2) pupae contain no detectable pheromone, and (3) the pheromone content of the gland increases considerably from eclosion to 2 days after eclosion, reaches a maximum after 2 to 4 days, and declines in older

insect (Jacobson, 1972). Furthermore the morphological studies have revealed that the relative concentration of sex pheromones in the moths of different age correlates with structural and ultrastructual changes (Smithwick and Brady, 1971; Wang, 1987)

The sex-pheromone glands of only a very few species among many thousands of Lepidoptera species have been examined. The reviewed works on the anatomy and physiology of the glands that produce sex pheromones in both male and female Lepidoptera have been published in many books and journals (Jacobson, 1972; Percy and Weatherston, 1971; Tamaki, 1985).

On the basic concept of functional morphology, we want to discuss the relationship between morphological aspects and some physiological phenomenons. We hope that this report will facilitate furture studies on the physiology, biochemistry, histochemistry and ultrastructure of sex-pheromone gland.

Spermatophore Formation in *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae). Phylogeny, Structure and Reproductive Functions of the Spermatophore

AMALDOSS G.

R. O. C. symposium on Insect Biochemistry and Physiology 113-129 (1988)

A Questionable Pronouncement on the Phylogeny of the Spermatophore

The pronouncement that the spermatophore is a primitive device in the phylogenetic evolution of animals when they invaded the land from water is highly debatable. The reasons that: (a) they did not develop copulatory organs in the process of invasion from water to land and (b) that using liquid semen is an advance over use of the spermatophore are

not any more completely tenable. Why then, within the same order and species, are there animals with differences? Spermatophore and copulatory organs can and do coexist. Animals in the same species may have or not have copulatory organs. Will the giant octopus be able to expel 10-20 μl semen over a distance of 2 meters without using a spermatophore? Though it is a single case, it is reported that it is possible to change over from using spermatophores to using liquid semen. *Grapholitha molesta,* the oriental fruit moth, after using spermatophores once, transfers liquid semen in subsequent matings (George and Howard, 1968). As numerous reports are available on the complexity of spermatophore usage, scientists are very reluctant to accept the view that the spermatophore is a primitive device in the phylogenetic evolution of animals when they invade the land from water (Alexander, 1964; Gerber, 1970; Parker, 1978; Mann T, 1984). The truth about the use of spermatophores by both aquatic and terrestrial animals as it is known today reveals that the use of spermatophores is "more directly related to the features of the habitat occupied than to the phylogeny of the group concerned" (Clark, 1981; T. Mann, 1984).

百香果採收成熟度之研究
(三)對果汁色澤及香氣之影響

方祖達* 史宏財* 陳雪娥

中國園藝 (Soc. Hort. Sci.) 34(1): 45-59, 1988

雜交種百香果汁的色澤深淺與所含的類胡蘿蔔素高低成正比，不同採收成熟度的果汁在波長 425 nm 下所測得的類胡蘿蔔素的吹光值隨成熟度之增加而增加，其吸光值與色差計測之 'a' 值成高度的相關 ($r=0.79$)。應用 Tenax GC 吸着法單離及 GC-MS 純化及鑑定出百香果汁在成熟期間所存在的揮發性成分計 30種，已檢定出醇類 3 種、萜類 (terpene) 3 種、酯類 17 種及 p-cymene 1 種，眞正表現百香果香氣的成分與總含量無關，但愈近成熟的果汁所含有的香氣成分種類愈多，揮發性香氣如歸類後依其含量高低觀察，除了酯類佔絕對高的百分率 (95%) 外，表現百香果芳香的醇類亦爲不可缺少的成分。

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葡萄酵素性褐變之研究

Ⅲ 金香葡萄 hydroxycinnamic acid 衍生物之鑑定及其含量之變化

陳 雪 娥

Journal of the Chinese Agricultural Chemical Society,
March, 1988 Vol. 26, No. 1, pp. 69～80

本實驗以栽種在后里及二林的金香葡萄爲材料，鑑定作爲聚酚氧化酶基質的酚化合物-—hydroxycinnamic acid 衍生物及調查葡萄發育成熟期間有關酚化合物含量之變化。結果顯示總酚、黃酮化合物及 hydroxycinnamoyl tartaric acids 之含量皆隨金香葡萄之發育成熟而減少，季節及地區間的差異很小。以 HPLC 配合 UV 光譜的分析及化學性質得知 hydroxycinnamoyl tartaric acids 包括 cis, trans-caffeoyl tartaric acid: cis, trans-para-coumaroyl tartaric acid 及 trans-feruloyl tartaric acid。其中 trans-caffeoyl tartaric acid 含量佔絕大部分，也是聚酚氧化酶最主要的基質。

環狀糊精之研究 6. β-環狀糊精之甲基化

丘志威 王一峯 郭賢明 張鎮平

界面科學會誌 第十一卷第一期 中華民國七十七年三月

以 β-環狀糊精 (β-CD) 爲原料，DMF爲溶劑，NaH 及 CH_3I 爲試劑合成甲基化 β-CD 的可行性已被探討。60 MHz 之 NMR 光譜顯示反應12小時所合成之甲基化 β-CD 大部份爲 2,6-di-O-methyl-β-CD 合成物之水解產物經 HPLC 分析發現仍有葡萄糖的成份，可能是由於脫甲基作用(demethyl-ation)或 β-CD C_2 及 C_6 之羥基並非已完全甲基化。而反應24小時所合成之甲基化 β-CD 則是 2,6-di-O-methyl- 和 2,3,6-tri-O-methyl-β-CDs，取代值 (D. S. value) 應在 2～3 之間。再由100 MHz 之 NMR 光譜分析，C_2-OCH_3，C_3-OCH_3 和 C_6-OCH_3 之吸收峯並沒有明顯分開，顯示反應 24 小時合成之甲基化 β-CD 產物中仍有不純物質存在。合成甲基化 β-CD 在水中的溶解度大於 17 g/100 ml。包接性實驗結果亦顯示合成甲基化 β-CD 與 KI/I_2 溶液形成之包接化合物的可見光及紫外光吸收强度比 β-CD 高。

β-環狀糊精功能性質及應用之研究：1. 乳化、去除苦味、吸濕和增泡

張鎮平　丘志威　林子清*
鄭淑文**　莊文媛

界面科學會誌　第十一卷第一期　中華民國七十七年三月

不同濃度 β-環狀糊精 (β-CD) 溶液的乳化容量均高於糊精及蔗糖脂，然而較酪蛋白鈉差。添加 β-CD 至葡萄柚汁和1%咖啡溶液均有降低苦味的效果。β-CD 由空氣中吸收15%水份而達到平衡，較玉米澱粉及糊精略佳。酪蛋白鈉與 β-CD 合用有較佳的增泡性，而且增加奶霜的膨脹率達73.86%。添加2% β-CD 很明顯的增加海綿蛋糕體積50%以上。

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環狀糊精之研究 4. 添加界面活性劑 SDS 於各種澱粉對環狀糊精產量的影響

丘志威

食品科學　第十四卷　第四期　第327-334頁　七十六年

添加界面活性劑，十二烷基硫酸鈉 (SDS)，於馬鈴薯澱粉、樹薯澱粉、臺中再來一號米澱粉及玉米澱粉，並與嗜鹼性 *Bacillus* 環狀糊精葡萄糖基轉移酶 (Alkalophilic *Bacillus* CGTase) 作用以探討環狀糊精 (CDs) 的產量與生成種類。含油脂澱粉例如臺中再來一號米澱粉經添加 SDS 後，CDs 產量由51%增加至60%；而脫脂或不含油脂之澱粉經添加 SDS 後，雖然反應初期 CDs 產量較未添加者高，但在反應2小時後，則彼此差距不大。SDS 雖然增加 α-CD 產量，減少 γ-CD 的生成，但是在整個反應液中仍以 β-CD 爲主。因此，添加 SDS 並無法改變嗜鹼性 *Bacillus* CGTase 以 β-CD 爲主要產物的特性。

Convective Heat Processing of Turkey Roll: Effects on Sensory Quality and Energy Usage

NANCY E. BROWN* and JONG-YU ADOL CHYUAN,

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Twenty-four frozen, raw, boneless, ready-to-cook turkey rolls were cooked in an institutional electric convection oven to an internal temperature of 77°C. Six treatment combinations of three cooking temperatures (105°C, 135°C, and 165°C) and two holding conditions (not chilled and chilled for 24 hours) were studied. Turkey rolls from each treatment combination were subjected to three hot-holding times (0, 60, and 120 minutes). Electrical energy usage was monitored during heat processing of the turkey rolls, reheating the turkey slices, and hot holding the turkey slices. Aroma, juicy mouthfeel, texture, flavor, and flavor off-notes of the cooked turkey were evaluated by seven judges using 150-mm unstructured line scales. Chew counts also were recorded. Turkey cooked at 105°C took significantly more time to cook (331 vs. 227 and 203 minutes) but consumed significantly less energy (3.4 vs. 3.8 and 4.5 kWh) than turkey rolls cooked at 135°C and 165°C, respectively. Significantly higher juicy mouthfeel scores were obtained when the turkey roll was cooked in the convection oven at an oven temperature of 105°C, the turkey was not chilled, and the slices were held hot for 60 minutes or less.

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從創造的角度看孔子的精神(上)

羅 秀 瑞　陳 月 卿 (譯)

神學論集㊴ 一九八八年春 p. 95 M18

孔子的智慧比任何的精神力量更原始且決定性地塑造了中國人的精神和生活方式。連道教、佛教都不能與之相比。中國人根據這穩實的智慧，成功地建構了自己獨特的文化，在漫長的歷史中羈旅前進。就是中國文化的悠久和昌明使得每位中國人心中——包括處處可見的庶民黎衆，充滿著一份深深的驕傲。然而，這份自豪雖然還有，可見它影響今日中國人生活素質的重大力量已逐漸萎弱。

這篇論文寫作的前提是：孔子親身履踐和教導的豐富精神（又叫「生活方式」），雖然飽受忽視與低估，但必能提供失去精神根基的今日中國人及全體人類生活的智慧和治療。這前提大爲學者所贊同，如柏禮・多瑪(Thoams Berry)

。他感嘆現代人和傳統脫節，不能將過去，如古老的精神價值和宗教信念，融入今日的價值體系裏。柏禮寫道：

「今日需要的不是對這些傳統加上外在的鑑認，而是能夠延續這些傳統的新詮釋，好使它們不再是博物館收藏的零碎廢片，而是今日文化的重要文獻。」

懷持這份鼓勵，我希望藉著西方以創造爲本的靈修 (Creation-Centered Spirituality) 來探討孔子的精神，以稍爲證實我所提出的前提。這份探討呈現一片樂觀，因爲這兩種精神都植根於智慧。猶如孔子的精神源自他的智慧教導和古老的傳統祖述，新興的西方靈修亦植根於聖經的智慧訓誨。啓示人類智慧的首要來源是天地萬物的創造，這是大家共有的實際經驗。因爲智慧總是根據經驗。由於天地萬物和人性同爲人類所共有，因此智慧必然是普遍性的。這也是我想徹底研究孔子精神的原因。

Carbamate Insecticide Removal in Laundering from Cotton and PolyesterFabrics

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and AHMED M. KADOUM*

Arch. Environ. Contam. Toxicol. 17, 87-94 (1988)

Even though carbamate insecticides are becoming increasingly important for insect control on field crops, few studies have focused on their removal from contaminated textiles. Hence, this study evaluated the effectiveness of selected laundering procedures in removing carbofuran and methomyl insecticides from 100% cotton and 100% polyester medium weight fabrics. After treating the fabric samples with 4.0% (w/w) aqueous solutions of Furadan® 4F Insecticide (carbofuran) or Lannate® L Insecticide (methomyl), they were air dried and laundered, using three detergents [All^R (nonionic), Tide^R (anionic), and Wisk^R (anionic and nonionic)] plus water only at two temperatures (warm: 49℃ wash/40℃ rinse and hot: 60℃ wash/40℃ rinse). The percentages of insecticide residue remaining on the fabrics after laundering were analyzed by high performance liquid chromatography (HPLC) with a fluorescence detector, and bioassay tests with *Drosophilia*

malanogaster Meigen were used to evaluate their relative toxicity.

All of the laundering procedures, including the water only wash, were effective in removing≥99% of the carbamate insecticides from both the cotton and polyester fabrics. Among the insecticide/fabric types evaluated, the highest percentages of residue remaining were associated with the polyester fabrics treated with methomyl. After 72 hr, fruit fly mortality occurred on only the methomyl treated polyester laundered in warm water. These findings support those reported in previous studies on the ease with which carbamate contaminants are removed from textiles, compared to other insecticidetypes.

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