TRIAL INTERCOUNTRY SHIPMENT OF IRRADIATED SPICES

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ABSTRACT

An experiment has been carried out to evaluate the quality of irradiated spices packaged in some indigenous packaging materials. Spices used were whole nutmeg (*Myristica fragans*) and whole white pepper (*Piper nigrum*). The spice samples were packaged in tin containers with or without oxygen absorber and in woven popypropylene (PP) bags, then irradiated at 5 kGy, and despatched from Jakarta to Wageningen by sea-freight. The shipment was performed in small and commercial size packages. The results showed that irradiation treatment could effectively disinfest and decontaminate the spices without altering their chemical composition and sensory properties. Polypropylene (PP) bags, particularly the ones without inner liner were unable to withstand rough handling and to prevent reinfestation during shipment. Tin containers were able to with-stand rough handling and prevent reinfestation. The oxygen absorber used had no effect on microbial count and the other parameters of the spices.

INTRODUCTION

Deterioration of Indonesian spices often appear after the commodities arrive at the importing countries. Therefore, the leading importing country of Indonesian spices i.e. USA, often complain regarding the poor quality of the products due to mouldiness and insect infestation. Actually, the exporters have taken all possible precautions to prevent deterioration of the commodities before exportation. However, they have no control over shipping and storage conditions such as fluctuation of temperature and humidity as well as insect infestation and rodent damage. Hence, the commodities may deteriorate during the shipment. In addition, the commonly used packaging material for spices, namely jute bag, cannot prevent insect species from entering through the existing openings.

In commercial practice, the exporters use fumigation to keep the quality of spices. The cancellation and phase-out of ethylene dibromide (EDB) as chemical fumigant for stored product insects by the United States Environmental Protection Agency (1) should encourage efforts to find out other alternatives. The use of gamma irradiation is one of the alternatives that can be taken into account since this method showed promising results (2, 3). Moreover, the recent clearance for irradiated spices by the United States Food and Drug Administration (4) will open more widely the possible application of irradiation to control microbial contamination in spices in the near future.

Irradiated spices should be packaged properly to protect the commodities from reinfestation, and moisture gain or loss during storage and shipment. HIGHLAND (5) has shown that composite cans are resistant to insect. The can could resist insect infestation up to 29 months of exposure to heavy population of insect. Our previous investigation (6) showed that tin container or woven polypropylene (PP) bag with PP liner could avoid changes in the moisture content of nutmegs and white peppers stored for 9 months at 70–90% RH. Woven PP bags have also been studied and was found to be suitable for packaging irradiated food (7). However, woven PP bags with-out PP liner could not maintain the moisture content of the samples.

The present study was carried out to evaluate the quality of irradiated and unirradiated spices packaged in tin cans and woven bags after being shipped under practical conditions. Effect of oxygen absorber incorporated in the packages was also observed.

MATERIALS AND METHODS

Materials

Whole nutmeg (*Myristica fragrans*) and white pepper (*Piper nigrum*) obtained from Manado and Lampung, respectively, were used for the experiment. The packaging materials used were tin containers (TC) of 0.5 and 13 kg capacities, and woven PP bags with or without PP film liner of 0.5 and 22 kg capacities, respectively.

Oxygen absorber used was Z-TYPE "AGELESS" produced by MITSUBISHI GAS CHEMICAL CO., INC., Japan.

Sample Preparation and Treatments

The samples were sorted and then irradiated with doses of 0 and 5 kGy. A part of samples packaged in tin containers were provided with oxygen absorber.

Irradiation was conducted in a panoramic batch type irradiator at the Centre for the Application of Isotopes and Radiation (CAIR), Jakarta, with a dose rate of 1.5 kGy/hour.

The first shipment consisting of samples in small size packages were despatched from Jakarta by sea-mail on 5 February and 15 February 1982. The samples reached Wageningen on 31 March and 24 April 1982, respectively. The qualities of the samples were evaluated at the International Facility For Food Irradiation Technology (IFFIT), Wageningen, The Netherlands; Central Food Research Institute (CFRI), Budapest, Hungary; and Laboratory of the Ten Doesschate B.V., Wapenveld, The Netherlands.

The second shipment using samples packed in commercial size packages was performed by sea-freight on 7 June and reached Wageningen on 12 August 1982. The quality of the spices and the condition of the packages were evaluated at the IFFIT and Ten Doesschate B.V.

In each shipment, some samples were kept at the CAIR as control, and the quality was compared with the despatched samples after certain periods of storage.

Visual Observation of the Packages

The packages were visually inspected upon arrival at Wageningen to see any damage in the packages.

Evaluation of Insect Infestation

One sample from each treatment of the first shipment was evaluated for insect damage. The number of insect-punctured nutmegs were counted, and total weight of the samples and the weight percentage of insect-punctured fraction were calculated. The sieving residues were checked for insects or excrements using a VIPO sieving machine performed for 5 minutes. The evaluations were carried out at CFRI and IFFIT.

Filth-test and evaluation of insect infestation on the second shipment samples were performed using WARENWET method (8) at IFFIT.

Microbiological Evaluation

Total aerobic bacterial count (TPC) and total mould and yeast count (TMYC) were determined using streak plate method on tryptone glucose yeast agar (TGYA) for TPC and on Saboraud glucose agar with 0.05% $CuSO_4.5\,H_2O$ (SA), and oxytetracycline glucose yeast agar (OGYA) for TMYC. The plate were incubated at 30°C for 48 hours for TPC, and at 24°C for 5 days for TMYC. The tests were carried out at CAIR for the non-despatched samples and at CFRI and IFFIT for the shipped samples.

Chemical Evaluation

Moisture content of the samples was determined using toluene distillation method. A_W value was measured by a NOVASIANA instrument at CFRI, and a BECKMAN HYGROLYNE Recorder at CAIR. Volatile oil content was determined according to the AOAC method (9) at IFFIT. Non-volatile oil ether extract and ash content were determined according to DUTCH standard methods (10, 11) at Ten Doesschate B.V.

Sensory Evaluation

Organoleptic tests were done at CAIR, IFFIT and Ten Doesschate. At CAIR, the test was done by 12 panelists using a 9 point hedonic scale (12) on finely ground samples. The procedure was slightly modified.

The procedure of organoleptic test applied at IFFIT was slightly different from that used at CAIR. The ground spice samples were first mixed with a neutral-taste carrier made of a starch-like powder prepared by the Naarden International Holland B.V., as neutral base for evaluation of their flavour products. Fourty grams of this powder was added to 20 ml of boiling water under continuous stirring and the suspension was cooked until a homogenous gelified puree was formed. The puree was then cooled to room temperature and mixed with 0.2% ground white pepper or 2% ground nutmeg to be tested. After thoroughly mixing, the samples were judged by 6 panelists using a 7 point scale of flavour intensity (1 = imperceptible, 4 = slightly pronounced and 7 = very pronounced). The scores were ranked and the rank-sum were evaluated by Kramer's quick rank test (13).

Ten Doesschate B.V. laboratory assessed the quality of spices based on odour, colour and grade.

RESULTS AND DISCUSSION

From visual inspection on the packages upon arrival at Wageningen, it was found that the lid of one of the tin containers from the first shipment was already loose and some nutmegs were found outside the container. Two of the woven PP bags from the first shipment were broken. The damages may be caused by rough handling during the shipment.

In samples of the second shipment, two woven PP bags were broken. The damaged packages contained nutmeg and white pepper, respectively.

The woven PP bags, particularly the ones without inner liner, were unable to withstand harsh treatment during transport, since the hard kernels in the bags did not provide a flexible background for the packaging material against mechanical stress.

The use of double layer or woven PP bags may prevent the damages. However, such a method needs further investigation, especially from the view-point of economical aspect. Furthermore, the labours in the sea-port usually use hooked stick or some other tools to remove the packages which can damage the packages. Instruction for careful handling should be given on the packages in order to prevent the damage.

Table 1 presents results of entomological as well as insect damage evaluation of nutmegs from the first shipment. Insect damages were found in both unirradiated and irradiated nutmegs. The incidence of worm-punctured nutmeg was 11.3 ± 5.4% in treated sample and 7.5 ± 4.3% in irradiated sample. However, living larvae or living beetles were only found in unirradiated samples. This indicates that insect damage in irradiated samples has occured before the irradiation treatment. It should be noted that the nutmeg samples contain worm-punctured kernel higher than the maximum level permitted by

Table 1. Results of entomological evaluation done by IFFIT (I) and CFRI (II) on nutmeg samples from the first shipment.

Sample code*	% number of warm-punctured kernels		Sieving residu		Insects infesting the samples	
	I	II	I	II	I**	II***
TC/A/D_0	12	14	Living and dead beetles and larvae, living mites, a lot of excrements.	Beetles, mites, insect eggs	*Tribolium castaneum, Oryzaephilus* (*mercator*?), *Lasioderma serricorne.*	Beetles : *Oryzaephilus surinamensis, Tribolium, Araeocerus.* Mites : *Tyrophagus palmarum, Cheyletus, Acodiledon.*
TC/D_0	9	14	Living beetles and mites, dead larvae, a lot of excrements.	Living and dead beetles and mites	*Tribolium castaneum, Oryzaephilus, Lasioderma serricorne.*	Beetles : *Oryzaephilus surinamensis, Anthribidae.* Mites : *Tyrophagus palmarum, Cheyletus, Acodiledon.*
PPL/D_0	6	3	Living and dead beetles and larvae, excrements	Beetles and mites, excrements	*Oryzaephilus* (*mercator*?), *Lasioderma serricorne.*	Beetles : *Oryzaephilus surinamensis.* Mites : *Tyrophagus palmarum, Cheyletus, Acodiledon.*
TC/A/D_5	2	8	Dead beetles	Dead beetles	*Tribolium castaneum, Lasioderma serricorne, Oryzaephilus* (*mercator*?), *Laemnophloeus* sp.	Beetles : *Oryzaephilus surinamensis.*
TC/D_5	10	8	Dead beetles and larvae, excrements	Dead mites and beetles	*Lasioderma serricorne, Oryzaephilus* (*mercator*?), *Tribolium castaneum, Laemnophloeus* sp.	Beetles : *Tribolium* sp. Mites : *Tyrophagus palmarum.*
PPL/D_5	10	7	Dead beetles and larvae, excrements	Dead beetles	*Tribolium castaneum, Lasioderma serricorne, Oryzaephilus* (*mercator*?), *unidentified fragments.*	Beetles : *Oryzaephilus surinamensis.*

* TC = tin container; A = oxygen absorber; PPL = woven polypropylene bag with PP film linier; D_0 = unirradiated; D_5 = irradiated at 5 kGy; I, II = replicate.

** Done by the Entomological Department of the Agricultural University, Wageningen, The Netherlands.

*** Done by the Natural History Museum, Budapest, Hungary.

Dutch Merchandise Act, i.e. 5% (14). However, to a certain extent, the quality of the samples still can satisfy the USFDA requirements, i.e. contain less than 10% of worm-punctured nutmegs (15). The genera of insects found in this study were more than those found in the previous experiment (2). All of the insects are the common insects attacking spices (16, 17).

Table 2 presents the data of entomological evaluation on white pepper from the first shipment. No insect infestation or insect damage were found in all of the samples. Mites were only found in the unirradiated samples.

Table 3 shows the results of entomological evaluation on the nutmeg from the second shipment. It can be seen that both unirradiated and irradiated nutmegs packed in woven PP bags contained living insects. The amount of

Table 2. Results of entomological evaluation on white pepper samples from the first shipment (CFRI, 9 April 1982).

Sample code*	Net-weight of samples (g)	Sieving residue	Insects infesting the samples**
TC/A/D_0-II	424.1	Mites	*Tyrophagus palmarum*
TC/D_0-II	431.0	Mites	*Tyrophagus palmarum*
PPL/D_0-II	436.3	Mites	*Tyrophagus palmarum*
TC/A/D_5-II	430.7	No insects	—
TC/D_5-II	433.5	No insects	—
PPL/D_5-II	456.2	No insects	—

* TC = tin container, A = oxygen absorber, PPL = woven polypropylene (PP) bag with PP liner, D_0 = unirradiated, D_5 = irradiated with 5 kGy.
II = replicate.

** Done by the Natural History Museum, Budapest, Hungary.

Table 3. Results of entomological evaluation on nutmeg samples from the second shipment. (IFFIT, September 1982).

Sample code*	Total weight of nutmeg checked (g)	% number of worm-punctured nutmeg	Number of insects found				Filth-test
			Living beetle	Living larvae	Dead beetle	Pupae	
TC/A/D_0	807	4.6	—	—	—	—	14
TC/D_0	1045	3.5	—	—	6	—	130
PP/D_0	960	7.4	14	4	—	3	92
TC/A/D_5	1020	0.4	—	—	—	—	26
TC/D_5	1018	1.9	—	—	2	—	48
PP/D_5	903	9.9	17	—	—	3	24

* TC = tin container; A = oxygen absorber; PP = woven polypropylene bag.
D_0 = unirradiated; D_5 = irradiated at 5 kGy.

worm-punctured nutmegs from samples packed in plastic bags were higher than those packed in tin containers. This means that woven PP bags without inner liner could not prevent reinfestation. It should be noted that spices are usually stored in the hold of the ship together with other crop products, hence cross infestation may occur during the shipment. Therefore, an insect resistant packaging material, such as tin container, should be used.

In nutmeg samples packed in tin containers, the amount of worm-punctured kernels in unirradiated sample was at least 3 times higher than those of the irradiated ones. This difference reflects the progress of insect infestation in the unirradiated samples between the date of irradiation treatment and the entomological evaluation. The results of filth-test did not follow the same pattern as the incidence of worm-punctured kernels.

Results of microbiological evaluation showed that the mould counts on Sabouraud agar and on OGYA-medium were almost similar. Considering the large heterogeneity distribution of micro-organisms in the spice packages, and the inherent error of the microbiological analysis, the mode of packaging did not show a clear-cut effect on the microbiological counts of the samples. Therefore, to illustrate the effect of irradiation treatment, the viable cell counts at the same dose level but from various packages or mould-counting media were pooled. Summary of the microbiological evaluation for both of the shipment is shown in Table 4. It shows that both the mould counts and the bacterial counts decrease by about 2 log cycles due to the 5 kGy irradiation treatment. These results are in agreement with our previous investigations (2, 6). Considering the recommended microbiological limits for spices published by ICMSF (1974), both the unirradiated nutmegs and unirradiated white peppers of the first shipment would be judged as defective regarding their mould counts. Mould count of the nutmeg seemed to be extremely high as compared

Table 4. Summary of the microbiological evaluation of spices from the first and the second shipment.

Dose (kGy)		CAIR				IFFIT			
		Nutmeg		White pepper		Nutmeg		White pepper	
		TMYC*	TPC*	TMYC*	TPC*	TMYC*	TPC*	TMYC*	TPC*
0	1st	4.01	3.94	3.80	5.02	5.32	4.79	4.16	4.74
	2nd	< 2.61	2.38	4.21	4.13	3.11	< 3.73	4.11	4.29
5	1st	3.62	3.51	< 2.23	2.49	3.33	2.52	2.39	2.61
	2nd	< 1.39	< 1.47	1.78	1.52	< 1.93	< 1.52	< 1.91	2.67

* Pooled averages (log number of colony forming units per gram).

with literature data (18). Therefore, measures seem to be necessary to prevent mould growth in white pepper and nutmeg, and insect infestation in nutmeg. The irradiation treatment should be used as a preventive measure, if both microbial contamination and insect damage are still under critical levels.

It appeared that nutmeg from the second shipment had lower microbial count than the first one. The white pepper showed similar contamination in both shipment, and the effect of irradiation treatment at 5 kGy level resulted a similar reduction of the viable counts in both cases.

The mould flora of the two spices were considerably different. In nutmeg, *Aspergillus niger* - type moulds dominated, while in white pepper, *Penicillium* spp. and yellow *Aspergilli* were dominant. The microflora of white pepper seemed to be more heterogeneous than that of nutmeg. This finding is in agreement with those of several other authors (19, 20, 21).

Table 5 summarizes results of chemical analyses on spices from the first shipment. The initial moisture content of nutmeg and white pepper studied were 7, and 11.8%, respectively with the respective a_w values of 0.721 and 0.746. The moisture contents of nutmeg stored at CAIR was increasing during storage, while those stored at IFFIT showed a slight decrease. The moisture content difference was due to the air humidity difference of the two countries.

Upon arrival at IFFIT, the moisture content of the majority of nutmeg samples were higher than the maximum level permitted by the Canadian Department of National Health and Welfare, i.e. 8% (18). However, the moisture content of white pepper samples could satisfy the requirement of that body, namely not more than 15%. In general, moisture content and a_w values of spices packed in woven PP bags were found to be lower than those packed in tin containers.

The variations among data of volatile oil, non-volatile oil and ash contents seem to be due to the analytical errors. These parameters seem to be uninfluenced by the irradiation treatment.

Table 6 summarizes the results of chemical analyses of spices from the second shipment. The moisture contents of nutmeg and white pepper samples after being shipped still satisfy the requirement of the Canadian Department of Health and Welfare. The a_w values of the samples were low enough to prevent mouldiness. The volatile oil contents of either irradiated nutmeg or irradiated white pepper tended to be higher than those of the unirradiated ones.

Tables 7 and 8 summarize results of sensory evaluation of spices from the first and second shipment, respectively. No significant different was found between the scores of irradiated and unirradiated samples in both of the shipment.

Table 5. Results of chemical analyses of spices from the first shipment.

Sample code*	Moisture content (%)			a_W-value		Volatile oil (%) (IFFIT July, 1982)	Non-volatile oil, ether extract (%) (Ten Doesschate July, 1982)	Ash (%) (Ten Doesschate July, 1982)
	CAIR (April, 1982)	CFRI (May, 1982)	IFFIT (July, 1982)	CAIR (April, 1982)	CFRI (May, 1982)			
Nutmeg:								
TC/A/D_0	8.5	7.3	7.2	0.734	0.733	6.6	38.8	1.7
TC/D_0	8.0	9.9	7.0	0.656	0.730	7.5	33.7	1.7
PPL/D_0	7.9	8.3	6.7	0.651	0.623	8.3	39.7	3.2
TC/A/D_5	8.7	8.8	6.7	0.735	0.715	6.5	36.2	1.6
TC/D_5	8.6	9.4	6.6	0.734	0.705	5.8	36.7	2.0
PPL/D_5	7.1	10.3	6.1	0.621	0.723	5.5	35.9	1.9
White pepper:								
TC/A/D_0	13.1	13.0	13.0	0.703	0.740	2.1	7.8	1.0
TC/D_0	12.6	12.8	12.8	0.671	0.775	2.2	7.4	0.6
PPL/D_0	13.5	13.7	13.7	0.671	0.700	1.9	7.5	0.9
TC/A/D_5	12.8	13.1	13.1	0.735	0.698	2.4	7.7	0.9
TC/D_5	12.8	13.2	13.2	0.672	0.698	2.1	7.2	0.8
PPL/D_5	12.2	13.2	13.2	0.712	0.660	2.6	7.6	1.0

* TC = tin container; A = oxygen absorber; PPL = woven polypropylene bag with PP film liner.
D_0 = unirradiated; D_5 = irradiated at 5 kGy.
Initial moisture content (February, 1982): Nutmeg = 7.2%; White pepper = 11.8%.
Initial a_W-value (February, 1982): Nutmeg = 0.721; White pepper = 0.746.

Table 6. Results of chemical analyses of spices from the second shipment (September 1982).

Sample code*	Moisture content (%)		a_w-value (CAIR)	Volatile oil (%) (IFFIT)	Non-volatile oil ether extract (%) (IFFIT)	Ash (%) (Ten Doesschate)
	CAIR	IFFIT				
Nutmeg:						
TC/A/D_0	7.8	8.2	0.647	6.7	37.1	1.6
TC/D_0	6.9	7.7	0.680	7.7	36.4	1.5
PP/D_0	6.4	7.1	0.471	8.8	39.0	1.5
TC/A/D_5	6.7	8.4	0.674	9.6	39.0	1.5
TC/D_5	7.1	8.2	0.672	8.0	34.4	1.4
PP/D_5	6.3	7.5	0.512	8.5	36.7	1.7
White pepper:						
TC/A/D_0	12.4	13.4	0.674	2.1	8.4	0.6
TC/D_0	12.3	13.0	0.659	1.8	7.5	0.6
PP/D_0	11.5	10.9	0.531	1.9	8.9	0.7
TC/A/D_5	12.4	13.3	0.674	2.5	7.9	0.6
TC/D_5	13.1	13.6	0.659	2.3	7.7	0.7
PP/D_5	12.4	12.8	0.531	2.5	8.3	0.7

* TC = tin container; A = oxygen absorber; PP = woven polypropylene bag.
D_0 = unirradiated; D_5 = irradiated at 5 kGy.
Initial moisture content (June, 1982): Nutmeg = 8%, White pepper = 12.6%.
Initial a_w-value (June, 1982): Nutmeg = 0.707; White pepper = 0.696.

Table 7. Results of sensory evaluation of spices from the first shipment.

Sample code*	CAIR (Febr, 1982)	CAIR (April, 1982)	IFFIT (July, 1982)		Ten Doesschate (July, 1982)
	Mean score	Mean score	Mean score	Rank total**	Remarks
Nutmeg:					*All samples*
$TC/A/D_0$		6.40	4.83	18.5^{ab}	Odour : characteristic, aromatic.
TC/D_0	7.0	6.25	4.33	23.0^{ab}	Free from mustiness and
PPL/D_0		6.37	5.33	14.0^{b}	rancidity.
$TC/A/D_5$		6.35	3.33	30.5^{a}	Colour : brown, Only slight differ-
TC/D_5	6.83	6.48	5.17	16.5^{ab}	ences in colour could be
PPL/D_5		6.23	4.33	24.0^{ab}	observed.
					Grade : acceptable to good.
White pepper:					*All samples*
$TC/A/D_0$		6.33	4.33	21.0^{a}	Odour : typical pungent. Free from
TC/D_0	6.90	6.66	4.50	21.5^{a}	foreign odour.
PPL/D_0		6.51	4.17	23.5^{a}	Colour : white to greenish yellow.
$TC/A/D_5$		6.56	4.17	22.5^{a}	Grade : acceptable to good.
TC/D_5	6.80	6.40	4.67	22.0^{a}	No significant different was found
PPL/D_5		6.52	5.33	14.5^{a}	between irradiated and unirradiated
					samples.

* TC = tin container; A = oxygen absorber; PPL = woven polypropylene bag with PP film liner.
D_0 = unirradiated; D_5 = irradiated at 5 kGy.

** Rank total in the same column denoted by the same letter are not significantly different from each other.

Table 8. Results of sensory evaluation of spices from the second shipment.

Sample code*	CAIR (June, 1982)	CAIR (Sept, 1982)	IFFIT (Sept, 1982)	Ten Doesschate (Sept, 1982)
	Mean score	Mean score	Remark	Remark
Nutmeg:				*All samples*
TC/A/D_0		6.1	No significant difference was found among the nutmeg samples.	Odour : characteristic, aromatic. Free from mustiness and rancidity.
TC/D_0	6.5	6.2		
PP/D_0		6.3		
TC/A/D_5		6.2		Colour : brown. Only slight differences in colour could be observed.
TC/D_5	6.1	6.1		
PP/D_5		6.2		
				Grade : acceptable to good.
White pepper:				*All samples*
TC/A/D_0		6.8	No significant difference was found among the white pepper samples.	Odour : typical pungent. Free from foreign odour.
TC/D_0	6.9	6.7		
PP/D_0		6.3		Colour : white to greenish yellow.
TC/A/D_5		6.4		Grade : acceptable to good.
TC/D_5	6.7	6.3		No significant difference was found between irradiated and unirradiated samples.
PP/D_5		6.2		

* TC = tin container; A = oxygen absorber; PP = woven polypropylene bag.
D_0 = unirradiated; D_5 = irradiated at 5 kGy.

CONCLUSION

Irradiation dose of 5 kGy is sufficient to disinfest and decontaminate properly packed spices without changing their chemical and organoleptic properties. Tin containers are suitable to protect the quality of irradiated spices and are durable for intercountry shipment of the commodity. The use of oxygen absorber in spice packages has no effect on microbial load, chemical and organoleptic qualities of spices.

ACKNOWLEDGEMENTS

This study is a part of a coordinated research program under Research Agreement No. 2630/R2/CF with the IAEA and was carried out in cooperation with the International Facility For Food Irradiation Technology (IFFIT) under Cooperation Agreement No. 3/1982. The authors are grateful to Ms. Eva Andrassy from CFRI, Budapest, Hungary; M.D.A. van Duren and J. Williams, Ms. Kstalin Schmidt from IFFIT, Wageningen, The Netherlands; Mr. A.A. Reimerink from Ten Doesschate B.V. Laboratory, Wapenveld, The Netherlands; Messrs. B. Abas, Darmawi, and Mrs. Tati Erlinda from CAIR, Jakarta, Indonesia, for their technical assistance. Thanks are also due to P.T. Djakarta Lloyd for the free-freight shipment.

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