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## Excretion of Causative PCDFs Congeners of Yusho by One Year Intake of FBRA in Patients with Yusho

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**Abstract** Thirty-eight years have passed since the outbreak of Kanemi rice oil poisoning, namely, Yusho in the western Japan. However, even now the patients with Yusho have been still suffering from several objective and subjective symptoms. In order to improve or, if possible, to cure the such symptoms, the most important therapeutic treatment is considered to actively excrete the causative agents, that is, polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs) from the bodies of the patients and to reduce their body burdens. In rats, dietary fiber and chlorophyll have been shown to promote the fecal excretion of dioxins and to reduce their levels in rat liver. In this study, we examined whether such kinds of effect were also observed by FBRA, which was the health food and relatively rich with dietary fiber and chlorophyll, in eighteen patients with Yusho, which were divided into two groups, namely group A, ten patients (Male: 3 and Female: 7) with the mean age of 67.7 years old and group B, eight patients (Male: 4 and Female: 4) with the mean age of 64.1 years. Respective mean concentrations of the three PCDF congeners, that is, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF and 1,2,3,6,7,8-HxCDF in the blood on whole weight basis just before initiating this study were as follows; group A: 1.36, 0.491 and 0.150 pg/g, and group B: 0.571, 0.159 and 0.064 pg/g. Contamination levels of these PCDF congeners in group A were 2 to 3 times higher than those in group B. Group A took 7.0 to 10.5g of FBRA after each meal and tree times a day for the first one year and for second one year, they did not take FBRA any more. Group B took FBRA with the same manner as the group A only for the second one year. The concentrations of these PCDFs congeners in the blood of groups A and B were also measured at the end of first and second year, respectively. Assuming that the lipid content of the blood is 0.3% in order to convert their concentrations on whole weight basis to those on lipid weight basis and also that the body fat is contaminated with these PCDF congeners at their concentrations on lipid weight basis and the content of body fat is 20% of the body weight (60 kg), we computed the average amounts in the net excretion of these PCDF congeners from the body of the patients due to the intake of FBRA in groups A and B. As a result, in group A, 120, 372 and 96 ng/patient of 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF and 1,2,3,6,7,8-HxCDF, respectively, were excreted from the body of the patients. In group B, however, 36 ng/patient of 2,3,4,7,8-PeCDF only was excreted, but

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other two PCDF congeners were not. Accordingly, promotive excretion of these PCDF congeners from the patients with Yusho seemed much effective in group A, of which their concentrations in the blood were much higher than those of group B.

### Introduction

Our environments including foods have been polluted with extremely toxic dioxins such as polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-*p*-dioxins (PCDDs) not only in Japan<sup>1)2)</sup> but also other countries<sup>3)~7)</sup>. Consequently, human beings also have already been contaminated with these dioxins<sup>8)~10)</sup>. We already have investigated the effects of this kind of compounds on the foetus and sucklings which are considered the most sensitive stages of human beings as well as animals, and observed their unfavorable effects on thyroid hormone and immune response systems in Japanese infants perinatally and lactationally exposed to them<sup>11)~14)</sup>. Their adverse effects on developmental condition have also been found in 10-month-old breast-fed Japanese infants<sup>15)16)</sup>.

PCDFs have been the most important etiological agents of Yusho<sup>17)</sup>, a mass food poisoning that occurred in western Japan in 1968 and even now<sup>18)</sup>. At present, namely, more than 38 years after the outbreak, many patients with Yusho are still suffering from several objective and subjective symptoms. In order to improve or to cure various symptoms of patients with Yusho, their promotive excretion from the body of the patients is considered very useful. In rats, dietary fiber and chlorophyll have been shown to promote the fecal excretion of dioxins, probably due to the restriction or some inhibition of their absorption and re-absorption in the digestive tract and therefore to reduce their levels in rat liver<sup>19)20)</sup>.

In this study, we examined whether such kinds of effect were observed by FBRA, which was the brown rice fermented with *Aspergillus-oryze* and rich with dietary fiber, or not in patients with Yusho.

### Materials and Methods

FBRA has been manufactured for over 35 years with Genmaikouso Corp., Sapporo, Japan, and taken by more than 100,000 people as one of the health foods. Ingredients of FBRA have already been reported in our previous study<sup>21)</sup>.

Eighteen patients with Yusho were voluntarily participated in this study, and divided into two groups in compliance with their wishes, namely, groups A and B. Group A consisted of 3 males and 7 females with the mean age of 67.7 years old and group B 4 males and 4 females with that of 64.1 years old. In group A, they took 7.0 to 10.5g of FBRA after each meal and three times a day for the first one year and didn't for the second one year. In group B, they took FBRA in the same way as group A in the second one year, but not in the first one year.

Just before starting this study, 20 ml of the peripheral blood was individually taken by venipuncture in both groups A and B, twice at one week intervals. These blood samples were analyzed for 2,3,4,7,8-pentachlorodibenzofuran (2,3,4,7,8-PenCDF), 1,2,3,4,7,8-hexachlorodibenzofuran (1,2,3,4,7,8-HxCDF) and 1,2,3,6,7,8-HxCDF, which were the most important causative compounds for Yusho disease, by HRGC-HRMS technique using a Micromass Autospec Ultima NT mass spectrometer directly interfaced

with an Agilent Technologies HP-6890A gas chromatography<sup>22)</sup>.

The average concentrations of these three PCDF congeners in the two blood samples of the same patient were expressed as the individual original ones in both groups A and B. In order to evaluate the effect of FBRA on their excretion from the patients, their blood concentrations were determined again exactly with the same manner as those measured just before beginning this study at the end of first and second year in both groups. Their concentrations measured at different times in each group were statistically examined by student's t-test.

### Results and Discussion

Changes in concentrations on wet weight basis of three PCDF congeners in the blood of patients with Yusho during the period of

this study were shown in Table 1. Just before starting this study, concentrations of 2,3,4,7,8-PenCDF, 1,2,3,4,7,8-HxCDF and 1,2,3,6,7,8-HxCDF in group A were  $1.36 \pm 1.71$ ,  $0.491 \pm 0.734$  and  $0.150 \pm 0.195$  pg/g wet weight, respectively, and those in group B  $0.571 \pm 0.465$ ,  $0.159 \pm 0.113$  and  $0.064 \pm 0.037$  pg/g wet weight. Although their concentrations were 2.3 to 3.1 times higher in group A than in group B, even in group B these were 3 to 10 times greater than those in healthy Japanese people, and the concentrations of 2,3,4,7,8-PenCDF, the main causative congener of Yusho, were the highest and 10 times over those of healthy persons<sup>23)</sup>. These results clearly indicate that patients with Yusho are still contaminated with high levels of PCDFs and in order to improve their objective and subjective symptoms, promotive excretion of these

**Table 1** Changes in concentrations on wet weight basis of three PCDFs congeners in the blood of patients with Yusho

Congener	Concentration, pg / g wet weight*		
	Initial	After 1st year	After 2nd year
2,3,4,7,8-PenCDF			
Group / A	$1.36 \pm 1.71$	$1.32 \pm 1.68$	$1.31 \pm 1.67$
B	$0.571 \pm 0.465$	$0.570 \pm 0.476$	$0.561 \pm 0.473$
1,2,3,4,7,8-HxCDF			
Group / A	$0.491 \pm 0.734$	$0.410 \pm 0.609^a$	$0.423 \pm 0.648^a$
B	$0.159 \pm 0.113$	$0.148 \pm 0.107$	$0.144 \pm 0.113$
1,2,3,6,7,8-HxCDF			
Group / A	$0.150 \pm 0.195$	$0.128 \pm 0.159^a$	$0.133 \pm 0.174^a$
B	$0.064 \pm 0.037$	$0.061 \pm 0.037$	$0.060 \pm 0.040$

\* : Mean  $\pm$  S.D.

<sup>a</sup> : Significantly different from the initial concentration in group A,  $p < 0.05$

**Table 2** Changes in mean concentrations on lipid weight basis of three PCDF congeners in the blood of patients with Yusho

Congener	Mean Concentration, pg/g lipid weight*		
	Initial	After 1st year	After 2nd year
2,3,4,7,8-PenCDF			
Group / A	453	440	437
B	190	190	187
1,2,3,4,7,8-HxCDF			
Group / A	164	137	141
B	53	49	48
1,2,3,6,7,8-HxCDF			
Group / A	50	43	44
B	21	20	20

\* : Lipid content of the blood was supposed 0.3%

**Table 3** Changes in average body burdens of three PCDF congeners in patients with Yusho

Congener	Average Body Burden, ng/patient*		
	Initial	After 1st year	After 2nd year
2,3,4,7,8-PeCDF			
Group / A	5,436	5,280	5,244
B	2,280	2,280	2,244
1,2,3,4,7,8-HxCDF			
Group / A	1,968	1,644	1,692
B	636	588	576
1,2,3,6,7,8-HxCDF			
Group / A	600	516	528
B	252	240	240

\* : Content of body fat was considered 20% of body weight (60kg)

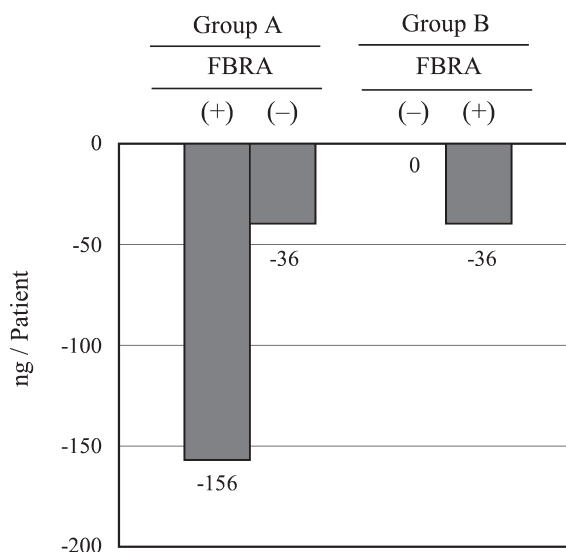
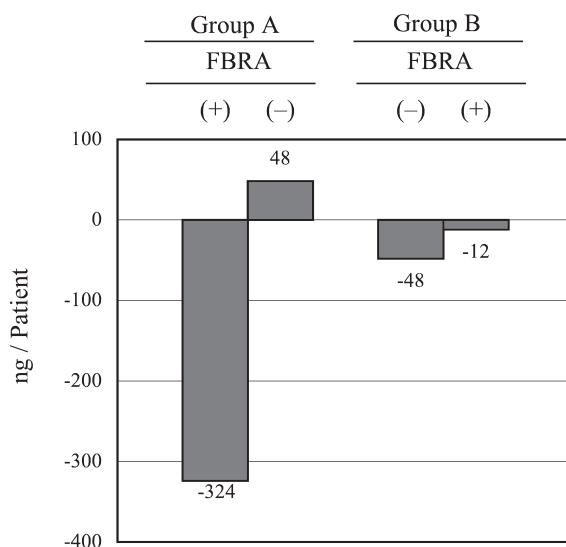
PCDFs congeners seems quite useful.

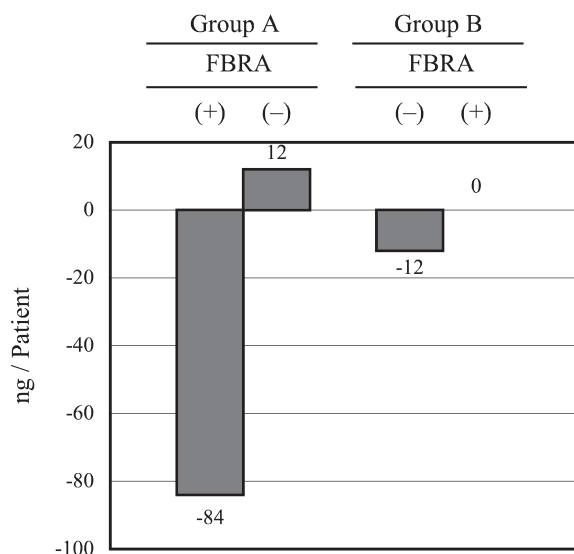
As indicated in Table 1, mean concentrations of 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF and 1,2,3,6,7,8-HxCDF gradually decreased from the beginning to the end of this study, except those of 1,2,3,4,7,8- and 1,2,3,6,7,8-HxCDFs in group A, in which their concentrations increased from the end of first year to the end of second year and in this period they did not take FBRA.

In order to convert the mean concentrations in Table 1 to those on lipid weight basis, we presumed the lipid content of blood was 0.3%, and the results are shown in Table 2. Again, on the assumption that the body fat was contaminated with these three PCDF congeners at their blood concentrations on the lipid weight basis and the content of body fat was 20% of body weight (60kg), we calculated their total body burdens and the results are indicated in Table 3.

As a result, effects of the intake of FBRA for one year on the excretion of the three PCDF congeners from the body of patients with Yusho in groups A and B are demonstrated in Figs. 1, 2 and 3.

Net reduction of 2,3,4,7,8-PeCDF in the body of patients with Yusho were 120 and 36 ng / patient in groups A and B, respectively, as shown in Fig. 1. Net reduction of 1,2,3,4,7,8- and 1,2,3,6,7,8-HxCDFs were 372 and 96

**Fig. 1** Effects of the intake of FBRA for one year on the excretion of 2,3,4,7,8-PeCDF from the body of patients with Yusho**Fig. 2** Effects of the intake of FBRA for one year on the excretion of 1,2,3,4,7,8- HxCDF from the body of patients with Yusho



**Fig. 3** Effects of the intake of FBRA for one year on the excretion of 1,2,3,6,7,8- HxCDF from the body of patients with Yusho

ng / patient, respectively, only in group A, as indicated in Figs 2 and 3. However, we could not find any significant reduction of these two HxCDFs congeners in group B.

We have already reported the promotive excretion of PCDFs and PCDDs from healthy Japanese people by one year intake of FBRA<sup>21)24)25)</sup>. Results of this study also confirmed the reduction of PCDFs congeners from the patients with Yusho by the intake of FBRA, and showed that this reduction seemed more effective in the patients with higher concentrations of PCDFs, namely, in group A.

## References

- Ohta S, Nakano T, Nishimura H, Okumura T, Aozasa O and Miyata H: Contamination levels of PBDEs, TBBPA, PCDDs / DFs, PBDDs / DFs and PXDDs / DFs in the environment of Japan. *Organohal. Comp.* 57 : 57-60, 2002.
- Uegaki R, Kurokawa S and Yoshimura Y: The fate of polychlorinated dibenzo-p-dioxins, dibenzofutans and coplanar PCBs in silage corn. *Ibid.* 51 : 302-305, 2001.
- Bocio A, Llobet JM, Domingo JL, Casas C, Teixido A and Muller L: Levels of PCDD / PCDFS in food samples from Catalonia, Spain. *Ibid.* 57 : 105-108, 2002.
- Coutinho M, Mata P, Borrego C and Boia C: Levels of PCDD / PCDF in agricultural materials in the region of Oporto, Portugal. *Organohal. Comp.* 57 : 101-104, 2002.
- Kim B-H, Jung J-S, Chang Y-S and Park Y-H: Congener specific distribution of polychlorinated dibenzo-p-dioxins, dibenzofurans and dioxin-like polychlorinated biphenyls in animal feed. *Ibid.* 57 : 121-124, 2002.
- Kiviranta H, Vartiainen T, Parmanne R, Hallikainen A, Ruokojarvi P and Koistinen J: PCDD/Fs in Baltic herring in the gulf of Finland during 1990's. *Ibid.* 57 : 153-156, 2002.
- Wu Y, Li J, Zhao Y, Chen Z, Li W and Chen J: Dietary intake of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in populations from China. *Ibid.* 57 : 221-224, 2002.
- Furst P and Papke O: PCDDs, PCDFs and dioxin-like PCBs in human milk and blood from Germany. *Ibid.* 55 : 251-254, 2002.
- Hirakawa H, Matsueda T, Iida T, Nakamura M, Nagata T and Nagayama J: Age-related increase of PCDDs/PCDFs and coplanar PCBs levels in human adipose tissue. *Ibid.* 21 : 419-421, 1994.
- Todaka T, Hirakawa H, Takenaka S, Tobiishi K, Nakagawa R and Iida T: New protocol for dioxins analysis of human blood. *Ibid.* 55 : 155-158, 2002.
- Nagayama J, Iida T, Nakagawa R, Matsueda T, Hirakawa H, Astuti ET, Yanagawa T, Fukushige J and Watanabe T: Condition of thyroid hormone system in 10-month-old Japanese infants perinatally exposed to organochlorine pesticides, PCBs and dioxins. *Ibid.* 48 : 236-239, 2000.
- Nagayama J, Iida T, Nakagawa R, Matsueda T, Hirakawa H, Astuti ET, Yanagawa T, Fukushige J and Watanabe T: Thyroid hormone status in Japanese infants lactationally exposed to organochlorine pesticides, PCBs and dioxins. *Ibid.* 53 : 140-144, 2001.
- Nagayama J, Tsuji H, Iida T, Nakagawa R, Matsueda T, Hirakawa H, Astuti ET, Yanagawa T, Fukushige J and Watanabe

- T: Condition of helper and suppressor T lymphocyte subpopulations in 10-month-old Japanese infants perinatally exposed to organochlorine pesticides, PCBs and dioxins. *Ibid.* 49: 87-90, 2000.
- 14) Nagayama J, Tsuji H, Iida T, Nakagawa R, Matsueda T, Hirakawa H, Astuti ET, Yanagawa T, Fukushige J and Watanabe T: Status of helper and suppressor T lymphocyte subpopulations in Japanese infants lactationally exposed to organochlorine pesticides, PCBs and dioxins. *Ibid.* 53: 121-125, 2001.
  - 15) Nagayama J, Fukushige J, Iida T, Nakagawa R, Matsueda T, Hirakawa H, Astuti ET, Yanagawa T and Watanabe T: Effects of exposure to organochlorine pesticides, PCBs and dioxins through human milk on total development in 10-month-old Japanese infants. *Ibid.* 48: 240-243, 2000.
  - 16) Nagayama J, Fukushige J, Iida T, Nakagawa R, Matsueda T, Hirakawa H, Astuti ET, Yanagawa T and Watanabe T: Developmental condition in 10-month-old Japanese infants perinatally exposed to organochlorine pesticides, PCBs and dioxins. *Ibid.* 48: 244-247, 2000.
  - 17) Nagayama J, Masuda Y and Kuratsune M: Determination of polychlorinated dibenzofurans in tissues of patients with 'Yusho'. *Fd Cosmet. Toxicol.* 15: 195-198, 1977.
  - 18) Iida T, Hirakawa H, Matsueda T and Nakagawa R: Concentrations of PCDDs, PCDFs and coplanar PCBs in blood of 83 patients with Yusho. *Fukuoka Acta Med.* 88: 169-176, 1997. (in Japanese)
  - 19) Morita K, Matsueda T and Iida T: Effect of dietary fiber on fecal excretion of polychlorinated dibenzo-p-dioxins in rat. *Jpn J. Toxicol. Environ. Health* 43: 35-41, 1997. (in Japanese)
  - 20) Morita K, Matsueda T and Iida T: Effect of chlorella, spirulina and chlorophyllin on fecal excretion of polychlorinated dibenzo-p-dioxins in rat. *Ibid.* 43: 42-47, 1997. (in Japanese)
  - 21) Nagayama J, Takasuga T, Tsuji H, Ume-hara M, Sada T and Iwasaki T: Active elimination of causative PCDFs/DDs congeners of Yusho by one year intake of FBRA in Japanese people. *Fukuoka Acta Med.* 94: 118-125, 2003.
  - 22) Todaka T, Hirakawa H, Hori T, Tobiishi K and Iida T: Follow-up survey of dioxins concentrations in the blood of Yusho patients in 2002-2003. *Ibid.* 96: 249-258, 2005.
  - 23) Todaka T, Hirakawa H, Tobiishi K and Iida T: New protocol of dioxins analysis in human blood. *Ibid.* 94: 148-157, 2003.
  - 24) Takasuga T, Senthilkumar K, Takemori H, Ohi E, Tsuji H and Nagayama J: Impact of FEBRA (fermented brown rice with *Aspergillus oryzae*) intake and concentrations of PCDDs, PCDFs and PCBs in blood of humans from Japan. *Chemosphere* 57: 1409-1426, 2004.
  - 25) Nagayama J, Takasuga T, Tsuji H and Iwasaki T: Promotive excretion of causative agents of Yusho by one year intake of FBRA in Japanese people. *Fukuoka Acta Med.* 96: 241-248, 2005.

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(和文抄録)

## 油症患者における FBRA 摂取による 油症原因 PCDFs 同族体の体外排泄促進

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カネミ油症中毒事件が発生してから 38 年が経過したが、今でも油症患者は種々様々な自覚および臨床症状で苦しんでいる。このような症状を改善し治療するには、その主要な原因物質であるポリ塩化ダイベンゾフラン (PCDFs) を積極的に体外へ排泄し、汚染レベルを低下させることが第一である。この研究では動物実験によりダイオキシン類の体外排泄促進作用が認められている食物繊維と葉緑素を比較的多量に含む栄養補助食品 FBRA (発酵玄米栄養補助食品ハイ・ゲンキ, (株)玄米酵素, 本社: 北海道札幌市) によるカネミ油症原因物質, 中でも特に重要な 2,3,4,7,8-五塩化ダイベンゾフラン (2,3,4,7,8-PenCDF), 1,2,3,4,7,8-六塩化ダイベンゾフラン (1,2,3,4,7,8-HxCDF) および 1,2,3,6,7,8-六塩化ダイベンゾフラン (1,2,3,6,7,8-HxCDF) の体外排泄促進を 18 名の油症患者の協力により調べた。

研究期間は 2 年間で、患者の希望により A, B 二群に分け、A 群は最初の 1 年間、B 群は 2 年目の 1 年間、毎食後 7.0~10.5g の FBRA を摂取した。A 群は 10 名 (男性 3 名, 女性 7 名) で、平均年齢が 67.7 歳、B 群は 8 名 (男性 4 名, 女性 4 名) で、平均年齢が 64.1 歳であった。

研究を始める前の血中 PCDFs 同族体の平均濃度は A 群が 2,3,4,7,8-PenCDF ; 1.36pg/g, 1,2,3,4,7,8-HxCDF ; 0.491pg/g, 1,2,3,6,7,8-HxCDF ; 0.150pg/g で、B 群が、それぞれ 0.571, 0.159, 0.064 pg/g であった。A 群のほうが、2~3 倍高かった。研究開始 1 年後と 2 年後にも両群の血中 PCDFs 同族体濃度を測定した。

これらの測定結果より、血液の脂肪含有率を 0.3% として、脂肪重量当りの濃度を算出した。この濃度で患者体内の脂肪組織が汚染されており、体重 60kg の患者について、体脂肪率を 20% と仮定して、これらの PCDFs 同族体の体内蓄積量を算出する。そして、この体内蓄積量が FBRA 摂取と非摂取の期間でどのように変化するかを、両群で比較検討した。

A 群の場合、すべての PCDFs 同族体で FBRA 摂取期間のほうが非摂取期間よりも減少量が多く、平均純減少量は患者一人当たり 2,3,4,7,8-PenCDF が 120ng, 1,2,3,4,7,8-HxCDF が 372ng, 1,2,3,6,7,8-HxCDF が 96ng であった。B 群では 2,3,4,7,8-PenCDF のみ、36ng 減少したが、他の二種の同族体では体外への排泄促進は認められなかった。

以上の結果より、FBRA には油症の原因となった PCDFs 同族体の体外排泄促進作用が認められ、その効果は汚染レベルの高い患者でより有効と考えられた。