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VITAMIN A FORTIFIED PEANUT BUTTER

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VITAMIN A FORTIFICATION OF PEANUT BUTTER AND SPREADS

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TABLE OF CONTENTS

		Page
	ACKNOWLEDGEMENT	5
Chapter 1	**Vitamin A Fortification of Unstabilized Peanut Butter by Direct Addition**	25
	Flor Crisanta F. Galvez, Ma. Leonora dL. Francisco, Alicia O. Lustre, and Anna V.A. Resurreccion	
	I. ABSTRACT	26
	II. INTRODUCTION	27
	III. OBJECTIVES	28
	IV. METHODS	28
	A. Identification of Industry Collaborator	28
	B. Preliminary Studies – Pilot Scale	28
	C. Vitamin A Fortification of Peanut Butter – Commercial Scale	32
	V. RESULTS	33
	A. Preliminary Studies – Pilot Scale	33
	B. Vitamin A Fortification of Peanut Butter – Commercial Scale	34
	C. Technology Transfer and Adoption	36
	VI. CONCLUSIONS	37
	VII. REFERENCES	37
	VIII. APPENDICES	39
	Appendix A Memorandum of Agreement and Confidentiality	39
	Appendix B Ballot for the Acceptability of Color of Peanut Butter	44
Chapter 2	**Premix Technology for the Vitamin A Fortification of Peanut Butter**	46
	Alicia O. Lustre, Gertrude M. Agustin, Ermina V. Edra, Flor Crisanta F. Galvez, and Anna V. A. Resurreccion	
	I. ABSTRACT	47

II. INTRODUCTION 49

III. REVIEW OF LITERATURE
A. Fortification Technologies 50
B. Vitamin A 50
C. Stability of Vitamin A 51

IV. OBJECTIVES 52

V. METHODS 52
A. Preliminary Trials 53
B. Laboratory Trials at FDC 56
C. Trials at the Industry Collaborator's Plant 59
D. Technology Transfer and Adoption 63

VII. RESULTS 63
A. Preliminary Trials 63
B. Laboratory Trials at FDC 63
C. Trials at the Industry Collaborator's Plant 66
D. Technology Transfer and Adoption 71

VIII. CONLCUSIONS 72

IX. REFERENCES 73

X. APPENDIX 74

Appendix A Procedural Guideline for the Vitamin A Fortification of Peanut Butter 74

Chapter 3 **Vitamin A Fortification of Stabilized Peanut Butter by Direct Addition** 81

Flor Crisanta F. Galvez, Ma. Leonora dL. Francisco, Blanca J. Villarino, Alicia O. Lustre, and Anna V.A. Resurreccion

I. ABSTRACT 82

II. INTRODUCTION 83

III. OBJECTIVES 84

IV. METHODS 84
A. Experimental Design 84
B. Test Materials 84
C. Vitamin A (retinol) and Beta-carotene Analysis 86
D. Influence of Type and Amount of Fortificant 88
E. Influence of Stabilizer on Vitamin A 88

F. Statistical Analysis 88
G. Technology Transfer and Adoption 89

V. RESULTS 89
A. Influence of Type and Amount of Fortificant 89
B. Influence of Stabilizer on Vitamin A 93
C. Technology Transfer and Adoption 95

VI. CONCLUSIONS 95

VII. REFERENCES 96

Chapter 4 **Vitamin A Fortification of Chocolate-Peanut Spread by Direct Addition** 98

Ma. Leonora dL. Francisco, Flor Crisanta F. Galvez, Alicia O. Lustre, and Anna V. A. Resurreccion

I. ABSTRACT 99

II. INTRODUCTION 100

III. OBJECTIVES 101

IV. METHODS 101
A. Establishment of Collaboration 101
B. Experimental Design 101
C. Test Materials 101
D. Preparation of Chocolate-Peanut Spread 102
E. Vitamin A (retinol) and Beta-carotene Analysis 103
F. Study 1: Influence and Type and Amount Of Fortificant 105
G. Study 2: Fortification of Chocolate-Peanut Spread Using Higher Levels of Vitamin A palmitate 105
H. Statistical Analysis 105
105

V. RESULTS 105
A. Study 1: Influence of Type and Amount of Fortificant 105
B. Study 2: Fortification of Chocolate-Peanut Spread Using Higher Levels of Vitamin A palmitate 107
C. Technology Transfer and Adoption 109

VI. CONCLUSIONS 109

VI. REFERENCES 109

Chapter 5a **Improvement of a Process for the Vitamin A Fortification of Peanut Butter for a Small Company** 111

Gertrude M. Agustin, Alicia O. Lustre, Liza C. Tenorio and Anna V. A.. Resurreccion

I. ABSTRACT 112

II. INTRODUCTION 114

III. OBJECTIVES 114

IV. METHODS 115
A. Preliminary Activities for Technology Transfer 115
1. Standardization of the Process at FDC Considering Collaborator's Facilities 115
Study 1. Preliminary Verification of the Direct Addition Procedure Developed by PCRSP for the Vitamin A Fortification of Peanut Butter 115
Study 2. Preliminary Verification of the Suitability of Incorporating the Fortificant and Stabilizer after the 2nd Grinding Step During the Vitamin A Fortification of Peanut Butter 117
Study 3. Establishment of Mixing Time for Incorporating the Vitamin A Fortificant to Peanut Butter 119
2. Standardization of the Process at the Collaborator's Plant 119
Study 1. Testing the FDC Direct Addition Method for Incorporating Vitamin A to Peanut Butter at the Collaborator's Plant 119
Study 2. Validation of the Results of Vitamin A Recovery and Stabilizer Performance in Fortified Peanut Butter Prepared Using Parameters Established for the Vitamin A Fortification and Stabilization of Peanut Butter 121
B. Technology Transfer and Adoption 122

V. RESULTS 122
A. Preliminary Activities for Technology Transfer 123
B. Evaluation of the Existing Facilities of the Collaborator 123
C. Evaluation of the Collaborator's Process Flow for the Preparation of Peanut Butter 123
D. Standardization of the Process at FDC Considering Collaborator's Facilities 125

Study 1. Preliminary Verification of the Direct Addition Method Developed Under PCRSP for the Incorporation of Vitamin A Fortificant to Peanut Butter 125
Study 2. Preliminary Verification of the Suitability of Incorporating the Fortificant and Stabilizer After the 2nd Grinding Step During the Vitamin A Fortification of Peanut Butter 126
Study 3. Establishment of Mixing Time for Incorporating Vitamin A to Peanut Butter by the Direct Addition Method 127

E. Standardization of the Process at Collaborator's Plant 129
Study 1. Testing the FDC Direct Addition Method for Incorporating Vitamin A to Peanut Butter at the Collaborator's Plant 129
Study 2. Validation of the Results of Vitamin A Recovery and Stabilizer Performance in Fortified Peanut Butter Prepared Using Parameters Established for the Vitamin A Fortification and Stabilization of Peanut Butter for a Small Company 131
F. Technology Transfer and Adoption 132
G. Constraints in the Transfer of Technology to the Industry Collaborator 132

VI. CONCLUSIONS 133

VII. REFERENCES 133

VIII. APPENDICES 135
Appendix A Process Flow for the Stabilization of a Flowing-Type Peanut Butter of Choulya Foods//biochemical, Inc. 135

Appendix B Process Flow for the Fortification of Peanut Butter of Choulya Foods/Biochemica, Inc. 139

Chapter 5b **Improvement of a Process for the Vitamin A Fortification of Peanut Butter for a Large Company** 143

Gertrude M. Agustin, Alicia O. Lustre, Liza C. Tenorio and Anna V. A.. Resurreccion

I. ABSTRACT 144

II. INTRODUCTION 145

III. OBJECTIVES 145

IV. METHODS 145
A. Preliminary Activities for Technology Transfer 145
B. Standardization of the Process at Collaborator's Plant 146
C. Preliminary Verification of the Direct Addition Procedure Developed by the Industry Collaborator for the Vitamin A Fortification of Peanut Butter 148
D. Collaborator's Procedure for the Addition of Vitamin A Fortificant to the Peanut Butter matrix 148
Study 1. Effect of Increasing the Number of Addition/mixing Times of Vitamin A Fortificant to Peanut Butter in the Developed Process of the Collaborator 150
Study 2. Effect of Incorporating the Vitamin A Fortificant in the Cooling Tank After the 2nd Grinding Step in the Existing Process for Peanut Butter Production of the Collaborator 150
Study 3. Effect of Incorporating the Vitamin A Fortificant in the Filler Tank in the Existing Fortification Process for Sweet and Creamy Peanut Butter of Tobi marketing Inc. 153
Study 4. Validation of the Recovery and Dispersion of Vitamin A in Fortified Sweet and Creamy Peanut Butter Prepared by the Direct Addition of the Fortificant at the Cooling Tank 155
E. Technology Transfer and Adoption 156

V. RESULTS 156
A. Standardization of the Process at Collaborator's Plant 156
Study 1. Effect of Increasing the Number of Addition/mixing Times of Fortificant to Peanut Butter in the Developed Process of the Collaborator for Stabilized Peanut Butter. 157
Study 2. Effect of Incorporating the Fortificant in the Cooling Tank Equipped with a Mixer After the 2nd Grinding Step in the Existing Process for Peanut Butter Production of the Collaborator 159
Study 3. Effect of Incorporating the Fortificant in the Filler tank in the Existing Fortification Process for Sweet and Creamy Peanut Butter of Tobi Marketing Inc. 160
Study 4. Validation of the Recovery and Dispersion of Vitamin A in Fortified Sweet and Creamy Peanut butter Prepared by the Direct Addition of the Vitamin A Fortificant at the Cooling Tank 161
C. Technology Transfer and Adoption 162

VI. CONCLUSIONS 163

VII. REFERENCES 163

VIII. APPENDIX 165
Appendix A Procedural Guideline for the Vitammin A Fortification of the Sweet and Creamy Peanut Butter of TMI Food Processing and Development, Inc. 165

Chapter 6 **Establishment of Sanitation Standard Operating Procedures for the Manufacture of Vitamin A Fortified Peanut Butter** 170

Alicia O. Lustre, Edith M. San Juan, Fe. R. Vito, Judith Manahan, Ma. Carlota R. Dy, and Anna V.A. Resurreccion

I. ABSTRACT 171

II. INTRODUCTION 172

III. OBJECTIVES 172

IV. METHODS 172
A. Establishment of Collaboration 172

V. RESULTS 173
Sanitation Standard Operating Procedure (SSOP) 174
A. Safety of Water Supply 174
B. Cleanliness and Condition of Food Contact Surfaces 176
C. Prevention of Cross- Contamination 177
D. Maintenance of Workers Sanitary Facilities Such as Hand Washing, Hand Sanitizing, Locker Rooms and Toilets 179
E. Protection of Food, Food Packaging Materials, and Food Contact Surfaces from Adulteration with Contaminants 180
F. Labeling, Storage and Use of Toxic Compounds 181
G. Control of Employee Health Conditions 182
H. Exclusion of Pests 183

VI. REFERENCES 183

Chapter 7 **Development of a Generic Hazard Analysis Critical Control Point Plan for Vitamin A Fortified Peanut Butter** 219

Alicia O. Lustre, Edith M. San Juan, Jocelyn M. Sales, Fe. R. Vito, Alberto R. Cariso, and Anna V.A. Resurreccion

I. ABSTRACT 220

II. INTRODUCTION 221

III. OBJECTIVES 221

IV. METHODS 221
A. Preliminary Activity 221
B. Creation of the FDC HACCP Plan Team 221
C. Hazard Identification and Ranking 221
D. Determination of Critical Control Points (CCPs) 222
E. Development of the HACCP Plan Form 222
F. Contents of the HACCP Plan 222
G. Technology Transfer 222
H. Reasons for Non-Adoption of the SSOP by Newborn Food Food Products, Inc. 222

V. RESULTS 224

Generic HACCP Plan for Vitamin A Fortified Peanut Butter 224

Section 1. Prerequisite Requirements 225
Section 2. Scope of the HACCP Plan 225
Section 3. Scope of the HACCP Plan 225
Section 4. Food Safety Objectives (FSOs) 226
Section 5. Process Flow Diagram for Vitamin A Fortification of Peanut Butter 227
Section 6. Process Description 230
Section 7. Hazard Analysis 234
Section 8. Critical Control Point (CCP) Determination 240
Section 9. HACCP Plan Form 245
Section 10. Validation of the HACCP Plan 247

VI. REFERENCES 248

VII. RECORDS 249

Record 1. Weights of Fortificant Monitoring Record 250
Record 2. Corrective Action Report 251
Record 3. Weighing Scale In-house Calibration Record 252
Record 4. Weights of Peanut Butter Premix Monitoring Record 253

VIII. APPENDICES 254

Appendix A. Risk Assessment Model for Determining The Risk Level of a Hazard of the Product Board Animal Feed (PDV) 255
Appendix B. Ten Components of A HACCP Plan 256

Appendix C. Recommended Prerequisite Requirements for HACCP of New Zealand 259
Appendix D. Components of the Prerequisite Program for HACCP of the US 260

Chapter 8 **Obtaining Sangkap Pinoy Seal for Vitamin A Fortified Peanut Butter from the Department of Health** 261

Alicia O. Lustre, Gertrude M. Agustin, Ermina V. Edra, Evangeline N. Fadrigalan, and Anna V. A. Resurreccion

I. ABSTRACT 262

II. OBJECTIVES 263

III. METHODS 263
A. Shelf-life Study of the Peanut Butter Premix 263
B. Shelf-life Study of Fortified Peanut Butter 264
C. Evaluation of the Product 264
D. Estimation of Shelf-life of Vitamin A 264
E. Evaluation of Documents for Sankap Pinoy Seal Application 265

IV. RESULTS 265

A. Shelf-life Study of the Peanut Butter Premix 265
B. Shelf-life Study of Fortified Peanut butter 266
C. Estimation of Shelf-life of Vitamin A 270
D. Evaluation of Documents for Sangkap Pinoy Seal Application 271

V. CONCLUSIONS 271

VI. REFERENCES 271

Note on the Adoption of the Improved Process for the Vitamin A Fortification of Stabilized Peanut Butter in a Small Company 273

Lutgarda S. Palomar, Lorina A. Galvez, Lucy B. Paloma and Rotacio T. Gravoso.

I. ABSTRACT 274

II. INTRODUCTION 274

III. OBJECTIVES 275

IV. METHODS 275
- A. Identification of Collaborators 275
- B. Product Processing 276

V. RESULTS 276
- A. Identification of a Collaborator 276
- B. Discussions and Identification of Problem 277
- C. Support Capability Building/cGMP, SSOP and HACCP Updates 277
- D. Needs for Training on Peanut Butter Preparation and on Sorting Technology 277
- E. Technology Transfer and Standardization of Stabilized Peanut Butter 277
- F. Technology Transfer of the Improved Method of Vitamin A Fortificant Application and Subsequent Training at Lola Concordia's Facility 278
- G. Determination of Product Cost Break-Even Price 278

VI. CONCLUSIONS 278

VII. REFERENCES 279

VIII. APPENDICES 280
- Appendix A Proposal for Collaboration Between Leyte State University and La Concordia Agro-Industrial Farm and Processing (LCA-IFP) 280
- Appendix B Signing of Memorandum of Agreement 283
- Appendix C Building and Facilities of Lola Concordia Agro-Industrial Farm and Processing 285
- Appendix D Sanitation Updates 287
- Appendix E Training on the Processing of Stabilized Peanut Butter at Leyte State University 292
- Appendix F Training on the Processing of Stabilized Peanut Butter at Lola Concordia Agro-Industrial Farm and Processing 294

LIST OF TABLES

Chapter 1. Vitamin A Fortification of Unstabilized Peanut Butter by Direct Addition

Table No.	Title	Page
Table 1.1	Percent vitamin A retention and amount of vitamin A (based on % RENI) retained after processing of peanut butter at different fortification levels	34
Table 1.2	Percent vitamin A retention and amount of vitamin A (based on % RENI) retained after processing of peanut butter fortified with vitamin A palmitate at different levels of fortification using different methods of addition during commercial studies	35
Table 1.3	Percent vitamin A retention and amount of vitamin A (based on % RENI) retained after processing of peanut butter fortified with vitamin A palmitate at different levels of fortification during commercial studies	35
Table 1.4	Percent vitamin A retention and amount of vitamin A (based on % RENI) retained after processing of peanut butter fortified with vitamin A palmitate at a level of 1/3 + 50% of RENI using different mixing times during commercial scale studies	36
Table 1.5	Percent vitamin A retention and amount of vitamin A (based on % RENI) retained after processing of peanut butter fortified with vitamin A palmitate at a level of 175% of RENI during verification studies in commercial scale	36

Chapter 2. Premix Technology for the Vitamin A Fortification of Peanut Butter

Table No.	Title	Page
Table 2.1	Effect of mixing time on the dispersion of dyed oil and of dyed peanut butter in a plain peanut butter matrix after 5 minutes and 10 minutes of mixing using Hobart Vertical Mixer Model HCM 300	64
Table 2.2	Effect of 10 minutes mixing time on vitamin A recovery during laboratory preparation premix at FDC	64
Table 2.3	Effect of 10 minutes mixing time on vitamin A recovery during laboratory preparation of fortified peanut butter	65
Table 2.4	Effect of absence of light on vitamin A recovery during laboratory preparation of fortified peanut butter	66
Table 2.5	Effect of vitamin A recovery of using the Horizontal Mixer of the industry collaborator in the preparation of premix	67

Table No.	Title	Page
Table 2.6	Effect of vitamin A recovery of using the Hobart Mixer of the industry collaborator in the preparation of premix	67
Table 2.7	Effect of fill-volume on vitamin A recovery when fortified peanut butter was prepared using the Horizontal Mixer of the industry collaborator	68
Table 2.8	Effect on vitamin A recovery of using premix prepared from the Horizontal Mixer of the industry collaborator commercially-prepared fortified peanut butter	70
Table 2.9	Effect on vitamin A recovery of using premix prepared from the Hobart Mixer of the industry collaborator commercially-prepared fortified peanut butter	71

Chapter 3. Vitamin A Fortification of Stabilized Peanut Butter by Direct Addition

Table No.	Title	Page
Table 3.1	Experimental design for the vitamin A Fortification of Stabilized Peanut Butter	85
Table 3.2	Percent vitamin A retention and amount of vitamin A (based on % on RENI) retained after processing of stabilized peanut butter fortified with vitamin A at different levels of fortification	90
Table 3.3	Analysis of variance (ANOVA) of overall effects and means of the factors studied on the amount of vitamin A (based on %RENI) retained in stabilized peanut butter after processing	91
Table 3.4	ANOVA of overall defects and interaction of factors and means of the factors studied on the percent vitamin A retention in fortified stabilized peanut butter after processing	93
Table 3.5	Analysis of the individual effects of the levels of fortification (ANOVA) and brand of stabilizer (t-Test) on the amount of vitamin A retained in stabilized peanut butter after processing per fortificant used	94
Table 3.6	Analysis of the individual effects of the level of fortification (ANOVA) and brand of stabilizer (t-Test) on percent vitamin A retention in fortified stabilized peanut butter after processing per fortificant used	95

Chapter 4. Vitamin A Fortification of Chocolate-Peanut Spread by Direct Addition

Table No.	Title	Page
Table 4.1	Experimental design for the vitamin A fortification of chocolate-peanut spread	102
Table 4.2	Percent vitamin A retention and amount of vitamin A (based RENI) retained after processing of chocolate peanut spread fortified with vitamin A at different levels of fortification	106
Table 4.3	Analysis of variance (ANOVA) of overall effects and means of the factors studied on the amount (based on %RENI) of vitamin A retained in chocolate-peanut spread after processing	107
Table 4.4	% Vitamin A retention and amount of vitamin A (based on %RENI) retained after processing of chocolate-peanut spread fortified with vitamin A at different levels of fortification using vitamin A palmitate (microencapsulated)	108
Table 4.5	t-test analysis of means on the % vitamin A (based on %RENI and retention) in chocolate-peanut spread after processing	108

Chapter 5a. Improvement of a Process for the Vitamin A Fortification of Peanut Butter for a Small Company

Table No.	Title	Page
Table 5a.1	Evaluation of available facilities at collaborator's processing plant	123
Table 5a.2	Evaluation of the collaborator's process flow for the preparation of peanut	124
Table 5a.3	Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared by the direct addition method of Galvez *et al*., 2003 (FDC, 2006b)	125
Table 5a.4	Vitamin A content and vitamin A recovery of fortified stabilized peanut butter prepared with the fortificant and stabilizer added before and after the 2nd grinding step (FDC, 2006c)	127
Table 5a.5	Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared with the fortificant and stabilizer added before the 2nd grinding step after 2, 5 and 10 minutes mixing time (FDC, 2006d)	128
Table 5a.6	Vitamin A content and vitamin A recovery of fortified stabilized peanut butter prepared with the vitamin A fortificant and stabilizer added after the 2nd grinding step at 2 and 5 minutes mixing time (FDC, 2006d)	129

Table 5a.7 Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared at the collaborator's plant after a mixing time of 2 and 5 minutes (FDC, 2006e) 130

Table 5a.8 Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared with the fortificant and stabilizer added at 2 minutes mixing time (FDC, 2006f) 131

Chapter 5b. Improvement of a Process for the Vitamin A Fortification of Peanut Butter for a Large Company

Table No.	Title	Page
Table 5b.1	Vitamin A content and vitamin A recovery of fortified peanut butter processed by the collaborator's direct addition procedure (FDC, 2006a)	157
Table 5b.2	Vitamin A content and vitamin A recovery of fortified sweet and creamy peanut butter prepared with the vitamin A fortificant added at a weight ratio of 2.3286 g vitamin A palmitate in oil to ~38.81 kg peanut butter (FDC, 2006b)	158
Table 5b.3	Vitamin A content and % vitamin A recovery of fortified peanut butter prepared with fortificant added at the cooling tank at 2 different mixing times (FDC, 2006c)	159
Table 5b.4	Vitamin A content, % vitamin A recovery and % variability of fortified stabilized peanut butter processed with the vitamin A fortificant added at the filler tank and at the cooling tank (FDC, 2006d)	161
Table 5b.5	Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter with the vitamin A fortificant added at the cooling tank at a weight ratio of 2.3286 g vitamin A palmitate to 38.81 kg peanut butter matrix (FDC, 2006e)	162

Chapter 8. Obtaining Sangkap Pinoy Seal for Vitamin A Fortified Peanut Butter from the Department of Health

Table No.	Title	Page
Table 8.1	Chemical characteristics of the premix at 30°C for 12 days	265
Table 8.2	Physical and sensory characteristics of the premix during storage at 30°C	266
Table 8.3	Visual evaluation of the packaging condition of vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at each accelerated temperatures	267

Table 8.4	Physical evaluation (oil separation) of vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at accelerated temperatures	267
Table 8.5	Initial sensory characteristics of vitamin A fortified peanut butter packed in transparent glass tumblers with design	268
Table 8.6	Development of rancid odor in vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at different accelerated temperatures	269
Table 8.7	Odor acceptability of vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at different accelerated temperatures	269
Table 8.8	Vitamin A content (μg/g) and vitamin A loss (%) in vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at accelerated temperatures	270
Table 8.9	Peroxide value of vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at ambient temperatures	270
Table 8.10	Results of regression analysis of vitamin A (retinal) in peanut butter packed in transparent glass tumbler with design	271

Note on Adoption of the Improved Process for the Vitamin A Fortification of Stabilized Peanut Butter in a Small Company

Table No.	Title	Page
Table 1	Criteria used in the identification and selection of a collaborator	277
Table 2	Product cost and break-even and selling prices of stabilized peanut butter based on 10-kilogram formulation	278

LIST OF FIGURES

Chapter 1. Vitamin A Fortification of Unstabilized Peanut Butter by Direct Addition

Fig. No.	Title	Page
Fig. 1.1	Flow diagram of process for vitamin A fortified unstabilized peanut butter (direct addition)	30

Chapter 2. Premix Technology for the Vitamin A Fortification of Peanut Butter

Fig. No.	Title	Page
Fig. 2.1	Schematic diagram of the procedure for the preparation of plain peanut butter at FDC	54
Fig. 2.2	Schematic diagram of the dye test procedure for the addition of dyed oil to plain peanut butter	55
Fig. 2.3	Schematic diagram of the dye test procedure for the addition of dyed peanut butter to plain peanut butter	56
Fig. 2.4	Schematic diagram of the procedure for the laboratory scale preparation of premix at FDC	57
Fig. 2.5	Schematic diagram of the procedure for the laboratory scale production of fortified peanut butter at FDC	58
Fig. 2.6	Schematic diagram of the procedure for the commercial production of peanut butter premix at the industry collaborator's plant	60
Fig. 2.7	Schematic diagram of the procedure for the commercial production of fortified peanut butter at industry collaborator's plant	61

Chapter 3. Vitamin A Fortification of Stabilized Peanut Butter by Direct Addition

Fig. No.	Title	Page
Fig. 3.1	Flow diagram of process of vitamin A fortified stabilized peanut butter	87

Chapter 4. Vitamin A Fortification of Chocolate-Peanut Spread by Direct Addition

Fig. No.	Title	Page
Fig. 4.1	Flow diagram of process for vitamin A fortified chocolate-peanut spread	103

Chapter 5a. Improvement of a Process for the Vitamin A Fortification of Peanut Butter for a Small Company

Fig. No.	Title	Page
Fig. 5a.1	Schematic diagram of the direct addition method for incorporating the vitamin A fortificant to peanut butter adapted from Galvez *et al*. (2003)	116
Fig. 5a.2	Schematic diagram of the procedure for incorporating vitamin A to the peanut butter matrix before and after the 2nd grinding step	118
Fig. 5a.3	Process flow for the preparation of vitamin A fortified stabilized peanut butter at collaborator's plant	120
Fig. 5a.4	Schematic diagram of the procedure for adding the fortificant to peanut butter after the grinding step	121
Fig. 5a.5	Schematic diagram of procedure for the stabilization of a flowing-type peanut butter	138
Fig. 5a.6	Schematic diagram of procedure for the vitamin A fortification of a stabilized peanut butter	142

Chapter 5b. Improvement of a Process for the Vitamin A Fortification of Peanut Butter for a Large Company

Fig. No.	Title	Page
Fig. 5b.1	Schematic diagram of the process flow for the preparation of peanut butter matrix for receiving the vitamin A fortificant	147
Fig. 5b.2	Schematic diagram of the collaborator's procedure for the one-time addition of the vitamin A fortificant to peanut butter	149
Fig. 5b.3	Schematic diagram of the FDC procedure for adding the vitamin A fortificant to the peanut butter matrix at the stainless steel vessel of the collaborator's processing line	151
Fig. 5b.4	Schematic diagram of the procedure for adding the vitamin A fortificant at the cooling tank	152
Fig. 5b.5	Schematic diagram of the procedure for adding the vitamin A fortificant at the filter tank	154

Chapter 8. Obtaining Sangkap Pinoy Seal for Vitamin A Fortified Peanut Butter from the Department of Health

Fig. No.	Title	Page
Fig. 8.1	Arrhenius plot of the rate vitamin A (retinal) deterioration of peanut butter packed in transparent glass tumbler versus the inverse of absolute temperature	272

Note on Adoption of the Improved Process for the Vitamin A Fortification of Stabilized Peanut Butter in a Small Company

Fig. No.	Title	Page
Fig. 1	Process flow for the preparation of a vitamin A fortified stabilized peanut butter to a small company in Leyte	276

CHAPTER 1

VITAMIN A FORTIFICATION OF UNSTABILIZED PHILIPPINE PEANUT BUTTER BY DIRECT ADDITION

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ABSTRACT

Experiments were conducted in Food Development Center (FDC) to develop a procedure on fortifying the industry collaborator's peanut butter with vitamin A. The industry collaborator in this study manufactures the most popular brand of peanut butter and it is the most widely consumed peanut butter in the Philippines. When the vitamin A-fortified peanut butter is introduced in the market, it is expected to contribute to the solution of a micronutrient-deficiency problem in the country.

The temperature (130, 140, 150°C) and time (40, 50, 60 min) of roasting peanuts after dry-blanching to produce a peanut butter that is most acceptable to consumers was optimized using a 3x3 full factorial experiment in pilot scale production. For the fortification of peanut butter, vitamin A palmitate and beta-carotene were used as fortificants at different concentrations to determine the most cost-effective fortificant to use that will meet Philippine regulations for vitamin A fortification of foods. Results of the preliminary experiments were applied and modified in commercial scale using the manufacturing facilities of an industry collaborator. Different levels of fortification with vitamin A palmitate (1/3, 2/3, 100% of Philippine RENI for male adult) and at 100, 200 and 300% levels of fortification in a commercial scale were undertaken. The time of mixing (5, 10 and 15 min) after the fortificant was added to the peanut butter that will result in highest retention was likewise determined. Verification studies were conducted at 175% fortification level in commercial scale.

Roasting of 20 Kg of dry-blanched peanuts at 140°C for 50 min resulted in a peanut butter that was most acceptable to consumers and to the industry collaborator. In terms of type of fortificant, vitamin A palmitate was found to be more economical to use. A fortification level of 175% of the RENI was sufficient to achieve the recommended level of 1/3 of Philippine RENI per serving in vitamin A-fortified foods in the Philippines. Commercial scale production using 4.8 g vitamin A palmitate for every 120 Kg peanut butter added during the final mixing before dispensing product into jars is the recommended procedure.

The technology transfer of the vitamin A fortification of unstabilized peanut butter to the industry collaborator was not immediately conducted. Peanut-CRSP investigators decided to further investigate the low % recovery of the vitamin A in the product.

INTRODUCTION

Physical and mental deformities, high risk of infection, low work productivity and increased mortality in children are some of the deleterious consequences of micronutrient malnutrition. Principal micronutrients that contribute to malnutrition are vitamin A, iron and iodine. The Food and Agriculture Organization/World Health Organization (FAO/WHO) International Conference on Nutrition (ICN), held in Rome in December 1992, recognized the widespread occurrence of micronutrient deficiencies, particularly in developing countries. The conference recognized food-based approaches as the most effective way to address existing micronutrient deficiencies.

Vitamin A deficiency (VAD) has long been recognized in the Philippines. The 4th National Nutrition Survey conducted in 1993 revealed that 3 to 4 out of 10 preschool-age children and 1 to 2 out of 10 pregnant and lactating women are afflicted with VAD (Kuizon, 1993). It has also been shown that women of reproductive-age living in VAD area frequently report night blindness during pregnancy and/or lactation (Villavieja et al, 2001).

The 5th National Nutrition Survey conducted in 1998 showed little improvement. The recent survey however affirmed that households with lower socioeconomic status (mothers/caregivers who are laborers, unskilled workers, agricultural workers and semi-skilled workers) were found to have higher prevalence of night blindness. This group generally has limited resources and is more often than not, deprived of better quality diets. With the very limited education attained by these women, it is expected that their knowledge is also limited with regard to proper choice of food (Villavieja et al, 2001). Overall, the situation remains a significant public health problem.

In response to the current state of micronutrient malnutrition in the Philippines, the Philippine Government, through the Department of Health (DOH) launched a program, the Philippine Plan of Action for Nutrition, as a response to the problems besetting the country. Strategies implemented in the program were (1) "*Araw ng Sangkap Pinoy*", periodic administration of high dose vitamin A supplement to children 1-5 years of age and, (2) "*Sangkap Pinoy* Seal (SPS)" program, a food fortification program where staple foods and widely consumed processed food products are used as vehicles for micronutrient supplementation. The latter strategy was recognized during the 1992 Food and Agricultural Organization (FAO)/World Health Organization (WHO) International Conference on Nutrition as the most viable and cost-effective food-based approach to address existing micronutrient deficiencies (Lofti *et al*., 1996; Oriss, 1998).

With the increasing number and types of processed foods in the market today, coupled with the changing lifestyle and increase in popularity of processed foods, convenience foods are presumably the popular vehicles for fortification. The Philippine's DOH, as of 1999, through its SPS program, has already approved the use of the seal of acceptance in 26 fortified food products (Villavieja *et al*., 2001).

The Philippine Peanut-CRSP team in 2002 conducted a nationwide survey on peanut butter consumption patterns of Filipinos (results are published in Monograph Series No. 2). This survey was conducted to identify new market opportunities for peanuts and peanut products in the Philippines. The survey included information regarding consumer's attitudes, behaviors, and concerns regarding vitamin fortication of foods. Results showed that Filipino consumers were, in general, aware and knowledgeable about vitamin A and the presence of vitamin A-fortified food products in the market. They were buying these products and indicated that they would buy vitamin A-fortified peanut butter when this is made

available to them. Most of the respondents (>70%) were willing to pay more than PhP 0.25 additional price with a large proportion who were willing to pay more than PhP 1.00.

With the products' popularity among consumers, a study was proposed to an industry collaborator on developing a procedure for vitamin A fortification of their peanut butter. The industry collaborator manufactures the oldest and leading brand of peanut butter in the market today and is characterized as having a sweet, flowing-type peanut butter.

OBJECTIVES

The objective of this study was to develop a procedure on vitamin A fortification of unstablized peanut butter. Specific objectives were to: (1) determine roasting temperature and time required to produce a peanut butter color similar to the color of peanut butter of the industry collaborator; (2) develop a commercial fortification procedure for an unstabilized peanut butter and; (3) establish the amount of fortificant to be added to unstabilized peanut butter to retain at least 1/3 of the Philippine RENI for vitamin A in the product.

METHODS

Establishment of Industry Collaboration

Consultations between the Food Development Center, University of the Philippines and one peanut product manufacturing company were initially set-up in 1999. This company indicated their desire for collaboration in a study on the fortification of their peanut butter with vitamin A. However, arrangements for the said study did not push through. Another company was contacted and discussions with the owner and top management revealed possible collaboration on the fortification of their peanut butter. The new industry collaborator manufactures the leading brand of "natural" peanut butter in the Philippines. This brand of peanut butter is the oldest in the country and, therefore, the most popular. It is characterized as having a sweet, unstabilized peanut butter. An agreement on the collaboration was drafted, discussed and signed by the representative of the collaborating company, by Dr. Alicia O. Lustre as P-CRSP Principal Investigator and by Dr. Flor Crisanta F. Galvez as P-CRSP Co-Principal Investigator. The agreement on collaboration is shown in Appendix A. This agreement included the details of the responsibilities of each party, the cost-sharing scheme adopted, use of industry facilities for the development of the technology, as well as the agreement of confidentiality.

Preliminary Studies

A preliminary study was conducted in the laboratory at the Food Development Center (FDC). The objective was to determine the roasting parameters for peanuts to produce a peanut butter that will approximate the color of the collaborator's peanut butter and also to determine the most acceptable peanut butter to Filipino consumers. A 3x3 full factorial experiment in pilot scale that included roasting temperature (130, 140 and 150°C) and time (40, 50 and 60 min) were conducted. Peanuts (large seed

variety from Vietnam, provided by the industry collaborator) were first dry-blanched following the procedure established by Peanut-CRSP team in 2002 (results are published in Monograph Series No. 3). Raw peanuts were dry-blanched at 140°C for 25 min using a prototype roaster (manufactured by Kosuge Takkosho, Japan), cooled, de-skinned and sorted for discolored and damaged kernels. Sorted peanuts were then roasted using the roasting conditions specified above. The roasted peanuts were then processed into peanut butter. Roasted peanuts were first chopped using the silent cutter (Model FC-380-3H, Fujimak, Japan). White sugar (20% w/w) was added to the chopped peanuts and the mixture was passed through the colloid mill (TUC/PROBST & CLASS – Rastatt, Baden, West Germany) that was set at no.2. The slurry was again passed through the colloid mill for a second time at 0 setting. Peanut butter samples were collected in jars and petri dishes and stored until use.

A preliminary meeting with the collaborator was initiated to determine the color reference that approximated the color of peanut butter that the collaborator produces. The peanut butter samples were presented and the collaborator preferred the peanut butter sample that was prepared by roasting at 140°C for 60 minutes with the color closest to the peanut butter color that they produce.

To determine the most acceptable peanut butter to Filipino consumers, a consumer acceptability test was conducted to determine the roasting parameters that will give the peanut butter that is most acceptable to Filipino consumers. A color rating test was conducted with 50 untrained panelists using a 150-mm unstructured line scale with "extremely light" to "extremely dark" color as anchors at both ends, followed by a question on whether they considered the sample as peanut butter to be answered by "definitely yes, this sample is a peanut butter", "maybe it is a peanut butter" or "definitely no, this sample is not a peanut butter" (Appendix B). All consumer tests were conducted under an environmentally controlled condition in individual partitioned booths in a sensory evaluation laboratory at the College of Home Economics, University of the Philippines.

Vitamin A Fortified Peanut Butter – Pilot Scale

Peanut butter was produced in pilot scale at the Food Development Center (Fig. 1.1). Twenty kilograms of peanuts (large seed variety from Vietnam, provided by the industry collaborator) were dry-blanched at 140°C for 25 min using a prototype roaster (manufactured by Kosuge Takkosho, Japan), cooled, de-skinned and sorted for discolored and damaged kernels. Blanched, sound, sorted peanuts were roasted based on the results of consumer acceptability and collaborator's preference. The roasted peanuts were chopped using a meat silent cutter (Model FC-380-3H, Fujimak, Japan). Sugar (white, refined) and chopped roasted peanuts were weighed separately and mixed. The mixture was passed through a colloid mill (TUC/PROBST & CLASS – Rastatt, Baden, West Germany) at #2 setting for the first grinding.

Pre-heat roaster to 140°C

↓

Fill roaster with raw peanuts

↓

Blanch peanut for 25 min maintaining
roaster temperature at 140°C

↓

Remove peanuts from the roaster

↓

Cool with electric fan

↓

Sort out discolored and damaged kernels

↓

Roast peanuts at 140°C for 60 min and then cool

↓

Chop the roasted peanuts using a silent cutter

↓

Weigh the different level of fortificants individually
with a little of the required sugar

↓

Mix the chopped peanuts with the remaining sugar

↓

Pass through a colloid mill at No. 2 setting

↓

Add the sugar-fortificant mixture and mix thoroughly

↓

Pass through a colloid mill at No. 0 setting

↓

Fill in clear 8 oz. glass bottles

↓

Refrigerate

Fig. 1.1 Flow diagram of process for vitamin A fortified unstabilized peanut butter by direct addition (Pilot Scale).

Two fortificants were used in this study: (1) an oily preparation of vitamin A palmitate, 1,000,000 IU (BASF Aktiengesellschaft Marketing Vitamine, Ludwigshafen, Germany) and (2) oily mixture of beta-carotene 30% FS (BASF Aktiengesellschaft Marketing Vitamine, Ludwigshafen, Germany). These were used at different concentrations in pilot scale production to determine the most stable and cost-effective source of vitamin A that will meet Philippine regulations on vitamin A fortification of foods. Normal consumption of peanut butter in the Philippines was two servings per day equivalent to 80 g based on the serving size as indicated on the label of the product of the industry collaborator. The addition of a fat soluble fortificant is commonly combined with the oils added to the peanut butter. Since the formulation did not include any addition of oil, the fortificants were instead premixed with a little of the required sugar and added to the mixture. The resulting mixture was passed through the same colloid mill at #0 setting for the second grinding. The peanut butter produced was filled in 8 oz. glass bottles and stored at refrigerated temperature (~10°C). Peanut butter samples were submitted to the FDC Analytical Laboratory for vitamin A (retinol) and beta-carotene analysis using AOAC Official Method #974.29 (AOAC, 1995).

Vitamin A (retinol) and Beta-carotene Analysis

Sample extraction

Vitamin A was extracted from peanut butter samples with vitamin A palmitate by mixing the sample with 95% ethanol (technical grade) and 70% potassium hydroxide (KOH) solution (analytical grade). The mixture was saponified for 30 min, with 3x mixing during saponification to disperse any aggregates formed. Alcohol-water (3:1) solution was added to dilute the mixture to 250 mL and mixed thoroughly. Twenty mL of sample solution was transferred to a 250 mL separatory funnel containing 8 mL and 20 mL hexane (HPLC grade, Merck Darmstadt, Germany), and partitioned by vigorously shaking the solution for 1 min. Sufficient time was allowed for the layer to separate, and the hexane layer (yellow) was extracted and washed with distilled water. Vitamin A retinol was eluted with 15% acetone (analytical grade) in a chromatographic tube (C18, 200 mm x 12 mm ID) packed with adsorbent (alumina, activity grade 1, No. A-950, Fisher Scientific).

Beta-carotene from peanut butter samples fortified with 30% beta-carotene was extracted using the same procedure for vitamin A extraction with modifications. From the extracted hexane layer, beta-carotene was eluted in the chromatographic tube using 4% acetone in hexane solution (15%) as eluant.

Preparation of Standards

The retinol and beta-carotene standards were obtained from Sigma (St. Louis, Mo., USA) and E. Merck (Darmstadt, Germany, respectively). To prepare the retinol stock solution, one capsule of USP vitamin A (retinol) reference standard (approximately 0.2-0.3 g) was added with 20 mL 70% KOH and 80 mL 95% ethanol and saponified for 30 min. The cooled standard solution was placed in an amber 250 mL solution flask. Ethanol and water (3+1) was added up to the mark. From the stock solution three to four series of standards with different concentrations depending on the concentration of retinol in the sample, were prepared. For the peanut butter samples, the retinol standards used ranged from 0.01 to 0.5 μg/mL.

For beta-carotene stock solution, 0.0026 g of the standard was weighed in a 25 mL volumetric flask, dissolved and diluted to volume with hexane. An intermediate solution was prepared by diluting 5 mL of the stock solution with hexane up to the mark of a 50 mL volumetric flask. Depending on the approximate concentration of the beta-carotene in the sample, 3 to 4 series of standard solutions were

prepared from the intermediate solution. For the determination of beta-carotene in stabilized peanut butter the standards used had concentrations of 0.125, 0.25 and 0.5 μg/mL.

HPLC quantification of vitamin A

Twenty μL of eluate was injected to HPLC (Shimadzu 10AVP, Shimadzu Corp., Columbia, Md., USA). Separation was achieved through a reversed phase column (Purosphere RP 18e, 5 um, 15-4, Merck, Darmstadt, Germany) equipped with a column oven at 28°C and a UV detector set to 326 nm. The analysis was carried out with 92% methanol (HPLC grade, Merck, Darmstadt, Germany) as the mobile phase at a flow rate of 1 mL/min. The concentration of retinol was calculated using the average peak areas compared between standards and samples. Results were reported as μg RE/g.

UV spectrophotometric quantification of beta-carotene

The resulting eluate from peanut butter samples fortified with beta-carotene was monitored in a UV Spectrophotometer (Model Lambda 20, Perkin Elmer, Norwalk, Connecticut, USA) at 436 nm. Absorbance was compared with the standard carotene curve read at the same wavelength and the concentration of beta-carotene was calculated. Results were reported as μg β-carotene/g. All beta-carotene analyses were run in duplicates. β-carotene was converted to vitamin A (retinol) using the equation:

$$\mu g\ RE/g = \mu g/g\ \beta\text{-carotene} \times 0.3\ \mu g\ RE/0.6\ \mu g/g\ \beta\text{-carotene}$$

The target vitamin A fortification levels were (1) just right (1/3 of the 525 μg RE Recommended Daily Allowance or RENI for Filipino male adult, (de Guzman *et al*., 1996), (2) 10% above just right and (3) 20% above just right. The amount of vitamin A retained equivalent to % of RENI and % vitamin A retention were computed as follows:

$$\%\ \text{of RENI for vitamin A} = \frac{\text{amount of vitamin A after processing } (\mu g\ RE)}{525\ \mu g\ RE} \times 100$$

$$\%\ \text{Recovery} = \frac{\text{amount of vitamin A after processing } (\mu g\ RE/g)}{\text{amount of vitamin A added } (\mu g\ RE/g)} \times 100$$

Vitamin A Fortification of Peanut Butter – Commercial Scale

The commercial production of the peanut butter in the collaboator's facility was slightly different from the pilot scale production done in FDC. The roaster was expectedly bigger, with maximum capacity of 120 Kg and is made of concrete materials with no temperature control. The manufacture of peanut butter starts from roasting the peanuts, then reducing the size of peanuts using a coarse grinder, followed by two fine grinding steps, a homogenization step, final mixing for 5 min, and then filling into bottles or jars.

The procedure for vitamin A fortication of peanut butter was then modified in commercial scale using the facilities of the industry collaborator. Since the collabotor's procedure involves many grinding and mixing steps, the best point of addition of the fortificant was determined. Two points of addition of the fortificant were determined and compared. These were: (a) in the mixture of peanuts and sugar before

the first grinding, and (b) in the peanut butter at the start of final mixing before the product is filled into the bottles. Fortification levels used were 1/3, 2/3 and 100% of Philippine RENI for male adult using vitamin A palmitate. Peanut butter samples were taken at the middle of filling and analyzed for vitamin A analysis.

Another trial production was conducted using higher levels of 100, 200 and 300% of the RENI since vitamin A analysis showed very low retention (see Table 1.2). Also, the time of mixing (5, 10 and 15 min) after the fortificant was added to the peanut butter that would give the highest retention was likewise determined since there was a possibility of even distribution of the fortificant. Verification studies were conducted at 175% fortification level in commercial scale.

RESULTS

Preliminary Studies

Results of the consumer acceptability tests conducted on peanut butter samples produced from peanuts roasted at different temperatures for different periods of time during the preliminary experiments indicated that roasting at 140°C for 60 min resulted in a peanut butter that is most acceptable to consumers. This peanut butter sample is the same peanut butter sample preferred by the industry collaborator.

Vitamin A Fortified Peanut Butter – Pilot Scale

Initial studies on the type and level of fortificant to use are shown in Table 1.1. The fortificants are known to be sensitive to heat, light and oxidation. Between vitamin A palmitate and beta-carotene, the former is the more bioavailable form of vitamin A. Though carotenoids are used as sources of vitamin A, the high conversion factor of beta-carotene to retinol and the bioavailability of carotenoids are greatly affected by the vitamin A status of the individual and by dietary composition (FAO, 1996). In terms of cost, vitamin A palmitate costs only $75/Kg (Astrec, 2002) while beta-carotene 30%, costs $238/Kg (Co, 2002).

Pilot scale trials conducted in FDC indicated that recovery of vitamin A in the product were minimal and were not able to meet the target vitamin A level in the fortified product of 175 μg RE for two servings (80 g). A fortification level greater than 20% above just right was needed to provide 1/3 of the daily requirement of the vitamin after processing. Since vitamin A palmitate in the oily preparation was advantageous in terms of cost, bioavailability and stability, the use of vitamin A palmitate at levels higher than 20% above just right was recommended.

Table 1.1 Percent vitamin A recovered[1] and amount of vitamin A (based on % RENI)[1] retained after processing of peanut butter at different fortification levels

Fortificant used	Level of Fortification					
	Just right [2]		Just right [2] + 10%		Just right [2] + 20%	
	% of RENI for Vit. A[3]	% Recovery	% of RENI for Vit. A[3]	% Recovery	% of RENI for Vit. A[3]	% Recovery
Vitamin A palmitate	0.32	27.66	0.97	39.38	1.61	9.37
Beta-carotene, 30%[4]	1.98	89.75	3.01	121.68	4.83	67.94

[1] Means of two replicates
[2] Just right = 1/3 of RENI, male adult (525 μg RE)
[3] Based on the RENI for Filipino male adult = 525 μg RE (de Guzman *et al*., 1996).
[4] Values were converted from μg/g Beta-carotene to μg/g RE using the formula:
μg/g RE = μg/g Beta-carotene x 0.3 μg RE/0.6 μg Beta-carotene/g.

Vitamin A Fortification of Peanut Butter – Commercial Scale

Higher fortification rates (1/3, 2/3 and 100% of RENI) were used during commercial scale trials as a result of very minimal retention rates obtained during pilot scale trials. Results indicated that higher retention rates may be obtained when the fortificant was added to the peanut butter during mixing prior to filling into bottles. More losses were incurred if vitamin A was added to the mixture of peanuts and sugar before grinding than if vitamin A was added during mixing prior to filling since there was greater exposure of the vitamin to heat and oxygen. Percent recovery however was still low (Table 1.2). Likewise, results of vitamin A retention in products added with 100% Philippine RENI for male adults did not meet the target vitamin A requirement of 175 μg RE for every two servings (80 g).

Trial productions using higher concentrations of 100 to 300% of the RENI showed that at fortification levels between 100 and 200% of Philippine RENI for male adults would give the desired level of vitamin A in the product because at 100% addition, the amount of vitamin A in the product was lower than the target while at 200% addition, the amount of vitamin A in the product was higher than the target (Table 1.3).

Table 1.2 Percent vitamin A recovered and amount of vitamin A (based on % RENI[1]) retained after processing of peanut butter fortified with vitamin A palmitate at different levels of fortification using different methods of addition during commercial studies.

Level of Vitamin A added	Point of Addition[2]	% of RENI for Vitamin A retained in product	% Recovery
1/3 of RENI	In peanut butter	6.41	20.00
1/3 of RENI	In sugar and peanuts	5.01	15.70
2/3 of RENI	In peanut butter	12.41	18.10
2/3 of RENI	In sugar and peanuts	9.42	13.73
100% of RENI	In peanut butter	14.95	14.86
100% of RENI	In sugar and peanuts	14.62	13.54

[1] Based on RENI of male adult = 525 µg RE (de Guzman *et al*., 1996).
[2] In the peanut butter at the start of mixing before the product is filled into the bottles; in peanuts and sugar before fine grinding.

Table 1.3 Percent vitamin A recovered and amount of vitamin A (based on % RENI) retained after processing of peanut butter fortified with vitamin A palmitate at different levels of fortification during commercial studies[1]

% Level of Fortification	% of RENI for Vitamin A retained in product	% Recovery
100	14.32	14.00
200	42.06	21.00
300	687.08	229.00

[1] Fortificant was added during final mixing before filling into bottles.

Results also showed that there was a possibility of uneven distribution of fortificant in the product. There was a 229% vitamin A retention in peanut butter that was fortified at 300% level. This result seems to indicate that the very low retention rates may actually be due to problems related largely to the inability of the process to ensure the homogeneous distribution of the fortificant in the product.

The mixing time was thought to have an effect in the homogeneous distribution of the fortificant in the product. Longer mixing times of up to 15 min were employed to determine if better retention rates will be obtained. However, the sampling scheme, which involved getting the samples from the middle part of the production batch, was still followed. It would have been ideal to analyze all the samples. The cost of analysis and the time to do analysis of all products prevented the researchers from doing this.

Commercial scale trials using longer mixing time showed 10-15 min of mixing the peanut butter before filling resulted in higher retention of vitamin A (Table 1.4). However, because the technical personnel of the industry collaborator expressed that longer than 10 min of mixing will significantly affect overall production time, this was not acceptable to them. Therefore, a mixing time of 10 min was adopted.

Table 1.4 Percent vitamin A recovered and amount of vitamin A (based on % RENI) retained after processing of peanut butter fortified with vitamin A palmitate at a level of 1/3 + 50% of RENI using different mixing times during commercial scale studies[1]

Time of mixing (min)	% of RENI for Vitamin A retained in product	% Recovery
5	8.30	42.73
10	9.68	49.78
15	20.88	53.70

[1] Fortificant was added during final mixing before filling into bottles.

Based on the results, it was decided that a fortification level of 175% of Philippine RENI for male adults will be sufficient to produce a vitamin A-fortified unstabilized peanut butter with the required amount of the vitamin. Results of the verification trial (Table 1.5) showed that at this level of fortification, and using a mixing time of 10 min, there was 18% retention and the amount of vitamin A was able to meet the target/requirement of at least 175 µg RE/2 servings (80 g) of the product.

Table 1.5 Percent vitamin A recovered and amount of vitamin A (based on % RENI) retained after processing of peanut butter fortified with vitamin A palmitate at a level of 175% of RENI during verification studies in commercial scale[1]

Level of Fortification, Point of Addition, Time of mixing (min)	% of RENI for Vitamin A retained in product	% Recovery
175% of RENI, added to mixer, 10 min	33.52	18.73

[1] Fortificant was added during final mixing before filling into bottles.

Technology Transfer and Adoption

The technology transfer of the vitamin A fortification of unstabilized peanut butter to the industry collaborator was not immediately conducted. Peanut-CRSP investigators decided to further investigate the low % recovery of the vitamin A in the product. Results of these studies are discussed in Chapter 2 of this monograph.

CONCLUSIONS

The study showed that peanut butter roasted at 140ºC for 60 min approximated the color of the peanut butter being produced by the industry collaborator. The use of vitamin A palmitate as fortificant was found to be the more cost effective ingredient, more bioavailable and a more stable form of fortificant than beta-carotene.

Fortification level, point of addition, and mixing time were all determined to establish the parameters that would meet at least 1/3 of the Philippine RENI for vitamin A. Results showed that a fortification level of 175% of RENI using vitamin A palmitate was required to meet the target %RENI level. It was also established that the fortificant should be added to the peanut butter during mixing prior to filling into bottles. Peanut butter with the fortificant should be mixed for 10 min before filling to achieve higher retention levels.

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APPENDIX A

COLLABORATION AND CONFIDENTIALITY AGREEMENTS WITH INDUSTRY COLLABORATOR

PROPOSAL FOR R&D COLLABORATION
WITH _____

A. Title: Vitamin A enriched Peanut Butter

B. Objective: To help alleviate Vitamin A malnutrition through the availability of Vitamin A enriched peanut butter.

Rationale: Peanut butter is a good medium for Vitamin A fortification. It is fat based and popular with low income families who use it as a spread and for cooking. A process for fortifying peanut butter with Vitamin A that meets regulatory requirements for consistency in nutrient quality is a prerequisite for availability of the product in the market.

C. Expected Output:

1. A process for fortifying peanut butter with Vitamin A.
2. A quality control procedure for ensuring consistency in Vitamin A content in the product.

D. Duration: February to June 1998

E. Activities and Cost Sharing Scheme

1. Product development at the laboratories and pilot plant of FDC.
2. Optimization and transfer of technology at the facilities of _____

Cost Sharing Scheme:

UP-FDC

1. Manpower, equipment, cost of vitamin A analysis and 50% of cost of peanuts during the 1st phase of the study.

Industry Collaborator

1. Cost of 50% of the peanuts during the 1st phase of the study.
2. Cost of the fortificant during the 1st and 2nd phases of the study.
3. Equipment, facilities, cost of peanuts and of vitamin A analysis during the 2nd phase of the study.

F. Terms of Collaboration

1. Industry to have exclusive use of the process for a period of one-year.
2. UP-FDC to provide technical manpower support during the one-year period.
3. Industry to agree to the publication of generic portions of the study e.g. "Shelf life of vitamin A in solid-type peanut butter" after due review of the material.

Proposed by: The Food Development Center

DR. ALICIA O. LUSTRE
Principal Investigator

The University of the Philippines

DR. FLOR CRISANTA F. GALVEZ
Co-Principal Investigator

Conforme: Industry Collaborator

_____

CONFIDENTIALITY AGREEMENT

This Agreement made and entered into this _____ day of _____ 1998, by and between

(Industry Collaborator), a corporation duly organized and existing under the Laws of the Philippines with office address at _____, represented herein by its duly authorized representative, _____ (hereinafter referred to as "_____")

And

Food Development Center, a government agency under the National Food Authority with office address at FTI Complex, Taguig, Metro Manila, represented herein by its duly authorized representative, Dr. Alicia O. Lustre (hereinafter referred to as FDC) and the University of the Philippines, College of Home Economics represented herein by Dr. Flor Crisanta F. Galvez (hereinafter referred to as UPCHE)

WITNESSETH: That

1. _____, as industry collaborator in the Peanut Collaborative Research Support Program (Peanut-CRSP) is the owner of all "confidential information" made available by NFPI to FDC and UPCHE regarding the manufacture and production of _____ brand peanut butter. Confidential information shall mean product specification, formulas, trade secrets and other confidential and proprietary information originally owned by _____ and disclosed to FDC and UPCHE. It does not include information developed during the conduct of the research. Such information produced by this project shall be termed R&D information and shall remain confidential and for the exclusive use of _____ for one year.

2. _____ is willing to disclose confidential information to FDC and UPCHE for certain limited purposed and provided the same is held in strict confidence by the latter.

3. FDC and UPCHE acknowledge and agree that the Confidential information is the property of NFPI and it includes valuable trade secrets of the latter such that any disclosure or unauthorized use thereof will cause irreparable harm and loss to the owner.

4. FDC and UPCHE acknowledges and agrees to keep Confidential information in strict confidence and undertake to do the following obligations:

   A. FDC and UPCHE shall use the confidential information for the sole purpose of the Peanut CRSP project as stated in the proposal signed and conformed to by _____ representative.

      Proposal I: Quality (color and oil dispersion stability) improvement for local unstabilized peanut butter.

      Proposal II: Vitamin A enriched peanut butter

   B. FDC and UPCHE shall not disclose any confidential information directly and indirectly to any third party, or use the same to another's benefit without the prior written consent of _____.

C. FDC and UPCHE shall return all confidential information including all copies and records used for the research study to _____ at the conclusion of the study or such other time as requested by _____.

5. _____ and FDC shall take all reasonable measures to prevent a breach of confidentiality under this Agreement. Both parties hereby agree that all provisions contained herein shall be deemed binding and enforceable between them.

_____ REPRESENTATIVE

_____
General Manager

FDC REPRESENTATIVE

DR. ALICIA O. LUSTRE
Director, FDC

UPCHE REPRESENTATIVE

DR. FLOR CRISANTA F. GALVEZ
Chairman/UPCHE

APPENDIX B

BALLOT FOR ACCEPTABILITY OF COLOR OF PEANUT BUTTER

Name_____

Instructions. Please evaluate the sample and mark the line that best reflects your feeling about the sample.

How would you rate the color of the sample?

Extremely light Extremely dark

Do you consider the sample as peanut butter?

_____Yes_____No_____Maybe

CHAPTER 2

PREMIX TECHNOLOGY FOR THE VITAMIN A FORTIFICATION OF PEANUT BUTTER

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Gertrude M. Agustin[2]
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ABSTRACT

Experiments were conducted by the Food Development Center (FDC) to fortify the peanut butter of an industry collaborator after procedures developed by the University of the Philippines (UP) showed low percentage recoveries of vitamin A and difficulty in tracing the cause of poor recovery. The technology developed was a two-step fortification process consisting of the preparation of a peanut butter premix containing high levels of vitamin A followed by the dilution of the premix with plain peanut butter at a weight ratio adequate to achieve the required level of fortification in the final fortified product. The fortified peanut butter prepared in this study achieved an actual vitamin A content of 8.50 and 8.59 micrograms retinol per gram peanut butter (µg RE/g peanut butter) for an average vitamin A recovery of 84.1% and 85.0%, respectively. This resulted in a fortified peanut butter with a level of vitamin A that is 65% of the Philippine Recommended Dietary Allowance (RENI). Philippine Guidelines on Micronutrient Fortification of Processed Foods specify that the level of vitamin A in fortified foods should supply at least one third (35%) to 150% of the RENI (DOH, 1995).

The study was conducted in three phases as follows: (1) Development of a dye test procedure to visually monitor the extent of dispersion of the fortificant in the premix. The resulting dye test procedure was used to determine the dispersion of the premix in the final fortified product, (2) Laboratory trials at FDC for the establishment of the level of fortificant in the premix and in the final fortified product, and (3) Trials at the industry collaborator's plant for the pilot-scale production of premix and fortified peanut butter.

Results of the dye test showed that when 2.72 g of dyed oil was added to 3 Kg of plain peanut butter or a ratio of ~1:100, the dyed oil was completely dispersed in plain peanut butter after a total mixing time of 10 min in a Hobart vertical mixer Model HCM 300 (Hobart Corporation, Troy, Ohio, U.S.A.). The same observation was noted when 60 g of dyed peanut butter was added to 3 Kg of plain peanut butter or a ratio of 1:50 to simulate dispersion of the premix into the final fortified product.

Laboratory trials conducted at FDC showed that there was good recovery and uniform dispersion of the vitamin A in the premix using a 10 min mixing time in a Hobart vertical mixer Model HCM 300 (Hobart Corporation, Troy, Ohio, U.S.A.). Trials on vitamin A recovery in the premix ranged from 88.3 – 93.1% or an average recovery of 90.3% while variability of replicate samples was 2.78%. For premix addition to plain peanut butter, vitamin A recovery in the final fortified product ranged from 83.8 - 85.5% or an average recovery of 84.4%. Percentage variability in replicate samples of fortified peanut butter was likewise low at <1.16%, indicating uniform dispersion of the premix in the final fortified products. The equipment was covered to ensure absence of light during mixing to give a satisfactory vitamin A recovery in the final fortified product. The above data indicates suitability of a 2-stage addition of vitamin A in a Hobart vertical mixer Model HCM 300 (Hobart Corporation, Troy, Ohio, U.S.A.) for the preparation of both premix and fortified peanut butter.

In trials conducted at the industry collaborator's plant, it was found that the type of mixer used in the preparation of the premix affected vitamin A recovery in the final fortified product. Fortified peanut butter using premix prepared from the industry collaborator's horizontal mixer consistently showed high vitamin A recoveries that ranged from 80.7 – 85.0% while fortified peanut butter using premix prepared from the industry collaborator's Hobart planetary mixer consistently showed low vitamin A recoveries that ranged from 35.3 - 39.1%. This is believed to be due to the possible incorporation of a greater volume of air when premix was prepared using the Hobart planetary mixer of the industry collaborator.

The Hobart planetary mixer had a vertical blade that rotated on its axis while moving around the food matrix in several small circular strokes. In contrast, the horizontal mixer at the industry collaborator's plant had a large horizontal blade that stayed in place while rotating on its axis in large circular strokes. The turbulence created in the mix likely results in less incorporation of air in the horizontal mixer. The above hypothesis was supported by the fact that if the premix prepared in the Hobart mixer was mixed for only 5 min, the vitamin A recovery in the final fortified product increased to 57.0%. This result indicates that incorporation of air in the premix stage is critical as this can be expected to subsequently cause oxidation of the vitamin A during the preparation of the final fortified product.

Based on the above findings, the horizontal mixer of the industry collaborator rather than its Hobart planetary mixer was recommended for the commercial production of premix and fortified peanut butter. A premix to plain peanut butter proportion of 1:25 was found necessary to give allowance for losses incurred during processing and storage, thereby ensuring the production of a final fortified product that meets the Philippines regulatory requirements for fortified food products.

The adoption of the premix technology by the industry collaborator in December 1999 paved the way for the introduction of the first fortified peanut butter in the Philippines. This resulted in the introduction of a peanut butter with improved nutritional quality in the local market.

INTRODUCTION

Vitamin A is an essential nutrient needed for many important functions such as proper vision, growth and immunity. In many developing countries, inadequate consumption of vitamin A by poor children is the leading cause of vitamin A deficiency (VAD). In the Philippines, vitamin A deficiency remains an important public health concern. It causes preventable blindness in children below six years of age and contributes to chronic infections. In some cases, it causes permanent blindness and death among young children (DOH, 1996).

One of the strategies identified in the Philippine Plan of Action for Nutrition to improve the nutritional status of Filipinos is to control, prevent and eliminate micronutrient deficiency through the fortification of staple foods and widely consumed food products. This strategy has led to the creation of the *Sangkap Pinoy Seal* (SPS) Program which encourages food manufacturers to fortify their products with essential micronutrients. Under this program, food manufacturers are allowed to use the Department of Health's Seal of Acceptance in their product labels after having complied with the prescribed criteria (DOH, 1996).

Peanut butter is a widely consumed peanut product in the Philippines making it an excellent vehicle for the addition of essential nutrients like vitamin A. The consistency of peanut butter and the sensitivity of vitamin A to oxygen, light, moisture and heat however, make fortification a difficult process. According to Kuntz (1994), difficulties in fortification can arise not only in getting the correct levels of vitamin A in the finished product but also in assuring that they are there after processing and during storage. In addition to these, there are problems in getting an even dispersion of the added fortificant. The point in the process at which the fortificant is best added and the mixing action provided by the equipment used to disperse it was found to be of critical importance to controlling vitamin A in the product.

Fortification, as defined by the Food and Agriculture Organization/World Health Organization (FAO/WHO) is the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population group (Clarke, 1995). Other terms that are interchangeably used with fortification are enrichment, nutrification and restoration. Enrichment refers to the addition of one or more nutrients to processed foods at levels specified in the international standards while restoration refers to the compensation for nutrient losses during processing. Nutrification, on the other hand, refers to making the dietary mixture of a food more nutritious. All of the above terms describe a process of nutrient addition to foods but the joint FAO/WHO Expert Committee on Nutrition considers the term "fortification" as the most appropriate (Lotfi *et al.*, 1996).

Food fortification continues to be a widely used strategy to combat micronutrient deficiency. Its main objective is to increase the level of consumption of the added nutrients thereby improving the nutritional status of a given population. Food fortification is carried out particularly for foods that are widely consumed by the at-risk population groups that include pregnant and lactating women, infants and children.

Food fortification may be used for various purposes as follows: (1) To correct a demonstrated dietary deficiency of those nutrient(s) added, (2) To restore nutrients initially present in significant amounts in a food but lost as a result of food processing and manufacturing, (3) To increase the

nutritional quality of manufactured food products that are used as the sole source of nourishment, e.g. infant formulas or formulated liquid diets and weaning foods, and (4) To ensure nutritional equivalency of manufactured food products substituting other foods, e.g. fortified margarine as a substitute for butter.

Food Fortification Techniques

Micronutrients may be added to foods in several ways, the simplest of which is using a mixing procedure. As in any mixing process, the goal of fortification aside from achieving the correct levels of fortificant in the fortified product is to obtain a homogenous distribution of at least one component in another component with different physical and/or chemical properties.

Different addition methods have been developed depending on the type of products to be mixed and the type of equipment used. Lotfi *et al.* (1996) mentioned that the mixing procedure for solids is much more complicated than for liquids as the process is influenced primarily by particle size distribution, particle shape and density of the components. Following are the different methods of adding the fortificant depending on the nature of the mixed components:

Solid-solid Mixing

In the solid-solid mixing (dry mixing), the most common method of fortifying dry foods with small quantities of micronutrients is by dry-blending, either in batches or continuously or a combination of both. The effectiveness of the mixing procedure generally depends on ingredient properties such as size, shape, density, hygroscopic and electrostatic properties of the particles and the proportions of the components being mixed. For uniform mixing and maintenance of mix, homogeneity during processing, packaging, and storage and distribution, the ingredient properties of all additives should be as close as possible. The larger the differences, the easier segregation will occur. The commonly used mixers for this type of mixing are the drum mixers, screw mixers, ribbon blenders and continuous mixers.

Solid-liquid Mixing

In solid-liquid mixing where the fortificant is in liquid form, the fortificant is fed to the food vehicle by spraying. The fortificant is added in a solution form as an atomized spray. The procedure of mixing is such that spray nozzles are positioned over a belt conveyor or a screw conveyor or inside a rotating drum. The “Nauta” mixer and the ribbon blender may be used for mixing liquids into solids by mounting spray nozzles.

Liquid-liquid Mixing

In liquid or semi-moist foods, the micronutrient is dissolved or dispersed in a liquid vehicle (water or oil) and subsequently blended or homogenized into the product. Mixing is done in vertical tanks filled with turbine or propeller agitators. The effectiveness of mixing depends on factors such as viscosity, flowing characteristics, mixing ability of components and proportion of the components being mixed.

Vitamin A

Vitamin A is a fat-soluble vitamin that occurs in two principal forms in nature – retinol (preformed vitamin A), which is found only in animal sources and certain carotenoids (provitamins), which are found only in plant sources. Vitamin A in the form of retinol or carotene is commercially

available for addition to foods mainly as food improvers and colorants but foods can also carry them to increase vitamin A intake of the populations consuming these foods. It is commercially prepared in the form of oil solutions, emulsions or dry stabilized preparations that can be incorporated into multivitamin-mineral premix or directly to food. A recent development is vitamin A in encapsulated form. Encapsulated vitamin A offer reduced after taste and off-flavors; are protected from hygroscopic, thermal or oxidative degradation and have enhanced shelf life.

The most important commercial forms of vitamin A are vitamin A acetate and vitamin A palmitate while the most abundant and best known of the carotenoids is beta-carotene. Beta-carotene is a precursor of vitamin A or "provitamin A" because its vitamin A activity occurs only upon its conversion to retinol within the body. The palmitate oil products are predominantly used for fortifying fats and oils such as margarine and vegetable oils while the acetates are preferred in pharmaceutical preparations and supplements. The powdered forms of vitamin A are used in the fortification of dry products and have been used in flour and sugar.

Vitamin A is usually expressed in international units (IU) particularly on food – and supplement labels, but difficulty in calculating the total vitamin A activity in the diet in terms of IU, has led to an international agreement that states vitamin A activity as a new unit called retinol equivalents or RE. By definition, one retinol equivalent is equal to:

1 RE = 1 μg retinol
= 6 μg beta-carotene
= 12 μg other provitamin A carotenoids
= 3.33 IU vitamin A activity from retinol
= 10 IU vitamin A activity from beta-carotene

Stability of Vitamin A

The stability of a micronutrient in a fortified food is highly dependent on several factors such as the selected compound, the processing conditions, the characteristics of the food, transport and storage conditions, and food preparation. Physical and chemical characteristics that affect stability of micronutrients include heat, moisture, exposure to air or light and acid or alkaline environments. Processing operations such as cleaning/rinsing, cooking, aeration, heating, extrusion, drying, etc. may likewise significantly affect the biological functions and stability of the added micronutrient. The exposure of a micronutrient to any of these factors during processing, distribution or storage therefore affects its stability.

Pure vitamin A and carotenoid structures are fairly stable when heated to a modest temperature, in an inert atmosphere and in the dark, but are unstable in the presence of oxygen or air or when exposed to ultraviolet light (Lotfi *et al*., 1996). Loss of activity is accelerated by heat and exposure to light while oxidation can destroy fat-soluble vitamins including vitamin A. Heavy metals and acids, even in trace amounts, can likewise accelerate decomposition of vitamin A (Bagriansky and Ranum, 1998).

Vitamin A is more stable in fats and oils than in other foods. This is because they are protected from air contact thereby delaying oxidation. The stability of vitamin A in oil however depends greatly on the stability of the oil medium. The higher the peroxide value of the oil, the greater is the loss in vitamin A. Using high quality oil and protecting the oil from oxidation and rancidity is therefore basic to preserving vitamin A (Bagriansky and Ranum, 1998). Addition of antioxidants such as Vitamin E,

butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), tocopherol reduces the rate of oxidative rancidity.

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To help improve the nutritional status of the Philippine population, a company engaged in the manufacture of peanut butter was tapped to be one of its collaborators for the project on vitamin A fortification. A Memorandum of Agreement was entered among the parties concerned, a copy of which is shown in Appendix A. Experiments were conducted by the Food Development Center (FDC) to fortify the peanut butter of the industry collaborator after procedures developed by the University of the Philippines (UP) showed low percentage recoveries of vitamin A and difficulty in tracing the cause of poor recovery.

OBJECTIVES

The objective of this study was to improve the nutritional quality of a Philippine commercial brand unstabilized peanut butter by developing a suitable technology for the vitamin A fortification of peanut butter. A fortification process that produced a vitamin A fortified peanut butter that meets the Philippine regulatory requirements for fortified food products without affecting the original product quality was developed and subsequently adopted by the industry collaborator in the production of their unstabilized peanut butter.

METHODS

The fortificant used was vitamin A palmitate in oil, which is a yellow oil at room temperature with a potency of 1.0 M IU/g oil. The fortificant was obtained from BASF Philippines, Inc. (Carmelray Industrial Park I, Canlubang, Laguna, Philippines).

Preparation of premix refers to the addition of vitamin A palmitate in oil to plain peanut butter while preparation of fortified peanut butter refers to the dilution of the premix with plain peanut butter. This is done at a weight ratio that ensures that the final fortified product conforms with the Philippine regulatory requirements for vitamin A fortified foods. Based on the Philippine Guidelines on Micronutrient Fortification of Processed Foods, the level of vitamin A added to foods should supply at least one third (35%) of the RENI of the target consumer (minimum level required) but shall not exceed 150% of the RENI (maximum level required) per prescribed serving(s) likely to be consumed per day (DOH, 1995). In this study, the Philippine RENI for vitamin A of a male adult (525 µg RE) and the industry collaborator's recommended serving size of 2 tbsp (40 g) and one serving per adult per day were used as bases for calculating the target minimum fortification level of 4.38 µg RE/g peanut butter.

The study was carried out in three phases as follows: (1) Preliminary trials to measure dispersion of the fortificant, (2) Laboratory trials at FDC to establish level of fortificant addition and (3) Trials at the Industry Collaborator's Plant for the pilot-scale production of premix and fortified peanut butter.

Preliminary Trials

A dye test procedure was developed to determine the extent of dispersion of the fortificant in the premix and of the premix in the final fortified product. Annatto powder was the dye used to color the oil that was added to plain peanut butter to simulate premix preparation. The same additive was used to color the peanut butter that was added to plain peanut to simulate the final fortification step. Plain peanut butter used in this study was prepared following the procedure of Galvez *et al*. (2000). Raw shelled peanuts were dry-blanched, i.e. roasted at 140°C for 25 min in a peanut roaster (Kosuge Takkosho, Japan), air cooled in a stainless steel table with the aid of a fan, manually de-skinned and sorted for discolored and damaged kernels. The sorted blanched peanuts were subjected to further roasting in the same peanut roaster at 140°C for about 60 min then air cooled in a stainless steel table with the aid of a fan. The roasted peanuts were transferred to a food cutter Model FC 3803H (Fujimak Fujichubo Setsubi Co., Ltd, Japan) and chopped to a size of about 5 mm. Sugar was added to roasted peanuts at a weight ratio of 1:4 and mixed together manually after which the mixture of dry ingredients was passed through a colloid mill (PUC-PROBST and Class, RASTATT Baden, West Germany) two times, first at setting #2 for the coarse grinding then at setting #0 for the fine grinding. The schematic diagram of the procedure for the preparation of plain peanut butter at FDC is shown in Fig. 2.1.

Preparation of Dyed Products

Dyed oil was prepared by adding ¼ teaspoon of annatto powder to 5 g of oil with constant stirring until the color of the oil turned reddish orange. Dyed peanut butter was prepared by adding 1 ½ tablespoons of annatto powder to 60 g of plain peanut butter, while constantly stirring the mixture until the color of the peanut butter turned reddish orange.

Methods of Dye Addition

Two methods of dye addition were tested as follows: (1) Direct addition of dyed oil to plain peanut butter in a manner that simulates the addition of the fortificant to plain peanut butter during premix preparation and (2) Direct addition of dyed peanut butter to plain peanut butter in a manner that simulates the dilution of the premix with plain peanut butter during the preparation of the final fortified product.

In the direct addition of dyed oil to plain peanut butter to simulate premix preparation, 2.7183g of dyed oil was directly added to 3 kg of plain peanut butter then mixed for 5 min using a Hobart vertical mixer Model HCM 300 (Hobart Corporation, Troy, Ohio, U.S.A.). The mixture was visually observed for presence or absence of reddish orange streaks at the top, middle and bottom portions of the peanut butter and at the sides and bottom of the mixer. Adhering peanut butter at the sides of the mixer was scraped off with a plastic spatula then added back to the mixture. The mixture was subjected to further mixing for another 5 min then evaluated for uniform dispersion by visual observation. Fig. 2.2 shows a schematic diagram of the dye test procedure for the addition of dyed oil to plain peanut butter. Results are shown in Table 2.1.

In the direct addition of dyed peanut butter to plain peanut butter to simulate the final fortification step, 60 g of dyed peanut butter was directly added to 3 Kg of plain peanut butter, corresponding to a

premix to plain peanut butter proportion of ~1:50. At this weight ratio, the final product was calculated to have a vitamin A content that meets at least one third of the RENI. The dyed peanut butter-plain peanut butter mixture was then transferred to a Hobart vertical mixer Model HCM 300 (Hobart Corporation, Troy, Ohio, U.S.A.) and mixed for a total of 10 min, stopping every 5 min interval to allow retrieval of adhering peanut butter that splattered at the sides of the mixer. The schematic diagram of the dye test procedure for the dilution of dyed peanut butter with plain peanut butter is shown in Fig. 2.3. The results are shown in Table 2.1.

Shelled Peanuts

↓

Roast peanuts at 140°C for 25 min in a peanut roaster

↓

Unload roasted peanuts from peanut roaster and immediately cool in a stainless steel table with the aid of a fan

↓

Manual de-skinning/sorting for discolored and damaged kernels

↓

Roast sorted peanuts at 140°C for approximately 60 min

↓

Unload roasted peanuts from peanut roaster and cool in a stainless steel table with the aid of a fan

↓

Chop roasted peanuts in a Food Cutter Model FC 3803H to a size of about 5 mm

↓

Add sugar to roasted peanuts then mix manually (For every kilo of peanuts, add 270 g sugar)

↓

Pass the mixture of dry ingredients through a colloid mill 2 times (1st pass - coarse grinding, 2nd pass - fine grinding)

↓

Manually fill the peanut butter in plastic containers

↓

Seal containers and store at refrigerated conditions

Fig. 2.1 Schematic diagram of the procedure for the preparation of plain peanut butter at FDC (Galvez *et al.*, 2000)

Prepare dyed oil by adding ½ teaspoon of annatto powder
to the oil until the color changes to reddish orange

↓

Weigh required amounts of dyed oil and
plain peanut butter in separate containers

↓

Transfer the plain peanut butter to a
Hobart vertical mixer Model HCM 300

↓

Add the dyed oil directly to the center of plain peanut butter

↓

Mix for 5 min

↓

Observe the sides and bottom portions of the mixer for presence
of reddish orange streaks indicative of the dye not yet
fully dispersed with peanut butter mixture

↓

Scrape off sides of mixer for adhering
peanut butter and add back to mixture

↓

Mix the peanut butter mixture for
another 5 min in the same mixer

↓

Observe the peanut butter mixture for disappearance
of reddish orange streaks in the mixture
and at the sides and bottom of the mixer

Fig. 2.2 Schematic diagram of the dye test procedure for the addition of dyed oil to plain peanut butter

Prepare dyed peanut butter by adding 1 ½ tablespoons
of annatto powder to plain peanut butter
until the color changes to reddish orange

↓

Weigh required amounts of dyed peanut butter and
plain peanut butter in separate containers

↓

Transfer the plain peanut butter to a
Hobart vertical mixer Model HCM 300

↓

Add the dyed peanut butter directly
to the center of plain peanut butter

↓

Mix for 5 min

↓

Observe the sides and bottom of the mixer for presence
of reddish orange streaks indicative of the dye not
yet fully dispersed with peanut butter mixture

↓

Scrape off sides of mixer for adhering
peanut butter and add back to mixture

↓

Mix the peanut butter mixture for another
5 min in the same mixer

↓

Observe the peanut butter mixture for disappearance of reddish orange
streaks in the mixture and at the sides and bottom of the mixer

Fig. 2.3 Schematic diagram of the dye test procedure for the addition of dyed peanut butter to plain peanut butter

Laboratory Trials at FDC

Laboratory trials were conducted at FDC to establish the level of vitamin A addition in the premix and in the final fortified product. Fortified peanut butter was prepared using a two-step fortification process that involved the preparation of a premix followed by the preparation of the final fortified product. The procedures for the preparation of premix and preparation of fortified peanut butter are described as follows:

Laboratory Procedure for the Preparation of Peanut Butter Premix at FDC

Prior to use, the fortificant (vitamin A palmitate in oil) was pre-heated at 40°C for 15 min in a water bath as recommended by the supplier (BASF, 1997). The required amounts of fortificant and plain peanut butter were weighed in separate containers after which the pre-weighed fortificant was added to the center of pre-weighed plain peanut butter. The mixture was manually mixed with a plastic spatula

until no trace of the fortificant was visible at the surface of the peanut butter. The mixture was then transferred to a Hobart vertical mixer model HCM 300 (Hobart Corporation, Troy, Ohio, U.S.A.) and mixed for a total of 10 min stopping every 5 min interval to allow retrieval of adhering peanut butter from the sides of the mixer. The resulting premix was manually filled into plastic containers, sealed and stored at refrigerated conditions until its intended use. The schematic diagram of the procedure for the laboratory preparation of peanut butter premix at FDC is shown in Fig. 2.4. Plain peanut butter used in this study was prepared following the procedure of Galvez *et al*. (2000) described in Fig. 2.1.

Pre-heat vitamin A palmitate in a water bath
maintained at 40°C for 15 min

↓

Weigh required amounts of vitamin A palmitate
and plain peanut butter in separate containers

↓

Add pre-weighed vitamin A palmitate to the center
of pre-weighed plain peanut butter

↓

Manually mix the vitamin A palmitate to plain peanut butter
with a plastic spatula until no trace of the fortificant
is visible from the surface of the peanut butter mixture

↓

Transfer the vitamin A palmitate-peanut butter mixture to
a Hobart vertical mixer Model HCM 300

↓

Mix for 5 min

↓

Scrape off adhering peanut butter from the sides
of the mixer and add back to the mixture

↓

Mix for another 5 min

↓

Manually fill the premix in plastic containers

↓

Seal containers and store in refrigerated conditions

Fig. 2.4 Schematic diagram of the procedure for the laboratory scale preparation of premix at FDC.

Laboratory Procedure for the Preparation of Fortified Peanut Butter at FDC

Fortified peanut butter was prepared by adding premix to the center of plain peanut butter in amounts that varied depending on the actual vitamin A content of the peanut butter premix used. The minimum target fortification level of the final fortified product was 4.38 µg RE/g peanut butter. The premix and plain peanut butter were mixed manually with a plastic spatula until no trace of the premix was visible at the surface of the mixture. The premix-plain peanut butter mixture was then transferred to a Hobart vertical mixer Model HCM 300 (Hobart Corporation, Troy, Ohio, U.S.A.) and mixed for a total of 10 min, stopping every 5 min interval to allow retrieval of adhering product from the sides of the

mixer. The final fortified peanut butter was manually filled in plastic containers, sealed and kept at refrigerated conditions. The schematic diagram of the procedure for the preparation of fortified peanut butter at FDC is shown in Fig. 2.5. The plain peanut butter and premix used in this study were prepared following Figures 2.1 and 2.4, respectively.

Weigh required amounts of premix and plain peanut butter in separate containers according to the required premix to plain peanut butter proportion

↓

Add pre-weighed premix to the center of pre-weighed plain peanut butter

↓

Manually mix the premix to plain peanut butter with a plastic spatula for approximately 1 min or until no trace of the premix is visible at the surface of the mixture

↓

Transfer the premix-plain peanut butter mixture to a Hobart vertical mixer Model HCM 300

↓

Mix for 5 min

↓

Scrape off adhering peanut butter from the sides of the mixer

↓

Mix for another 5 min

↓

Manually fill the fortified peanut butter in plastic containers

↓

Seal containers and store at refrigerated conditions

Fig. 2.5 Schematic diagram of procedure for the laboratory scale preparation of fortified peanut butter at FDC.

Experiment 1: Validation of the adequacy of the ten minute mixing time established in the dye test.

Experiments were conducted to validate the adequacy of the 10 min mixing time established in the dye test, for the dispersion of the fortificant in the premix and of the premix in the final fortified product. Adequacy of the mixing time was evaluated based on % recovery of vitamin A in the premix and in the final fortified product and % variability of replicate samples. Percent recovery and % variability were obtained using the following formula:

$$\% \text{ Recovery} = \frac{\text{Vitamin A content in the product after processing}}{\text{Expected level of vitamin A in the product}} \times 100$$

$$\% \text{ Variability} = \frac{\text{Average vitamin A in replicate samples}}{\text{Standard deviation of replicate samples}} \times 100$$

The vitamin A content present in the product after processing was determined using Official Method No. 974.29 of the Official Methods of Analysis (AOAC, 1995) while the expected level of vitamin A in the premix and in the final fortified product was computed using the following formulas:

$$\text{Expected level of Vit. A in the premix} = \frac{\text{Weight of fortificant added (g) x Potency of fortificant}(\mu g/g)}{\text{Weight of plain peanut butter (g) + Wt. of fortificant (g)}}$$

$$\text{Expected level of Vit. A in final fortified product} = \frac{\text{Weight of premix added (g) x Vit. A content of premix}(\mu g/g)}{\text{Weight of plain peanut butter (g) + Weight of premix (g)}}$$

Premix preparation. Premix was prepared in two production batches (Trials 1 and 2) following the procedure described in Fig. 2.4. In Trial 1, premix was prepared by adding 2.72 g of vitamin A palmitate in oil to 3 Kg of plain peanut butter. From the production batch, one sample each was taken at the start, middle and end of filling and analyzed for vitamin A content. Vitamin A recovery and % variability were then computed as bases for evaluating dispersion of the fortificant in the premix.

For the second trial, the same procedure as above was repeated but higher levels of the fortificant (7.42 g) was added to 3 Kg of plain peanut butter after the fortificant was found to have lost its potency following 3 months of storage in a refrigerator held at 5°C. Vitamin A concentration of the fortificant decreased from an initial of 322,163.41 µg RE to 117,735.51µg RE. Dispersion was not measured in this trial to save on cost. Results are shown in Table 2.2.

*Preparation of fortified peanut butter***.** Fortified peanut butter was prepared by adding 60 g of peanut butter premix to 3 Kg of plain peanut butter following the procedure described in Fig. 2.5. The proportion of premix to plain peanut butter used was ~1:50. This was the ratio calculated as necessary to meet 4.38 µg RE/g peanut butter, the minimum requirement for vitamin A in the final fortified product assuming 2 servings/day (40 grams per serving) of peanut butter. From the production batch, one sample each was taken at the start, middle and end of filling and analyzed for vitamin A content. The vitamin A recovery and percentage variability of the three samples were then evaluated. Results are shown in Table 2.3.

Experiment 2: Determination of the effect of light on vitamin A recovery and dispersion in fortified peanut butter.

This experiment was conducted to determine if processing in the absence of light would affect vitamin A recovery. Fortified peanut butter was prepared by adding 60 g of peanut butter premix to 3 Kg of plain peanut butter following the procedure described in Fig. 2.5. In this experiment, aluminum foil was used to wrap the clear polycarbonate cover of the Hobart vertical mixer Model HCM 300 to prevent light exposure of the product during mixing. A premix to plain peanut butter proportion of ~1:50 was used for the fortification process. From the production batch, one sample each taken at the start, middle and end of filling were analyzed for vitamin A content then evaluated for vitamin A recovery and % variability as a means to evaluate uniform dispersion of the fortificant. Results are shown in Table 2.4.

Trials at the Industry Collaborator's Plant

Fortified peanut butter was prepared at the industry collaborator's plant following the same two-step fortification process used in the laboratory trials at FDC with modifications on the mixing procedure and type of equipment used.

In the premix preparation, the modification consisted of the continuous mixing of the fortificant-plain peanut butter mixture for 10 min. The Hobart planetary mixer and the locally fabricated horizontal mixer of the industry collaborator were used for mixing. For the preparation of the final fortified product, the same mixing procedure as above was followed to mix the premix with plain peanut butter mixture. The same horizontal mixer of the industry collaborator was used for mixing. The schematic diagrams of the procedure for the preparation of premix and fortified peanut butter are shown in Figures 2.6 and 2.7, respectively.

Pre-heat vitamin A palmitate in a water bath maintained at 40°C for 15 min

↓

Weigh required amount of vitamin A palmitate and plain peanut butter in separate containers

↓

Add pre-weighed vitamin A palmitate to the center of pre-weighed plain peanut butter

↓

Manually mix vitamin A palmitate to plain peanut butter with a plastic spatula until no trace of the fortificant is visible from the surface of the peanut butter mixture

↓

Transfer the mixture of vitamin A palmitate and plain peanut butter to a mixer

↓

Mix for 10 min

↓

Manually fill the premix in plastic containers

↓

Seal containers and store in a cool dark place

Fig. 2.6 Schematic diagram of the procedure for the commercial production of peanut butter premix at the industry collaborator's plant.

Weigh required amounts of premix and plain peanut butter in separate containers based on the required premix to plain peanut butter proportion

↓

Add pre-weighed premix to the center of pre-weighed plain peanut butter

↓

Manually mix the premix to plain peanut butter with a plastic spatula for approximately 1 min or until no trace of the premix is visible at the surface of plain peanut butter

↓

Transfer the premix-plain peanut butter mixture to a Horizontal Mixer

↓

Mix for 10 min

↓

Manually fill the fortified peanut butter in plastic/glass containers

↓

Seal containers and store in a cool dark place

Fig. 2.7 Schematic diagram of the procedure for the commercial production of fortified peanut butter at the industry collaborators plant

Experiment 3: Evaluation of the suitability of the two different types of mixers of the industry collaborator for the commercial production of premix.

Experiments were conducted to determine the suitability of the horizontal mixer and Hobart planetary mixer, of the industry collaborator, for the preparation of premix. The possibility of using the Hobart planetary mixer was made upon the request of the industry collaborator as they intended to use said equipment solely for the preparation of premix while using the horizontal mixer for all other peanut butter productions. This was to prevent mix-up of the premix with other peanut butter products during production.

*Production of premix using the horizontal mixer of the industry collaborator***.** Premix was prepared in three production batches (Trials 1, 2 and 3) by adding vitamin A palmitate in oil to 40 Kg of plain peanut butter following the procedure described in Fig. 2.6. The horizontal mixer of the industry collaborator was used for mixing. In Trial 1, 38.86 g of vitamin A palmitate was added to 40 Kg of plain peanut butter, from which one sample was taken at the middle of filling. In Trial 2, 38.86 g of vitamin A palmitate was added to 40 Kg of plain peanut butter, from which one sample each was taken at the middle and end of filling. In Trial 3, 39.10 g of vitamin A palmitate was added to 40 Kg of plain peanut butter, from which one sample each was taken at the start, middle and end of filling. All samples taken were analyzed individually for vitamin A content. Suitability of the horizontal mixer for the preparation of premix was evaluated based on % vitamin A recovery and % variability of replicate samples. Results are shown in Table 2.5.

*Production of premix using the Hobart planetary mixer of the industry collaborator***.** Premix was prepared in three production batches (Trials 1, 2 and 3) by adding vitamin A palmitate in oil to plain peanut butter following the procedure described in Fig. 2.6. The Hobart planetary mixer of the industry collaborator was used for mixing. In Trial 1, 19.44 g of vitamin A palmitate was added to 20 Kg plain peanut butter. In Trial 2, 19.55 g of vitamin A palmitate was added to 20 Kg of plain peanut butter. In Trial 3, 19.57 g of vitamin A palmitate was added to 20 Kg of plain peanut butter. From each production

batch, one sample each was taken at the start, middle and end of filling and analyzed for vitamin A content. Suitability of the industry collaborator's Hobart mixer for the preparation of premix was evaluated based on % vitamin A recovery and uniform dispersion of the fortificant in the premix. Results are shown in Table 2.6.

Experiment 4: Determination of the appropriate fill-volume of the industry collaborator's Horizontal Mixer for the commercial production of fortified peanut butter.

This experiment was conducted to establish the fill-volume of the Horizontal mixer of the industry collaborator that would give good recovery and dispersion of the premix in fortified peanut butter. In order to reduce cost, performance of the mixer was initially tested using premix prepared at FDC. Three production volumes were tested, 10, 80 and 100 Kg.

In the 10 Kg batch, fortified peanut butter was prepared in two production batches (Trials 1 and 2) by mixing premix to plain peanut butter following the procedure described in Fig. 2.7. Two proportions of premix to plain peanut butter were used, 1:22 for the first trial and 1:18 for the second trial. From each production batch, one sample each was taken at the middle and end of filling to evaluate uniform dispersion of the premix in the final fortified product. Results are shown in Table 2.7.

In the 80 Kg batch, fortified peanut butter was prepared by mixing premix to plain peanut butter following the procedure described in Fig. 2.7. A 1:12 and 1:50 proportion of premix to plain peanut butter proportions were used for the first and second trials, respectively. This production volume was tested as this was the level where the peanut butter was just enough to cover the blades of the mixer. For each production batch, only one sample was analyzed for vitamin A content. Results are shown in Table 2.7.

In the 100 Kg batch, fortified peanut butter was prepared using a 1:50 premix to plain peanut butter proportion following the procedure described in Fig. 2.7. This production volume was tested upon the request of the industry collaborator as this was the usual volume used in their production. Result is shown in Table 2.7.

Experiment 5: Determination of the effect on vitamin A recovery and dispersion of using premix prepared from two different types of mixers.

Experiments were conducted to determine the effect of using premix prepared from two different types of mixers, on vitamin A recovery and dispersion of the premix in the final fortified product.

*Production of fortified peanut butter using premix prepared from the horizontal mixer of the industry collaborator***.** Fortified peanut butter was prepared in three production batches (Trials 1, 2 and 3) following the procedure described in Fig. 2.7. For trial 1, a 1:100 proportion of premix to plain peanut butter was used, from which one sample each was taken at the middle and end of filling. In trials 2 and 3, a 1:25 proportion of premix to plain peanut butter was used. From each production batch, one sample each was taken at the start, middle and end of filling. Premix used in this experiment was prepared from the horizontal mixer of the industry collaborator. Results are shown in Table 2.8.

Production of fortified peanut butter using premix prepared from the Hobart Planetary mixer of the industry collaborator. Fortified peanut butter was prepared in four production batches (Trials 1, 2, 3 and 4) following the procedure described in Fig. 2.7. In Trial 1, a 1:50 proportion of premix to plain peanut butter was used, while for trials 2, 3, and 4, a 1:25 proportion of premix to plain peanut butter was

used. From each production batch, one sample each was taken at the start, middle and end of filling. Premix used in this experiment was prepared using the Hobart planetary mixer of the industry collaborator. Results are shown in Table 2.9.

Technology Transfer and Adoption

To transfer the vitamin A fortification technology using a premix, a demonstration of the recommended process for vitamin A fortification of peanut butter was done during the standardization of the process at the collaborator's plant. The R&D Head, Production Head and two (2) production workers of the industry collaborator were trained on the proper method of adding and mixing the fortificant to peanut butter. A procedural guideline of the recommended process was likewise provided to the collaborator, a copy of which is shown in Appendix A.

RESULTS

Preliminary Trials

Results of the dye test shown in Table 2.1 indicate that the dyed oil dispersed into the plain peanut butter after 5 min of mixing. Visual examination however, showed some of the dyed oil splattered at the sides of the mixer while some was noted at the bottom portion of the mixer. Scraping off of adhering product from the mixer and mixing of the peanut butter for another 5 min resulted in the full dispersion of the dyed oil into the plain peanut butter as indicated by the absence of reddish orange streaks in any part of the peanut butter mixture. The same observations were noted for the addition of dyed peanut butter to plain peanut butter. Considering the good dispersion of the dyed oil and of the dyed peanut butter in the plain peanut butter matrix, it was recommended that a total mixing time of 10 min be adapted for the mixing of the fortificant with plain peanut butter during the preparation of premix and of the premix during the preparation of the final fortified product. Manual mixing of the fortificant and premix with plain peanut butter was likewise recommended prior to mechanical mixing to facilitate their dispersion in the peanut butter matrix.

Laboratory Trials at FDC

Experiment 1: Validation of the adequacy of the 10 min mixing time established in the dye test

Premix preparation. Results presented in Table 2.2 showed that peanut butter premix prepared in Trial 1 had an average vitamin A content of 263.70 µg RE/g peanut butter or a vitamin A recovery of 90.3%, indicating that approximately 10% of the vitamin A palmitate added was lost during processing. In terms of dispersion, it was found that the vitamin A added was uniformly distributed in the peanut butter premix as indicated by the low percentage variability of 2.78%. Premix prepared in Trial 2 likewise showed an acceptable vitamin A content of 273.61 µg RE/g peanut butter or a vitamin A recovery of 93.7%.

Table 2.1 Effect of mixing time on the dispersion of dyed oil and of dyed peanut butter in a peanut butter matrix after 5 and 10 min of mixing using a Hobart vertical mixer Model HCM 3

Expt.	Activity	Observations	
		After 5 min mixing	After additional 5 min mixing
1	Direct addition of dyed oil to plain peanut butter	Presence of reddish orange streaks at the sides and bottom of mixer and occasional reddish streaks in the mixture; Bubble formations observed in the peanut butter mixture	Absence of reddish orange streaks at the sides and bottom of the mixer and on the mixture; Bubble formations observed in the peanut butter mixture
2	Direct addition of dyed peanut butter to plain peanut butter	Presence of reddish orange streaks at the sides and bottom of mixer and occasional reddish streaks in the mixture; Bubble formations observed in the peanut butter mixture	Absence of reddish orange streaks at the sides and bottom of the mixer and on the mixture; Bubble formation observed in the peanut butter mixture

Table 2.2 Effect of 10 min mixing time on vitamin A recovery during laboratory preparation of premix at FDC

Sampling Point (during filling)	Vitamin A Recovered			
	Trial 1		Trial 2	
	Vit. A Content (µg RE/g)	% Recovery[1]	Vit. A Content (µg RE/g)	% Recovery[2]
Start	271.97	93.10	---	N/A
Middle	261.16	89.40	273.61	93.70
End	257.96	88.30	---	N/A
Average	263.70	90.30	273.61	93.70
Std. Deviation	7.34	2.515	N/A	N/A
% Variability	2.78	2.78	N/A	N/A

[1] Expected level of vitamin A in the premix is 292 µg RE/g peanut butter. This was computed based on a fortificant with a vitamin A assay of 322,163.41 µg RE.
[2] Expected level of vitamin A in the premix is 292 µg RE/g peanut butter. This was computed based on fortificant with a vitamin A assay of 117,735.51 µg RE.
--- = No sample analyzed.

*Preparation of fortified peanut butter***.** Results shown in Table 2.3 indicate that the fortified peanut butter had a vitamin A content that ranged from 3.73 - 3.92 µg RE/g peanut butter or an average of 3.85 µg RE/g peanut butter. The level of vitamin A in the final fortified product did not meet the minimum target fortification level of 4.38 µg RE/g peanut butter as the % recovery was relatively low. At this level, the vitamin A recovery ranged from 69.2 - 72.7% or an average of 71.4%. The relatively low vitamin A recovery was attributed to factors such as presence of light during production and oxidation of vitamin A when premix was subjected to further mixing during the preparation of fortified peanut butter.

Table 2.3 Effect of 10 min mixing time on vitamin A recovery during laboratory preparation of fortified peanut butter

Sampling Point (during filling)	Vitamin A Recovered	
	Vitamin A Content (µg RE/g)	% Recovery[1]
Start	3.73	69.2
Middle	3.89	72.2
End	3.92	72.7
Average	3.85	71.4
Std. Deviation	0.10	1.89
% Variability	2.65	2.65

[1] Expected level of vitamin A in the final fortified product was 5.39 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 263.70 µg RE/g peanut butter.

In terms of dispersion, it was found that the percentage variability of the three replicate samples was 2.65%. The low percentage variability indicates uniform dispersion of the premix in the final fortified product.

Considering the high vitamin A recoveries obtained in both production batches and the low percentage variability of replicate samples in the 1st trial, it was concluded that the 10 min mixing time was adequate to fully disperse the vitamin A palmitate in the premix.

Experiment 2: Determination of the effect of light on vitamin A recovery in fortified peanut butter.

Results presented in Table 2.4 showed that fortified peanut butter processed in the absence of light had a higher percentage vitamin A recovery (84.4%) than that processed in the absence of light (71.4%). As only one trial was conducted, it could not be ascertained whether the increase in vitamin A recovery was due to the absence of light or to some other factors.

In terms of vitamin A content, the final fortified product showed a vitamin A content that ranged from 3.01 – 3.07 µg RE/g peanut butter or an average recovery of 3.03 µg RE/g peanut butter. Since the value obtained did not meet the minimum target fortification level, it was recommended to add an overage to give allowance for losses incurred during processing.

Table 2.4 Effect of absence of light on vitamin A recovery during laboratory preparation of fortified peanut butter

Sampling Point (during filling)	Vitamin A Recovered	
	Vitamin A Content (µg RE/g)	% Recovery[1]
Start	3.01	83.8
Middle	3.07	85.5
End	3.01	83.8
Average	3.03	84.4
Std. Deviation	0.03	0.98
% Variability	1.14	1.16

[1] Expected level of vitamin A in the final fortified product was 3.59 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 175.46 µg RE/g peanut butter.

Trials at the Industry Collaborator's Plant

Experiment 3: Determination of the suitability of the two different types of mixers of the industry collaborator, for the commercial preparation of premix

Results of vitamin A analysis (Table 2.5) in premix prepared using the industry collaborator's horizontal mixer indicated high vitamin A recoveries that ranged from an average of 86.2% to 96.9%. In terms of dispersion, replicate samples taken from the second and third trials showed that there was uniform dispersion of the vitamin A in the premix as indicated by the low percentage variabilities (5.58% and 2.72%).

Likewise, premix prepared using the industry collaborator's Hobart Planetary mixer indicated high vitamin A recoveries in the peanut butter premix ranging from an average of 89.5% to 102.6% (Table 2.6). Percentage variabilities were relatively low (2.58, 4.92% and 9.46%), indicating that the vitamin A palmitate added was uniformly distributed in the premix. Based on the above findings, both the Horizontal mixer and Hobart Planetary mixer of the industry collaborator were found suitable for the preparation of premix.

Table 2.5 Effect on vitamin A recovery of using the horizontal mixer of the industry collaborator in the preparation of premix

Sampling Point (during filling)	Vitamin A Recovered					
	Trial 1[1]		Trial 2[1]		Trial 3[2]	
	µg RE/g	% Recovery	µg RE/g	% Recovery	µg RE/g	% Recovery
Start	---	N/A	---	N/A	247.19	84.3
Middle	282.42	96.90	255.71	87.70	260.44	88.8
End	---	N/A	276.63	94.90	250.40	85.4
Average	282.42	96.90	266.17	91.30	252.68	86.2
Std. Deviation	N/A	N/A	14.79	5.09	6.91	2.34
% Variability	N/A	N/A	5.56	5.58	2.74	2.72

[1] Expected level of vitamin A in the premix was 291.45 µg RE/g peanut butter. This was computed based on a fortificant with a vitamin A assay of 300,000 µg RE.
[2] Expected level of vitamin A in the premix was 293.25 µg RE/g peanut butter. This was computed based on a fortificant with a vitamin A assay of 300,000 µg RE
--- = No sample analyzed.

Table 2.6 Effect on vitamin A recovery of using the Hobart planetary mixer of the industry collaborator in the preparation of premix

Sampling Point (during filling)	Vitamin A Recovered					
	Trial 1[1]		Trial 2[2]		Trial 3[3]	
	µg RE/ g	% Recovery	µg RE/g	% Recovery	µg RE/g	% Recovery
Start	251.58	86.28	294.32	100.36	262.85	89.54
Middle	242.28	83.09	309.36	105.49	264.03	89.94
End	288.94	99.09	298.63	101.83	286.54	97.61
Average	260.93	89.49	300.77	102.56	271.14	92.36
Std. Deviation	24.70	8.47	7.74	2.64	13.35	4.55
% Variability	9.46	9.46	2.58	2.58	4.92	4.92

[1] Expected level of vitamin A in the premix was 291.60 µg RE/g peanut butter. This was computed based on a fortificant with a vitamin A assay of 300,000 µg RE.
[2] Expected level of vitamin A in the premix was 293.25 µg RE/g peanut butter. This was computed based on a fortificant with a vitamin A assay of 300,000 µg RE.
[3] Expected level of vitamin A in the premix was 293.55 µg RE/g peanut butter. This was computed based on a fortificant with a vitamin A assay of 300,000 µg RE.

Experiment 4: Determination of the appropriate fill-volume of the horizontal mixer of the industry collaborator.

Table 2.7 shows the effect of fill-volume on vitamin A recovery in fortified peanut butter prepared using the Horizontal Mixer of the industry collaborator. Results showed that fortified peanut butter in the 10 Kg production batch had unacceptably low vitamin A recoveries that ranged from an average of 29.1% to 37.6%. The premix however was found to be uniformly distributed in the final fortified product as indicated by the low percentage variabilities in replicate samples (0.49 and 0.75%). The low vitamin A recoveries were attributed to the low volume of the product causing the possible incorporation of air in the fortified product during mixing as the blade of the mixer reached only half of the product.

Table 2.7 Effect of fill-volume on vitamin A recovery when fortified peanut butter is prepared using the horizontal mixer of the industry collaborator

Sampling Point (during filling)	Vitamin A Recovered									
	10 Kg				80 Kg				100 Kg	
	Trial 1[1] (1:22)		Trial 2[2] (1:18)		Trial 1[3] (1:12)		Trial 2[4] (1:50)		Trial 1[5] (1:50)	
	µg RE/g	% R[6]	µg RE/g	% R	µg RE/g	% R	µg RE/g	% R	µg RE/g	% R
Middle	1.69	29.0	2.72	37.40	22.81	95.80	4.37	79.9	4.17	73.8
End	1.70	29.2	2.75	37.80	---	N/A	---	N/A	---	N/A
Average	1.70	29.1	2.74	37.60	22.81	95.80	4.37	79.9	4.17	73.8
Std. Deviation	0.01	0.14	0.02	0.28	N/A	N/A	N/A	N/A	N/A	N/A
% Variability	0.42	0.49	0.77	0.75	N/A	N/A	N/A	N/A	N/A	N/A

[1] Expected level of vitamin A in the final fortified product was 5.82 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 128.02 µg RE/g peanut butter. Premix was prepared using FDC's Hobart mixer.

[2] Expected level of vitamin A in the final fortified product was 7.28 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 128.02 µg RE/g peanut butter. Premix was prepared using FDC's Hobart mixer.

[3] Expected level of vitamin A in the final fortified product was 23.82 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 285.71 µg RE/g peanut butter. Premix was prepared using FDC's Hobart mixer.

[4] Expected level of vitamin A in the final fortified product was 5.47 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 273.61 µg RE/g peanut butter. Premix was prepared using FDC's Hobart mixer.

[5] Expected level of vitamin A in the final fortified product was 5.65 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 282.32 µg RE/g peanut butter.

[6] % Recovery

--- = No sample analyzed.

On the other hand, fortified peanut butter in the 80 Kg production batch showed acceptable vitamin A recoveries of 95.8 and 79.9% for the 1st and 2nd production batches, respectively. For the 100 Kg production batch, the fortified peanut butter had a slightly lower vitamin A recovery of 73.8% as compared to the 79.9 – 95.8% recovery obtained in the 80 Kg production batch but the recovery was still considered acceptable.

Considering the relatively high vitamin A recovery and uniform dispersion of the premix in the final product in the 80 Kg production batch, this was recommended as the appropriate fill-volume of the horizontal mixer of the industry collaborator, for the commercial production of fortified peanut butter.

Experiment 5: Determination of the effect on vitamin A recovery using premix prepared from two different types of mixers for the commercial production of fortified peanut butter

Tables 2.8 and 2.9 show the effect of using premix prepared from the horizontal mixer and Hobart planetary mixer of the industry collaborator on vitamin A recovery in the final fortified product. Fortified peanut butter prepared using premix from the horizontal mixer showed acceptable vitamin A recoveries ranging from an average of 80.7% to 85.0% with low percentage variability that ranged from 1.83 – 9.95%. Above data indicates uniform dispersion of the premix in the final fortified product. Above data confirms suitability of the horizontal mixer of the industry collaborator for the preparation of fortified peanut butter.

On the other hand, vitamin A recovery in the final fortified product using premix prepared from the Hobart planetary mixer showed low vitamin A recoveries (39.1, 35.3 and 35.6%). This was the case even if vitamin A recovery in the premix using the Hobart planetary mixer was good (Table 2.6). The low vitamin A recoveries in the final fortified product using premix prepared from the Hobart planetary mixer of the collaborator was attributed to the possible incorporation of too much air in the premix causing the vitamin A to oxidize when subjected to further mixing during the final fortification step. A comparison of the mixing action of the industry collaborator's horizontal mixer and Hobart planetary mixer showed that the two equipment exhibited a different manner of mixing the product. In the Hobart planetary mixer, mixing of the product was accomplished by an agitator that was mounted on top of the mixing vessel in a vertical off center position. This was observed to move in a planetary motion, i.e. as the agitator rotates on its axis in circular strokes, it repeatedly moves around the mixing vessel at a fast speed. This type of mixing creates a vortex owing to the centrifugal force acting on the product. As there is a limit to the rotational speed of an equipment, there is a tendency for a severe entrapment of air to occur once the vortex reaches the agitator (Perry and Chilton, 1973). With the horizontal mixer, the agitator was mounted horizontally near the bottom of the mixing vessel. Mixing was accomplished as the stationary blade rotated on its axis providing large circular strokes at a relatively low to medium rate. The circulatory strokes cause the product to flow in the direction of motion of the agitator causing the relative velocity between the blades and the product to be reduced.

Reducing the mixing time of premix production to five minutes with the Hobart planetary mixer of the industry collaborator increased vitamin A recovery to 57% (from a low of 35.3%, see Trial Batch 2). This data supports the above hypothesis that the low vitamin A recovery in fortified peanut butter using premix prepared from the industry collaborators' Hobart planetary mixer, was due to the incorporation of too much air in the premix. It will be noted that low vitamin A recoveries in premix preparation was not experienced in the use of the Hobart vertical mixer Model HCM 300 as the said mixer, unlike that of the industry collaborator did not rotate in a planetary motion. Based on the above findings, it was found that the type of mixer used for premix preparation affected vitamin A recovery in the final fortified product.

Table 2.8 Effect on vitamin A recovery using premix prepared from the horizontal mixer of the industry collaborator in commercially-prepared fortified peanut butter

Sampling Point (during filling)	Vitamin A Recovered					
	Trial 1[1] (1:100)		Trial 2[2] (1:25)		Trial 3[3] (1:25)	
	µg RE/g	% Recovery	µg RE/g	% Recovery	µg RE/g	% Recovery
Start	---	N/A	8.75	86.60	8.64	85.40
Middle	1.96	73.70	8.66	85.70	8.54	84.50
End	2.33	87.60	8.37	82.80	8.33	82.40
Average	2.14	80.70	8.59	85.00	8.50	84.10
Std. Deviation	0.21	8.02	0.20	1.98	0.16	1.54
% Variability	9.95	9.95	2.31	2.34	1.86	1.83

[1] Expected level of vitamin A in the final fortified product was 2.66 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 266.17 µg RE/g peanut butter.
[2] Expected level of vitamin A in the final fortified product was 10.11 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 252.68 µg RE/g premix.
[3] Expected level of vitamin A in the final fortified product was 10.11 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 252.68 µg RE/g peanut butter.
--- = No sample analyzed.

Further evaluation of the level of vitamin A in fortified peanut butter prepared from premix using the horizontal mixer of the industry collaborator indicated that using a 1:25 proportion of premix to plain peanut butter resulted in a final fortified product with a vitamin A content that ranged from 8.5 to 8.59 µg RE/g peanut butter. Using the collaborators recommended serving size of 40 g, it was noted that one serving of vitamin A fortified peanut butter per day would ensure the target consumer a daily vitamin A supply of 340-344 µg RE. This fortification level meets the regulatory requirements for fortified foods as it represents 65% of the RENI.

Considering the above findings, a 1:25 proportion of premix to plain peanut butter was recommended for use in the commercial preparation of fortified peanut butter to give allowance for losses incurred during processing and storage.

Table 2.9 Effect on vitamin A recovery using premix prepared from the Hobart mixer of the industry collaborator in commercially-prepared fortified peanut butter

Sampling Point (during filling)	Vitamin A Recovered							
	Trial 1[1] (1:50)		Trial 2[2] (1:25)		Trial [2] (1:25)		Trial 4[3] (1:25)	
	µg RE/g	% Recovery	µg RE/g	% Recovery	µg RE/g	% Recovery	µg RE/g	% Recovery
Start	---	N/A	4.02	33.40	4.60	38.2	6.09	56.2
Middle	1.79	34.3	4.30	35.70	4.18	34.7	6.59	60.8
End	2.29	43.9	4.41	36.70	4.09	34.0	5.85	54.0
Average	2.04	39.1	4.24	35.30	4.29	35.6	6.18	57.0
Std. Deviation	0.35	6.79	0.20	1.69	0.27	2.25	0.38	3.47
% Variability	17.30	17.40	4.74	4.80	6.34	6.31	6.11	6.09

[1] Expected level of vitamin A in the final fortified product was 5.22 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 261 µg RE/g peanut butter. Premix was prepared using 10 minutes mixing time.

[2] Expected level of vitamin A in the final fortified product was 12.03 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 300.77 µg RE/g peanut butter. Premix was prepared using 10 minutes mixing time.

[3] Expected level of vitamin A in the final fortified product was 10.83 µg RE/g peanut butter. This was computed based on a premix with a vitamin A content of 270.81 µg RE/g peanut butter. Premix was prepared using 5 minutes mixing time.

--- = No sample analyzed

Technology Transfer and Adoption

A signing ceremony was held last June 1999 to mark the formal turnover of the premix technology to the collaborator. In December 1999, 100% of the peanut butter of the collaborator was fortified and distribution of fortified peanut butter in the local market bearing the vitamin A sticker was started. Production of the fortified product however was discontinued sometime in 2005 because the company experienced labor problems which resulted in the resignation of personnel including the persons trained in the preparation of the fortificant and its addition to peanut butter. Other reasons cited by the collaborator for the removal of the fortified product in the market were the following: (a) lack of manpower to oversee the additional step of incorporating the fortificant, (b) the additional step for incorporating the fortificant delayed production because of the need to prepare the premix at the start of the day's production to be used in the fortification of the final fortified product. There was also a need to cool the peanut butter coming from the homogenizer overnight prior to addition of the fortificant to prevent the loss of vitamin A due to heat generated during the grinding and homogenization steps, (c) the lack of government assistance in the promotion of the fortified product and (d) unconfirmed feedback received from a customer that the fortified product developed faster than plain peanut butter.

Constraints in the Adoption of the Technology

1) Apprehensions of management that the addition of the fortificant may affect the company's claim that their product is all-natural. Since the fortificant is synthetic, the all-natural claim may no longer be applicable if vitamin A is added.

2) Delayed approval of product registration. Processing of product registration for fortified peanut butter took four months before approval of product registration from BFAD was obtained.

3) Lack of technical manpower. A food technologist had to be hired and trained on the proper method of weighing, addition and mixing of the fortificant since the existing manpower complement of the company did not have technical background,.

4) Delay in the improvement of plant facilities to enable the company to improve its plant rating.

For future projects, it is recommended that sufficient time of at least 6 months should be given to industry collaborators from the time the technology was transferred to enable the company to upgrade and/or improve its existing facilities, hire additional personnel and documents needed for distribution of the new product.

CONCLUSIONS

The conduct of a dye test proved useful in showing the extent of dispersion of the dyed oil in plain peanut butter and of dyed peanut butter in plain peanut butter. It likewise gave an indication of how much mixing time was needed to allow full dispersion of the dyed oil in peanut butter and of dyed peanut butter in plain peanut butter.

The type of mixer used for premix preparation was found to affect vitamin A recoveries in the final product. Different types of mixers have a different way of agitating or mixing the product. It is thus important that the type of mixer used especially in the premix preparation should not incorporate too much air in the product as this could affect vitamin A recovery.

The two-step fortification process was found to be a suitable technology for the vitamin A fortification of peanut butter. The type of mixer used in the preparation of peanut butter premix and of fortified peanut butter should however be evaluated prior to use as this could affect vitamin A recovery, likely due to its effect on incorporation of air.

The two-step fortification process developed by FDC for the industry collaborator was adopted six months after the transfer of technology. Delayed approval of product registration for fortified peanut butter, hiring of technical personnel to oversee preparation of the fortificant and its addition during commercial production as well as the need to improve existing plant facilities were cited as the main reasons for the delayed adoption of the premix technology.

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APPENDIX A

PROCEDURAL GUIDELINE FOR THE VITAMIN A FORTIFICATION OF PEANUT BUTTER USING COLLABORATOR'S HORIZONTAL MIXER

Procedural Guideline for the Vitamin A Fortification of Peanut Butter using Collaborator's Horizontal Mixer

A. PREPARATION OF FORTIFICANT

Per recommendation of the supplier (BASF Philippines, Inc. Emerald Building, Emerald Avenue, Pasig City), pre-heat the vitamin A palmitate prior to use to 40ºC in its container using a water bath for 15 minutes.

B. PREPARATION OF PEANUT BUTTER PREMIX USING COLLABORATOR'S HORIZONTAL MIXER

1. Prepare plain peanut butter using the procedure of the industry collaborator, as shown in Fig. 2.8. After the homogenization step, ensure that the prepared peanut butter is cooled to a temperature of 65ºC or lower prior to use.

2. Weigh 40 kg of the plain peanut butter prepared in Step B.1 in a stainless steel container using a platform balance.

3. Weigh the require amount of fortificant with the aid of a medicine dropper in a beaker using a balance. For every 40 kg of plain peanut butter, 40 g of vitamin A palmitate (Assay: 1.0 – 1.1 Million IU) will be needed.

4. Pour the pre-weighed fortificant (40g) contained in a beaker directly at the center of the 40 Kg pre-weighed peanut butter contained in a stainless steel container. Store the remaining fortificant at refrigerated conditions in an aluminum container with cover.

5. Ensure that all of the fortificant in the beaker is transferred by adding a little amount of the pre-weighed peanut butter into the beaker in areas where adhering fortificant id present. Scrape off the peanut butter from the beaker making sure that no fortificant is left adhering on the container. Add the scrapings back to the container of the pre-weighed peanut butter.

6. Manually mix the fortificant with plain peanut butter contained in the stainless steel container from Step B.4. Mix using circular strokes with the aid of a spatula until no sign of the fortificant is visible at the surface of the peanut butter mixture. Mix for approximately one minute.

7. Pour the fortificant-plain peanut butter mixture in the stainless steel container into the horizontal mixer. Make sure that all adhering peanut butter in the stainless steel container is totally scraped off with the aid of a spatula and added into the horizontal mixer.

8. Switch on the horizontal mixer to start mixing the fortificant-peanut butter mixture. Mix for ten minutes.

(Note: Recommended mixing time of ten minutes should be strictly followed. Excessive mixing of the premix causes the incorporation of too much aire in the premix that could lead to degradation of the added fortificant.)

9. After the recommended mixing time is reached, switch off the horizontal mixer and collect the premix in a stainless steel container. Place the cover of the stainless steel container to prevent the premix form being exposed to light.

10. Get 20 pcs of 2.5 Kg capacity clean plastic containers. Measure the weight of one plastic container and adjust the weighing balance to zero to recore the tare weight of the plastic container.

11. Transfer the collected premix into the clean plastic containers and put the plastic containers with premix on top of the weighing balance one by one. Each conainer should have 2 Kg of premix.

12. Cover all containers with the plastic lids and pack the plastic containers with premix in corrugated cartons.

13. Set aside the premix in a clean cool area until used in the preparation of fortified peanut butter.

The schematic diagram of the process flow for the preparation of peanut butter premix is shown in Fig. 2.9.

C. PREPARATION OF FORTIFIED PEANUT BUTTER

1. Prepare peanut butter using the procedure of the industry collaborator as shown in Appendix A. After the homogenization step, cool the peanut butter to a temperature of 65°C or lower prior to use.

2. Weigh 50 Kg of plain peanut butter prepared from Step C.1 into a stainless steel container using a platform balance.

3. Add the 2 Kg pre-weighed premix from Step B.11 at the center of the 50 Kg pre-weighed plain peanut butter in the stainless steel container from Step C.2. Scrape off all adhering premix from the plastic container and add into the stainless steel container containing pre-weighed plain peanut butter.

4. Manually mix the premix with plain peanut butter in the 50 kg capacity stainless steel container using circular strokes with the aid of a spatula until the premix is no longer visible at the surface of the premix-peanut butter mixture. Mix for approximately one minute.

5. Repeat Steps C.2 to C.4 using another 50 Kg batch of plain peanut butter.

6. Pour the premix-plain peanut butter mixtures from the two (2) stainless steel containers into a horizontal mixer one after the other. Make sure that all adhering premix-plain peanut butter mixture from the two (2) stainless steel containers are totally scraped off and added into the horizontal mixer.

7. Switch on the mixer to start mixing of the premix-peanut butter mixture and mix for ten minutes.

(Note: Recommended mixing time of ten minutes should be strictly followed as excessive mixing of the product may cause incorporation of too much air in the premix which could result in the fast degradation of the added fortificant)

8. Collect the fortified peanut butter in two (2) stainless steel containers then transfer contents into a filling machine.

9. Fill desired container sizes with fortified peanut butter according to the required fill-in-weight of the container. Cover the containers with their lids and place tamper proof seals.

10. Pack containers with fortified peanut butter in corrugated cartons.

11. Store in a clean cool area.

The above procedure for the preparation of fortified peanut butter calls for a weight ratio of 1 part premix to 25 parts plain peanut butter to achieve the regulatory requirements for a vitamin A fortified peanut butter. The schematic diagram of the procedure for the preparation of vitamin A fortified peanut butter is shown in Fig. 2.10.

Shelled peanuts
↓
Roast peanuts
↓
Weigh ingredients
(peanuts, sugar and salt)
↓
Mix roasted peanuts, sugar and salt
↓
Pass through Mill #1
↓
Pass through Mill #2
↓
Pass through Mill #3
↓
Collect peanut butter in stainless steel containers
↓
Cool to temperature of 65ºC or lower
↓
Set aside for use in the preparation of premix and fortified peanut butter

Fig. 2.8 Schematic Diagram of the Process for the Production of Peanut Butter.

(1) Prepare plain peanut butter as in Fig. 2.8

↓

(2) Weigh 40 Kg of plain peanut butter in a stainless steel container

(3) Weigh 40 g of vitamin A palmitate in a beaker

↓

(4) Transfer the pre-weighed vitamin A palmitate in the beaker to the pre-weighed peanut butterz at the center of the stainless steel container

↓

(5) Add a little amount of the pre-weighed plain peanut butter into the beaker and scrape off all adhering fortificant from the beaker and add back to the container of pre-weighed peanut butter

↓

(6) Manually mix the vitamin A palmitate with plain peanut butter in circular strokes with the aid of a spatula. Mix for approximately 1 minute.

↓

(7) Pour the vitamin A palmitate-peanut butter mixture in the stainless steel container into a horizontal mixer

↓

(8) Mix the vitamin A palmitate-plain peanut butter mixture for 10 minutes

↓

(9) Collect the premx in a stainless steel container

↓

(1) Get 20 pcs of 2.5 Kg capacity clean plastic containers and determine the weight of one plastic container. Adjust the weighing balance to zero to record the tare weight of the container.

↓

(11) Transfer 2 Kg of the collected premix in the plastic containers and weigh.

↓

(12) Cover all containers with plastic lids and pack in corrugated cartons

↓

(13) Store in a clean cool area until used in the preparation of fortified peanut butter. Do not store premix for more than 12 days.

Fig. 2.9 Schematic diagram of the procedure for the preparation of 40 kg of peanut butter premix.

(1) Prepare plain peanut butter as in Fig. 2.8

↓

(2) Weigh 50 Kg of plain peanut butter in a stainless steel container

↓

(3) Add 2 Kg of the pre-weighed premix prepared in Step B.11 at the center of the 50 Kg pre-weighed peanut butter in the stainless steel container. Scrape off all adhering premix from the plastic container and add back to the pre-weighed plain peanut butter.

↓

(4) Manually mix the premix with the pre-weighed plain peanut butter in the stainless steel containers in circular strokes with the aid of a spatula until the premix is no longer visible at the surface of the mixture. Mix for approximately 1 minute.

↓

(5) Repeat Steps 2 to 4 using another 50 Kg batch of plain peanut butter

↓

(6) Pour the premix-peanut butter mixture from the 2 stainless steel containers into the horizontal mixer. Scrape off all adhering peanut butter from the 2 stainless steel containers with the aid of a spatula and add back to the Horizontal Mixer.

↓

(7) Mix the premix-plain peanut butter mixture for 10 minutes

↓

(8) Collect the fortified peanut butter in stainless steel containers and transfer the contents to a filling machine

↓

(9) Fill desired container sizes with fortified peanut butter according to required fill-in-weight of the containers. Cover the container with their lids and place tamper proof seals

↓

(10) Pack in corrugated cartons

↓

(11) Store in a clean cool area

Fig. 2.10 Schematic diagram of the procedure for the preparation of 100 Kgs of fortified peanut butter.

CHAPTER 3

VITAMIN A FORTIFICATION OF STABILIZED PEANUT BUTTER BY DIRECT ADDITION

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ABSTRACT

In a survey on peanut butter consumptions in the Philippines by Galvez *et al*. (1999), a greater part of the peanut butter consumers prefer the firm type (stabilized) peanut butter. With the product's popularity among consumers, a study was conducted to develop a procedure for vitamin A fortification of stabilized peanut butter as a food vehicle to eliminate vitamin A deficiency in the Philippines. Vitamin A fortified stabilized peanut butter was formulated using three types of fortificants at three levels of fortification and two brands of stabilizers. Vitamin A palmitate (oily and microencapsulated forms) and an oily preparation of beta-carotene (10%) were used as fortificants at varying concentrations (70, 140 and 210% of the Philippine RENI for male adult) to determine the most cost-effective fortificant to use that will meet Philippine regulation on vitamin A fortification of foods. The performance of a local and imported brand of stabilizers in terms of vitamin A retained in peanut butter after processing was also compared.

Vitamin A palmitate in microencapsulated form has the advantage in terms of cost, bioavailability and stability as compared to the other fortificants. A fortification level as low as 70% of the RENI for all types of fortificant used provided at least 1/3 of the RENI (184.60 μg RE/day) and some samples fortified at 210% of RENI exceeded the 100% of RENI (531.82 to 920.7 μg RE/day).

The performance of locally available and imported brand stabilizers in terms of amount of vitamin A (as % of RENI) retained in the sample after processing was significantly different. However, the % vitamin A retention for all stabilized peanut butter samples showed no significant differences, hence; the use of a locally available stabilizer is recommended. To account for vitamin A losses that may occur during storage of peanut butter, a fortification rate between 70 to 140% of the RENI with microencapsulated vitamin A palmitate and stabilized with a locally available stabilizer can provide 175 μg RE/day of vitamin A with minimum cost.

The technology of fortifying stabilized peanut butter by direct addition was later adopted by two industry collaborators. Details of transfer of technology and adoption are presented in Chapters 5a and 5b of this monograph.

INTRODUCTION

Vitamin A deficiency continues to be a public health problem in the Philippines, as evidenced by the 34% subclinical prevalence of the disorder (Solon, 1998). The vitamin A intake of the population is low in both urban and rural areas and vitamin A is consumed mostly in the form of provitamin A carotenoids. Low fat intake and high prevalence of infections and parasitic infestations further compound this situation (Solon, 1998). In most developed countries, food fortification programs are established to provide optimal health. In the Philippines, however, food fortification is done to address nutrient deficiencies in the general population.

The Philippine Plan of Action for Nutrition includes fortification of staple foods and widely consumed food products (Solon, 1998). The *Sangkap Pinoy* Seal Program sponsored by the Philippine Department of Health (DOH) encourages food manufacturers to fortify food products with essential micronutrients such as vitamin A, iodine and iron. Products in the Philippines, which passed government standards on vitamin A fortification, were authorized to use a seal of acceptance known *as Sangkap Pinoy* Seal (SPS) (DOH, 2000). Foods in the Philippines that were fortified with vitamin A included margarine, noodles, milk, biscuits, weaning foods (Nutrition Center of the Philippines, 2001), monosodium glutamate and wheat bun (Solon *et al*., 1985; 2000). According to the Guidelines on Micronutrient Fortification of Processed Foods (Administrative Order No. 4-A, Series of 1995, Department of Health), a level of vitamin A added to foods should supply at least one third (33%) of the Recommended Daily Allowance (RENI) of the target consumer but shall not exceed 150% of the RENI per prescribed serving(s) likely to be consumed everyday.

Peanuts are popular food items in the Philippines and peanut butter is the most widely consumed peanut product, making it a good vehicle for fortification. Types of peanut butter available in the local market are the natural (unstabilized) type and firm (stabilized) peanut butter. A recent survey on peanut butter consumption in the Philippines revealed that both low-income and middle-income families preferred the firm peanut butter (Galvez *et al*, 2002b). The survey likewise showed that the respondents were willing to buy vitamin A-fortified peanut butter and pay as high as 1.00 Philippine peso additional price for the product.

In a study of fortification of peanut butter with vitamin A by Galvez *et al.* (1999) they recommended a 175% of the RENI target fortification using an oily preparation of vitamin A palmitate for peanut butter, which provided at least 1/3 of the RENI for vitamin A. Fortification at lower than the recommended level of fortification (175% of RENI) resulted in vitamin A retained in the sample lower than the recommended minimum of 1/3 of the RENI for vitamin A.

Freeman and Singleton (1952) as cited by Hinds *et al.* (1994) discussed that stabilizers in peanut butter prevent gravitational separation of less dense oil from solid particles during storage at ambient temperatures. Stabilizers used for peanut butter include partially hydrogenated vegetable oils, monoglycerides, diglycerides of vegetable oils, or a combination of these oils (Woodroof, 1983). Imported commercial stabilizers such as Fix-X™ are currently used in the U.S. for stabilized peanut butter. Fix-X™ is not available in the Philippines and produced by P&G (Ohio, U.S.A.) for exclusive use in their products (Hinds *et al*, 1994). Galvez *et al*. (2002a) compared several locally available stabilizers with Fix-X™. Based on the results of this study, one stabilizer was chosen to compare its performance in vitamin A-fortified stabilized peanut butter so that a recommendation may be given to peanut processors as to the stabilizer that is available in the Philippines that may be used in these products.

OBJECTIVES

This study was conducted to develop a vitamin A fortified stabilized peanut butter that can provide 175 µg RE per day. Specific objectives were to: (1) establish the amount of the fortificant to produce a stabilized peanut butter with at least 1/3 and maximum of 100% Philippine RENI for vitamin A, (2) compare the performance of a locally available stabilizer with an imported brand in terms of amount of vitamin A retained in stabilized peanut butter, and (3) determine the most cost-effective fortificant in stabilized peanut butter.

METHODS

Experimental Design

Three factors: type of fortificant, level of fortification and brand of stabilizer, were studied. The factors were studied in a 3x3x2 full factorial experiment. The experiment was replicated twice. The experimental design used in the study is shown in Table 3.1.

Test Materials

Three fortificants that included: (1) an oily preparation of vitamin A palmitate, 1,000,000 IU (F. Hoffman-La Roche, Ltd., Basel, Switzerland); (2) microencapsulated or dry vitamin A palmitate beadlets, 170,729.17 IU, Type 250 CWS/F (Wright Nutrition, Inc., Crowley, Louisiana, U.S.A.); and (3) powdered beta-carotene 10% CWS (F. Hoffman-La Roche, Ltd., Basel, Switzerland) were used. The fortificants were incorporated in the peanut butter preparations at three levels: 70%, 140% and 210% of the 525 µg RE Recommended Daily Allowance or RENI for Filipino male adult.

Two commercial stabilizers (imported and locally available) were used in the experiment. Fix-X™(mp = 65.5°C, P&G, Ohio, U.S.A.) is a fully hydrogenated blend of rapeseed and cottonseed oils containing 33-37% C22:0 (behenic acid). Myvatex monoset® (mp = 63°C, Malabon Long Life, Inc., Manila, Philippines) is also a fully hydrogenated rapeseed and cottonseed oil blend, containing high erucic acid.

Table 3.1 Experimental design for the vitamin A fortification of stabilized peanut butter

Treatment Number	Rep	Stabilizer Brand	Fortificant	Level of fortification (% of RENI[1])
1	1	Fix-X™	Vit. A palmitate (oily)	70
2	1	Fix-X™	Vit. A palmitate (oily)	140
3	1	Fix-X™	Vit. A palmitate (oily)	210
4	1	Fix-X™	10% beta-carotene	70
5	1	Fix-X™	10% beta-carotene	140
6	1	Fix-X™	10% beta-carotene	210
7	1	Fix-X™	Vit. A palmitate (ME[2])	70
8	1	Fix-X™	Vit. A palmitate (ME[2])	140
9	1	Fix-X™	Vit. A palmitate (ME[2])	210
10	1	Myvatex®	Vit. A palmitate (oily)	70
11	1	Myvatex®	Vit. A palmitate (oily)	140
12	1	Myvatex®	Vit. A palmitate (oily)	210
13	1	Myvatex®	10% beta-carotene	70
14	1	Myvatex®	10% beta-carotene	140
15	1	Myvatex®	10% beta-carotene	210
16	1	Myvatex®	Vit. A palmitate (ME[2])	70
17	1	Myvatex®	Vit. A palmitate (ME[2])	140
18	1	Myvatex®	Vit. A palmitate (ME[2])	210
19	2	Fix-X™	Vit. A palmitate (oily)	70
20	2	Fix-X™	Vit. A palmitate (oily)	140
21	2	Fix-X™	Vit. A palmitate (oily)	210
22	2	Fix-X™	10% beta-carotene	70
23	2	Fix-X™	10% beta-carotene	140
24	2	Fix-X™	10% beta-carotene	210
25	2	Fix-X™	Vit. A palmitate (ME[2])	70
26	2	Fix-X™	Vit. A palmitate (ME[2])	140
27	2	Fix-X™	Vit. A palmitate (ME[2])	210
28	2	Myvatex®	Vit. A palmitate (oily)	70
29	2	Myvatex®	Vit. A palmitate (oily)	140
30	2	Myvatex®	Vit. A palmitate (oily)	210
31	2	Myvatex®	10% beta-carotene	70
32	2	Myvatex®	10% beta-carotene	140
33	2	Myvatex®	10% beta-carotene	210
34	2	Myvatex®	Vit. A palmitate (ME[2])	70
35	2	Myvatex®	Vit. A palmitate (ME[2])	140
36	2	Myvatex®	Vit. A palmitate (ME[2])	210

[1] RENI for Filipino male adult= 525 μg RE
[2] ME = microencapsulated

Vitamin A (retinol) and Beta-carotene Analysis

Sample extraction

Vitamin A was extracted from peanut butter samples with vitamin A palmitate (microencapsulated and oily preparation) by mixing the sample with 95% ethanol (technical grade) and 70% KOH solution (analytical grade). The mixture was saponified for 30 min, mixing 3x during saponification to disperse any aggregates formed. Alcohol- water (3:1) solution was added to dilute the mixture to 250 mL and mixed thoroughly. Twenty mL of sample solution was transferred to a 250 mL separatory funnel containing 8 mL and 20 mL hexane (HPLC grade, Merck Darmstadt, Germany), and partitioned by vigorously shaking the solution for 1 min. Sufficient time was allowed for the layer to separate, and the hexane layer (yellow) was extracted and washed with distilled water. Vitamin A retinol was eluted with 15% acetone (analytical grade) in a chromatographic tube (C18, 200 mm x 12 mm ID) packed with adsorbent (alumina, activity grade 1, No. A-950, Fisher Scientific).

Beta-carotene from peanut butter samples fortified with 10% beta-carotene was extracted using the same procedure for vitamin A extraction with modifications. From the extracted hexane layer, beta-carotene was eluted in the chromatographic tube using 4% acetone in hexane solution (15%) as eluant.

Preparation of Standards

The retinol and beta-carotene standards were obtained from Sigma (St. Louis, Mo., U.S.A.) and E. Merck (Darmstadt, Germany), respectively. To prepare the retinol stock solution, one capsule of USP vitamin A (retinol) reference standard (approximately 0.2-0.3 g) was added with 20 mL 70% KOH and 80 mL 95% ethanol and saponified for 30 min. The cooled standard solution was placed in an amber 250 mL solution flask. Ethanol and water (3+1) was added up to the mark. From the stock solution, an intermediate solution of 10 μg/mL was prepared. From the intermediate solution three to four series of standard with different concentrations depending on the concentration of retinol in the sample, were prepared. For the peanut butter samples, the retinol standards used ranged from 0.01 to 0.5 μg/mL.

For beta-carotene stock solution, 2.6 mg of the standard was weighed in a 25 mL volumetric flask, dissolved and diluted to volume with hexane. An intermediate solution was prepared by diluting 5 mL of the stock solution with hexane up to the mark of a 50 mL volumetric flask. Depending on the approximate concentration of the beta-carotene in the sample, 3 to 4 series of standard solutions were prepared from the intermediate solution. For the determination of beta-carotene in stabilized peanut butter the standards used had concentrations of 0.125, 0.25 and 0.5 μg/mL.

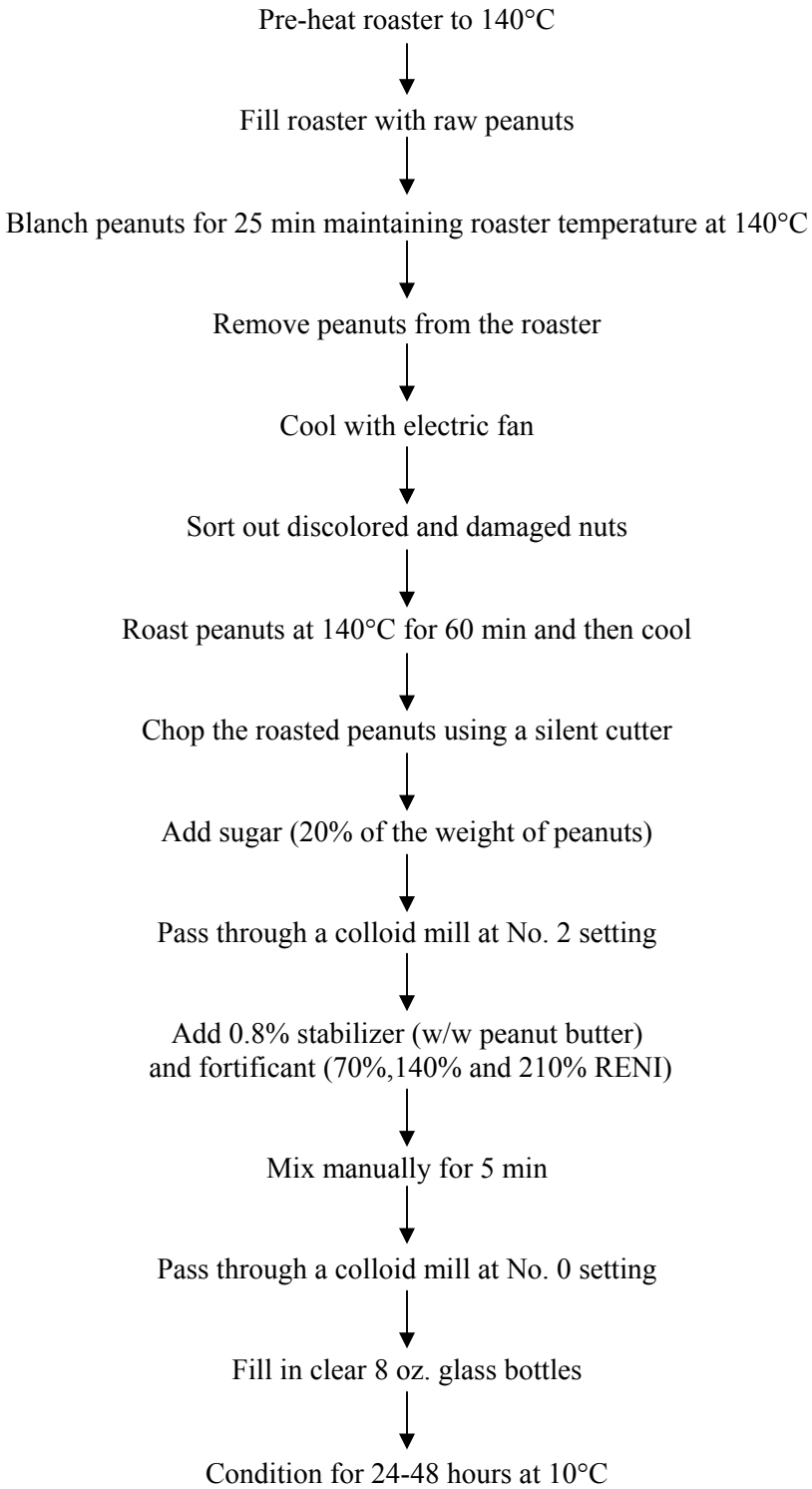

Fig. 3.1 Flow diagram of process for vitamin A fortified stabilized peanut butter

HPLC quantification of vitamin A

Twenty µL of eluate was injected to HPLC (Shimadzu 10AVP, Shimadzu Corp., Columbia, Md., U.S.A.). Separation was achieved through a reverse phase column (Purospher RP 18e, 5 µm, 15-4, Merck, Darmstadt, Germany) equipped with column oven at 28°C and UV detector set to 326 nm. The analysis was carried out with 92% methanol (HPLC grade, Merck, Darmstadt, Germany) as the mobile phase at a flow rate of 1 mL/min. The concentration of retinol was calculated using the average peak areas compared between standards and samples. Results were reported as µg RE/g.

UV spectrophotometric quantification of beta-carotene

The resulting eluate from peanut butter samples fortified with beta-carotene was analyzed for beta-carotene using a UV Spectrophotometer (Model Lambda 20, Perkin Elmer, Norwalk, Connecticut, U.S.A.). Absorbance of the eluate at 436 nm was compared with the standard carotene curve read at the same wavelength and concentration of beta-carotene was calculated. Results were reported as µg ß-carotene/g. All beta-carotene analyses were run in duplicate. Beta-carotene was converted to vitamin A (retinol) using the equation:

$$\mu g\ RE/g = \mu g\ \text{Beta-carotene}/g \times 0.3\ \mu g\ RE/0.6\ \mu g/g\ \text{Beta-carotene}$$

Influence of Type and Amount of Fortificant

The type and amount of vitamin A fortificant that can be used for stabilized peanut butter was based on the vitamin A retention equivalent of not less than 1/3 of Philippine RENI (175 µg RE) for male adults assuming 2 servings of peanut butter a day. This is the target vitamin A level in fortified foods set by the Philippine regulatory agencies such as the Bureau of Food and Drug. It was assumed that normal consumption of peanut butter in the Philippines was two servings per day, equivalent to 80 g based on the serving size of 40 g/serving as indicated on the label of peanut butter available in the market. The computation of the amount of fortificant added was based on the vitamin A level that would give 70%, 140% and 210% of Philippine RENI per 80 g of stabilized peanut butter prior to processing. The amount of vitamin A retained equivalent to % of RENI and % vitamin A retention were computed as follows:

$$\%\ \text{of RENI for vitamin A} = \frac{\text{amount of vitamin A after processing } (\mu g\ RE)}{525\ (\mu g\ RE)} \times 100$$

$$\%\ \text{Recovery} = \frac{\text{amount of vitamin A after processing } (\mu g\ RE/g)}{\text{amount of vitamin A added } (\mu g\ RE/g)} \times 100$$

Influence of Stabilizer on Vitamin A

The influence of stabilizers on the vitamin A retention using different types and level of fortificant used was determined. Both stabilizers were added at 0.8% level based on the weight of peanut butter. The target amount of vitamin A retained in the sample after processing is likewise 175 µg RE of stabilized peanut butter sample.

Statistical Analysis

Statistical analysis (ANOVA and t-Test) was performed with the use of the SAS Statistical Analysis System (SAS Institute Inc., 1990). Means were compared using Duncan's Multiple test at P= 0.05.

Technology Transfer

The technology of fortifiying stabilized peanut butter by direct addition was adopted by two industry collaborators. The level of fortification was established and verified at commercial scale to insure that the Filipino consumers are provided with at least 1/3 of Philippine RENI per serving of peanut butter. Results of technology transfer and adoption are reported in Chapters 5a and 5b of this monograph.

RESULTS

Influence of Type and Amount of Fortificant

Table 3.2 shows the amount of vitamin A (based on % RENI) in stabilized peanut butter after processing, using three fortificants at three levels of fortification and two brands of stabilizers. All stabilized peanut butter samples fortified with beta-carotene had the highest (64.22 -175.37% of RENI) amount of vitamin A retained after processing. Peanut butter samples fortified with microencapsulated vitamin A palmitate had significantly higher (43.04-103.99%) amount of vitamin A than samples with oily preparation of vitamin A at all levels of fortification. Use of vitamin A palmitate (oily preparation) as a fortificant had the lowest (35.14 -101.30% of RENI) amount of vitamin A retained after processing.

The significant differences in the amount of vitamin A (based on % RENI) in stabilized peanut butter retained after processing as affected by the type of fortificant and level of fortification may be due to the differences in the stability of the fortificants used (Table 3.3). According to Gregory (1996), beta-carotene has a 30% maximum cooking loss compared to 40% of vitamin A (retinol). Beta-carotene is one of the more stable vitamins found in vegetables (Roche Vitamins Ltd., 2001d). Synthetically produced carotenoids (oil or water soluble) are unstable in light but exhibit good stability in food applications (de Man, 1990). The commercial form is sold as a 1% or 10% preparation in gelatin beadlets that can last up to 12 months if stored properly (Roche Vitamins Ltd., 2001a). Losses of beta-carotene activity occur mainly through reductions involving unsaturated isopoprenoid side chain by either autoxidation or geometric isomerization. Moreover conversion of all-*trans* forms to *cis* forms of carotenoids are induced by heat, light, acid, chlorinated solvents and dilute iodine (Gregory, 1996).

The study conducted by Dutra-de-Oliviera *et al* (1998) on the stability of beta-carotene in fortified soybean oil, showed that heating the oil at 100°C for 20 min resulted in 100% beta-carotene retention. In the fortification of stabilized peanut butter with beta-carotene an average of 90.20% vitamin A was retained during processing which is low compared to the vitamin A retention in soybean oil. This might be due to the increased stability of vitamin A (retinol and beta-carotene) in oil than other currently used food vehicles such as flour, sugar or corn soy blends (Bagriansky and Ranum, 1998). They reported that vitamin A losses from cooking using vitamin A fortified oil ranged from 5% for boiling or simmering to 20% when the food is fried.

Vitamin A palmitate on the other hand, is commercially available in the form of an oily preparation and as microencapsulated or dry beadlets. The dry beadlets is a free-flowing form of vitamin A compounded with sugar, fish gelatin and modified food starch, with dL-alpha tocopherol as antioxidant. The oily preparation can crystallize upon storage while the dry beadlets or microencapsulated form, cakes with moisture (Wright Nutrition, 1999). de Man (1990) noted that vitamin A in beadlet or dry form is more stable than the oily preparation since beadlets have a protective coating.

Table 3.2 Percent vitamin A recovered[1] and amount of vitamin A (based on % RENI)[1] retained after processing of stabilized peanut butter fortified with vitamin A at different levels of fortification

Fortificant	Stabilizer Added	Level of Fortification					
		70% RENI[2]		140% RENI[2]		210% RENI[2]	
		% of RENI for vitamin A retained[2]	% Recovery	% of RENI for vitamin A retained[2]	% Recovery	% of RENI for vitamin A retained[2]	% Recovery
Vitamin A Palmitate (oily preparation)	Myvatex monoset®[3]	35.14	50.20	57.72	41.23	93.74	41.23
	Fix-X™[4]	36.57	52.24	62.73	44.81	101.30	44.81
Vitamin A Palmitate (microen-capsulated)	Myvatex monoset®[3]	51.72	73.88	77.98	55.70	82.76	55.70
	Fix-X™[4]	43.04	61.49	64.70	46.21	103.99	46.21
Beta-carotene (10%)[5]	Myvatex monoset®[3]	64.22	91.75	133.08	95.06	170.06	95.06
	Fix-X™[4]	68.09	97.27	129.67	92.62	175.37	92.62

[1] Means of two replicates
[2] Based on the RENI for Filipino male adult = 525 µg RE
[3] Local brand
[4] Imported brand
[5] Values were converted from µg/g beta-carotene to µg/g RE using the formula:
µg/g RE= µg/g beta-carotene x 0.3 µg RE/ 0.6 µg beta-carotene /g

Table 3.3 Analysis of Variance (ANOVA) of overall effects and means of the factors studied on the amount of vitamin A (based on % RENI) retained in stabilized peanut butter after processing

Factors	Amount of Vitamin A retained (% of RENI for Vitamin A)	
	Means[1]	p-value
Type of fortificant:		0.0001[5]
Vitamin A (Oily Preparation)	66.54b	
Vitamin A (Microencapsulated)	48.61b	
10% Beta-carotene	155.36a	
Level of fortificant[2]		0.0001[5]
70% of RENI	46.07c	
140% of RENI	83.26b	
210% of RENI	141.18a	
Stabilizer brand:		0.0053[5]
Myvatex monoset®[3]	77.55b	
Fix-X™[4]	102.79a	

[1] Means within each factor followed by the same letters are not significantly different at 5% level.
[2] Based on the RENI for Filipino male adult= 525 µg RE.
[3] Local brand
[4] Imported brand
[5] Significant at 5% level

Willich *et al*. (1954) showed that vitamin A palmitate added to peanut butter had retention values of 93-95% after processing. Brewing of vitamin A fortified tea at 100°C for 5 min to 1 hr resulted to 100% retention of vitamin A (Brooke and Cort, 1972) while various cooking methods for fortified rice resulted in 75 to 87% retention values (Lee *et al*., 2000). In this study of vitamin A fortification of stabilized peanut butter, retention of vitamin A palmitate (microencapsulated and oily preparation) ranged from 39.41 to 73.88% after processing. These values are lower than the vitamin A retention values resulting from the study of Willich *et al.* (1954), Brooke and Cort (1972) and Lee *et al.* (2000). A possible explanation for the difference in the retention values of vitamin A in stabilized peanut butter and the peanut butter samples used by Willich *et al*. (1954), was the dissolution of the vitamin A palmitate in peanut oil prior to addition to peanut butter in the latter study. As discussed previously, vitamin A is quite stable in oil. The peanut oil had a protective effect on the vitamin A palmitate during processing especially during grinding. Tea on the other hand had natural antioxidants such as catechol, epicathecol and gallic acid, which may have protected vitamin A from degradation during brewing, thus retaining 100% of the vitamin A added. In fortified rice, factors such as heat, light and oxygen accounted for the vitamin A loss but in stabilized peanut butter vitamin A oxidation was not only due to the same factors but also enhanced by the presence of moisture and catalyzed by metal ions. According to Roche Vitamins Ltd. (2001c) oxidation of vitamin A can also be accelerated by moisture and catalyzed by small quantities such as copper. Peanut butter contains 0.5-20% moisture content and 0.7-3.0 mg/100g copper (Woodroof, 1983).

The amount of vitamin A retained after processing was also significantly ($p<0.05$) affected by the level of fortification (Table 3.3). Seventy percent level of fortification gave low (35.14-68.09% of RENI) amount of vitamin A retained in the peanut butter sample after processing. Fortification at 140% RENI resulted in higher (57.72-129.67% of RENI) amount of vitamin A retained in all stabilized peanut butter fortified than samples with 70% level of fortification. On the other hand, 210% RENI of provided the highest (93.74-175.37%) vitamin A content after processing, except with samples fortified with vitamin A palmitate stabilized with Myvatex monoset® and beta-carotene. The amount of vitamin A retained in the stabilized peanut butter after processing was significantly influenced by the amount of vitamin A added to the sample. This implied that the higher the amount of fortificant used in the processing of stabilized peanut butter, the lower the amount of vitamin A will be retained in the sample.

The amount of fortificant added did not significantly affect the % vitamin A retention in peanut butter samples fortified with vitamin A palmitate (oily preparation) and beta-carotene (Table 3.4). However, all stabilized peanut butters fortified with vitamin A palmitate (microencapsulated) are significantly different in terms of % vitamin A retention.

Effects of level of fortification on the amount of vitamin A retained using individual fortificants are shown in Table 3.5. Samples fortified with the same fortificant were significantly different from each other in terms of the amount of vitamin A retained in peanut butter after processing at different levels of fortification. In peanut butter samples fortified with microencapsulated vitamin A palmitate and beta-carotene the amount of vitamin A retained after processing significantly increased as the level of fortification increased. On the other hand, peanut butter with oily vitamin A palmitate at 210% level of fortification had significantly higher amount of vitamin A than the samples fortified at 140 and 70% RENI.

All stabilized peanut butter samples retained the amount of vitamin A that was at least 1/3 of the Philippine RENI ranging from 35.14 to 175.371 % (Table 3.2). Some peanut butter samples fortified at 210% RENI except for samples with vitamin A palmitate (microencapsulated and oily preparation) and stabilized with Myvatex monoset®, retained vitamin A exceeding the recommended maximum level of 150% of the RENI. Although high vitamin A values (some samples even exceeding RENI) were found in some of the fortified peanut butter, vitamin A intake must also be controlled to prevent vitamin A hypervitaminosis in humans (Roche Vitamins Ltd., 2001c). Hypervitaminosis A which causes intercranial hypertension occurs after administration of very high amounts of vitamin A, usually in single dose (Braesco and Pascal, 2000). Russell (2000) reported a case where a patient taking an average of 400,000 IU of vitamin A for 8 years had hepatic congestion and fibrosis, particularly in the central vein. High dosage of vitamin A can also cause teratogenesis causing birth defects called retinoic acid syndrome according to Hatchcock *et al* (1990) as cited by Braesco and Pascal (2000).

Among the fortificants used, vitamin A palmitate has the advantage of being more available, biologically. Beta-carotene on the other hand is the pre-cursor of vitamin A, where its vitamin A activity occurs only upon conversion to retinol in the intestines (Bowles, 1993). In terms of cost, Vitamin A palmitate costs $40/Kg in dry form (microencapsulated) and $75/Kg in oily form while beta-carotene costs $113/Kg (L. Astrec of Roche Philippines, personal communication, 2002).

To minimize the cost of production, addition of microencapsulated vitamin A palmitate at a level of not less than 70% of the RENI is recommended in the vitamin A fortification of peanut butter. Vitamin A palmitate (microencapsulated) is also recommended due to its advantages in terms of bioavailability and stability. However, storage losses should also be considered in terms of level of fortification. It had been reported that vitamin A palmitate undergo changes during storage. According to Bauernfeind

(1983) as cited by Solon *et al.* (1985), an average of 76% vitamin A is lost after 6 mos of storage. Fortified peanut butter was shown to lose 12% of vitamin A after 180 days of storage at 80°F (Willich *et al.,* 1954). Peanut spread with nonfat dairy milk fortified with vitamin A only retained 30% vitamin A after 3 mos of storage in the dark at 23 or 40°C (Yeh *et al.,* 2002). About one-half of the amounts of vitamin A added to fortified rice were lost after 24 wks of storage at 35°C (Lee *et al*, 2000). Storage of cornflakes fortified with vitamin A palmitate at 23 and 45°C for 6 to 8 weeks resulted in more than 90% loss in vitamin A.

Influence of Stabilizer

The amount of vitamin A retained (as % of RENI) in stabilized peanut samples was significantly affected by the brands of stabilizers used (Table 3.3). All stabilized peanut butter samples with Fix-X™ generally showed higher amounts of vitamin A except for samples with microencapsulated vitamin A palmitate fortified at 70% and 140% and beta-carotene at 140% RENI, than samples with Myvatex monoset®. The type of fortificant used and the level of fortification significantly influenced the effects of stabilizers on vitamin A retained after processing of peanut butter.

Peanut butter samples fortified with vitamin A palmitate (oily preparation and microencapsulated) and stabilized with the two brands of stabilizers did not significantly differ in terms of vitamin A retained after processing (Table 3.5). However, peanut butter samples fortified with beta-carotene and stabilized with Fix X™ contained higher amounts of vitamin A than samples stabilized with Myvatex monoset®. Likewise the combined effects of the level of fortification and the brand of stabilizer significantly affected the amount of vitamin A retained in peanut butter samples with beta-carotene.

Table 3.4 Analysis of Variance (ANOVA) of overall effects and interaction of factors and means of the factors studied on the percent vitamin A recovered in fortified stabilized peanut butter after processing

Factors	% Recovery	
	Means[1]	p-value
Type of fortificant:		0.0001[5]
Vitamin A (Oily Preparation)	46.88c	
Vitamin A (Microencapsulated)	54.38b	
10% Beta-carotene	89.43a	
Level of fortificant[2]		0.0019[5]
70% of RENI	71.22a	
140% of RENI	61.76b	
210% of RENI	57.71c	
Stabilizer brand:		0.7555
Myvatex monoset®[3]	63.13	
Fix-X™[4]	64.00	

[1] Means within each factor followed by the same letters are not significantly different at 5% level.
[2] Based on the RENI for Filipino male adult= 525 µg RE
[3] Local brand
[4] Imported brand
[5] Significant at 5% level

Table 3.5 Analysis of the individual effects of the level of fortification (ANOVA) and brand of stabilizer (t-Test) on the amount of vitamin A retained in stabilized peanut butter after processing per fortificant used

Factors	Vitamin A Palmitate (oily preparation)		Vitamin A Palmitate (microencapsulated)		Beta-carotene (10%)	
	Means[1]	p-value	Means[1]	p-value	Means[1]	p-value
A. Level of fortification[2]		0.0081[5]		0.0007[5]		0.0001[5]
70% RENI	38.10b		32.76c		67.34c	
140% RENI	63.50b		49.10b		137.18b	
210% RENI	98.01a		63.96a		261.56a	
B. Brand of stabilizer (t-Test)		0.6375		0.9523		0.0001[5]
Myvatex monoset®[3]	64.05		48.50		120.09b	
Fix-X™[4]	69.03		48.71		190.62a	

[1] Means within each factor in a column followed by the same letters are not significantly different at 5% .
[2] Based on the RENI for Filipino male adult= 525 µg RE
[3] Local brand
[4] Imported brand
[5] Significant at 5% level

Although higher (36.57-175.37% RENI) amount of vitamin A was retained in peanut butter samples stabilized with Fix X™, as discussed previously, all samples retained at least one-third of RENI of vitamin A. Moreover, since the % vitamin A retention in all stabilized peanut butter samples did not significantly differ (Table 3.6), this demonstrates that Myvatex monoset® can be substituted to Fix X™ in stabilized peanut butter fortified with vitamin A that will give at least 1/3 of RENI.

The study by Chapman *et al*. (1998) on vitamin A degradation in chocolate milk stabilized with carrageenan, showed that colloidal suspensions effectively scattered light, thus, minimized photooxidation of vitamin A. Stabilization of the peanut butter with the stabilizers containing rapeseed and cottonseed oils was shown to be through a fat crystal network or matrix, which held peanut solids in suspension (Aryana *et al.,* 2000). This matrix may also help prevent photooxidation of vitamin A in the product upon storage.

Table 3.6 Analysis of the individual effects of the level of fortification (ANOVA) and brand of stabilizer (t-Test) on percent vitamin A recovered in fortified stabilized peanut butter after processing per fortificant used

Factors	Vitamin A Palmitate (oily preparation)		Vitamin A Palmitate (microencapsulated)		Beta-carotene (10%)	
	Means[1]	p-value	Means[1]	p-value	Means[1]	p-value
A. Level of fortification[2]		0.4504		0.0005[5]		0.3404
70% RENI	51.26		67.75a		94.65	
140% RENI	42.97		50.91b		91.39	
210% RENI	46.43		44.47b		82.24	
B. Brand of stabilizer (t-Test)		0.5616		0.1433		0.6110
Myvatex monoset®[3]	45.34		56.33		87.72	
Fix-X™[4]	48.43		52.43		91.13	

[1] Means within each factor in a column followed by the same letters are not significantly different at 5%
[2] Based on the RENI for Filipino male adult= 525 µg RE
[3] Local brand
[4] Imported brand
[5] Significant at 5% level

Technology Transfer

Details of technology transfer and adoption are presented in Chapters 5a and 5b of this monograph.

CONCLUSIONS

The study showed that vitamin A palmitate (microencapsulated and oily preparation) and beta-carotene at 70% RENI level of fortification in stabilized peanut butter could provide Filipino consumers at least 1/3 of Philippine RENI per serving of peanut butter. However, fortification of stabilized peanut butter with vitamin A palmitate (microencapsulated) had the advantages in terms of cost, bioavailability and stability. It was also determined that locally available stabilizer used in this study can be substituted for the imported brand used in producing stabilized peanut butter.

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CHAPTER 4

VITAMIN A FORTIFICATION OF CHOCOLATE-PEANUT SPREAD BY DIRECT ADDITION

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ABSTRACT

Chocolate-peanut spread was fortified using three types of fortificants at three levels of fortification. Vitamin A palmitate (in oil and microencapsulated forms) and an oily preparation of beta-carotene (10%) were used as fortificants at varying concentrations to meet the vitamin A requirement of at least 1/3 of the Philippine RENI for male adult. The fortificants were added prior to filling of chocolate-peanut spread into bottles.

All fortificants showed similar stability and % retention in the chocolate-peanut spreads. However, vitamin A palmitate in microencapsulated form had the advantage in terms of cost, bioavailability and stability. Fortification rates using 1/3, 2/3 and 100% of RENI showed increasing vitamin A values (based on %RENI) but the target level of 1/3 of the RENI was not met.

Higher fortification levels (133% and 166% of the RENI) were then studied but results obtained were still below the target RENI level. The inability of the fortificant to be homogeneously distributed throughout the sample may be the cause behind the low retention values. The mixture was found to be too viscous, where manual mixing may not be sufficient to distribute the fortificant.

INTRODUCTION

International Organizations such as the FAO/WHO and UNICEF recognize the continuing problem of macro and micronutrient malnutrition in the world. The Philippines, being one of the signatories to the 1992 International Conference on Nutrition goals for 2000, through the Department of Health, have formulated and implemented strategies to increase the intake of essential nutrients by the vulnerable groups (Eusebio, 2000). The *Araw ng Sangkap Pinoy* campaign, which administer vitamin A supplements to children (1 to 5 years old) twice a year and the "*Sangkap Pinoy* Seal (SPS)" program, a food fortification project, has encouraged a number of respondents, both from the public and private institutions and agencies for the proper implementation of the programs. The efforts done by the Government however were poorly reflected in the recently concluded 5th National Nutrition Survey conducted in 1998. Results continue to show the continuous prevalence of micronutrient malnutrition, specifically for vitamin A, iron and iodine within the preschool children and pregnant and lactating women (Bowley, 2000).

Studies have shown that the most common underlying cause of nutritional deficiencies is the habitual low intake of the nutrients in relation to need (Underwood and Arthur, 1996). Since it has been recognized that fortification of foods is the most cost-effective and sustainable strategy to alleviate nutritional deficiencies, the availability of more fortified foods in the market should be able to increase the intake of these essential micronutrients.

As of 1999, the total number of fortified foods with the SPS is 26, and the number continuously increases as demand for public acceptance of processed food increases. With a mean intake of processed foods among Filipinos estimated at least 60g per capita per day (based on the 1987 survey of FNRI-DOST), the figures as well may have shifted to higher values as a result of marked changes in the diet of individuals (Parce, 1995; Villavieja, 2001). This trend may work well with the public since it will be to their advantage that the food products fortified with essential vitamins and minerals are the food items that the consumers commonly use or consume (Villavieja, 2001).

Previous studies by Galvez *et al* (1999, 2002b) dwelt on the vitamin A fortification of unstabilized and stabilized peanut butter by direct addition. For the traditional unstabilized type, the recommended vitamin A fortification level using an oily preparation of vitamin A palmitate added at least 175% of the Philippine RENI (male adult) in order to provide at least 1/3 of the RENI, as stipulated in the Guidelines on Micronutrient Fortification of Processed Foods (Administrative Order No. 4-A, Series of 1995, Department of Health). As for the stabilized peanut butter, a fortification range of 70-140% of the RENI using microencapsulated vitamin A palmitate can provide the target level at minimum cost. For both products, the fortificant was added prior to filling the peanut butter into the bottles. The fortification levels established for both products were found to be different, and the type of food product being fortified and the form of fortificant may have an effect on the variations that were noted.

Another variant of the peanut butter, the chocolate-peanut spread, was also proposed for fortification with vitamin A. Based on a recent survey conducted by Galvez *et al*. (2002c), a chocolate-flavored peanut butter was the most favored flavor added in peanut butter. The addition of vitamin A in chocolate-peanut spread will presumably have more appeal to Philippine consumers and therefore can be considered to be a good vehicle for fortification.

OBJECTIVES

This study was undertaken to produce a chocolate-peanut spread for Philippine consumers that contains at least 1/3 of the Philippine RENI for vitamin A per serving, hence, improving the nutritional quality of the product. Specifically, the objectives were to (1) determine the best fortificant to use in the fortification of a chocolate-peanut spread and; (2) determine the level of fortificant that will deliver the target level of at least 1/3 of Philippine RENI for vitamin A per serving of chocolate-peanut spread.

METHODS

Establishment of Collaboration

The company who adopted the technology for producing chocolate-peanut spread (Monograph Series No. 6) was approached for possible collaboration in the study on the fortification of chocolate-peanut spread with vitamin A. An agreement for the collaboration was drafted, discussed and signed by the representative from the collaborating company, Dr. Alicia Lustre as P-CRSP Principal Investigator and Dr. Flor Crisanta F. Galvez as P-CRSP Co-Principal Investigator, after discussion with the top management and owner. The agreement included the details of the cost-sharing scheme adopted, use of the collaborator's facilities for scale-up, as well as the specified agreement on the confidentiality period.

Experimental Design

Two factors: type of fortificant and level of fortification, were studied. The factors were studied in a 3x3 full factorial experiment. The experiment was replicated thrice. The experimental design used in the study is shown in Table 4.1.

Test Materials

Three fortificants that included: (1) an oily preparation of vitamin A palmitate, 1.7 m IU/g (F. Hoffman-La Roche, Ltd., Basel, Switzerland); (2) microencapsulated or dry vitamin A palmitate beadlets, 250,000 IU/g, Type 250 CWS/F (Wright Nutrition, Inc., Crowley, Louisiana, U.S.A.); and (3) powdered beta-carotene 10% CWS (F. Hoffman-La Roche, Ltd., Basel, Switzerland) were used. The fortificants were incorporated in the chocolate-peanut spread preparations at three levels: 1/3, 2/3 and 100% of the 525 µg RE Recommended Daily Allowance or RENI for Filipino male adult. Fortification procedure established by Galvez *et al*. (2002b) was adapted for the chocolate-peanut spread.

Table 4.1 Experimental design for the vitamin A fortification of chocolate-peanut spread

Treatment Number	Fortificant	Level of Fortification (% of RENI[1])
1	Vit. A palmitate (oily)	1/3
2	Vit. A palmitate (oily)	2/3
3	Vit. A palmitate (oily)	100
4	Vit. A palmitate (ME[2])	1/3
5	Vit. A palmitate (ME[2])	2/3
6	Vit. A palmitate (ME[2])	100
7	10% beta-carotene	1/3
8	10% beta-carotene	2/3
9	10% beta-carotene	100

[1] RENI for Filipino male adult=525 μgRE.
[2] ME stands for microencapsulated.

Preparation of Chocolate-Peanut Spread

Chocolate-peanut spread developed by Galvez *et al* (2002b) was produced (Fig. 4.1), in laboratory scale at the Food Developoment Center. Nine batches of 50-Kg peanuts (large seed variety from Vietnam) were dry-blanched at 140°C for 20 to 30 min, cooled, de-skinned and sorted for discolored and damaged kernels (Galvez *et al*, 2002a). Blanched peanuts were de-skinned using a fabricated peanut blancher (Model Ex, Ashton Food Machinery Inc., Newark, New Jersey). Dry-blanched, sound, sorted peanuts were roasted at 140°C for 40 min. For each treatment, roasted peanuts (75% w/w of chocolate-peanut spread) were chopped in a meat silent cutter (Model FC-380-3H, Fujimak, Japan). Washed sugar (22% w/w of chocolate-peanut spread, refined), cocoa powder (3% w/w of chocolate-peanut spread, sifted), and chopped roasted peanuts were weighed separately and mixed. The mixture was passed through a colloid mill (TUC/PROBST & CLASS – Rastatt, Baden, West Germany) at #2 setting. The stabilizer (1% w/w of ground peanuts, Myvatex monoset®, mp=63ºC, Malabon Long Life Inc., Manila Philippines) and fortificant (weight is according to stated level of fortification in Table 1) were added to the mixture and manually mixed with a wooden spoon for 5 min. The chocolate-peanut mixture was again passed through the colloid mill at #0 setting. The fortified stabilized chocolate-peanut spread was packed in glass bottles and conditioned at 10ºC for 24-48 hours. Chocolate-peanut spread samples were submitted to FDC Analytical Laboratory for Vitamin A (retinol) and beta-carotene analysis using AOAC Official Method #974.29.

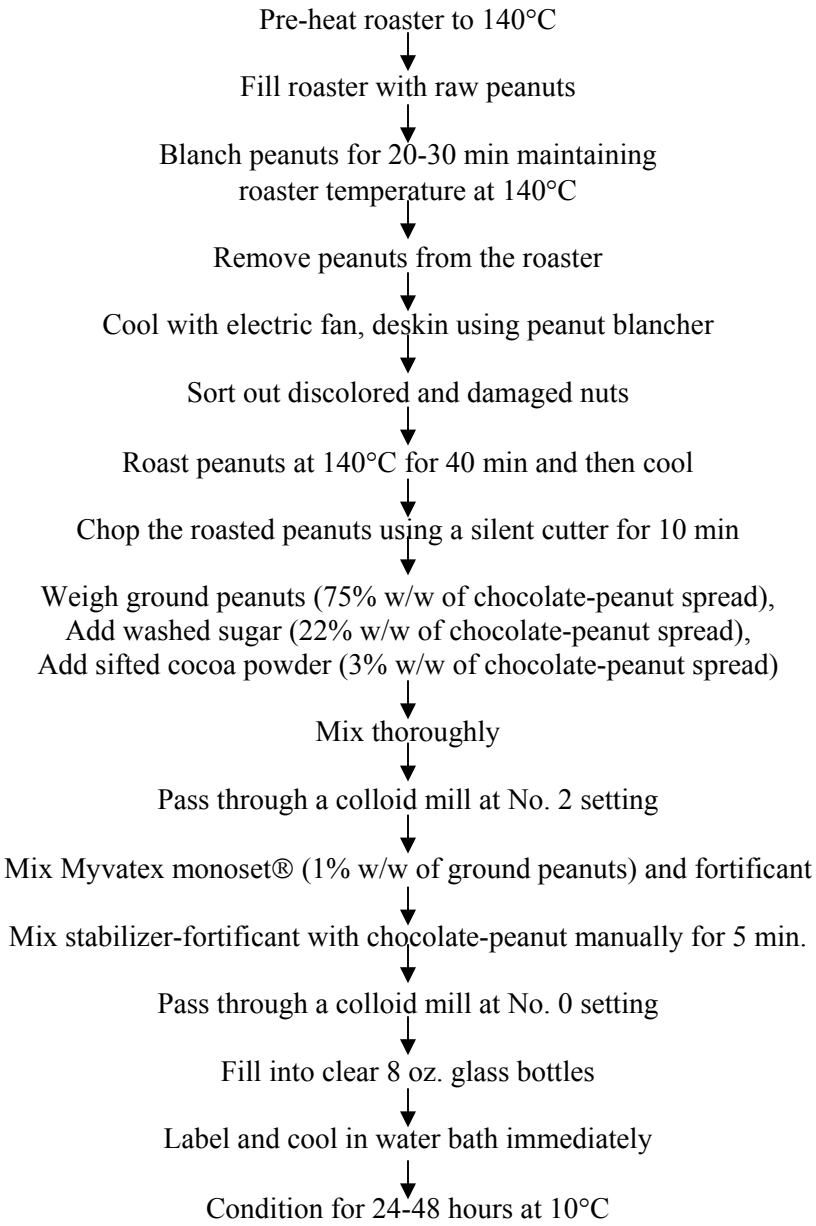

Fig. 4.1 Flow diagram of process for vitamin A fortified chocolate-peanut spread

Vitamin A (retinol) and Beta-carotene Analysis

Sample extraction

Vitamin A was extracted from chocolate-peanut spread samples with vitamin A palmitate (microencapsulated and oily preparation) by mixing the sample with 95% ethanol (technical grade) and 70% KOH solution (analytical grade). The mixture was saponified for 30 min, mixing 3x during saponification to disperse any aggregates formed. Alcohol- water (3:1) solution was added to dilute the

mixture to 250 mL and mixed thoroughly. Twenty mL of sample solution was transferred to a 250 mL separatory funnel containing 8 mL and 20 mL hexane (HPLC grade, Merck Darmstadt, Germany), and partitioned by vigorously shaking the solution for 1 min. Sufficient time was allowed for the layer to separate, and the hexane layer (yellow) was extracted and washed with distilled water. Vitamin A retinol was eluted with 15% acetone (analytical grade) in a chromatographic tube (C18, 200 mm x 12 mm ID) packed with adsorbent (alumina, activity grade 1, No. A-950, Fisher Scientific).

Beta-carotene from chocolate-peanut spread samples fortified with 10% beta-carotene was extracted using the same procedure for vitamin A extraction with modifications. From the extracted hexane layer, beta-carotene was eluted in the chromatographic tube using 4% acetone in hexane solution (15%) as eluant.

Preparation of Standards

The retinol and beta-carotene standards were obtained from Sigma (St. Louis, Mo., U.S.A.) and E. Merck (Darmstadt, Germany, respectively. To prepare the retinol stock solution, one capsule of USP vitamin A (retinol) reference standard (approximately 0.2-0.3 g) was added with 20 mL 70% KOH and 80 mL 95% ethanol and saponified for 30 min. The cooled standard solution was placed in an amber 250 mL solution flask. Ethanol and water (3+1) was added up to the mark. From the stock solution, an intermediate solution of 10 µg/mL was prepared. From the intermediate solution three to four series of standard with different concentrations depending on the concentration of retinol in the sample, were prepared. For the chocolate-peanut spread samples, the retinol standards used ranged from 0.01 to 0.5 µg/mL.

For beta-carotene stock solution, 0.0026 g of the standard was weighed in a 25 mL volumetric flask, dissolved and diluted to volume with hexane. An intermediate solution was prepared by diluting 5 mL of the stock solution with hexane up to the mark of a 50 mL volumetric flask. Depending on the approximate concentration of the beta-carotene in the sample, 3 to 4 series of standard solutions were prepared from the intermediate solution. For the determination of beta-carotene in stabilized chocolate-peanut spread, the standards used had concentrations of 0.125, 0.25 and 0.5 µg/mL.

HPLC quantification of vitamin A

Twenty µL of eluate was injected to HPLC (Shimadzu 10AVP, Shimadzu Corp., Columbia, Md., U.S.A.). Separation was achieved through a reverse phase column (Purospher RP 18e, 5 µm, 15-4, Merck, Darmstadt, Germany) equipped with column oven at 28 C and UV detector set to 326 nm. The analysis was carried out with 92% methanol (HPLC grade, Merck, Darmstadt, Germany) as the mobile phase at a flow rate of 1 mL/min. The concentration of retinol was calculated using the average peak areas compared between standards and samples. Results were reported as µg RE.

UV spectrophotometric quantification of beta-carotene

The resulting eluate from peanut butter samples fortified with beta-carotene was monitored to UV Spectrophotometer (Model Lambda 20, Perkin Elmer, Norwalk, Connecticut, U.S.A.) at 436 nm. Absorbance was compared with the standard carotene curve read at the same wavelength and concentration of beta-carotene was calculated. Results were reported as µg ß-carotene/g. All beta-carotene analyses were run in duplicate. ß-carotene was converted to vitamin A (retinol) using the equation:

$$\mu gRE/g = \mu g/g\ \beta\text{-carotene} \times 0.3\ \mu g\ RE / 0.6\ \mu g/g\ \beta\text{-carotene}$$

Study 1. Influence of Type and Amount of Fortificant

The type and amount of vitamin A fortificant that can be used for chocolate-peanut spread was based on the vitamin A retention equivalent to not less than 1/3 of Philippine RENI (175 µg RE) for male adult assuming 2 servings of chocolate-peanut spread a day. This is the target vitamin A level in fortified foods set by the Philippine regulatory agencies such as BFAD. It was assumed that normal consumption of chocolate-peanut spread in the Philippines was two servings per day, equivalent to 80 g based on the serving size of 40 g/serving as indicated on the label of peanut butter (as reference) available in the market. The computation of the amount of fortificant added was based on the vitamin A level that would give 1/3, 2/3 and 100% of Philippine RENI per 80 g of chocolate-peanut spread prior to processing. The amount of vitamin A retained equivalent to % of RENI and % vitamin A retention were computed as follows:

$$\%\ \text{of RENI for vitamin A} = \frac{\text{amount of vitamin A after processing } (\mu gRE)}{525\ (\mu g\ RE)} \times 100$$

$$\%\ \text{Recovery} = \frac{\text{amount of vitamin A after processing } (\mu gRE)}{\text{amount of vitamin A added } (\mu gRE)} \times 100$$

Study 2. Fortification of Chocolate-Peanut Spread Using Higher Levels of Vitamin A palmitate.

Another trial production at laboratory scale was conducted using higher levels of 133 and 166% of the RENI since vitamin A analysis showed very low retention. Fortificant used was vitamin A palmitate.

Statistical Analysis

Statistical analysis (ANOVA and t-Test) was performed with the use of the SAS Statistical Analysis System (SAS Institute, Inc., 1990). Means were computed using Duncan's Multiple test at $p = 0.05$.

RESULTS

Study 1. Influence of Type and Amount of Fortificant

Chocolate-peanut spread fortified with vitamin A was produced at laboratory scale. Nine treatments, which included three types of fortificants at three levels of fortification, were studied. The influence of type and amount of fortificant on the amount of vitamin A (based on % of RENI and % retention) in the sample after processing is shown in Table 4.2.

The amount of vitamin A expressed as % of RENI across all fortificants showed increasing values as level of fortification increased from 1/3 of RENI to 100% of RENI. For vitamin A palmitate

(oily preparation), % of RENI for vitamin A increased from 5.84 to 16.51%. For vitamin A palmitate (microencapsulated), values increased from 6.15 to 17.07%, while for beta-carotene, values increased from 4.38 to 17.94%.

As shown in Table 4.3, statistical analysis revealed that the type of fortificant did not have any significant effect (p>0.05) on the amount of vitamin A retained (as % of RENI). This shows that the retention of the three fortificants used for the chocolate-peanut spread were almost similar. Previous studies by Galvez *et al* (2002b, 2002c) on the vitamin A fortification of the unstabililzed and stabilized peanut butter showed greater amount of vitamin A (as % of RENI) in samples fortified with beta-carotene than those with vitamin A palmitate (oily and microencapsulated forms). Based on literature, the performance of carotenoids is better in terms of stability, however, vitamin A palmitate (microencapsulated) was chosen as fortificant due to bioavailability and cost. As for this study, since no differences were observed for the three types of fortificants, the use of vitamin A palmitate in microencapsulated form is likewise recommended for use due to its bioavailability, cost and stability.

Table 4.2 Percent vitamin A recovered[1] and amount of vitamin A (based on RENI)[1] retained after processing of chocolate-peanut spread fortified with vitamin A at different levels of fortification

Fortificant	Level of Fortification					
	1/3 of RENI[2]		2/3 of RENI[2]		100% of RENI[2]	
	% of RENI for vit A[2] retained	% Recovery	% of RENI for vit A[2] retained	% Recovery	% of RENI for vit A[2] retained	% Recovery
Vit. A palmitate (oily preparation)[3]	5.84	17.03	10.61	15.85	16.51	16.34
Vit. A palmitate (microencap-sulated)[4]	6.15	18.58	11.38	17.27	17.07	17.33
Beta-carotene 10%[5,6]	4.38	16.05	8.50	16.20	17.94	23.25

[1] Means of three replicates
[2] Based on the RENI for Filipino male adult = 525µg RE
[3] Purity of vitamin A palmitate (oily) = 1,662,411.83 IU/g
[4] Purity of vitamin A palmitate (microencapsulated) = 246,256.10 IU/g
[5] Purity of beta-carotene = 8%
[6] Values were converted from µg/g B-carotene to µg RE/g using the formula:
µg RE/g = µg B-carotene/g x 0.3 µg RE/0.6 µg/ g B-carotene

Table 4.3 Analysis of Variance (ANOVA) of overall effects and means of the factors studied on the amount (based on % RENI) of Vitamin A retained in Chocolate- Peanut Spread after processing

Variables	Amount of Vitamin A (% of RENI for Vitamin A		% Recovery	
	Means[1]	p-value	Means[1]	p-value
Type of fortificant:		0.4929		0.6714
Vitamin A (oily preparation)	11.71		16.51	
Vitamin A (microencapsulated)	11.53		17.73	
10% beta-carotene	9.54		18.08	
Level of fortification[2]:		0.0001[3]		0.5624
1/3 of RENI	5.59a		17.37	
2/3 of RENI	10.37b		16.47	
100% of RENI	17.08c		18.44	

[1] Means within each variable followed by different letters are not significantly different at 5% level.
[2] Based on the RENI for Filipino male adult=525 μg RE
[3] Significant at 5% level

The amount of vitamin A retained (as % of RENI) was significantly affected as the level of fortification increased ($p<0.05$). Samples fortified at 100% of RENI showed the highest level of vitamin A retained as expected. Results were found to be low, as compared to previous studies by Galvez *et al* (1999, 2002c). Almost half of the target RENI was only obtained at 100% level of fortification. Whereas, the fortification of stabilized peanut butter with vitamin A palmitate showed that fortification at a level of at least 70% already met the target of 1/3 of RENI per serving (Galvez *et al*. 2002c). This implies that the formulation and process may have an effect on the vitamin A retention in the sample. Chocolate-peanut spread employed a roasting time of only 40 min, as compared to 60 min for a typical peanut butter. The addition of cocoa powder and more sugar to the formulation may also have an impact on the vitamin A retention in the sample.

Vitamin A retention was shown not to be significantly affected ($p>0.05$) when different types of fortificant and level of fortification were used (Table 4.3). Percent mean values for the type of fortificant were 16.51-18.98%, whereas, % mean values for the level of fortification was 16.47-18.44%. Retention values obtained were also found to be very low as compared to the retention values obtained in the study of fortification of stabilized peanut butter. It was observed in this study that during the production of chocolate-peanut spread, the mixture had a very viscous appearance. Since the roasting time was less compared to the normal roasting time used by Galvez *et al* (2002c), less oil was extracted from the peanuts, making the mixture very viscous. The addition of the fortificant and the stabilizer made the mixture even harder to mix as the stabilizer began to set in. More effort was given to mixing, which may have affected the retention of the vitamin A in the product.

Study 2. Fortification of Chocolate-Peanut Spread Using Higher Levels of Vitamin A palmitate.

Because of the very low amount of vitamin A (% of RENI) obtained, another trial production was conducted employing higher levels of fortification, using vitamin A palmitate (microencapsulated). Two levels of fortification (1 1/3 and 1 2/3 of RENI) were employed in order to meet the target RENI. The amount of vitamin A (based on % of RENI and % retention) is shown in Table 4.4.

The amount of vitamin A (as % of RENI) for both levels of fortification increased as compared to previous chocolate-peanut spreads fortified at a level of 100% of RENI. However, the target level of 1/3 of the RENI (or 33% of RENI) was not met by both fortification rates. Moreover, the higher fortification level of 1 2/3 resulted in lower amount of vitamin A retained. T-test analysis for amount of vitamin A (as % of RENI) showed no significant differences between the two fortification rates used (Table 4.5).

The same trend was also observed for % retention of vitamin A. Values were found to be significantly different from each other. Results show that increasing the fortification level equivalent to 166% (1 2/3 of RENI) of RENI was still not sufficient to meet the target RENI. Consistency of the mixture was very viscous, such that, homogenous distribution of the fortificant throughout the sample was greatly affected. The possibility that the fortificant was not homogeneously distributed in the product can be seen in the data were retention decreased as the level of fortification was increased. The low values obtained may actually be due to problems related to the inability of the process to ensure the homogeneous distribution of the fortificant in the product. This implies then that the fortification procedure established from previous studies cannot be adapted for the chocolate-peanut spread. Further studies need to be conducted regarding the delivery of the fortificant into the mixture.

Table 4.4 Percent Vitamin A recovered[1] and amount of vitamin A (based on % RENI) retained after processing of Chocolate-Peanut Spread fortified with vitamin A at different levels of fortification using vitamin A palmitate (microencapsulated)[2]

Level of Fortification[3]	Amount of Vitamin A	
	% of RENI retained	% Recovery
133% of RENI	23.20	17.40
166% of RENI	21.60	13.02

[1] Means of three replicates.
[2] Purity of vitamin A palmitate (microencapsulated)=246,256.10 IU/g
[3] Based on the RENI for Filipino male adult=525 μg RE

Table 4.5 t-Test analysis of means on the % Vitamin A (based on % RENI and recovery) in Chocolate-Peanut spread after processing

Variable	Means[1]	p-value
% of RENI[2]		0.3755
1 1/3 of RENI	23.20	
1 2/3 of RENI	21.60	
% Recovery		0.0304[3]
1 1/3 of RENI	17.40a	
1 2/3 of RENI	13.02b	

[1] Means within each factor followed by different letters are not significantly different at 5% level.
[2] Based on the RENI for Filipino male adult=525 μg RE
[3] Significant at 5% level

Technology Transfer

Results of the vitamin A fortification of chocolate-peanut spread was presented to the industry collaborator. Adoption of the technology did not push through as per management's decision. In a telephone conversation dated July 23, 2002, the management declined the collaboration, as the company still has many pending projects to finish.

CONCLUSIONS

Chocolate-flavored peanut spread is one of the most favored flavor added in peanut butter. The addition of vitamin A in chocolate-peanut spread will presumably have more appeal to Philippine consumers and therefore can be considered to be a good vehicle for fortification. Based on cost and bioavailability, vitamin A palmitate (microencapsulated form) was chosen as the fortificant. Trial productions using fortification rates of 1/3, 2/3 and 100% of the RENI resulted in low vitamin A retention (based on % RENI). Higher fortification rates were further tested to meet the target RENI. The additional fortification rates were found to be inadequate. Non-homogeneity of the fortificant throughout the sample may be the cause of low retention values.

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CHAPTER 5a

IMPROVEMENT OF A PROCESS FOR THE VITAMIN A FORTIFICATION OF PEANUT BUTTER FOR A SMALL COMPANY

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ABSTRACT

Studies were undertaken by the Food Development Center (FDC) to improve the direct addition method developed by Galvez *et al*. (2003) for incorporating a vitamin A fortificant to peanut butter that would suit the available facilities and existing process for peanut butter production of a small company, in order to transfer the technology. The goal was to encourage adoption by the company resulting in commercialization of the product.

The studies looked into the effect of heat during the grinding process on the stability of the vitamin A fortificant by comparing the effects of adding the fortificant before and after the 2nd grinding step on the percentage recovery of vitamin A. Product temperature before the grinding step is 58°C and after the grinding step is 68°C.

The results of the study showed that changing the point of addition from before to after the 2nd grinding step had no effect on vitamin A recovery. What appeared to be important was proper mixing of the vitamin A fortificant into the product. This was achieved by incorporation of the fortificant in staggered strokes, use of stabilizer as carrier for the small amount of fortificant that is added, and optimization of mixing time.

When the vitamin A fortificant was added before the 2nd grinding step, the average vitamin recovery was 87.95% and the variability was 5.92% at a mixing time of two minutes. At a mixing time of five minutes, the average vitamin A recovery was 90.13% and the variability was 7.08%. At a mixing time of 10 minutes, the average vitamin A recovery was 87.93% and the variability was 4.42%.

When the vitamin A fortificant was added after the 2nd grinding step, the vitamin A recovery was 90.08% and the variability was 12.63% after mixing for two minutes. At a mixing time of five minutes, the vitamin A recovery was 103.36% and the variability was 0.4%.

When the FDC improved process was tested at the collaborator's plant, high vitamin A recoveries were initially obtained; 110.13% for two minutes and 109.89% for five minutes mixing. Consistent high recoveries however were not obtained. This variability could be due to the fact that the mixing process carried out manually and as the product is viscous, it is likely that the mixing strokes are not carried out with uniform efficiency between personnel. This possibility is being evaluated.

In summary, the process for fortification is as follows: (1) Addition of the vitamin A fortificant after the one-time grinding of roasted peanuts and sugar, (2) Addition and manual mixing of the vitamin A fortificant to Myverol prior to incorporation to the peanut butter matrix, (3) Manual mixing of the mixture of vitamin A fortificant and stabilizer to peanut butter matrix for two minutes, (4) Rapid cooling of the fortified peanut butter in an ice water bath using ice packs in plastic containers to maintain the required 10°C temperature, (5) Conditioning/tempering of the fortified peanut butter in a household refrigerator at a temperature range of 2 – 8°C.

The technology for the vitamin A fortification and stabilization of peanut butter was formally transferred to the small company in February 2007. The technology for the stabilization of peanut butter was readily adopted by the collaborator but the technology for vitamin A fortification was temporarily shelved for the following reasons: (a) Need to hire a technical personnel to oversee the addition/mixing of fortificant because the present manpower complement of the company do not have a technical

background, (b) Need to purchase additional equipment and other processing equipment to enable the company to adopt the recommended process, (c) Need to improve the plant conditions to enable the company to meet GMP requirements, (d) Need to register the fortified peanut butter with BFAD before the product could be distributed in the market.

INTRODUCTION

Two methods for the vitamin A fortification of peanut butter have been developed under the Peanut Collaborative Research Support Program (PCRSP) namely, the premix method by the Food Development Center (FDC, 2003) and the direct addition method by Galvez *et al.* (2003). The former is a two-step fortification process that involves the preparation of peanut butter with a high concentration of vitamin A followed by the preparation of fortified peanut butter that meets the target fortification level of at least 33% of the Recommended Energy and Nutrition Intake (RENI) for Filipinos. In the latter method, the vitamin A fortificant is added directly to the peanut butter matrix before the 2nd grinding step in a colloid mill then manually mixed with the peanut butter matrix.

In the premix method, the peanut butter premix is manually added and mixed with plain peanut after the 2nd grinding step in a colloid mill then transferred to a Horizontal mixer where the fortified product is mixed mechanically for 10 minutes. A mixer that does not incorporate too much air is needed to prevent vitamin A loss during the mixing process. The existing facilities of the industry collaborator, however, do not have a mixer which is necessary in the fortification of peanut butter by the premix method. In the absence of a mixer at the collaborator's plant, which is required for the addition of fortificant using a premix, the direct addition method developed by Galvez *et al*. (2003) had to be evaluated as an alternative.

Since a technology for the vitamin A fortification of peanut butter is available under PCRSP and the industry collaborator to which the fortification technology was initially transferred has stopped the distribution of the fortified product in the local market, the technology for vitamin A fortification of peanut butter was offered to a small company who sought the assistance of Dr. Anna V.A. Resurreccion, PCRSP US Principal Investigator, for the stabilization of its flowing-type peanut butter. A Memorandum of Agreement was signed between the parties concerned, a copy of which is shown in Appendix A. Under the MOA, the industry collaborator shall provide the raw materials needed and to make available its facilities during the standardization of the process at the collaborators' plant. FDC, on the other hand, shall transfer the fortification technology to the industry collaborator taking into consideration the collaborators' existing facilities while the University of Georgia shall provide funding for the raw materials and vitamin A analysis of fortified peanut butter and fortificant.

OBJECTIVES

The goal of the study is to encourage adoption of the fortification technology of peanut butter developed under PCRSP by a company that would result in the commercialization of the product. The general objective of the study was to transfer the technology for the vitamin A fortification of a stabilized peanut butter to a small company engaged in peanut butter production. The specific objective of the project was to improve the direct addition method developed under PCRSP to suit the existing process flow and available facilities of the collaborator for peanut butter production.

METHODS

For this project, the vitamin A fortificant used was a microencapsulated vitamin A palmitate obtained from BASF Philippines (Carmelray Park, Canlubang, Laguna). It was contained in a laminated foil pouch at 50 g per pack. The vitamin A fortificant was described as a free flowing, light yellow powder consisting of spherical particles that contain vitamin A palmitate in droplets of 1-2 µm embedded in a matrix of gum arabic (E 414) and sucrose, coated with starch, t-butyl-hydroxytoluene (BHT, E321) and sodium ascorbate (E301) as antioxidants and tricalcium phosphate (E-341) as an anti-caking product (BASF, 2005).

The stabilizer used in this project was Myverol 18-04, a distilled monoglyceride derived from fully hydrogenated fats and oils. It was purchased at BNC Ingredients Corporation (252 Sen. Gil Puyat Avenue, Makati City) and C.K. Baker (EDSA Muñoz, Quezon City).

The study was undertaken in three phases as follows: (1) Preliminary activities for technology transfer, (2) Standardization of the process at FDC considering the collaborating industry's facilities, and (3) Standardization of the process at the collaborator's plant.

Preliminary Activities for Technology Transfer

A plant visit and a seminar on Good Manufacturing Practices (GMP) were conducted at the collaborator's plant as preliminary activities for the transfer of a technology for the vitamin A fortification of a stabilized peanut butter. The former was conducted to evaluate the collaborator's existing process for peanut butter production and to identify suitability of its available facilities for vitamin A fortification. The latter was conducted to create awareness among the production workers on the importance of GMP.

Standardization of the Process Considering Collaborator's Facilities

Three studies were conducted at FDC to improve the direct addition method developed by Galvez *et al.* (2003) for incorporating the vitamin A fortificant to peanut butter. Modification of the process was necessary as the collaborator's process for the production of peanut butter was a one-time grinding step, thus, addition of the fortificant can only be done after the grinding step. In the direct addition method developed by Galvez *et al*. (2003), the vitamin A fortificant was added to the peanut butter matrix before the 2nd grinding step in a colloid mill. The three studies conducted were as follows:

Study 1. Preliminary Verification of the Direct Addition Procedure Developed by PCRSP for the Vitamin A Fortification of Peanut Butter

This study was conducted to verify if the same % recovery of vitamin A achieved in the direct addition method for vitamin A fortification developed by Galvez *et al*. (2003) can be replicated using conditions existing in the industry collaborator's plant and using the new type of available stabilizer in the market.

Procedure for the preparation of fortified stabilized peanut butter adapted from Galvez et al. (2003). Fortified stabilized peanut butter was prepared following the direct addition procedure of Galvez *et al*. (2003) shown in Fig. 5a.1. The vitamin A fortificant was added at a level of 0.3678 g per 6 Kg peanut butter while the level of stabilizer was 0.8% Myverol (w/w combined weight of roasted peanuts

and sugar). The fortified stabilized product was evaluated for vitamin A recovery, dispersion and for presence of oil separation.

*Method of sampling and analysis***.** One sample each of fortified peanut butter was collected at the start, middle and end of the filling operations in plastic bottles, for vitamin A analysis. A 10 g sample of the vitamin A fortificant was taken from the 5 Kg capacity aluminum can and transferred to a 100 mL capacity aluminum can, for vitamin A analysis. The vitamin A content of the fortified product and vitamin A fortificant were analyzed at the FDC Chemistry Laboratory using AOAC (1995) Official Methods of Analysis # 974-29.

Vitamin A recovery and percentage variability. Using the data on vitamin A content, the % vitamin A recovery and % variability of replicate samples were calculated using the formula:

$$\% \text{ Recovery of vitamin A} = \frac{\text{Amount of vitamin A found } (\mu gRE/g)}{\text{Amount of vitamin A added } (\mu gRE/g)} \times 100$$

$$\% \text{ Variability} = \frac{\text{Standard deviation of vitamin A in replicate samples}}{\text{Average vitamin A content found in replicate samples}} \times 100$$

Blanched peanuts stored in freezer (-9 to -12°C) for 4 months

↓

Roasting of blanched peanuts to light brown color in a pan under medium heat

↓

Chopping of roasted peanuts in a silent cutter (Model FC-380-3H, Fujimak, Japan)

↓

Addition and mixing of sugar (20% w/w peanuts) to chopped peanuts

↓

1st grinding of chopped peanuts and sugar in a colloid mill at No. 2 setting

↓

Addition and manual mixing of vitamin A fortificant with stabilizer (0.8% w/w roasted peanuts and sugar) for 5 min

↓

2nd grinding of mixture of peanut butter, vitamin A fortificant and stabilizer in a colloid mill at No. 0 setting

↓

Manual filling of fortified peanut butter in 8 oz glass bottles

↓

Cooling of fortified peanut butter in an ice-water bath (10°C) for two hrs

↓

Conditioning/tempering of cooled fortified peanut butter in a refrigerator (2 – 8°C) for 24 - 48 hrs

Fig. 5a.1 Schematic diagram of the direct addition method for incorporating the vitamin A fortificant to peanut butter adapted from Galvez *et al*. (2003)

Study 2. Preliminary Verification of the Suitability of Incorporating the Fortificant and Stabilizer After the 2nd Grinding Step During the Vitamin A Fortification of Peanut Butter

This study was conducted to determine the effect of process change, on vitamin A recovery and dispersion. The process change was on the point of addition of the vitamin A fortificant, previously added before, to after the 2nd grinding step in a colloid mill. Addition of the vitamin A fortificant after the 2nd grinding step is expected to prevent exposure of the vitamin A added to the heat generated during the grinding step in a colloid mill. This study was undertaken because in the collaborator's process for the preparation of peanut butter, only a one-time grinding step was necessary to prepare peanut butter with a fine texture, thus it is only after the grinding stage that the fortificant can be added. Since the colloid mill at FDC requires a two-step grinding to obtain a fine textured peanut butter, addition of the vitamin A fortificant will be done after the roasted peanuts and sugar have passed the 2nd grinding step.

Experimental design. About 6 Kg of fortified stabilized peanut butter was prepared following the schematic diagram shown in Fig. 5a.2. Two treatments were done as follows: (1) Incorporation of the fortificant and stabilizer before the 2nd grinding step (control) and (2) Incorporation of the fortificant and stabilizer after the 2nd grinding step. Vitamin A recovery and dispersion were evaluated.

In (1), the amount of vitamin A fortificant added per kg peanut butter was 0.06125 g microencapsulated vitamin A palmitate (or 4.364 µgRE) or a total of 0.3675 g for a 6 Kg batch peanut butter. In (2), the amount of vitamin A added per kg of peanut butter was 0.0613 g microencapsulated vitamin A palmitate (or 4.367 µgRE/g) or a total of 0.3678 g. The amount of Myverol added was 48g.

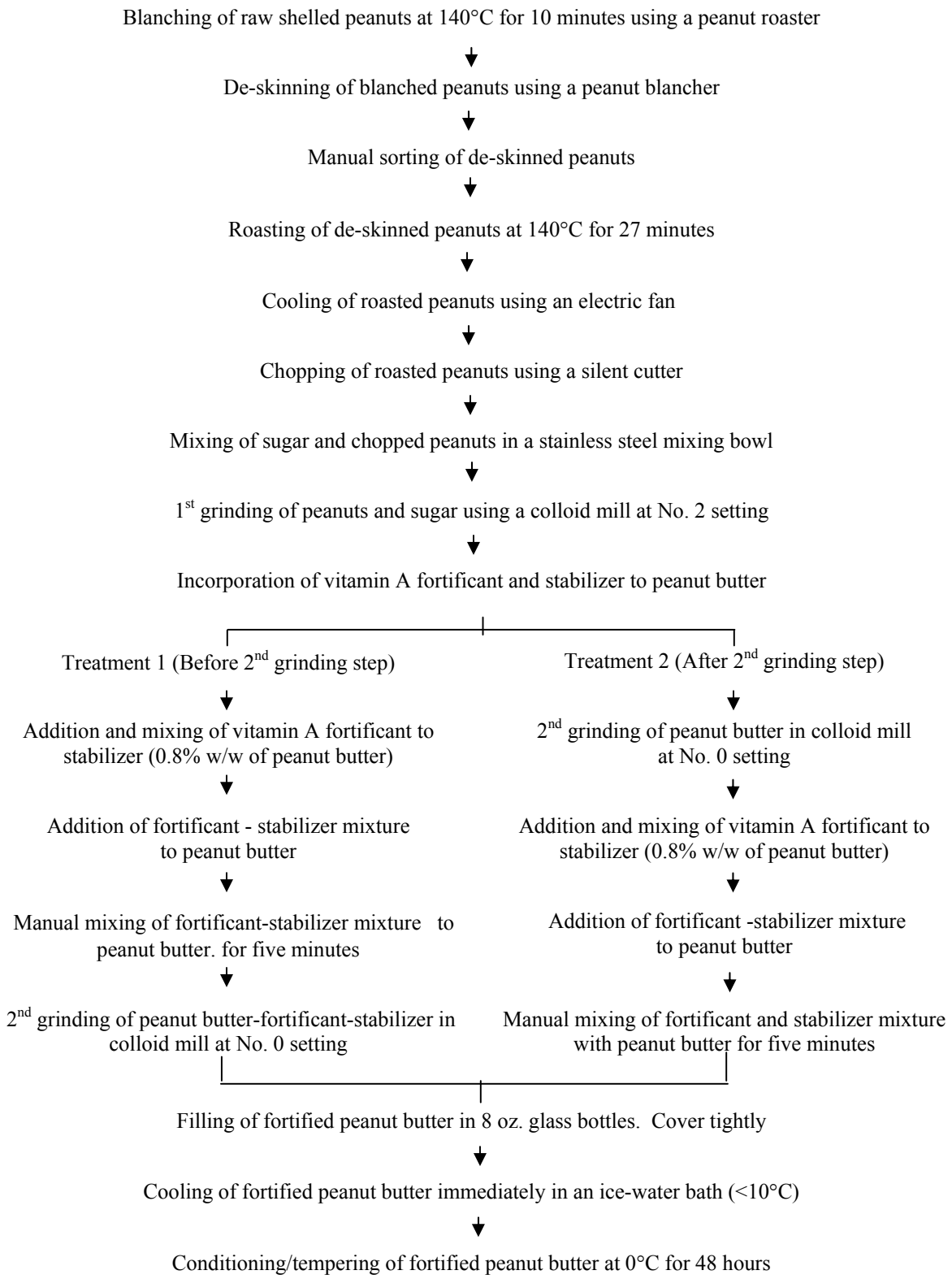

Fig. 5a.2 Schematic diagram of the procedure for incorporating vitamin A in the peanut butter matrix before and after the 2nd grinding step

Study 3. Establishment of Mixing Time for Incorporating the Vitamin A Fortificant to Peanut Butter

This study was conducted to optimize the mixing time for incorporating the vitamin A fortificant to peanut butter. This was undertaken after results of a previous study (FDC, 2006c) showed low vitamin A recoveries when the fortificant was mixed for 5 min after addition in the peanut butter matrix at two points in the process, i.e. before and after the 2nd grinding step in a colloid mill. The mixing time for incorporating the fortificant before the 2nd grinding step was first established after which the two mixing times (2 and 5 min) that gave good vitamin A recoveries were used in adding the fortificant after the 2nd grinding step.

*Experimental design. A*bout 6 Kg of fortified peanut butter was prepared following the schematic diagram shown in Fig. 4a.2 with modification on the mixing time. The mixing times for incorporating the fortificant to peanut butter before the 2nd grinding step were varied at 2, 5 and 10 min. The mixing times for incorporating the fortificant after the 2nd grinding step were 2 and 5 min. The treatments done in this study were as follows: (1) Addition of the fortificant before the 2nd grinding step at a mixing time of 2, 5 and 10 min and (2) Addition of the fortificant after the 2nd grinding step at a mixing time of 2 and 5 min. Mixing of the fortificant was done manually. Vitamin A recovery and dispersion were evaluated.

Standardization of the Process at the Collaborator's Plant

For this phase of the project, two studies were undertaken using the production facilities of the industry collaborator. The two studies undertaken were as follows:

Study 1. Testing the FDC Direct Addition Method for Incorporating Vitamin A to Peanut Butter at the Collaborator's Plant

This study was conducted to determine if the same vitamin A recovery and dispersion obtained during laboratory trials at FDC for a fortified stabilized peanut butter prepared by direct addition can be replicated at the industry collaborators plant.

Preparation of vitamin A fortified stabilized peanut butter at industry collaborator's plant. Two batches of about 6 Kg fortified stabilized peanut butter was prepared using the available facilities of the collaborator following the schematic diagram shown in Fig. 5a.3. The amount of microencapsulated vitamin A palmitate added was 0.3676 g while the stabilizer was added at a level of 0.8% Myverol (w/w peanut butter). The point of addition of the fortificant and stabilizer was done after the grinding of roasted peanuts and sugar in a fabricated Almedah brand grinder (Almedah Food Equipment, 2337 Dalaga St., Tondo, Manila) using a mixing time of 2 and 5 min.

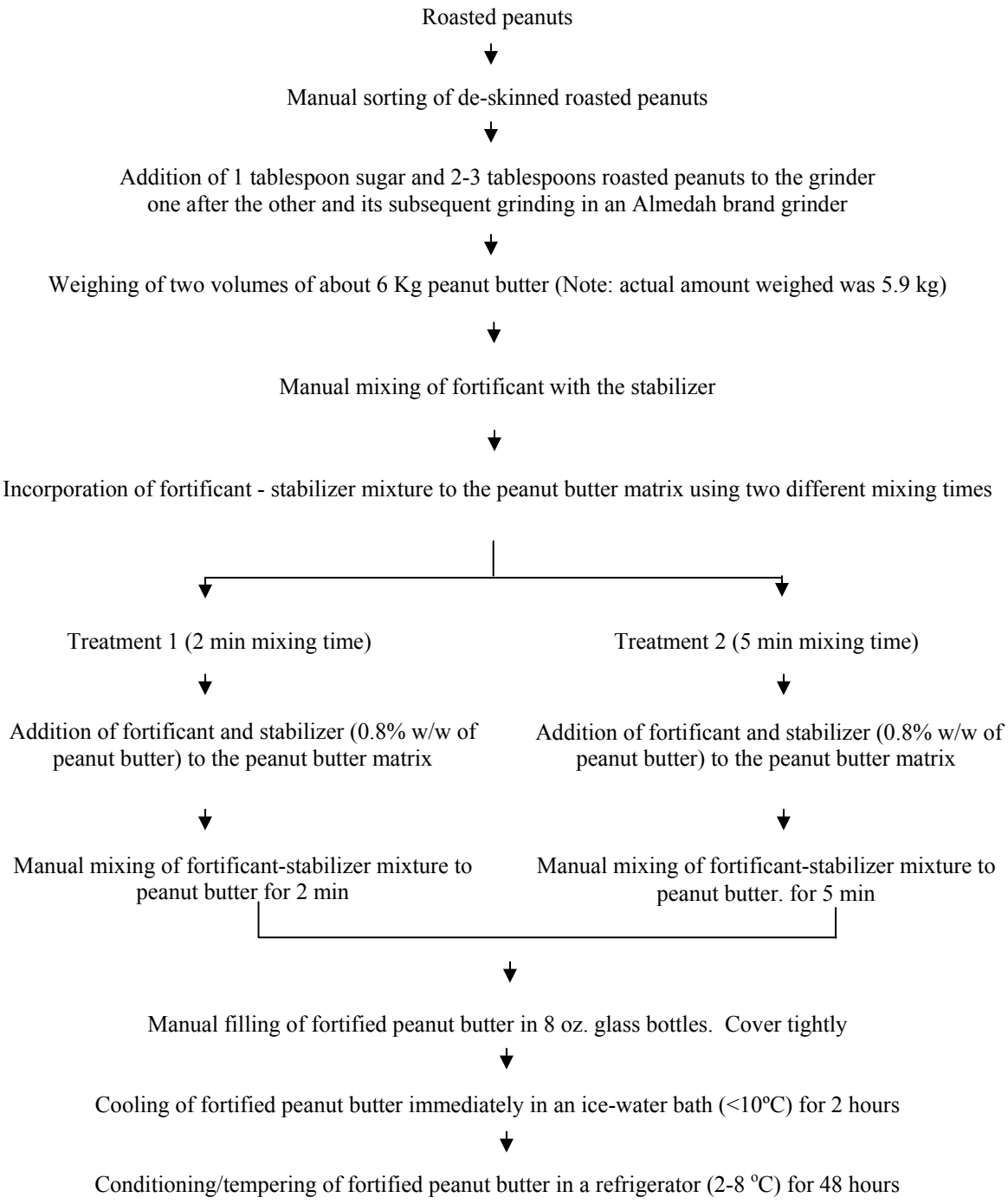

Fig. 5a.3 Process flow for the preparation of Vitamin A fortified stabilized peanut butter at collaborator's plant

Study 2. Validation of the Results of Vitamin A Recovery and Stabilizer Performance in Fortified Peanut Butter Prepared Using Parameters Established for the Vitamin A Fortification and Stabilization of Peanut Butter

This study was conducted to verify vitamin A recovery at a level of addition of 0.4790 g per 6 Kg peanut butter and stabilizer performance at a level of addition of 2% Myverol and a mixing time of 2 min.

About 6 Kg of fortified peanut butter was prepared following the schematic diagram shown in Fig. 4a.4 using a level of addition of 0.4790 g microencapsulated vitamin A palmitate and 2.0% Myverol (w/w of peanut butter). The vitamin A fortificant was added after the grinding step at a mixing time of two minutes. Three trials were conducted. Trials 2 and 3 were conducted at the same time while Trial 1 was conducted 19 days ahead of Trials 2 and 3.

Sorted peanuts roasted to medium to dark brown color

↓

Weighing of roasted peanuts and sugar
(180g sugar to 1 Kg of roasted peanuts)

↓

Addition of 1 tablespoon sugar and 2-3 tablespoons roasted peanuts to an Almedah brand Emulsifier one after the other and its subsequent grinding

↓

Weighing of about 6 kg peanut butter

↓

Addition of 0.4790g microencapsulated vitamin A to 120g Myverol (2.0% w/w of peanut butter)

↓

Manual mixing of the vitamin A fortificant to stabilizer for ~10 seconds using a stirring rod

↓

Addition of fortificant-stabilizer mixture to the peanut butter matrix

↓

Manual mixing of fortificant-stabilizer mixture to peanut butter. for 2 min using plastic spatula

↓

Manual filling of fortified peanut butter in 8 oz. glass bottles. Cover tightly

↓

Immediate cooling of fortified peanut butter in an ice-water bath (<10ºC) for 2 hours.

↓

Conditioning/tempering of fortified peanut butter in a household refrigerator (2-8 ^{o}C) for 48 hours

Fig. 5a.4 Schematic diagram of the procedure for adding the fortificant to peanut butter after the grinding step

Technology Transfer and Adoption

The technologies for the stabilization and vitamin A fortification of the peanut butter of the collaborator were transferred by demonstrating the proper technique of adding and mixing the fortificant to the owner of the business (represented by the daughter and son-in-law who manages the peanut butter business) and to two of its production workers. A procedural guideline showing a detailed description of the recommended process flow was transmitted to the collaborator on February 20, 2007 to serve as a guide in the adoption of the technology (Appendices A and B). In addition to the technologies for the stabilization and vitamin A fortification of peanut butter, the technology for sorting of blanched peanuts was likewise introduced in the process.

RESULTS

Preliminary Activities for Technology Transfer

The plant visit and GMP seminar were conducted on December 5, 2005 by two FDC personnel. The GMP Seminar was attended by the daughter and son-in law of the owner of the company and two production workers involved in the business' peanut butter manufacture. The topics discussed were the following: Basic Microbiology, Extraneous Matter (Filth), Requirements for Personal Hygiene, and Cleaning and Disinfection.

Two areas were visited by two FDC personnel namely Mr. Albert Cariso, Division Chief and Ms. Jenny Manalo, Research Analyst, the production area and packaging area for peanut butter. Since the two areas were located in different subdivisions, it was recommended that the filling operations should be done within the processing area as the fortification technology for a stabilized peanut butter does not allow movement of the product after this has been filled in the glass bottles.

Evaluation of the Existing Facilities of the Collaborator

Evaluation of the existing facilities of the collaborator for peanut butter production showed that the processing plant had adequate facilities for preparation of a flowing-type peanut butter. However, to enable the company to fortify and stabilize its peanut butter, there was a need to invest on an analytical balance to measure the required amount of fortificant, a thermocouple to accurately measure the temperature of the oven and that of peanut butter coming out of the colloid mill, and a cold storage facility that can maintain a temperature of at least $10^{o}C$ for use in the conditioning/tempering of the fortified stabilized peanut butter (FDC, 2006A). Table 5a.1 shows the evaluation of the collaborator's available facilities for peanut butter production.

Table 5a.1 Evaluation of available facilities at collaborator's processing plant

Equipment	Description	Evaluation
Convection oven	Jackson brand, non-rotating cabinet-type oven with 4 layers of drying racks and built-in thermometer	Suitable for roasting 20 kg peanuts. Location of drying racks should be interchanged from time to time and manual mixing of the peanuts had to be done to allow uniform roasting of peanuts. Built-in thermometer needs to be calibrated to ensure accurate temperature measurement of the oven.
Weighing scale	Has capacity of 10 Kg with 0.01 graduation	Suitable for weighing peanuts. Not suitable for weighing of the vitamin A fortificant.
Kitchen type weighing scale	2 Kg capacity	Suitable for weighing sugar. Not suitable for weighing the vitamin A fortificant.
"Bilao" or winnowing tray	Round shaped with mat-like implement	Suitable for sorting and manual de-skinning of roasted peanuts
Colloid Mill	Almedah brand fabricated colloid mill	Suitable for one-time grinding of roasted peanuts and sugar.
Plastic containers	Rectangular shaped and with a capacity of 40 Kg	Used for storing roasted peanuts. Not suitable for storing roasted peanuts for a long period of time.
Plastic bowls	Round shaped; capable of holding 1 Kg roasted peanuts	Suitable for containing roasted peanuts while grinding. Additional plastic bowls are needed to replace cracked units.

Evaluation of the Collaborator's Process Flow for the Preparation of Peanut Butter

Table 5a.2 shows the evaluation of the existing process flow for the preparation of peanut butter by the collaborator:

Table 5a.2 Evaluation of the collaborator's process flow for the preparation of peanut butter

Process Flow	Observation	Evaluation
Roasting of peanuts	Peanuts are roasted in the oven for 25 min at 250°F until the desired color is reached. The oven is opened every 8 – 10 min to mix the peanuts.	Dry-blanching of peanuts is not practiced by the collaborator. The lack of a dry-blanching step in the process will make it difficult to sort out aflatoxin contaminated peanuts because brown discoloration which is an indication of aflatoxin contaminated peanuts would be hard to distinguish from dark roasted peanuts.
Cooling of roasted peanuts	Roasted peanuts are placed in rectangular containers after roasting and allowed to cool overnight	Cooling of peanuts overnight may cause the overcooking of roasted peanuts due to the heat dissipated by peanuts. Immediate cooling with the use of an.electric fan is recommended after roasting.
De-skinning of peanuts	The skin of the peanuts is removed by rolling a 1 liter glass bottle of Sprite to facilitate the removal of the skins.	Use of a.glass bottle to facilitate de-skinning is not recommended as this could break and contaminate the roasted peanuts. A rolling pin made of fiber glass is recommended.
Sorting of peanuts for damaged kernels	Sorting of the roasted peanuts was done manually.	Sorting for aflatoxin infected kernels is difficult due to the dark color of the roasted peanuts. Dry blanching of peanuts is recommended prior to roasting to desired color to facilitate sorting.
Weighing of ingredients	Roasted peanuts are weighed in plastic bowls at 1 kg/bowl using a weighing balance of 10 Kg capacity. Sugar is weighed in a kitchen type weighing balance of 2 Kg capacity	Acceptable. Regular calibration of the equipment however is necessary to ensure accurate measurement of the ingredients needed for peanut butter.
Grinding of peanuts	2-3 tablespoons of roasted peanuts and 1 tablespoon of sugar is added one after the other in an Almedah grinder. Resulting product is a peanut butter with fine texture.	Grinding of roasted peanuts and sugar is done only once. There is a need to evaluate suitability of adding the fortificant and stabilizer after the grinding step.
Cooling of peanut butter	Peanut butter is collected in rectangular plastic containers and allowed to cool overnight	Not applicable if a stabilizer will be added to the peanut butter as immediate cooling of the product is recommended. A container for ice-water bath (10°C) is needed to allow the product to immediately cool.
Transport of cooled peanut butter to packaging area	Cooled peanut butter is transported by car to the packaging area	Not recommended if product is to be stabilized as crystal formation is affected by any movement of the product.

Process Flow	Observation	Evaluation
Filling of peanut butter and sealing	Cooled peanut butter is filled in 8 oz glass bottles using a spoon or a measuring cup.	Immediate filling of the product after addition of the stabilizer is recommended

Standardization of the Process at FDC Considering Collaborator's Facilities

Study 1. Preliminary Verification of the Direct Addition Method Developed Under PCRSP for the Incorporation of Vitamin A Fortificant to Peanut Butter

Table 5a.3 shows the vitamin A content and % recovery of vitamin A fortified stabilized peanut butter prepared following the direct addition method for incorporating vitamin A developed by Galvez *et al*. (2003).

Table 5a.3 Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared by the direct addition method of Galvez *et al*., 2003 (FDC, 2006b)

Sampling point (during filling)	Vitamin A added (µg RE/g)	Vitamin A found (µg RE/g)	Vitamin A Recovery (%)
Start	4.56	1.30	28.44
Middle	4.56	1.27	27.94
End	4.56	1.29	28.33
Average	4.56	1.29	28.24
Std. deviation	0.00	0.01	0.26
% variability	0.00	3.24	0.93

Results of the study showed a consistently low vitamin A content in replicate samples of fortified peanut butter with an average vitamin A content of 1.288 µg RE/g. The value obtained was only 56.2% of the target fortification level of 2.292 µg RE/g (or 183.33 µgRE/g). The vitamin A fortificant however, was found to be uniformly dispersed in the fortified product as shown by the low variability of 0.93%.

In terms of vitamin A recovery, it was noted that the fortified product had low vitamin A recoveries in all replicate samples with an average recovery of 28.24%. The vitamin A recoveries obtained were ~38% lower than the 74% vitamin A recovery reported by Galvez *et al*. (2003). The low vitamin A recoveries were attributed to several factors such as (1) Length of exposure of the product to light and air during the mixing of the vitamin A fortificant with the stabilizer and during the bottle filling operation, (2) Length of exposure of the product to heat during the 2nd grinding step and (3) Possible adherence of fortified peanut butter in the colloid mill. Other factors which may have contributed to the non-attainment of the same recoveries obtained by Galvez *et al.* (2003) were the following:

Use of a different brand of fortificant. In the study of Galvez *et al.* (2003), the microencapsulated vitamin A palmitate used was from Wright Enrichment, Inc. and was described as a free flowing form of vitamin A compounded with sugar, fish gelatin and modified food starch with dL-alpha tocopherol as antioxidant. In this study, the microencapsulated vitamin A palmitate used by FDC was from BASF (Carmelray Compound, Canlubang, Laguna) which was described as a free flowing, light yellow powder consisting of spherical particles that contain vitamin A palmitate in droplets of 1-2 µm embedded in a matrix of gum arabic (E 414) and sucrose, coated with starch, t-butyl-hydroxytoluene (BHT, E321) and sodium ascorbate (E301) as antioxidants and tricalcium phosphate (E-341) as an anti-caking product. The difference in the composition of the vitamin A fortificants and the amount of fortificant added, may have affected vitamin A stability in the finished product. Galvez et al (2003) reported that the combined effects of the type of fortificant and level of fortification significantly affected the amount of vitamin A retained in the sample.

Use of a different stabilizer. In the study of Galvez *et al*. (2003), it was reported that the amount of vitamin A retained in stabilized peanut butter samples was significantly affected by the brands of stabilizer used. The study of Galvez *et al*. (2003) used Myvatex, a hydrogenated rapeseed and cottonseed oil blend while FDC used Myverol, a hydrogenated palm oil. The latter was used upon the recommendation of the local distributor who mentioned that Myvatex was no longer available in the domestic market.

Study 2. Preliminary Verification of the Suitability of Incorporating the Fortificant and Stabilizer After the 2nd Grinding Step During the Vitamin A Fortification of Peanut Butter at the FDC Product Development Laboratory

Table 5a.4 shows the vitamin A content and vitamin A recoveries of fortified peanut butter prepared with the vitamin A fortificant and stabilizer added before and after the 2nd grinding step.

Fortified peanut butter prepared with the fortificant and stabilizer added before the 2nd grinding step resulted in vitamin A contents of 2,195 µgRE/g, 1.966 µgRE/g and 1.622 µgRE/g. These corresponded to vitamin A recoveries of 50.30%, 45.74%, and 37.17% or an average vitamin A recovery of 44.4% and variability of 15.01%. The relatively low vitamin A recoveries were unacceptable as they resulted in vitamin A contents that did not meet the target fortification level of 33% RENI or 2.292 µgRE/g. The high percentage variability of the vitamin A contents was likewise unacceptable as it indicates non-uniform dispersion of the vitamin A added.

When the fortificant and stabilizer were added after the 2nd grinding step, the resulting vitamin A contents were 2.202 µgRE/g, 2.057 µgRE/g, and 2.061 µgRE/g. These values corresponded to vitamin A recoveries of 50.42%, 47.10%, and 47.19% or an average vitamin A recovery of 48.24% and a variability of 3.92% (Table 5a.4). As in Treatment 1, the vitamin A recoveries were relatively low and were considered unacceptable. The vitamin A added however uniformly dispersed in the peanut butter matrix as indicated by the low percent variability.

Table 5a.4 Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared with the fortificant and stabilizer added before and after the 2nd grinding step (FDC, 2006c)

Sampling point (during filling)	Point of Addition of Fortificant and Stabilizer					
	Treatment 1 (Before 2nd grinding)			Treatment 2 (After 2nd grinding)		
	Vitamin A added (µg RE/g)	Vitamin A found (µgRE/g)	Vitamin A recovery (%)	Vitamin A added (µg RE.g)	Vitamin A found (µgRE/g)	Vitamin A recovery (%)
Start	4.36	2.20	50.30	4.37	2.20	50.42
Middle	4.36	2.00	45.74	4.37	2.06	47.10
End	4.36	1.62	37.17	4.37	2.06	47.19
Average	4.36	1.94	44.40	4.37	2.11	48.24
Std. deviation	0.00	0.29	6.67	0.00	0.08	18.91
% Variability	0.00	15.01	15.01	0.00	3.92	3.92

Statistical analysis using t-test of the vitamin A recoveries showed that there was no significant difference among samples of fortified peanut butter prepared with the fortificant and stabilizer added before and after the 2nd grinding step. The 10°C increase in temperature after passing the product in the colloid mill appears to have not affected the vitamin A added. This indicates that the heat expected to be generated during the grinding step in the colloid mill did not appear to have contributed to the loss of vitamin A in the fortified product. The exposure of the fortified peanut product to oxygen and light during the mixing process may have contributed more to the loss of vitamin A rather than the heat generated during the 2nd grinding step. Since vitamin A is sensitive to oxygen and light, it is necessary to establish the mixing time for incorporating the fortificant that would minimize vitamin A loss without jeopardizing the dispersion of the vitamin A added in the fortified product.

Study 3. Establishment of Mixing Time for Incorporating Vitamin A to Peanut Butter by the Direct Addition Method

*Effect of adding the vitamin A fortificant before the 2nd grinding step after a mixing time of 2, 5 and 10 min***.** Table 5a.5 shows the vitamin A content and vitamin A recoveries of fortified peanut butter prepared with the fortificant and stabilizer added before the 2nd grinding step at 2, 5 and 10 min mixing times.

Manual mixing of the vitamin A fortificant and stabilizer to peanut butter for 2 min resulted in vitamin A contents of 3.51 µgRE/g, 3.72 µgRE/g and 3.30 µgRE/g for an average vitamin A content of 3.51 µgRE/g. These values corresponded to an average vitamin A recovery of 87.97% and a variability

of 5.98%. Based on a serving size of 2 tbsp (80g) at 2 servings per day, the vitamin A present in the fortified peanut butter ranged from 48 – 54% of RENI. The low variability of the vitamin A contents indicates uniform dispersion of the vitamin A added in peanut butter.

When the fortificant and stabilizer was mixed with the peanut butter for 5 min, the resulting vitamin A contents were 3.32 µgRE/g, 3.65 µgRE/g and 3.82 µgRE/g for an average vitamin A content of 3.60 µgRE/g. These values corresponded to an average vitamin recovery of 90.14% and a variability of 7.07%. The vitamin A present in the fortified peanut butter ranged from 48.29% to 55.56% of RENI.

On the other hand, manual mixing of the fortificant and stabilizer to peanut butter for 10 min resulted in vitamin A contents of 3.54 µgRE/g, 3.34 µgRE/g and 3.64 µgRE/g for an average vitamin A content of 3.50 µgRE/g. These values corresponded to an average recovery of 87.88% and variability of 4.36%. The vitamin A present in the fortified peanut butter ranged from 48.58% to 52.95% of RENI.

In terms of dispersion, it was found that the % variability of the vitamin A content in all samples of fortified peanut butter were <10%, indicating that the vitamin A added was uniformly dispersed in the fortified peanut butter.

Table 5a.5 Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared with the fortificant and stabilizer added before the 2nd grinding step after 2, 5 and 10 min mixing time (FDC, 2006d)

Sampling Point (during filling)	Effect of Different Mixing Time on Vitamin A Recovery								
	2 Minutes Mixing			5 Minutes Mixing			10 Minutes Mixing		
	Vit. A added (µg RE/g)	Vit. A found (µgRE/g)	Vit. A recovery (%)	Vit. A added (µgRE/g)	Vit. A found (¦µgRE/g)	Vit. A recovery (%)	Vit. A added (µgRE/g)	Vit. A found (µgRE/g)	Vit. A recovery (%)
Start	3.99	3.51	87.97	3.99	3.32	83.21	3.99	3.54	88.72
Middle	3.99	3.72	93.23	3.99	3.65	91.48	3.99	3.34	83.70
End	3.99	3.30	82.71	3.99	3.82	95.74	3.99	3.64	91.22
Average	3.99	3.51	87.97	3.99	3.60	90.14	3.99	3.51	87.88
Std. deviation	0.00	0.21	5.26	0.00	0.25	6.37	0.00	0.15	3.83
% variability	0.00	5.98	5.98	0.00	7.07	7.07	0.00	4.36	4.36

Effect of adding the vitamin fortificant after the 2nd grinding step after a mixing time of 2 and 5 min. Table 5a.6 shows the vitamin A content and vitamin A recoveries of fortified peanut butter prepared with the fortificant and stabilizer added after the 2nd grinding step at a mixing time of 2 and 5 min.

Manual mixing of the fortificant and stabilizer to peanut butter for 2 min resulted in vitamin A contents of 3.71µRE/g, 3.19 µgRE/g and 4.12 µgRE/g. These corresponded to vitamin A recoveries of 90.93%, 78.19% and 100.98% or an average vitamin recovery of 90.08% and a variability of 12.69%. The vitamin A present in the fortified peanut butter ranged from 46.4% to 59.93% of RENI.

When the fortificant and stabilizer was mixed to peanut butter for 5 min, the vitamin A contents were 3.99 µgRE/g, 4.01 µgRE/g and 4.01 µgRE/g. These corresponded to vitamin A recoveries of 103.10% and 103.62% for an average vitamin A recovery of 103.44% and a variability of 0.40%. The vitamin A present in the fortified peanut butter ranged from 58.03% to 58.33% of RENI (Table 5a.6).

Table 5a.6 Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared with the vitamin A fortificant and stabilizer added after the 2nd grinding step at 2 and 5 min mixing time (FDC, 2006d)

Sampling Point (during filling)	2 Minutes Mixing Time			5 Minutes Mixing Time		
	Vitamin A added (µgRE)	Vitamin A found (µgRE/g)	Vit. A recovery (%)	Vitamin A added (µgRE/g)	Vitamin A found (µgRE/g)	Vit. A recovery (%)
Start	4.08	3.71	90.93	3.87	3.99	103.10
Middle	4.08	3.19	78.19	3.87	4.01	103.62
End	4.08	4.12	100.98	3.87	4.01	103.62
Average	4.08	3.67	90.03	3.87	4.00	103.44
Std. deviation	0.00	0.47	11.42	0.00	0.01	0.30
% variability	0.00	12.69	12.69	0.00	0.29	0.29

The % variability of vitamin A content in replicate samples were relatively low regardless of the mixing time, indicating that the vitamin A added was uniformly dispersed in the fortified peanut butter.

Considering the acceptable recoveries and dispersion of the vitamin A added after the 2nd grinding step when mixed for 2 and 5 min mixing time, this point of addition for incorporating the fortificant is recommended for testing at the collaborators' plant. This recommendation was made since the existing process of the collaborator for the preparation of peanut butter involves only a one-time grinding step. Addition of the fortificant at this point in the process will prevent the exposure of the vitamin A fortificant to heat generated in the colloid mill which may contribute to the loss of vitamin A.

Standardization of the Process at Industry Collaborator's Plant

Study 1. Testing the FDC Direct Addition Method for Incorporating Vitamin A to Peanut Butter at the Collaborator's Plant

Table 5a.7 shows the vitamin A content and vitamin A recoveries of fortified peanut butter processed after a mixing time of 2 and 5 min.

Table 5a.7 Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared at the collaborator's plant after a mixing time of 2 and 5 min (FDC, 2006e)

Sampling Point (during filling)	Two Minutes Mixing Time			Five Minutes Mixing Time		
	Vitamin A added (µg RE/g)	Vitamin A found (µgRE/g)	Vitamin A recovery (%)	Vitamin A added (µg RE.g)	Vitamin A found (µgRE/g)	Vitamin A recovery (%)
Start	3.76	4.12	109.61	3.76	4.16	110.65
Middle	3.76	4.16	110.89	3.76	4.08	108.57
End	3.76	4.13	109.90	3.76	4.16	110.65
Average	3.76	4.14	110.13	3.76	4.13	109.96
Std. Deviation	0.00	0.02	0.67	0.00	0.04	1.20
% Variability	0.00	0.61	0.61	0.00	1.09	1.09

Fortified peanut butter prepared at a mixing time of 2 min resulted in vitamin A contents of 4.117 µgRE/g, 4.165 µgRE/g and 4.128 µgRE/g for an average vitamin A content of 4.137 µgRE/g. These corresponded to vitamin A recoveries of 109.61%, 110.89% and 109.90% for an average vitamin A recovery of 110.13% and a variability of 0.61%. The vitamin A added was uniformly dispersed in the peanut butter matrix as shown by the low % variability of vitamin A in replicate samples.

On the other hand, mixing of the fortificant-stabilizer mixture to the peanut butter matrix for 5 min resulted in vitamin A contents of 4.156 µgR/g, 4.078 µgRE/g and 4.156 µgRE/g for an average vitamin A content of 4.13 µgRE/g. These corresponded to vitamin A recoveries of 110.65%, 108.57% and 110.65% for an average vitamin A recovery of 109.96% and a variability of 1.09%. The vitamin A added likewise was uniformly dispersed in the peanut butter matrix.

The average vitamin A recoveries in this study of 110.13% and 109.96% were found to be comparable to the 90.08% and 103.56% recoveries obtained in previous laboratory trials (FDC, 2006d) using the same mixing time of 2 min and 5 min respectively. The dispersion of the vitamin A added was acceptable regardless of the mixing time used as indicated by the low percent variabilities of 0.61% and 1.09% which were found to be comparable to the results of previous laboratory trials at FDC (FDC, 2006d). These data could reflect the spread in percent recovery of vitamin A measurable in the product.

Visual examination of the fortified product 2 weeks after processing showed the presence of slight oil separation at the surface of the fortified product. This indicates that the 0.8% (w/w peanut butter) level of stabilizer used in the study was not effective in preventing oil separation from taking place during storage contrary to the results of a previous similar laboratory study (FDC, 2006b). The failure of the fortified product to stabilize was attributed to the increase in roasting time brought about by the roasting of the peanuts to medium to dark color resulting in the extraction of more oil. In the past, the end point of roasting of peanuts by the collaborator was light brown.

Since the collaborator decided to use medium to dark roasted peanuts as starting raw material for its peanut butter, an increase in the level of the stabilizer from 0.8% to 1.5% and 2.0% was recommended. Increasing the level of the stabilizer is expected to improve the stability of the fortified product. Details of the study on the standardization of the process for a stabilized peanut butter to a small company is described in Chapter 5 of Monograph 6 entitled Peanut Spreads and Confections (PCRSP, 2006).

Study 2. Validation of the Results of Vitamin A Recovery and Stabilizer Performance in Fortified Peanut Butter Prepared Using Parameters Established for the Vitamin A Fortification and Stabilization of Peanut Butter for a Small Company.

Table 5a.8 shows the vitamin A content and vitamin A recoveries of fortified peanut butter prepared with the fortificant and stabilizer added after grinding step at 2 min mixing time.

Table 5a.8 Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter prepared with the fortificant and stabilizer added at 2 min mixing time (FDC, 2006f)

Sampling Point (during filling)	Vitamin A Content and % Vitamin A Recovery								
	Trial 1			Trial 2			Trial3		
	Vit. A added (µgRE/g)	Vit. A found (µgRE/g)	Vit. A recovery (%)	Vit. A added (µgRE/g	Vit. A found (µgRE/g)	Vit. A recovery (%)	Vit. A added (µgRE/g	Vit. A found (µgRE/g)	Vit. A recovery (%)
Start	4.56	4.27	93.66	4.51	7.19	156.66	4.51	7.21	159.90
Middle	4.56	4.71	103.29	4.51	7.22	160.12	4.51	4.54	100.73
End	4.56	4.72	103.56	4.51	7.24	160.54	4.51	7.54	167.22
Average	4.56	4.56	100.17	4.51	6.97	154.67	4.51	6.40	142.03
Std. deviation	0.00	0.26	5.63	0.00	0.48	10.76	0.00	1.34	29.79
% variability	0.00	5.63	5.63	0.00	6.96	6.96	0.00	20.98	20.98

Fortified peanut butter prepared in Trial 1 resulted in relatively good vitamin A recoveries and variability which were noted to be comparable with the 110.13% average vitamin A recovery and 0.61% variability (FDC, 2006e) and 90.03% average vitamin A recovery and 11.42% variability (FDC, 2006d), reported in previous studies. The vitamin A recoveries obtained were 93.66%, 103.29% and 103.56% or an average vitamin A recovery of 100.17% and a variability of 5.63%. The vitamin A added was noted to have uniformly dispersed in the fortified product as indicated by the <10% variability of vitamin A recoveries. Oil separation in the fortified product was likewise absent in all of the fortified samples after 36 days in storage.

When the same fortification process was repeated on two other batches (Trials 2 and 3), the vitamin A recoveries obtained were not replicated. Fortified peanut butter prepared in Trial 2 had vitamin A recoveries of 159.50%, 160.54% and 138.54% or an average vitamin A recovery of 160.05% and variability of 0.33%. Fortified peanut butter prepared in Trial 3 had vitamin A recoveries of 159.90%, 100.73%, 167.22% and 140.27% or an average vitamin A recovery of 142.03% and a variability of 20.98%. The vitamin A recoveries obtained in both trials were higher compared to results of Trial 1 and of a previous similar study (FDC, 2006e). Dispersion of the vitamin A added likewise varied for both trials. Fortified peanut butter prepared in Trial 2 was uniformly dispersed in the peanut butter matrix.

However, in Trial 3, the vitamin A added did not uniformly disperse in the fortified product as indicated by the high % variability of the vitamin A recoveries.

In terms of stabilizer performance, visual examination of the fortified products prepared in Trials 2 and 3 after 16 days in storage at ambient conditions, showed signs of a very slight flowing product when the bottle was tilted which was not observed in Trial 1. The failure of the product to fully stabilize was attributed to insufficient conditioning likely brought about by the disturbance of the formation of crystals during the cooling and conditioning/tempering step. It should be noted that during the cooling step, the ice used melted easily causing the temperature of the ice-water bath to increase. The addition of more ice to the ice-water bath in order to maintain a 10°C temperature may have disturbed the formation of crystals. According to Woodroof (1973), any procedure or temperature which disturbs the setting and allows a reset, seems to increase firmness and separation of oil on the surface.

Technology Transfer and Adoption

The technologies for sorting blanched peanuts and stabilization of peanut butter were readily adopted by the collaborator. However, adoption of the technology for vitamin A fortification of peanut butter was temporarily shelved in favor of the technology for stabilization of peanut butter. The latter was prioritized to enable the company to continue distribution of its peanut butter in the Visayas and Mindanao regions which was discontinued sometime in 2006 because of high product returns due to oil separation. Another reason for the delayed adoption of the technology is the on-going negotiation of the collaborator with a large company who is interested in subcontracting the production of the stabilized peanut butter. Other reasons cited for the delayed adoption of the fortification technology were the following:

(a) The need to hire a technical personnel to oversee the addition/mixing of fortificant because the present manpower complement of the company do not have a technical background;
(b) The need to purchase additional equipment and other processing equipment to enable the company to adopt the recommended process;
(c) The need to improve the plant conditions to enable the company to meet GMP requirements;
(d) The need to register the fortified peanut butter with BFAD before the product could be distributed in the market.

Constraints in the Transfer of Technologies for Stabilization and Vitamin A Fortification of Peanut Butter

Following were the constraints encountered during the transfer of technology to the industry collaborator:

(a) Lack of equipment in the collaborator's plant for measuring the required amount of fortificant. The available weighing scale of the collaborator is not suitable for measuring the small volume of fortificant (0.4790 g) needed to fortify a 6 kg production batch of peanut butter. Thus, during the standardization of the process at the collaborator's plant, the fortificant needed had to be weighed at FDC and brought to the processing plant.

(b) Lack of facilities for cooling and conditioning/tempering of the fortified stabilized peanut butter. The collaborator did not have an ice-water bath for cooling and a cold storage area for conditioning/tempering the fortified stabilized product, thus, plastic basins filled with ice and water had to be used for immediate cooling of the product while conditioning/tempering of the fortified stabilized product had to be done in a household refrigerator.

(c) Processing area is too small such that the additional steps recommended in the stabilization and fortification of peanut butter such as de-skinning and sorting of roasted peanuts, addition and mixing of the fortificant to peanut butter and cooling had to be done outside of the processing area.

d) The proper method of weighing the fortificant was not transferred to the collaborator because of the inavailability of an analytical balance or any weighing balance that can weigh small volumes.

CONCLUSIONS

The studies done in this project showed that high vitamin A recoveries and uniform dispersion can also be achieved when point of addition of the vitamin A fortificant is done after a one-time grinding step of roasted peanuts and sugar. The vitamin A recoveries obtained at this point of addition were found to be even higher compared to those obtained when the vitamin A fortificant was added before the final grinding step in a two-time grinding process for peanut butter. The higher vitamin A recoveries was attributed to the lower exposure of the vitamin A fortificant to heat generated in the colloid mill.

Conditioning/tempering of a fortified stabilized peanut butter may be affected by the type of ice used in maintaining the required 10°C temperature of the ice-water bath used for rapid cooling of the fortified stabilized peanut butter. Use of tube ice in maintaining the temperature of the ice-water bath is not recommended as it melts easily thereby, requiring the addition of more ice to the ice-water bath. The addition of more ice to the ice-water bath causes unnecessary movement to the filled bottles thus disturbing the formation of crystals that bind with the oil during the cooling step. Ice in plastic containers that have been stored in the freezer for at least one day was found to be capable of maintaining the required cooling temperature for at least two hours.

The transfer of the technology for vitamin A fortification of peanut butter to a small company was affected by the lack of facilities at the collaborator's plant. Since upgrading of equipment and improvement of the production area will entail cost to the collaborator, immediate adoption of the technology can not readily be made. Considering these constraints, it is recommended that the collaborator be given sufficient time to prepare the plant for the addition of a new step such as hiring and training of technical personnel to oversee preparation and addition of the fortificant to peanut butter, upgrading of equipment and improvement of plant facilities, as well as preparation of documents needed for product registration.

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APPENDIX A

PROCESS FLOW FOR THE STABILIZATION OF THE FLOWING-TYPE PEANUT BUTTER

Process Flow for the Stabilization of the Flowing-Type Peanut Butter

1. Prepare the peanut butter matrix for receiving the stabilizer. This is done as follows:

   a. Dry blanch the shelled peanuts in a convection oven at a temperature of 121°C until the skin of the peanuts easily peels off.

      (Note: During the dry-blanching step, the location of the drying trays should be interchanged every after 15 minutes and the peanuts on each tray is mixed manually to ensure uniform roasting)

   b. After blanching, place the blanched peanuts in a winnowing tray or "bilao" and with the aid of a rolling pin, apply slight pressure on the peanuts to facilitate de-skinning and splitting into half of the peanut kernels.

      (Note: A rolling pin made of fiberglass or plastic is recommended for applying pressure to roasted peanuts to facilitate removal of skin and splitting of the peanut kernels. The use of glass bottle as currently practiced by the company, is not recommended as this could break and glass splinters can mix with the peanut kernels.)

   c. Sort the de-skinned peanuts for damaged and aflatoxin infected kernels which appear as brown spots on the center of the kernels.

   d. After sorting, the blanched peanuts is roasted further at 121°C until the color of the peanuts turns to medium to dark brown.

      (Note: During the roasting step, the location of the drying trays are interchanged every 15 minutes and the peanuts on each tray is mixed manually to ensure uniform roasting)

   e. The sorted roasted peanuts is then stored in a clean cool place until the intended use.

      (Note: Roasted peanuts should be stored in a clean cool place to prevent the peanuts from turning rancid during storage)

2. Weigh the required amount of roasted peanuts and sugar in separate containers based on the company's established formulation.

3. Grind the roasted peanuts and sugar in an Almedah grinder following the company's existing procedure as follows: 1-2 tablespoons of roasted peanuts and 1 tablespoon of sugar is added alternately to the Almedah grinder until all of the roasted peanuts and sugar have been ground and turns into a fine textured flowing-type peanut butter.

(Note: The use of a wooden rod to push the roasted peanuts and sugar to the grinder as currently practiced by the company is not allowed in processing as it is porous, hard to clean, cannot be sanitized and has the tendency to chip off or dilapidate after prolonged usage. A rod made of plastic material or stainless steel is recommended.

4. Weigh 6 Kg of peanut butter and 120 g stabilizer in separate containers.

(Note: The amount of the stabilizer represents 2% of the weight of the peanut butter matrix)

5. Slowly add the stabilizer to 6 kg peanut butter while the peanut butter matrix is being mixed in circular strokes. Mix for two (2) minutes.

(Note: Temperature of peanut butter should at least be greater than 50°C when the stabilizer is added to allow it to melt and form crystals that would form a matrix with the peanut fiber and oil)

6. When the required mixing time is reached, immediately fill the stabilized product in glass jars. Slowly tap the filled bottles to remove any entrapped air during the filling step then cover the bottle.

7. Immediately put the filled bottles in an ice water bath maintained at 10°C leaving it undisturbed for two (2) hours. Check the temperature of the water bath from time to time to ensure that the required temperature of 10°C is maintained during the cooling period.

(Note: During the cooling step, it is recommended that ice packs in plastic bags instead of ice cubes are used for the ice water bath. Unnecessary movement of the filled bottles while in the ice water bath should be avoided so as not to disrupt the formation of crystals. Additional ice may be added to the water bath when temperature increases however care should be taken to prevent unnecessary movements to the filled bottles).

8. After the required cooling time, the product is transferred to a cold storage area and stored in upright position for conditioning/tempering.

(Note: During the conditioning/tempering step, the product should be left undisturbed for 48 hours. Unnecessary movements of the filled bottles should be avoided to allow the stabilizer to fully set. A refrigerator may be used for conditioning provided the required temperature of conditioning is reached.)

9. After 48 hours, remove the stabilized peanut butter from the cold storage area and store at ambient conditions in a clean storage area.

A schematic diagram of the procedure for the stabilization of a flowing-type peanut butter is shown in Fig. 5a.5.

Raw shelled peanuts

↓

Dry-blanching of shelled peanuts in an oven until the skin easily peels off

↓

De-skinning and splitting of blanched peanut kernels

↓

Sorting of blanched peanuts for damaged, discolored and aflatoxin contaminated peanuts

↓

Roasting of peanuts to medium to dark brown color

↓

Weighing of roasted peanuts and sugar
(180g sugar to every kg of roasted peanuts)

↓

Grinding of roasted peanuts and sugar in an Almedah brand grinder

↓

Weighing of 6 kg peanut butter and 120 g Myverol as stabilizer

↓

Addition of Myverol to the peanut butter matrix

↓

Manual mixing of the stabilizer with the peanut butter matrix for two (2) minutes

↓

Manual filling of stabilized peanut butter in 8 oz. glass bottles. Cover tightly

↓

Immediate cooling of stabilized peanut butter in an ice-water bath ($\leq$10ºC) for 2 hours

↓

Conditioning/tempering of stabilized peanut butter in a refrigerator (2-8 ^{o}C) for 48 hours

Fig. 5a.5 Schematic diagram of procedure for the stabilization of a flowing-type peanut butter

APPENDIX B

PROCESS FLOW FOR THE VITAMIN A FORTIFICATION OF PEANUT BUTTER

Process Flow for the Vitamin A Fortification of Peanut Butter

1. Prepare the peanut butter for receiving the fortificant according to the procedure described in Steps 1 to 3 of the process flow for the stabilization of a flowing-type peanut butter shown in Appendix A.

2. Weigh the following amounts of peanut butter matrix, stabilizer and vitamin A fortificant in separate containers: 6 Kg peanut butter in a mixing bowl, 120 g Myverol 18-04 in a plastic container and 0.4790 g microencapsulated vitamin A in a wide mouthed opaque container with cover.

   (Note: An analytical balance is recommended for use in the weighing of the fortificant. Weighing of the fortificant should be made as fast as possible to prevent the exposure of the fortificant to light and atmospheric oxygen. A wide mouth opaque container preferably of aluminum material is recommended for containing the vitamin A fortificant. Calibration of weighing scales/balances and temperature measuring devices are likewise recommended at least once a year to ensure the accurate measurement of weights and temperature.)

3. Measure the temperature of the peanut butter and check if product temperature falls between 43°C $\leq$ 70°C. If temperature of peanut butter is greater than 70°C, cool the product by manual mixing. If temperature of peanut butter is less than 43°C, allow the peanut butter to pass through the grinder to increase product temperature.

4. Add the vitamin A fortificant to the stabilizer and mix in circular strokes using a small rubber spatula for about 10 seconds.

5. Slowly pour the mixture of fortificant and stabilizer into the peanut butter matrix while the peanut butter is being mixed manually. Continue mixing the product for two (2) minutes using circular strokes using a big stainless steel ladle or a plastic spatula.

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6. When the required mixing time is reached, immediately fill the stabilized product in glass jars. Slowly tap the filled bottles to remove any entrapped air during the filling step then cover the bottle.

   (Note: The fortified stabilized product should be filled as fast as possible as the product will start to set causing difficulty in filling the product in the glass jars).

7. Immediately place the filled bottles in an ice water bath maintained at 10°C leaving it undisturbed for two (2) hours. Check the temperature of the ice water bath from time to time to ensure that the required temperature of 10°C is maintained during the entire cooling period.

   (Note: During the cooling step, it is recommended that ice packs in plastic bags instead of ice cubes are used for the ice water bath. Unnecessary movements of the filled bottles in the ice water bath should be avoided so as not to disrupt the formation of crystals. Additional ice may be added to the water bath when temperature increases however care should be taken to prevent unnecessary movements to the filled bottles).

8. After the required cooling time, the product is transferred to a cold storage area and stored in upright position, for conditioning/tempering

(Note: During the conditioning/tempering, the product should be left undisturbed for 48 hours. Unnecessary movements of the filled bottles should be avoided to allow the stabilizer to fully set. A refrigerator may be used for conditioning provided the required temperature of conditioning is reached).

9. After 48 hours, remove the fortified stabilized peanut butter from the cold storage area and place in master cartons. Store the product at ambient conditions in a clean storage area.

A schematic diagram of the procedure for the vitamin A fortification of a stabilized peanut butter is shown in Fig. 5a.6.

Raw shelled peanuts

↓

Dry-blanching of shelled peanuts in an oven until the skin easily peels off

↓

De-skinning and splitting of blanched peanuts

↓

Sorting of blanched peanuts for damaged, discolored and aflatoxin contaminated peanuts

↓

Roasting of peanuts to medium to dark brown color

↓

Weighing of roasted peanuts and sugar (180g sugar to every kg of roasted peanuts)

↓

Griding of roasted peanuts and sugar in an Almedah grinder

↓

Weighing of 6 kg peanut butter, 120 g Myverol and 0.4790 g microencapsulated vitamin A palmitate

↓

Addition of vitamin A fortificant to Myverol

↓

Manual mixing of vitamin A fortificant with stabilizer using circular strokes for about 10 seconds

↓

Addition of forticant-stabilizer mixture to peanut butter matrix

↓

Manual mixing of fortifciant-stabilizer mixture with the peanut butter matrix for two (2) minutes

↓

Manual filling of stabilized fortified peanut butter in 8 oz. glass bottles. Cover tightly

↓

Immediate cooling of stabilized fortified peanut butter in an ice-water bath ($\leq$10ºC) for 2 hours

↓

Conditioning/tempering of stabilized fortified peanut butter in a refrigerator (2-8 ^{o}C) for 48 hours

Fig. 5a.6 Schematic diagram of procedure for the vitamin A fortification of a stabilized peanut butter

CHAPTER 5b

IMPROVEMENT OF A PROCESS FOR THE VITAMIN A FORTIFICATION OF STABILIZED PEANUT BUTTER FOR A LARGE COMPANY

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ABSTRACT

Studies were conducted by the Food Development Center (FDC) to improve the existing process developed by a large company for the vitamin A fortification of its sweet and creamy peanut butter variant. These were undertaken after verification of the process showed that the vitamin A concentrated in the area where it was added. The vitamin A recoveries obtained were highly variable ranging from 29.24% to 127.38% with a percent variability of dispersion of 71.32% (FDC, 2006a).

The process used by the company was to directly add the vitamin A fortificant to the peanut butter after 50% of the total volume of product had been poured into the stainless steel vessel and to add the remaining 50% volume thereafter.

The first modification carried out to improve the process was to add the vitamin A fortificant four times, after every 25% of the volume of peanut butter had been poured into the stainless steel vessel. The ratio of fortificant to peanut butter during each addition was 2.3286 g vitamin A palmitate in oil for every volume of about 39 kg of peanut butter. This modification led to better dispersion of the vitamin A. The percent variability of dispersion was reduced from 71.32% for the original company process to 5.34%. The actual recovery of the fortificant however was low and ranged from 29.95% to 33.32%.

Attempts were made to increase vitamin A recovery by changing the point of addition of the fortificant from the stainless steel vessel located prior to the 2nd grinding step to two other vessels located after the grinding step in consideration of the possibility that heat generated during grinding might affect vitamin A stability. Thus, the fortificant was added at (1) the cooling tank and (2) the filler tank. The mixing time was also varied from 5 to 10 min.

Addition of the fortificant at the cooling tank after the 2nd grinding step and increasing the mixing time to 10 min, increased vitamin A recovery slightly to 50.89%. However, the fortificant appeared to be well dispersed as the variability of dispersion of vitamin A remained low at 3.43%. Another trial showed higher vitamin A recoveries of 82.03% and 93.21% and a percent variability of dispersion of 6.54% (FDC, 2006c) which however could not be reproduced in succeeding trials. Validation studies showed vitamin A recoveries of 39.37% to 42.37% for Trial 1 and 35.38% to 39.90% for Trial 2 and percent variability of 3.87% and 6.90% (FDC, 2006e). The product temperature at the cooling tank was 55 – 65°C. This was lower than the product temperature at the original point of addition of fortificant at the stainless steel vessel prior to the grinding step which ranged from 81.5^{o}C to 82.1^{o}C.

Addition of the fortificant to the filler tank resulted in a high variability of dispersion of the vitamin A of 19.88%. The poor dispersion was also reflected in abnormally high vitamin A recoveries of 111.76% to 162.5%. It was noted that the filler tank mixer did not reach the bottom of the vessel as a result of which, the initial volume of product which flowed to the bottom of the tank had to be manually mixed (FDC, 2006d).

Although the desired vitamin A recovery was not obtained in this study, it showed that in carrying out the process, the ratio of fortificant to product volume should be kept as small as possible, the point of addition of the fortificant should carefully consider product temperature and the appropriateness of the mixer desing should be evaluated.

INTRODUCTION

Vitamin A deficiency is one of the leading causes of child and adult blindness in the Philippines. To alleviate this problem, vitamin A fortification of foods that is widely consumed by the population has been adapted as one of the strategies in the Philippine Plan of Action for Nutrition. Vitamin A fortification has been recognized worldwide as a means to eliminate the problem of this micronutrient deficiency.

Peanut butter has long been considered a health food because it contains protein, fiber, niacin, zinc, vitamin E and folic acid. It is also a widely consumed product by the low income segment of the population. Thus, peanut butter is considered a good vehicle for vitamin A fortification.

A process for the vitamin A fortification of peanut butter has been developed by a large company tapped to be one of the industry collaborators for this project. Result of the preliminary verification of the fortification process developed by the collaborator however, showed that the vitamin A added was not uniformly dispersed in the peanut butter matrix. Vitamin A recovery was noted to be highest in the area where the vitamin A fortificant was added. Since vitamin A is toxic when taken over the recommended levels, it is important that the vitamin added should be uniformly dispersed within a production batch. Uniform dispersion of the added vitamin A fortificant is necessary to ensure that the entire production batch meets the target fortification level of at least 1/3 of the Recommended Energy and Nutrition Intake (RENI). The fortification process of the collaborator involved a one-time addition of the vitamin A fortificant in a stainless steel vessel prior to the 2nd grinding step in a colloid mill.

OBJECTIVES

The general objective of the project was to transfer a technology for the vitamin A fortification of peanut butter to a large-scale company. The specific objective of the studies under this project was to improve vitamin A recovery to acceptable levels and to uniformly disperse the vitamin A added in the peanut butter matrix.

METHODS

The project was undertaken in two phases as follows: (1) Preliminary activities for technology transfer and (2) Standardization of the process at the collaborator's plant.

Preliminary Activities for Technology Transfer

A plant visit and a seminar on Good Manufacturing Practices (GMP) were conducted at the collaborator's plant as preliminary activities for the technology transfer of vitamin A fortification of peanut butter. The objective of the plant visit was to assess adequacy of available facilities and suitability

of the collaborators' existing process for the incorporation of vitamin A in peanut butter. The objective of the seminar was to train the collaborators' production personnel on the importance of GMP.

Plans for the technology transfer of vitamin A fortified peanut butter and impact assessment of technology adoption were presented to the Operations Manager and R&D Head during the plant visit. Specifically, the responsibilities of parties concerned namely the Food Development Center (FDC), University of Georgia (UGA), and the industry collaborator as specified in the Memorandum of Agreement (MOA) were discussed.

After presentation of the plans for technology transfer, a tour of the roasting area for peanuts and the processing area for peanut butter production was made with the guidance of the R&D Head. The equipment available in the areas visited was noted and the process flow and raw materials used for flavored peanut butter were observed and documented. Unfortunately, at the time of the plant visit, only the production of plain peanut butter in institutional packs was being processed, thus, the actual incorporation of the vitamin A fortificant was not observed.

Standardization of the Process at Collaborator's Plant

A preliminary verification of the fortification process developed by the collaborator was conducted. This was done by collecting samples of fortified peanut butter that was processed by the collaborator based on its existing fortification process, for submission to the Chemistry Laboratory of FDC for vitamin A analysis. Based on the results of the preliminary verification, four studies were conducted at the industry collaborators' processing plant to improve recovery and dispersion of the vitamin A added to the peanut butter matrix. The four studies undertaken were as follows:

Study 1. Effect of increasing the number of addition/mixing times of vitamin A fortificant to peanut butter in the developed process of the collaborator

Study 2. Effect of incorporating the vitamin A fortificant in the cooling tank equipped with a mixer after the 2nd grinding step in the existing process for peanut butter production of the collaborator

Study 3. Effect of incorporating the vitamin A fortificant in the filler tank in the existing fortification process for sweet and creamy peanut butter of the collaborator

Study 4. Validation of the recovery and dispersion of vitamin A in fortified sweet and creamy peanut butter prepared by the direct addition of the vitamin A fortificant at the cooling tank

Raw Materials

Peanut butter. The peanut butter matrix for receiving the vitamin A fortificant used in the studies was the sweet and creamy peanut butter variant of the industry collaborator. It was prepared by the collaborator following the company's existing procedure for preparing peanut butter up to the point in the process where the vitamin A fortificant was identified to be added. A schematic diagram of the collaborator's procedure for the preparation of peanut butter matrix for receiving the vitamin A fortificant is shown in Fig. 5b.1. Four volumes of about ~38.81 kg peanut butter were prepared each time a study was conducted.

Fortificant. The vitamin A fortificant used in the studies was vitamin A palmitate in oil packed in 5 Kg capacity aluminum container with a declared value of 1.0 Million IU/g. The fortificant was purchased by

the collaborator at Vitachem Industries (44 Zamboanga St., Quezon City). According to the collaborator, the vitamin A fortificant was opened in January 2006 and stored thereafter at refrigerated conditions (10°C). The vitamin A fortificant was described in the Product Data Sheet supplied by the collaborator as a greenish-yellow to golden-yellow, oily liquid which may crystallize on storage. It consists of pure vitamin A palmitate in peanut oil, and contains d*l*-α-tocopherol as an antioxidant (DSM Nutritional Products, No date). The vitamin A fortificant was assayed for vitamin A content prior to every use to determine its actual potency at the time of use.

Weighing of ingredients
[roasted peanuts, sugar, salt, oleo flakes (Oleo Fats, Inc., 2000), and vegetable oil]
↓
Transfer of each ingredient to a fabricated tumbler mixer
↓
Mixing of all ingredients in a fabricated tumbler mixer
↓
Manual transfer of the combined ingredients to an Almedah Emulsifier
↓
1st grinding of the combined ingredients in an Almedah Emulsifier
↓
Repeat of above steps until four volumes of ~38.81 kg peanut butter have been prepared
↓
Manual transfer of four volumes of ~38.81 kg peanut butter to a stainless steel vessel
↓
Manual mixing of four volumes of ~38.81 kg peanut butter in a stainless steel vessel
↓
2nd grinding of four volumes of ~38.81 kg peanut butter in a colloid mill for 15 minutes
↓
Cooling of peanut butter to 60°C in a cooling tank equipped with a mechanical mixer
↓
Mixing of cooled peanut butter in a filler tank equipped with a mechanical mixer

Fig. 5b.1 Schematic diagram of the process flow for the preparation of peanut butter matrix for receiving the vitamin A fortificant

Method of Sampling and Analysis

One sample each of fortified peanut butter was collected at the start, middle and end of the filling operations in plastic bottles, for vitamin A analysis. A 10 g sample of the vitamin A fortificant was taken from the 5 Kg capacity aluminum can and transferred to a 100 mL capacity aluminum can, for vitamin A assay. The vitamin A content of the fortified product and vitamin A fortificant were analyzed at the FDC Chemistry Laboratory using AOAC (1995) Official Method of Analysis # 974-29.

Method of Evaluation

Using the data obtained on vitamin A content, the % vitamin A recovery and % variability were calculated using the following formula:

$$\% \text{ vitamin A recovery} = \frac{\text{Amount of vitamin A found } (\mu gRE/g)}{\text{Vitamin A added } (\mu gRE/g)} \times 100$$

$$\% \text{ variability} = \frac{\text{Standard deviation of vitamin A found in replicate samples}}{\text{Average vitamin A found in replicate samples}} \times 100$$

Preliminary Verification of the Direct Addition Procedure Developed by the Industry Collaborator for the Vitamin A Fortification of Peanut Butter

A preliminary verification of the industry collaborator's fortification process was conducted to: (1) obtain baseline information and determine status of the current technology used by the collaborator, and (2) determine if the vitamin A added is uniformly dispersed in the fortified product.

Newly processed samples of fortified sweet and creamy peanut butter produced by the industry collaborator were collected from the processing plant and analyzed for vitamin A content at FDC. Vitamin A recovery and dispersion were evaluated based on the vitamin A content found in the samples of fortified peanut butter that were submitted for vitamin A analysis.

Collaborator's Procedure for the Addition of Vitamin A Fortificant to the Peanut Butter Matrix

About 155.24 Kg of fortified sweet and creamy peanut butter was prepared by the collaborator following the company's existing direct addition method for incorporating the vitamin A fortificant to the peanut butter matrix. The collaborator's method for incorporating the fortificant to the peanut butter matrix was a one-time direct addition of 9.3144 g vitamin A palmitate in oil to two volumes of 38.81 Kg peanut butter with the stainless steel vessel before the 2nd grinding step as point of addition. A schematic diagram of the collaborator's procedure for adding the vitamin A fortificant to peanut butter is shown in Fig. 5b.2.

Four volumes of ~38.81 kg peanut butter from the 1st grinding step (See Fig. 4b.1)

↓

Manual transfer of two volumes of ~38.81 kg peanut butter from the 1st grinding step to a stainless steel vessel

↓

Addition of vitamin A fortificant to the peanut butter matrix (9.3144 g vitamin A palmitate fortificant to two volumes of ~38.81 kg peanut butter matrix)

↓

Manual mixing of the vitamin A fortificant with two volumes of ~38.81 kg peanut butter from the 1st grinding step

↓

Manual transfer of another two volumes of ~38.81 kg peanut butter from the 1st grinding step to the stainless steel vessel

↓

Manual mixing of four volumes of ~38.81 kg peanut butter matrix in the stainless steel vessel

↓

2nd grinding of the fortified peanut butter in a colloid mill for 15 min

↓

Cooling of the fortified peanut butter to 60°C in a cooling tank equipped with mechanical mixer

↓

Mechanical mixing of the fortified peanut butter in a filler tank while automatic filling in plastic bottles is in progress

↓

Removal of air from fortified peanut butter using a fabricated vibrating machine

↓

Conditioning/tempering of fortified peanut butter in a cold storage area (10°C)

↓

Sealing and labeling of filled bottles

Fig. 5b.2 Schematic diagram of the collaborator's procedure for the one-time addition of the vitamin A fortificant to peanut butter

Study 1. Effect of Increasing the Number of Addition/mixing Times of Vitamin A Fortificant to Peanut Butter in the Developed Process of the Collaborator

This study aims to improve vitamin A recovery and dispersion by increasing the number of addition/mixing times of the vitamin A fortificant to the peanut butter matrix at the stainless steel vessel prior to the 2nd grinding step. This study was conducted after the preliminary verification of the one-time addition of the vitamin A fortificant to the peanut butter matrix as practiced by the collaborator resulted in a high variability of 71.33%. The high percent variability is an indication of non-uniform dispersion of the vitamin A added to the peanut butter.

FDC Method for the Addition of the Vitamin A Fortificant to Peanut Butter

About 155.24 Kg of sweet and creamy peanut butter was fortified following the FDC recommended modification of increasing the number of addition/mixing times of the vitamin A fortificant to the peanut butter matrix. The FDC recommended procedure for adding the vitamin A fortificant was a four-time addition of the vitamin A fortificant at a weight ratio of 2.3281 g vitamin A palmitate in oil to every ~38.81 Kg peanut butter. The amount of vitamin A fortificant added and the volume of peanut butter matrix for receiving the vitamin A fortificant represent 25% of the total amount of fortificant needed to fortify a 155.24 Kg production batch of peanut butter. In this study, the point of addition of the vitamin A fortificant was done at the stainless steel vessel before the 2nd grinding step in a colloid mill. The addition of the vitamin A fortificant was done after the complete transfer of each ~38.81 Kg peanut butter to the stainless steel vessel. A schematic diagram of the FDC procedure for adding the fortificant to the peanut butter matrix is shown in Fig. 5b.3. The peanut butter matrix for receiving the fortificant was prepared up to the 1st grinding step as described in Fig. 5b.1.

Study 2. Effect of Incorporating the Vitamin A Fortificant in the Cooling Tank After the 2nd Grinding Step in the Existing Process for Peanut Butter Production of the Collaborator

This study was conducted to determine if adding the vitamin A fortificant in the cooling tank equipped with a mechanical mixer in the collaborators processing line, can uniformly disperse the vitamin A added and increase vitamin A recovery to acceptable levels. This modification corresponds to changing the point of addition of the vitamin A fortificant from before to after the 2nd grinding step in a colloid mill in order to reduce potential losses of vitamin A from the heat released during grinding. Mixing times of 5 and 10 min were also compared.

Procedure for Adding the Vitamin A Fortificant at the Cooling Tank

Two production batches of about 155.24 Kg of fortified sweet and creamy peanut butter were prepared under the supervision of FDC following the collaborators' existing process for preparation of peanut butter matrix for receiving the vitamin A fortificant (Fig. 5b.1) and FDC's method of adding the vitamin A fortificant at a ratio of 2.3286 g vitamin A palmitate to every volume of ~38.81 Kg peanut butter (Fig. 5b.3). For this study, the vitamin A fortificant was added to the peanut butter matrix at the cooling tank after the 2nd grinding step in a colloid mill. Two mixing times for incorporating the fortificant to the peanut butter matrix was used, i.e. 5 and 10 min. A schematic diagram of the procedure for incorporating the vitamin A fortificant at the cooling tank is shown in Fig. 5b.4.

4 parts of ~38.81 Kg peanut butter matrix from the 1st grinding step (See Fig. 4b.1)

↓

Manual transfer of one part of peanut butter to the stainless steel vessel

↓

1st Addition of 2.3286 g vitamin A fortificant on the surface of the 1st part of peanut butter

↓

Manual mixing of the vitamin A fortificant with 1 part of peanut butter matrix for 5 min

↓

Manual transfer of another 1 part of peanut butter to the stainless steel vessel

↓

Addition of 2.3286 g vitamin A fortificant on the surface of a 2nd part of peanut butter

↓

Manual mixing of the vitamin A fortificant with 2 parts of peanut butter matrix for 5 min

↓

Manual transfer of another 1 part of peanut butter matrix to the stainless steel vessel

↓

Addition of 2.3286 g vitamin A fortificant on the surface of a 3rd part of peanut butter

↓

Manual mixing of the vitamin A fortificant with 3 parts of peanut butter matrix for 5 min

↓

Manual transfer of another 1 part of peanut butter to the stainless steel vessel

↓

Addition of 2.3286 g vitamin A fortificant on the surface of a 4th part of peanut butter

↓

Manual mixing of the vitamin A fortificant with 4 parts of peanut butter matrix for 5 min

↓

2nd grinding of the fortified peanut butter in a colloid mill

↓

Cooling of the fortified peanut butter to 60°C in a cooling tank equipped with mechanical mixer

↓

Mechanical mixing of the fortified peanut butter in a filler tank while automatic filling in plastic bottles is in progress

↓

Removal of air from fortified peanut butter using a fabricated vibrating machine

↓

Conditioning/tempering of fortified peanut butter in a cold storage area (10°C)

↓

Sealing and labeling of filled bottles

Fig. 5b.3 Schematic diagram of the FDC procedure for adding the vitamin A fortificant to the peanut butter matrix at the stainless steel vessel of the collaborator's processing line

Four parts of ~38.81 kg peanut butter from the 2nd grinding step (See Fig. 4b.1)

↓

Mechanical transfer of 1 part of peanut butter to the cooling tank

↓

1st addition of vitamin A fortificant on the surface of 1 part of peanut butter

↓

Manual mixing of vitamin A fortificant with 1 part of
peanut butter followed by mechanical mixing at the required mixing time
(Mixing time: Treatment 1 = 5 min; Treatment 2 = 10 min)

↓

Mechanical transfer of another 1 part of peanut butter to the cooling tank

↓

2nd addition of vitamin A fortificant on the surface of a 2nd part of peanut butter

↓

Manual mixing of vitamin A fortificant with 2 part of
peanut butter followed by mechanical mixing at the required mixing time
(Mixing time: Treatment 1 = 5 min; Treatment 2 = 10 min)

↓

Mechanical transfer of another 1 part of peanut butter to the cooling tank

↓

3rd addition of vitamin A fortificant on the surface of a 3rd part of peanut butter

↓

Manual mixing of vitamin A fortificant with 3 partsof
peanut butter followed by mechanical mixing at the required mixing time
(Mixing time: Treatment 1 = 5 min; Treatment 2 = 10 min)

↓

Mechanical transfer of another 1 part of peanut butter to the cooling tank

↓

4th addition of the vitamin A fortificant on the surface of a 4th part of peanut butter

↓

Manual mixing of fortificant with 4 parts of
peanut butter followed by mechanical mixing at the required mixing time
(Mixing time: Treatment 1 = 5 min; Treatment 2 = 10 min)

↓

Additional mixing of the fortified product until temperature reaches 60°C (optional)

↓

Mechanical mixing of the fortified peanut butter at the
filler tank while automatic filling in plastic bottles is in progress

↓

Removal of air from the fortified peanut butter using a vibrating machine

↓

Conditioning/tempering of the fortified peanut butter in the cold storage area (10°C)

↓

Sealing and labeling of filled bottles

Fig. 5b.4 Schematic diagram of the procedure for adding the vitamin A fortificant at the cooling tank

Study 3. Effect of Incorporating the Vitamin A Fortificant in the Filler Tank in the Existing Fortification Process for Sweet and Creamy Peanut Butter of Tobi Marketing Inc.

This study aims to determine if changing the point of addition of the vitamin A fortificant from the cooling tank to the filler tank will uniformly disperse the vitamin A added and improve vitamin A recovery to acceptable levels. This study was undertaken after results of the previous study (FDC, 2006c) showed that the vitamin A recoveries obtained after addition of the vitamin A fortificant at the cooling tank at a mixing time of 5 and 10 min were still found to be low. Addition of the fortificant at the filler tank is expected to eliminate exposure of the vitamin A fortificant to air generated by mechanical mixing during the cooling step as well as prevent it from being exposed to the high temperature (82°C) of the product coming out from the colloid mill.

Procedure for Adding the Vitamin A Fortificant to Peanut Butter at the Filler Tank and Cooling Tank

Two production batches of ~155.24 Kg fortified sweet and creamy peanut butter were prepared at the collaborators plant under the supervision of FDC using the company's existing procedure for preparation of peanut butter matrix for receiving the vitamin A fortificant (Fig. 5b.3) and the FDC recommended procedure for adding the vitamin A fortificant at a weight ratio of 2.3286 g vitamin A palmitate in oil to every volume of ~38.81 Kg peanut butter (Fig. 5b.3). Two treatments were conducted as follows: (1) Addition of the vitamin A fortificant at the filler tank, and (2) Addition of the fortificant at the cooling tank (control).

Treatment 1. Addition of the vitamin A fortificant in the filler tank. For this treatment, the recommended mixing time of 10 min for adding the vitamin A fortificant to the peanut butter after each addition was not followed because according to the R&D Head of the collaborator's company, a waiting time of 10 min will cause the cooled product in the cooling tank to set making it difficult to transfer the product from the cooling tank to the filler tank. Thus, the vitamin A fortificant added to the 1st and 2nd volumes of peanut butter matrix in the filler tank was only mixed manually for 1-2 min while in the 3rd and 4th volumes of peanut butter, this was mixed mechanically for 5 min. A schematic diagram of the procedure for adding the vitamin A fortificant at the filler tank is shown in Fig. 5b.5.

Treatment 2: Addition of vitamin A fortificant at the cooling tank. The procedure for adding the vitamin A fortificant at the cooling tank for Treatment 2 followed the procedure described in Fig. 5b.4 with modifications on the manner of adding the fortificant. The modification made was adding of the vitamin A fortificant while the peanut butter from the 2nd grinding step was being transferred mechanically to the cooling tank instead of adding the fortificant after the entire ~38.81 Kg peanut butter has been transferred to the cooling tank as done in a previous study (FDC, 2006c). The modified procedure for adding the vitamin A fortificant at the cooling tank was as follows: While the peanut butter from the 2nd grinding step was being transferred to the cooling tank up to the level marked for ~38.81 Kg peanut butter, the pre-weighed vitamin A fortificant (2.3286 g) was added to the peanut butter matrix and manually mixed until no sign of the vitamin A fortificant was visible from the surface of the peanut butter matrix. The peanut butter with fortificant was then mixed mechanically for 10 min. This procedure was repeated each time another volume of ~38.81 Kg peanut butter was transferred to the cooling tank.

Four parts of ~38.81 Kg peanut butter from the cooling tank (See Fig. 4b.1)

↓

Mechanical transfer of 1 part of peanut butter to the filler tank

↓

1st addition of vitamin A fortificant on the surface of 1 part of peanut butter

↓

Manual mixing of vitamin A fortificant to 1 part of peanut butter for 1 – 2 min

↓

Mechanical transfer of another 1 part of peanut butter to the filler tank

↓

2nd addition of vitamin A fortificant on the surface of the 2nd part of peanut butter

↓

Manual mixing of vitamin A fortificant to 2 parts of peanut butter for 1 – 2 min

↓

Mechanical transfer of another 1 part of peanut butter to the filler tank

↓

3rd addition of vitamin A fortificant on the surface of the 3rd part of peanut butter

↓

Manual mixing of vitamin A fortificant with 3 parts
of peanut butter followed by mechanical mixing for 5 min

↓

Mechanical transfer of another 1 part of peanut butter to the filler tank

↓

4th addition of the vitamin A fortificant on the
surface of the 4th part of peanut butter

↓

Manual mixing of vitamin A fortificant with 4 part
of peanut butter followed by mechanical mixing for 5 min

↓

Automatic filling of fortified peanut butter in plastic bottles

↓

Removal of air from fortified peanut butter using a vibrating machine

↓

Conditioning/tempering of the fortified peanut butter in the cold storage area (10°C)

↓

Sealing and labeling of filled bottles

Fig. 5b.5 Schematic diagram of the procedure for adding the vitamin A fortificant at the filler tank

Study 4. Validation of the Recovery and Dispersion of Vitamin A in Fortified Sweet and Creamy Peanut Butter Prepared by the Direct Addition of the Fortificant at the Cooling Tank

This study was conducted to verify if the vitamin A recovery of 82.03% to 93.21% and dispersion of 6.54% obtained in a previous study (FDC, 2006d) can be replicated when the fortificant was added at the cooling tank as point of addition.

About 155.24 Kg of sweet and creamy peanut butter was fortified with vitamin A palmitate in oil at a ratio of 2.3286 g to every 38.81 Kg of the peanut butter matrix following the modified procedure for adding the fortificant at the cooling tank as done in Treatment 2 of the previous study (FDC, 2006d). The vitamin A fortificant was manually added while the peanut butter was being transferred to the cooling tank then mixed mechanically for 10 min after each addition. Two trials were conducted.

Preliminary Activities for Technology Transfer

Presentation of Plans for Technology Transfer and Impact Assessment to Industry Collaborator

The meeting with the Operations Manager and R&D Head for the presentation of plans for technology transfer resulted in the following: (1) Agreement of the Operations Manager to proceed with the implementation of the project even if the company has already an existing process for the vitamin A fortification of its flavored peanut butter. As an initial activity, FDC recommended the validation of the results of the direct addition procedure developed by the collaborator for the fortification of sweet and creamy peanut butter, one of six variants of flavored peanut butter currently produced by the company; (2) Agreement of the collaborator to provide the raw materials and other ingredients as well as use of their facilities for experiments to be conducted during the standardization of the fortification process at the industry collaborators processing plant; and (3) Agreement of the collaborator to provide data needed for the impact assessment of technology adoption such as but not limited to production volume, product sales, and marketing outlets before and after technology adoption.

Identification, Evaluation and Documentation of Suitability of Equipment in Collaborators Plant for Peanut Butter Production and Fortification

The collaborator's processing plant had a separate area for the roasting of peanuts and for peanut butter production. It also had a laboratory area where R&D work and product analysis were undertaken and a Cold storage area where peanut butter products were conditioned/tempered.

The processing plant was equipped with adequate facilities for peanut butter production and for fortification of the product with vitamin A. In particular, the stainless steel vessel used for mixing four volumes of peanut butter prior to the 2nd grinding step in the colloid mill, the cooling tank equipped with mechanical mixer and the filler tank equipped with mechanical mixer were identified as possible points of addition for the vitamin A fortificant to the peanut butter matrix.

Process Flow for the Production of Fortified Peanut Butter

Based on an interview with the R&D Head during the plant visit, the raw materials used in the production of peanut butter were roasted peanuts, refined sugar, iodized salt, stabilizers (Oleo flakes and distilled monoglyceride), and a cholesterol free vegetable oil to improve spreadability. The fortificant used in fortification was a vitamin A palmitate in oil with a declared assay of 1 Million IU/g (300,000 µgRE/g). The fortification process developed by the collaborator was a one-time direct addition of the

vitamin A fortificant to the peanut butter matrix. The schematic diagram of the collaborator's procedure for adding the vitamin A fortificant was presented in Fig. 5b.2.

GMP Seminar

The ½ day seminar entitled "Plant Inspection, Personnel Hygiene for Plant Workers" was conducted by Mr. Albert Cariso in the morning of March 4, 2006 at the collaborator's processing plant. It was attended by the Operations Manager and R&D Head together with thirty nine (39) production personnel. The participants were comprised of 14 production staff, 14 repackers, 2 from production utility, 3 machine operators, 1 from Roaster quality, 2 from kitchen, and 3 from Butterfield Commissary. The topics discussed were the following: Important Microorganisms in Food and Food Poisoning, Extraneous Matter (Filth) in Foods, Requirements for Personal Hygiene, and Cleaning and Disinfection.

The seminar was evaluated as excellent by 59.73% of the participants and 35.54% of the participants as very good.

Technology Transfer and Adoption

The improved technology for the vitamin A fortification of sweet and creamy peanut butter was transferred to the industry collaborator by demonstrating to the R&D Head the method of adding the fortificant at the cooling tank and the proper technique of mixing to the peanut butter matrix. A detailed description of the recommended process (Appendix A) for the vitamin A fortification of sweet and creamy peanut butter was likewise submitted to the industry collaborator on February 13, 2007.

RESULTS

Standardization of the Process at Collaborators Plant

Preliminary Verification of the Direct Addition Procedure Developed by the Industry Collaborator for the Vitamin A Fortification of Flavored Peanut Butter

Table 5b.1 shows the vitamin A contents and vitamin A recoveries of fortified sweet and creamy peanut butter that was processed by the direct addition procedure developed by the industry collaborator for the vitamin A fortification of its peanut butter.

Table 5b.1 Vitamin A content and vitamin A recovery of fortified peanut butter processed by the collaborator's direct addition procedure (FDC, 2006a)

Sampling point (during filling)	Vitamin A Added (µgRE/g)	Vitamin A Found (µgRE/g)	Vitamin A Recovery (%)
Start	14.99	4.38	29.24
Middle	14.99	19.10	127.38
End	14.99	8.47	56.48
Average	14.99	10.65	71.00
Std. deviation	0.00	7.60	50.66
% variability	0.00	71.32	71.32

Fortified sweet and creamy peanut butter taken at the start, middle and end of the filling operation into plastic bottles resulted in vitamin A contents of 4.384 µgRE/g, 19.10 µgRE/g and 8.468 µgRE/g, respectively or an average vitamin A content of 10.651 µgRE/g. Above data corresponded to vitamin A recoveries of 29.24%, 127.38% and 56.48% or an average vitamin A recovery of and a 71.03% and a variability of 71.32% (Table 5b.1). Vitamin A recovery was highest in fortified sweet and creamy peanut butter taken at the middle of the bottle filling operations, indicating that the vitamin A fortificant added was not fully dispersed at the top and bottom portions of the peanut butter matrix. Passing the fortified product in the colloid mill for the 2nd grinding step and mechanical mixing of the fortified product at the cooling tank and filling tank, did not help in the dispersion of the fortified product.

The highly viscous nature of peanut butter and the one-time addition of the vitamin A fortificant at the middle of the production batch, i.e. after two volumes of ~38 Kg peanut butter were transferred to the stainless steel vessel, were considered as the possible causes of low recovery and poor dispersion of the vitamin A in the fortified peanut butter. It is possible that when the vitamin A fortificant was added at the middle of the production batch (155.24 Kg) and subsequently mixed manually prior to the 2nd grinding in the colloid mill and mixing in the cooling tank equipped with mechanical mixer, the fortificant did not fully disperse to other portions of the sweet and creamy peanut butter, i.e. at the top and bottom of the production batch, resulting in a higher concentration of the vitamin A at the middle of the production batch.

To improve dispersion and recovery, it was recommended that the equivalent amount of vitamin A fortificant be added to each of the four volumes of ~38.81 Kg peanut butter in the stainless steel vessel after the 1st grinding step. The amount of vitamin A fortificant to be added is 2.3286 g to every ~38.81 Kg peanut butter. The incorporation of the vitamin A fortificant to the peanut butter matrix in four portions, each added after 25% of the volume of the production batch is transferred to the stainless steel vessel, is expected to lead to better recovery and dispersion of the vitamin A fortificant in the peanut butter.

Study 1. Effect of increasing the number of addition/mixing times of fortificant to peanut butter in the developed process of the collaborator for stabilized peanut butter.

Table 5b.2 shows the vitamin A content and vitamin A recovery of fortified sweet and creamy peanut butter processed by the four-time addition of the vitamin A fortificant at a weight ratio of 2.3286 g vitamin A palmitate in oil to every volume of ~38.81 Kg peanut butter.

Fortified sweet and creamy peanut butter samples taken at the start, middle and end of the filling operation in plastic bottles resulted in vitamin A contents of 4.472 µgRE/g, 4.826 µgRE/g and 4.964 µgRE/g, respectively or an average vitamin A content of 4.754 µgRE/g. These corresponded to vitamin recoveries of 29.95%, 32.32% and 33.25%, respectively for an average vitamin A recovery of 31.84% and a variability of 5.34% (Table 5b.2). The low vitamin A contents were attributed to the exposure of the fortificant to the heat generated in the colloid mill during the subsequent 2nd grinding step. The air incorporated during the subsequent mechanical mixing of the fortificant to the peanut butter matrix during the cooling and filling steps likewise could have contributed to the loss in vitamin A added.

Table 5b.2 Vitamin A content and vitamin A recovery of fortified sweet and creamy peanut butter prepared with the vitamin A fortificant added at a weight ratio of 2.3286g vitamin A palmitate in oil to ~38.81 Kg peanut butter (FDC, 2006b)

Sampling Point (during filling)	Vitamin A Added (µgRE/g)	Vitamin A Found (µgRE/g)	Vitamin A Recovery (%)
Start	14.93	4.47	29.95
Middle	14.93	4.83	32.32
End	14.93	4.96	33.25
Average	14.93	4.75	31.84
Std. deviation	0.00	0.25	1.70
% Variability	0.00	5.34	5.34

The vitamin A added however dispersed uniformly in the product as shown by the low variability of 5.34%. The percent variability obtained in this study was acceptable compared to the high 71.32% variability obtained in a previous study (FDC, 2006a) when a one-time addition of 9.3144 g vitamin A fortificant was added to two volumes of ~38.81 Kg peanut butter matrix. Thus, increasing the number of addition/mixing time of the vitamin A fortificant to the peanut butter matrix played an important role in improving the dispersion of the vitamin A added to the fortified sweet and creamy peanut butter.

To further improve vitamin A recovery, the point of addition of the vitamin A fortificant was recommended to be changed from before the 2nd grinding step to after the 2nd grinding step, to prevent the exposure of the vitamin A to heat generated during the 2nd grinding step. The method of addition of fortificant using a four-step process will be maintained.

Study 2. Effect of incorporating the fortificant in the cooling tank equipped with a mixer after the 2nd grinding step in the existing process for peanut butter production of the collaborator.

Table 5b.3 shows the vitamin A contents and vitamin A recoveries of fortified sweet and creamy peanut butter prepared with the fortificant added at the cooling tank at a mixing time of 5 and 10 min.

Table 5b.3 Vitamin A content and % vitamin A recovery of fortified peanut butter prepared with fortificant added at the cooling tank at 2 different mixing times (FDC, 2006c)

Sampling Point (during filling)	Mixing Time of Fortificant to Peanut Butter Matrix					
	Treatment 1 (5 min)			Treatment 2 (10 min)		
	Vit. A added (µgRE/g)	Vit. A found (µgRE/g)	Vit. A recovery (%)	Vit. A added (µgRE/g)	Vit. A found (µgRE/g)	Vit. A recovery (%)
Start	13.611	5.958	43.77	13.611	5.886	43.250
Middle	13.611	6.215	45.66	13.611	6.150	45.180
End	13.611	8.606	63.23	13.611	5.749	42.240
Average	13.611	6.926	50.89	13.611	5.928	43.560
Std. deviation	0.000	1.460	1.460	0.000	0.204	0.204
% Variability	0.000	21.090	21.090	0.000	3.430	3.430

Fortified sweet and creamy peanut butter processed by the direct addition of the fortificant at the cooling tank at a mixing time of 5 minutes resulted in vitamin A contents of 5.958 µgRE/g, 6.215 µgRE/g and 8.606 µgRE/g. Above data corresponded to vitamin A recoveries of 43.78%, 45.66% and 63.23% and a variability of 21.09%. Both the vitamin A recoveries and % variability were unacceptable as it indicates non-uniform dispersion of the vitamin A added to the peanut butter matrix. The vitamin A recoveries obtained in this treatment however were noted to be higher than the 31.84% average vitamin A recovery obtained in a previous study (FDC, 2006b) where the fortificant was added at the stainless steel vessel before the 2nd grinding step in a colloid mill.

On the other hand, mixing of the fortificant with the peanut butter matrix for 10 minutes resulted in vitamin A contents of 5.886 µgRE/g, 6.150 µgRE/g and 5.749 µgRE/g which corresponded to vitamin A recoveries of 43.25%, 45.18% and 42.24% (Table 5b.3). The average vitamin A recovery was 43.56% while the variability was 3.43%. Like Treatment 1, the vitamin A recoveries were relatively low. The vitamin A added however was noted to have uniformly dispersed in the peanut butter matrix as indicated by the low percent variability.

A comparative analysis of the results of vitamin A recovery in this study to the 31.84% average vitamin A recovery obtained in a previous study (FDC, 2006b) where the vitamin A fortificant was added before the 2nd grinding step, showed higher vitamin A recoveries when the vitamin A fortificant was

added after the 2nd grinding step. The increase in vitamin A recovery was attributed to the less exposure of the product to the heat generated during the grinding step in the colloid mill.

Since the improved vitamin A recoveries were still unacceptable, addition of the fortificant at the filler tank at a mixing time of 10 min was recommended to determine if vitamin A recovery can be further improved as product temperature (60°C) at this step is lower than the product temperature after the colloid mill (84°C) and the filler tank is equipped with a mechanical mixer.

Study 3. Effect of incorporating the fortificant in the filler tank in the existing fortification process for sweet and creamy peanut butter of Tobi Marketing Inc.

Table 5b.4 shows the vitamin A content, vitamin A recovery and percent variability of fortified sweet and creamy peanut butter processed with the fortificant added at the cooling tank and at the filler tank.

Fortified sweet and creamy peanut butter processed with the fortificant added at the filler tank resulted in vitamin A contents of 15.0 µgRE/g, 21.8 µgRE/g and 21.6 µgRE/g or an average vitamin A content of 19.5 µgRE/g. The data corresponded to vitamin recoveries of 111.86%, 162.57% and 161.07%, respectively for an average vitamin A recovery of 145.17% and a variability of 19.88% (Table 5b.4). The vitamin A recoveries and percent variability were both high, indicating non-uniform dispersion of the vitamin A added in the peanut butter matrix. Inadequate mixing due to poor mixer design was attributed as the possible cause of the non-dispersion of the vitamin A fortificant in the peanut butter. This is because when the 1st and 2nd volumes of ~38.81 kg peanut butter were added to the filler tank, it could not be adequately mixed with the vitamin A fortificant because the mixer did not reach the surface of the peanut butter matrix. As a result, it became necessary to manually mix the vitamin A fortificant at this stage.

On the other hand, mixing of the fortificant at the cooling tank resulted in vitamin A contents of 11.0 µgRE/g, 12.5 µgRE/g, 12.1 µgRE/g or an average vitamin A content of 11.9 µgRE/g. These corresponded to vitamin A recoveries of 82.03%, 93.21%, 90.23% for an average vitamin A recovery of 88.49% and a variability of 6.54% (Table 5b.4). The vitamin A recoveries and % variabilities were both acceptable. The relatively good recovery and low variability of the vitamin A contents were both acceptable as it indicates uniform dispersion of the vitamin A added in the fortified peanut butter. The vitamin A recoveries obtained in this treatment were likewise noted to be higher than those obtained in a previous study (FDC, 2006c) where the vitamin A fortificant was added at the same point of addition at the cooling tank. The higher recoveries of vitamin A obtained in this study were attributed to the following: (1) Lower temperature of the peanut butter during the addition of the vitamin A fortificant. It should be noted that in the previous study, the temperature of the peanut butter when the vitamin A fortificant was added ranged from 82–88°C while the temperature of the peanut butter in this study ranged only from 55–65°C. Since the vitamin A fortificant is sensitive to heat, the addition of the fortificant at lower temperatures may have prevented the loss of vitamin A; (2) Addition of the vitamin A fortificant while the peanut butter was being transferred to the cooling tank. In the previous study, the vitamin A fortificant was added after the complete transfer of about ~38.81 Kg peanut butter to the cooling tank. The former method of incorporating the vitamin A fortificant may have contributed to the more uniform dispersion of the vitamin A fortificant to the peanut butter because it introduces the fortificant from the start to the end of the transfer process.

Table 5b.4. Vitamin A content, % vitamin A recovery and % variability of fortified stabilized peanut butter processed with the vitamin A fortificant added at the filler tank and at the cooling tank (FDC, 2006d)

Sampling point (during filling)	Treatment 1 (Mixing at filler tank)			Treatment 2 (Mixing at cooling tank)		
	Vit. A added (µgRE/g)	Vit. A found (µgRE/g)	Vit. A recovery (%)	Vit. A added (µgRE/g)	Vit. A found (µgRE/g)	Vit. A recovery (%)
Start	13.41	15.0	111.86	13.41	11.0	82.03
Middle	13.41	21.8	162.57	13.41	12.5	93.21
End	13.41	21.6	161.07	13.41	12.1	90.23
Average	13.41	19.5	145.17	13.41	11.9	88.49
Std. deviation	0.00	3.87	3.87	0.00	0.77	0.77
% Variability	0.00	19.88	19.88	0.00	6.54	6.54

Considering the difference in the results of vitamin A recovery in this study and in the previous study (FDC, 2006b), it was recommended that the results of the Treatment 2 where the fortificant was added at the cooling tank after the 2nd grinding step, be confirmed through another trial.

Study 4. Validation of the recovery and dispersion of vitamin A in fortified sweet and creamy peanut butter prepared by the direct addition of the vitamin A fortificant at the cooling tank.

Table 5b.5 shows the vitamin A content, % recovery and % variability of vitamin A in fortified peanut butter prepared with the fortificant added at the cooling tank at a weight ratio of 2.3286 g vitamin A palmitate to ~38.81 Kg peanut butter.

Table 5b.5. Vitamin A content and % vitamin A recovery of fortified stabilized peanut butter with the vitamin A fortificant added at the cooling tank at a weight ratio of 2.3286 g vitamin A palmitate to 38.81 Kg peanut butter matrix (FDC, 2006e)

Sampling Point (during filling)	Trial 1			Trial 2		
	Vitamin A added (µgRE/g)	Vitamin A found (µgRE/g)	Vitamin A recovery (%)	Vitamin A added (µgRE/g)	Vitamin A found (µgRE/g)	Vitamin A recovery (%)
Start	13.94	5.907	42.37	13.94	5.562	39.90
Middle	13.94	5.488	39.37	13.94	4.932	35.38
End	13.94	5.585	40.06	13.94	4.962	35.60
Average	13.94	5.660	40.60	13.94	5.152	36.96
Std. deviation	0.00	0.219	1.57	0.00	0.360	2.55
% variability	0.00	3.870	3.87	0.00	6.900	6.90

Fortified sweet and creamy peanut butter prepared in Trial 1 resulted in vitamin A contents of 5.907 µgRE/g, 5.488 µgRE/g and 5.585 µgRE/g or an average vitamin A content of 5.66 µgRE/g. Above data corresponded to vitamin recoveries of 42.37%, 39.37% and 40.06% for an average vitamin A recovery of 40.60% and a variability of 3.87%. The low vitamin A recoveries were not comparable with the results of a previous study (FDC, 2006d) where vitamin A recoveries ranging from 82.03% - 90.23% were obtained. The vitamin A recoveries however were found to be comparable to the results of an earlier similar study (FDC, 2006b) where vitamin A recoveries ranging from 43.24% - 3.25% were obtained. The vitamin A added was noted to have uniformly dispersed in the peanut butter matrix as indicated by the low % variability. Based on a serving size of 2 tbsp (or 30 g) per serving at 2 servings per day, the vitamin A contents obtained in this trial ranged from 60 – 64% of the Recommended Energy and Nutrition Intake (RENI) which is equivalent to 3.05 µgRE.

When the same fortification process was repeated in Trial 2, vitamin A contents of 5.562 µRE/g, 4.932 µgRE/g and 4.962 µgRE/g were obtained. These values corresponded to vitamin A recoveries of 39.9 %, 35.38 % and 35.96 % giving an average vitamin A recovery of 36.96 % and a variability of 6.9 % (Table 5b.5). As in Trial 1, the vitamin A recoveries were low and the vitamin A added uniformly dispersed in the peanut butter matrix. The low recovery of vitamin A in this study was attributed to the exposure of the product to oxygen incorporated by the mechanical mixing of the fortified product during the cooling process.

Technology Transfer and Adoption

The improved technology consisting of a four-time addition of the fortificant to peanut butter at the cooling tank was adopted on February 28, 2007. According to the collaborator, the improved technology will also be adopted for its other peanut butter variants.

CONCLUSIONS

Based on the results of studies conducted in this project, it was noted that vitamin A recovery and dispersion can be affected by factors such as the point of addition, mixing time and manner in which the vitamin A forticant is added.

A one-time direct addition of the vitamin A fortificant to a peanut butter of large capacity was found to cause non-uniform dispersion of the vitamin A added. Since peanut butter is a highly viscous product, difficulty in dispersing the vitamin A fortifcant can take place, causing the vitamin A fortificant to concentrate on the area where this was added.

Increasing the number of addition/mixing times for incorporating the vitamin A fortificant to a peanut butter matrix, improved dispersion of the vitamin A in the fortified peanut butter. When the vitamin A fortificant was added at a weight ratio of 2.3286 g vitamin A palmitate in oil to 38.81 Kg peanut butter, the vitamin A added uniformly dispersed in the fortified product. Vitamin A recovery however, was noted to be low. The exposure of the vitamin A fortificant to heat generated in the colloid mill during the 2nd grinding step may have caused the loss of vitamin A thereby affecting the vitamin A recovery.

Changing the point of addition of the vitamin A fortificant from the stainless steel vessel before the 2nd grinding step to the cooling tank after the 2nd grinding step, was noted to have increased vitamin A recovery. The increase in vitamin A recovery was attributed to the less exposure of the fortified product to heat generated during the grinding step in a colloid mill.

Addition of the vitamin A fortificant to the filler tank in the collaborator's processing line is not recommended as dispersion of the vitamin A fortificant in the fortified product is affected.

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APPENDIX A

PROCEDURAL GUIDELINE FOR THE VITAMIN A FORTIFICATION OF THE SWEET AND CREAMY PEANUT BUTTER

Procedural Guideline for the Vitamin A Fortification of the Sweet and Creamy Peanut Butter

A. Procedure for the preparation of fortificant

1. Remove the fortificant from the cold storage area and let stand at ambient condition to allow the fortificant to return to its original state.

2. Weigh the required amount of fortificant, i.e. 2.3286 g vitamin A palmitate in a wide mouth opaque bottle with cover.

   (Note: Weighing of the fortificant should be done as fast as possible to prevent exposure of the fortificant to light and atmospheric oxygen as these factors contribute to the loss of vitamin A. A calibrated analytical balance is likewise recommended for weighing the fortificant to ensure the accurate measurement of the fortificant)

3. Cover the container immediately and set aside until intended use.

B. Procedure for the vitamin A fortification of about 155.24 kg of sweet and creamy peanut butter

1. Prepare the peanut butter matrix for receiving the fortificant. This is done by preparing four (4) volumes of sweet and creamy peanut butter according to the established formulation and process flow of the company up to the point in the process where the product has been subjected to a 2nd grinding step in a colloid mill.

2. Mechanically transfer one (1) volume of ~38.81 kg peanut butter from the stainless steel vessel to the cooling tank. While the peanut butter is being transferred to the cooling tank, slowly pour 2.3286 g vitamin A palmitate to the peanut butter matrix taking care not to splatter the fortificant on the blades of the cooling tank mixer. Pour a small amount of peanut butter into the container of the fortificant and scrape off adhering fortificant with the aid of a rubber spatula and add to the rest of peanut butter in the cooling tank.

3. Manually mix the fortificant with the peanut butter matrix with the aid of a stainless steel ladle until no sign of the fortificant is visible at the surface of the peanut butter matrix.

4. After manual mixing, mix the fortificant-peanut butter mixture mechanically for ten (10) minutes. Stop mixing after the required mixing time.

   (Note: Since the fortificant is sensitive to heat, oxygen and light, it is recommended that the cooling tank should be covered during the cooling step. It is important that the recommended mixing time of ten (10) minutes per addition of fortificant is followed as excessive mixing may cause incorporation of too much air in the product which could result in the fast degradation of the added fortificant.)

5. Repeat Steps 2 to 4 on another volume of ~38.81 kg peanut butter until all four (4) volumes of peanut butter has been transferred to the cooling tank and fortified.

6. When all four (4) volumes of peanut butter had been fortified, check if temperature of the peanut butter is 60°C. If temperature is higher than 60°C, continue mixing the product until the required temperature is reached. If temperature is lower than 60°C, transfer the fortified product mechanically to the filler tank.

7. When the cooled product has been completely transferred to the filler tank, immediately fill the fortified product in desired container sizes. Mechanically mix the fortified product while filling of the product is on-going to prevent the product from setting.

   (Note: Immediate filling of the product in desired container sizes when product temperature reaches 60°C is recommended to prevent long exposure of the fortified product to air incorporated during the mixing of the product at the cooling tank and filler tank. It should be noted that continuous mixing of the product allows the incorporation of more air into the product which could affect the vitamin A added)

8. Remove entrapped air from the filled bottles using a vibrating machine.

9. Cover the container with their lids.

   (Note: Immediate sealing of the filled bottles is recommended to prevent product contamination and exposure of the fortified product to light and atmospheric oxygen during the conditioning step.)

10. Transfer the sealed bottles to the cold storage area (10°C) and allow the product to temper/condition undisturbed based on the established conditioning time of the company.

11. After conditioning/tempering, put labels on the filled bottles and pack in corrugated cartons.

12. Store in a clean cool area.

The above procedure for the vitamin A fortification of sweet and creamy peanut butter calls for the direct addition of the fortificant at a weight ratio of 2.3286 g vitamin A palmitate in oil to ~38.81 kg volumes of peanut butter. These amounts represent 25% of the total volume of fortified peanut butter which is 155.4 kg peanut butter and 9.3144 g vitamin A palmitate. A schematic diagram of the FDC recommended process for the vitamin A fortification of sweet and creamy peanut butter is shown in Fig. 5b.6

Step No.	*Process Flow*
1	Prepare four volumes of ~38.81 kg sweet and creamy peanut butter up to the 2nd grinding step
	↓
2	Transfer one volume of ~38.81 kg sweet and creamy peanut butter to the cooling tank
	↓
3	Add the fortificant to the peanut butter matrix while the peanut butter is being transferred to the cooling tank
	↓
4	Get a small amount of peanut butter from the cooling tank and pour into the container of the fortificant
	↓
5	Scrape off adhering fortificant from the container with the use of a rubber spatula and add back to the peanut butter in the cooling tank
	↓
6	Manually mix the fortificant with the peanut butter until no sign of the fortificant is visible at the surface of the peanut butter matrix
	↓
7	Mechanically mix the fortificant-peanut butter mixture for ten minutes
	↓
8	Add another volume of ~38.81 kg sweet and creamy peanut butter to the cooling tank
	↓
9	Repeat Steps 3 to 9 until all four volumes of peanut butter has been transferred to the cooling tank
	↓
10	Check product temperature if $\leq$ to 60°C
	↓
11	If product temperature is $\geq$ 60°C, continue mixing until temperature drops to 60°C> (Optional)
	↓
12	If product temperature is $\leq$ 60°C, transfer product to the filler tank
	↓
13	Mechanically mix the fortificant in the filler tank while filling in plastic bottles is on-going
	↓
14	Remove entrapped air from the filled bottles using a vibrating machine
	↓
15	Cover the filled bottles immediately
	↓
16	Transfer the sealed bottles to a cold storage area (10°C) until the product has set
	↓

Step No.	*Process Flow*
17	Put label on the filled bottles
	↓
18	Pack filled bottles in master cartons
	↓
19	Store fortified peanut butter in a clean cool place

Fig. 5b.6 Schematic diagram of the FDC recommended process for the vitamin A fortification of sweet and creamy peanut butter

CHAPTER 6

A SANITATION STANDARD OPERATING PROCEDURE (SSOP) FOR THE MANUFACTURE OF VITAMIN A FORTIFIED PEANUT BUTTER

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ABSTRACT

This document describes the objectives, procedures for control and methods for inspection, recording and corrective action for eight areas requiring sanitary control during food processing. These areas are the following: (1) safety of the water supply, (2) cleanliness and condition of food contact surfaces, (3) prevention of cross-contamination, (4) maintenance of workers sanitary facilities, (5) protection of food, packaging materials and food contact surfaces from adulteration with contaminants, (6) labeling, storage and use of toxic compounds, (7) control of employee health conditions, and (8) exclusion of pests. The eight are taken from 21 CFR Part 123.11 of the U.S. Food and Drug Administration on Sanitation Control Procedures.

The sanitary procedures recommended in this document are adopted from the above reference using the Food Development Center's experience and a generic process for Vitamin A Fortification of Peanut Butter developed separately in this study. The document is in generic form and will require adaptation to processes and conditions existing in specific plants producing this product.

INTRODUCTION

A Sanitation Standard Operating Procedure (SSOP) Manual was developed by FDC to serve as the industry collaborator's guide in establishing plant hygiene and sanitation in its operations. Documented SSOP is one of the prerequisite programs of HACCP that must be effectively operating before the HACCP plan is developed and implemented (Ministry of Agriculture and Forestry - Food Assurance Group, 1999).

Establishment of a Sanitation Standard Operating Procedure (SSOP) and development of Hazard Analysis Critical control Point (HACCP) Plan were the outputs of the project on the development of a HACCP Based Quality Control Program for Vitamin A Fortified Peanut Butter. The project aimed to ensure that vitamin A peanut butter would be safe and consistent in quality per production batch that would lead to accreditation by the Department of Health's Sangkap Pinoy Seal Program.

OBJECTIVES

1. To develop a guide for the establishment of industry specific procedures for the control of sanitary practices in the manufacture of Vitamin A fortified peanut butter.
2. To ensure that the benefits of better nutritional quality in a vitamin A fortified product are not negated by problems arising from sanitation deficiencies.

METHODS

Establishment of Collaboration

The identified industry collaborator for this activity was the one that received the technology for vitamin A fortified peanut butter developed separately by FDC in this project (Proposal for R&D collaboration is shown in Appendix A).

As an initial activity, a Seminar on Good Manufacturing Practices (GMP) was conducted by FDC for 59 plant workers, manager, consultant and the owner of the plant. Two plant inspections were then conducted; the first inspection was to assess the initial plant condition and the second, to determine the extent of improvements made on the plant

The sanitary procedures for the eight areas in food processing requiring sanitation control prescribed in 21 CFR Part 123.10 of the USFDA, were modified and adopted to peanut butter manufacturing and vitamin A fortification.

The process for the Vitamin A fortification of peanut butter developed separately by the project for an industry collaborator was converted into a generic manufacturing procedure and used as the basis for the recommendations made.

The SSOP Manual developed by FDC was submitted to the industry collaborator for adoption. However, the plant has not implemented the SSOP for the following reasons: (1) the plant is old and needs major repair to comply with the GMP requirements; (2) a labor problem arise, and (3) there was a plan to transfer the plant to a better location.

RESULTS

The following is a recommended procedure for the control of sanitation in the manufacture of vitamin a fortified peanut butter. The industry collaborator was not able to adopt the SSOP due to the following:

1. Food plant is old and would need major repairs to be able to comply with GMP requirements

The owner of the plant seemed to be uninterested in doing major repairs to the plant because it is old. Based on an initial inspection conducted to determine compliance of the plant to GMP requirements, the plant is required to correct identified deficiencies to qualify for accreditation, but had not done so.

2. The company experienced a labor problem and was forced to stop production

The workers staged a strike against the management that forced the company to stop production.

3. The company planned to transfer to a new location

As a consequence of the strike, the company planned to transfer to a new location and is presently operating in Bulacan.

STANDARD SANITATION OPERATING PROCEDURE (SSOP) FOR THE CONTROL OF SANITATION IN THE MANUFACTURE OF VITAMIN A FORTIFIED PEANUT BUTTER[1]

(Name of Company)
(Address of Company)

CONTROL NO I. SAFETY OF WATER SUPPLY.

A. Objective:

To ensure a consistent supply of an adequate volume of potable water for use in food processing and other operations in a food plant. It includes water used in processing, personnel hygiene and cleaning of equipment and facilities.

B. Procedure:

1. **Water supply source**: Water should be supplied from a source that meets the standards shown in Appendix A. It should be analyzed by a reputable laboratory to check compliance with the standards. Deep well water should be checked for possible cross contamination by ground water and/ or during handling, prior to and when delivered to the plant.

2. **Evaluation of water quality and potability**: The water supply is checked daily for physical characteristics and monthly for microbiological quality. The procedure for evaluating the water for physical characteristics is in Appendix B. The results of evaluation are recorded in numbers 1.2 – 1.5 in Record No 1, Appendix C. The procedure for evaluating for microbiological quality is in Appendix D. Results are recorded in the Report of Microbiological Analysis, Record No. 2, Appendix E.

3. **Treatment with chlorine**: The water should be treated to ensure its potability at all times, such as chlorination. If chlorine treatment is used, the chlorine level of the water should be maintained at 0.25 to 1.0 ppm (WHO, 1984). A procedure for water chlorination is in Appendix F.

4. **Inspection and maintenance of chlorine level**: The required level of chlorine should be maintained by Engineering personnel. It is also checked daily by the assigned Quality Control personnel (QC personnel) every production shift or once a day if there is no processing operation. A procedure for checking the chlorine level is shown in Appendix G. Results of inspections are recorded in number 1.1 in the Daily Sanitation Inspection Checklist, Record No 1, Appendix C.

   The detection of a low chlorine level at anytime is immediately reported by assigned QC personnel to Engineering personnel through a Communication Slip, Record No. 3, Appendix H. Chlorine should be manually added immediately by Engineering or QC personnel or the production is stopped if the level required is not reached immediately. Engineering should check the water chlorinator machine and other possible sources of the problem and take action to ensure that the required chlorine level is reached.

5. **Storage of water supply**: Water is stored in a clean and fully enclosed water tank. The water tank is cleaned every three months by Engineering personnel or as necessary based on the results of inspection of QC personnel and as recorded in the Report on Inspection of Water Tank, Record No. 4, Appendix I. The Water Tank Cleaning Procedure is found in Appendix J.

C. Records

1. Standards for Water Quality (Appendix A)
2. Sampling and Evaluation of Water for Physical Quality (Appendix B)
3. Daily Sanitation Inspection Checklist (Record No. 1, Appendix C)
4. Sampling and Evaluation of Water for Microbiological Quality (Appendix D)
5. Report of Microbiological Analysis (Record No. 2, Appendix E)
6. Water Treatment Procedure for Chlorination (Appendix F)
7. Procedure for Checking of Chlorine Level (Appendix G)
8. Communication Slip (Record No. 3, Appendix H)
9. Report on Inspection of Water Tank (Record No. 4, Appendix I)
10. Water Tank Cleaning Procedure (Appendix J)

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[1] Adapted from: Hazard Analysis and Critical Control Point Training Curriculum. 2nd ed., 1997. Developed by the Seafood HACCP Alliance for Training and Education. Publication UNC-SG-96-02, North Carolina Sea Grant, Box 8605, N.C. State University, Raleigh, NC 27695-8605.919/515-2454.

CONTROL NO. II. CLEANLINESS AND CONDITION OF FOOD CONTACT SURFACES

A. Objectives

1. To ensure that all food contact surfaces are made of appropriate materials, can withstand repeated cleaning and sanitation and are free from pitting, cracks or crevices.

2. To ensure that food contact surfaces of equipment are properly cleaned and sanitized and free of chemical, microbiological and physical residues and or visible contaminants.

B. Procedures

1. **Inspection of condition of food contact surfaces and equipment:** Materials of all food contact surfaces and equipment should be smooth, non-corrosive, non-absorbent and non-toxic. The condition of equipment is checked daily by QC personnel and recorded in numbers 2.1a to d of the Daily Sanitation Inspection Checklist, Record No.1, Appendix C. Condition of equipment is audited monthly or as often as necessary by Engineering personnel. The results are recorded in numbers A.1 and A.2 of the Plant Audit Report, Record No. 5, Appendix K.

2. **Repair of equipment:** If the equipment used is found to be defective, QC will evaluate the defect together with engineering and recommend corrective action to prevent product quality deterioration. Processing may have to be stopped and if it does, QC should ensure that products are properly handled and stored to prevent spoilage. The QC report on the defect is given to Engineering for repair of the defect, through the Communication Slip, Record No. 3, Appendix H. Operations will resume only when the equipment is returned to good working condition. Repair activities should be scheduled by Production personnel so as not to affect processing activities or adjacent areas and equipment. Repair activities are recorded by Engineering in the Equipment History Record per equipment, a sample of which is shown in Record No. 6, Appendix L.

3. **Cleaning of equipment and utensils:** Equipment and utensils are cleaned at a frequency following an established schedule determined by the type and frequency of use of the item. All utensils and equipment are cleaned and sanitized daily at the end of every operation. Equipment Cleaning and Sanitizing Procedure for equipment used in the manufacture of vitamin A fortified peanut butter are shown in Appendixes M-1 and M-2.

4. **Inspection and recording:** QC personnel inspect the equipment and utensils for cleanliness at the following times: (a) prior to the start of a working day, (b) once per shift or after any work interruption during which the equipment or utensil may have become contaminated, and/or (c) after the scheduled cleaning operations. The QC personnel ensure that workers re-wash any equipment or utensil that drop on the floor or get in contact with dirty material. The results of inspection are recorded in numbers 2.1a to d of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C.

5. **Corrective action:** If results of inspection are not satisfactory, the operations will not commence or will be stopped if it is on-going, until cleaning, sanitizing and drying of particular equipment or utensils are satisfactorily carried out. The results of inspection are recorded in the Remarks

column of numbers 2.1 to 2.3 of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C.

6. **Storage of equipment and utensils**: Cleaned and sanitized equipment and utensils especially portable equipment are dried and stored in designated storage areas. QC inspects for proper storage and results are recorded in the Remarks column of numbers 2.1a to d of the Daily Sanitation Audit Form Record No. 1, Appendix C.

C. Records

1. Daily Sanitation Inspection Checklist (Record No. 1, Appendix C)
2. Plant Audit Report (Record No. 5, Appendix K)
3. Communication Slip (Record No. 3, Appendix H)
4. Equipment History Record (Record No. 6, Appendix L)
5. Daily Cleaning and Sanitizing Procedures for Equipment (Appendix M-1)
6. Weekly Cleaning and Sanitizing Procedures for Equipment (Appendix M-2)

CONTROL NO. III. PREVENTION OF CROSS – CONTAMINATION

A. Objectives

To ensure that raw materials, products and ingredients are not exposed to undue risk of contamination from personnel and workers and from operating practices and conditions.

B. Procedures

1. Procedure for Personnel

1.1 **Training**: All workers should attend a course that will provide proper instructions on personnel hygiene and good manufacturing practices. See Appendix N for the course outline. List of personnel that attend the course are kept on file as Record No. 7, Appendix O.

1.2 **Use of working garments:** All workers should be given clean working garments that protect food from contamination by street clothes, the mouth, face, hands and arms and head hair, as appropriate. Working garments will usually include aprons, head caps, facemask and footwear. Clean footwear is provided for use at the dry areas of the plant. All working garments should be worn prior to entry and while inside the processing plant and should not be worn outside of the processing area. These should also be in good condition and clean. If at any time these are soiled, they should be immediately replaced.

1.3 **Hand sanitation:** Plant personnel and workers entering the plant should wash and scrub their hands thoroughly with soap and water and sanitize and dry these prior to start of work, upon resumption to work and whenever hands are contaminated, i.e. used to handle waste, touch the floor or other unsanitary objects. Hands of personnel should not be re-contaminated by the washing and drying procedures used. To ensure this, foot operated water faucets, liquid soap and air drying of hands are recommended. Hands of workers selected randomly are subjected to swab test on a regular basis to validate efficiency of hand washing procedures. The procedure for hand swabbing is found in Appendix P.

Results are recorded in the Internal Report on Hand Swab Test, Record No. 8, Appendix Q.

1.4 **Hygiene and hygienic practices:** Plant personnel and workers should have clean fingernails, appropriately worn working gears, and appear clean. They should not wear jewelries, heavy cosmetics, lotions and perfumes on skin prior to entry to production areas. Eating, chewing gum, and drinking are prohibited. Personal belongings and clothing left by workers in the processing area should be immediately removed.

1.5 **Inspection:** The QC personnel is responsible for compliance with procedural requirements for sanitary practices of workers. He/she should maintain a strong sensitivity to worker compliance with sanitary procedures. Checks are made at the beginning of each production shift, after break times and prior to entry of workers in the plant.

1.6 **Corrective action and recording:** Non-compliant workers should not be allowed in the processing area. They should be called to a meeting to explain and remedy the problem. Violations are also an indication of inappropriate training. Re-training should be considered. Observations and corrective actions are recorded in numbers 3.1a to I of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C.

2. Control of operating practices and conditions inside the plant

2.1 **Working space:** There should be sufficient area for processing, packaging, ingredient storage, and finished product warehousing. Avoid overcrowding of people and equipment. Space and clear areas around, over and under the equipment must be adequate for efficient operation, maintenance and clean up (Katsuyama and Strachan, 1980).

2.2 **Layout:** There should be adequate separation of clean and dirty areas and/or materials. For example, the peanut butter should not be placed near raw materials, waste, refuse or laid directly on the floor.

2.3 **Inspection**: The QC personnel checks on the above conditions at the beginning of every production and at least once per shift or as often as necessary.

3. Corrective action and recording: If the above conditions are not met the operation should be stopped and the process layout re-arranged by the Production Supervisor. If the recommendations for space layout is not implemented products produced on the day should not be distributed, should be specially marked and/or put on hold for extensive sampling and quality evaluation. Observations and corrective action are recorded in numbers 3.2 to 3.4 of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C.

C. Records

1. Course Outline for An In-house Orientation Course on Good Manufacturing Practices (Appendix N)

2. List of Personnel Who Attended In-House Training on Good Manufacturing Practices (Record No. 7, Appendix O)
3. Procedure for hand Swabbing (Appendix P)
4. Internal Report on Hand Swab Test (Record No. 8, Appendix Q)
5. Daily Sanitation Inspection Checklist (Record No. 1, Appendix C)

CONTROL NO. IV. MAINTENANCE OF WORKERS SANITARY FACILITIES: SUCH AS HANDWASHING, HANDSANITIZING, LOCKER ROOMS AND TOILETS

A. Objectives

To ensure that the conditions of the sanitary facilities provided for workers do not pose a risk of contamination to products, materials and ingredients.

B. Procedures

1. **Provision of hand sanitizing equipment, soaps and sanitizers:** Hand washing stations and hand dryers located at the toilets, locker rooms, main entrance and at strategic places inside the processing areas should be functioning and properly supplied with liquid soap and sanitizing dips. An assigned worker should provide the latter prior to start of the processing operation. If requirements are not prepared in advance, workers should not be allowed to enter the plant until soap and chlorine dips are provided. If the hand dryer is not operational, disposable paper towels should be provided.

2. **Chlorination of hand dips:** The concentration of chlorine hand dips are maintained at 50 ppm and adjusted by the QC personnel if below this level.

3. **Maintenance of toilet and locker facilities:** The Engineering Section keeps the toilet and locker facilities operational and in good repair while the assigned worker keeps it clean based on the procedures for cleaning toilets and locker facilities described in Appendixes R and S.

4. **Inspection:** The QC personnel inspect hand washing provisions (1-2 above) daily. The condition of the toilets and locker area is inspected twice daily.

5. **Corrective action and recording:** QC will inform the Engineering section if toilets and locker rooms are not in good working condition and/or dirty through issuance of a Communication Slip, Record No. 3, Appendix H. After repair and/or cleaning activities, the QC personnel will inspect if results are acceptable. The results of inspection are recorded in numbers 4.1 to 4.5 of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C.

C. Records:

1. Procedure for Cleaning Toilets (Appendix R)
2. Cleaning Procedure for Locker Rooms (Appendix S)
3. Communication Slip (Record No. 3, Appendix H)
4. Daily Sanitation Inspection Checklist (Record No. 1, Appendix C)

CONTROL NO. V. PROTECTION OF FOOD, FOOD PACKAGING MATERIALS, AND FOOD CONTACT SURFACES FROM ADULTERATION WITH CONTAMINANTS

A. Objective

To ensure that the product, food contact surfaces and packaging materials are protected from adulteration with chemicals such as lubricants, fuel, pesticides, cleaning and sanitizing compounds, physical contaminants such as metal fragments and biological contaminants such as molds.

B. Procedures

1. **Procedures for plant premises**: The Engineering personnel ensure that plant premises and equipment such as floor, walls, ceilings, drainage canals, windows, non-food contact surfaces of equipment, lights and other fixtures inside the production area and equipment washing area are in good condition and clean at all times, otherwise repair and cleaning must be carried out.

   If repair condition of the plant and/or equipment is not acceptable such as leak, dripping, malfunctioning fans, busted lights, etc. and there is a need for immediate repair, the QC personnel will inform the Engineering through issuance of request for the implementation of necessary corrective action using Record No. 9, Appendix T. Engineering and QA personnel will coordinate schedules so that repair activities will not pose contamination to the product.

   If processing area and/or equipment are dirty, operation will not start until the area and/or equipment is cleaned by the assigned cleaning personnel. The QC personnel re-check the cleanliness of the area prior to start of operation.

2. **Provision of proper ventilation:** The Engineering personnel ensure that there is adequate ventilation to minimize odors. If odors are present, the area should be ventilated using fans and other air blowing equipment.

3. **Provision of adequate lighting:** The Engineering personnel ensure that there is adequate lighting in hand washing areas, locker rooms, toilets, food handling and storage areas. The lightings will be of the safety type or properly shielded.

4. **Control of lubricants:** The Engineering personnel ensure that food, food contact surfaces or food packaging materials are not exposed to lubricants, fuel, metal and any other contaminants that may come from the equipment. If process line becomes contaminated by any form of waste, lubricants or floor splash, the QC Officer will stop the operation and the section affected will be cleaned, sanitized and inspected before production starts again.

5. **Appropriate cleaning procedures:** The Production Supervisor ensures that cleaning procedures are done in a manner that will not pose contamination to food, food contact surfaces or food packaging materials. Cleaning activities should comply with the procedures described in Appendixes U to W. If inadequate cleaning was observed, all food contact surfaces should be re-cleaned and checked for cleanliness prior to start of operation. The QC personnel checks on these after every break time or whenever necessary and is recorded in number 5.6 of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C.

6. **Handling of raw materials:** The Production Supervisor ensures that raw peanuts and ingredients, i.e. sugar, refined salt, are packed in clean containers prior to acceptance and stored properly away from where food is handled or prepared. If raw peanuts and ingredients are packed in dirty containers, these will be transferred to a clean container prior to acceptance. The plant worker assigned in the receiving of raw materials will inform his supervisor and the supervisor will notify their supplier regarding this.

7. **Handling of product:** The Production Supervisor ensures that the peanut butter is properly handled during storage and transportation to prevent contamination and deterioration. The storage and transport facilities should be maintained at ambient condition (≈ 30°C) to prevent deterioration of the product. If temperature of the storage becomes high (≈35°C), adequate ventilation should be provided using fans.

8. **Inspection and recording**: The QC Officer checks on procedures 1-7 above daily. Observations are recorded in numbers 5.1 to 5.8 of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C.

C. Records

1. Request for Implementation of Corrective Measure (Record No. 9, Appendix T)
2. Cleaning Procedure for Loading Areas (Appendix U)
3. Cleaning Procedure at Workers' Eating Area (Appendix V)
4. Cleaning Procedure for Processing Rooms, Wash Rooms (Appendix W)
5. Daily Sanitation Inspection Checklist (Record No. 1, Appendix C)

CONTROL NO. VI. LABELING, STORAGE AND USE OF TOXIC COMPOUNDS

A. Objective

1. To ensure that toxic compounds such as cleaning and sanitizing compounds, compounds used for pest control, and compounds used for testing, maintenance and operations used in the plant are all necessary and are properly handled and stored to prevent contamination of the product.

2. To ensure that the vitamin A fortificant is properly handled and stored to prevent its degradation and inappropriate use.

B. Procedure

1. **Use and storage of toxic compounds**: Engineering personnel will use and store only those toxic compounds which are necessary for cleaning and sanitizing purposes, testing, maintenance and operation of plant equipment as listed in Appendix X. These compounds should be stored away from the production area and separate from raw materials, ingredients and packaging materials and should be immediately removed when found in areas where they are not supposed to be stored. QC personnel checks that toxic compounds and all chemicals are properly stored and labeled with a warning sign about their toxicity.

2. **Use of insecticides and rodenticides**: Insecticides, including household insecticides or rodenticides are used only under the supervision of a pest control officer or trained personnel.

3. **Handling and storage of Vitamin A fortificant**: QC ensures that Vitamin A fortificant, which is used to fortify peanut butter, is properly labeled and stored in a chiller, and that the packaging is intact to prevent leakage and contamination.

4. **Corrective action and recording**: In cases where the above requirements are not met and/or where spillage has unnecessarily occurred, or where there are obvious risks of food contamination resulting from the improper handling, use and storage of chemicals, production will be stopped and the affected areas thoroughly cleaned and sanitized as needed. The QC personnel inspect the area prior to resumption of operation. QC observations on the above are recorded in numbers 6.1 to 6.5 of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C.

C. Records:

1. List of Toxic Compounds Used in the Plant (Appendix X)
2. Daily Sanitation Inspection Checklist (Record No. 1, Appendix C)

CONTROL NO. VII. CONTROL OF EMPLOYEE HEALTH CONDITIONS

A. Objective

To ensure that all workers handling the product are free from any disease conditions that could contaminate the product.

B. Procedure

1. **Medical requirements**: Prior to employment, workers should be required to submit a copy of their medical certificate together with the results of X-ray, stool and urine analysis. All plant personnel are also required to undergo an annual medical examination, records of which are kept on file. The QC personnel checks on these and lists down workers with acceptable medical tests in the Workers File Form, Record No. 10, Appendix Y.

2. **Inspection**: The QC personnel observe the workers for any sign of medical problems daily before operations begin.

3. **Corrective action and recording**: Workers with observed ailments will either: (a) be given first-aid treatment, (b) reassigned to non-food handling tasks, and/or (c) sent home depending on the type of the ailment. Reassignment can only be applied to workers with minor cuts or bruises. Others will be sent home until they are fit to resume work. All observations are recorded in numbers 7.1 to 7.2 of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C.

C. Records

1. Workers File Form (Record No. 10, Appendix Y)
2. Daily Sanitation Inspection Checklist (Record No. 1, Appendix C)

CONTROL NO. VIII. EXCLUSION OF PESTS

A. Objective

To ensure that insects, rodents and other pests and animals have no access to food materials, ingredients, products and the processing plant.

B. Procedures

1. **Checking for and treatment of infestation**: The QC checks for signs of infestation daily and for gaps and possible entry points for insects and pests, weekly. If latter are found, engineering is informed to close the gaps and a Pest Control Officer, to apply treatment. These are carried out as soon as possible, with urgency. Pest control treatments are applied for so long as infestation is observed. Treatments carried out inside the plant such as placing insect and rodent repellants and/or baits at strategic areas, should not contaminate food products, equipment and facilities contained.

2. **Recording**: QC observations on infestation and treatments are recorded in numbers 8.1 to 8.2 of the Daily Sanitation Inspection Checklist, Record No. 1, Appendix C. Pest control treatments are recorded in the Pest Control Report, Record No. 11, Appendix Z by the Pest Control Officer or trained personnel.

C. Records

1. Daily Sanitation Inspection Checklist (Record No. 1, Appendix C)
2. Pest Control Report (Record No. 11, Appendix Z)

REFERENCES

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Oxoid. 1995. *The Oxoid Manual*. Compiled by Bridson, E. Y. 7th ed. p.5-6 – 5-7. Unipath Limited. Hampshire, England.

USFDA. 1997. *Code of Federal Regulations, Title 21, Part 123.10. HACCP Training Curriculum.* North Carolina Sea Grant. Box 8605, NC State University, Raleigh, NC.

World Health Organization. 1984. Guidelines for Drinking Water Quality. Volume 2. *Health Criteria and Other Supporting Information.* p. 11. Office of Publication. World Health Organization. Geneva, Switzerland.

SSOP APPENDIXES

Appendix No.	Record No.	Particulars
A		Standards for Water Quality
B		Sampling and Evaluation of Water for Physical Quality
C	1	Daily Sanitation Inspection Checklist
D		Sampling and Evaluation of Water for Microbiological Quality
E	2	Report of Microbiological Quality
F		Water Treatment Procedure for Chlorination
G		Procedure for Checking Chlorine Level
H	3	Communication Slip
I	4	Report on Inspection of Water Tank
J		Water Tank Cleaning Procedure
K	5	Plant Audit Report
L	6	Equipment History Record
M-1		Daily Cleaning and Sanitizing Procedure for Equipment
M-2		Weekly Cleaning and Sanitizing Procedure for Equipment
N		Course Outline for an In-House Orientation Course on Good Manufacturing Practices
O	7	List of Personnel Who Attended In-House Training Course on Good Manufacturing Practices
P		Procedure for Hand Swabbing
Q	8	Internal Report on Hand Swab Test
R		Procedure for Cleaning Toilets
S		Cleaning Procedure for Locker and Change Rooms
T	9	Request for Implementation of Corrective Measure
U		Cleaning Procedure for Loading Areas
V		Cleaning Procedure for Workers' Eating Areas
W		Cleaning Procedure for Processing Rooms, Wash Rooms
X		List of Toxic Materials Used in the Plant
Y	10	Workers File Form
Z	11	Pest Control Report

Appendix A

(Name of Company)

STANDARDS FOR WATER QUALITY

1. Odorless, colorless and free from any kind of flavor and taint.

2. Potable and conforms with the following microbiological specifications (WHO, 1984)

   a) Aerobic Plate Count : < 100 cfu per mL

   b) Coliforms : MPN per 100 mL = 3 in an occasional sample but not in consecutive samples

   c) *E. coli* : MPN per 100 mL = 0

Appendix B

(Name of Company)

SAMPLING AND EVALUATION OF WATER FOR PHYSICAL QUALITY

Materials Needed:

75 liters capacity, white utility drum

Procedure:

1. Choose two sources of tap water; one source that is directly connected with the main supply, and another source that is obtained from the water reservoir.
2. Collect about 50 liters of water from each source in two separate white utility drums.
3. Allow the water to settle.
4. Observe for quality of water, such as clarity, presence of sediments, sands, and color.
5. Record results in the Daily Sanitation Inspection Checklist.

Appendix C

(Name of Company)

DAILY SANITATION INSPECTION CHECKLIST
Record No. 1

Date of Inspection: _____
Shift : _____

Sanitary Condition/Practices	**Findings***		**Remarks**
	Time Checked ____	**Time Checked ____**	
1. Safety and Quality of Water Supply			
1.1 Chlorine level			
1.2 Clear, no sediments			
1.3 No discoloration			
1.4 No off odor			
1.5 No flavor taint			
2. Cleanliness and Condition of Food Contact Surfaces			
2.1 Equipment clean and sanitized			
a. Packaging equipment (Capping machine, filling machine)			
b. Processing equipment (Colloid mill, grinder, peanut roaster)			
c. Weighing equipment (Weighing scales)			
d. Tubs (Wash tub, basins)			
2.2 Presence of chlorine sanitizing solution for equipment and utensils			
2.3 Chlorine level of sanitizing solution: 100 ppm chlorine			
3. Prevention of Cross Contamination			
3.1 Personnel Sanitary Practices			
a. Personnel in complete and clean working gears			
b. Workers not wearing jewelries			

*** Note:** √ = acceptable, no deviation found
X = not acceptable, with deviation found
NA = not applicable

Appendix 3 Record No. 1 continued…

Sanitary Condition/Practices	Findings		Remarks
	Time Checked ____	**Time Checked ____**	
c. Workers with trimmed fingernails and without nail polish and heavy make-up			
d. Workers not eating, spitting or smoking inside plant premises			
e. Workers wash and sanitize hands whenever necessary			
f. Workers use hand dryers			
g. Equipment that touch dirty surfaces were washed and sanitized prior to use			
h. No personnel belongings and clothing left in food handling areas			
i. Others (please specify)			
3.2 Production area with adequate space			
3.3 Clean operations separated with dirty operations			
3.4 Product properly handled during production			
4. Maintenance of Workers Sanitary Facilities, such as Handwashing, Handsanitizing, Locker Rooms and Toilets			
4.1 Handwashing stations with liquid soap and chlorine dips			
4.2 Hand dryers in good repair			
4.3 Hand dips maintained at 50 ppm chlorine			
4.4 Toilets clean and in good repair			
4.5 Others (please specify)			
5. Protection of Food, Packaging Materials and Food Contact Surfaces From Adulteration with Contaminants			
5.1 Equipment for non-food contact surfaces clean and in good repair			
- stands, frames of equipment			
- motors			
- floor racks			
- others (specify)			

Appendix 3 Record No. 1 continued …

Sanitary Condition/Practices	Findings		Remarks
	Time Checked ____	**Time Checked ____**	
5.2 Production area with adequate ventilation			
5.3 Fans and air blowing equipment properly located inside the plant			
5.4 Areas properly lighted			
a. Handwashing areas			
b. Locker rooms			
c. Toilets			
d. Food Handling Areas			
e. Food Storage Areas			
5.5 Equipment lubricants away from food and food contact surfaces			
5.6 Cleaning activities done in appropriate manner			
5.7 Food additives containers clean			
5.8 Finished products properly handled during storage and transportation			
6. Labeling, Storage and Use of Toxic Compounds			
Cleaning and sanitizing compounds of approved type			
6.2 Toxic compounds stored in an area segregated from food, ingredients, packaging materials and food contact surfaces			
6.3 Toxic compound handled and used as required			
6.4 Cleaning and sanitizing compounds properly labeled and stored			
6.5 Food grade lubricants properly labeled and stored			
7. Control of Employee Health Conditions			
7.1 No worker with sign of illness			
7.2 No worker with wound or cuts on hands			
8. Control of Pests/Insects Inside Plant			
8.1 No entry points for animals, insects and pests			
8.2 No signs of insect/pest and animal activity inside the plant			

Checked by: _____

Reviewed by: _____

Date: _____

Remarks:

_____

_____

Appendix D

(Name of Company)

SAMPLING AND EVALUATION OF WATER FOR MICROBIOLOGICAL QUALITY

Materials needed:

Sterile polyethylene bags to contain at least 300 grams of ice
Sterile bottles with cover to contain at least 300 mL water
Alcohol lamp
Denatured alcohol
Match
Rubbing alcohol (for disinfecting hands)
Cotton balls
A pair of tongs or forceps
A piece of clean cloth (for wiping top)
A styropore box and ice for keeping samples

Procedure:

1. Ice sample
   a. Use an inverted sterile polyethylene bag as hand glove.
   b. Place ice sample (approximately 300 g) in double layer sterile polyethylene bag and seal.
   c. Keep refrigerated until analyzed.

2. Water sample
   a. Choose tap water which is directly connected with the main supply.
   b. Turn on the tap and allow water to run waste for 2-3 minutes. Then turn off. Dry the outer surface with a clean cloth.
   c. Sterilize the tap.
      c.1 Moisten a piece of cotton with denatured alcohol.
      c.2 Ignite and hold it with a pair of tongs (or forceps).
      c.3 Flame the top.
   d. Cool the tap by allowing water to run to waste for a few seconds.
   e. Open sample bottle. It should be held by the base in one hand while the cover is held by the other.
   f. Fill the bottle from a gentle stream of water. Avoid splashing. During the whole procedure, the cover and the mouth of the bottle should not be allowed to touch anything.
   g. Flame mouth of the bottle, then replace cap.
   h. Keep sample in refrigerated container during transport.

Appendix 4 continued…

Important points to remember when collecting samples:

1. Sample container should be sterile and should be kept unopened until it is required for filling.
2. The faucet should be clean.
3. Hands of the one collecting sample should be clean.
4. Care should be taken to avoid accidental contamination during collection.
5. Sample should be representative of the water to be examined.
6. The changes which occur in the bacterial content of samples can be reduced by transporting the sample to the laboratory in a refrigerated container.
7. Time between collection and examination of samples should be within six hours. It is important, however, that samples should be examined as soon as possible after collection.

Appendix E

(Name of Company)

REPORT OF MICROBIOLOGICAL QUALITY
Record No. 2

Report No. _____

Date: _____

Sample: Water
Source: _____ Plant
Package Description and Code: Packed in unlabeled glass bottle, uncoded
Number of Sample/s and Size: One (1) bottle of about 350 milliliters (mL)
Date Sample Submitted: _____
Date Sample Evaluated: _____
Type of Analysis and Purpose: Aerobic Plate Count as colonies per milliliter (col/mL, *Coliform* Count as Most Probable Number per one hundred mL (MPN/100 mL) and *E. coli* count (MPN/100 mL). [United States Food & Drug Administration. 1998. Bacteriological Analytical Manual. 8th ed. Revision A. Chapters 3 and 4. AOAC International, Gaithersburg. Maryland, USA], as requested by the Pilot Plant.
Reference Document: RAF # ILIS 02-011
Other Information: Sample submitted by _____
Result: (based on sample submitted):

Analysis	Result	Evaluation

This report shall not be reproduced **<u>except in full</u>** without the approval of the Food Development Center.

Evaluated by:

_____
Microbiology Section

Appendix F

(Name of Company)

WATER TREATMENT PROCEDURE FOR CHLORINATION

1. Prepare a chlorine stock solution

A chlorine stock solution of specific brand will be prepared to be used to treat the water for potability. Based on the declared available chlorine on the label, enough volume of chlorine stock solution with 10,000 ppm concentration will be prepared as follows:

1.1 Materials:

a. Calcium hypochlorite granules
b. Mortar and pestle
c. Weighing scale
d. Beaker or plastic container for weighing of chlorine granules
e. Glass or plastic stirrer
f. One-gallon plastic container for mixing chlorine granules and water to make a stock solution

1.2 Procedure:

a. Calculate for the amount of chlorine granules to be made into a stock solution using the formula

$$X_1 = \frac{P_2 X_2}{P_1}$$

where: X_1 = Amount of hypochlorite granules required to prepare the stock solution in Kg

P_1 = Percent available chlorine in the hypochlorite

P_2 = Percent available chlorine desired in the stock solution

X_2 = weight of stock solution to be prepared in Kg

Example:

How much hypochlorite granules is required to prepare 10,000 ppm (1%) chlorine concentration of a 3.78 (1 gallon) Kg stock solution, using hypochlorite granules with 70% available chlorine?

$$X_1 = \frac{P_2 V_2}{P_1}$$

$$X_1 = \frac{(1\%)\ (3.78\ Kg)}{70\%}$$

X_1 = 0.054 kg or 54 grams hypochlorite granules

b. Weigh 54 grams of hypochlorite granules. Place adequate amount of granules in a suitable container (e.g. mortar). Grind the granules using a pestle.

c. Transfer the ground granules in a beaker or plastic container. Add a small amount of water. Stir the mixture to dissolve the granules.

d. Decant the liquid and transfer to a plastic gallon.

e. Add a small amount of water to the remaining granules in the beaker or plastic container and repeat steps c and d until the required amount of liquid, which is 3.78 Kg is attained.

f. Transfer the remaining granules in the plastic gallon, replace plastic cap, and mix thoroughly by shaking the contents. Keep the plastic gallon tightly closed.

2. Chlorinate the water supply

The amount of chlorine stock solution required to be pumped out to chlorinate a volume of water is computed based on the flow rate of water that is pumped to the tank, or on the flow rate of water that is released from the tank which is distributed to the different water lines to obtain 0.5 ppm chlorine in the chlorinated water. The computation is as follows:

$$(C_1)\ (V_1) = (C_2)\ (V_2)$$

where: C_1 = concentration of the stock solution (10,000 ppm)
V_2 = volume of the required stock solution (unknown)
C_2 = concentration of the required chlorine solution (0.5 ppm)
V_2 = volume of water that is pumped to the tank or pumped from the tank based on the flow rate of water (e.g. 500 gal/min or 1890 L/min)

$$V_1 = \frac{C_2 \times V_2}{C_1}$$

$$V_1 = \frac{0.5\ ppm \times 1{,}890\ liters}{10{,}000\ ppm}$$

V_1 = 9.45 liters

Measure 9.45 liters stock solution and place in the chlorinator. This volume of stock solution is used to chlorinate 500 gallons or 1890 liters of water per minute to obtain 0.5 ppm free chlorine in the chlorinated water.

The chlorine stock solution is mixed with water with the aid of a lift pump. When the storage tank is filled with water or when water is released from the water tank, the amount of chlorine stock solution required to chlorinate a volume of water based on the flow rate of water is simultaneously mixed with the water.

Prepared by:

_____
QC personnel
Date: _____

Checked by:

_____
QA Supervisor
Date: _____

Appendix G

(Name of Company)

PROCEDURE FOR CHECKING OF CHLORINE LEVEL

Materials Needed:

Chlorine Test Kit, which includes the following:
Dispenser - for collecting water
DPD Test Ta–let No. 1 - to test for the residual chlorin–
Color Comparator - for determining the range of chl–rine level

Procedure:

1. Get water sample from faucet which is connected to the main supply.
2. Fill the dispenser with water up to the required level mark.
3. Get a DPD tablet from the kit and allow it to dissolve in the water sample in the dispenser.
4. Observe the change in color of the water with DPD tablet and compare with the comparator to determine the range of chlorine level in the water sample.
5. Record the results in the Daily Sanitation Inspection Checklist.

Appendix H

(Name of Company)

COMMUNICATION SLIP
Record No. 3

Date: _____
Time: _____

For:
From:
SUBJECT:

Details:

_____
Received by:

_____
Signature of QC Personnel

_____
Engineering Section

Appendix I

(Name of Company)

REPORT ON INSPECTION OF WATER TANK
Record No. 4

Report No. _____

Date: _____

Water Tank No. _____
Location: _____

Date Inspected: _____

Actions taken:

_____
_____
_____
_____
_____

Comments / Recommendations:

_____
_____
_____
_____
_____

Prepared by:

_____

Noted by:

_____
Plant Supervisor

Appendix J

(Name of Company)

WATER TANK CLEANING PROCEDURE

Materials to be used: High pressure water cleaner
Detergent
Scrubbing pad

Procedure:

1. Close the water service valves.
2. Water must be drained from a specified reservoir tank that will be cleaned by opening the drain valve.
3. When the tank is empty, scrub thoroughly all inner perimeter surface with unused scrubbing pad and freshly prepared detergent solution.
4. After scrubbing, rinse thoroughly all scrubbed surfaces with water using a pressurized washer.
5. Open the water service valves to rinse off remaining dirt.
6. Continue the rinsing procedure until the tank inner surfaces is free from any dirt, detergent and other foreign materials.
7. Drain the tank thoroughly before filling it with water.

Appendix K

(Name of Company)

PLANT AUDIT REPORT
Record No. 5

QC Report No. _____
Date: _____

Date of Inspection: _____
Time of Inspection: _____

FINDINGS	CORRECTIVE ACTION
A. EQUIPMENT	
1. The following equipment had rusty portions: 1.1 1.2 1.3	
2. The following equipment found to be defective: 2.1 2.2 2.3	
B. PROCESSING AREA	
1. Processing Room	
2. Packaging Room	
3. Wash Room	
4. Loading/Unloading Dock	

FINDINGS	CORRECTIVE ACTION
5. Workers Nook	
6. Locker Room (Male)	
7. Locker Room (female)	
8. Comfort room (male)	

Prepared by: Noted by:

_____ _____

Appendix L

(Name of Company)
EQUIPMENT HISTORY RECORD
Record No. 6

Equipment Name:	
Manufacturer / Supplier:	Property Code:
Type:	
Model:	
Serial No.	
Location:	
Date Received:	
Date Installed:	

Repair and Maintenance Activities

Date Started	Findings	Action Taken	Date Completed	Repaired by:

Reviewed by:

_____
Date:

Remarks:

_____
_____

Appendix M-1

(Name of Company)

DAILY CLEANING AND SANITIZING PROCEDURE FOR EQUIPMENT

EQUIPMENT A: Basins, Drums, Ladles

Frequency: End of processing, after last shift of production
Equipment: Wall unit hose, Hand brush, Pink sponge, Wash tub, Dipper
Chemical: Detergent powder, chlorine solution

Precautions and Preparations

1. Handle the equipment carefully to avoid dropping or banging. This may cause breakage or dents to the equipment.
2. Be sure to arrange the equipment carefully during cleaning.

Cleaning Procedures

1. Remove all solid waste using hands and put in the garbage bin.
2. Pre-rinse with water from the hose to remove adhering dirt.
3. Put small amount of detergent powder solution (1/4 dipper: 1 Basin), brush outside surface thoroughly and use pink sponge on the inside surface.
4. Dip the equipment in the wash tubs with water to rinse. Repeat as necessary.
5. Dip again in another wash tub containing 100 ppm of chlorine solution to sanitize it.
6. Arrange the equipment on an upside down position on top of the table. For the polylugs, same position but on the floor using the blue polylug as base. Let it dry.

Clean Up

1. Return all chemicals to proper storage area.

Appendix M-2

(Name of Company)

WEEKLY CLEANING AND SANITIZING PROCEDURE FOR EQUIPMENT

EQUIPMENT A: Peanut Roaster, Colloid Mill, Grinder, Filling Machine

Frequency: Weekly (preferably SatuRENIy) after last shift of peanut butter production
Equipment for Cleaning: Sponge (Blue for outside surfaces and Pink for inside surface), Wall Unit Hose, Wash Tub, Dippers
Chemicals: Detergent Powder, Chlorine Solution (20,000 ppm)

Precautions:

1. Be careful in moving the equipment from one place to another to avoid damaging the wheels.
2. Do not place too much weight on top or inside the equipment when moving it from other places.

Cleaning and Sanitizing Procedures:

1. Remove all solid wastes on top or inside the equipment by hand and collect in the garbage bin.
2. Rinse by hosing with water to remove adhering dirt.
3. Put small amount of detergent solution (1-liter dipper: 20 liter basin) on food contact surfaces using pink dipper and scrub with pink sponge. Dip the blue sponge in blue dipper containing detergent solution and scrub the equipment outside surfaces.
4. Rinse thoroughly by hosing with water.
5. Dip or splash equipment using dipper with 100 ppm chlorine solution to sanitize it.
6. Let it dry.

Clean Up:

1. Return detergent, chlorine and cleaning implements to proper storage area.

Appendix N

(Name of Company)

COURSE OUTLINE FOR AN IN-HOUSE ORIENTATION COURSE ON GOOD MANUFACTURING PRACTICES FOR WORKERS

1. Introduction to the seminar objective
2. The Hidden Enemies in a Manufacturing Plant
3. Requirements for Personal Hygiene and Cleanliness Inside a Manufacturing Plant

Appendix O
(Name of Company)

LIST OF PERSONNEL WHO ATTENDED IN-HOUSE TRAINING COURSE ON GOOD MANUFACTURING PRACTICES
Record No. 7

Date: _____
Name of Trainor: _____
Client Name: _____

Name of Employee	Position	Signature

Prepared by: _____

Noted by: _____
Date: _____
Remarks: _____
_____
_____

Appendix P

(Name of Company)

PROCEDURE FOR HAND SWABBING

Materials Needed:

Sterile cotton swab
15 mL Ringers solution (Oxoid, 1995)
Screw cap test tube
Sterile aluminum template, with 5 cm x 1 cm hole
Alcohol lamp
Denatured alcohol
Match
Rubbing alcohol
Ice chest with ice

Procedure:

1. Moisten a sterile cotton swab with 15 mL Ringers solution. Remove excess Ringers solution by rotating the cotton swab against the wall of the test tube. Remove the swab aseptically.
2. Swab the hand by moving the cotton through a 5 cm x 1 cm hole of a sterile aluminum template. Move the cotton back and forth through the hole five times, rotating the cotton each time to insure that the entire cotton swab made contact with the hand.
3. Return the cotton swab into the Ringers solution and excess liquid is removed by pressing the wall of the tube.
4. Repeat swabbing using the same cotton swab on two other areas of the same hand.
5. After swabbing the third area, place the swab inside the test tube, break the wooden stick leaving about 1 inch of the stick with the swab.
6. Cap the test tube and shake.
7. Label test tube and place in the ice chest.
8. Keep sample in refrigerated container during transport.
9. Time between swabbing and analysis of samples should not exceed six hours.

Appendix Q

(Name of Company)

INTERNAL REPORT ON HAND SWAB TEST
Record No. 8

Worker's Name	**Date of Swab Test**	**Results**	**Remarks/ Action Taken**	**Analyzed by:**

Reviewed by: _____
Date: _____

Remarks: _____
_____
_____

Appendix R

(Name of Company)

PROCEDURE FOR CLEANING TOILETS

Frequency: Start of the day or as necessary (General cleaning every SatuRENIy)
Equipment: Floor Polisher with mechanical husk and brush, Mop, Brush, Scrubbing Pad
Chemicals: Easy White Toilet Bowl Cleaner, Detergent Powder

Precautions and Preparations:

1. Remove all solid wastes from waste bin in the toilet.
2. Avoid using harsh chemicals that will damage the bowl.

Cleaning Procedures:

A. Monday to Friday

a.1 Remove remaining solid wastes by sweeping the floor and put it in the garbage bin.
a.2 Put small amount of easy white toilet bowl cleaner on the bowl and scrub using brush and scrubbing pad.
a.3 Rinse with water from the hose and wipe with dry cloth.
a.4 Mop the floor.
a.5 Empty the garbage bin. Replace with new garbage bag.

B. SatuRENIy

b.1 Remove remaining solid wastes by sweeping the floor and put it in the garbage bin.
b.2 Put small amount of easy white toilet bowl cleaner on the floor and scrubbed using floor polisher.
b.3 Rinse with water from the hose and mop to dry.
b.4 While polishing the floor small amount of toilet bowl cleaner is poured on the bowl and leave it there until polishing is finished.
b.5 The bowl is scrubbed using brush and scrubbing pad.
b.6 Rinse with water from the hose and wipe with dry cloth.

Clean Up:

1. Return detergent and cleaning equipments to proper storage area.

Appendix S

(Name of Company)

CLEANING PROCEDURE FOR LOCKER AND CHANGE ROOMS

Frequency: Start of the Day
Equipment: Floor polisher with mechanical husk and brush, mop,
Chemical: Easy white toilet bowl cleaner, detergent powder

Precautions and Preparations:

1. Remove all things left in the locker.
2. Throw the garbage in the garbage bin.

Cleaning Procedures:

1. Sweep the floor and ceiling with brooms.
2. Put "easy white" solution on floors.
3. Use polisher to make the floor white and shine.
4. Mop the floor to dry.

Clean Up:

1. Return detergents and cleaning equipment to proper storage area.

Appendix T

(Name of Company)

REQUEST FOR IMPLEMENTATION OF CORRECTIVE MEASURE
(Record No. 9)

Report No. _____
Date: _____

Date of new request	Nature of new request	Findings based on previous request / date of previous request	Date of implementation of new request	Comments

Prepared by: _____
Date: _____

Noted by: _____
Date: _____

Appendix U

(Name of Company)

CLEANING PROCEDURE FOR LOADING AREAS

Frequency: Start and End of the Production or as necessary
Equipment: Wall unit house, broomstick, dustpan, push brush, pressurized hose, floor polisher
Chemical: Detergent powder, chlorine solution (300 ppm)

Precautions and Preparations:

1. Remove all foodstuffs, packaging materials or other items in the way or those that should not be soaked or contaminated.

Cleaning Procedures:

1. Collect solid wastes/dirt by using broomstick and dust pan and put in the garbage bin.
2. Rinse with water from the hose.
3. Put detergent powder solution and scrub using floor polisher or push brush.
4. Rinse with water from the hose or pressurized hose.
5. Use dipper to splash the whole area with 300 ppm chlorine solution to sanitize.
6. Lower portion of loading dock is cleaned by brushing the rubber lining and sidings with soap and water.
7. Rinse with water from the hose.

Clean Up:

1. Return all tools and chemicals to proper storage area.

Appendix V

(Name of Company)

CLEANING PROCEDURE FOR WORKER EATING AREAS

Frequency: Start of the day, after every break time
Equipment: Broomstick, dust pan, clean rags
Chemical: Detergent powder, chlorine solution (300 ppm)

Precautions and Preparation:

Not Applicable

Cleaning Procedures:

1. Remove solid wastes and dirt on top of the table by wiping and put in garbage bin.
2. Wipe table with rags dipped in detergent solution and chlorinated water.
3. Wipe again with dry cloth.
4. Wipe with rags the side portion of the sink, no food particles should be left on the sink.
5. Sweep solid wastes on the floor by broomstick and dust pan.
6. All wastes material removed from worker's nook should be thrown on garbage bins near the back gate.

Clean Up:

1. Return all tools to proper storage area.

Appendix W

(Name of Company)

CLEANING PROCEDURE FOR PROCESSING ROOMS, WASH ROOMS

Frequency: Start and End of the Day; Before break time or as necessary
Equipment: Wall unit house, broomstick, dustpan, push brush, pressurized hose
Chemical: Detergent powder, chlorine solution (300 ppm)

Precautions and Preparations:

1. Remove all foodstuffs, packaging materials, portable equipment or other items in the way, or those that should be soaked or contaminated.
2. Cover all electrical outlets.
3. Clean equipment in the area before cleaning the floor

Cleaning Procedures:

1. Remove all railing and clean with broomstick.
2. Collect all solid wastes/dirt by the use of broomstick and dust pan.
3. Scrub walls, plastic curtains, floors and drainage canal (in this order) with detergent solution ensuring all adhering dirt and/or molds, slime, if any, are removed.
4. Rinse with water. Repeat as necessary.
5. Used pressurized hose on railings, if necessary
6. After the entire area is cleaned, rinse with clean water and sanitize with chlorine solution (300 ppm).

Clean Up:

1. Return all tools and chemicals to proper storage area.

Appendix X

(Name of Company)

LIST OF TOXIC MATERIALS USED IN THE PLANT

A. Used for Cleaning and Sanitizing

1. Hi- Chlon 70 Nisso (Calcium hypochlorite)
2. Detergent Powder

B. Used for Pest Control

1. Bayer Premise Cockroach Bait
2. Bayer Blattanex Aerosol
3. Bayer Baygon Aerosol
4. Bayer Blattanex E.C.
5. Bayer Mafu 25 E.C.
6. Solfac W. P.
7. Baygon Fly Bait

C. Used for Testing, Maintenance and Operation

1. Lubriplate
2. American Super Hi-temp Lithium grease
3. WD-40
4. LPS Bolt Dressing
5. Havoline Motor Oil
6. Boysen Enamel Paints
7. Paint Thinner

Appendix Y

(Name of Company)

WORKERS FILE FORM
Record No. 10

Name of worker	**Medical requirements ***			
	Medical certificate	**X-ray results**	**Stool analysis**	**Urine analysis**

***** Please check column if the worker has acceptable medical result.

Prepared by: _____

Noted by: _____
Date: _____
Remarks: _____
_____
_____

Appendix Z

(Name of Company)

PEST CONTROL REPORT
Record No. 11

Date of Treatment	Purpose	Type of Treatment Applied	Location	Remarks	Conducted by:

Reviewed by: _____
Date: _____

Remarks: _____
_____
_____

CHAPTER 7

DEVELOPMENT OF A GENERIC HAZARD ANALYSIS CRITICAL CONTROL POINT (HACCP) PLAN FOR VITAMIN A FORTIFIED PEANUT BUTTER

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ABSTRACT

This generic Hazard Analysis Critical Control Point (HACCP) Plan was prepared for manufacturers of vitamin A fortified peanut butter. It aims to serve as a guide to ensure product safety during manufacture and that levels of vitamin A consistently meet the requirements of local regulations. The Plan is based on observations made at an industry collaborator's plant using the technology for vitamin A fortification established separately by the project. Procedures at FDC for the preparation of a HACCP Plan by a HACCP Team with diverse but relevant experience on a product were adopted.

The major hazards identified were the potential presence of aflatoxin in raw peanuts and the possibility of excessive addition of vitamin A during production. Aflatoxin is a known hazard in both unfortified and fortified peanut butter but its control in a fortified product is critical because of the possibility of consumption by nutrient deficient consumers. Over addition of vitamin A on the other hand, could lead to toxic levels of the nutrient.

To implement this generic Plan, personnel from the company with knowledge of the HACCP principles are needed to adopt and handle the implementation.

INTRODUCTION

Development of a generic HACCP plan was one of the outputs of the project on the development of a HACCP Based Quality Control Program for Vitamin A Fortified Peanut Butter. The project aimed to ensure that vitamin A peanut butter would be safe and consistent in quality per production batch that would lead to accreditation by the Department of Health's Sangkap Pinoy Seal Program.

The generic HACCP plan for vitamin A fortified peanut butter was developed by FDC to serve as the industry collaborator's guide to ensure product safety during manufacture and that levels of vitamin A consistently meet the requirements of local regulations.

OBJECTIVES

The objective of the study was to develop a generic Hazard Analysis Critical Control Point (HACCP) Plan to help companies produce vitamin A fortified peanut butter that is safe and which consistently meets the requirements for vitamin A fortification of foods by the Department of Health.

METHODS

Preliminary Activity

Observations were made on the process for vitamin A addition in peanut butter manufacture. This was carried out at the plant of an industry collaborator which received the technology for vitamin A fortified peanut butter developed separately by FDC in this project.

Creation of the FDC HACCP Plan Team

After several plant visits and interviews, FDC created its HACCP Plan Team which carried out the analysis of hazards and other tasks required in the development of a HACCP Plan. The HACCP Plan Team was led by Edith M. San Juan, Supervising Research Specialist and was supported by Jocelyn M. Sales, Division Chief, Fe R. Vito, Supervising Research Specialist, and Alberto R. Cariso Jr., Division Chief. Dr. Alicia O. Lustre, Director, FDC-NFA, reviewed the analysis and the developed Plan.

Hazard Identification and Ranking

Potential hazards were identified based on scientific literature and results of FDC's applied research or experience. Market regulations also provided a clue to potential hazards. The identified hazards were evaluated and ranked as to severity and likelihood of occurrence using the risk ranking model of the Netherlands Product Board Animal Feed (PDV, 2001) shown in Appendix A. The rank of

the identified hazard determined the type of control measure that would be necessary to control the hazard.

Determination of critical control points (CCPs)

CCPs were identified using the Codex CCP Decision Table. CCPs are points in the process where control measures should be adapted to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

Development of the HACCP Plan Form

This form identifies the CCPs, prescribes the control measures to be adopted at each CCP, the critical limits for each control measure, corrective actions to be taken when needed, monitoring and recording procedures to ensure that all control measures are properly implemented and procedures for independent verification that the Plan is implemented as prescribed and documented. The contents were developed by the HACCP Team.

Contents of the HACCP Plan

This HACCP Plan has ten sections, the definitions of which are described in Appendix B. The ten sections are: (1) the pre-requisite requirements, (2) scope, (3) product description and intended use, (4) initial food safety objectives (FSOs), (5) process flow diagram, (6) process description, (7) hazard analysis, (8) critical control point determination, (9) HACCP Plan form development, and (10) HACCP Plan verification. The approaches used for each section were based on recommendations of the Codex Alimentarius Commission (1997), for sections 1, 2, 3, 5, 7, 8, 9 and 10; the Meat Industry Association (MIA, 1999) and the Ministry of Agriculture and Forestry (MAF, 1999) of New Zealand for section 4; Price (1996) for section 6; and the Netherlands Product Board Animal Feed (PDV, 2001) for the ranking of hazards.

Technology Transfer

A one-day seminar on HACCP was conducted by FDC on March 10, 2000 to orient the HACCP Team of Newborn Food Products, Inc. on the principles of HACCP and the steps for its implementation. The HACCP Team of the collaborator was composed of five personnel from the management, production and research.

Reasons for Non-Adoption of the SSOP by Newborn Food Products, Inc.

1. Processing plant failed to comply with GMP requirements

Due to non-compliance to GMP requirements, the company was unable to adopt the HACCP Plan developed for their product. Several plant deficiencies remained uncorrected and the developed SSOP was still not implemented.

2. HACCP is not mandatory

As HACCP is not mandatory for peanut butter, the management was not pressured to comply with its requirements. However, the management decided to control one critical control point (CCP) in their process, and this is the sorting step for aflatoxin infected kernels.

RESULTS

GENERIC HACCP PLAN FOR VITAMIN A FORTIFIED PEANUT BUTTER

Table of Contents

	Page
Generic HACCP Plan for Vitamin A Fortified Peanut Butter	224
Section 1. Pre-requisite Requirements	225
Section 2. Scope of the HACCP Plan	225
Section 3. Product Description and Intended Use	225
Section 4. Food Safety Objectives (FSOs)	226
Section 5. Process Flow Diagram	227
Section 6. Process Description	230
Section 7. Hazard Analysis	234
Section 8. Critical Control Point (CCP) Determination	240
Section 9. HACCP Plan Form	245
Section 10. Validation of the HACCP Plan	247
References	248
Records	
Record No. — Title of Record	
1 — Weights of Fortificant Monitoring Record	250
2 — Corrective Action Report	251
3 — Weighing Scale In-house Calibration Record	252
4 — Weights of Peanut Butter Premix Monitoring Record	253
Appendixes	
A — Risk Assessment Model for Determining the Risk Level of a Hazard of the Product Board Animal Feed (PDV)	255
B — Ten Components of a HACCP Plan	256
C — Recommended Prerequisite Requirements for HACCP of New Zealand	259
D — Components of the Prerequisite Program for HACCP of the United States	260

GENERIC HACCP PLAN FOR VITAMIN A FORTIFIED PEANUT BUTTER

Section 1. Pre-requisite Requirements

Prior to implementing a HACCP Plan, pre-requisite programs for Good Manufacturing Practices and Sanitation should be documented and effectively implemented. These programs can be based on Codex Principles of Food Hygiene and appropriate Codex Codes of Practice (CAC, 1997). A list of recommended pre-requisites of the Ministry of Agriculture and Forestry–Food Assurance Group of the New Zealand (MAF, 1999) is shown in Appendix C as an example. In the United States, the pre-requisite program for HACCP is the Sanitation Standard Operating Procedure (USFDA, 1997. 21 CFR 123; USFDA, 2001. 21 CFR 120), the components of which are listed in Appendix D.

Section 2. Scope of the HACCP Plan

This Plan applies to controlling biological, chemical and physical hazards to acceptable levels from receipt of raw shelled peanuts and other raw materials, production of the premix, addition of vitamin A to the peanut butter and storage and transport of the product.

Section 3. Product Description and Intended Use

3.1 Product name	Vitamin A Fortified Peanut Butter
3.2 Important product characteristics, composition, physical/chemical structure, processing treatments	Vitamin A fortified peanut butter has a deep brown color and a fine smooth texture, with a characteristic roasted peanut odor and flavor and a moderately sweet taste. The product has a vitamin A content of 8.5 – 11.6 μg retinol/g peanut butter or 340 – 464 μg retinol for a serving size of 40 g. The product should meet minimum requirements for physical, sensory, chemical, and microbiological qualities of regulatory agencies, and buyers. The product is produced by mixing plain peanut butter with a premix consisting of peanut butter with added vitamin A.
3.3 Packaging	The product is packed in glass jars with metal caps or in plastic jars and caps.
3.4 Shelf life and storage requirements	At ambient temperatures* of 30°C and normal conditions of handling, the product has a shelf life of 6 months. (*Philippine ambient conditions[1])

[1] Information taken from the shelf life study conducted on the product as per PCRSP Final Report for Project 3.2.13C (Obtaining *Sangkap Pinoy* Seal for Vitamin A Fortified Peanut Butter for the Department of Health).

Section 3 (continued)

3.5 Method of distribution	The product is distributed at ambient conditions all over the country at a temperature of 30°C. It is unlikely to be stored for long periods of time.
3.6 Intended use	Ready-to-eat or as an ingredient in food preparations.
3.7 Intended consumers	The general public.

Section 4. Food Safety Objectives (FSOs) [2]

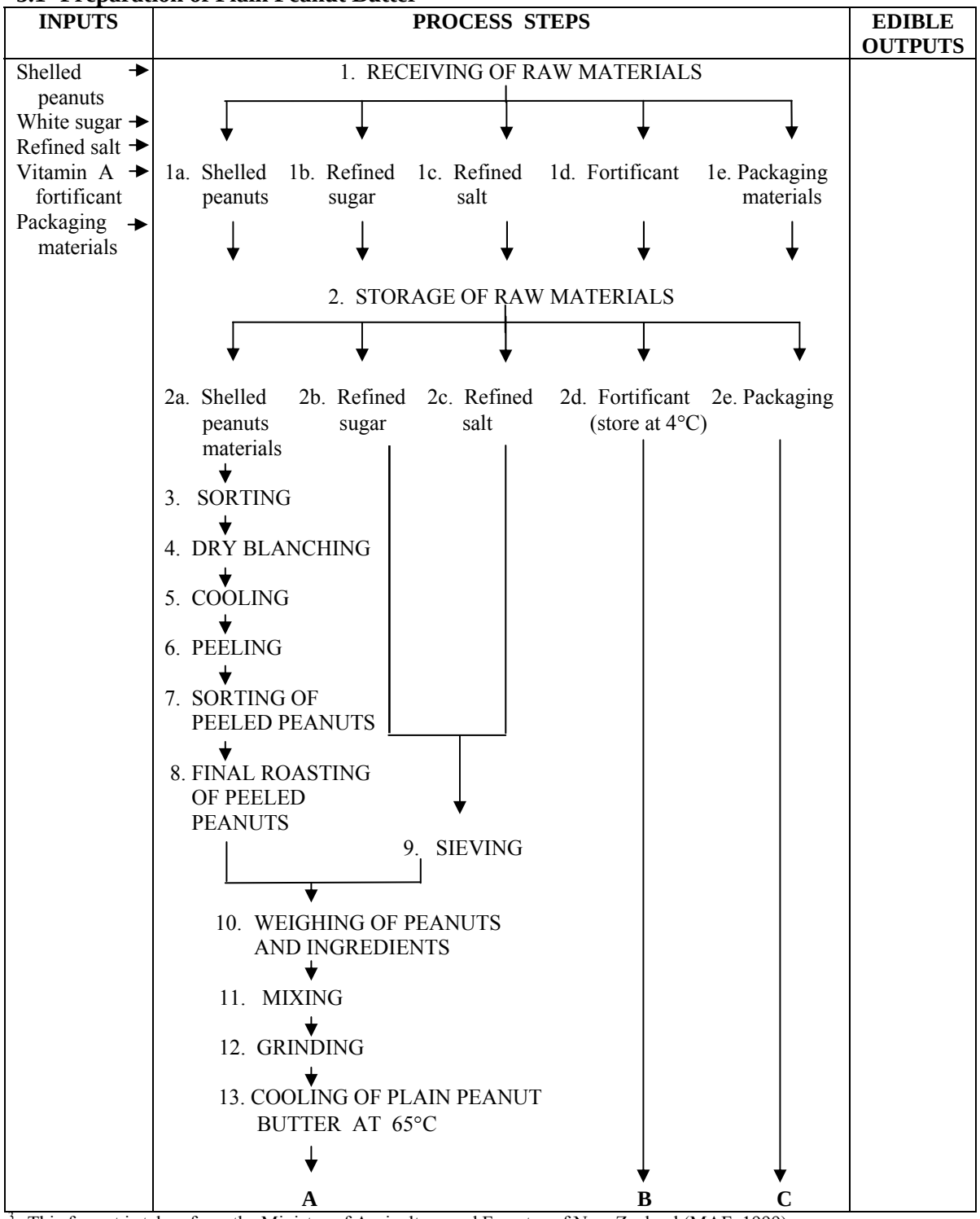
FSO1: To ensure that the correct amount of vitamin A fortificant is present in the peanut butter premix and in the vitamin A fortified peanut butter. The peanut butter premix, is peanut butter to which a known amount of vitamin A fortificant has been added at levels that will ensure that the right amount of vitamin A is in the final fortified product after incorporation of the premix.

Basis: Addition of excessive amounts of the fortificant to the premix or of excessive amounts of premix at the final mixing stage, could make the product toxic.

[2] This format is taken from the Meat Industry Association of New Zealand (MIA, 1999).

Section 5. Process Flow Diagram for Vitamin A Fortification of Peanut Butter [3, 4]

5.1 Preparation of Plain Peanut Butter



[3] This format is taken from the Ministry of Agriculture and Forestry of New Zealand (MAF, 1999).

[4] Process flow is based on actual on-site observation and the information furnished by a collaborator to the Food Development Center

5.2 Preparation of Peanut Butter Premix

INPUTS	PROCESS STEPS	EDIBLE OUTPUTS
	A **B** **C**	
Vitamin A Fortificant →	14. BRINGING OF FORTIFICANT TO AMBIENT TEMPERATURE, 30°C	
Plain peanut Butter →	15. WEIGHING OF FORTIFICANT AND PLAIN PEANUT BUTTER	
	16. MANUAL MIXING	
	17. MIXING IN A HORIZONTAL MIXER	
	18. WEIGHING AND PACKING OF PEANUT BUTTER PREMIX	
	A **D** **C**	

5.3 Preparation of Fortified Peanut Butter

INPUTS	PROCESS STEPS	EDIBLE OUTPUTS
	A **D** **C**	
Plain peanut butter →	19. WEIGHING OF PLAIN PEANUT BUTTER	
Peanut butter premix →	20. PRELIMINARY MIXING OF PEANUT BUTTER PREMIX INTO PLAIN PEANUT BUTTER	
	21. MIXING IN HORIZONTAL MIXER	
Packaging materials →	22. MANUAL FILLING ← Glass / plastic jars	
	23. SEALING ← Metal / plastic caps	
	24. PACKING ← Master	
	25. STORAGE AND DISTRIBUTION	→ Vitamin A fortified peanut butter packed in glass or plastic jars

Section 6. Process Description [5,6]

6.1 Preparation of Plain Peanut Butter

STEP	DETAILED DESCRIPTION
1. RECEIVING OF RAW MATERIALS	
1a. Shelled peanuts	Shelled peanuts are inspected for defects (moldy and damaged peanuts) and cleanliness based on the company's sampling plan. Only lots that are within specifications are accepted for processing.
1b. Refined sugar	Refined sugar is inspected for appearance such as color, dryness, impurities and general cleanliness based on the company's sampling plan. Only lots that are within specifications are accepted for processing.
1c. Refined salt	Refined salt is inspected for appearance such as color, dryness, impurities and general cleanliness based on the company's sampling plan. Only lots that are within specifications are accepted for processing.
1d. Vitamin A fortificant	Vitamin A fortificant is obtained from reputable suppliers. A certificate from the supplier indicating that the product contains the level of vitamin A declared on the label, is required before the fortificant is received. Upon receipt the fortificant is immediately stored at 4°C and is unopened until use.
1e. Packaging materials	New and unused packaging materials are purchased from approved suppliers and inspected for cleanliness upon receipt.
2. STORAGE OF RAW MATERIALS	
2.a Shelled peanuts	Shelled peanuts are stored in sacks in a clean and dry warehouse.
2.b Refined sugar	Refined sugar is stored in a clean and dry storage warehouse.
2.c Refined salt	Refined salt is stored in a clean and dry storage warehouse.
2d. Vitamin A fortificant	Vitamin A fortificant is stored at 4°C.
2.e Packaging materials	Packaging materials are stored on pallets in the storage warehouse.
3. SORTING	Shelled peanuts are manually sorted to eliminate damaged or moldy kernels.

[5] This format is taken from Price (1996).
[6] This process is based on the study of the Food Development Center.

STEP	DETAILED DESCRIPTION
4. DRY BLANCHING	Sorted shelled peanuts are roasted to a specified color at a specified time and temperature. During roasting, peanuts are agitated for even roasting of kernels (PCRSP, 2002).
5. COOLING	Roasted peanuts are cooled to a maximum temperature of 65°C in a stainless steel vat with the use of a blower. Peanuts are agitated or mixed thoroughly with a stainless steel paddle to hasten cooling.
6. DE-SKINNING	The skin of the peanuts breaks loose from the kernel during the cooling step as the nuts are agitated with a stainless steel paddle. The loose skins are manually removed with the aid of a blower.
7. SORTING OF DE-SKINNED PEANUTS	De-skinned peanuts are 100% sorted for damaged or moldy kernels.
8. FINAL ROASTING OF DE-SKINNED PEANUTS	Sorted peanuts are again roasted to the desired color at a specified time and temperature.
9. SIEVING	Refined sugar and salt are sieved to remove iron and metal filings and other foreign matters such as hair, dirt, tiny pieces of stones, wood and plastic materials.
10. WEIGHING OF PEANUTS AND INGREDIENTS	Pre-determined amounts of de-skinned peanuts, refined sugar and refined salt are weighed which correspond to one production batch of plain peanut butter.
11. MIXING	The ingredients are mixed manually in stainless steel drums or vats before passing through the grinder.
12. GRINDING	Grinding of the mixture is done by passing it through a mill at a specified setting. The mixture is ground until a very smooth and thick paste known as peanut butter is obtained.
13. COOLING OF PLAIN PEANUT BUTTER AT 65°C	The peanut butter is transferred to stainless steel vats after grinding to cool. The product is brought to room temperature before use in the preparation of peanut butter premix for fortified peanut butter. The temperature of the plain peanut butter must not exceed the maximum limit of 65°C as significant losses in vitamin A will take place at temperatures higher than 65°C (Willich *et al*., 1954).

6.2 Preparation of Peanut Butter Premix

STEP	DETAILED DESCRIPTION
14. BRINGING FORTIFICANT TO AMBIENT TEMPERATURE, 30°C	Vitamin A palmitate, which is stored in the chiller at 4°C, is allowed to come up to room temperature of 30° overnight prior to use. This is done to obtain a homogeneous distribution of vitamin A in the oil. Storage of the fortificant in a chiller causes crystallization of the fortificant. The entire content is then portioned into smaller amounts equivalent to that required for a single production batch of peanut butter premix.
15. WEIGHING OF FORTIFICANT AND PLAIN PEANUT BUTTER	Plain peanut butter and vitamin A are weighed accurately. The fortificant is weighed in a top loading balance in a wide-mouthed amber colored bottle with cover.
16. MANUAL MIXING	The fortificant and plain peanut butter are mixed manually in a stainless steel container. The fortificant is added directly at the center of the container of the pre-weighed plain peanut butter and mixed immediately to protect the fortificant from light. Before mixing, the internal temperature of the plain peanut butter should not be more than 65°C to prevent degradation of the fortificant when added. A small amount of the pre-weighed peanut butter is added into the container of the fortificant to scrape off any adhering fortificant. The peanut butter/fortificant mixture is mixed manually in circular strokes using a rubber spatula until no sign of the fortificant is visible at the surface of the peanut butter mixture.
17. MIXING IN HORIZONTAL MIXER	The mixture is transferred to the horizontal mixer for thorough mixing of the peanut butter and fortificant. The mixer is set to low speed for even mixing for 10 minutes. The mixer is turned off every five minutes to scrape off peanut butter mixture that splatters at the sides of the mixer. The temperature of the mixture is monitored so as not to exceed 65°C during mixing.
18. WEIGHING AND PACKING OF PEANUT BUTTER PREMIX	Peanut butter premix is weighed and packed in rigid plastic containers with cover. The weight per container is equivalent to that required for use in a production batch of the vitamin A fortified product.

6.3 Preparation of Fortified Peanut Butter

STEP	DETAILED DESCRIPTION
19. WEIGHING OF PLAIN PEANUT BUTTER	A specified amount of plain peanut butter is weighed which is equivalent to that required in the incorporation of peanut butter premix for one production batch of vitamin A fortified peanut butter.
20. PRELIMINARY MIXING OF PEANUT BUTTER PREMIX INTO PLAIN PEANUT BUTTER	The plain peanut butter and the peanut butter premix are mixed in a stainless steel container. The premix is added to the center of the plain peanut butter. Adhering premix in its original plastic container is scraped off with a spatula by adding a small amount of the pre-weighed plain peanut butter. The mixture is mixed in circular strokes using a rubber spatula.
21. MIXING IN HORIZONTAL MIXER	The mixture is transferred to a horizontal mixer for thorough mixing of the peanut butter and peanut butter premix. The temperature of the mixture is monitored so that this does not exceed 65°C. The product coming out of the horizontal mixer is the vitamin A fortified peanut butter.
22. MANUAL FILLING	The fortified peanut butter product is poured manually into the filling machine and filled to the desired weights of a given container size.
23. SEALING	The filled jars are covered and sealed with metal or plastic caps.
24. PACKING	The product in glass jars and/or plastic jars is packed in master cartons and coded.
25. STORAGE AND DISTRIBUTION	The product is stored and distributed at ambient condition.

Section 7. Hazard Analysis [7]

(1) Process Step	(2) Potential hazard at each step *(Hazard Identification)*	(3) Risk Ranking *(Hazard Characterization)*					(4) Target Value [9]	(5) Type of Control Measure Required [10]
		(3.1) Chance or Probability of Occurrence in the end product; at consumption		(3.2) Severity or Seriousness of the hazard if it occurs		(3.3) Risk Level[8]		
		Rank	Justification	Rank	Justification			
A. PREPARATION OF PLAIN PEANUT BUTTER								
1. RECEIVING OF RAW MATERIALS								
1a. Shelled peanuts	None							
1b. Refined sugar	None							
1c. Refined salt	Nome							
1d. Vitamin A fortificant	None							
1e. Packaging materials - Glass jars with metal caps - Plastic jars with Plastic Caps	None							

[7] This worksheet is adapted from the Product Board Animal Feed of the Netherlands (PDV, 2001).
[8] Risk levels, i.e. 1, 2, 3, 4 based on the risk assessment model of the Product Board Animal Feed (PDV, 2001), see Appendix A.
[9] Target value or the standards in the legislation (PDV, 2001).
[10] Type of control measure required for the identified risk level, i.e. Periodic, GMP (Good Manufacturing Practice), or CCP (critical control point) control measures (PDV, 2001), see Appendix A.

(1) Process Step	(2) Potential hazard at each step *(Hazard Identification)*	(3) Risk Ranking *(Hazard Characterization)*					(4) Target Value [9]	(5) Type of Control Measure Required[10]
		(3.1) Chance or Probability of Occurrence in the end product; at consumption		(3.2) Severity or Seriousness of the hazard if it occurs		(3.3) Risk Level [8]		
		Rank	Justification	Rank	Justification			
2. STORAGE OF RAW MATERIALS								
2.a. Shelled peanuts	None							
2.b. Refined sugar	None							
2c. Refined salt	None							
2d. Vitamin A fortificant	None							
2e. Packaging materials	None							
3. SORTING	None							
4. DRY BLANCHING	None							
5. COOLING	None							
6. DE-SKINNING	None							
7. SORTING OF DE-SKINNED PEANUTS	None							
8. FINAL ROASTING OF DE-SKINNED PEANUTS	None							

(1) Process Step	(2) Potential hazard at each step *(Hazard Identification)*	(3) Risk Ranking *(Hazard Characterization)*					(4) Target Value [9]	(5) Type of Control Measure Required [10]
		(3.1) Chance or Probability of Occurrence in the end product; at consumption		(3.2) Severity or Seriousness of the hazard if it occurs		(3.3) Risk Level [8]		
		Rank	Justification	Rank	Justification			
9. SIEVING								
10. WEIGHING OF PEANUTS AND INGREDIENTS	None							
11. MIXING	None							
12. GRINDING	None							
13. COOLING OF PLAIN PEANUT BUTTER AT 65°C	None							
14. PREPARATION OF PEANUT BUTTER PREMIX								
15. BRINGING OF FORTIFICANT TO AMBIENT TEMPERATURE, 30°C	None							

(1) Process Step	(2) Potential hazard at each step *(Hazard Identification)*	(3) Risk Ranking *(Hazard Characterization)*					(4) Target Value [9]	(5) Type of Control Measure Required [10]
		(3.1) Chance or Probability of Occurrence in the end product; at consumption		(3.2) Severity or Seriousness of the hazard if it occurs		(3.3) Risk Level[8]		
		Rank	Justification	Rank	Justification			
16.WEIGHING OF FORTIFICANT AND PLAIN PEANUT BUTTER	Excessive amount of fortificant due to incorrect weighing of fortificant	Medium	Excessive amounts of fortificant due to incorrect weighing could occur because the amount of fortificant used is small and is not pre-weighed at source according to the requirements of a production batch.	Great	Vitamin A in excessive amount is toxic to the consumer.	4	Established amount of fortificant to plain peanut butter, 40g fortificant to 40 Kg plain peanut butter	CCP
17. MANUAL MIXING	None							
18. MIXING IN A HORIZONTAL MIXER	None							
19. WEIGHING AND PACKING OF PEANUT BUTTER PREMIX	Excessive amount of fortificant due to incorrect weighing of peanut butter premix	Medium	Excessive amount of fortificant due to incorrect weighing is likely to occur during production if the weighed amount of plain peanut butter is not the correct requirement of a production batch.	Great	Vitamin A in excessive amount is toxic to the consumer.	4	Established amount of premix to plain peanut butter, 4 Kg premix to 100 Kg plain peanut butter	CCP

(1) Process Step	(2) Potential hazard at each step *(Hazard Identification)*	(3) Risk Ranking *(Hazard Characterization)*					(4) Target Value [9]	(5) Type of Control Measure Required [10]
		(3.1) Chance or Probability of Occurrence in the end product; at consumption		(3.2) Severity or Seriousness of the hazard if it occurs		(3.3) Risk Level [8]		
		Rank	Justification	Rank	Justification			
20. PREPARATION OF VITAMIN A FORTIFIED PEANUT BUTTER								
21. WEIGHING OF PLAIN PEANUT BUTTER	Inadequate weight of plain peanut butter	Small	The proportion of plain peanut butter to the weight of peanut butter premix may be incorrect if weight of plain peanut butter does not meet the weight required in the preparation of vitamin A fortified peanut butter.	Great	The occurrence of inadequate weight of plain peanut butter will result in excessive level of vitamin A in the fortified peanut butter.	3	Established amount of premix to plain peanut butter, 4 Kg premix to 100 Kg plain peanut butter	GMP
22. PRELIMINARY MIXING OF PEANUT BUTTER PREMIX INTO PLAIN PEANUT BUTTER	None							
24. MIXING IN HORIZONTAL MIXER	None							

(1) Process Step	(2) Potential hazard at each step *(Hazard Identification)*	(3) Risk Ranking *(Hazard Characterization)*					(4) Target Value [9]	(5) Type of Control Measure Required [10]
		(3.1) Chance or Probability of Occurrence in the end product; at consumption		(3.2) Severity or Seriousness of the hazard if it occurs		(3.3) Risk Level [8]		
		Rank	Justification	Rank	Justification			
24. MANUAL FILLING	None							
25. SEALING	None							
26. PACKING IN CARTONS	None							
27. STORAGE AND DISTRIBUTION	None							

Section 8. Critical Control Point (CCP) Determination

Process Step	*Hazards identified as requiring CCP control measures in Section 7*	Q1 Do control measure(s) exist? If Yes = Proceed to Q2 If No= Proceed to Q1a	Q1a Is control at this step necessary for safety? If Yes = Modify step, process or product. If No = Not a CCP. Proceed to next identified hazard	Q2 Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level? If Yes=CCP If No= Proceed to Q3	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable level(s)? If Yes= Proceed to Q4 If No= Not a CCP. Proceed to next identified hazard	Q4 Will a subsequent step eliminate identified hazard(s) or reduce likely occurrence to acceptable level? If Yes= Not a CCP. Proceed to next identified hazard If No= CCP	CCP No.
A. PREPARATION OF PLAIN PEANUT BUTTER							
1. RECEIVING OF RAW MATERIALS							
1a. Shelled peanuts	None						
1b. Refined sugar	None						
1c. Refined salt	None						
1d. Vitamin A fortificant	None						
1e. Packaging materials	None						
2. STORAGE OF RAW MATERIALS	None						
2a. Shelled peanuts							
2b. Refined sugar	None						
2c. Refined salt	None						
2d. Vitamin A fortificant	None						
2e. Packaging materials	None						
3. SORTING	None						
4. DRY BLANCHING	None						

Process Step	*Hazards identified as requiring CCP control measures in Section 7*	Q1 Do control measure(s) exist? If Yes = Proceed to Q2 If No= Proceed to Q1a	Q1a Is control at this step necessary for safety? If Yes = Modify step, process or product. If No = Not a CCP. Proceed to next identified hazard	Q2 Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level? If Yes=CCP If No= Proceed to Q3	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable level(s)? If Yes= Proceed to Q4 If No= Not a CCP. Proceed to next identified hazard	Q4 Will a subsequent step eliminate identified hazard(s) or reduce likely occurrence to acceptable level? If Yes= Not a CCP. Proceed to next identified hazard If No= CCP	CCP No.
5. COOLING	None						
6. DE-SKINNING	None						
7. SORTING OF DE-SKINNED PEANUTS	None						
8. FINAL ROASTING OF DE-SKINNED PEANUTS	None						
9. SIEVING	None						
10. WEIGHING OF PEANUTS AND INGREDIENTS	None						
11. MIXING	None						
12. GRINDING	None						
13. COOLING OF PLAIN PEANUT BUTTER AT 65°C	None						

Process Step	*Hazards identified as requiring CCP control measures in Section 7*	Q1 Do control measure(s) exist? If Yes = Proceed to Q2 If No= Proceed to Q1a	Q1a Is control at this step necessary for safety? If Yes = Modify step, process or product. If No = Not a CCP. Proceed to next identified hazard	Q2 Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level? If Yes=CCP If No= Proceed to Q3	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable level(s)? If Yes= Proceed to Q4 If No= Not a CCP. Proceed to next identified hazard	Q4 Will a subsequent step eliminate identified hazard(s) or reduce likely occurrence to acceptable level? If Yes= Not a CCP. Proceed to next identified hazard If No= CCP	CCP No.
14. PREPARATION OF PEANUT BUTTER PREMIX							
15. BRINGING OF FORTIFICANT TO AMBIENT TEMPERATURE, 30°C	None						
16. WEIGHING OF FORTIFICANT AND PLAIN PEANUT BUTTER	Excessive level of fortificant due to incorrect weighing of fortificant	Yes	NA	Yes	NA	NA	CCP 1
17. MANUAL MIXING	None						
18. MIXING IN A HORIZONTAL MIXER	None						

Process Step	*Hazards identified as requiring CCP control measures in Section 7*	Q1 Do control measure(s) exist? If Yes = Proceed to Q2 If No= Proceed to Q1a	Q1a Is control at this step necessary for safety? If Yes = Modify step, process or product. If No = Not a CCP. Proceed to next identified hazard	Q2 Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level? If Yes=CCP If No= Proceed to Q3	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable level(s)? If Yes= Proceed to Q4 If No= Not a CCP. Proceed to next identified hazard	Q4 Will a subsequent step eliminate identified hazard(s) or reduce likely occurrence to acceptable level? If Yes= Not a CCP. Proceed to next identified hazard If No= CCP	CCP No.
19. WEIGHING AND PACKING OF PEANUT BUTTER PREMIX	Excessive level of fortificant due to incorrect weighing of premix	Yes	NA	Yes	NA	NA	CCP 2
20. PREPARATION OF VITAMIN A FORTIFIED PEANUT BUTTER							
21. WEIGHING OF PLAIN PEANUT BUTTER	None						
22. PRELIMINARY MIXING OF PEANUT BUTTER PREMIX INTO PLAIN PEANUT BUTTER	None						
23. MIXING IN HORIZONTAL MIXER	None						
24. MANUAL FILLING	None						

Process Step	*Hazards identified as requiring CCP control measures in Section 7*	Q1 Do control measure(s) exist? If Yes = Proceed to Q2 If No= Proceed to Q1a	Q1a Is control at this step necessary for safety? If Yes = Modify step, process or product. If No = Not a CCP. Proceed to next identified hazard	Q2 Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level? If Yes=CCP If No= Proceed to Q3	Q3 Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable level(s)? If Yes= Proceed to Q4 If No= Not a CCP. Proceed to next identified hazard	Q4 Will a subsequent step eliminate identified hazard(s) or reduce likely occurrence to acceptable level? If Yes= Not a CCP. Proceed to next identified hazard If No= CCP	CCP No.
25. SEALING	None						
26. PACKING IN CARTONS	None						
27. STORAGE AND DISTRIBUTION	None						

Section 9. HACCP Plan Form [11]

Firm Name : _____

Firm Address: _____

_____

Product Description: **Vitamin A fortified peanut butter**

Method of Storage and Distribution: **Dry storage at ambient condition**

Intended Use and Consumer: **Direct consumer use or as an ingredient in cooking.**

Step	Significant Hazard	Control Measure/s	CCP No.	Critical Limit/s	Monitoring Procedures	Corrective Actions	Verification	Records
Weighing of fortificant and plain peanut butter (Step 16)	Excessive level of fortificant due to incorrect weighing of fortificant	Correct weighing procedure	1	Established amounts of vitamin A	What: Checking of weights of fortificant How: Use of weighing scale Frequency: Every end of weighing Who: QC / Production personnel	• Adjust weight of fortificant to required level • Put the affected batch on hold and analyze level of fortificant of premix • Retrain workers on proper weighing	• Daily review of records by supervisor • Daily in-house calibration of weighing scales before use • Annual calibration of weighing scale by reputable laboratory • QA audit on a quarterly basis • Annual HACCP Review	• Weights of Fortificant Monitoring Record • Corrective Action Report • Weighing Scale In-House Calibration Record • Official Report on Calibration of Weighing Scale • Audit Verification Report • Report on Annual HACCP Review

Weighing and packing of premix (Step 19)	Excessive level of fortificant due to incorrect weighing of premix	Correct weighing procedure	3	Established weights of premix used for every batch of plain peanut butter	What: Checking of weight of premix per pack used for every batch of plain peanut butter How: Use of weighing scale Frequency: Every end of weighing Who: QC / Production personnel	• Adjust weight of premix to required level • Put the affected batch on hold and analyze for level of vitamin A in the fortified peanut butter • Retrain workers on proper weighing	• Daily review of records by supervisor • Daily in-house calibration of weighing scales before use • Annual calibration of weighing scale by reputable laboratory • QA audit on a quarterly basis • Annual HACCP Review	• Weights of Premix Monitoring Record • Corrective Action Report • Weighing Scale In-House Calibration Record • Official Report on Calibration of Weighing Scale • Audit Verification Report • Report on Annual HACCP Review
Name and Signature of Official Company Representative: _____ Date: _____								

Page 1 of 1

This is only a summary of the HACCP Plan. The company shall have documented procedures for all sampling and testing used during monitoring and verification.

Section 10. Validation of the HACCP Plan

Validation of the HACCP Plan involves activities to establish that the HACCP plan is adequate to achieve the stated Food Safety Objectives. It involves the following (MAF, 1999):

A. Initial and on-going confirmation

Initial and on-going confirmation activities serve to provide information that determines whether the HACCP Plan achieves the FSOs. The activities can include product evaluation and testing and market surveys and could also include R&D to validate existence and control of hazards.

This HACCP Plan will be validated as follows:

To validate achievement of FSO1, i.e**.,** ***To ensure that correct amount of vitamin A fortificant is added to plain peanut butter during the preparation of the peanut butter premix, and that the correct amount of premix is added to plain peanut butter during the preparation of VITAMIN A fortified peanut butter.***

- Testing of vitamin A content of the peanut butter premix and fortified peanut butter

B. Re-validation

Re-validation activities are carried out whenever changes are made in the preparation of the product as in ingredients, product specifications, processing and packaging procedures and equipment; changes are made on the intended use of the product, and other changes made that could have an impact on the hazard and its control (MAF, 1999).

REFERENCES

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Codex Alimentarius Commission. 1997. Recommended International Code of Practice. General Principles of Food Hygiene. In Codex Alimentarius Food Hygiene Basic Texts. Viale delle Terme di Caracalla, Rome, Italy: Joint FAO/WHO Food Standards Programme. Food and Agriculture Organization of the United Nations and World Health Organization. Pp. 1-32.

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RECORDS FOR
HAZARD ANALYSIS CRITICAL CONTROL POINTS (HACCP) PLAN

(Name of Company)

VITAMIN A FORTIFIED PEANUT BUTTER

WEIGHTS OF FORTIFICANT MONITORING RECORD
(HACCP Record No. 1)

Instruction: The weight of fortificant should be _____ per _____ Kg of plain peanut butter.

Date of Production	Production Batch / Code	Actual Weight of Fortificant	Actual Weight of Plain Peanut Butter	Remarks	Monitored by

Reviewed by: _____ Date: _____
(Authorized company representative)

Remarks:

cc: Plant Manager

(Name of Company)

VITAMIN A FORTIFIED PEANUT BUTTER

CORRECTIVE ACTION REPORT
(HACCP Record No. 2)

Date of Production: _____
Production Batch: _____

CCP # / Processing Step: _____

Description of Occurrence:

Action Taken / Action to be Taken:

Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____
(Authorized company representative)

Remarks:

cc: Plant Manager

(Name of Company)

VITAMIN A FORTIFIED PEANUT BUTTER

WEIGHING SCALE IN-HOUSE CALIBRATION RECORD
(HACCP Record No. 3)

Date Calibrated	Code/No. of Weighing Scale	Weighing Scale Reading (g)		Remarks	Calibrated by
		Reference	Test		

Reviewed by: _____ Date: _____
(Authorized company representative)

Remarks:

cc: Plant Manager

(Name of company)

VITAMIN A FORTIFIED PEANUT BUTTER

WEIGHTS OF PEANUT BUTTER PREMIX MONITORING RECORD
(HACCP Record No. 4)

Instruction: The weight of PEANUT BUTTER PREMIX should be _____ per _____ Kg of plain peanut butter.

Date of Production	Production Batch / Code	Actual Weight of Peanut Butter Premix	Actual Weight of Plain Peanut Butter	Remarks	Monitored by

Reviewed by: _____ Date: _____
(Authorized company representative)

Remarks:

cc: Plant Manager

APPENDIXES FOR
HAZARD ANALYSIS CRITICAL CONTROL POINTS (HACCP) PLAN

Appendix A

RISK ASSESSMENT MODEL FOR DETERMINING THE RISK LEVEL OF A HAZARD OF THE PRODUCT BOARD ANIMAL FEED (PDV, 2001) [12]

Table for the determination of the risk levels of the identified hazards

Severity	**Probability of occurrence (in end product; at consumption)**		
	Small	Medium	Great
Great	3	4	4
Medium	2	3	4
Small	1	2	3

Table for the determination of the control measures required for the specified risk level

Risk Level	**Type of Control Measure Required**
1	No control measures are necessary.
2	Periodic control measures, often activities to be carried out once and which are periodically reviewed/assessed.
3	General control measures, e.g. hygiene programs, maintenance and calibration programs, purchasing procedures, quality assurance programs, etc. These measures are often called Point of Attention (POA) or Good Manufacturing Practices (GMP) control measures.
4	Specific control measures that is necessary for that particular situation. These are also called critical control point (CCP) control measures.

[12] PDV (Product Board Animal Feed). Requirements for Foreign Suppliers of Feed Ingredients. Version 1, May 2001. pp. 7, 13. P. O. Box 29739, 2502 LS, Den Haag, The Hague, The Netherlands: Product Board Animal Feed.

Appendix B

TEN COMPONENTS OF A HACCP PLAN
(CAC, 1997; MIA, 1999; MAF, 1999; Price, 1996)

This generic HACCP Plan is intended as a guide for the development of a company's HACCP Plan for an identical product. The Plan is to be used as a guide as types of hazards and their likelihood of occurrence vary with non-generic factors as sources of raw materials and ingredients, methods of handling, plant environment, processing systems, volumes of operations, and others. The user of this guide should have the basic knowledge of the HACCP principles needed to adopt this document to his/her product.

This Generic HACCP Plan assumes that Good Manufacturing Practices (GMP) is effectively in place during the manufacture of the product. Its successful implementation requires the commitment and involvement of management and the workforce.

This HACCP Plan has ten sections which are described below. The contents of the sections are based on the "Hazard Analysis and Critical Control Point (HACCP) System and Guidelines for Its Application" of the Codex Alimentarius Commission (1997) except Sections 4 and 6. Section 4 is taken from the Meat Industry Association (MIA, 1999) and Ministry of Agriculture and Forestry (MAF, 1999) of New Zealand. Section 6 is taken from Price (1996).

1. Pre-requisite Requirements – These are the sanitation and quality control procedures and practices that should be operating in any sector of the food chain prior to application of HACCP. These pre-requisites are based on the Codex Principles of Food Hygiene, the appropriate Codex Codes of Practice, and the appropriate food safety regulations.

2. Scope of the HACCP Plan – This is the identification or description of which segment of the food chain is involved and the general classes of hazards to be addressed (e.g. does it cover all classes of hazards or only selected classes).

3. Product Description and Intended Use – This is the full description of the finished product including the information relevant to its safety as composition, physical/chemical structure (including A_w, pH, etc.), processing treatments (e.g. heat treatment, freezing, brining, smoking, etc.), packaging, durability and storage conditions and method of distribution, its intended use, and its intended consumers. It creates a risk profile for the product and assists in identifying food safety hazards (MIA, 1999).

4. Food Safety Objectives (FSOs) - A Food Safety Objective is the *level* of a hazard that may be considered tolerable or acceptable in the food product to meet consumer protection goals (adapted from McDorman, 2000). The FSO provides an indication of the level of protection which the HACCP Plan will achieve. The FSO is usually determined from actual experience, published technical information, regulations of importing countries or buyer's requirements (MIA, 1999; MAF, 1999).

5. Process Flow Diagram – This is the systematic representation of the sequence of steps used in the production or manufacture of the food item. On-site confirmation of the flow diagram must be conducted during all steps and hours of operation, and amended, where appropriate.

6. Process Description – This is the detailed description of the process steps and the process conditions of the production process (Price, 1996).

7. Hazard Analysis – This is the process of collecting and evaluating information on potential biological, chemical, and physical hazards, and of the conditions leading to their presence to decide which are significant for food safety and therefore should be addressed in the HACCP Plan.

   Potential hazards are identified based on scientific literature, applied research or experience. Market regulations for identical or similar products also provide a clue to potential hazards. The identified hazard is then evaluated by ranking it as to its severity and likelihood of occurrence using the risk ranking model of the Netherlands Product Board Animal Feed (PDV, 2001) shown in Appendix A. The rank of the identified hazard determines the type of control measure that would be necessary to control the hazard. A hazard ranking of 4 indicates that the identified hazard is significant because it is severe in its consequences and has a high likelihood of occurrence and requires a critical control point (CCP) control measure, and therefore needs to be addressed in the HACCP Plan.

8. CCP Determination – This is the identification of critical control points (CCPs) for those significant hazards identified as requiring CCP control measures in Section 7. CCP is defined as a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. CCP is needed to control or eliminate those hazards found to be unacceptable in relation to FSOs set (see Section 4 above). The Codex CCP Decision Table is used for identifying whether a particular process step is a CCP or not.

9. HACCP Plan Form – This is a documentation containing the following elements of the HACCP plan:

   9.1 CCPs identified in Section 8 above.

   9.2 Significant hazard to be controlled at the identified CCP.

   9.3 Control measure or any action or activity that can be used to prevent or eliminate a food safety hazard or reduce it to an acceptable level.

   9.4 Critical limit or the criterion which separates acceptability from unacceptability. Critical limits are established for each control measure of the identified CCPs.

   9.5 Monitoring procedures or planned sequence of observations and measurement of control measures to assess whether a CCP is under control.

   9.6 Corrective action or any action to be taken when the results of monitoring at the CCP indicate a loss of control. This includes actions taken to regain control of the process, prevent recurrence of the problem, and control product disposition (MIA, 1999).

   9.7 Verification procedures or the methods, procedures, tests and other evaluations <u>in addition</u> to monitoring (see 9.5 above), to determine compliance with the items in the HACCP Plan Form.

   9.8 Documentation or the records appropriate to all sections of the HACCP Plan (MIA, 1999).

10. Validation of the HACCP Plan- This involves activities to establish that the HACCP plan is adequate to achieve the stated Food Safety Objectives. It involves the following (MAF, 1999):

    10.1 Initial and on-going confirmation activities that serve to provide information that determine whether the HACCP Plan achieves the FSOs. The activities can include product evaluation and testing and market surveys and could also include R&D to validate existence and control of hazards.

    10.2 Revalidation activities carried out whenever changes are made in the preparation of the product as in ingredients, product specifications, processing and packaging procedures and equipment; changes are made on the intended use for the product and other changes made that could have an impact on the hazard and its control.

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Appendix C

RECOMMENDED PRE-REQUISITE REQUIREMENTS FOR HACCP OF NEW ZEALAND (MAF, 1999)

Prior to starting the HACCP Plan, the HACCP team [13] should ensure that all relevant pre-requisite programmes such as Codex Principles of Food Hygiene, the appropriate Codex Codes of Practice, and the appropriate food safety regulations are documented and effectively being implemented.

The following is a list of recommended pre-requisite requirements by the Ministry of Agriculture and Forestry–Food Assurance Group of the New Zealand (MAF, 1999).

- sanitary design;
- potable water quality;
- sanitation and clean-up procedures for edible areas and food contact surfaces (pre-operational and operational);
- personal hygiene (protective clothing requirements, personal equipment and use of amenities, hygienic practices);
- training of personnel;
- hygienic processing (processing techniques and procedures including separation of raw and cooked product);
- rework procedures;
- recall procedures;
- food contact materials (specifications, handling and storage);
- supplier quality assurance (ingredient specifications, supplier audits, product testing);
- handling and storage of incoming raw materials and finished product;
- product testing procedures;
- calibration, installation and maintenance of processing equipment and instruments;
- repairs and maintenance of equipment;
- control of chemicals;
- pest control;
- waste management;
- handling and disposition of detained and non-conforming products.

[13] *HACCP team is a multidisciplinary team that has specific knowledge and expertise appropriate to the product. Where such expertise is not available on site, expert advice should be obtained from other sources. (CACx, 1997).*

Appendix D

COMPONENTS OF THE PRE-REQUISITE PROGRAM FOR HACCP OF THE UNITED STATES (USFDA, 1997. 21 CFR 123; USFDA, 2001. 21 CFR 120)

In the United States, the pre-requisite program for HACCP is the Sanitation Standard Operating Procedure (USFDA, 1997. 21 CFR 123; USFDA, 2001. 21 CFR 120), the components of which are listed below:

- safety of the water that comes in contact with food or food contact surfaces, or used in the manufacture of ice;
- condition and cleanliness of food contact surfaces, including utensils, gloves, and outer garments; prevention of cross-contamination from unsanitary objects to food, food packaging materials, and other food contact surfaces, including utensils, gloves, and outer garments, and from raw product to cooked product;
- maintenance of hand washing, hand sanitizing, and toilet facilities;
- protection of food, food packaging material, and food contact surfaces from adulteration with lubricants, fuel, pesticides, cleaning compounds, sanitizing agents, condensate, and other chemical, physical, and biological contaminants;
- proper labeling, storage, and use of toxic compounds;
- control of employee health conditions that could result in the microbiological contamination of food, food packaging materials, and food contact surfaces; and exclusion of pests from the food plant.

CHAPTER 8

OBTAINING SANGKAP PINOY SEAL FOR VITAMIN A FORTIFIED PEANUT BUTTER FROM THE DEPARTMENT OF HEALTH

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ABSTRACT

A study to determine the stability of the premix for use in manufacturing when kept in storage at ambient conditions for two weeks and the stability of vitamin A in fortified peanut butter at the target shelf-life of six months was conducted, to comply with the Philippine Department of Health's technical requirements for the application of *Sangkap Pinoy* Seal.

Result of stability test for the premix showed that it is stable at the target holding period of twelve days at ambient conditions without affecting its vitamin A content and its odor and color characteristics. During the twelve days holding period, the premix was evaluated by trained panelists as negative for change in color and presence of rancidity. The vitamin A content and peroxide values, despite slight changes, remained acceptable at the end of the two weeks holding time.

Results of shelf-life testing of fortified peanut butter at accelerated temperatures of 35, 40 and 45°C showed that vitamin A degradation, oil separation and development of rancid odor occurred at a faster rate at accelerated temperatures. The vitamin A added in the fortified product was predicted to have a shelf-life of 194 days or 6.5 months when stored at 30°C, based on 20% loss of vitamin A from the claimed value of 4.6 μg retinol/g peanut butter. Based however on the combined physical, chemical and sensory characteristics of the product, the fortified peanut butter was predicted to have a shelf-life of 188 days or 6.25 months. Above data indicates that the vitamin A added will remain stable at the target shelf-life of 6 months.

OBJECTIVES

The general objective was to prepare the requirements needed by manufacturers of vitamin A fortified peanut butter in obtaining a *Sangkap Pinoy* Seal. The specific objectives were to: (1) verify stability of the peanut butter premix at ambient conditions at the target holding time of two weeks, (2) determine stability of vitamin A in fortified peanut butter using the Accelerated Shelf Life Testing Method, and (3) evaluate documents needed for *Sangkap Pinoy* Seal application

METHODS

The activity was conducted in two phases: (1) shelf- life testing of the premix and (2) shelf-life study of fortified peanut butter. In phase 1, the stability of vitamin A in peanut butter premix when stored at ambient conditions at the target holding time of two weeks was conducted, consisting of production of the premix and the conduct of the shelf life study. In phase 2, the stability of vitamin A in fortified peanut butter packed in bottles was conducted through production of the fortified peanut butter and conduct of the shelf life study.

Shelf-Life Study of the Peanut Butter Premix

Production of the Premix

The premix was prepared by adding 38.86 g of vitamin A palmitate in oil (1.0M IU/g oil, BASF Philippines, Inc., Carmelray Industrial Park I, Canlubang, Laguna, Philippines) to 40 Kg of plain peanut butter using the following procedure: Vitamin A palmitate which was pre-heated at 40°C for 15 minutes in a water bath was added at the center of plain peanut butter. The plain peanut butter that was used in the study was prepared by an industry collaborator. The fortificant was manually mixed with plain peanut butter using a plastic spatula until no trace of the fortificant was visible from the surface of the peanut butter mixture. The vitamin A palmitate-peanut butter mixture was transferred to a horizontal mixer and allowed to mix for a total of 10 min.

Shelf-Life Testing of the Premix

The peanut butter premix was subjected to a shelf life study at ambient conditions (≈ 30°C). Two Kg of premix were packed in 2.5 Kg plastic containers manually. The initial quality of the product was evaluated for vitamin A content, peroxide value, color and presence of rancid odor prior to its storage. Periodic evaluation of the product was conducted by trained panelists for changes in color, odor and oil separation every two days until the product reached the target holding period of 12 days. At the end of 12 days, the premix was evaluated for final vitamin A content, peroxide value, color and odor acceptability.

Shelf-Life Study of Fortified Peanut Butter

Production of Fortified Peanut Butter

One hundred (100) Kg of fortified peanut butter was prepared using a premix to plain peanut butter weight ratio of 1:25. This was done by adding 2 Kg of pre-weighed premix in 50 Kg pre-weighed plain peanut butter. The premix was manually mixed with the plain peanut butter with the aid of a plastic spatula until a homogenous mixture was achieved. Above steps were repeated in another container of 50 Kg pre-weighed peanut butter. The mixtures in the two separate containers were transferred to a horizontal mixer and allowed to mix for 10 min. After mixing, the fortified product was transferred to a filling machine, and filled in glass tumblers with a capacity of 155 g. A plastic tape was wrapped around the metal lids and glass tumbler for added protection together with a tamper proof plastic seal.

Shelf-Life Testing of Fortified Peanut Butter

The main objective of the study was to estimate the shelf-life of the vitamin A added in fortified peanut butter based on 20% loss of vitamin A from the claimed value of 4.6 μg retinol/g peanut butter. Other product characteristics likely to affect shelf life of the product such as presence of rancid-like odor and oil separation were likewise evaluated. The shelf-life study was conducted using the accelerated shelf-life method as follows: fortified peanut butter was packed in 155 g glass bottles and stored at three accelerated temperatures, i.e. 35, 40 and 45°C and at room condition (≈30°C). Prior to storage of the product at the above accelerated temperatures and at ambient condition, sampling was conducted at pre-determined storage times and evaluated for its physical, chemical and sensory characteristics.

Evaluation of the Product

The physical characteristics of the product were evaluated as to the condition of the glass tumbler and caps (which were checked visually for presence of defects such as oil leaks in the caps and sides of the glass tumbler, dirt on the caps and cracks and breaks in the bottle), and appearance of the product (oil separation in particular which was measured using a vernier caliper as soon as the bottle was opened).

The sensory characteristics of the product were evaluated by six trained panelists. Descriptive testing was used to evaluate the initial quality of the product based on color, odor, flavor, and product acceptability. For succeeding evaluations, only the presence of rancid-like odor was evaluated.

For the chemical characteristics of the fortified product, the level of vitamin A, expressed as microgram retinol per gram (μg/g) peanut butter and the peroxide value, expressed as milligram peroxide/Kg of oil were evaluated. At pre-determined storage times, two replicate samples were analyzed for vitamin A content for each storage temperatures. For peroxide value analysis, samples were taken only at the start, 3rd month and 6th month of storage of the product at ambient temperature.

Estimation of Shelf-Life of Vitamin A

To estimate the shelf-life of vitamin A in the fortified product, the average vitamin A concentration of the replicate samples was plotted against storage time for the given accelerated temperatures. The lines were fitted to the points by linear regression using the Kwikstat 4 computer statistical software. The rates of vitamin A loss were determined by calculating for the slope of the linear regression equation between the amount of vitamin A and storage time. To determine the temperature relationship of the rate of vitamin A loss of the fortified product, the Arrhenius relationship (Labuza, 1984) was used. This was done by plotting the natural logarithm (ln) of the rate of vitamin A loss at the

different accelerated temperatures against the reciprocal of storage temperature, expressed in Kelvin units. From the Arrhenius plot, the rate constant for vitamin A loss at 30°C can be estimated by extrapolation. The estimated shelf life of fortified peanut butter, based on 20% loss of vitamin A from claimed value of 4.8 μg retinol/g peanut butter, may be obtained using the following zero-order reaction model:

$$C = Co - kt$$

Where C = amount of vitamin A at time t, expressed in μg retinol/g peanut butter
Co = initial amount of vitamin A, expressed in μg retinol/g peanut butter
k = reaction rate constant, expressed in μg/g/day
t = time, in days

Evaluation of Documents for Sangkap Pinoy Seal Application

Coordination with the industry collaborator for the preparation of documents needed for *Sangkap Pinoy* Seal accreditation was likewise requested to enable FDC to evaluate these documents prior to its submission to the Department of Health.

RESULTS

Shelf-Life Study of the Peanut Butter Premix

Tables 8.1 and 8.2 show the physico-chemical and sensory characteristics of the premix during the target holding period. Results of test showed that the premix can be kept for 12 days at ambient conditions without affecting its vitamin A content, color and odor characteristics. Though a slight oil separation was observed starting on the 5th day of storage, the final height of the oil recorded at ~2.5 cm at the end of 12 days remained acceptable based on standards of the industry collaborator. Trained panelists found the product negative for presence of rancid odor and change in color. The peroxide value, on the other hand, exhibited a slight increase from an initial value of 1.71 meq/Kg oil but the values were found to be within the acceptable limits for vegetable oils. Based on the 1993 Codex Alimentarius (Volume 8), the allowable peroxide value for vegetable oils is 10 meq/Kg oil.

In terms of vitamin A stability, a slight increase in vitamin A content was noted from an initial value of 266.17 μg retinol/g peanut butter to a final value of 271.33 μg retinol/g peanut butter. The difference in vitamin A content may be attributed to distribution effects.

Table 8.1 Chemical characteristics of the premix at 30°C for 12 days

Type of Analysis	Unit	Initial	Final
Vitamin A content	μg retinol/g peanut butter	266.17[1]	271.33
Peroxide Value	meq peroxide/Kg oil	1.05	1.71

[1] Value is average of two measurements. Variability is 5.6%.

Table 8.2 Physical and sensory characteristics of the premix during storage at 30°C

Storage Time (days)	Storage Temperature (°C)	Presence of Rancid-like Odor	Change in Color	Height of Oil Separation (mm)
0	29	negative	none	none
2	30	negative	none	none
5	30	negative	none	0.5
7	30	negative	none	1.5
9	28	negative	none	2.0
12	29	negative	none	2.5

Shelf-Life Study of Fortified Peanut Butter

Evaluation of the Product

Physical Characteristics

Results shown in Table 8.3 indicate that the packaging condition of the fortified product remained normal throughout the storage period regardless of the storage temperatures at which the product was subjected to. Oil separation was observed during storage regardless of the storage temperature but the rate of separation was fastest at the highest accelerated temperature as shown in Table 8.4.

Table 8.3 Visual evaluation of the packaging condition of Vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at each accelerated temperatures

Storage Time (days)	Temperature 30°C	35°C	40°C	45°C
0	Normal [1]	- [2]	-	-
1	Normal	-	-	-
10	-	-	-	Normal
15	-	-	Normal	-
20	-	-	-	Normal
21	-	Normal	-	-
26	-	-	Normal	Normal
28	-	-	Normal	Normal
30	Normal	-	-	-
43	-	Normal	-	-
50	-	-	-	-
62	-	Normal	-	-
63	-	Normal	-	-
77	Normal	-	-	-
84	-	Normal	-	-
90	Normal	-	-	-
92	Normal	-	Normal	-
120	Normal	Normal	-	-
127	-	Normal	Normal	-
136	-	-	Normal	-
187	Normal	Normal	Normal	Normal

[1] Normal = packaging material had no defects
[2] (-) = no evaluation done

Table 8.4 Physical evaluation (oil separation) of Vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at accelerated temperatures.

Storage Time (days)	Height of oil separation (mm) 30°C	35°C	40°C	45°C
0	0.0	- [1]	-	-
1	0.0	-	-	-
10	-	-	-	1.60
15	-	-	1.50	-
20	-	-	-	3.45
21	-	1.50	-	-
28	-	-	2.65	4.65
30	2.35	-	-	-
42	-	-	-	-
84	-	3.80	-	-
90	5.00	-	-	-
126	-	4.00	-	-
187	5.80	4.55	5.05	5.25

[1] (-) = no evaluation done

Sensory Characteristics

Results of initial sensory evaluation shown in Table 8.5 indicate that the fortified product had a moderate roasted peanut odor and flavor and a perceptible burnt-like odor and flavor. No stored-like, rancid-like, fortificant-like/medicinal-like and other off-odors were detected by panelists. The product was noted to have a slightly sweet taste with perceptible salty and bitter taste.

During storage at different temperatures, the product was observed to have developed a rancid odor as shown in Table 8.6. A slight rancid odor was noted after the product was kept in storage for 127 days at 45°C, perceptible rancid odor after 136 days storage at 40°C, and slight to perceptible rancid odor after 188 days at 35 and 30°C, respectively. At these storage times, the panelists evaluated the product as unacceptable (Table 8.7).

Table 8.5 Initial sensory characteristics of vitamin A fortified peanut butter packed in transparent glass tumblers with design

Sensory Characteristic	Evaluation
1. Odor	
1.1 Intensity of characteristic roasted peanut odor	Moderate
1.2 Intensity of fortificant-like/medicinal-like odor	None
1.3 Presence of burnt-like odor	Perceptible
1.4 Presence of stored-like odor	None
1.5 Presence of rancid-like odor	None
1.6 Presence of other off-odor	None
2. Flavor	
2.1 Intensity of characteristic roasted peanut flavor	Moderate
2.2 Intensity of fortificant-like/medicinal-like flavor	None
2.3 Presence of burnt-like flavor	Perceptible
2.4 Presence of stored-like flavor	None
2.5 Presence of rancid-like flavor	None
2.6 Presence of other off-flavor	None
2.7 Intensity of sweet taste	Slight
2.8 Intensity of salty taste	Perceptible
2.9 Presence of bitter taste	Perceptible
3. Acceptability Test	
3.1. Overall	Like Moderately
3.2. Odor	Like Moderately
3.3. Flavor	Like Moderately

Table 8.6 Development of rancid odor in vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at different accelerated temperatures

Storage time (days)	30°C	35°C	40°C	45°C
Initial	None	None	None	None
21	-[1]	-	-	None
30	-	-	None	-
43	-	None	-	-
62	-	-	None	-
84	-	None	-	-
92	None	-	None	-
127	-	None	None	Slight
136	-	-	Perceptible	
188	Perceptible	Slight	-	Moderate

[1] (-) = no evaluation done

Table 8.7 Odor Acceptability of Vitamin A Fortified Peanut Butter packed in transparent glass tumbler with design during storage at different accelerated temperatures

Storage time (days)	Acceptability			
	30°C	35°C	40°C	45°C
Initial	Acceptable	Acceptable	Acceptable	Acceptable
92	Acceptable	Acceptable	Acceptable	Acceptable
127	Acceptable	Acceptable	Acceptable	Unacceptable
136	Acceptable	Acceptable	Unacceptable	-
188	Unacceptable	Unacceptable	-	-

Chemical Characteristics

Table 8.8 shows that there was a loss in the initial vitamin A content of 8.17 μg/g peanut butter during storage regardless of the storage temperature. Vitamin A degradation occurred faster at accelerated temperatures as compared to the control. After 28 days in storage at 45°C, vitamin A loss was 22.28% and 20.81% at 40°C. At approximately the same storage time, vitamin A loss after 21 days at 35°C was only 12.12% and 13.46% after 29 days at 30°C.

From Table 8.9, the peroxide value of fortified peanut butter stored at ambient condition (30°C) was found to increase from an initial of 0.11 meq peroxide/Kg of oil to 11.30 meq peroxide/Kg of oil after 188 days in storage. The final value was found unacceptable based on the 1993 Codex Alimentarius standards.

Table 8.8 Vitamin A content (μg/g) and vitamin A loss (%) in vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at accelerated temperatures[1]

Temperature (^{0}C)	Time (days)	Vitamin A (μg/g)	% Vitamin A loss
45	0	8.17	0
	10	6.96	14.81
	20	6.69	18.12
	26	6.39	21.79
	28	6.35	22.28
40	15	6.75	17.38
	26	6.30	22.89
	28	6.47	20.81
35	21	7.18	12.12
	43	7.01	14.20
	63	6.23	23.74
	120	4.46	45.41
30	29	7.07	13.46
	77	6.20	24.11
	90	5.32	34.88
	120	4.73	42.10

[1] Each data point is the average of two samples

Table 8.9 Peroxide value of vitamin A fortified peanut butter packed in transparent glass tumbler with design during storage at ambient temperatures

Storage Time (days)	Peroxide Value (meq peroxide/ Kg oil)
0	0.11
90	5.32
188	11.30

Estimation of Shelf-Life of Vitamin A

From a plot of the vitamin A concentration vs. storage time, the rates of vitamin A loss (Table 8.10) in the fortified products stored at 35, 40 and 45°C were 0.0299, 0.0636 and 0.0648, respectively. The data indicate that the higher the storage temperature, the faster is the rate of vitamin A degradation. From the Arrhenius plot (Labuza, 1984) shown in Fig. 8.1, extrapolation of the straight line to 30°C indicate a rate of vitamin A loss of 0.0231 μg retinol/g peanut butter. Substitution of this rate constant into the zero-order reaction equation, showed that the time to reach end of shelf life of peanut butter, based on 20% loss of vitamin A from claimed value was calculated to be 194 days.

Based on the above results, the predicted shelf-life of the vitamin A in fortified peanut butter is 6.5 months at Philippine ambient condition of 30°C. However, based on the combined results of its physical, chemical and sensory characteristics, the fortified product has only a shelf life of 188 days or 6.25 months.

Table 8.10 Results of regression analysis of Vitamin A (retinol) in peanut butter packed in transparent glass tumbler with design.

Temperature (°C)	Co (μg Vitamin A /g peanut butter)	k (μg Vitamin A/ g peanut butter/day	ln k	R^2
45	8.17	0.0648	-2.74	0.9005
40	8.17	0.0636	-2.76	0.9174
35	8.17	0.0299	-3.51	0.9830

Evaluation of Documents for Sangkap Pinoy Seal Application

FDC was informed that the industry collaborator do not intend to apply for *Sangkap Pinoy* Seal because of the need to focus on the correction of plant deficiencies. The latter is needed to enable the company for GMP Accreditation and HACCP Certification which incidentally are one of the requirements for obtaining the *Sangkap Pinoy* Seal.

CONCLUSION

Knowledge of the holding time of the premix prior to its use in manufacturing is necessary to ensure that no vitamin A is lost during its target storage of 12 days. The stability of vitamin A in the premix is important so that the level of vitamin A in the final product is able to meet the regulatory requirements for fortified foods. The stability of vitamin A in the final product is one of the requirements in the application of the *Sangkap Pinoy* Seal.

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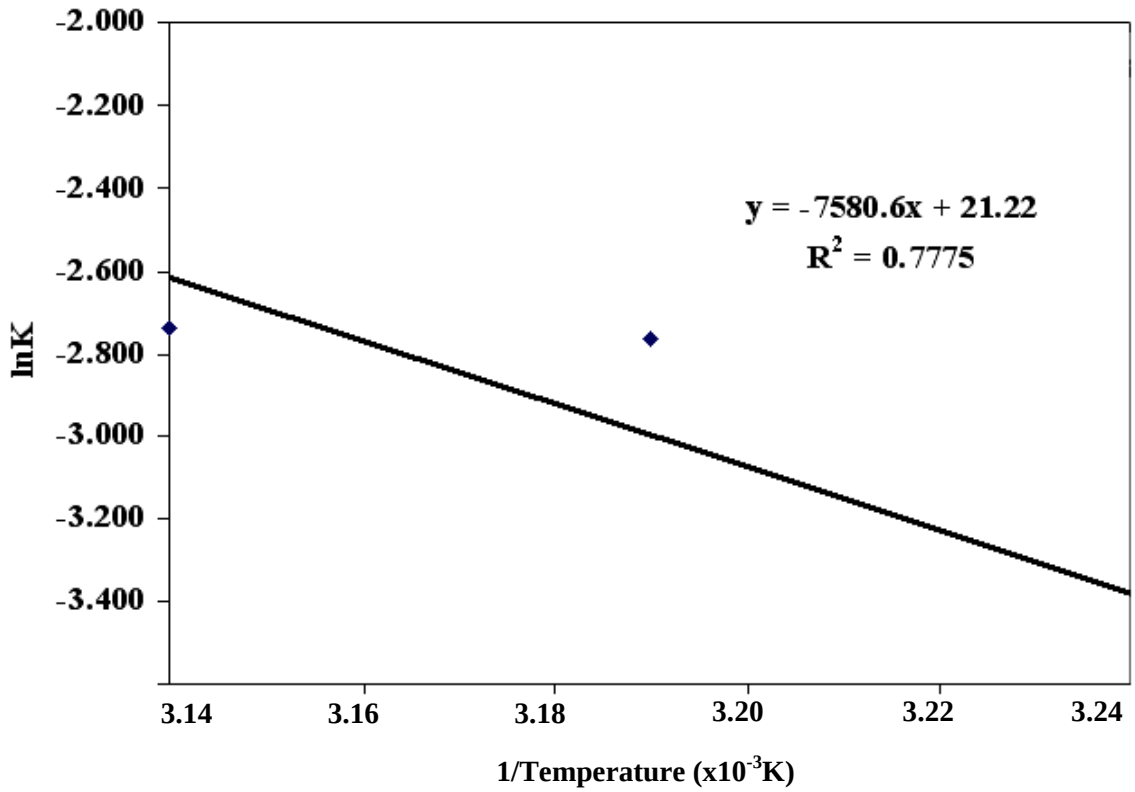

Fig. 8.1 Arrhenius plot of the rate of Vitamin A (retinal) deterioration of peanut butter packed in transparent glass tumbler versus the inverse of absolute temperature

NOTE ON ADOPTION OF THE IMPROVED PROCESS FOR THE VITAMIN A FORTIFICATION OF STABILIZED PEANUT BUTTER IN A SMALL COMPANY

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ABSTRACT

Food fortification of stabilized peanut butter with vitamin A is necessary in order to minimize if not to eliminate vitamin A deficiency. A collaboration was signed between the Leyte State University and the Lola Concordia Agro-Industrial Farm and Processing (LCAIFP) from Bato, Leyte, which is one of the peanut-producing areas in Leyte. The objective was to verify the improved process for the vitamin A fortification of stabilized peanut butter in a small company. A letter of interest was the basis in the development and signing of memorandum of agreement. Based on the observation, the process used by Agustin *et al* (2006) can also be employed with standardization done at LSU and at LCAIFP**.** Lack of knowledgeable workers, especially about aflatoxin and the hazards associated with it, was the main problem which was focused at the start of collaboration through the adoption of the sorting technology earlier developed in the project with the need to update cGMP, SSOP and HACCP. The electric peanut roaster which was transferred earlier to LCAIFP facility was used but two grindings had to be followed since only a modified peanut grinder was used.

INTRODUCTION

Food fortification has been defined as the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups (FAO/WHO 1994). Food scientists have risen to the challenges posed by micronutrient fortification. Evidence of their success is clearly demonstrated by the number of fortified products on the supermarket shelves in most developed countries.

The collaborator for this project is a dried mango small-scale company with a capitalization of more than PhP3M. It has a state-of-the-art drying facilities and has presently availed of the Agricultural Council Enhancement Fund (ACEF) loan. However, use of its facilities has not been maximized by the company considering that mango processing is a seasonal activity. The conversion of the plant into a processing plant for peanut butter will help to maximize its use especially that Bato, Leyte is a peanut-producing area. Lola Concordia has been trained in cGMP and SSOP and even ready for accreditation. Furthermore, the ACEF loan requirements included a capitalization counterpart so it is ready for packaging and other expenses that could be incurred in the commercialization of the product. It is also one of the food companies included in a Coaching Program of Advocates for Philippine Fair Trade Inc. (APFTI) and of the Department of Trade and Industry (DTI). Above all, the management has expressed interest in collaborating with the P-CRSP project investigators (Appendix A). The adoption of the improved method of Agustin *et al.* (2006) in fortifying peanut butter by the company seems fruitful.

OBJECTIVES

The general objective of the study was to adopt the improved process for the vitamin A fortification of stabilized peanut butter in a small company. The specific objectives were to: (1) identify a small peanut industry to commercialize vitamin A fortified stabilized peanut butter; (2) identify product/process problems; and (3) standardize the process at LSU and at the collaborator's facility.

METHODS

Identification of Collaborators

Search and identification of Collaborator was done using a criteria after which, a memorandum of agreement (MOA) was developed (Appendix A) and signed in separate schedules. Appendix B showed the signing of MOA by Mrs. Angelina Kuizon and the Co-Investigator, Dr. Lutgarda S. Palomar at the Office of the Head, Department of Food Science and Technology (DFST), LSU, Visca, Baybay, Leyte on May, 2005.

Product Processing

The processing of peanut butter including manual sorting of Galvez *et al.* (2002) and the method of application of fortificant of Agustin *et al*. (2006) was followed with some modifications:

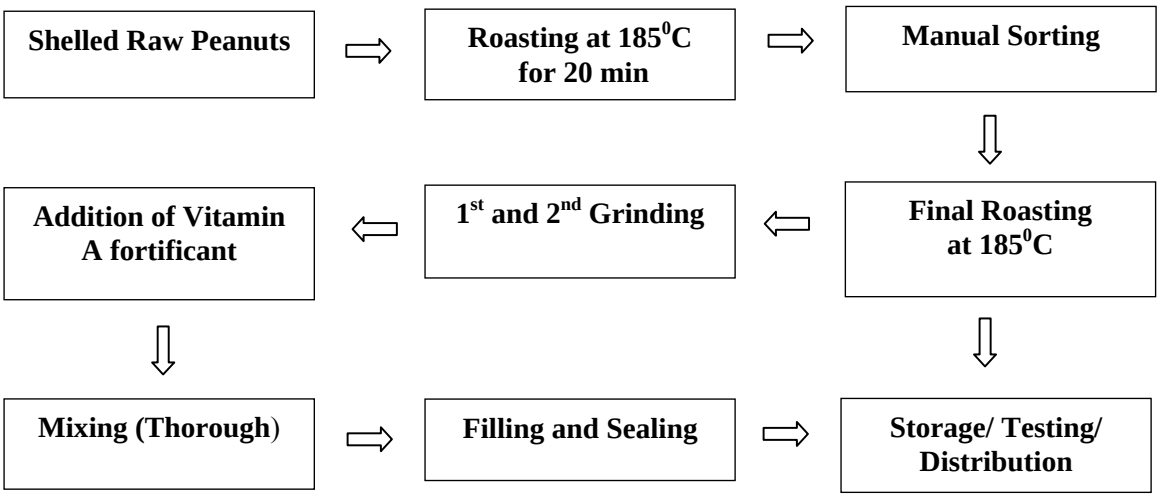

Fig. 1 Process flow for the preparation of a vitamin A fortified stabilized peanut butter to a small company in Leyte

RESULTS

The adoption of the improved method of Agustin *et al* (2006) of vitamin A fortification followed a series of activities which are still on-going.

Identification of a Collaborator

Based on the criteria (Table 1), Lola Concordia Agro-Industrial Processing/Leyte's First was identified and selected. It can be considered as a small scale industry since it has more than PhP3-M assets and an existing processing building (Appendix C) which is under-utilized due to the seasonality of mango for the production of dried mangoes. The company can also purchase the needed equipment since Lola Concordia was able to avail of an ACEF Loan in 2005. In addition, due to the collaboration activity, the electric peanut roaster acquired by LSU through P-CRSP has been temporarily transferred to Lola Concordias' facility and is now used by the company until they can purchase their own or until it is deemed found necessary to return the equipment to LSU.

Table 1 Criteria used in the identification and selection of a collaborator

Criteria	Lola Concordia's Status
1. At least a small scale industry	Has more than P3-M capital
2. Willingness to Collaborate	A letter of interest
3. Located in a peanut-producing area	Bato, Leyte, the site is a peanut-producing municipality
4. Existing building and facility	As shown in Appendix C, it has more than the minimum requirements
5. Has assured capital	Has acquired/received an ACEF Loan

Discussions and Identification of Problem

Lack of knowledgeable workers especially about aflatoxin and the hazards associated with it was the main problem which was focused at the start of collaboration through the adoption of the sorting technology developed by Galvez *et al*. (2002) Their earlier practice was to utilize all the peanuts into peanut butter since according to an old woman, who attended the lecture and is a peanut butter processor-neighbor, *"Sayang kung dili gamiton, dili na man maklaro na sa peanut butter kay masagol na man lagi."* (It is a waste if we do not utilize the discarded/sorted-out peanut kernels. Anyway, it cannot be noticed anymore in the peanut butter).

Support Capability Building/cGMP, SSOP and HACCP Updates

A lecture on current good manufacturing practices (cGMP), sanitation standard operating procedure (SSOP) and hazard analysis critical control points (HACCP) updates have been conducted (Appendix D).

Needs for Training on Peanut Butter Preparation and on Sorting Technology

Due to lack of knowledge about aflatoxin and peanut butter, a training was conducted at LSU using the information from the LSU Student Research on stabilized peanut butter.

Technology Transfer and Standardization of Stabilized Peanut Butter

A process for stabilized peanut butter and the use of the sorting technology developed by Galvez *et al*. (2002) was used during the standardization of the process at LSU conducted by the P-CRSP-LSU Team. One worker from Lola Concordia was trained at LSU for the stabilized peanut butter (Appendix E and three at Lola Concordia's facility (Appendix F).

Technology Transfer of the Improved Method of Vitamin A Fortificant Application and Subsequent Training at Lola Concordia's Facility

The adoption of the improved method of Agustin *et al.* (2006) for vitamin A fortificant application which addition is to be done after the second and final grinding (Fig. 1) is pending until the distributor will be able to find a smaller pack of the fortificant. Negotiations have already been done after which the products will be tested for stability of vitamin A. The vitamin A fortified peanut butter products will be launched later and results included in the impact assessment report.

Determination of Product Cost Break-Even Price

Table 2 shows that in a 10-kilogram formulation, the break-even cost of a jar containing 250 grams was PhP49.78 and the company can sell it at 20% mark up or at PhP60.00/jar which is still competitive since the existing price of a stabilized peanut butter is PhP75.00 computed to a 250-gram jar.

Table 2. Product cost and break-even and selling prices of stabilized peanut butter based on 10-kilogram formulation.

Item	Level (%)	Actual Amount	Price/unit	Cost
Roasted peanut	84.5	8.45 Kg.	PhP120/Kg	PhP1014.00
sugar	14.0	1.4 Kg.	40/Kg	56.00
salt	0.5	0.05 Kg.		2.00
Stabilizer	1.0	0.1 Kg.		50.00
Labor (2 workers at P150/day)				300
Fuel				50
Packaging and label	37 jars			370.00
Total				1842.00
Break-even price/jar				49.78
Selling Price/jar (with a 20% mark up)				PhP60.00
Competitor's price				PhP75.00

CONCLUSIONS

Knowledge of sorting, use of stabilizer in peanut butter and fortification had to be incorporated for the adoption of improved method in peanut butter processing.

The success in the adoption and commercialization will be dependent not only on the acceptability of the quality of the products but also on the price so economics of scale will be considered throughout the period of the collaboration.

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APPENDIX A

PROPOSAL FOR R&D COLLABORATION

PROPOSAL FOR R&D COLLABORATION

_____ expressed its interest in the Vit. A-Fortified Peanut Butter Technology of Leyte State University. Thus _____ is willing to participate in this project with the following objectives and expected output:

Objectives:

1. To transfer the technology on Vitamin A Fortified Peanut Butter technology.
2. To strengthen sorting activity for aflatoxin control.
3. To scale-up the operation/production of Vitamin A Fortified Peanut Butter technology at collaborator's plant.
4. To conduct market testing of Vitamin A Fortified Peanut Butter technology.
5. To develop the product within the cost objective.
6. To launch and maintain Vitamin A Fortified Peanut Butter technology in the market.
7. Collaborator to share information for impact assessment especially scales of production.

Expected Outputs:

1. Technology on Vitamin A Fortified Peanut Butter technology transferred to collaborator,
2. Standardized process Vitamin A Fortified Peanut Butter technology.
3. Sorting activity for aflatoxin control of the collaborator strengthened.
4. Vitamin A Fortified Peanut Butter technology peanuts market tested by collaborator and developed within the cost objective.
5. Vitamin A Fortified Peanut Butter technology launched at the market.
6. Information for impact assessment especially on volume of production shared to LSU-PCRSP.

Duration:

The transfer of technology on Vitamin A Fortified Peanut Butter technology will be done not later than September 1, 2005.

Activities and Cost Sharing Scheme

Activities:

1. Transfer of the technology on Vitamin A Fortified Peanut Butter technology to collaborator
2. Scaling-up of the operation/production of Vitamin A Fortified Peanut Butter technology at collaborator's plant.
3. Conduct of market testing of Vitamin A Fortified Peanut Butter technology.
4. Development of the product within the cost objective.
5. Launching of Vitamin A Fortified Peanut Butter technology products in the market.
6. Share of information for impact assessment especially scale of production.

Cost Sharing Scheme:

LSU

1. Manpower on the technology transfer of Vit. A-Fortified Peanut Butter technology.
2. Technical assistance throughout the techno transfers stage.

COLLABORATOR

1. Full cost of peanuts and other ingredients during the scaling up operation of Vitamin A Fortified Peanut Butter technology.
2. Availability of equipment, facilities, and other operation requirements provision throughout the duration of the project.
3. Conduct of market testing of Vitamin A Fortified Peanut Butter technology.
4. Local air transportation cost, accommodations and meals of the trainers on the transfer of Vitamin A Fortified Peanut Butter technology and the control of aflatoxin in peanut products through proper sorting.

Exclusivity:

As mutually agreed by both parties, the technology on Vitamin A Fortified Peanut Butter technology will be transferred to _____ not later than September 1, 2005 and launched not later than April 1, 2006. In the event that Industry Collaborator does not launch the product in the market by April 1, 2006, it is agreed that the technology will be transferred to all interested industries.

Terms for Collaboration

1. LSU to provide expertise and material sorting support during the techno transfer period.

   _____ to provide sales and production volume before and after product launching in the market.

Proposed by: The Leyte State University

(Original signed)
LUTGARDA S. PALOMAR

Conforme: _____

(Original signed)
COLLABORATOR (Representative)

APPENDIX B

SIGNING OF MEMORANDUM OF AGREEMENT

SIGNING OF MOA

Ms. Angelina Kuizon, the manager/owner, signed the MOA with Dr. Lutgarda S. Palomar, Co-Investigator and Head, Department of Food Science and Technology, Leyte State University who served as the witness.

APPENDIX C

BUILDING AND FACILITIES OF LOLA CONCORDIA AGRO-INDUSTRIAL FARM AND PROCESSING

BUILDING AND FACILITIES OF LOLA CONCORDIA AGRO-INDUSTRIAL FARM AND PROCESSING

APPENDIX D

SANITATION UPDATES

SANITATION UPDATES
LOLA CONCORDIA AGRO-INDUSTRIAL FARM AND PROCESSING

I. Company History

Lola Concordia Agro-Industrial Farm and Processing was set-up in 2002, first as a Mango Farm, later as a processing. The company has 28 hectares planted with at least 1,800 trees of mangoes. Processing officially started in 2003. LCAIFF operates 4 times a year. It has 30 personnel. The plant's maximum processing capacity is 1000 Kg of fresh mangoes daily. However, to maximize the use of the facility in times that mango is not in season, the company decided to adopt the Vitamin A Fortified Peanut Butter technology. The plant is located at Bato, a peanut area in Leyte. Presently, its finished products are distributed locally but aim to export, that is why HACCP has to be established.

II. Company Quality and Safety Policy

Company Quality and Safety Policy (Revised)

1. Total commitment for fair trade practices and customer satisfaction
2. Protection and Advancement of Environmental conservation
3. Market Leadership
4. Strive for Quality Excellence
5. Sustainable Development of Stakeholders

Our commitment to quality is unflinching, our hunger for growth is deep-rooted and our capacity for details is striking. Over the decades, we have demonstrated a rare resilience and fortitude. The company is determined to improve productivity and to focus continuously on innovation and upgrade of its products and people.

Company Quality and Safety Policy (Initial)

1. Total commitment for customer satisfaction.
2. Protection and Advancement of Environment
3. Market Leadership
4. Strive for Quality Excellence.
5. Sustainable Development of Stakeholders.

Quality and Safety Principles

1. Processed peanut products should be safe, reliable and of highest quality
2. The company has quality assurance procedures which are strictly implemented.
3. Products and raw material specification will be strictly followed
4. Raw materials and ingredients, suppliers are required by the company to be visited regularly for monitoring to assure adherence to quality specifications.
5. The company seeks technical assistance from authorized government agencies to improve its company quality and safety procedures.

D. Sanitation and Hygienic Practices

STANDARD SANITATION OPERATING PPROCEDURE

A. PERSONNEL

	Procedure	Monitoring/Record	Corrective Measures/Actions
Pre-Process	1. Take a bath or shower every before processing 2. Wear prescribed uniform and garments	Daily log-in of personal hygiene logbook	Worker who has not taken a bath or shower and those without proper uniform is not allowed to enter the processing area.
In-Process	1. Wear gloves, head cover, hood and other hygienic garments 2. No eating, spitting, smoking or bringing any contaminants in the working area 3. Regular sanitation of working area 4. Regular washing/ sanitizing of gloves/ hands	Spot checking or assign line supervisors to do the checking/Checklist	Agreed written warning/Reward scheme
Post-Process	1. Change working clothes 2. Wash and sanitize working garments	Spot checking or assign line supervisors to do the checking/Checklist	Agreed written warning/Reward scheme

B. RAW MATERIALS AND OTHER INGREDIENTS

	Procedure	Monitoring/Record	Corrective Measures/Actions
Pre-Process	Inspection of quality	Visual Inspection	Accept those which meet spec and Reject those which do not
In-Process	Segregate seeds from the cut –up flesh.	Visual Inspection	Separate or segregate and process into puree
Post-Process	Inspection of finished products (Each bottle should be inspected for possible defect.	Record of damaged packs	Separate and label for immediate action

C. FACILITIES

	Procedure	Monitoring/Record	Corrective Measures/Actions
Pre-Process	1. Clean and sanitize 2. Provide a clean waste container	Cleaning and sanitation checklist	1. Responsible person to clean the area 2. Do not start until the area is provided with waste containers
In-Process	1. Processing Area processes before and after use 2. Facilities – regular checking of facilities and equipment 3. Cleaning in between batches	Check and inspect the water supply Periodic surface swabbing of surfaces of facilities and equipment	Responsible persons to check or do the tasks
Post-Process	1. Cleaning and sanitizing 2. Dispose wastes and replace with clean waste container	Cleaning and sanitizing checklist	Responsible persons to check or do the tasks

D. EQUIPMENT

	Procedure	Monitoring/Record	Corrective Measures/Actions
Pre-Process	Clean and sanitize equipment and tools	Monitoring checklist	Do not start until all equipment has been properly cleaned and sanitized
In-Process	Clean in-between batches	Visual Inspection record	Agreed written warning/Reward scheme
Post-Process	Clean and sanitize	Sanitation checklist	Agreed written warning/Reward scheme

E. PEST CONTROL			
	Procedure	**Monitoring/Record**	**Corrective Measures/Actions**
Pre-Process	1. Proper cleaning and sanitation. 2. Proper plant lay-outing	Visual inspection/Manifestation of pest	1. Apply appropriate pesticides 2. Provide pest control structures such as screen, etc.
In-Process	1. Immediate segregation of seeds and other wastes 2. Provision of clean covered waste containers 3. Placement of garbage outside the processing area	Regular inspection	Responsible persons to check or do the tasks
Post-Process	1. Regular disposal of garbage to DENR approved recycling structure 2. Chemical application	Regular inspection	1. Have an immediate control process but call attention of a third party pest control company 2. Apply appropriate pesticides

APPENDIX E

TRAINING ON THE PROCESSING OF STABILIZED PEANUT BUTTER AT LEYTE STATE UNIVERSITY

TRAINING ON THE PROCESSING OF
STABILIZED PEANUT BUTTER AT LEYTE STATE UNIVERSITY

APPENDIX F

TRAINING ON THE PROCESSING OF STABILIZED PEANUT BUTTER AT LOLA CONCORDIA AGRO-INDUSTRIAL FARM AND PROCESSING

Training on the Processing of Stabilized Peanut Butter
at LOLA CONCORDIA Agro-Industrial Farm and Processing