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FORTIFICATION OF MSG WITH VITAMIN A IN INDONESIA, PHASE II  
Helen Keller International  
September 1989

PREPARED FOR:

S&T/OFFICE OF NUTRITION  
AID/WASHINGTON

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## NATIONAL FORTIFICATION OF MSG WITH VITAMIN A

### I. Project Design Summary

The current Phase II stage of the fortification project involves all 3 major MSG manufactures in a pilot program to provide fortified MSG to 3 diverse areas containing 3 million people. Its primary purpose is to test the technical and commercial feasibility of MSG fortification and develop a plan for financially self-sustained national expansion.

#### A. Statement of Country Project Objectives:

1. Produce, distribute and market "white" vitamin A-fortified MSG (MSG-F) in 3 diverse provinces (one district in each province) through normal commercial distribution channels.
2. Provide an intake of approximately half the RDA of vitamin A to 500,000 children less than 6 years of age through the consumption of MSG-F.
3. Maintain consumer acceptance of fortified MSG and verify that vitamin A intake can be increased without increased consumption of MSG.
4. Identify and recommend alternative methods for financing a national program. Such methods cannot affect MSG consumption patterns or market shares of the participating manufacturers. The project will test and, by the end of the third year, recommend an appropriate cost-recovery method to finance a national fortification program.
5. Develop a national fortification plan acceptable to the Department of Health and the MSG producers.

These are the original project objectives as stated in our grant proposal and Detailed Implementation Plan, and they remain unchanged. However, their timing will be delayed beyond the original grant period in order to provide sufficient time to solve technical problems with the white vitamin A and develop and implement a cost recovery mechanism acceptable to all parties. Within a few months of the initiation of commercial production and distribution of MSG-F, it was found

that Indonesia's hot, humid climate causes the white vitamin A to deteriorate in the MSG, causing it to become unacceptably yellowish and clumpy. Commercial fortification activities have been temporarily suspended while this problem is addressed.

**B. Location and Size of Priority Population**

The priority population is approximately 500,000 children aged 0-59 months in 3 districts -- Sambas, Cianjur and Bone. This remains unchanged.

**C. Strategies for Identifying and Providing Follow-up Service to High Risk Groups.**

Provinces demonstrating a high level of xerophthalmia will receive priority in developing a national fortification plan. Fortification in a given area is a non-selective "blanket" activity which covers the large majority of those who consume MSG. As such, there have been no changes in the project's approach to high risk groups. Similarly, no follow-up services will be provided beyond the intended objective of expanding fortification nationally.

**D. Child Survival Interventions**

Fortification of MSG with vitamin A is the intervention of choice for this project. This remains unchanged.

**E. Improvements in Program Quality**

Fortification is a public/private endeavor, involving HKI, the Government of Indonesia and the 3 MSG manufacturers. As such, it involves far more than project implementation. It is an evolutionary process that has required much goodwill, patience, persistence, creativity and flexibility to ensure that the needs of all parties are reasonably met. While there have been setbacks, the above parties now represent a team working to make fortification commercially viable.

**F. Response to Technical Review of CSIV DIP**

Not applicable.

## II. Linkages to Community, Government and NGO Activities

Community health committees and activities are not relevant to a macro-level project such as this. However, the project has developed substantial and diverse government and private linkages, as discussed below.

The project has promoted the fortification of MSG with vitamin A over several years, developing strong and direct linkages with the Indonesian Departments of Health, Food & Drug, Industry, Finance, and the National Planning Board, all of whom have high level representatives who sit on the project Steering Committee.

As this is a private/public project, every effort has been made to include the 3 major MSG manufacturers -- Sasa, Ajinomoto & Miwon -- in all aspects of project deliberations, operations and planning. The local president or director of each sits on the Steering Committee. An important outcome of this phase of fortification has been the signing of a formal agreement between the Department of Health (Depkes) and the 3 MSG manufacturers, detailing agreed upon project objectives and the responsibilities of each, which laid the groundwork for fortification to begin.

The Philippines is considering an MSG fortification project and is therefore watching the Indonesian project closely. Key Filipino health officials visited Indonesia twice in the last year in order to gain an in-depth understanding of project concept and progress. These included Dr. Consuelo Aranas, Dr. Cecilia Florencio and Mrs. Adelisa Ramos. Dr. Muhilal, a world renowned Indonesian vitamin A expert and long-time principal project consultant, actively interacted and consulted with his Filipino counterparts, both during their trips to Indonesia and during a trip he made to the Philippines for this purpose.

Prof. M.J. Rand, of the Department of Pharmacology at the University of Melbourne and Chairman of the WHO/FAO Joint Expert Committee on Food Additives (which lifted the ADI on MSG in 1987), spoke in Jakarta in November following the international vitamin A conference about recent findings regarding the safety of MSG.

Several meetings were held during the last year with members of the Indonesian Consumers Union (YLK), which has long opposed the fortification project's use of MSG, for the purpose of educating them more about MSG and the massive health benefits the project promises. Recognizing the potential of the project, the YLK agreed to withdraw its opposition to the project, while maintaining the right to continue to oppose MSG per se.

HKI has also maintained close contact with a principal donor to the project, Hoffmann LaRoche, both through meetings with personnel from their Jakarta office and by hosting visits of the head of their Sight & Life arm, Dr. John Gmunder.

### III. Human Resources and Technical Support

The fortification project has a host of support resource personnel involved both in Indonesia and in the U.S.

Primary Indonesian resources include:

Benny Kodiat, Head of the Nutrition Directorate (which has executive authority for the project)

Asmira Sutarto, head of Subdirectorate for Nutritional Deficiency Control

Ramchan Raoef, Key Nutrition Directorate staff assigned to fortification project

Dr. Muhilal, Principal Research Scientist, National Center for Nutrition Research & Development

M. Saidin, Key staff assigned to fortification from the National Center for Nutrition Research & Development

Technical support from the U.S. has come from a variety of sources:

Susan Eastman, Director of Vitamin A Programs, HKI New York

Ros Crowley, Office of International Cooperation & Development, u.S. Department of Agriculture

Dr. Patricia Murphy, Professor of Food Science  
Technology, Iowa State University

Dr. James Olson, Distinguished Professor of  
Biochemistry, Iowa State University

Harlan Hall, President, The Coating Place, Inc.

Dr. Ben Borenstein, Private food science consultant  
(formerly with Roche/Nutley)

IV. Project Health Information System

A. Community Survey

A Stability Study was begun in July to monitor the extent of commercial MSG-F distribution in the field and the stability of vitamin A therein. This was to be a monthly activity for the first 6 months and quarterly for the next 6 months. Training of field workers and the first month's data collection occurred before work was suspended due to the white vitamin A problems mentioned earlier.

The study primarily involved the systematic taking of MSG-F samples from foodstalls and households and testing them for vitamin A content and potency. Within each of the 3 districts, 16 villages (4 in each of 4 subdistricts) were randomly selected. Within each village, MSG-F samples were taken from 4 households and 48 foodstalls.

There was no interviewing; only MSG-F sample taking, which was done by local health center workers, one for each subdistrict, trained for this purpose. After collecting samples, they qualitatively tested them using a simple chemical test, recorded the results, and sent these along with untested samples to the National Center for Nutrition Research for more detailed spectrophotometric analysis.

Analysis of data was not completed due to suspension of fortification.

The total cost of the Stability Study, when completed, will approximate \$17,000.

No special problems were encountered in conducting the survey.

An English translation of survey forms and instructions is attached.

## B. Indicators

Three main indicators have been used to track project sustainability. The first is an MSG Consumption Study (pre- and post-fortification) to determine MSG consumption (and therefore vitamin A fortification) levels and ensure that fortification can be effected without changing MSG consumption/purchase patterns or market shares. The baseline survey was conducted in the summer of 1988.

The second indicator is a Biologic Efficacy Study, the main purpose of which is to measure, both before and after fortification, key biologic indicators (Bitot's spots and vitamin A levels in the blood of children under 6 and in the breast milk of lactating mothers). Although the biologic efficacy of fortification was clearly established by a preliminary field trial in the Bogor area in 1985, the World Bank has financed a repetition of this component for Phase II of the fortification project. Baseline work was completed in January and February 1989.

The third main indicator used to track project sustainability is the Stability Study, described in detail above.

Assuming development of a stable white vitamin A, the largest issue regarding sustainability of fortification is economic -- development of, agreement upon and implementation of an effective cost-recovery mechanism to pay for ongoing vitamin A and administrative expenses. This aspect of the project will be addressed after technical and commercial feasibility have been clearly established.

There have been no changes in the indicators used to monitor CS activities.

Of project expenditures since October 1988, about 2% have been spent on monitoring costs (excluding the World Bank-funded Biologic Efficacy Study).

### C. Midterm Evaluation

A midterm evaluation was performed in July 1989. It involved a team of 4 people reviewing and evaluating the project on-site from July 5-15. Team members included:

Dr. James Olson, Distinguished Professor of Biochemistry, Iowa State University

Dr. John Erdman, Professor of Food Science and Nutrition, University of Illinois

Susan Eastman, Director of Vitamin A Programs, Helen Keller International

Sukarno Noer, Department of Health, Republic of Indonesia

At the time of the evaluation, the recent technical problems with vitamin A were just surfacing. Principal findings and recommendations therefore focused heavily on additional required research related to the deterioration of white vitamin A in MSG, and suggestions for its improvement and consistent production quality henceforth. The work plan for the coming year of the project will be substantially revised to reflect the suspension of fortification and related monitoring activities, and the new emphasis on the additional research required.

The midterm evaluation cost approximately \$15,000. A copy of the report is attached.

### V. Work Plan and Constraints

Fortification by the 3 MSG manufacturers began in April/May 1989, followed by commercial distribution in June. In mid-July, samples of MSG-F blended in April were found to be turning yellow and clumpy. At a subsequent meeting of the Steering Committee in early August, the manufactureres complained about this problem and Depkes agreed to suspend fortification until a more durable white vitamin A could be developed.

In late August, a 3-person technical team from the U.S. spent a week in Indonesia investigating the problem first-hand, assessing local climatic exposure and interviewing the manufacturers and other key players. They found the main problem to be the tendency of the WVA to absorb moisture in Indonesia's hot, humid climate. The gum acacia binder in which the vitamin A droplets are suspended is somewhat hygroscopic and over time deteriorates in humidity, releasing its vitamin A onto the surrounding MSG particles, causing yellowing and clumping.

One of the members of the technical team, the president of the Coating Place, Inc. (which coats the WVA white), is hopeful that a new WVA coating process can be designed which will make the WVA more moisture resistant and protect it from humidity for up to a year. In addition, Hoffmann LaRoche is now in the final development stages of a new form of vitamin A which uses fish gelatin, a much less hygroscopic substance. Over the coming months, the Coating Place will develop several new WVA prototypes using both forms of vitamin A, which will be subjected to stress tests at Iowa State University. Survivors from these tests will then be further tested in the laboratory and in the field during 1990 to make certain the new WVA can stand up to the local climate before resuming fortification about a year from now.

While this setback is disappointing, much has been accomplished in the last two years:

- o baseline monitoring studies were completed
- o a working agreement between the MSG manufacturers and Depkes was negotiated and signed.
- o resistance from the Indonesian Consumers Union was countered and overcome.
- o internal consensus supporting the project was reached with Depkes.
- o large pharmaceutical blenders were imported duty-free
- o MSG-F was blended and distributed commercially. The manufacturers, Depkes and HKI are now aligned toward project goals and working as a team.
- o the mid-term evaluation was completed

As a result of the new R&D emphasis, criticality has been largely shifted stateside to the Coating Place and Iowa State University as the new WVA prototypes are developed and tested. Thus the workplan for the next year, described in general above but still in development, is therefore being revised to reflect this. Field-testing of new prototypes will be monitored out of Jakarta.

VI. Project Expenditures and Budget Revision

See Form A, "PVO Country Pipeline Analysis."

HELEN KELLER INTERNATIONAL, INC.  
 1989 ANNUAL REPORT FORM A: COUNTRY PROJECT PIPELINE ANALYSIS  
 PVO / COUNTRY PROJECT- DAN-0045-G-SS-7116-00

INDONESIA COST ELEMENTS	ACTUAL EXPENSES TO DATE (9/30/87 to 9/30/89)			PROJECTED EXPENSES AGAINST REMAINING OBLIGATED FUNDS (10/1/89 to 9/29/90)			TOTAL AGREEMENT BUDGET (8/30/87 to 9/29/90)		
	AID	HKI	TOTAL	AID	HKI	TOTAL	AID	HKI	TOTAL
SALARIES	\$181,993	\$54,907	\$236,900	\$95,093	(\$41,407)	\$53,686	\$277,086	\$13,500	\$290,586
LOCAL CONSULTANTS	\$13,880	\$12,050	\$25,930	\$58,620	(\$12,050)	\$46,570	\$72,500	\$0	\$72,500
SUPPLIES	\$4,316	\$1,373	\$5,689	\$50,984	\$150,127	\$201,111	\$55,300	\$151,500	\$206,800
EQUIPMENT	\$80,204	\$8,378	\$88,582	\$16,796	\$2,122	\$18,918	\$97,000	\$10,500	\$107,500
TRAINING	\$3,441	\$3,192	\$6,633	\$7,559	(\$3,192)	\$4,367	\$11,000	\$0	\$11,000
TRAVEL	\$45,598	\$14,934	\$60,532	\$27,470	\$1,066	\$28,536	\$73,068	\$16,000	\$89,068
DISSEMINATION/INFORMATION	\$11	\$42	\$53	\$17,306	(\$42)	\$17,264	\$17,317	\$0	\$17,317
REPORTING EVALUATION	\$3,122	\$8,095	\$11,217	\$18,574	(\$8,095)	\$10,479	\$21,696	\$0	\$21,696
OTHER DIRECT COST	\$32,911	\$13,661	\$46,572	(\$10,928)	(\$13,661)	(\$24,589)	\$21,983	\$0	\$21,983
TOTAL DIRECT COST	\$365,476	\$116,632	\$482,108	\$281,474	\$74,888	\$356,362	\$646,950	\$191,500	\$838,450
INDIRECT COST	\$34,854	\$20,760	\$55,614	\$18,196	\$21,073	\$39,268	\$53,050	\$41,833	\$94,883
TOTAL COST	\$400,330	\$137,392	\$537,722	\$299,670	\$95,961	\$395,630	\$700,000	\$233,333	\$933,333

12/06/89

## STABILITY STUDY METHODOLOGY

### Time of sample collection

The period of sample collection is one year, starting from July 1989 to June 1990 as shown below.

### MSG-F SAMPLE COLLECTION SCHEDULE

Location of MSG-F Sample Collection	1989							1990					
	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
1. Factory	x			x			x			x			
3. Regency		x	x	x	x	x	x			x			x
4. Subdistrict													
Village		x	x	x	x	x	x			x			x
Household		x	x	x	x	x	x			x			x

### SAMPLE ANALYSIS

From the number of samples collected from each level, a half of it will be taken for at site semi-quantitative analysis. The rest will be sent to Puslitbang Gizi for quantitative analysis. At each package of samples to be sent to Puslitbang Gizi codes will be written with spidol :

- P = for samples from the factory
- K = for samples from the regency
- W = for samples from the foodstalls
- R = for samples from the Households

The date of sample collection and name of village will also be written on the packages.

### Semi-Quantitative Analysis

The practice of semi-quantitative analysis is done with the purpose of identifying estimates of vitamin A levels in MSG-F in simple way in the field.

#### Equipment

Semi-quantitative analysis will use equipment/instrument available in the kit, that consists of :

- 40 bottle (small) of TCA
- 2 big bottles of chloroform
- 4 pasteur pipet and its rubber
- 1 mixing slick (small)
- 1 tea spoon
- 1 petricup
- 1 small scissor
- paper filter
- 4 tube of standard color
- 1 napkin
- spidol
- report sheet.

#### Procedure

1. Place the kit at the table.
2. Prepare MSG-F for analysis
3. Write down completely code of packet (use FORM 1)
4. Take one bottle/small of TCA (brown color), open the cap. Take pasteur pipet no.1, pipet of 1 ml chloroform from big white bottle (stop at sign) and add it to TCA in brown colored bottle. Shut the bottle tightly and shake until all TCA is mixed. This solution, made during examination, is just enough for 5 times of analysis. This could not be kept for more than 4 hours. Be careful, danger : don't spil on your hand.
5. Prepare pasteur pipet no.2
6. Cut MSG-F sample with scissor.
7. Pour content in petri plate  $\pm$  1 tea spoon. For small sachets : use two packets.
8. Add 1 ml of chloroform with pasteur pipet no.1. stir for 1 minute (count 1-60 and stop); by that time all MSG-F is already wet.
9. Put the wet MSG-F on filter paper and spread it on the paper
10. Put 5 to 6 drops of TCA-chloroform solution on the MSG-F spread. Use pasteur pipet no.2
11. Wait until count no.30 compare color that come up with available standard color.

12. Record output of examination in FORM 1. Compare experiment color with standard color. Start with the most solid color.
  - 0 = No Vitamin A
  - 500 = According to blue color in vials
  - 1000 = "
  - 2000 = "
  - 3000 = "
  - >3000 = Darker than vials
13. Throw away the discarded MSG-F packets and filter paper in the waste basket.
14. Clean all used equipment and put it back properly in the kit.

#### Quantitative Analysis

The result of quantitative analysis of vitamin A in MSG-F which will be conducted by Puslitbang Gizi Bogor will serve as a comparison for judging the feasibility semi-quantitative analysis conducted in the field.

#### REPORT SHEET

There are two types of report sheets used in this vitamin A stability study: FORM 1 and FORM 2.

FORM 1a, 1b, and 1c will be used to record the outcome of semi-quantitative of vitamin A quality each with regard to the distributors, foodstall and household, while FORM 2a, 2b and 2c will be used for sending samples of MSG-F.













Recording Sheet

Sheet 1a.

- Name of shop : to be recorded fully .
- Address : address of MSG-F selling shop at regency capital
- Number of sample : consecutive sample taking from 1 to 8.
- Column a : consecutive number of packet starting from the biggest packet
- Column b : Code of packet  
example :  
Sasa : price tag Rp.25/packet = S 25  
Miwon : price tag Rp.10/packet = M 10  
Ajinomoto : price tag Rp. 5/packet = A 5
- Column c : Date of production = date of production printed on the inside of long card.
- Column d : Date of collection = date of sample collection.
- Column e : Shows vitamin A level in MSG-F sample from first, second and third packets resulted from semi-quantitative analysis.
- Column f : to be used for important "issues" or information such as certain MSG-F names not on sale in shops or foodstalls.
- Date of analysis : the day (date) in which vitamin A level of MSG-F is analysed in the field.
- Name of workers : to be written in full/complete.
- Signature : to be signed by the person who conduct the analysis.

Sheet 1b

to be used in the same ..... as for FORM 1a.

Sheet 1c

Same as for FORM 1a. Column on date of production is not available because date of production is not printed on MSG-F package.

Sheet 2a

Regency : already clear.  
Name of shop : Write down name of shop where MSG-F is purchased  
Column e : Number of package = the number of MSG-F to be dispatched.

Sheet 2b

Same as explanation on form 2a.

Sheet 2c

Same as explanation for form 2a. Column on date of production is not available because date of production is not printed on MSG-F packets.

Dispatch of Sheets

All filled FORM 1 and FORM 2 by the Puskesmas monitoring worker, together with MSG-F samples is to be delivered to the regency level monitoring worker. The regency level monitoring worker should send (dispatch) all sheets (forms) and MSG-F samples to :

The Biochemic Nutrition Laboratory  
Puslitbang Gizi Ministry of Health  
Jl. Dr. Sumeru  
Bogor, Jawa Barat

Together with above mentioned sheets and samples, FORM 1, FORM 2, and samples of MSG-F as collected by the regency level monitoring worker should be sent to the above mentioned Laboratory.

All sheets and MSG-F samples should be sent by the end of the 3rd week of the same month. One copy of each of the dispatched FORMS should be kept as archives at the Regency Health Office.

SAMPLING DESIGN  
VITAMIN A STABILITY STUDY ON MSG-F

PLACE OF SAMPLE COLLECTION	NUMBER OF SAMPLE FOR ANALYSIS	
	SEMI QUANTITATIVE (IN THE FIELD)	QUANTITATIVE (AT PUSLITBANG GIZI)
Factory	3 brands x 3 packages x 5 packets = 45 packets	Each dispatch of 45 packets consist of : - 15 Sasa packets (5 S-25, 5 S-10 and 5 S-5) - 15 Miwon packets (5 M-25, 5 M-10 and 5 M-5) - 15 Ajinomoto packets (5 A-25 5 A-10 and 5 A-5)
Distributor/ Regency	3 brands x 3 packages x 5 packets = 45 packets	Each dispatch of 45 packets consist of : - 15 Sasa packets (5 S-25, 5 S-10 and 5 S-5) - 15 Miwon packets (5 M-25, 5 M-10 and 5 M-5) - 15 Ajinomoto packets (5 A-25 5 A-10 and 5 A-5)
Village foodstall	1 foodstall x 3 brands x 3 package x 5 packets = 45 packets. For each village to be selected 1 foodstall only, and for each type of packet from available brand take 5 packets.	For each dispatch from each village 45 packets that consist of : - 15 Sasa packets (5 S-25, 5 S-10 and 5 S-5) - 15 Miwon packets (5 M-25, - 15 Ajinomoto packets (5 A-25 5 A-10 and 5 A-5)
Household	From each village take 2 household. From each Household take 1-2 packets.	From each of the same village take 2 other household and from each of them take 1-2 packets.

TRAINING SCHEDULE FOR MONITORING WORKERS  
OF VITAMIN A STABILITY IN MSG-F

TIME	ACTIVITIES	SPEAKER
1st day		
08.30 - 09.00	Opening Session	Committee
09.00 - 10.00	Vitamin A Stability in MSG-F Study	Central Team
10.00 - 10.30	Break	
10.30 - 12.00	Techniques in Sample Training	Central Team
12.00 - 13.00	Discussion/Questions	Committee
13.00 - 14.00	Lunch	
14.00 - 15.30	Methods of Semi-Quantitative Analysis	Central Team
15.30 - 16.30	Discussion/Questions	Committee
2nd day		
08.30 - 11.00	Practise in Semi-Quantitative Analysis	Central Team
11.00 - 12.00	Recording and Reporting	Central Team
12.00 - 13.00	Final Discussion	Committee
13.00 - 14.00	Lunch	
14.00	Closing	

Report of a Mid-Term Evaluation  
Fortifying Monosodium Glutamate with Vitamin A: Phase II  
USAID Grant No. DAN-0045-G-SS-7116-00  
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## I. PURPOSE:

The purpose of the mid-term evaluation was to assess the current status of the project, to identify its strong and weak points, and to provide recommendations for its improvement. More specifically, each of the following 5 project objectives were considered:

- 1) to market monosodium glutamate (MSG) fortified with Vitamin A in selected districts in 3 provinces,
- 2) to provide approximately 50% of the vitamin A requirement for 500,000 pre-school children under 6 years of age, via fortified MSG (MSG-F),
- 3) to maintain consumer acceptance of MSG without promoting its use because of fortification,
- 4) to develop cost recovery procedures, and,
- 5) to develop an acceptable national fortification plan.

## II. ACTIVITIES:

Of the consultants, Ms. Susan Eastman, Vitamin A Program Director for Helen Keller International (HKI), New York, has been associated with vitamin A programs for over a decade.

Prof. Olson, a HKI consultant, lived in Asia for over a decade and has been interested in, and associated with, vitamin A-related activities in Indonesia for over 20 years.

Prof. John W. Erdman, Jr. of the University of Illinois, who is well known for his studies on food technological and metabolic aspects of vitamin A and carotenoids, was asked to evaluate the food technological aspects of this project as well as other similar projects in Indonesia for the Bureau of Science and Technology, AID, Washington D.C.

Mr. Soekarno Noer of the Department of Health has a long-standing interest in aspects of nutrition in Indonesia and Thailand.

During the 10 day visit (July 5 - 15, 1989) the consultants were briefed by Mr. John Penberthy, Project Manager, at the HKI office (Jakarta), met Dr. Leimana, Director General of Community Health, interacted on several occasions with Pak Benny, Head of Directorate of Community Nutrition, and his associates in the Ministry of Health, met twice with personnel in the USAID mission, Jakarta, visited field sites in Cianjur (Bogor) and MSG factories in Surabaya, interacted with Prof. Karyadi and Dr. Muhilal of the Nutrition Research and Development Center, Bogor, and discussed relevant issues with Mr. Wilbur, HKI Country Director in Indonesia, and other HKI personnel in Jakarta. The itinerary of the evaluation team is provided in Appendix 1, the individuals contacted in Appendix 2, resource documents in Appendix 3, and comments on technical recommendations in Appendix 4.

### III. EVALUATION:

#### A. Time Table

The phase II fortification time table (Appendix 3, doc. 1) cites 19 tasks for completion during the 3-year period. Of the 14 that should have been initiated or completed by 30 June 1989, 10 are on schedule. The remaining 4 are:

- 1) distribution of fortified monosodium glutamate (MSG-F) to the 3 test districts, which is 6 months behind but is now starting,
- 2) stability and quality assurance assessments, which necessarily accompany distribution of MSG-F,
- 3) cost analysis, which will be initiated in August, 1989 and,
- 4) a pricing study, in which the impact of a price increase on market demand will be analyzed.

The delay in items 1 and 2 were caused by a variety of factors, including the negotiations for an agreement between the manufacturing companies and the government of Indonesia (GOI), ultimately signed on 6 April, 1989, the development of an understanding between Dr. Leimena and the YLK (Consumer's Union), and the reaching of a consensus position about the program among professionals in the Department of Health. This delay is really very short, considering the complexity of the task. Preliminary analysis of items 3 and 4 have been made (Appendix 3, doc. 5-7). Because of the nature of the market for MSG, the pricing study may not be needed. The cost-recovery plan, which is scheduled to start soon, will crucially affect the success of expanded fortification.

The review team is well satisfied with the progress made thus far.

#### B. Distribution of MSG-F in 3 selected districts

Fortified MSG is being distributed in packets of 5, 10 and 25 Rp, in Cianjur, Bone, and Sambas Districts by the 3 manufacturers. The approximate initiation dates for retail distribution of MSG-F in these districts for each manufacturer were: Ajinomoto (15 June, 1989), Sasa (15 June, 1989) and Miwon (1 July, 1989). By assuming that displayed MSG packets will be consumed in 1 month and that an additional month of inventory exists, most small-packet MSG on sale will be fortified by 15 August, 1989. The MSG consumption study has been completed, and baseline values for serum and breast milk vitamin A values have been obtained in the 3 test districts as well as in 3 control (unfortified) areas in each province.

Recently, a more sensitive indicator of vitamin A status than serum vitamin A levels has been developed, the modified relative dose response (MRDR). This test of marginal vitamin A status, developed as a collaboration between Dr. Muhilal and Prof. Olson should be seriously considered as an indicator of efficacy in the program (Rec. E1).

C. The fortification process

Stock fortified MSG, which contains approximately 5% retinol in the form of retinyl palmitate, has been sent by airfreight in well sealed 35-kg drums to Indonesia by the Coating Place in Wisconsin, USA. A newly opened drum of the stock vitamin A from the first major shipment, when inspected at the Miwon factory at Surabaya, was found to be unacceptably yellow.

This situation was reported by HKI/Jakarta to the USDA and The Coating Place in February, 1989. Suitable modification in the production of future batches was verbally assured. Clearly, quality control standards and inspection at the Coating Place are needed to insure the delivery of a suitable product (Rec. T1).

The fortification process would be enhanced as well by packaging stock vitamin A in 4.2 kg sealed plastic sacks, the unit currently used in the batch mixing process (Rec. T2). The large sealed aluminum sacks are considered to be highly satisfactory in preventing humidity damage during transport and storage. No gross evidence of hydration of the stock vitamin A was noted in Surabaya.

D. Stability of MSG-F under field conditions

Vitamin A, particularly as its esters, is stable for long periods under anhydrous conditions in the dark at low (< 0 C) temperatures. When exposed to moisture or high humidity, higher temperature (> 55 C), and strong light, however, degradation occurs, including the formation of yellow products. Extensive laboratory studies have been conducted on the time-dependent adverse effects of these parameters and others on vitamin A stability (Muhilal, unpublished observations; Appendix 3, doc. 18). Because conditions that exist during the transport of vitamin A and its exposure in local shops and vending stalls influence vitamin A stability, efforts to improve the product and to reduce unfavorable conditions and their effects should continue. Ultimately, the objective must be to maintain the quality of MSG-F at an acceptable level for the consumer during the period that the product is exposed to transport and market conditions, i.e. 2-3 months on the average.

The Ajinomoto Co. has reported:

- 1) that MSG-F becomes hygroscopic and yellow when stored under "local" conditions of light, humidity and temperature at their Surabaya plant for more than 3 months,
- 2) that non-fortified MSG showed no changes when similarly exposed for a year,
- 3) that a shipment of MSG-F sent by truck and ship from Surabaya via Jakarta to West Kalimantan became caked and yellow. Although conditions of exposure are not known, the transit time presumably is <1 month,
- 4) that shipments of MSG-F to other locations, e.g. Bone and Cianjur, were not apparently affected, and
- 5) that MSG-F stored under "office" conditions for at least 6 months showed no deterioration.

Mr. Penberthy also noted that a 5 Rp pack of MSG-F (Ajinomoto), which was placed in a Jakarta vending stall in late March, showed no changes at 2 months but appeared caked and yellow at 3.5 months.

The other 2 manufacturers have reported no problems with their fortified products.

In the Ajinomoto exposure studies in Surabaya, MSG-F in the 5 Rp packets showed more deterioration than in the larger packets. MSG-F is presumably less stable in the smaller packets because the exposed surface per unit weight is greater than in the larger packets.

In earlier studies (Phase I) by Dr. Muhilal, MSG fortified with vitamin A coated with MSG powder was stable under actual market conditions for a significant period. Similarly, Iowa State University (Appendix 3, doc. 18) reported that the titanium dioxide-coated form of vitamin A was more stable than the yellow uncoated form, that high light intensity was the single most destructive factor, and that significant yellowing was not seen below 55 C. All manufacturers doubly coat the cellophane used for packaging with polyethylene and/or polypropylene, which presumably renders it largely impermeable to water. The water permeability of the heat seal, however, has not been tested in Indonesia.

In general, the temperature and relative humidity range in Indonesia are 21-33 C and 60 - 90%, respectively. Temperatures may become higher, however, in trucks or ships transporting the product. A given pack of the product is on sale-display in Java, on the average, for 2-4 weeks. Exposure periods in other Indonesian locations are not known. Once purchased, the product is probably used in the home within 1 week.

The stability of MSG-F is a key issue that requires further attention, in terms of:

- 1) the local exposure conditions, i.e. light, temperature, humidity, both for transport by truck and ship and in shops,
- 2) water permeability of the sealed package,
- 3) the range of periods that any product package is displayed in shops in different locations,
- 4) further technological improvement of "white" vitamin A,
- 5) further laboratory stability studies of the packaged product under simulated local conditions of transport and sale, including the effects of temperature on the dehydration and rehydration of monohydrated MSG, the commercial form and,
- 6) systematic monitoring of the stability of MSG-F of all 3 manufacturers as a function of exposure time in vending stalls.

These recommendations are summarized in Rec. T3 - T9. Comments on these technical recommendations are given in Appendix 4.

#### E. Level of fortification

The second objective of the fortification project is to provide a

daily intake of 700 IU, or approximately half of the RDA, to children < 6 years old. Because the mean daily intake of MSG by children was ca. 0.23 g, MSG was fortified at a level of 3000 IU/g. In the latest released FAO/WHO expert report (1987) on requirements for vitamin A, a two-tier system is used: 670 IU per day are judged sufficient to meet all physiological needs for vitamin A in young children and 1330 IU per day should provide for a generous body reserve of the vitamin. Half of these values are 335 IU and 665 IU, respectively. Even these values contain a safety factor of approximately 40%. Thus, a reduction in the fortification level by 1/3, i.e. to 490 IU/day and to 2000 IU/g MSG, should be seriously considered (Rec. E2).

Although this lower level of fortification has not been directly tested in Indonesia, much international data suggest that efficacy would be minimally affected, if at all, providing, of course, that the product is stable. Program costs, currently estimated to be US\$ 6 million for a national program (approximately 80% of which are wholesale vitamin A costs), could be substantially reduced by a lower level of fortification, thus enhancing political and commercial feasibility. Furthermore, the apparent "whiteness" of MSG-F would also be greater.

#### F. Consumers' perceptions of MSG fortification

Although MSG, under conditions of normal use, has been shown to be safe, opposition to its use by the YLK (Consumer's Union in Indonesia) continues. The primary reason for their position is that MSG is used to replace conventional, nutritious, low cost foods in the diet of the poor. They continue to raise, nonetheless, the question of toxicity. Fortification of MSG with an essential nutrient now poses a dilemma for the YLK, in that a commodity whose use they oppose now provides a distinct benefit.

During the past 6 months, a truce seems to have been reached; namely, that MSG-F will not be promoted by the government of Indonesia (GOI) or the manufacturers of MSG because of its vitamin A content, whereas the YLK may continue their opposition to MSG, but without publicly attacking vitamin A fortification. This truce seems to be a reasonable middleground that hopefully can be maintained.

Another issue is "truth in labeling", a viewpoint generally endorsed by consumer advocates. Thus, the possibility of labelling MSG-F appropriately without public promotion of its use might be a new, mutually acceptable position that should be discussed (Rec. M1).

As an extension of such procedures, updates of program developments should be discussed frankly and periodically with interested parties, such as the YLK, MSG manufacturers, and others. Such interactions, regardless of the formal positions held by various parties, can only be beneficial (Rec. M2). The benefits of using fortified MSG, as well as the success in other countries of fortifying various commodities with needed nutrients, might also be explained in news releases of the National Nutrition Network (Rec. M2).

G. Cost recovery of MSG fortification

It is expected that a national program of MSG fortification (covering only the highest risk, half of the country) will cost up to \$6 million annually. An appropriate vehicle for financing these costs on an ongoing basis must be established for the program to be sustained in the long run.

As a first step in this effort, a cost study is being initiated in August to determine the exact costs projected for the program. The next step will then be to evaluate various cost recovery mechanisms and to identify and implement the best alternative. Although this step was originally included in Phase II, the MSG manufacturers recognize that it probably implies an MSG price increase, to which they object in principle. They have also stated that they would like technical and commercial feasibility clearly established before discussing cost recovery. Therefore, they asked that this cost recovery issue be omitted from their formal agreement with the Department of Health (which extends through June 1990), to which the Department of Health agreed.

Many possibilities have been considered in financing fortification on an ongoing basis—raising MSG prices, direct government financing, donor agency financing and a MSG export tax. There are no doubt other alternatives that could be explored. However, at this time, it appears that by far the most likely vehicle is simply a MSG price increase. Assuming that this alternative is chosen, it is suggested that an across-the-board price increase be effected so that the costs of fortification are spread among all MSG consumers and not just the target population (which is least able to afford it).

Given Indonesia's increased efforts toward government deregulation, any price increase should probably be set by free market mechanisms:

- The government should identify industry standards as to vitamin A levels in MSG, geographic target areas, phasing, etc.
- The MSG manufacturers should determine and implement a resultant price increase as they see fit.
- The government's role would be limited primarily to monitoring MSG-F coverage and facilitating the duty-free import of vitamin A.
- In the case of infractions, penalties would be assessed according to law.

At this time it is not known what penalties, if any, would legally apply to infractions of the MSG manufacturers. Loss of operating license is, of course, a compelling incentive to comply; however, it is extremely severe. Less drastic remedial penalties are clearly needed if the program is to ensure manufacturer compliance. It is suggested that legal penalties applicable under Indonesian law be identified and communicated to all parties.

In keeping with the government's increased laissez faire posture, Dr. Soekirman recently indicated that no subsidies would be provided by

the government to offset the cost of vitamin A to the manufacturers. As it now stands, a MSG price increase of an estimated 10% will be necessary to pay for a national fortification program. Implementing this price increase over a period of 2-3 years would be an effective way of minimizing the impact on the manufacturers and on consumers. In order to generate an initial cash reserve for vitamin A purchases, the initial price increase might be implemented 6 months prior to the manufacturers' first vitamin A purchase.

#### H. Project management

The MSG fortification program is a GOI activity, the key administrative unit being the Directorate of Community Nutrition, with technical support from the Nutrition Research and Development Center in Bogor. Technical and program assistance is provided by HKI, with funding from AID/S&T/Office of Nutrition, technical backup from USDA/OICD and Iowa State University, and commodity support through Hoffmann-La Roche's Task Force SIGHT AND LIFE.

This complex partnership is running smoothly. HKI's grant manager has demonstrated an effective approach combining push and patience. His analytical skills have served well in problem assessment and issue identification. As indicated earlier, the project is on schedule in the majority of its objectives to date.

The team considered, however, that communications could be strengthened between HKI/Jakarta, HKI/New York, USDA/OICD, and Iowa State University regarding specific technical issues and their program implications. One suggestion was for HKI to retain external counsel in food technology to oversee the series of technical recommendations arising from the evaluation. A second mechanism strongly recommended is to have periodic meetings of key technical and management personnel—including external technical advisors, i.e., from Iowa State University and the Coating Place—in Indonesia, as needed, to assess technical developments and program implications (Rec. M3). Such a meeting is recommended within the next three months.

Project drawdown of finances is on schedule, with sufficient funds remaining to fulfill current project obligations. Some additional financial support for the life of the grant will be required to implement the recommendations of the evaluation team: specifically, \$15-20,000 to incorporate the MRDR assessment technique in the evaluation; and \$30-35,000 for two technical meetings in Indonesia of key personnel. Heretofore, biochemical and lab tests have been funded through a cooperative agreement between AID/S&T, USDA/OICD, and Iowa State University. Such technical (and financial) backup is essential through the life of the grant, including the implementation of the technical recommendations that follow.

Relatedly, it is recognized that significant external financial resources have been made available to this project above and beyond the AID/HKI grant: i.e., the S&T cooperative agreement with USDA/OICD, USDA's agreement with Iowa State University, original research and development work of the Coating Place, World Bank funding to the GOI for the biological

efficacy field surveys, Hoffmann-La Roche's Task Force SIGHT AND LIFE, as well as GOI basic support from the Directorate of Community Nutrition in Jakarta and the Nutrition Research and Development Center in Bogor. Specific cost figures for these contributions to the project should be cited so that the total resources supporting this Phase II program might be fully understood and appreciated.

Finally, the GOI is to be commended for its sensitivity to concerns arising from such interest groups as the YLK (Consumers Union) and the MSG Manufacturers Association. In addition, the Head of the Directorate of Community Nutrition has initiated monthly Steering Committee meetings to assess program progress and to identify problems. Communications should be maintained, and issues addressed, as quickly and appropriately as possible. Information dissemination is also recommended to the public at large, i.e., via press releases, as well as through the National Nutrition Network (Rec. M2).

Information about the success of fortification and its relationship to the health and nutrition status of other countries is strongly recommended. Such information can increase public awareness and build favorable perceptions related to fortification.

#### I. Future activities and interim program funding

Although some issues clearly require attention, Phase II of the MSG fortification project is going well. The purpose of Phase II, it must be emphasized, is to identify aspects of the fortification process that required attention or modification before the national fortification effort is launched. In the light of developments in Phase II, planning for Phase III should be initiated now (Rec. M4). At this juncture, it is also clear that a national fortification plan, even under the best of circumstances, cannot be ready by 1 October 1990, the termination date for funding of the current project. Thus, to maintain the momentum of the program, a bridge grant of \$450,000 to \$600,000 for a period of 18 months seems to be essential (Rec. M5) in order to assure technical quality control, to define marketing patterns, to develop and test cost recovery mechanisms, and to target selected provinces for the national program.

#### IV. RECOMMENDATIONS

##### A. Management

- M1. In accord with the principle of "truth in labeling", the appropriate labeling of packets of MSG-F without public promotion of its use should be discussed with manufacturers and consumer advocates.
- M2. Updates of program developments should be discussed periodically with interested and involved parties, such as the Consumers Union (YLK) and MSG manufacturers. Furthermore, social marketing of the project, including the success in other countries of fortifying various commodities with needed nutrients, should be fostered in general news releases and through the National Nutrition Network.

- M3. Technical expertise on vitamin A stability and product formulation must be available to the project during the next critical 15 months. Key technical and management personnel—including external technical advisors—should meet periodically in Indonesia, as needed, to assess technical developments in the program. In this same regard, communications should be strengthened between HKI/Jakarta, HKI/New York, USDA, Iowa State University and the Coating Place in terms of technical issues and program implications.
- M4. Planning for the national fortification program (Phase III), in the light of developments in Phase II, should be initiated, such as addressing issues of cost recovery strategies and geographic targeting.
- M5. To maintain the momentum of the program, a "bridge" grant of \$450,000 - \$600,000 for 18 months is strongly supported.

B. Evaluation

- E1. The modified relative dose response (MRDR) test, which is a sensitive indicator of marginal and deficient vitamin A status, should be considered for assessing program efficacy.
- E2. Serious consideration should be given, particularly in reference to Phase III, of lowering the fortification level from 700 IU/day to 490 IU/day (i.e., from 3000 IU/gram MSG to 2000 IU/gram MSG).

C. Technical

- T1. Appropriate quality control standards for "whiteness" should be set and inspection should be conducted at The Coating Place before shipment of stock white vitamin A to Indonesia.
- T2. Stock white vitamin A should be sub-packaged in airtight plastic bags at The Coating Place in 4.2 kg. amounts, the unit currently used in batch fortification of MSG.
- T3. Local exposure conditions (light, humidity, and temperature) during transport and in foodstalls should be assessed as a function of exposure time.
- T4. The stability of MSG-F of all three manufacturers during transport and under foodstall conditions should be assessed as a function of exposure time.

- T5. The range of times that any single package of MSG remains for sale under vending stall conditions should be assessed in each of the three areas selected for Phase II.
- T6. Stability studies of the packaged product should be conducted in the laboratory under simulated local market and transport conditions.
- T7. The technology of preparing "white" vitamin A to improve "whiteness" and to prevent yellowing should be reexamined for purposes of reducing hygroscopic tendencies.
- T8. The water permeability of the sealed packages of all 3 manufacturers should be studied.
- T9. Alternate modes of packaging and sealing, which might reduce the exposure of MSG-F to light and moisture, might be explored.

APPENDIX I

Itinerary of the Evaluation Team for the MSG Fortification Project

Team Members

- Prof. James A. Olson, Distinguished Professor, Iowa State University, Ames, IA, USA
- Prof. John W. Erdman, Jr., Professor, University of Illinois, Champaign, IL, USA
- Ms. Susan J. Eastman, Director, Vitamin A Program, Helen Keller International, NY, NY, USA
- Mr. Sukarno Noer, Division of Nutrition, Dept. of Health, GOI, Jakarta, Indonesia

Program Contact Person

- Mr. John Penberthy, Fortification Project Manager, Helen Keller International, Jakarta, Indonesia

Wednesday, July 5

Dinner: Dr. Leimena, Prof. Karyadi, Pak Benny, Dr. Muhilal, Pak Tarwotjo, Prof. Sommer, Prof. Olson, Ms. Eastman; Orleans Restaurant, Jakarta.

Thursday, July 6

All-day briefing of the program by Mr. Penberthy, HKI Office, Kuningan, Jakarta

Friday, July 7

- Meeting with personnel at the USAID mission, Jakarta
- Lunch with Pak Benny and his associates.
- Meeting with personnel at the Hoffman LaRoche Office, Jakarta

Sunday, July 9

- Fly to Surabaya: Dr. Muhilal, Mr. Penberthy, and the Evaluation Team.

Monday, July 10

- Visit to the Miwon MSG factory, Driorejo, Surabaya region.
- Visit to the Ajinomoto MSG factory, Mojokerto, Surabaya region.
- Return to Jakarta.

Tuesday, July 11

- Meeting with Prof. Karyadi and Dr. Muhilal, Nutrition Research and Development Center, Bogor.
- Visit to observe foodstalls and MSG distribution in and around Kabupaten Cianjur.

Wednesday, July 12

- Meeting with Pak Benny, his staff, and members (or representatives) of the Steering Committee; Dept. of Health, Jakarta
- Report writing, discussion of recommendations.

Thursday, July 13

- Report writing, discussion of recommendations.

Friday, July 14

- Exit meeting with personnel at the USAID mission, Jakarta
- Report, review-and-approval of recommendations by Evaluation Team members, HKI office, Jakarta.

APPENDIX 2

Individuals Contacted in Indonesia

HKI/Jakarta

- Mr. Steven E. Wilbur, Country Director
- Mr. John R. Penberthy, Fortification Project Manager

USAID/Jakarta

- Mr. William Carter, Chief, FVA/PVC
- Ms. Joy Riggs-Perla, Office of Population and Health
- Ms. Jennifer Brinch, Child Survival/Health Coordinator, FVA/PVC
- Mr. David Nelson, FVA/PVC
- Ms. Georgia McCauley, Project Implementation Assistant, Office of Population and Health
- Dr. Emmanuel Voulgaropoulos, Chief Officer, Population & Health
- Ms. Kathleen McDonald, Project Officer, Population & Health
- Ms. JoEllen Lambiotte, Contractor, Voluntary & Humanitarian Program
- Mr. Tendi Mainardi, Program Specialist, Voluntary & Humanitarian Program
- Mr. Jan Waworuntu, Program Assistant, Voluntary & Humanitarian Program

Dept. of Health, Government of Indonesia, Jakarta

- Dr. S. L. Leimena, Director General of Community Health
- Dr. Benny A. Kodyat, MPA, Head of Directorate of Community Nutrition

Dept. of Health, Government of Indonesia, Surabaya

- Mr. Sudibya, Head of Nutrition Section of East Java Provincial Health Office

PT. MIWON INDONESIA, Surabaya

- Mr. D. S. Lim, Factory Manager

PT. AJINOMOTO INDONESIA, Surabaya

- Mr. Hirata, Quality Assurance Manager
- Mr. I. Takemura

PT. ROSINDO HUSADA PRATAMA/HOFFMAN LAROCHE, Jakarta

- Mr. Andre Indarto, Marketing Manager

Nutrition Research and Development Center, Bogor

- Prof. Darwin Karyadi, Director
- Dr. Muhilal, Chairman, Main Nutritional Problems

Others

- Prof. Alfred Sommer, Director, International Center of Epidemiological and Preventive Ophthalmology, John Hopkins Univ., Baltimore, MD, USA
- Dr. Robert Tilden, Univ. of Michigan, Ann Arbor, MI, USA; former Country Director, HKI/Jakarta
- Ignatius Tarwotjo, former Head, Directorate of Community Nutrition, Dept. of Health, GOI, Jakarta

APPENDIX 3

List of Resource Documents

1. Implementation Plan, Fortification of MSG with Vitamin A: Indonesia (with appendices), April 1988.
2. First semi-annual report : John Penberthy, HKI, 12 August, 1988
3. Second semi-annual report : John Penberthy, HKI, 10 October, 1988
4. Third semi-annual report : John Penberthy, HKI, 30 March, 1989
5. Memo: Pricing study component of fortification project, Penberthy to Wilbur/Eastman, 5 April, 1988
6. Memo: Cost Analysis, Penberthy to Tarwotjo/Wilbur/Eastman/Yoewono, 7 April, 1988
7. Memo: Locational expansion of national fortification, Penberthy to Eastman, 27 March, 1989
8. Memo: Expansion of Indonesian fortification program, A. Sommer to Eastman, 19 May, 1989
9. Production and Quality Assurance Guidelines: Fortification of MSG with Vitamin A, Penberthy and Quality Assurance Committee, January 1989
10. MSG-F Production and Quality Assurance Monitoring Checklist, Penberthy, January 1989
11. MSG-F Storage and Distribution Guidelines, Penberthy, 12 January 1989
12. Memo: MSG fortification, Penberthy to Rod Crowley, USDA , 7 July, 1989
13. Agreement between the Dept. of Health, GOI, and PT. Ajinomoto Indonesia, 6 April, 1989
14. Letter: Implementation of the 2nd phase of A program ... vitamin A, H. Ushioda to S. L. Leimena, 22 April, 1989
15. Letter: Implementation ... vitamin A, S. L. Leimena to H. Ushioda, 2 June, 1989
16. Presentation regarding the safety of MSG, Prof. M. J. Rand, 7 November 1988
17. MSG safe according to WHO expert, news release, November 1988
18. Report: Fortification of MSG with "White" Vitamin A in Indonesia, P. Murphy et al, September 1987
19. Memo: MSG manufacturers' questions, R. Crowley to Wilbur, 25 April, 1988
20. Report: Baseline MSG consumption study, Directorate of Nutrition, GOI-HKI, October 1988
21. Report: Vitamin A content of MSG-F, H. Muhilal, 8 March, 1989
22. Memo: Evaluation of Vitamin A-Fortified MSG, R. Crowley to Penberthy, 20 April, 1989
23. Report: Vitamin A project site visit: J. McKigney/S. Pettiss to F. R. Davidson, August, 1988
24. Memo: Financial management analysis: Penberthy to Tarwotjo/Wilbur/Eastman, 7 April, 1988
25. Correspondence between Penberthy and R. Crowley, September 7-23, 1988 plus addenda. Discussion of MSG-F degradation and yellowing.
26. Report: Baseline survey of Vitamin A status in the 3 selected test districts and in 3 similar control districts, Muhilal, Jan/Feb, 1989
27. Memos: MSG Fortification, Murphy to Crowley (7 July, 1989), Crowley to Penberthy, 10 July, 1989

## APPENDIX 4

### Comments on Technical Recommendations

- T1. Whiteness of the stock vitamin A can be estimated qualitatively in relation to reference cards from bone-white to various off-white shades with different amounts of yellow color. Quantitative measurements of yellowness can be determined spectrophotometrically at 325 nm and 370 nm (yellow) or by standard food technological methods, such as Hunter color determinations for "lightness" and "yellowing". Acceptable cut-off values should be established by the GOI and HKI that each batch must meet.
- T2. Packaging of stock vitamin A in suitable packs (4.2 kg) for MSG fortification rather than in bulk would be more convenient and would reduce exposure of the whole 35-kg batch to light and moisture. Presumably, suitable equipment for packaging such quantities exists at The Coating Place. If the fortification level in MSG is reduced by 1/3, the unit package of the stock vitamin A would be decreased to 2.8 kg.
- T3. Mean relative humidity and temperature values for various provinces in Indonesia at various seasons are available, in all likelihood, from the Meteorology Unit of the GOI. Spot checks might be made in typical vending stalls by posting thermometers and relative humidity instruments. Light intensity might be measured in typical vending stalls at suitable times; e.g. 9 am, 1 pm, and 5 pm by use of a foot-candle meter. The range of values as well as mean values for various seasons should be calculated. Similar studies, particularly in regard to temperature, should be conducted on MSG-F during transport by truck and by sea and during storage in warehouses.
- T4. The stability of MSG-F produced by all 3 manufacturers under typical food stall conditions should be assessed. Measurements would include:
- Qualitative examination of "flow" and color (yellowness) relative to fresh, non-exposed standard packs.
  - Vitamin A content.
  - Yellowness, as measured by methods described in #1 above. The stability of MSG-F in packs of 5 Rp, 10 Rp and 25 Rp should be compared.
- T5. The date of packaging of MSG-F sachets is stamped on the cardboard hanger to which they are attached. The date that a new hanger is first displayed in a vending stall should be noted in selected locations of all 3 test areas. The rate of usage of packs from a given hanger can then be determined by biweekly visits. If 10 representative sites in each province are selected, the range and mean time of exposure to sale display can be calculated. The time of movement of a shipment of MSG-F from factory to vending stall can be determined in a similar way.

- T6. From the data obtained in # 4 and # 5, both the range of time and of mean conditions of exposure of MSG-F to light, humidity, and temperature should be known. Under similar laboratory conditions, with particular attention to the upper limits of the ranges, the stability of MSG-F can be evaluated. Measurements would include water uptake, yellowing, and vitamin A content.
- T7. The test batch of "white" stock vitamin A (June '88) is significantly whiter than the later major airfreight shipment (Nov' 88). The addition of more titanium dioxide or other technical modifications might provide a whiter product. In all probability, yellowing occurs by the following mechanisms: MSG picks up water under conditions of high temperature and high humidity. The acidic highly hydrated MSG interacts with vitamin A, made more accessible to MSG by partial hydration of the cellulose and gelatin binders, thereby yielding anhydro-vitamin A. Anhydro-vitamin A (anhydroretinol) shows a major absorption peak at ca 370 nm, which is perceived as a strong yellow color. Vitamin A itself, with an absorption maximum at 325 nm, a wavelength at the limit of visual detection, is perceived as having a very light yellow color. Thus, the conversion of < 5% of the vitamin A to anhydroretinol will have a marked effect on the appearance of the product.
- Concentrated MSG solutions can also cyclize to pyrrolidone carboxylic acid and probably makes polymers as well when exposed to high temperatures and intense light. Thus, MSG alone yellows under such conditions.
- If a small amount of a nonhygroscopic alkaline salt were added to the coated vitamin A particle, the formation of anhydroretinol may well be inhibited. This issue might well be explored.
- T8. Because the relative humidity is high (60-90%) in Indonesia, the permeability of MSG packets to water vapor is a key consideration in maintaining product stability. MSG in the package can be replaced with easily hydrated materials, e.g. anhydrous calcium chloride ( $\text{CaCl}_2$ ) or phosphorus pentoxide ( $\text{P}_2\text{O}_5$ ), with or without a color indicator of hydration. After exposure to various conditions of temperature and humidity, the water uptake in the package as a function of time can be measured by weighing or by color development. Furthermore, one hypothesis suggests that monohydrate MSG yields one molecule of water under very high temperature, which could contribute to clumping. This should be investigated.
- T9. If packages prove to be "leaky" and MSG-F thereby deteriorates under market conditions, alternate modes of packaging and sealing might be explored. Modifications might include packaging in light-tight and moisture-impermeable aluminum sheets, the incorporation of a UV-light screen into the cellophane sheeting, use of a thicker coat of polypropylene or polyethylene on the cellophane sheeting, and improving the heat sealing process. Such changes would be expensive for the manufacturers, thereby raising a new set of issues dealing with recovery and willingness to participate. Nonetheless, the possibility of improving these aspects of the manufacturing process should be considered.

Table 2

Effect of Temperature on Relative Humidity  
at Constant Absolute Humidity

<u>Absolute Humidity (Grains)</u>	<u>Dew Point (°F)</u>	<u>Temperature</u>		<u>RH At Temp.</u>
		<u>°F</u>	<u>°F</u>	
236 grains	75°	100°	100°	80%
236 grains	75°	122°	50°	42%
430 grains	110°	122°	50°	85%

Table 3

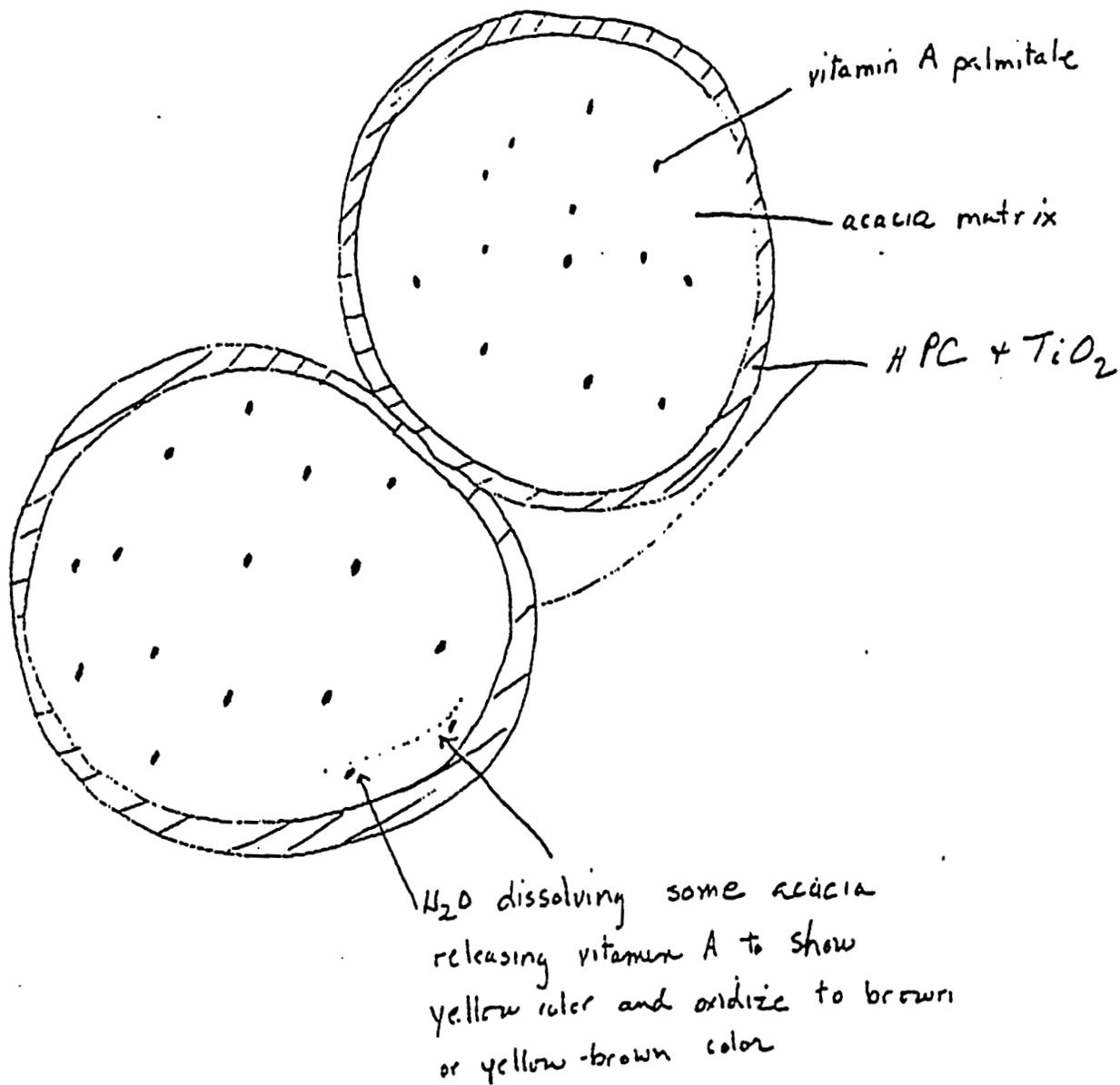
Surface to Mass Ratio for MSG Packets

<u>Sachet Rp</u>	<u>Surface (mm<sup>2</sup>)</u>	<u>MSG Mass (g)</u>	<u>Surface/Mass (mm<sup>2</sup>/g)</u>	<u>Moisture* Uptake (mg/24 hr)</u>
5	21 mm	0.6	35	0.105
10	31.5 mm	1.2	26	0.168
25	55 mm	5.5	10	0.275

\*40°C/90% RH

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DAIRY INDUSTRY



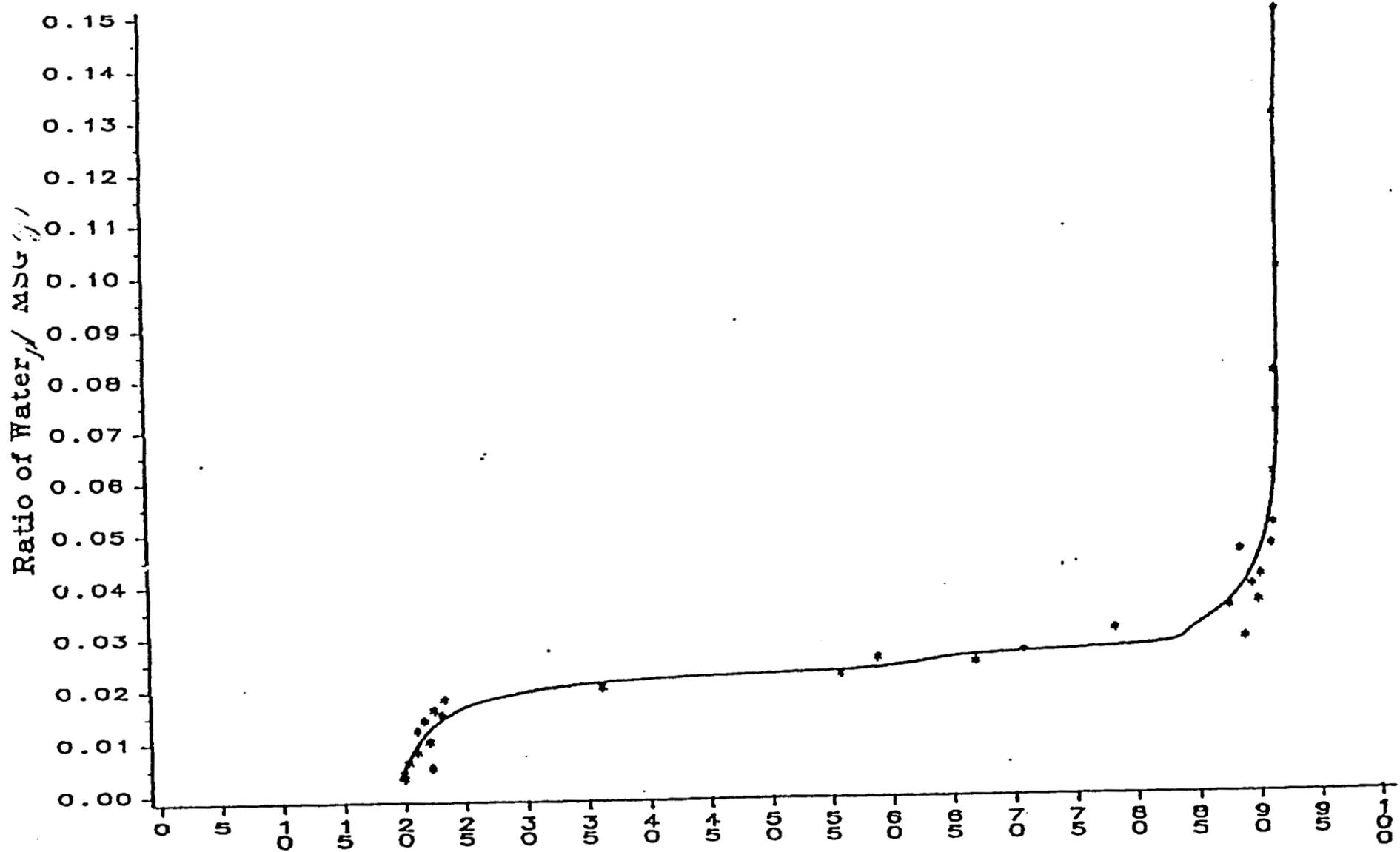
White Vitamin Agglomerate

EFFECTS OF CLOFIBRIC ACID ON PORCINE HEPATOCYTES: A NEW MODEL FOR THE  
STUDY OF PEROXISOMAL METABOLISM. Kenneth W. Turteltaub and Patricia A.  
Murphy, Department of Food Technology, Iowa State University, Ames, IA  
50011.

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# MSG ISOTHERM

Water / MSG vs. Water Activity



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Water Activity (Effective Relative Humidity)

Trip Report

Investigation of Vitamin A-Fortified Monosodium Glutamate  
Discoloration in Indonesia  
August 29 - September 2, 1989

Dr. Patricia A. Murphy  
Iowa State University

Harlan S. Hall  
The Coating Place, Inc.

Dr. Benjamin Borenstein  
B & B Consultants

### Introduction

In mid-July, 1989, it was discovered that MSG fortified with white vitamin A (MSG-F) in Indonesia begins to become clumpy and discolored approximately 2+ months after blending/packageing. In order to evaluate and solve this problem, a technical team assembled in Indonesia the week of August 28 to observe the situation first-hand and gain an in-depth understanding of the nature of the problem.

The main objectives of the team were: 1) to determine ways to make future batches of white vitamin A (WVA) whiter, 2) to assess the hydroscopic tendencies of MSG-F which result in yellowing, clumping and loss of potency as they relate to local climatic exposure and shelf-life, 3) to design alternative production and material parameters which might make MSG-F less hydroscopic, and 4) to devise a research plan and budget for testing the viability of resultant new prototypes of MSG-F. A more detailed description of visit objectives appears in Appendix 1, "Scope of Work".

Team members included Dr. Benjamin Borenstein, formerly of Hoffman LaRoche and now an independent food technology consultant; Dr. Patricia Murphy, long-time project technical consultant with Iowa State University; and Mr. Harlan Hall, President of the Coating Place (the company that coats the vitamin A white).

### Historical Perspective

Development of the current form of WVA has been an incremental process. The Coating Place, Inc. (CPI) first became involved in 1983 when approached to develop an improved binder to adhere vitamin A (VA) beads (Roche) and MSG crystals to each other. Previous work using petroleum jelly and other agents had been less than satisfactory due to melting of the binder, resulting in poor flow of fortified product. (Solon et al., Food Tech 39(11) 71, 1985; R. Tilden to R. Crowley, 4/19/83). CPI developed a binder system based on hydroxypropylcellulose (HPC) which could be applied with alcohol and dried. Upon removal of the alcohol, HPC forms a dry film which dissolves completely in water, leaving no residue. A secondary objective to mask the bright yellow color of VA was achieved by adding white pigment ( $TiO_2$ ) to the HPC/alcohol binder system (Figure 1). The resulting product was then dusted with powdered MSG to further mask the color and prevent caking of the product during tray drying.

In 1984, Harlan Hall and Rod Crowley traveled to Indonesia to demonstrate preparation of this product. Under the guidance of Dr. Muhilal of the National Center for Nutrition Research, the formulation was modified and  $TiO_2$  eliminated (Muhilal, Am. J. Clin. Nutri. 48:1271, 1988). This product was used for phase I, the Bogor field trial of fortified MSG in 1985. The product was deemed to be a technical success (Muhilal, 1988) with no solubility problems noted. The only reported concern was a desire for improved whiteness of the MSG.

In 1987, a sample of WVA was prepared using fluid bed coating technology. This sample was whiter than previous samples and was judged acceptable in color by the MSG manufacturers. Tests of product at Iowa State University (ISU) revealed serious segregation of the WVA beads from the MSG crystals. Additional work by CPI and ISU and agreement by manufacturers to use a single size MSG crystal for the small packets (5, 10, 25 Rp) established

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size specification for WVA to prevent segregation (Murphy et al., 1987). (Samples 871020-A and 880224-A)<sup>1</sup>.

In September, 1988, Ajinomoto reported that under the combined conditions of 50°C, 75% RH and direct sunlight, samples of WVA were turning light tan (probably samples 8904XX which were sent in large quantities). These conditions are extreme (HSH to PRC, September 8, 1988) because even very humid air has a low RH when heated up and the highest temperatures will be encountered in the dark (a closed van or storage building) conditions (Table I). ISU reported (RC to JP, September 27, 1988) that exposure to temperatures as high as 65°C at low humidities resulted in little or no color development. On September 30, 1988 (JP to SE), it was reported that Ajinomoto was satisfied.

Initiation of fortification (Phase II) began with scale-up of the agglomeration/coating of WVA by CPI in November, 1988. Some difficulty in sealing up the process from research to production scale was anticipated, however, achieving particle size specifications proved more difficult than anticipated. During the processing of this first commercial-scale quantity, the process was adjusted until the product conformed to product size limits determined above.

The resulting product (8811XX) was not as white as the small scale samples produced earlier (880224-A) but was deemed acceptable by CPI and later by USDA. Due to delays in shipping and utilization, the WVA (8811XX) was first opened in Indonesia in February, 1989 (JP to SE, February 10, 1989) and it was noted that the color was not white but off-white. This was perceived in the United States as being the off-white color noted by CPI above.

In August, 1989, a sample of discolored WVA (8811XX) was carried by Jim Olson from Indonesia to ISU as an example of discolored material. This sample was much darker than retained samples held by CPI, indicating darkening occurring in the months of shipping and storage. This has not been previously observed.

At the same time, samples of discolored MSG-F were received. Microscopic examination of these revealed that the beads were not discolored; they were gone! Only a stain remains.

ISU did a series of tests (WVA alone and with MSG) at extreme T and RH which resulted in a damp appearance within 48 hrs along with discoloration of the product. All samples, including uncoated 250 CWS and earlier "good" batches of WVA absorbed water and began to discolor. The production materials (8811XX and 8904XX) showed the effect more rapidly (<24 hr) indicating some difference from earlier samples, probably related to scale-up conditions. At this time, Hoffman-LaRoche (Nutley) (HLR-N) has not indicated anything different about the starting 250 CWS. MSG alone picks up water (Figure 2; Sasa) and discolors, but at a slower rate.

ISU repeated the tests using packaged MSG-F from Ajinomoto and Miwon with similar results. The packaging materials are moderately good water vapor barriers, but the duration in the marketplace (Table 1) and surface area to mass (SA/M) of MSG ratio indicated that marked improvement in packaging is not likely. The significance of film permeability was confirmed by field observations during our visit where the smallest packets (greater SA/M) show caking and discoloration first (Table 2). For example, Ajinomoto packaged

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<sup>1</sup>CPI numbering code = AABCC-XX, in which AA = year and BB = month. Thus, 8802 was processed in February, 1988.

March 8 showed the 25 Rp is still good and the 5 Rp is in stage 3. The stages of MSG-F deterioration are ranked on the Penberthy scale (JP to file, August 14, 1989) as follows:

Stage 1: Normal. WVA and MSG particles are completely separate and integral, in their original colors and free-flowing. WVA looks like popcorn under microscope.

Stage 2: MSG particles stick to WVA in small clumps. Some clumps may stick to upper interior of sachet above the bulk of MSG-F. Slight yellowing concentrated in clumps, with overall package appearing off-white at arms length. WVA looks like popcorn with MSG stuck to it under microscope.

Stage 3: Clumps much larger (most MSG involved in clumps), with more widespread discoloration, causing contents to appear slightly yellowish at arms length. MSG-F appears damp and does not flow normally. WVA looks like smashed popcorn with MSG stuck to it under microscope.

Stage 4: Entire contents involved in clumping and thoroughly discolored. MSG-F appears wet and caky and has poor pouring characteristics. No WVA agglomerates present, just stains, under microscope.

#### Activities

All the visiting consultants have extensive technology background in fortification with VA and/or VA market form development. Dr. Pat Murphy, Professor, ISU, has been associated with monitoring VA stability and in fortification feasibility in several international programs, including the Philippines, Bangladesh, Nepal and Malawi as well as the Indonesian project. Mr. Harlan Hall, President, CPI, an expert in fluid bed coating has been involved in this project since 1983 in developing and commercializing the process for color and product-size modification of the VA beadlets. Dr. Ben Borenstein, President, B & B Consultants, was Director of Product Development, Roche Chemical Division, Nutley, NJ, and has extensive experience and publications in vitamin stabilization, bioavailability and fortification.

During the six-day visit (August 28 through September 2), the team was briefed and dialogued continuously with Mr. John Penberthy, HRI project manager, met Dr. Karyadi, Director, Research and Development, NIHRD, interacted with Pak Benny, Head, Directorate Community Nutrition, and Dr. Muhilal, NRDC. Extensive meetings were held with Ajinomoto management, technical and production experts in Jakarta and Surabaya, and similarly with Sasa. The plant, packaging and warehouse visits were valuable. The open and detailed discussions were excellent. The collaboration of the manufacturers and Mr. Penberthy were essential to the success of the mission. Individuals visited are listed in Appendix 1; the itinerary is Appendix 2.

#### Current Status

The fortification project has been suspended pending resolution of the darkening problems. The darkening of WVA derives from two different sources: A) darkening of WVA between time of manufacture and use in blending and B) darkening of blended MSG-F.

- A. Darkening before blending: There is significant variability in the rate of darkening between individual drums of WVA. Some of the material (Ajinomoto, August 31, 1989) looks quite good after 10 months of storage in original containers at  $\leq 29^{\circ}\text{C}$ . Other containers were noticeably yellow at 4 months (JP to SE, February 10, 1989) and at least certain samples have continued to darken under variable conditions.

Factors thought to contribute to this early darkening reaction relate to probable damage to the beads during processing (Figure 1).

1. In the large-scale processing, the modest amount of water used in the process seems to have a greater effect on the beads than was noted in the small-scale trials.
  2. Some beads appear to be physically damaged (broken). This may occur during sizing resulting in exposure to air and degradation of VA.
  3. Factors 1 and 2 can be better controlled in the manufacturing process. This will be addressed in the work planned for September through December, 1989.
  4. All drums sampled have not been resealed since date of sampling allowing moisture uptake before indicated date of blending. This probably has more effect on later darkening.
  5. Various delays have resulted in WVA still being unused after 10 months, much longer than the projected 3 months. This has resulted in further degradation of the product. Although WVA has been kept below  $30^{\circ}\text{C}$  during this time, the storage area is not dehumidified. No color change has been observed in samples stored  $\leq 22^{\circ}\text{C}$  and dew points  $\leq 14^{\circ}\text{C}$ .
- B. Darkening of blended MSG-F
1. After blending with MSG, the resulting MSG-F is packaged in 5, 10 and 25 Rp packs. From hereon, MSG-F is handled like unfortified MSG. Storage at the factory is variable. Ajinomoto has records indicating a maximum storage temperature of  $29^{\circ}\text{C}$ .
  2. Test by ISU, field observations and data from the manufacturers confirm that moisture vapor will permeate the sealed packages. This is expected to be dependant upon time and conditions of storage, i.e., humidity. Pure MSG will cake and discolor under severe conditions, but the WVA dissolves in free water. This releases the VA which is unstable and quickly degrades.
  3. This problem was not observed in Phase I, the Bogor trials. This may be due to a shorter time of exposure after packaging, i.e., higher turnover on Java. Slightly lower humidity at the higher elevation may have further extended shelf-life.

Product Goals

MSG-F should have a similar shelf-life profile to the current unfortified commercial Indonesian MSG, with respect to color and flow properties. This means that the product must survive, at least, six months in the warung (outside stall). MSG-F should not segregate physically and packaging rates should be similar to current practice. Attainment of these goals requires that the vitamin A be white in color, have a majority of the particle sizes in the range from .25 to .71 mm, be sufficiently nonhydroscopic to prevent discoloration, clumping and loss of product integrity. Attainment of these goals will also optimize the chemical stability of VA. Specifications must be developed for WVA which insure achievement of these goals. Color will be measured by Hunter instrumentation on experimental batches in September/October, 1989, and tentative specifications established when performance data are available. Accelerated tests will be developed to predict rate of field discoloration and clumping.

Tentative Specifications for WVA

Size Distribution - same as earlier agglomerated WVA.

Color - to be established.

- A. Hunter Color Difference Meter
- B. Color Chips Meeting Color Test

Potency -  $\geq 165,000$  IU/g at CPI manufacture  
 $\geq 120,000$  IU/g at 6-month storage at 45°C, 40% RH  
in dark

These specifications may be modified depending on data obtained in testing prototypes.

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Recommendations

1. Current WVA is not water/humidity resistant; an improved product is needed. Although 250-GWS is hygroscopic, it is the only VA fortificant that conforms with religious dietary laws.
2. CPI will modify process to minimize darkening resulting from processing.
3. CPI will develop prototype samples for water resistance and submit samples to ISU for evaluation.
4. Samples will be tested as follows:
  - a. whiteness,
  - b. high stress test, and
  - c. hot water dissolution of coated beads.
5. Those prototypes passing above tests will be placed by ISU in long-term test for functional and cosmetic stability. Simultaneously, CPI will scale-up to commercial-size operation with up to 4 of the same samples to determine any problems in large scale processing. Samples will be sent to ISU for testing.
6. Samples that appear promising will be sent to Indonesia via HKI for evaluation in field conditions.
7. A member of this technical evaluation team should meet with the manufacturers in Indonesia to discuss and view results of their evaluation. Completion of the circle of communication is vital for final success. Too much useful information is lost via third-party messages.
8. Re-establishment of fortification may be reconsidered in high turnover areas based on 6-month stability data. Other areas in Indonesia should wait for longer term data.

Testing Parameters for New White Vitamin A Prototypes

The protocol for tasting new white vitamin A prototypes will consist of two phases. Initially, each new prototype will be subjected to a rapid stress test. This will involve subjecting the prototype, alone and with MSG, to high relative humidity (75% and 90%) and high temperature (55°C) for several hours to several days. Visual inspection of the material will be used to evaluate stability using the stage scale of Penberthy (August 14 memo) in comparison with 88/89 white vitamin A materials. Resistance to moisture uptake (longer than 88 white vitamin A) will be considered evidence of increased stability. These prototypes will be used in the second phase.

Survivors of Phase I will be subjected to more critical evaluation with respect to vitamin A stability, size of agglomerates, mixing and size segregation stability, warm water (85°C) solubility and color as well as resistance to moisture uptake. The first six parameters will be evaluated by established procedures. Resistance to moisture uptake testing will be designed to try to replicate conditions that MSG-F will experience in Indonesia. Efforts to predict stability to water uptake will be accomplished by measuring rates of H<sub>2</sub>O uptake at elevated temperatures and humidities

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(controlling for MSG moisture uptake). These data will give us an estimate of stability of the new white vitamin A's. To obtain a realistic estimate of stability, samples of MSG and new prototypes will be packaged in 5 Rp sachets (at ISU and in Indonesia) and subjected to cycling changes in temperature and humidity (constant absolute humidity) for 6 months. (If A<sub>2</sub> chambers cannot be set to cycles, stability will be evaluated at 35°C, 75% RH and at 50°C, 42% RH. Several high temperatures at 75% RH will also be employed. Successful prototypes will show no color change nor observable moisture uptake as well as reasonable vitamin A levels.

#### Transfer of Coating Technology

Assuming eventual project success and expansion, it is desirable to coat the vitamin A white in Indonesia. As no fluid bed technology now exists in Indonesia for such activities, transfer of such technology will eventually be warranted. According to Dr. Muhilal, it is the intention of the Indonesian Department of Health that a local pharmaceutical company incorporate coating operations into their activities. This is a theoretical plan only, no specific firms have yet been identified or solicited.

Mr. Hall estimates that required capital equipment costs will range from \$250,000 to \$500,000. In addition, there will be plant, training and other start-up costs. It is assumed that this would be a privately funded operation based upon normal proforma financial prospects. Thus, before Indonesian coating activities can begin 1) commercial and technical feasibility of MSG fortification must be clearly established and 2) the project will need to be scaled up to a high semi-national level so as to maximize economies of scale for the coating operation. Given the current outlook, this appears to be at least three years in the future. Mr. Hall has generously offered to share technological assistance and know-how when the time comes.

Appendix I  
Individuals Contacted  
September 1, 1989

HKI/Jakarta

John Penberthy, Fortification Project Manager

Nutrition Research and Development Center, Bogor

Prof. Darwin Karyadi, Director

Dr. Muhilal, Chairman, Main Nutritional Problems

Department of Health, Government of Indonesia, Jakarta

Dr. Benny A. Kodyat, MPA, Head of Directorate of Community  
Nutrition

P. T. Ajinomoto, Indonesia

Isao Miyaaki, President Director, Jakarta

T. Motooka, Director of Marketing, Jakarta

Isao Takemura, Vice President Director, Mojokerto

M. Huiata, Assistant Plant Manager, Mojokerto

P. T. Sasa

Y. Kobayashi, Executive Vice President of Marketing, Jakarta

Margono, Director and President, Jakarta

I. Liang, Product and Development, Jakarta

Hartono, Plant Manager, Surakaya

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## Appendix II

## Itinerary for Technical Team Evaluation of MSG Fortification

August 27 - September 2, 1989

Team Members

Dr. Patricia Murphy, Iowa State University  
Mr. Harlan Hall, The Coating Place  
Dr. Ben Borenstein, Hoffman LaRoche

Sunday, August 27

Arrival in Jakarta. Pick up at airport. Reservations at Hotel Kemang.

Monday, August 28

8:30 a.m. All-day briefing at HKI offices.

Tuesday, August 29

9:00 a.m. Meeting with Prof. D. Karyadi and Dr. Muhilal in Bogor.  
2:00 p.m. Meeting with Mr. Motooka, Marketing Director for Ajinomoto.  
7:00 p.m. Dinner at Penberthy's.

Wednesday, August 30

9:00 a.m. Meeting with Pak Margono, President of Sasa.  
3:30 p.m. Flight to Surabaya. Reservations at Hotel Elmi.

Thursday, August 31

9:30 a.m. Visit Ajinomoto factory.  
1:00 p.m. Visit Sasa factory.  
4:00 p.m. Return flight to Jakarta.

Friday, September 1

9:00 a.m. Meeting with Prof. D. Karyadi and Dr. Muhilal in Bogor.  
7:00 p.m. Dinner at Penberthy's.

Saturday, September 2

9:00 a.m. Meeting with Pak Benny, MPA, Head of Directorate of  
Community Nutrition.  
Afternoon Wrap-up, reporting and evaluation.  
Team departs Jakarta.

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Table 1  
 Preliminary Estimates - (Off) Hot on Java  
 Time & Temperature Exposure of MSQ-F  
 at Various Stages of Marketing Distribution

Manufacturer \_\_\_\_\_  
 Destination Kabupaten \_\_\_\_\_

	1. Factory Storage bulk & boxed	2. Truck Shipment	3. Warehouse Storage	4. Ship Shipment	5. Agent Storage	6. Local Truck Delivery	7. Waring Display	Total Total
<u>Time (Days)</u>								
Average	20	2	30	7	30	2	45	4.5 mo
Extreme (longest)	30	3	90	10	60	3	180	± 1 yr
<u>Temperature</u>								
Average (24 hr.)	29	30	29	29?	29	40	29	
(Range)	(24-34)	(24-37)	(24-34)	(24-34)	(24-34)	(24-55)	(24-34)	
Extreme (highest)	34	40	50	?	50	60	34	

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