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PEANUT BUTTER AND SPREADS

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PEANUT BUTTER AND SPREADS

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CHAPTER 1

QUALITY IMPROVEMENT FOR LOCAL UNSTABILIZED PEANUT BUTTER

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ABSTRACT

Color standards for peanut butter were developed by roasting peanuts at 140-150°C. Samples were taken every five min and processed into peanut butter. A maximum of 60 min of roasting was employed. Color analysis resulted in decreasing L (lightness) values as roasting time was increased indicating the expected development of a darker color.

A commercial stabilizer (Fix-X) was added to peanut butter at three different levels. Different roasting time and method of storage were incorporated into the study. Addition of stabilizer after six months of storage resulted in oil separation for the control samples (without stabilizer) and those with 0.5% stabilizer (both for samples conditioned and not conditioned). Peanut butter samples with 1% stabilizer remain stable. Color analysis (based on L values) showed decreasing values as roasting time was increased. On the other hand, L values showed negligible differences upon storage.

A consumer test was conducted to evaluate the texture of the peanut butter samples with varying levels of Fix-X. Results were tabulated and analyzed using Statistical Analysis System V8 (SAS, 2001) and Response Surface Regression Analysis (PROC RSREG) to determine the effects of the variables studied on the quality of peanut butter. When peanut butter is treated “with” conditioning, the level of stabilizer used in the formulation cannot be lower than 0.1% to meet acceptable consistency and spreadability.

Results of the study were presented to the industry collaborator and a trial production was done using the collaborator’s facilities but the technology was not adopted. The collaborator decided not to add any stabilizers to their peanut butter to retain their characteristic flowing-type peanut butter and to prevent any changes to their labels due to the addition of stabilizer to their natural peanut butter.

INTRODUCTION

Peanut butter is a semi-perishable product that is subject to a number of microbial, chemical and physical deteriorative changes, which affect the final quality of the finished product. The shelf life is greatly dependent on the quality of peanuts used and the conditions of the peanuts used for making the peanut butter. Deterioration of peanut butter arises from putrefaction of protein fraction caused by bacterial metabolism; darkening, which results from an interaction between sugar and protein in the product and; oxidative rancidity that develops in the unsaturated portion of oil when it is exposed to air (Woodroof, 1983).

There have been many studies to improve peanut butter as a food commodity. Most of these addressed such problems as (1) the prevention of oil separation on the surface, (2) improvement of smoothness and spreadability, (3) improvement of the consistency and stickiness, (4) development of a type that can be blocked and sliced, (5) enhancement of flavor by the addition of optional ingredients, (6) effects of added fats, carbohydrates and stabilizers on the final quality, and (8) prevention of rapid deterioration of peanut butter during storage. All these problems define or set the limits of the shelf-life stability of peanut butter.

Color along with other quality, safety and nutritional factors have achieved a more preeminent position in the minds of the consumers. This has necessitated a greater concern on the part of the food manufacturers in assessing the color of foods. Muego *et al.* (1990) reported that peanuts that are water blanched at 90ºC for 10 minutes are lighter in color. The color of peanut butter is basically affected by roasting time.

The most serious problem of natural peanut butter is the tendency of the oil to separate. Oil is released during the grinding of peanuts. The improvement of emulsion stability in peanut butter is characterized by the absence of two layers of oil and meal phase during ordinary conditions of storage, and improved texture, consistency, spreadability, flavor, color as well as nutritional value. Without stabilizers, the peanut meal settles at the bottom and forms a hard layer while the oil remains on top (Aryana *et al*, 2000). Several efforts have already been made to answer the problem. Among the solutions arrived at and researches done to address this particular problem were those cited by Gills and Resurreccion (2000) and Woodroof (1983), which include special grinding of roasted peanuts, the heat treatment of butter after packaging, and the incorporation in peanut butter of various substances, including water, honey, glycerin, mono- and di- glycerides, and vegetable oils hydrogenated to various degrees of hardness. Some peanut butters were stabilized by incorporating into them a commercially hydrogenated peanut oil (m.p. 148ºC) and iodine value of eight (Mitchell, 1950). Other commercial stabilizers incorporated in peanut oil, are hydrogenated peanut oil, and salt (Holman and Quimby, 1950). Stabilizers used for peanut butter are partially or fully hydrogenated vegetable oils. Hydrogenated oils are usually suggested as stabilizing agents for peanut butter because of their efficient homogenization and crystallization. The use of unhydrogenated palm oil has also been studied for its stabilizing action on peanut butter (Gills and Resurreccion, 2000; Hinds *et al,* 1994). Other known important factors contributing to the protection of the peanut butter from oil separation that have been cited in literature are the storage temperature and the temperature at which the stabilizer was incorporated.

OBJECTIVES

Natural peanut butter, a popular product among Filipino consumers, does not contain a stabilizer, is less firm, and flows more easily than stabilized peanut butter. Peanut butter without a stabilizer exhibits oil separation problems, coupled with the formation of a hard layer of peanut solids at the bottom of the container due to settling (Aryana *et al*, 2000).

This study was undertaken to improve natural peanut butter's color and oil stability. Specifically, this study aimed to: (1) determine the roasting temperature and time of peanuts to achieve the most desirable color for peanut butter using consumer acceptance tests (Resurreccion, 1998) and; (2) determine the level of stabilizer to be incorporated in the peanut butter for greater oil stability while maintaining acceptable texture properties.

METHODS

Establishment of Collaboration

An invitation was extended to a company that produces the natural type of peanut butter for possible collaboration on a Peanut Collaborative Research Support Program (Peanut CRSP) funded activity entitled Quality (Color and Oil Dispersion Stability) Improvement for Local Flowing Type of Peanut Butter. Discussions with the company owner revealed willingness to collaborate on this project. An agreement on the collaboration was drafted, discussed and signed by the representative from the company, by Dr. Alicia O. Lustre as Peanut-CRSP Principal Investigator in the Philippines and Dr. Flor Crisanta F. Galvez as Peanut-CRSP co-Principal Investigator. The signed agreement on the collaboration is shown as 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.

Establishment of Color Reference Standards

Roasted Peanuts. The first part of the study involved establishment of color reference standards for roasted peanuts intended to be used for the manufacture of peanut butter. A total of 60 Kg of peanuts was blanched for 25 min using standard blanching procedure from previous studies. The peanuts were de-skinned and sorted for aflatoxin-contaminated kernels. After de-skinning, the peanuts were fed back into the roaster with temperature of 140-150°C, with burner nos. 2, 6, 7, 8 and 9 maintained at 1.5 setting. Two kilograms of peanut samples were taken for every 5-min roasting interval until the color of the peanuts became burnt.

The 2-Kg roasted peanut samples were subjected to instrumental color analysis using a S2 80 II Color Measuring System (Nippon Denchoku Kogyo Co., Ltd.). L (lightness), a (greenness or redness), and b (blueness or yellowness) values were obtained. Measurements were made against a standard white tile with Y = 95.70, X = 93.86, Z = 113.56. Color reference standards for roasted peanuts were developed using the roasted peanut samples. Samples of roasted peanuts for evaluation were photographed to capture the true color under natural light using the Macro (1.6 mm) lens of a Nikon FG with Tamron lens 35-210 mm camera.

Consumer acceptability tests (Resurreccion, 1998) were conducted on the color of the roasted peanut samples. Twenty-four consumer panelists evaluated acceptability (from dislike extremely to like extremely) of color using a 9-point Hedonic scale and rated the lightness/darkness of color (from extremely light to extremely dark) of all samples using 15-cm unstructured line scales. Samples of the roasted peanuts for evaluation were placed in clear glass Petri plates coded with 3-digit random numbers.

Peanut Butter. The roasted peanuts were then processed into peanut butter following the procedure shown in Fig. 1.1. For each roasted peanut sample, peanuts were chopped in a meat silent cutter (Model FC-380-3H, Fujimak, Japan). Washed sugar (20% w/w of peanuts, refined) was weighed and added to the peanuts. The mixture was passed through a colloid mill (TUC/PROBST & CLASS – Rastatt, Baden, West Germany) at no. 2 setting. The slurry was again passed through the colloid mill at no. 0 setting. The peanut butter was collected in a Petri dish for color analysis as previously described.

Consumer acceptability tests were conducted in two parts on the peanut butter samples, including seven commercial samples one of which was an imported product. In the first part, the panelists were made to identify among the samples presented to them which ones they considered peanut butter and the reason why. Responses were one of the following: definitely yes, maybe or not sure, and definitely no. The second part involved evaluations of the acceptability of the color of the peanut butter samples and their corresponding ratings as described previously.

Establishment of Optimum Level of Stabilizer for Peanut Butter

Peanut butter was processed using different roasting times and levels of stabilizer to determine any variability in color upon storage and determination.

Test Material. The stabilizer (Fix-X) was obtained from Proctor and Gamble, USA. It is a fully hydrogenated blend of rapeseed and cottonseed oils containing 33-37% C22:0 (behenic acid).

Experimental Design. A 3x3x2 full factorial design was established which include: three roasting times (40, 50 and 60 min at 140-150°C), three levels of stabilizers (0, 0.5 and 1%) and two conditioning methods (with conditioning and without conditioning). One set was conditioned or stored at 10°C for two days after processing and the other set was stored at ambient temperature right after processing.

Oil Separation Analysis. For each treatment, samples were placed in three 100-ml graduated cylinders for the weekly oil separation determination. The graduated cylinders were stored undisturbed at ambient conditions for 12 weeks. Percent oil separation was calculated after 12 weeks of storage.

Peanut Butter Preparation. Peanut butter was produced as shown in Fig. 1.1. The stabilized peanut butter was filled in 8-oz glass jars. For peanut butter without conditioning, peanut butter samples were immediately stored at ambient conditions. Whereas for conditioned peanut butter samples, the glass jars were stored for 48 hr at 10°C, after which, samples were withdrawn and stored at ambient conditions.

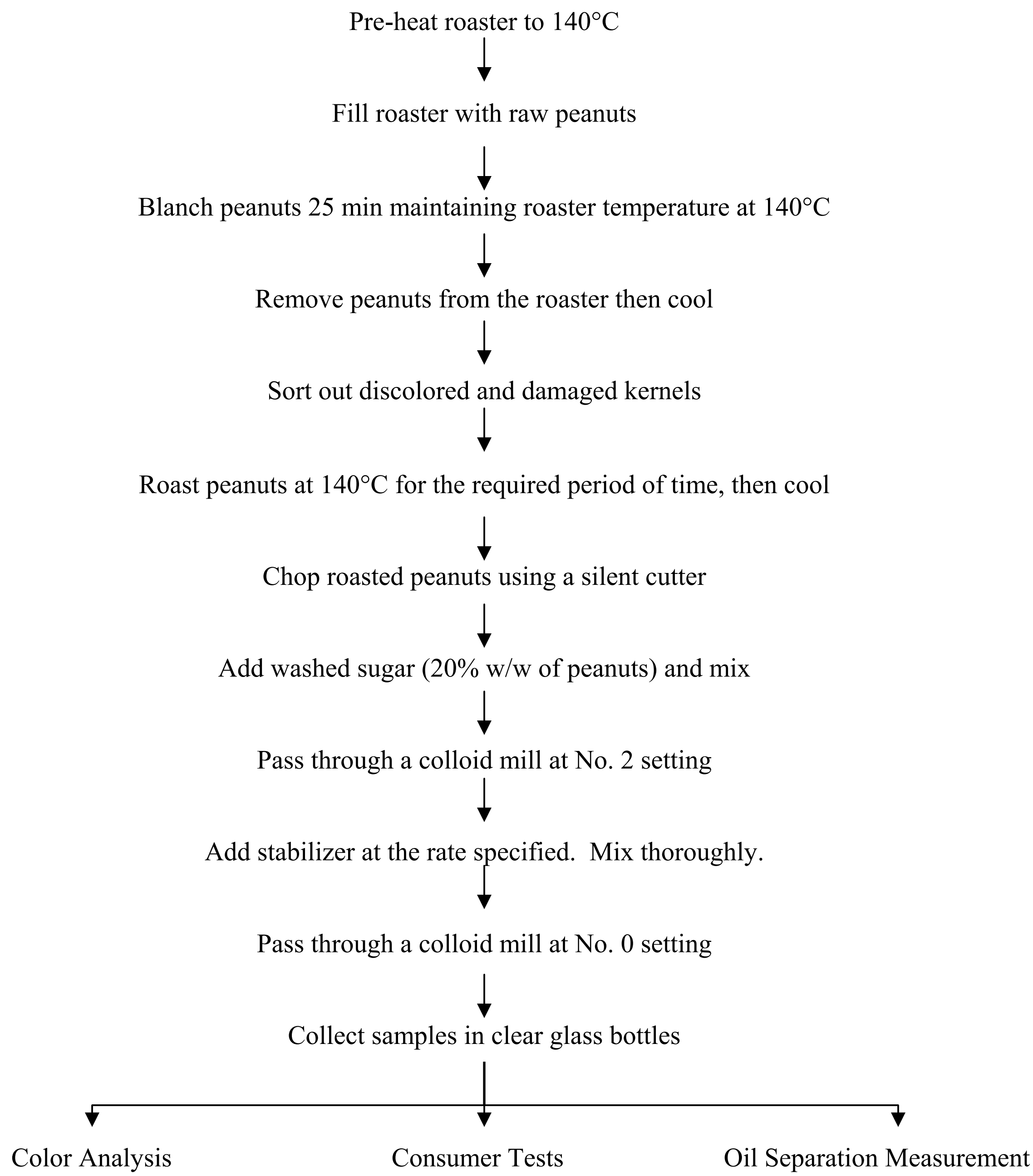

Fig. 1.1 Flow diagram of process for the production and testing of peanut butter.

Consumer Acceptance Test

Scales. Peanut butter samples were evaluated by consumers for acceptability of spreadability and consistency using 9-point Hedonic scales where 1=dislike extremely, 5=neither like nor dislike, and 9=like extremely. Participants were also asked to rate the color, spreadability and consistency of the peanut butter.

Panel. Fifty consumers were randomly selected to determine the acceptability of the stabilized peanut butter. Consumers were recruited from the administrative staff of the College of Home Economics.

Test procedure. Three sets of six samples each from the 18 treatment combinations were presented to each participant. Participants were instructed to take a compulsory break between each set of samples. Samples were evaluated in the order of appearance in the ballot. Participants were asked to place spoonful of the peanut butter in plain bread when evaluating spreadability and consistency. They were likewise told to rinse their mouth with water between samples.

Statistical Analysis and Modeling

Results were tabulated and analyzed using SAS Software v.8 (SAS Institute Inc., 2001). A quadratic response surface model was fitted to the data using Response Surface Regression (PROC RSREG) Analysis to determine the behavior of the response variable in relation to the set of factors (independent variables) studied. Response Surface Methodology (RSM) was used to determine the effects of all variables on the quality of the peanut butter produced.

The prediction models obtained were used to plot response surfaces and contour maps and the direction of responses was analyzed to determine the optimum level of stabilizer. Regions in which operating specifications were met were estimated. Constraints used were consumer acceptability ratings of 7, equivalent to like moderately.

Technology Transfer

A meeting with the industry collaborator was held to determine their interest in adopting the technology of adding a stabilizer to their peanut butter. Results of the study were given to the collaborator showing that all factors studied (i.e. conditioning, stage of roasting, time of roasting and level of stabilizer) affected the quality of the product. It was agreed after that a trial production of stabilized peanut butter will be done at collaborator's plant.

A total of 20 Kg of peanut butter was used for trial production. The level of stabilizer added was 0.7% which was added before the third grinding of peanut butter. Samples were collected in ten 100 mL graduated cylinders and the rest were collected in 504 bottles. Half of the bottles were conditioned for 24 hrs at 5-10°C, while the rest were stored at ambient temperature right after processing. The volume of oil separated from the peanut butter was monitored every week and peanut butter samples were subjected to consumer analysis using 50 untrained panelists.

RESULTS

Establishment of Color Reference Standards for Roasted Peanuts and Peanut Butter

Color reference standards for roasted peanuts were developed using the roasted peanut samples as shown in Fig. 1.2. Samples of roasted peanuts were photographed to capture the true color under natural light using the Macro (1.6 mm) lens of a Nikon FG with Tamron lens 35-210 mm camera.

In the early stages of roasting, cell walls become wet with oil producing the change in color on the peanut surface. The stage is referred to as the "white roast". As roasting time is prolonged, the skin becomes wet with oil and darker in color. The final stage of roasting is the development of brown color, which usually occurs after 30-60 min (Woodroof, 1983). In this study, the white roast stage was observed during the first 25 min of roasting at 140°-150°C. "Steam blisters" were quite noticeable after 30 min of roasting. From the 30 min roasting time up to 70-80 min, gradual development of the brown color was observed. This development was manifested in the decrease in L (lightness) values as indicated in Table 1.1 and may be seen in Fig. 1.2.

Consumer acceptability of the roasted peanuts increased as roasting time was increased from 0-30 min at 140°-150°C after which consumer acceptability already decreased (Table 1.2). The most acceptable color was that of the sample roasted for 30 min, which received the highest mean acceptance ratings of 5.9 equivalent to like slightly. The panelists rated the color of this sample as "slightly light".

The roasted peanuts were processed into peanut butter and results of color analysis are shown in Table 1.3. Results of all consumer tests are presented in Tables 1.4 and 1.5.

Table 1.1 Hunter L, a, b values for the peanut samples roasted at 140°C and 170°C at different time periods

Sample No.			Hunter values		
			L[1]	a[2]	b[3]
1	Control		76.54	-2.03	9.70
2	140°C	5 min.	77.24	-1.69	9.60
3		10	76.91	-1.79	9.58
4		15	75.20	-2.99	10.81
5		20	74.06	-0.49	10.52
6		25	71.16	0.13	11.12
7		30	70.33	-0.63	12.24
8		35	68.46	-1.98	12.66
9		40	65.28	1.35	11.63
10		45	61.74	-1.47	12.21
11		50	60.64	-2.04	11.93
12		55	59.93	-2.12	11.79
13		60	59.54	-3.24	12.12
14		65	59.21	-2.83	12.13
15		70	59.12	-3.32	11.69
16		80	55.21	-2.35	10.76
17	170°C	10 min.	75.18	-2.76	10.45
18		20	68.88	-1.57	12.18
19		30	60.24	-2.14	11.97
20		40	54.31	-1.01	10.23
21		50	48.43	-5.21	9.80
22		60	47.73	-6.27	9.87

[1]L=lightness
[2]a=greenness or redness
[3]b=blueness or yellowness

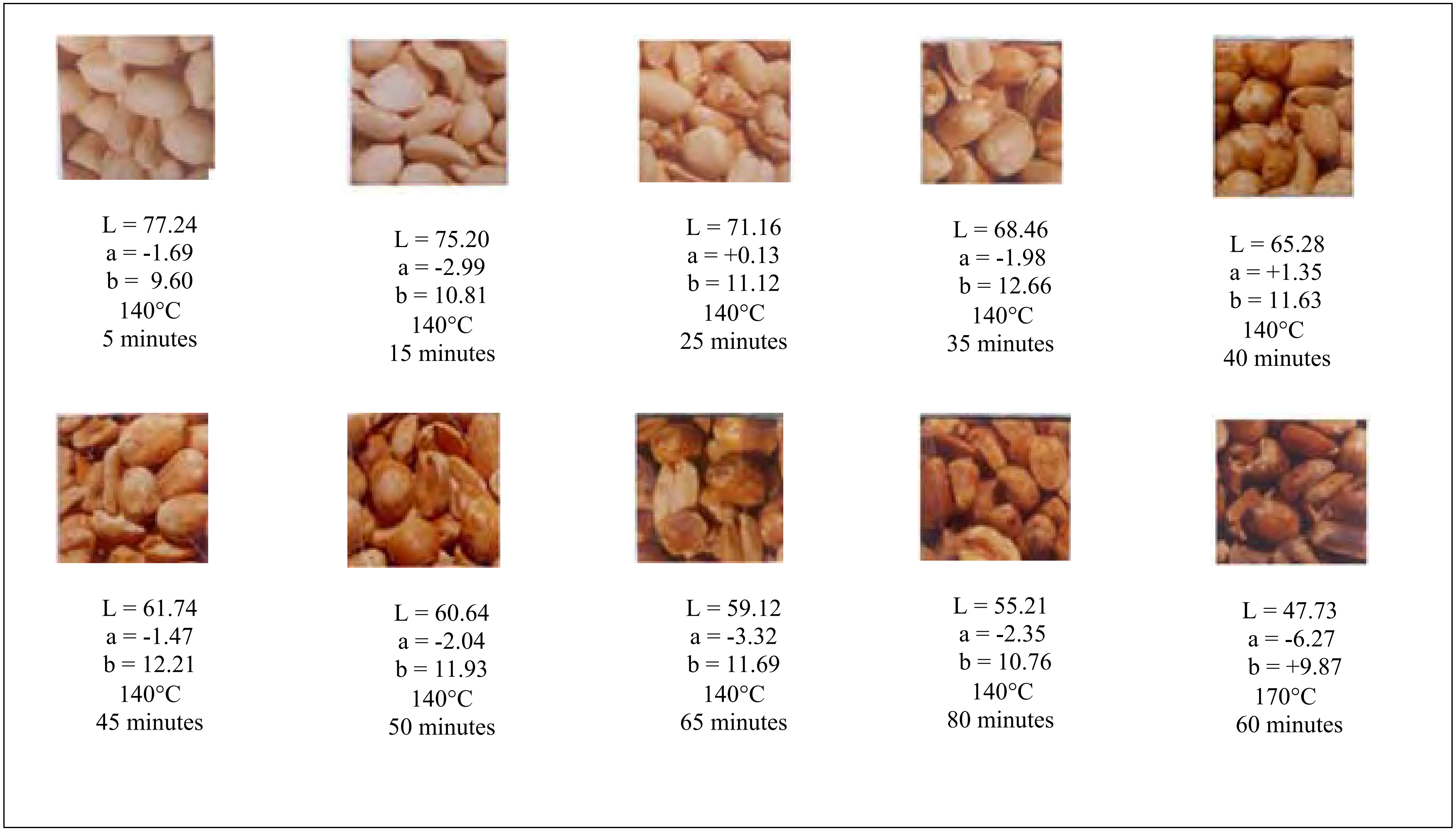

Fig. 1.2 Color standards developed for roasted peanuts. L=lightness; a=greenness or redness; b=blueness or yellowness; roasting temperature (°C); roasting time (min).

Table 1.2 Consumer acceptability and rating for the color of peanut samples roasted at 140°C and at 170°C at different time periods

Treatment		Consumer Rating		Consumer Acceptability	
		Means[1]	Description[2]	Means[1]	Description[3]
Control		0.9	Extremely light	3.4	Dislike moderately
140°C	5 min	1.3	Extremely light	3.4	Dislike moderately
	10	1.9	Very light	3.5	Dislike slightly
	15	3.2	Very light	4.7	Neither like nor dislike
	20	4.7	Moderately light	5.1	Neither like nor dislike
	25	6.0	Slightly light	5.0	Neither like nor dislike
	30	6.6	Slightly light	5.9	Like slightly
	35	7.1	Neither dark nor light	4.6	Neither like nor dislike
	40	8.4	Neither light nor dark	4.7	Neither like nor dislike
	45	9.6	Slightly dark	3.9	Dislike slightly
	50	10.4	Moderately dark	3.9	Dislike slightly
	55	10.5	Moderately dark	3.8	Dislike slightly
	60	10.1	Slightly dark	4.1	Dislike slightly
	65	10.8	Moderately dark	3.6	Dislike slightly
	70	11.6	Moderately dark	3.1	Dislike moderately
	80	12.1	Very dark	2.8	Dislike moderately
170°C	10 min	1.9	Very light	3.1	Dislike moderately
	20	5.7	Slightly light	5.3	Neither like nor dislike
	30	9.8	Slightly dark	4.4	Dislike slightly
	40	11.3	Moderately dark	2.8	Dislike moderately
	50	12.6	Very dark	2.5	Dislike very much
	60	13.0	Very dark	2.1	Dislike very much
	70	14.6	Extremely dark	1.6	Dislike extremely

[1]Mean values given by 24 panelists. Except for first two samples, all samples are significantly different at the 5% level

[2]Consumer ratings: 0=Extremely light, 7.5=Neither light nor dark; 15=Extremely dark

[3]Consumer acceptability ratings: 1=Dislike extremely; 5=Neither like nor dislike; 9=Like extremely

Table 1.3. Hunter L, a, b values for the peanut butter samples prepared from peanuts roasted at 140°C at different time periods, including commercial samples

Sample No.	Product Description Roasting time/Brand name	Hunter Values		
		L[1]	a[2]	b[3]
1	0 – control	66.95	-3.53	8.69
2	5 min	67.41	-3.91	8.81
3	10	66.56	-3.70	8.69
4	15	67.76	-3.65	8.60
5	20	67.39	-4.02	8.74
6	25	67.40	-4.32	9.12
7	30	65.38	-4.34	10.12
8	35	62.81	-4.03	11.19
9	40	57.65	-3.20	10.78
10	45	51.50	-5.20	10.30
11	50	45.30	-6.14	8.94
12	55	39.99	-11.68	55.50
13	60	32.62	-10.16	6.16
14	Unstabilized-Local Brand 1	55.95	-4.95	11.02
15	Unstabilized-Local Brand 2	55.12	-5.75	11.14
16	Unstabilized-Local Brand 3	53.86	-6.06	11.04
17	Stabilized-Local Brand 1	56.40	-4.64	11.29
18	Stabilized-Local Brand 2	57.47	-3.68	11.31
19	Stabilized-Local Brand 3	57.22	-3.62	10.91
20	Stabilized-Imported	56.14	-4.84	10.99

[1]L=lightness
[2]a=greenness or redness
[3]b=blueness or yellowness

Table 1.4 Consumer perception (% total number of consumers) on whether the peanut butter samples prepared from peanuts roasted at 140°C for different periods of time are considered peanut butter

Description (Roasting time / brand name)	Percentage (%)			Total for "Yes" and "Maybe" responses (%)
	Yes(Y)	Maybe (M)	No(N)	
0- control	0	4	96	4
5 min	4	12	84	16
10	0	24	76	24
15	0	4	96	4
20	0	12	88	12
25	0	8	92	8
30	0	8	92	8
35	12	36	52	48
40	48	44	8	92
45	20	40	40	60
50	12	12	76	24
55	4	20	76	24
60	4	12	84	16
Unstabilized-Local Brand 1	72	28	0	100
Unstabilized-Local Brand 2	60	24	16	84
Unstabilized-Local Brand 3	48	40	12	84
Stabilized-Local Brand 1	28	52	20	88
Stabilized-Local Brand 2	44	40	16	84
Stabilized-Local Brand 3	28	56	16	84
Stabilized-Imported	64	28	8	92

Table 1.5 Consumer acceptability and ratings for color of samples highly recognized as peanut butter

Description	Total Percentage	Mean Consumer Color Acceptability Ratings[1]		Mean Consumer Color Ratings[2]	
		Mean	Description	Mean	Description
Unstabilized – Local Brand 1	100	5.3	Neither like nor dislike	7.4	Slightly light
40 minutes – Unstabilized	92	5.1	Neither like nor dislike	6.9	Slightly light
Stabilized – Imported	92	4.5	Dislike slightly	7.5	Slightly light
Unstabilized – Local Brand 2	84	4.8	Neither like nor dislike	6.7	Slightly light
Unstabilized – Local Brand 3	84	5.0	Neither like nor dislike	6.6	Slightly light
Stabilized – Local Brand 1	88	4.1	Dislike slightly	6.9	Slightly light
Stabilized – Local Brand 2	84	4.4	Dislike slightly	6.3	Slightly light
Stabilized – Local Brand 3	84	4.2	Dislike slightly	6.3	Slightly light

[1] Consumer acceptability scores: 1=Dislike extremely, 5=Neither like nor dislike, 9=Like extremely
[2] Consumer ratings: 1=Extremely light, 7.5=Neither light nor dark, 15=Extremely dark

Table 1.6 Mean values of lightness (L-value) and volumes of oil separation (%) of peanut butter samples prepared using different roasting times and levels of stabilizer and stored "with" and "without" conditioning after 12 weeks of storage.

Roasting time % stabilizer	L[1] Values taken				Oil Separation	
	With Conditioning		Without Conditiong		With Conditioning	Without Conditioning
	Initial[2]	Final[3]	Initial[2]	Final[3]	% Oil Separated[3]	% Oil Separated[3]
40 min, 0%	57.46	57.34	63.78	63.16	2.8	4.0
40 min, 0.5%	64.06	63.26	64.06	62.98	2.0	3.0
40 min, 1%	58.08	57.12	64.12	63.12	0.0	0.0
50 min, 0%	56.02	55.74	60.58	59.81	2.2	3.8
50 min, 0.5%	60.32	60.06	60.40	59.98	2.2	1.5
50 min, 1%	56.48	55.71	60.40	59.84	0.0	0.0
60 min, 0%	44.98	45.32	54.42	54.00	2.3	4.2
60 min, 0.5%	54.13	54.14	54.42	53.72	1.3	1.8
60 min, 1%	44.92	45.24	54.52	54.01	0.0	0.0

[1]L=lightness
[2]Initial = Day 0 storage
[3]Final = 12 weeks storage

Modeling of the Physical and Sensory Attributes of Stabilized Peanut Butter

Table 1.6 shows the results of the color analysis (in L values) for peanut butter samples with conditioning and without conditioning, and the extent of oil separation for all products produced. Lightness of peanut butter samples after processing for both conditioning methods decreased with prolonged roasting. From a range of L = 57-58 for the 40 min roasting to a range of L = 44-46 for the 60 min roasting.

For oil separation, all control samples for "with" or "without" conditioning had % oil separation greater than 2% after 12 weeks of storage. At roasting times of 40 and 60 min with 0.5% stabilizer, more oil separated from peanut butter samples with that were not conditioned compared to conditioned samples. A different effect was observed for samples prepared using peanuts roasted at 50 min, with 0.5% stabilizer. Non-conditioned samples had less oil separation than the conditioned samples. As for color variation upon storage, variation in lightness was very minimal indicating that darkening reactions did not occur upon storage.

Consumer acceptance ratings were tabulated and analyzed using RSREG Analysis. Results showed significant regression models at α=0.05 for consumer acceptability of consistency and spreadability (Table 1.7). Roasting time was shown to have statistically significant effect only on consumer acceptability of spreadability and on consumer ratings for consistency and color when samples were stored "with conditioning". When samples were stored "without conditioning", roasting time was found to have significant effect on consumer acceptability of consistency, on oil separation, and on consumer ratings for color. The level of stabilizer used was found to have significant effect on all attributes tested (consumer acceptability of consistency and spreadability, oil separation, and consumer ratings on consistency, spreadability and color), whether the samples were stored "with" or "without" conditioning.

It was decided to use full regression models as the predictive models for all attributes used during optimization. A list of the parameter estimates are presented in Tables 1.8 and 1.9. Color was identified not to be important to the consumers during a survey conducted on consumer preferences for peanut butter (Galvez et al., 1999) and was therefore not considered as one of the parameters for optimization.

The contour plots in Figs. 1.3 and 1.4 were obtained using the predictive models for consumer acceptability of consistency and spreadability to determine the region of the total space of the variables in which certain operating specifications are met. The shaded regions represent values for a particular measurement corresponding to the constraints specified previously.

Attaining the Optimum Formulation

The contour plots for each storage condition ("with" or "without" conditioning) were overlaid to determine the region where the operating conditions were satisfied or met. The overlapped regions are shown in Fig. 1.5. The shaded areas represent the ranges for all attributes which satisfy consumer acceptability ratings of at least 7 (like moderately). When samples were stored "with conditioning", the consistency and spreadability of the peanut butter were apparently more acceptable to the consumers.

When peanut butter is treated "with" conditioning, the level of stabilizer used in the formulation cannot be lower than 0.1% to meet the acceptable consistency and spreadability. If peanut butter is treated "without" conditioning, however, results indicated that the level of stabilizer used in the formulation can be as low as 0.01%, at roasting time of 60 min. This is an unexpected result and needs to be verified. Figs. 1.6 and 1.7 show the expected consumer ratings of the samples produced at optimum

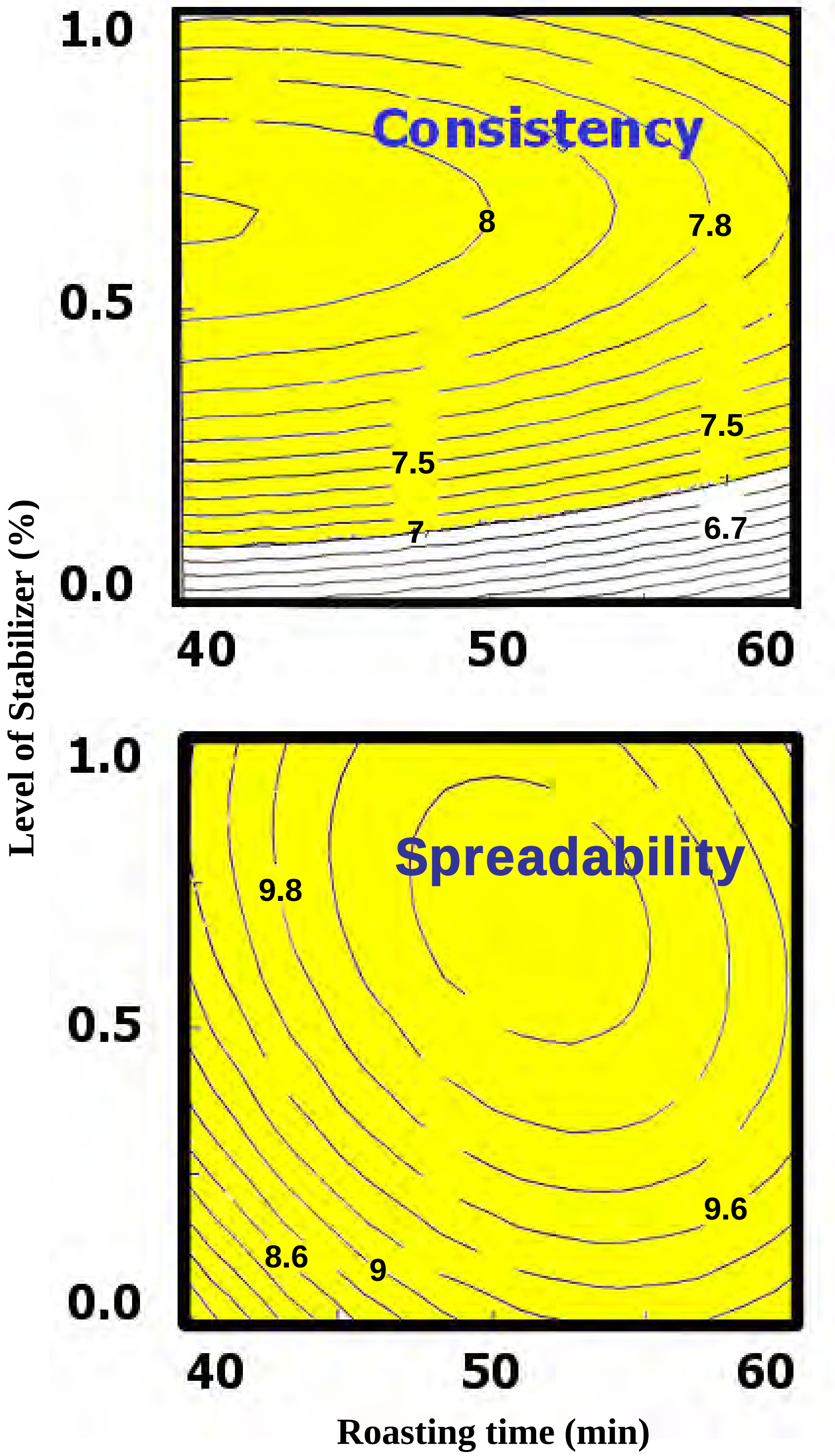

Fig. 1.3 Contour plots of consistency and spreadability acceptability of stabilized peanut butter (with conditioning) produced during optimization of process. The shaded regions represent acceptance ratings of 7 or greater using 9-point hedonic scales where 1=dislike extremely, 5=neither like nor dislike and 9=like extremely.

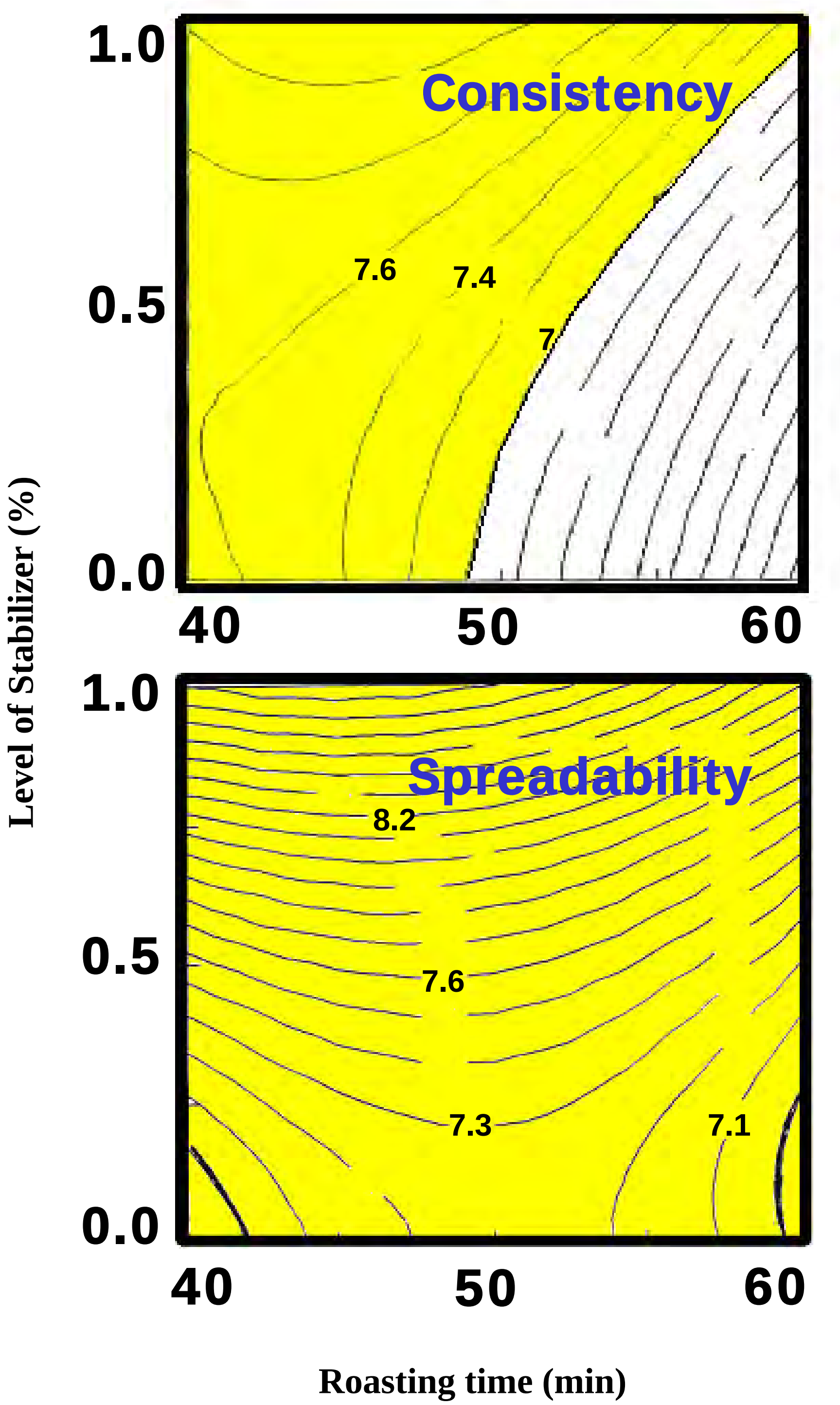

Fig. 1.4 Contour plots of consumer acceptance of consistency and overall acceptability of stabilized peanut butter (without conditioning) produced during optimization of process. The shaded regions represent acceptance ratings of 7 or greater using 9-point hedonic scales where 1=dislike extremely, 5=neither like nor dislike and 9=like extremely.

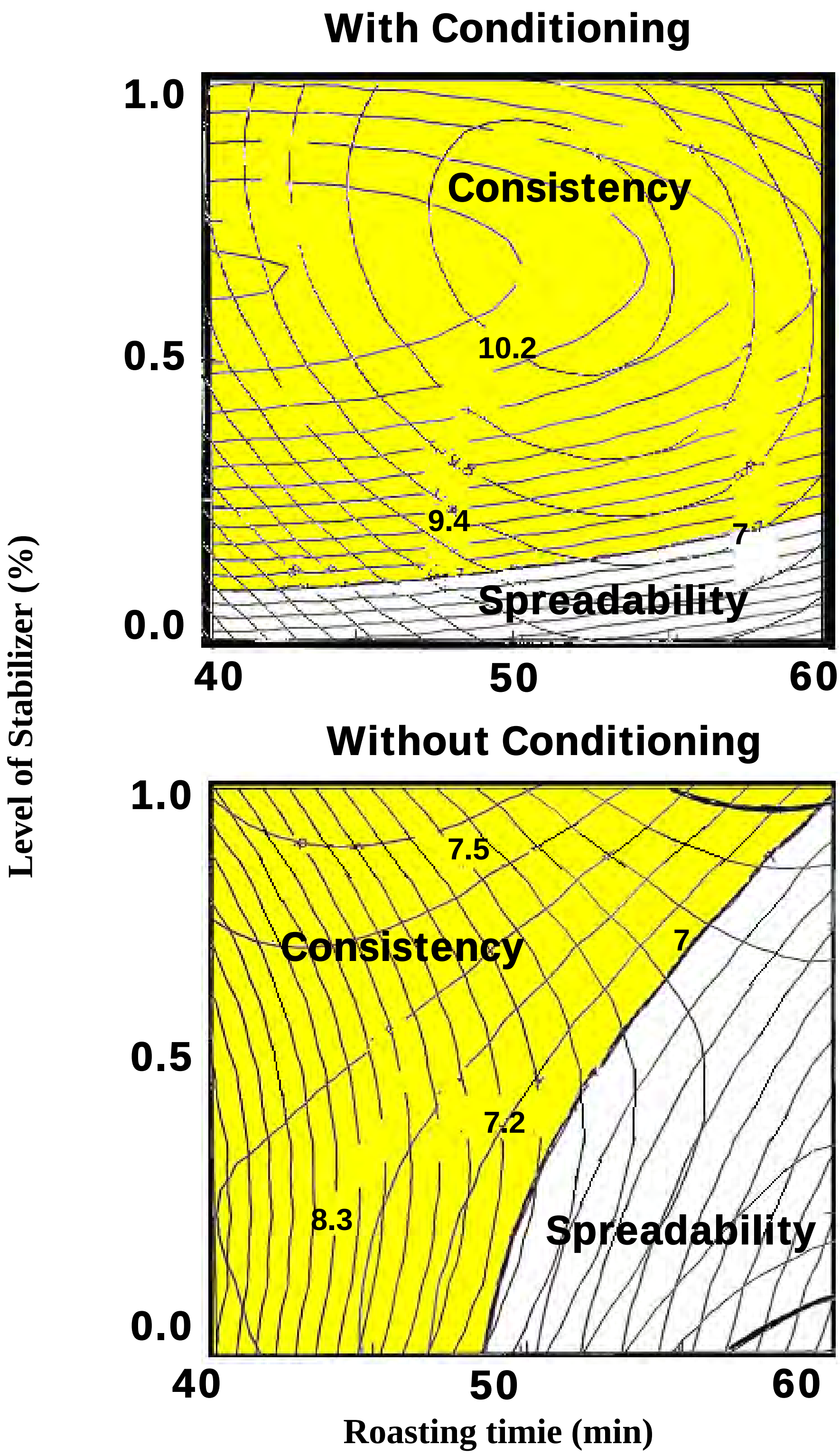

Fig. 1.5 Optimum regions obtained by superimposing contour plots of consumer acceptance of consistency and spreadability of stabilized peanut butter (with and without conditioning) produced during optimization of process. The shaded regions represent acceptance ratings of 7 or greater using 9-point hedonic scales where 1=dislike extremely, 5=neither like nor dislike and 9=like extremely.

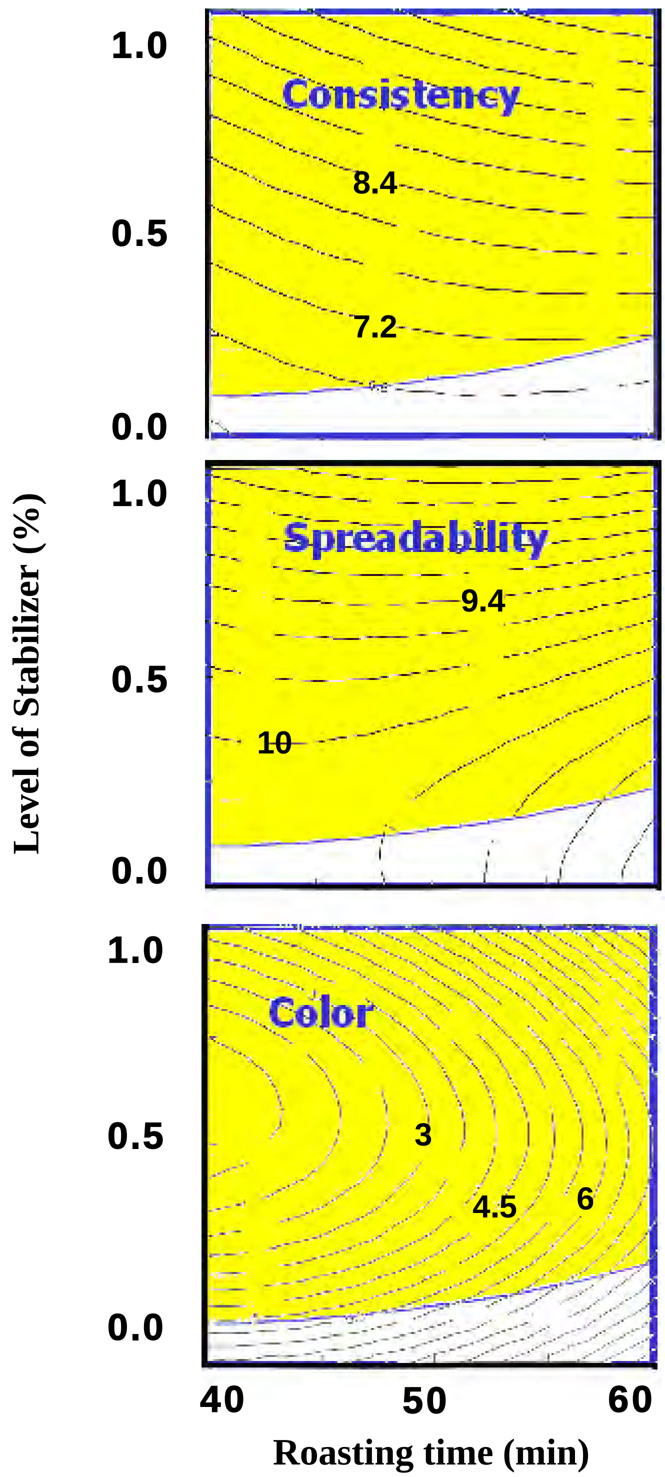

Fig. 1.6 Contour plots of consumer ratings for color, consistency and spreadability of stabilized peanut butter (with conditioning) produced during optimization of process. The shaded regions represent consumer ratings corresponding to the optimized region.

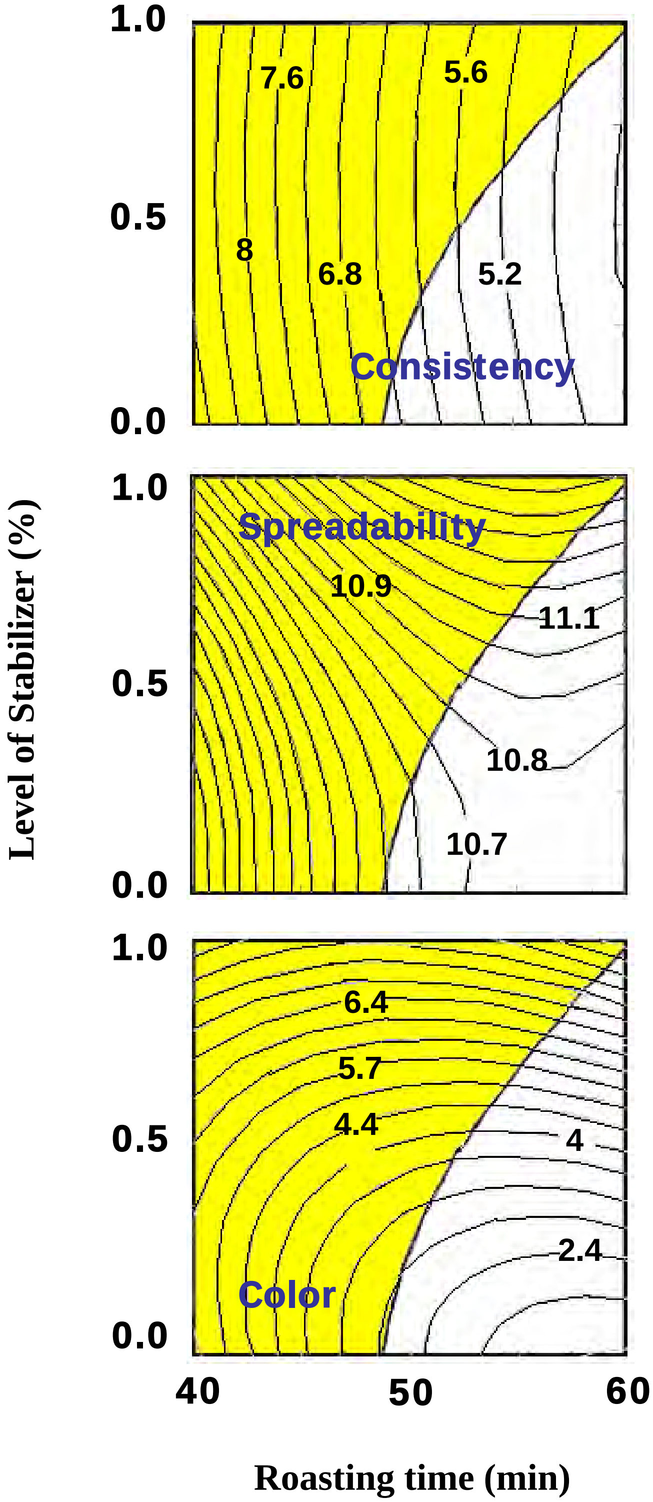

Fig. 1.7 Contour plots of consumer ratings for color, consistency and spreadability of stabilized peanut butter (without conditioning) produced during optimization of process. The shaded regions represent consumer ratings corresponding to the optimized region.

conditions "with" or "without" conditioning (shaded regions). A list of the parameter estimates for the quadratic equations used to generate the contour plots are shown in Tables 1.10 and 1.11.

Table 1.7 F-statistic and parameter estimates for variables used in the final prediction models for the consumer acceptability of spreadability and consistency of stabilized peanut butter (with conditioning) processed during optimization of process for its manufacture

	Parameter Estimates	
Variables[1]	**Acceptability of Consistency**	**Acceptability of Spreadability**
Intercept	5.105735	-14.592244
RT	0.075951	0.873244
LOS	4.590410	7.343725
RT*RT	-0.000886	-0.008402
LOS*RT	0.004726	-0.077706
LOS*LOS	-3.670237	-2.374372
F-statistic[2]	2.96	4.10

[1] Variables were: RT = roasting time in minutes, LOS = level of stabilizer used in percent (%)
[2] F-Statistic is to test significant differences between full and reduced models.

Table 1.8 F-statistic and parameter estimates for variables used in the final prediction models for the consumer acceptability of spreadability and consistency of stabilized peanut butter (without conditioning) processed during optimization of process for its manufacture

	Parameter Estimates	
Variables[1]	**Acceptability of Consistency**	**Acceptability of Spreadability**
Intercept	5.697210	-0.468680
RT	-0.097076	0.303701
LOS	8.134160	1.660482
RT*RT	0.002406	-0.002770
LOS*RT	-0.085000	-0.032500
LOS*LOS	-2.087218	1.571901
F-statistic[2]	3.76	4.29

[1] Variables were: RT = roasting time in minutes, LOS = level of stabilizer used in percent (%)
[2] F-Statistic is to test significant differences between full and reduced models.

Table 1.9 Analysis of variance for the overall effects of the factors studied and significance of the full regression models for the consumer ratings and acceptability of stabilized peanut butter produced during optimization of process

Factors	F-ratio				
	Acceptability of Consistency	**Acceptability of Spreadability**	**Consistency Rating**	**Spreadability Rating**	**Color Rating**
With Conditioning					
Roasting time (mins)	0.106	3.101*	2.282*	0.813	242.6*
Level of stabilizer (%)	4.822*	4.651*	48.019*	14.872*	134.5*
Without Conditioning					
Roasting time (mins)	3.542*	0.515	1.788	0.275	177.3*
Level of stabilizer (%)	3.097*	6.793*	60.041*	4.643*	33.328*
F-ratio for total regression:					
With conditioning	2.96*	4.10*	29.29*	9.00*	220.30*
Without conditioning	3.76*	4.29*	37.08*	2.94	116.30*

*Significantly different at 5% level

Table 1.10 F-statistic and parameter estimates for variables used in the final prediction models for the consumer ratings of spreadability, consistency and color of stabilized peanut butter (with conditioning) processed during optimization of process for its manufacture

	Parameter Estimates		
Variables[1]	**Consistency**	**Spreadability**	**Color**
Intercept	1.520637	12.984563	24.273779
RT	0.200032	-0.153593	-0.879945
LOS	-2.226538	3.024513	-25.434403
RT*RT	-0.002194	0.001836	0.011281
LOS*RT	0.088312	-0.057332	0.155825
LOS*LOS	1.887536	-2.209030	16.304296
F-statistic[2]	29.29	9.00	220.30

[1] Variables were: RT = roasting time in minutes, LOS = level of stabilizer used in percent (%)
[2] F-Statistic is to test significant differences between full and reduced models.

Table 1.11 F-statistic and parameter estimates for variables used in the final prediction models for the consumer ratings of spreadability, consistency and color of stabilized peanut butter (without conditioning) processed during optimization of process for its manufacture

	Parameter Estimates		
Variables[1]	**Consistency**	**Spreadability**	**Color**
Intercept	9.459316	16.214654	17.879616
RT	-0.201809	-0.257166	-0.919160
LOS	2.958676	0.196748	9.290963
RT*RT	0.002419	0.002502	0.013179
LOS*RT	-0.007900	0.010300	-0.231500
LOS*LOS	1.912216	-1.834499	3.814247
F-statistic[2]	37.08	2.94	116.30

[1] Variables were: RT = roasting time in minutes, LOS = level of stabilizer used in percent (%)
[2] F-Statistic is to test significant differences between full and reduced models.

Technology Transfer

The technology was not transferred to the collaborator. The collaborator decided not to add any stabilizers to their peanut butter to retain their characteristic flowing-type peanut butter and to prevent any changes to their labels due to the addition of stabilizer to their natural peanut butter.

CONCLUSION

Color analysis of roasted peanuts resulted in decreasing L values as roasting time was increased indicating the expected development of a darker color. The corresponding peanut butter produced showed the same trend in L values vs. roasting time. On the other hand, L values showed negligible differences upon storage.

All control samples for “with” or “without” conditioning had % oil separation greater than 2% after 12 weeks of storage. At roasting times of 40 and 60 min with 0.5% stabilizer, more oil separated from peanut butter samples with that were not conditioned compared to conditioned samples. A different effect was observed for samples prepared using peanuts roasted at 50 min, with 0.5% stabilizer. Non-conditioned samples had less oil separation than the conditioned samples. When samples were stored “with conditioning”, the consistency and spreadability of the peanut butter were apparently more acceptable to the consumers. If peanut butter is treated “without” conditioning, however, results indicated that the level of stabilizer used in the formulation can be as low as 0.01%, at roasting time of 60 min. This is an unexpected result and needs to be verified.

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APPENDIX A

PROPOSAL FOR R&D COLLABORATION WITH A PEANUT PROCESSOR

A. Title: Quality (Color and Oil Dispersion Stability) Improvement for Local Flowing Type Peanut Butter

B. Objective: To improve the quality (color and oil dispersion stability) of local flowing type peanut butter.

Rationale: Flowing type peanut butter is a very popular peanut product especially to low income families. This type of peanut butter is lower in price than the hard type and is usually sold in wet markets. Oil separation and color change in flowing type peanut butter is an industry wide problem due to shorter shelf life and undesirable appearance. Inconsistency in color greatly affects market acceptability.

C. Expected Output:

1. A technology for improved color and oil dispersion stability of local flowing type peanut butter.
2. Consumer and market acceptability of the product quantified and shelf life predicted.

D. Duration: March to June 1998

E. Activities and Cost Sharing Schemes

1. Product development at the laboratories and pilot plant of FDC.
2. Optimization and verification of the process at the plant of industry collaborator.

Cost Sharing Scheme:
UP-FDC:

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

Industry Collaborator:

1. Cost of 50% of peanuts during the 1st phase of the study.
2. Cost of stabilizer during the 1st and 2nd phase of the study.
3. Availability of facilities and cost of peanuts during the 2nd phase.
4. Cost of color and viscosity analysis during the 2nd phase.

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. "Improving the quality (color and oil dispersion stability) of flowing type peanut butter to increase marketability: after due review of the material.

Proposed by:	The Food Development Center	The University of the Philippines
	Dr. Alicia O. Lustre Principal Investigator (Original signed)	Dr. Flor Crisanta F. Galvez Co-Principal Investigator (Original signed)
Conforme:	Industry Collaborator (Original signed)	

CHAPTER 2

SCREENING OF LOCAL STABILIZERS FOR PHILIPPINE PEANUT BUTTER

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ABSTRACT

The type and level of stabilizer, conditioning methods and roasting time that will be used in the production of a stabilized peanut butter that is most acceptable to consumers were determined in a 3x3x2x3 full factorial experiment. Myvatex monoset®, Distilled monoglyceride Type P(V) and κ-carrageenan were used as stabilizers at different concentrations (0, 0.5, 1.0%) to determine the most effective local stabilizer that will produce the most stable product. The effectiveness of stabilizers was measured on its ability to prevent oil separation in peanut butter. The stabilizing effect of the three test materials showed that Myvatex monoset® at 1% level has the greater ability to prevent oil separation in peanut butter at ambient conditions. Conditioning was found not to have any effect on the % oil separation of peanut butter samples.

The roasting time of peanuts at 140˚C (40, 50, 60 min) and the after process applications (with or without conditioning) were likewise determined for peanut butter samples stabilized with Myvatex monoset®. Consumer acceptance tests were conducted to determine optimum conditions for processing of stabilized peanut butter. The level of stabilizer and conditioning methods on the other hand did not have any significant effect on the acceptability of peanut butter. Color, consistency and spreadability were found to have significant effect on the stability and acceptability of peanut butter. Recommended processing conditions for stabilized peanut butter at 140°C include roasting time of 50 minutes and maximum of 1.0% stabilizer.

INTRODUCTION

Peanut butter is a water-in-oil emulsion (Aryana *et al*, 2000). Emulsions are defined as "a heterogenous system, consisting of at least one immiscible liquid intimately dispersed in another in the form of droplets, whose diameter, in general, exceeds 0.1 micron. Such systems possess a minimal stability, which may be accentuated by such additives as surface-active agents, finely divided solids, etc." (Becher, 1957).

Stabilizers, as defined by *21 Code of Federal Regulations,* are "substances used to produce viscous solutions or dispersions, to impart body, improve consistency, or stabilize emulsions, including suspending and bodying agents, setting agents, jellying agents and bulking agents" (Stauffer, 1992, p. 680). Ockerman (1991) defines stabilizers as a food additive that thickens, prevents separation, prevents flavor deterioration, and retards oxidation by increasing the viscosity and gives smoother product. It normally works by absorbing water, and it also prevents evaporation and deterioration of volatile flavors.

The commonly used stabilizers incorporated in peanut butter are partially or fully hydrogenated vegetable oils, monoglycerides, diglycerides of vegetable oils or combination of any of these. Hydrogenation is a pertinent process for the alteration of the chemical and physical properties of vegetable oils.

Mono and diglycerides are the most commonly used stabilizers in the peanut butter industry. According to Furia (1972), they are added to the crystalline part of the free oil during processing and thus prevent the oil and peanut fibers from separating during storage. Other benefits obtained by adding mono- and diglycerides to peanut butter are improved stability, gloss appearance, excellent spreadability over a wide temperature range, versatility in production and improved palatability. The suggested surfactant concentration is from 1.0-2.5%.

Woodroof (1983) identified the important considerations to be made when adding stabilizers to the peanut butter. The type and amount of stabilizer to be added is dependent on the desired consistency and mouthfeel of the peanut butter, the amount of oil present and particle size. The maximum level of stabilizer is 5.5% with 3.25% as the most common. The temperature of the peanut butter during the addition of the stabilizer should be above the melting point of the stabilizer added to produce a more homogenized product. Recommended temperature for blending of stabilizers is 140ºF to 165 ºF.

Another method used to prevent oil separation is called conditioning. Here, the mixture is shock chilled and the hydrogenated oil forms finely divided and sufficient amount of hard fat crystals. The amount and nature of the crystals determines the stability of the product. The rate of cooling determines the size of the crystals. The finer the size, the smoother is the peanut butter produced. As the peanut butter cools, the stabilizer begins to crystallize, forming the matrix. Furthermore, it was suggested that for improved stability, the peanut butter should be packed at the proper temperature and it should be tempered for a minimum of 24 hours before shipping. This tempering allows time for additional crystal growth and formation of a good crystalline network (Woodroof, 1983).

Stabilizers in the form of carrageenan cover a family of sulfated linear polysaccharides of D-galactose and 3,6 anhydro-D-galactose extracted from various red seaweeds. There are currently seven types of carrageenans (kappa κ, lambda λ, iota ι, mu μ, nu, ν, xi ε, theta θ) (Charalambous and Doxastakis, 1989). Only three of them are considered commercially and industrially significant. They are usually utilized as additives in order to provide the desired texture in products, to prevent evaporation and deterioration of volatile flavor oils, as thickener, as gelling agent, and stabilizer (Branen *et al*., 1990).

Their sulfate concentration must be within 20-40% on a dry weight basis. Their concentration used in food systems must not exceed the required amount to accomplish gelling, thickening, emulsifying, and stabilizing effects. Food grade carrageenans possess GRAS (Generally Regarded As Safe) status provided they are not degraded and with molecular weights ranging between 1000,000 to 500,000 daltons (Charalambous and Doxastakis, 1989).

One of the most significant properties of carrageenans is the ability to form various types of gels in water and milk-based food systems. Gelation is influenced by the type of carrageenan, cations in solution, and carrageenan concentraton. Approximately 70% of carrageenan applications are in the food industry. Its application to food systems may be classified into two major categories: milk-based and water-based. Proper addition of carrageenan in food systems must be done properly to prevent lumping. This may be done by (1) premixing with a dispersant (e.g. sugar); (2) addition of a retardant (e.g. salt); (3) slow addition of the stabilizer in agitated cold solvent; and (4) use of a high-speed mixer (Charalambous and Doxastakis, 1989).

OBJECTIVES

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. Several stabilizers are available locally in the market and these may not necessarily behave in the same way. Therefore, there is a need to determine the performance of local stabilizers in peanut butter and optimize the process for the use of a locally available stabilizer in the manufacture of a stabilized peanut butter that meets consumer requirements. Specifically, this study aims to (1) produce peanut butter using different types and levels of stabilizers, roasting times and conditioning methods; (2) monitor changes in quality of the peanut butter in terms of extent of oil separation and; (3) conduct consumer acceptance tests to determine optimum conditions for processing of stabilized peanut butter.

METHODS

Test Materials

Three locally available stabilizers that were studied include: (1) Myvatex monoset® (mp=63°C, 18% monoester content, Malabon Long Life, Inc., Manila, Philippines), a fully hydrogenated rapeseed and cottonseed oil blend, containing high erucic acid; (2) Distilled monoglyceride Type P(V)®, (mp=63-68°C, 95% monoester content, Vitachem Industries, Q.C. Philippines), also a fully hydrogenated vegetable oil and; (3) κ-carrageenan (Marine Resources Development Corp., Q.C. Philippines). The stabilizers were incorporated in the peanut butter at three levels: 0, 0.5 and 1.0%, w/w of peanut butter.

Preparation of Peanut Butter

Peanut butter was produced, in laboratory scale, as shown in Fig. 2.1. Nine batches of 20-Kg peanuts (large seed variety from Vietnam) 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. For each treatment, 5 Kg of peanuts were roasted at 140°C at the specified roasting time. Roasted peanuts were chopped in 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 no. 2 setting. The stabilizer was added to the mixture and manually mixed with a wooden spoon for about five min. The peanut butter was again passed through a colloid mill at zero setting. The stabilized peanut butter was filled in three 100-mL graduated cylinders. For peanut butter without conditioning, peanut butter samples were immediately stored at ambient conditions. While for conditioned peanut butter samples, the graduated cylinders and glass jars were stored for 48 hours at 10°C. After which, samples were withdrawn and stored at ambient conditions.

Oil Separation Analysis

Experimental Design

Four factors: roasting time, type of stabilizer, conditioning method and level of stabilizer, were studied. The factors were studied in a 3x3x2x3 full factorial experiment. For each treatment, samples were placed in three 100-ml graduated cylinders for the weekly oil separation determination. The graduated cylinders were stored at ambient conditions for 12 weeks. Percent oil separation was calculated after 12 weeks of storage. Effectivity of stabilizers was determined based on the definition of Hinds et al (1994) as the ability to prevent oil separation in peanut butter.

Optimization

Experimental Design

Response Surface Methodology was used to determine optimum combinations of the chosen stabilizer (0.0, 0.5 and 1.0%, w/w) and roasting time (40, 50, and 60 min) per conditioning method to produce a stable product. This factorial design necessitated 18 treatment combinations.

Peanut butter was produced as shown in Fig. 2.1. The stabilized peanut butter was filled in 8-oz glass jars. For peanut butter without conditioning, peanut butter samples were immediately stored at ambient conditions after cooling. While for conditioned peanut butter samples, the glass jars were stored for 48 hours at 10°C. After which, samples were withdrawn and stored at ambient conditions.

Consumer Acceptance Test

Scales. Peanut butter samples were evaluated by consumers for overall acceptability, acceptability of color, peanut flavor, roasted flavor, spreadability and consistency using 9-point Hedonic scales where 1=dislike extremely, 5=neither like nor dislike and 9=like extremely. Participants were asked to check the box corresponding to their perceived acceptability rating of a particular attribute.

Panel. Fifty consumer panelists were randomly selected to determine the acceptability of the stabilized peanut butter. Consumers were recruited from the administrative staff of the College of Home Economics.

Test procedure. Three sets of six samples each from the 18 treatment combinations were presented to each participant. Participants were instructed to take a compulsory break between each set of samples. Samples were evaluated in the order of appearance in the ballot. Participants were asked to place a spoonful of the peanut butter on plain bread when evaluating spreadability and consistency. They were likewise asked to rinse their mouth with water between samples.

Pre-heat roaster to 140ºC

↓

Fill roaster with raw peanuts

↓

Blanch peanuts 25 min maintaining roaster temperature at 140ºC

↓

Remove peanuts from roaster

↓

Cool with electric fan

↓

Sort out discolored and damaged nuts

↓

Roast peanuts at 140°C for 60 minutes then cool

↓

Chop the roasted peanuts using a silent cutter

↓

Weigh required amount of sugar

↓

Mix chopped peanuts with the sugar

↓

Pass through a colloid mill at No. 2 setting

↓

Add stabilizer and mix thoroughly

↓

Pass through a colloid mill at No. 0 setting

↓

Fill in clear 8 oz. glass bottles

↓

Refrigerate at 2-4°C

Fig. 2.1 Flow diagram of process for stabilized peanut butter.

Statistical Analysis and Modeling

All statistical analyses were performed using SAS v.8 (SAS Institute Inc., 2001). Analysis of Variance (ANOVA) was performed to determine the effects of the independent variables (stabilizer, roasting time, conditioning method and level of stabilizer) on the percent oil separation analysis of peanut butter samples.

The Response Surface Regression (PROC RSREG) Analysis using SAS Software v.8 (SAS Institute Inc., 2001) was used to determine the effects of the independent variables (roasting time, level of stabilizer and conditioning method) on the sensory characteristics of peanut butter samples. Percent oil separation from the previous experiment was also included in the analysis.

According to Abdullah et al (1993), first-order models as opposed to full models are often inadequate and response surfaces generated are poorly defined. For this study, full models that were significant ($p<0.05$) and had an R^2 of 0.70 or greater were used to generate contour plots.

Limits were set for the optimization procedure. For all sensory attributes, a hedonic scale of 6, equivalent to like slightly was adopted. For oil separation, the limit set by Hinds *et al.* (1994) and Galvez *et al.* (1999) was adopted, which is 2% oil separation at 30-35°C. Identified boundaries were superimposed to establish the process combinations.

RESULTS

Oil Separation Analysis

The % oil separation of the different treatments employed in the stabilized peanut butter is shown in Table 2.1. Percent oil separation generally decreased as the level of stabilizer increased from 0.0 to 1.0% except for peanut butter samples stabilized with carrageenan. Some peanut butter samples on the other hand showed no oil separation even after 12 weeks of storage.

Statistical analysis showed (Table 2.2) that type and level of stabilizer had a significant effect ($p<0.05$) on the amount of oil separation in peanut butter. Myvatex monoset® had the least amount of oil separation, followed by Distilled Monoglyceride Type P(V)®, then κ-carrageenan. The first two stabilizers are both distilled monoglycerides, but Dist. Monoglyceride Type P(V)® is more highly concentrated than Myvatex monoset® (monoester content if 95% and 18%, respectively). The high monoester content of Dist. Monoglyceride Type P(V)® was designed to perform a number of different functions and provide capabilities that are unique among emulsifiers. These include margarine and spreads, pastas and cereals, whipped toppings, bakery products, puddings and jams and peanut butter. Whereas Myvatex monoset® was primarily designed for premium peanut butter that requires good spreadability, resistance to oil separation and good flavor release (Product Data Sheet, 1998). As for κ-carrageenan, a level of as high as 1.0% resulted in least 3% oil separation, which shows how ineffective carrageenans are in stabilizing peanut butter.

Table 2.1 Percent oil separation[1] in peanut butter stabilized using different types and levels of stabilizers and roasted at varying times after 12 weeks of storage at ambient conditions

Roasting Time	Stabilizer[1]	Level of stabilizer (%) 0		0.5		1.0	
		WC[2]	WOC[3]	WC[2]	WOC[3]	WC[2]	WOC[3]
40	A	1.65	1.78	1.21	1.42	0.03	0.00
	B	2.80	2.53	2.70	3.03	2.80	3.37
	C	2.73	2.20	1.93	2.10	0.03	0.00
50	A	1.71	1.38	1.34	0.09	0.00	0.00
	B	2.50	2.27	2.43	2.57	2.50	2.60
	C	2.50	2.27	1.33	0.83	0.00	0.00
60	A	1.08	1.71	0.20	0.60	0.00	0.00
	B	3.93	2.70	3.23	3.50	3.20	2.67
	C	3.10	4.47	1.23	1.03	0.20	0.00

[1] Means of three trials
[2] A=Myvatex monoset®; B=κ-carrageenan; C= Distilled monoglyceride Type P(V)®
[3] WC= with conditioning
[4] WOC= without conditioning

The level of stabilizer also significantly affected ($p<0.05$) the amount of oil separation. The % oil separation decreased as the level of stabilizer increased in concentration. Varying roasting times and conditioning methods after processing of peanut butter to induce crystal formation did not have any effect on the amount of oil separation.

To determine the effect of the individual stabilizer used, results showed (Table 2.3) that roasting time had a significant effect on the amount of oil separation in peanut butter samples treated with Distilled Monoglyceride Type P(V)® only. While % oil separation of samples with Myvatex monoset® and κ-carrageenan were significantly affected by the level of stabilizer used. Conditioning methods were found not to have any effect on the % oil separation of peanut butter samples.

Roasting time was found not to have any significant effect on % oil separation. The roasting of peanuts involves reduction in moisture content of the kernels followed by the release of oil from the cytoplasm of the cells. The release of oil generally affects the color of the peanuts. When ground, oil is released from the peanuts and becomes integrated with the peanut meal solids.

The level of stabilizer affects the stability of the peanut butter where increased in level will lead to more network formed between the peanut solids and stabilizer. Results show that κ-carrageenan does not prevent oil separation and is not feasible for use as a stabilizer for peanut butter. Although carrageenan is commonly used as an emulsifier, its use is more beneficial to oil-in-water systems than in water-in-oil systems like the peanut butter. κ-carrageenan cannot form a three-dimensional network if oil is the continuous phase.

The stabilizing effect of the three test materials showed that Myvatex monoset® has the greater ability to prevent oil separation in peanut butter at ambient conditions. Myvatex monoset® was then used as stabilizer in subsequent steps to optimize the processing conditions for peanut butter.

Table 2.2. ANOVA of overall effects and means of the factors studied on the percent oil separation in stabilized peanut butter after 12 weeks of storage at ambient conditions

	% Oil Separation	
Factors	**Means[1]**	**P-value**
Roasting time		0.2204
40 min	1.80	
50 min	1.46	
60 min	1.82	
Type of stabilizer		0.0001[2]
Myvatex monoset®	0.79a	
Dist. Monoglyceride Type P(V)®	1.44b	
κ-carrageenan	2.85c	
Level of stabilizer		0.0001[2]
0.0%	2.41a	
0.5%	1.71b	
1.0%	0.97c	
Conditioning method		0.8060
With conditioning	1.72	
Without conditioning	1.67	

[1] Means within each factor followed by the same letters are not significantly different at 5% level.
[2] Significant at 5% level.

Table 2.3 Analysis of the individual effects of stabilizers on the roasting time, level of stabilizer and conditioning methods on the percentage of oil separation in stabilized peanut butter after storage for 12 weeks at ambient conditions

	Myvatex monoset®		κ-carrageenan		Distilled Monoglyceride Type P(V)®	
Factors	**Means[1]**	**P-value**	**Means[1]**	**P-value**	**Means[1]**	**P-value**
Roasting time		0.1747		0.0151[2]		0.3264
40 min	1.02		2.87a		1.50	
50 min	0.75		2.48a		1.16	
60 min	0.60		3.20b		1.67	
Level of stabilizer		0.0001[2]		0.8451		0.0001[2]
0.0%	1.55a		2.79		2.88a	
0.5%	0.81b		2.91		1.41b	
1.0%	0.01c		2.86		0.04c	
Conditioning method		0.8786		0.5898		0.9524
With	0.80		2.90		1.45	
Without	0.78		2.80		1.43	

[1] Means within each factor followed by the same letters are not significantly different at 5% level.
[2] Significant at 5% level.

Modeling of the Physical and Sensory Attributes of Stabilized Peanut Butter and Identification of Important Variables

Peanut butter samples were evaluated for consumer acceptance. Mean values for the consumer acceptance ratings for the different treatment combinations studied are presented in Table 2.4.

Generally, the acceptance of the sensory attributes color and consistency increased as roasting time increased from 40 to 60 min. Acceptance of spreadability appeared to be highest when roasting time was 50 mins. Overall acceptance was higher in samples roasted for 50 to 60 min compared to say roasted for 40 min. The level of stabilizer and conditioning methods on the other hand did not have any significant effect on the acceptability of peanut butter. As previously mentioned, %oil separation decreased as roasting time and level of stabilizer increased.

RSREG analysis of the data resulted in significant regression models (α=0.05 and $R^2 \geq 0.70$) for consistency acceptability, spreadability acceptability and % oil separation. A listing of the coefficients of determination (R^2) and parameter estimates for the prediction models for all significant variables are shown in Tables 2.5 to 2.8.

Table 2.5 Coefficients of determination (R^2), and parameter estimates for variables used in the final prediction models for variables for the physical and consumer acceptability of peanut butter stabilized with Myvatex monoset® (with conditioning)

Variables[1]	Parameter Estimates			
	Attribute			
	Oil	Color	Consistency	Spreadability
Intercept	-4.33056	-43.27778	-24.06667	-27.25556
Roasting Time	0.28133	1.78500	1.10667	1.32333
Level of stabilizer	-2.13333	0.03333	-0.20000	0.83333
RT x RT	-0.00322	-0.01583	-0.01000	-0.01267
Level x RT	0.02700	0.02000	0.02000	-0.04000
Level x Level	-0.68667	-1.13333	-0.40000	1.13333
R^2	0.9284	0.9767	0.9912	0.9020

[1] RT=roasting time

Table 2.6. Coefficients of determination (R^2), and parameter estimates for variables used in final prediction models for variables for the physical and consumer acceptability of peanut butter stabilized with Myvatex monoset® (without conditioning)

Variables[1]	Parameter Estimates			
	Attribute			
	Oil	Color	Consistency	Spreadability
Intercept	16.09750	-39.02500	-26.69722	-12.51944
Roasting Time	-0.59492	1.66583	1.22583	0.75083
Level of stabilizer	-0.89833	0.48333	-0.41667	-2.18333
RT x RT	0.00595	-0.01500	-0.01117	-0.00733
Level x RT	0.00350	-0.00500	0.00500	0.04500
Level x Level	-0.90000	-0.20000	-0.0666	-0.13333
R^2	0.8655	0.9882	0.9906	0.6945

[1] RT=roasting time

Table 2.4 Mean values for overall acceptability, color, peanut flavor, roasted flavor, consistency, spreadability and %oil separation of peanut butter stabilized with Myvatex monoset®

Treatment	Factor levels[1]			Acceptability Ratings				
	X1	X2	X3	Overall	Color	Consis[2]	Spread[3]	%Oil[4]
1	40	W	0.0	3.3	2.3	3.9	5.0	1.65
2	40	W	0.5	3.9	3.2	3.9	4.8	1.21
3	40	W	1.0	3.7	2.1	4.0	5.1	0.03
4	40	WO	0.0	4.2	3.4	4.2	5.6	1.78
5	40	WO	0.5	4.2	3.1	3.8	4.7	1.42
6	40	WO	1.0	4.3	3.6	3.8	4.7	0.00
7	50	W	0.0	5.7	5.9	5.6	6.2	1.71
8	50	W	0.5	5.4	5.8	5.9	6.4	1.34
9	50	W	1.0	6.1	5.8	6.2	6.7	0.00
10	50	WO	0.0	5.8	6.1	5.9	5.5	1.38
11	50	WO	0.5	5.7	6.3	6.0	6.2	0.09
12	50	WO	1.0	5.7	6.0	5.8	6.3	0.00
13	60	W	0.0	5.2	6.3	5.7	6.2	1.08
14	60	W	0.5	5.5	6.1	6.2	5.4	0.20
15	60	W	1.0	5.3	6.4	6.1	5.4	0.00
16	60	WO	0.0	6.0	6.1	6.0	5.7	1.71
17	60	WO	0.5	5.7	6.4	6.0	5.8	1.60
18	60	WO	1.0	6.1	6.2	5.7	5.6	0.00

[1] X1=roasting time (in min); X2=conditioning method (where W=with conditioning, WO=without conditioning; X3=level of stabilizer(%)
[2] Consis=consistency
[3] Spread=spreadability
[4] %Oil=% oil separation

Attaining the Best Process Combination

Variables found to have significant effect on the stability and acceptability of peanut butter are % oil separation, color, consistency and spreadability. Oil separation in peanut butter is largely determined by the nature and amount of crystals present. It was also found that higher storage temperatures have a significant effect on oil separation. Based on the product sheet given by the supplier, recommended level of Myvatex monoset® was from 1.3-1.75% (w/w). And for high erucic rapeseed oil, maximum level can be up to 2% as stated by the U.S. Food and Drug Administration (21 CFR 184.1555(a)(3)). The maximum amount of Myvatex monoset® used in the study was only 1%. However, results show that peanut butter with 1% stabilizer was able to maintain oil separation in the product for three months at ambient conditions.

The brown color of peanut butter is largely dependent on the extent of roasting the peanuts. Studies have shown that peanut butter made from medium-roasted peanuts exhibits the most desirable color and flavor (Morris and Freeman, 1954). Similar results were obtained by Galvez *et al* (2002) in a consumer survey where respondents were asked for their peanut butter color preference. A brown peanut butter was most preferred, equivalent to 50 mins of roasting as compared to 40 mins (pale brown) and 60 mins (dark brown) roasting.

Consistency has been defined as that property of the material by which it resists permanent change of shape and is defined by the complete force flow relation. Peanut butter exhibits viscoelastic behavior due to the network formed by the peanut solids with the added stabilizer. High amounts of stabilizer will make the product very viscous and therefore hard to spread. The study by Galvez et al (1999) showed almost equal preference for the flowing and firm-type peanut butter. If the flowing texture would be maintained, a lower level of stabilizer may be used. A very high concentration on the other hand would make the peanut butter firm, but it may be hard to spread. Based on the survey conducted, spreadability was found to be one of the important factors that affect consumer's preference for peanut butter texture.

The contour plots in Figs. 2.2 to 2.3 were obtained using the predictive models for color, consistency, spreadability and oil separation to determine the regions of the total space of the variables in which certain specifications are met. Roasting time and level of stabilizer were considered the most important factors that affect the response variables measured. The shaded region represents values corresponding to the constraints specified previously.

The contour plots for each storage condition (with or without conditioning) were overlaid to determine the region where the operating conditions were satisfied or met. The overlapped regions are shown in Fig. 2.4. The shaded areas represent the ranges for all attributes which satisfy the following: consumer acceptability ratings of at least 6 (like slightly) and a maximum of 2% oil separation. Consumer acceptability ratings for color were found to be the limiting factor during optimization. The shaded area represents the ranges for the attributes which satisfy the following: roasting time > 45 mins, level of stabilizer from 0 to 1.0%. From the results, it was apparent that processing of stabilized peanut butter should be directed towards a medium to dark roast of peanuts and that the addition of at least 1% stabilizer did not affect the consistency and spreadability of the stabilized peanut butter.

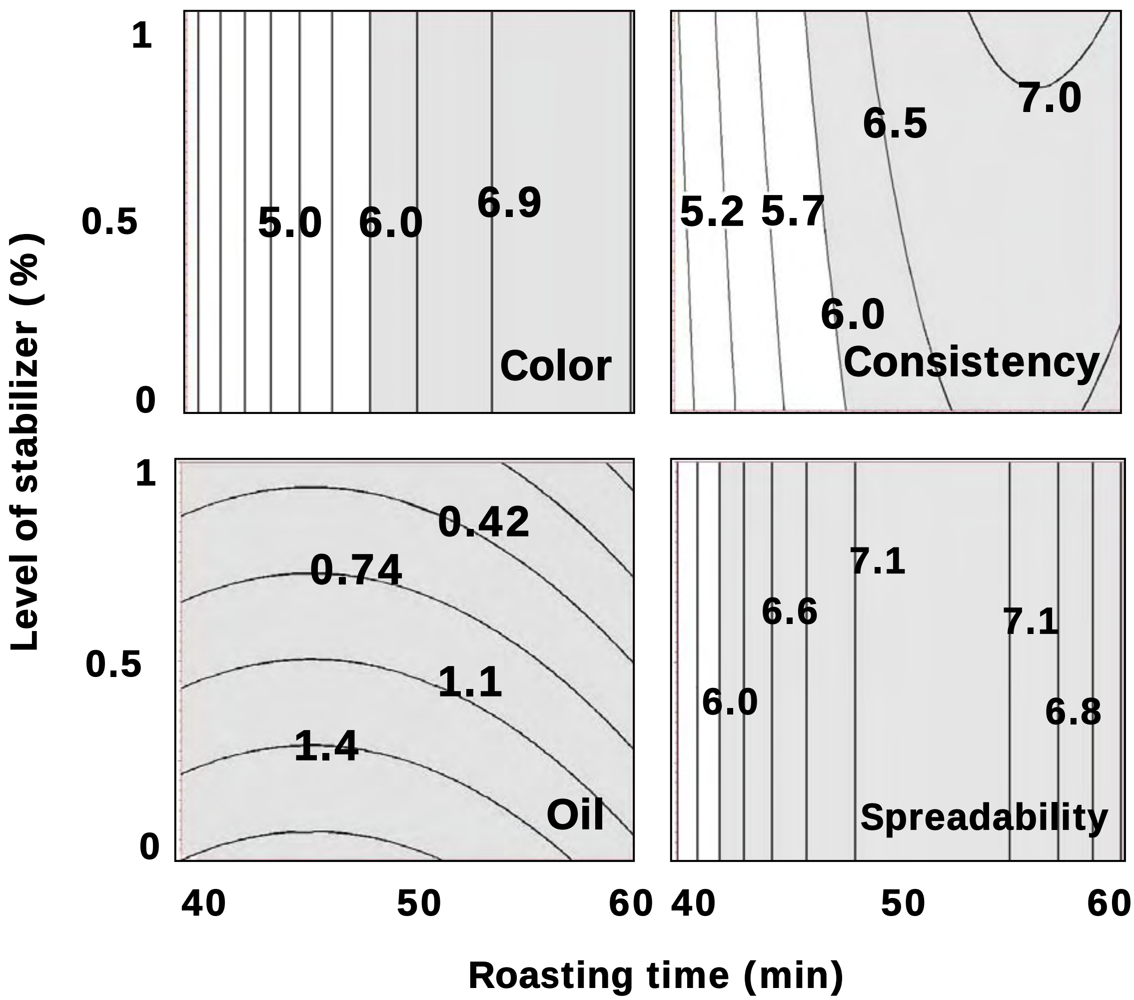

Fig. 2.2 Contour plots of oil separation (%), color, consistency and spreadability acceptability of stabilized peanut butter (with conditioning) produced during optimization of process. The shaded regions represent acceptance ratings of 6 or greater using 9-point hedonic scales where 1=dislike extremely, 5=neither like nor dislike and 9=like extremely, and acceptable oil separation of 2% or less.

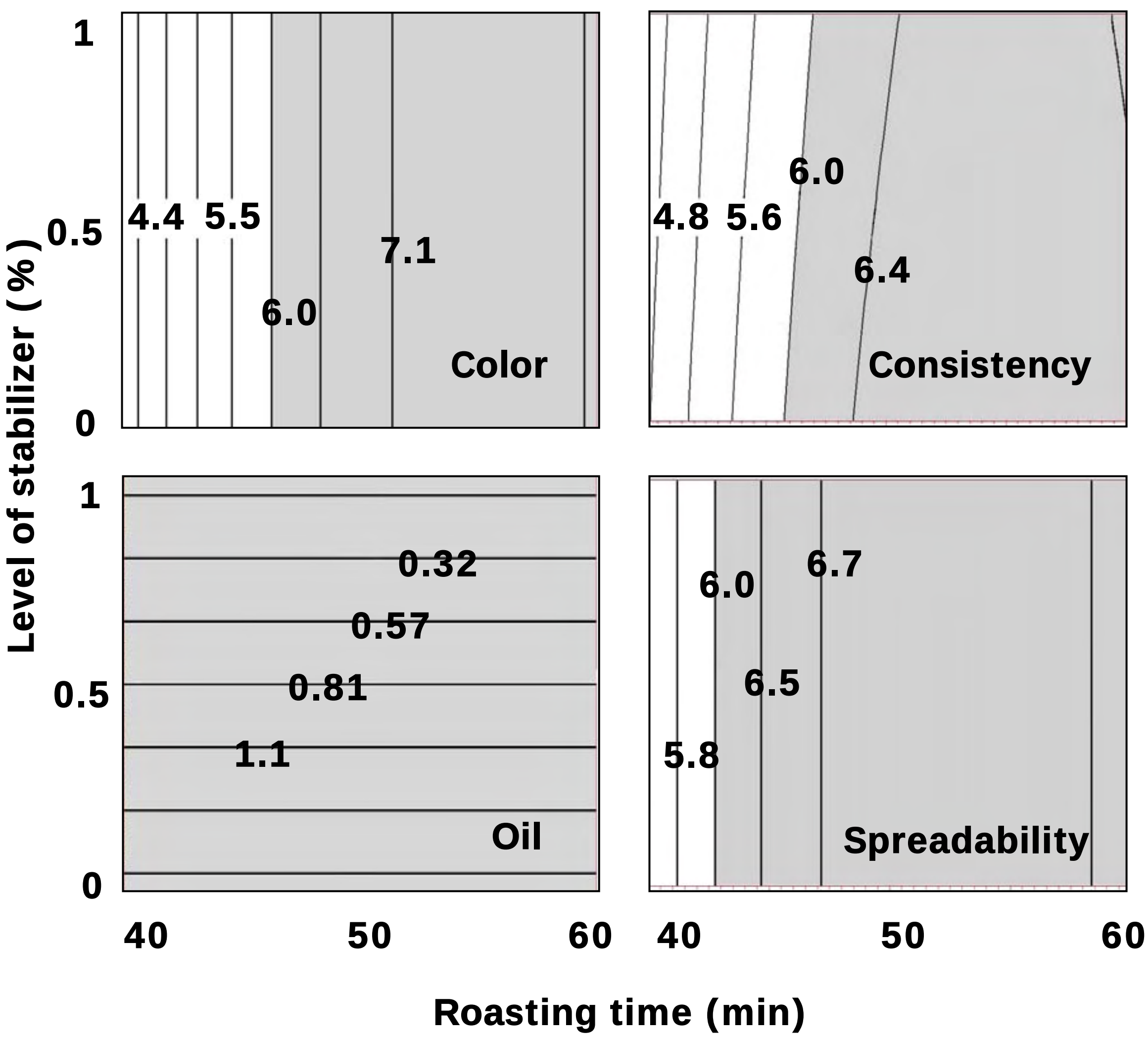

Fig. 2.3. Contour plots of consumer acceptance of color, consistency and overall acceptability, and oil separation (%) of stabilized peanut butter (without conditioning) produced during optimization of process. The shaded regions represent acceptance ratings of 6 or greater using 9-point hedonic scales where 1=dislike extremely, 5=neither like nor dislike and 9=like extremely, and acceptable oil separation of 2% or less.

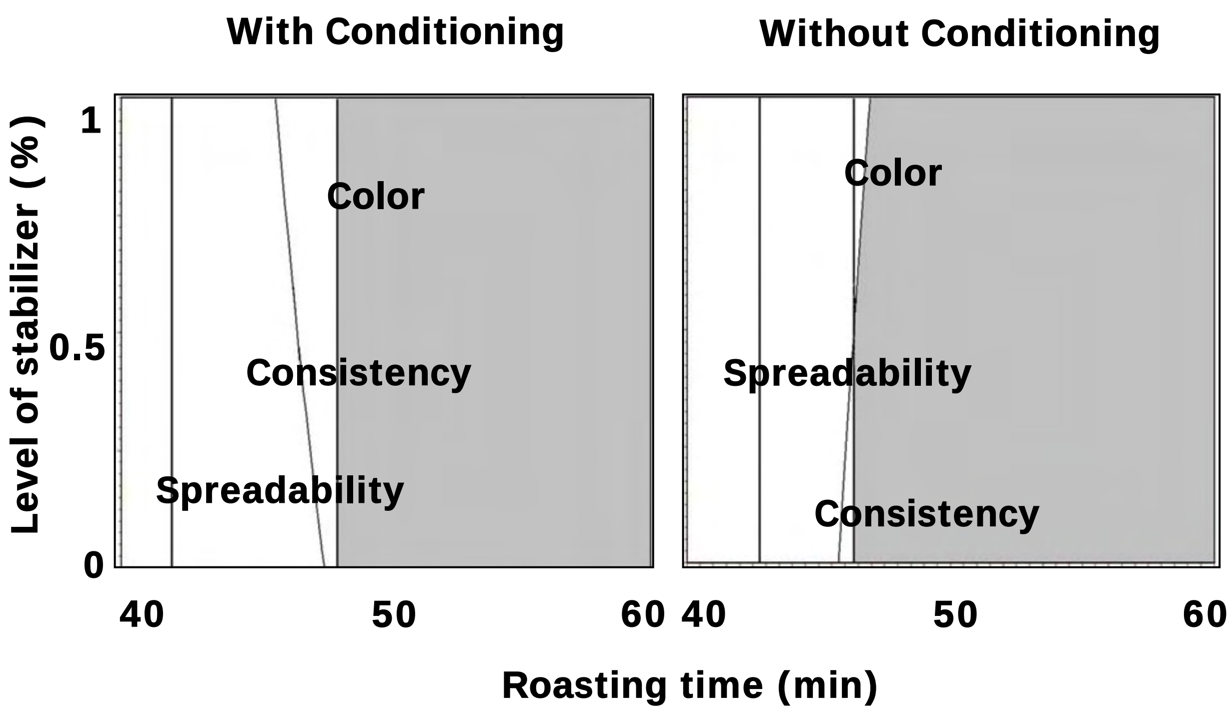

Fig. 2.4 Optimum regions obtained by superimposing contour plots of consumer acceptance of color, consistency, spreadability and oil separation (%) of stabilized peanut butter (with and without conditioning) produced during optimization of process. The shaded regions represent acceptance ratings of 6 or greater using 9-point hedonic scales where 1=dislike extremely, 5=neither like nor dislike and 9=like extremely, and acceptable oil separation of 2% or less.

CONCLUSIONS

A stabilized peanut butter was formulated using three types of local stabilizers at different levels and samples were analyzed in terms of % oil separation. Myvatex monoset® at 1.0% level had the greatest ability to prevent oil separation in peanut butter up to for three months of storage at ambient conditions of 30°C.

Consumer acceptance for determination of optimum processing conditions revealed that a brown peanut butter was most preferred by consumers, equivalent to 50 minutes of roasting as compared to 40 minutes (pale brown) and 60 minutes (dark brown) roasting. The increasing level of stabilizer in peanut butter reduced the amount of oil separation. Consumer acceptability ratings for color were found to be the limiting factor during optimization. The optimum process requires roasting of peanuts for peanut butter roasted at > 45 mins with added stabilizer up to 1.0% w/w.

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CHAPTER 3

DEVELOPMENT AND OPTIMIZATION OF CHOCO-PEANUT SPREAD

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ABSTRACT

A mixture design was used to optimize the sensory acceptability (overall liking, color, peanut flavor, chocolate flavor, consistency and spreadability) of a chocolate-peanut spread containing roasted peanuts, sugar and two types of chocolate flavor. Results indicated that choco-peanut spread could be prepared using either cocoa powder or chocolate syrup as the source of chocolate. When using cocoa powder, a choco-peanut spread that is acceptable to the consumers maybe produced with any of the combinations of 69-79% peanuts, 15-25% sugar, and with a maximum of 6% cocoa powder in the formulation. When using chocolate syrup, a choco-peanut spread that is acceptable to the consumers may be produced with any of the combinations of 35-75% peanuts, 19-25% sugar and with a maximum of 40% chocolate syrup in the formulation.

The technology for processing choco-peanut spread was first transferred to the collaborator in 2002 and then again in 2003. The collaborator reformulated the ratio of the ingredients for the production of choco-peanut spread. The PCRSP investigators met with the technology adaptor of chocolate peanut spread last January 2005. The product had not been launched, and the company indicated it was in the process of refining the technology. The cause of the delay in adoption was claimed to be mainly due to change in R&D staff responsible for the adoption of the technology. As of June 2005, the company was conducting the shelf life study of the choco-peanut spread and no predicted time was given as to when they can launch the product. The exclusivity of this product with the industry collaborator already expired. Therefore, the Peanut CRSP investigators offered the technology to a new collaborator and results will be reported in Monograph Series No. 9.

INTRODUCTION

Peanut and Peanut Products Studied

Peanuts (*Arachis Hypogea* L.*)* are significant sources of proteins and fat, which contribute to solving world food shortages (Abdullah, 1993). Approximately half of the total food use of peanuts is attributed to the production and consumption of peanut butter (Resurreccion, 1988). Other products include peanut beverages (Rubico *et al.* 1987, 1988, 1989; Galvez *et al*. 1990), peanut flour (Holt *et al*, 1992), coffee whitener (Abullah *et al.* 1990), buttermilk substitute (Lee 1990), imitation cheese spreads (Santos *et al*. 1989) and peanut paste (Muego-Gnanasekharan & Resurreccion 1993). Aside from the aforementioned studies on other peanut products, extensive studies had previously been conducted on peanut butter. These included the use of different varieties of peanuts, methods of roasting and blanching, grades of peanut butter, effect of particle size, means of preventing oil separation, improving spreadability, preventing sticking to the roof of mouth and extending shelf-life.

Most of these improved peanut butters are already available in the market. There are various types of peanut butter that currently exist in the Philippine market ranging from the traditional smooth, regular and chunky peanut butter to the peanut butter and jelly stripes and chocolate and peanut butter stripe.

Peanut Butter Preferences

Until the 1940's, only 25% of edible peanuts in America were used as peanut butter but by 1964, it rose to 63%. In the Philippines, peanut butter was found to be the most liked peanut product (Garcia et al., 1990). In a study by Galvez et al. (2001), it was stated that the average monthly household consumption of peanut butter was 432 grams. Consumption of peanut butter has steadily increased mainly because it has a pleasing flavor that enables it to be used in various concoctions; convenient to use since it does not require cooking, dilution or compounding; and it is fairly stable since it is not prone to bacterial or fungal growth. Preferences for peanut butter vary and there are different types and grades available.

Peanut butter may be classified by textures and by grades. There are three texture classifications: (a) smooth – even texture with no perceptible grainy peanut particles; (b) regular – definitely grainy texture with perceptible peanut particles not more than 1/16 inches in diameter; (c) chunky – partially fine and partially grainy particles with substantial amounts larger than 1/16 inches in diameter (Woodroof, 1973). In the U.S., classifications according to grade are U.S. Grade A, U.S. Standard and Sub-standard.

A recent nationwide survey on Filipino consumer preferences for peanut butter (Galvez *et al,* 1999) showed that peanut butter consumers wanted to have added flavors in their peanut butter. Chocolate flavor was preferred by consumers.

Consumer Sensory Evaluation

Consumers play a vital role in the success of a product in the market. Hence, it is the primary purpose of affective tests to assess the personal response (preference or acceptance) of current or potential consumers of a product, a product idea, or specific product characteristics (Meilgaard, 1988).

Producers of consumer goods, service providers such as hospitals and banks and even the Armed Forces use affective tests (Meilgaard, 1988). As the years progress, consumer tests are being applied increasingly and were proven to be highly effective in designing products and services that will be sold in large quantities and/or attract higher price.

Meilgaard (1988) emphasized that the most effective consumer acceptance or preference tests were based on "carefully designed test protocols run among carefully selected subjects with representative products." The selection of test protocols and subjects should depend on well-defined project objectives. Possible reasons for conducting consumer tests usually fall into any of the following categories: (1) product maintenance; (2) product improvement/optimization; (3) development of new products; and (4) assessment of market potential.

OBJECTIVES

This study developed and optimized a chocolate flavored peanut butter that was acceptable to the consumers using mixture response surface methodology to address the results of the aforementioned survey. Specific objectives were to: (1) to determine the best form of chocolate to be added to the peanut butter, and (2) to optimize roasting process (time and temperature) and amounts of peanut butter, chocolate flavor and sugar for a choco-peanut spread that is acceptable to consumers.

METHODS

Establishment of Collaboration with Industry

Collaboration with a manufacturer was first established by contacting a peanut product manufacturer who was interested in working together with the project on development and optimization of a choco-peanut spread. 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 signed agreement for collaboration is shown in Appendix A. This 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

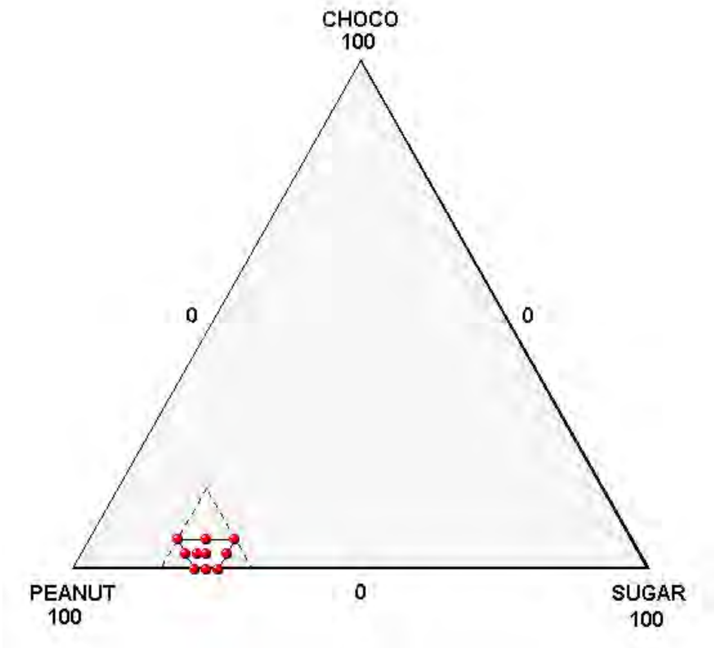
A three-variable (amounts of peanut, chocolate flavor, and sugar) constrained mixture design was used for each of two types of chocolate flavors (powdered and liquid chocolates) studied to optimize the formulation for a choco-peanut spread that is acceptable to consumers. In addition, the effect of degree of roasting the peanuts (roasting times of 40, 50, and 60 min) was studied. Preliminary studies were done to determine the range of experimental points in the constrained region. The number of points was $2^q - 1$, q being equal to the number of variables (Holt *et al* 1992) in the formulation (peanut, chocolate flavor, sugar) and excluded the process variable (roasting time). This resulted in seven formulations (including the control) for each type of chocolate flavor within a 2-dimensional simplex region (Cornell & Harrison 1999). Aside from the corner points on the constrained region, a midpoint was also included. The experimental ranges of factors (Table 3.1) mentioned were established from preliminary experiments. The points in the experimental design were identified such that they were within the limitations or constraints of the formulation. The location of each formulation in the simplex coordinate system was plotted (Fig. 3.1). Two replicates of the study were conducted. The experimental design is shown in Table 3.2.

Production of Chocolate Flavored Peanut Butter

Figure 3.2 presents the flow diagram for the processing of chocolate peanut spread. For the two replicates, 300 kilograms of raw peanuts (runner variety from China) were mixed and divided into two lots. This total amount takes into consideration the losses that occur during blanching, de-skinning and sorting. The peanut kernels were then blanched at 140^0C for 30 minutes to facilitate de-skinning. After blanching, peanuts were cooled immediately to prevent any residual heat from further roasting the peanut kernels. The blanched peanuts were de-skinned using a fabricated peanut blancher (Blancher EX-516, Ashton Food Machinery Inc., New Jersey, USA) prior to sorting. The sorted, de-skinned peanuts were further divided into three lots for the three roasting process. Five kilograms of peanuts were roasted in a peanut roaster (Manufactured by Kosuge Takkosho, Japan) for each treatment to produce stabilized peanut butter. Roasted peanuts were ground using a silent cutter (FC –38-3H FUJIMAK, Japan) after which the chocolate flavor (cocoa powder or chocolate syrup), sugar, stabilizer (Myvatex Monoset, Malabon Long Life, Valenzuela, Phils.) were added. The choco-peanut mixture was passed through a colloid mill (D-7550 PUC Probest and Class, Western Germany) twice, first with #2 setting and the second at # 0 setting. The chocolate-flavored peanut spread was packed in sterile containers, labeled and cooled in water bath. The products were conditioned at 10^0C for 24-48 hours. Figure 3.2 illustrates the process flow chart for choco-peanut spread production.

In an initial study made regarding the use of chocolate syrup for the choco-peanut spread, it was found that the water content in the syrup caused the peanut butter to harden, the resulting mixture of which could no longer be passed through the colloid mill. Since chocolate syrup without water was not commercially available, a different formulation of chocolate syrup was developed for the choco-peanut spread. The percentage composition is presented in Table 3.3. The chocolate syrup was mixed thoroughly and no other processing was needed prior to addition in the ground, roasted peanut.

a



b

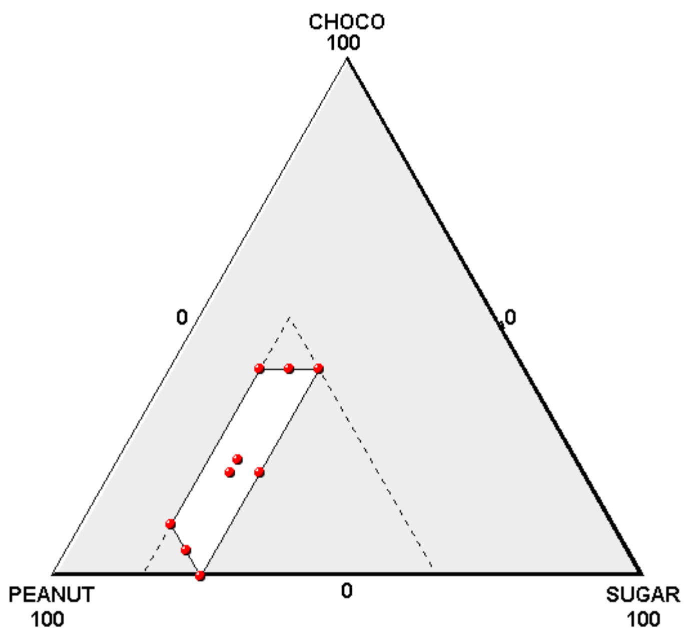


Fig. 3.1 Region of experimental points during optimization for the formulation of peanut-choco spread. (a) Cocoa powder (peanut butter: 69-79%; sugar: 15-25%; cocoa powder: 0-6%. (b) Chocolate syrup (peanut butter: 25-75%; sugar: 15-25%; chocolate syrup:0-40%).

Table 3.1. Factors and their levels studied in the optimization of the formulation and process for choco-peanut spread

	Symbols	Levels						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Type of chocolate flavor	Y	powder	liquid					
Roasting time (min)	X_4	40	50	60				
Amount of peanut butter (% of total desired yield of choco-peanut spread) using cocoa powder	X_1	69	72	74	75	77	79	80
Amount of peanut butter (% of total desired yield of choco-peanut spread) using chocolate syrup	X_1	35	40	45	55	60	75	80
Amount of chocolate flavor (% of total desired yield of choco-peanut spread) using cocoa powder	X_2	0	3	6				
Amount of chocolate flavor (% of total desired yield of choco-peanut spread) using chocolate syrup	X_2	0	20	40				
Amount of sugar (% of total desired yield of choco-peanut spread)	X_3	15	20	25				

Table 3.2. Experimental Design: Chocolate Flavored Peanut Spread

Treatment	Factors[a]				
	X_1	X_2	X_3	X_4	X_5
1*	1	1	1	2	2
2	1	1	2	3	1
3	1	2	3	3	1
4	1	3	4	3	1
5	1	2	5	2	1
6	1	3	6	2	1
7	1	3	7	1	1
8	1	1	2	3	2
9	1	2	3	3	2
10	1	3	4	3	2
11	1	2	5	2	2
12	1	3	6	2	2
13	1	3	7	1	2
14	1	1	2	3	3
15	1	2	3	3	3
16	1	3	4	3	3
17	1	2	5	2	3
18	1	3	6	2	3
19	1	3	7	1	3
20*	2	1	1	2	2
21	2	1	2	3	1
22	2	2	3	3	1
23	2	3	4	3	1
24	2	2	5	2	1
25	2	3	6	2	1
26	2	3	7	1	1
27	2	1	2	3	2
28	2	2	3	3	2
29	2	3	4	3	2
30	2	2	5	2	2
31	2	3	6	2	2

Table 3.2. Continued.

Treatment	Factors[a]				
	X_1	**X_2**	**X_3**	**X_4**	**X_5**
32	2	3	7	1	2
33	2	1	2	3	3
34	2	2	3	3	3
35	2	3	4	3	3
36	2	2	5	2	3
37	2	3	6	2	3
38	2	3	7	1	3

*Represents control where level of chocolate flavor is 0%, level of peanut butter is 80%, level of sugar is 20% and roasting time is 50 minutes

[a] Factors were:

X_1 – type of chocolate flavor
(powder or liquid)

X_2 – level of chocolate flavor (%)
(1= 0, 2= 3, 3= 6; 1=0, 2= 20, 3= 40)

X_3 – level of peanut butter (%)
(1= 80, 2= 75, 3= 72, 4= 69, 5= 77, 6= 74, 7= 79 for powder;
1= 80, 2= 75, 3= 55, 4= 25, 5= 60, 6=40, 7= 45 for liquid)

X_4 – level of sugar (%)
(1=15, 2=20, 3=25)

X_5 - roasting time (minutes)
(1= 40, 2= 50, 3= 60)

Table 3.3. Chocolate Syrup Formulation

Ingredient	% Composition by weight
Washed Sugar	44.0
Cocoa Powder	12.0
Skim milk	12.0
Fat (Corn Oil)	32.0
Total	100.0

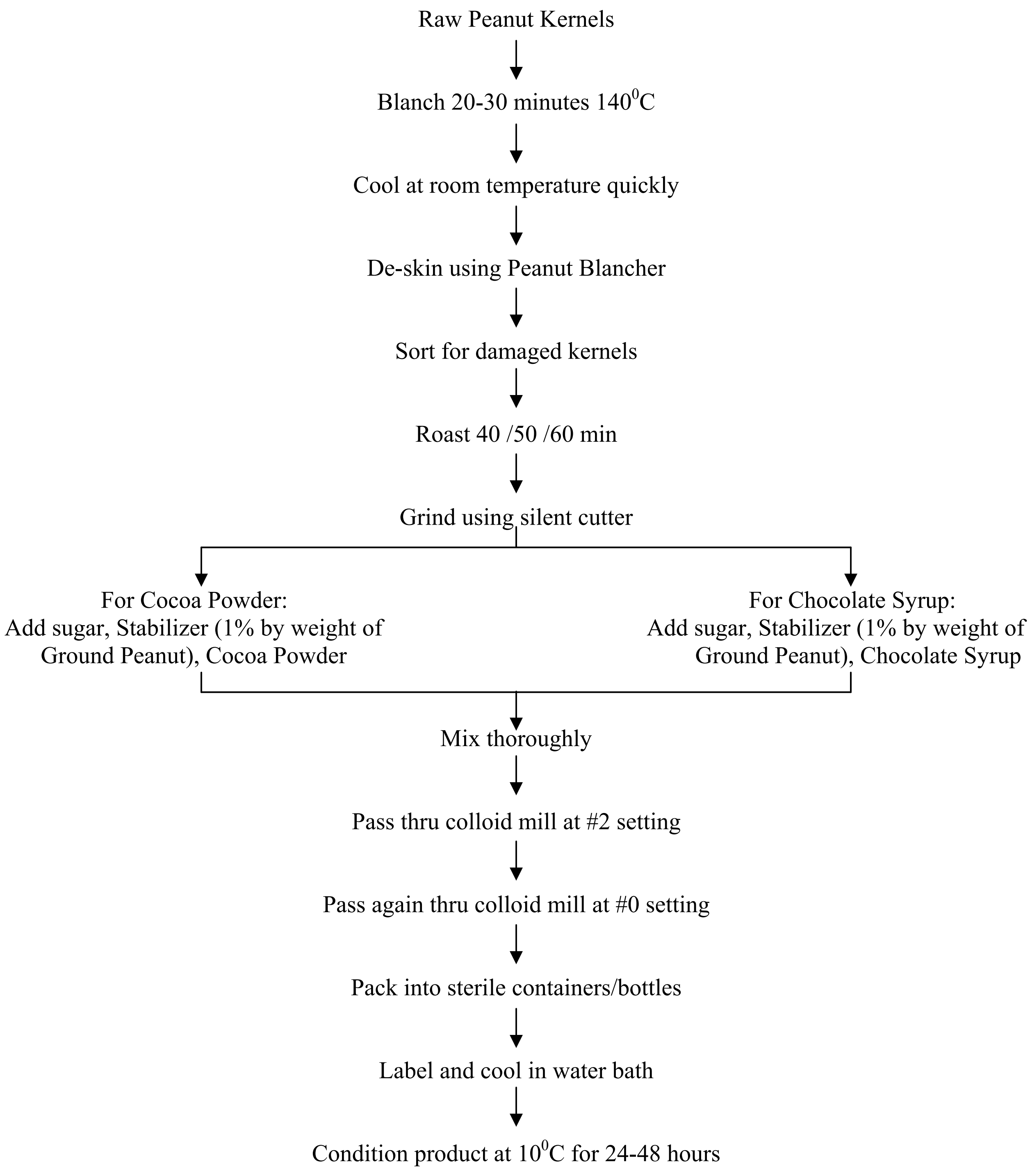


Fig. 3.2 Process flow chart for the production of choco-peanut spread

Consumer Acceptance Test

In order to determine the optimum formulation of the chocolate flavored peanut butter samples, consumer acceptance test was conducted (Resurreccion, 1998).

Scales. Choco-peanut spread samples were evaluated by consumers for overall acceptability and acceptability of peanut flavor, chocolate flavor, sweetness, and spreadability using 9-point Hedonic scales where 1=dislike extremely, 5=neither like nor dislike, and 9=like extremely. Consumers were asked to check the corresponding perceived acceptability rating of a particular attribute (See Appendix B for ballot).

Panel. Fifty consumers participated in the test. Most of them belong to the administrative staffs of the College of Home Economics. All participants were peanut butter consumers.

Test Location. The tests were conducted at the Tea Room and the Sensorium at the College of Home Economics, University of the Philippines Diliman. These rooms are fully air-conditioned, appropriately illuminated with cool white fluorescent lights, and free from environmental elements that would distort normal perceptions.

Test Material. Samples were prepared by placing two tablespoonfuls (approximately 80 grams) of choco-peanut spread in coded white sample cups with lids (Family Sauce Container manufactured by Dynaplas, Inc., Manila, Philippines). Lids were used to prevent escape of the aroma.

Test Procedure. The tests were conducted for two sessions per day at 10:00-11:00 a.m. and 3:00-4:00p.m. for 4 days. One set of five samples each for the morning and the other set in the afternoon session were presented to the panelists. Each panelist evaluated all 76 samples, which represent the treatments for both liquid and powdered chocolate and their replicates. Samples were evaluated in the order of their appearance in the ballot. Panelists were asked to rinse their mouth with water or eat bread between samples. In evaluating the spreadability of the samples, participants were asked to spread samples on the piece of bread provided.

Statistical Analysis and Modeling

All analyses were performed using Statistical Analysis System V8 (SAS, 2001). Analysis of Variance using General Linear Models was performed to determine significant effects of independent variables. In order to determine which independent variables contributed significantly to the component variables, Stepwise Regression Analysis was done on full models of each overall acceptability and attribute acceptability as dependent variables and the following linear terms peanut (X1), chocolate flavor (X2), sugar (X3) and roasting time (X4) as independent variables and the cross product terms. The prediction models include all linear and quadratic terms in the individual variables and all cross products of linear terms. The equation outlined by Cornell and Harrison (1999) for mixture component-process variable model was followed in obtaining the equation for the choco-peanut spread. The model can be represented as follows:

$$E(Y) = \beta^0{}_1X_1 + \beta^0{}_2X_2 + \beta^0{}_3X_3 + \beta^0{}_{12}X_1X_2 + \beta^0{}_{13}X_1X_3 + \beta^0{}_{23}X_2X_3 + \{\beta^1{}_1X_1 + \beta^1{}_2X_2 + \beta^1{}_3X_3 + \beta^1{}_{12}X_1X_2 + \beta^1{}_{13}X_1X_3 + \beta^1{}_{23}X_2X_3\}\ X_4$$

Where: $E(Y)$ = the expected value of the response variable.

$\beta^0{}_1, \beta^0{}_2, \beta^0{}_3, \beta^0{}_{12}, \beta^0{}_{13}, \beta^0{}_{23}, \beta^1{}_1, \beta^1{}_2, \beta^1{}_3, \beta^1{}_{12}, \beta^1{}_{13}, \beta^1{}_{23}$, = parameter estimates for each linear and cross product terms produced from the prediction models

x_i = linear terms of the independent variables (I = 1……k), as

Follows:
x_1 = level of peanut
x_2 = level of chocolate flavor type
x_3 = level of sugar
x_4 = roasting time
$x_i x_j$ = cross-product terms representing all interactions between the independed variables (i = 1……k-1 ; j = 1…..k)

Multiple regression analysis (PROC REG) was performed next on each attribute acceptability rating using the models containing variables determined to be significant by Stepwise Regression analysis. Model significance at the 0.05 level was determined using the F-ratio of means square quantities. Regression analysis using the "with intercept" function was performed in order to determine what model could be used. Regression analysis was then performed on the acceptability rating of each attribute using the "no intercept" function to determine parameter estimates. No intercept was specified due to the constraint that X_1, X_2, and X_3 must equal 100%. Prediction models to be used in the optimization process were selected on the basis of model significance equal to the 0.05 level.

Optimization

Mixture Response Surface Methodology (RSM) was used to determine the effects of the factors studied on the quality of the choco-peanut spread. The prediction models obtained previously were used to estimate regions of optimum response through RSM.

Response surfaces and contour maps were plotted representing all combinations of the independent variables that were found to have significant effects on the quality attributes of the product. Consumer acceptability ratings of 5 for the attributes tested were used as boundaries for optimization. A score of 5 was used as boundary to account for the tendency of panelists to score at the center of the Hedonic scale. The optimum area determined by superimposing acceptable areas represented by all combinations of mixtures that would meet pre-set criteria for an acceptable product.

Technology Transfer and Adoption

The technology was transferred and adopted by the industry collaborator in February 2002. As per terms of reference of the collaboration agreement, the investigators were to provide technical assistance for one year. A follow up was made in September 2002 and it was found that the collaborators were having problems with the production of choco-peanut spread, particularly source of chocolate flavor and oil separation of the product upon storage. After three months, the collaborator wrote a letter to the investigators that they are shelving the project as it has not been fruitful. The collaborator was then reminded of that the exclusivity of the technology to their company will lapse in April 2003. After this date, the technology will now be shared with other interested peanut manufacturing companies

A meeting was held again at the collaborator's plant last May 2003 between the consultant of the collaborator and the Peanut-CRSP team led by Dr. Anna V.A. Resurreccion of the University of Georgia. An invitation was again extended to collaborator to revive the project related to the manufacture of choco-peanut spread. Discussions with the consultant resulted in willingness to collaborate again on this project. An agreement on the collaboration was drafted, discussed and signed by the representative from the collaborator, and Lotis dL. Francisco as Peanut-CRSP Co-Principal Investigator to conduct the research.

A manual of procedures was prepared by U.P. College of Home Economics and submitted to the collaborator in September 2003. The manual contains the manufacture of choco-peanut spread with emphasis on the following topics: (1) preparation of peanuts for processing; (2) raw material specifications; (3) choco-peanut formulation; and (4) processing of choco-peanut spread. The collaborator made an initial production run using 10 kilos of roasted peanuts (manually prepared in the collaborator's plant) in December 2003. The product was packaged in 450g plastic jars. Initial observation on the prepared choco-peanut spread was that the mixture became very dry upon the addition of cocoa powder. The grinder that they are using cannot accommodate grinding of all ingredients (peanut, cocoa, sugar) at the same time. So the procedure was modified by their Research and Development staff as follows: peanuts are ground first, then dry ingredients are added prior to the second grinding step.

A second production run was conducted in January 2004, incorporating the modified procedure using 10 kilos of roasted peanuts. The products were cooled in a water bath but no conditioning was employed. Internal sensory evaluation was conducted and the product was found to be acceptable. However, after a week of storage at room temperature, oil separation was observed on the product.

A third production run was again conducted in February 2004 using 5 kilos of roasted peanuts prepared in the collaborator's other plant. Oil separation was still observed after one week storage. The company does not have a big facility to condition the product – a requirement critical to the stability of the product. Alternative methods were being investigated by the collaborator's regarding how to condition the product.

The PCRSP investigators met with the technology adaptor of chocolate peanut spread last January 2005. The product had not been launched, and was still in the process of refining the technology. The cause of the problem was mainly due to change in R&D staff responsible for the adoption of the technology. The previous R&D staff, to whom the manual of procedure was given, did not turn-over the project to the new R&D staff, hence, the company was using a different formulation, compared to what was planned. The company requested that the manual of procedure be forwarded to them again, to facilitate the technology of the choco-peanut spread. As of June 2005, the company was conducting the shelf life study of the choco-peanut spread and no predicted time was given as to when they can launch the product.

RESULTS

Modeling the Consumer Acceptance of Choco-Peanut Spread

Results showed that overall acceptability, and acceptability of peanut flavor, chocolate flavor, sweetness and spreadability increased with increased amount of peanut in the product while decrease in sugar level consequently decreased the ratings for the aforementioned sensory parameters.

Roasting time was found to have significant effect on consumer acceptability of the choco-peanut spread. Products that used peanuts roasted at 140^0C for 40 minutes received the highest ratings for overeall acceptability and for acceptability of peanut flavor. The overall rating of peanut flavor acceptability of products with peanuts roasted at 140ºC for 40 minutes were significantly different from samples with peanuts roasted for 50 minutes and 60 minutes.

RSREG Analysis of the data resulted in significant regression models at α = 0.05 for all variables. The roasting time of peanuts as well as the amount of chocolate flavor was shown to have a statistically significant effect on the overall acceptability as well as the acceptability of peanut flavor, chocolate flavor, sweetness and spreadability of the choco-peanut spread (Tables 3.4 and 3.5).

Results of the regression analyses are presented in Tables 3.6 and 3.7 listing the parameter estimates for the prediction models for overall acceptability, and acceptability of peanut flavor, chocolate flavor, sweetness and spreadability all of which were significant at $p<0.05$. The prediction models obtained were used to generate contour plots.

Table 3.4 Analysis of variance for the overall effects of the factors studied and significance of the full regression models for the consumer acceptability of choco-peanut spread using cocoa powder processed during optimization of formulation for its manufacture.

Factors	F- ratio				
	Overall acceptability	Acceptability of peanut flavor	Acceptability of Chocolate flavor	Acceptability of Sweetness	Acceptability of Spreadability
Roasting time (min)	52.79*	54.64*	25.01*	35.87*	19.55*
Amount of chocolate flavor (%)	39.00*	36.53*	1.33	22.63*	26.06*
Amount of peanut butter (%)	0.60	0.04	13.47*	6.02*	2.06
Amount of sugar (%)	--	--	--	--	--
F-ratio for total regression	30.80	30.40	13.27	21.50	15.89

*Significant at α = 0.05

Table 3.5 Analysis of variance for the overall effects of the factors studied and significance of the full regression models for the consumer acceptability of choco-peanut spread using chocolate syrup processed during optimization of formulation for its manufacture.

Factors	F- ratio				
	Overall acceptability	Acceptability of peanut flavor	Acceptability of Chocolate flavor	Acceptability of Sweetness	Acceptability of Spreadability
Roasting time (min)	2.63	7.48*	0.48	5.93*	24.75*
Amount of chocolate flavor (%)	8.50*	26.50*	3.82	19.19*	44.36*
Amount of peanut butter (%)	1.17	0.10	5.93*	9.54*	0.05
Amount of sugar (%)	--	--	--	--	--
F-ratio for total regression	4.10	11.36	3.41	11.55	23.05

*Significant at $\alpha = 0.05$

Table 3.6 Coefficients of determination (R^2), F-statistic and parameter estimates for variables used in the final prediction models for the consumer acceptability and consumer ratings of choco-peanut spread using cocoa powder

Variables[1]	Acceptability				
	Overall	Peanut Flavor	Chocolate Flavor	Sweetness	Spreadability
Peanut	-3.09	-10.06	1.13	-4.30	-0.11
Choco	--	1.07	-253.83	302.34	--
Sugar	-2.16	-76.73	24.10	-47.57	-46.83
Time	0.09	-0.97	0.002	-0.04	0.24
Choco*Sugar	--	--	467.28	-82.28	--
Peanut*Choco	--	--	245.00	-373.05	--
Peanut*Sugar	67.29	199.62	--	128.41	112.71
Time*Choco	--	3.36	--	--	--
Time*Sugar	-0.66	0	-1.53	--	-0.50
Time*Peanut	--	1.16	--	0.19	-0.22
Time*Peanut*Choco	--	-3.82	--	--	--
Time*Peanut*Sugar	--	--	1.82	-0.89	--
Time*Choco*Sugar	--	4.22	--	--	--
R^2	0.89	0.91	0.89	0.91	0.89
F-statistic[2]	1469.38	1016.00	999.54	1037.16	1306.40

[1] Variables are RTI = Roasting time (min), PBL = Peanut Butter Level (%), LCF = Chocolate Flavor Level (%), SUG = Sugar Level (%)
[2] F-statistic is to test significant differences between full and reduced models.

Table 3.7 Coefficients of determination (R^2), F-statistic and parameter estimates for variables used in the final prediction models for the consumer acceptability and consumer ratings of choco-peanut spread using chocolate syrup

Variables[1]	Acceptability				
	Overall	Peanut Flavor	Chocolate Flavor	Sweetness	Spreadability
Peanut	13.63	25.68	10.12	0.05	20.71
Choco	21.79	34.16	7.80	20.11	37.14
Sugar	-384.67	-201.34	-6.28	-439.22	-93.75
Time	-0.38	-0.64	-0.08	-0.09	-0.48
Choco*Sugar	663.06	357.14	--	729.74	172.74
Peanut*Choco	-141.28	-132.21	--	-131.02	-105.86
Peanut*Sugar	502.48	211.94	--	632.57	95.27
Time*Choco	--	--	0.07	-0.19	-0.12
Time*Sugar	4.28	--	0.26	5.31	--
Time*Peanut	--	--	--	--	0.08
Time*Peanut*Choco	2.51	2.25	--	2.30	1.92
Time*Peanut*Sugar	-3.98	3.07	--	-6.88	1.85
Time*Choco*Sugar	-7.46	--	--	-9.38	--
R^2	0.90	0.91	0.85	0.90	0.94
F-statistic[2]	776.19	1011.62	885.27	737.18	1473.47

[1] Variables are RTI = Roasting time (min), PBL = Peanut Butter Level (%), LCF = Chocolate Flavor Level (%), SUG = Sugar Level (%)
[2] F-statistic is to test significant differences between full and reduced models.

Optimization of Choco-Peanut Spread

The contour plots for predicted acceptability values for overall acceptance, acceptability of peanut flavor, chocolate flavor, sweetness and spreadability for the two types of chocolate flavor at various roasting times are presented in Figs. 3.3 to 3.8.

In the production of choco-peanut spread using cocoa powder as source of chocolate flavor and roasted for 40 min, showed that overall acceptability and peanut flavor were found to be acceptable for all types of formulation. While chocolate flavor, sweetness and spreadability were the limiting variables. On the other hand, spreadability was found to be acceptable for all types of formulation of choco-peanut spread roasted at 50 and 60 min.

Response surfaces (Figs. 3.3 to 3.5) showed that at 40 min roasting time, consumers prefer higher amounts of cocoa powder and sugar in the formulation, whereas at 50 and 60 min, consumers prefer higher amounts of sugar and peanuts in the formulation. Any amount of cocoa powder could be used using these roasting times. A high roast is usually preferred for maximum flavor development. A light roast usually has less flavor and pale color. The preference for higher amounts of cocoa powder and sugar for choc-peanut spread using peanuts roasted for 40 min may compensate for the weak flavor of light roasted peanuts.

In the production of choco-peanut spread using chocolate syrup as source of chocolate flavor, results showed that overall acceptability, peanut flavor, chocolate flavor, sweetness and spreadability were affected by the various formulations.

Response surfaces (Figs. 3.6 to 3.8) showed that at 40 min roasting time, consumers prefer higher amounts of peanut and lower amounts of sugar in the formulation, whereas at 50 and 60 min, consumers prefer higher amounts of chocolate syrup and lower amounts of sugar in the formulation. Since the chocolate syrup already contains 44% (w/w) sugar, the need for sugar in the choco-peanut spread may be at its minimum.

The acceptable regions obtained per roasting time and type of chocolate flavor were superimposed to obtain optimum area, representing all combinations of mixtures that would meet pre-set criteria for an acceptable choco-peanut spread (Figs. 3.9 to 3.10). It was found that a choco-peanut spread that is acceptable to the consumers may be produced using either cocoa powder or chocolate syrup as the source of chocolate. When using cocoa powder, a choco-peanut spread that is acceptable to consumers maybe produced with any of the combinations of 69-70% peanuts, 24-25% sugar and 5.5-6% cocoa powder with peanuts roasted for 40 min. At roasting time of 50 min, the acceptable formulation is composed of 69-79% peanut, 17-25% sugar and a maximum of 6% cocoa powder. For roasting time of 60 min, the acceptable formulation is 69-76% peanut, 15-25% sugar and a maximum of 6% cocoa powder. When using chocolate syrup, a choco-peanut spread that is acceptable to consumers may be produced with any of the combinations of 73-79% peanut, 15-25% sugar and a maximum of 40% chocolate syrup in the formulation for a total of 100% for a roasting time of 40 min. At roasting time of 50 min, the acceptable formulation is composed of 35-75% peanut, 15-25% sugar and a maximum of 40% chocolate syrup. For roasting time of 60 min, the acceptable formulation is 35-74% peanut, 15-25% sugar and 2-40% chocolate syrup.

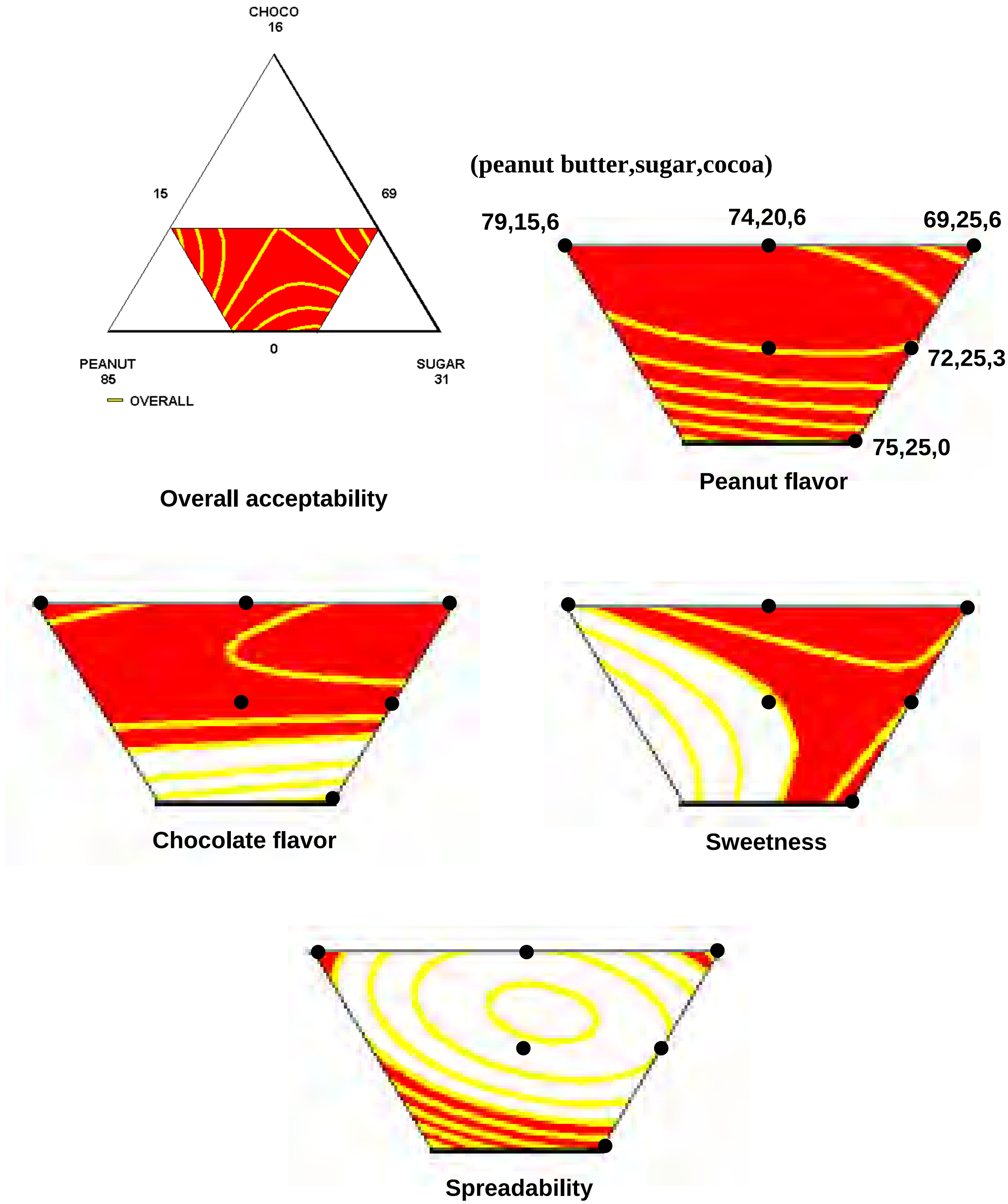


Fig. 3.3 Contour plots for predicted acceptability values of overall acceptance, peanut flavor, chocolate flavor, sweetness and spreadability of choco-peanut spread (chocolate powder as flavor, roasting time of 40 min). Shaded areas represent ranges of formulation combinations that will result in acceptability ratings $\geq$ 5.0.

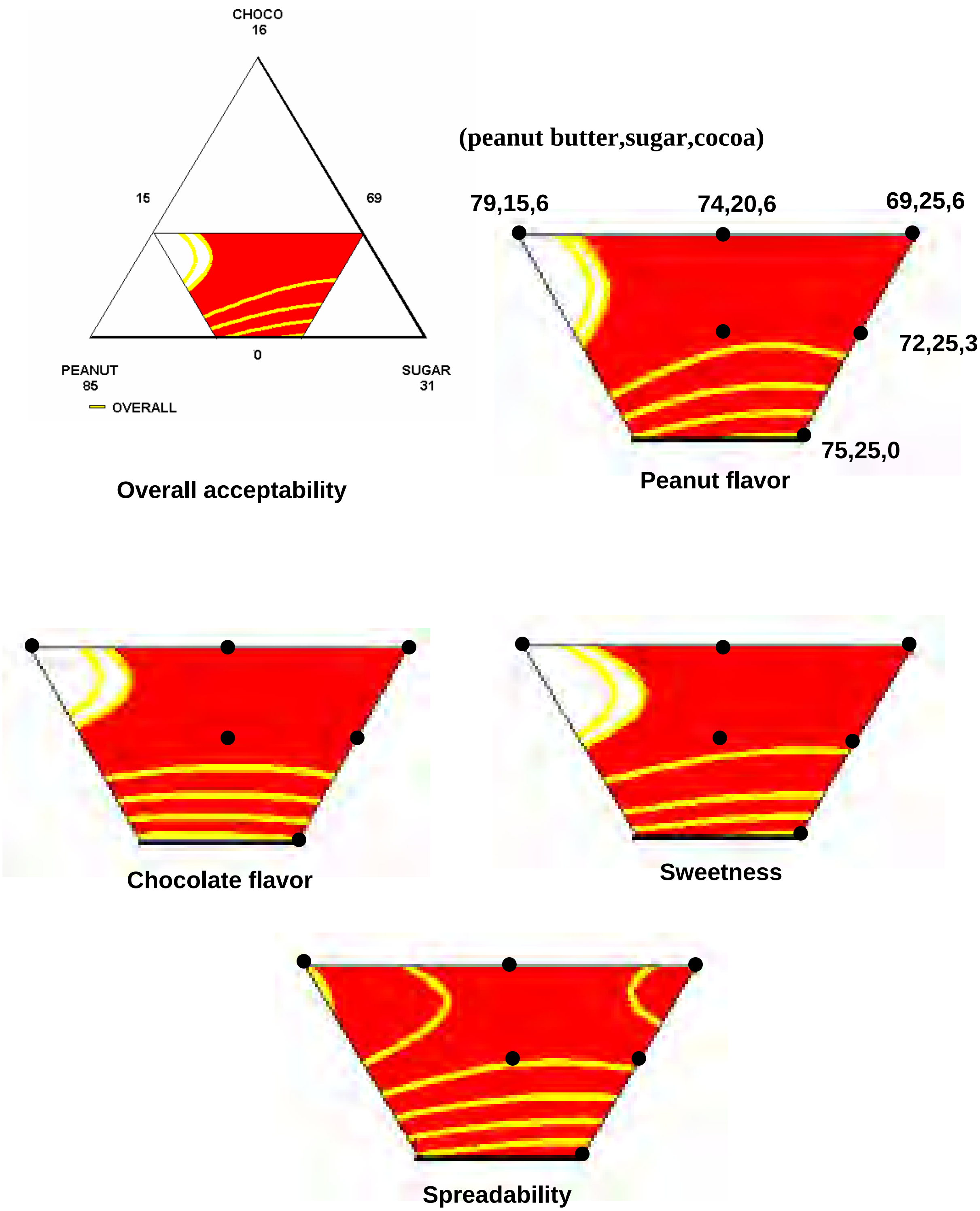


Fig. 3.4. Contour plots for predicted acceptability values of overall acceptance, peanut flavor, chocolate flavor, sweetness and spreadability of choco-peanut spread (chocolate powder as flavor, roasting time of 50 min). Shaded areas represent ranges of formulation combinations that will result in acceptability ratings $\geq$ 5.0

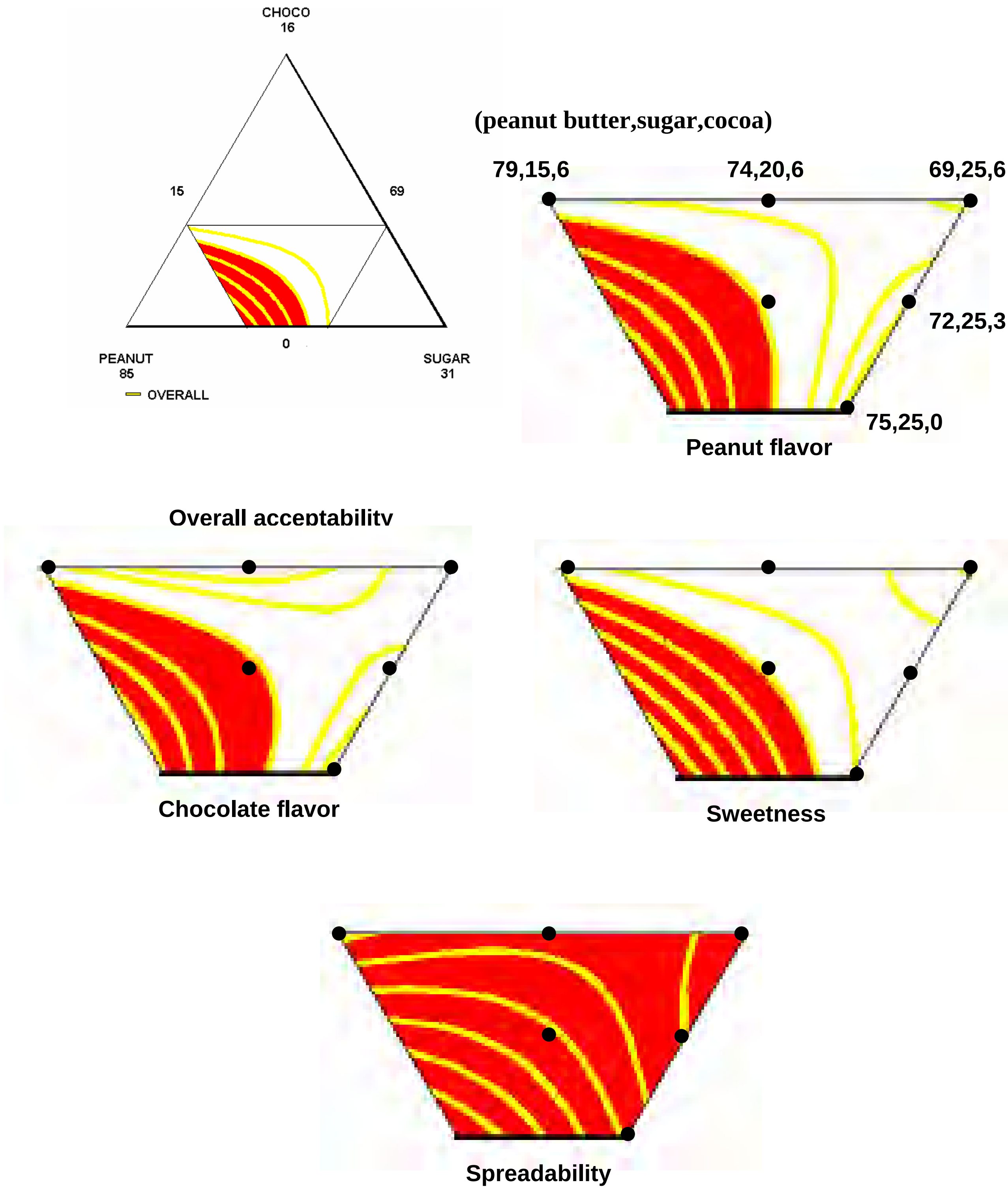


Fig. 3.5 Contour plots for predicted acceptability values of overall acceptance, peanut flavor, chocolate flavor, sweetness and spreadability of choco-peanut spread (chocolate powder as flavor, roasting time of 60 min). Shaded areas represent ranges of formulation combinations that will result in acceptability ratings ≥ 5.0.

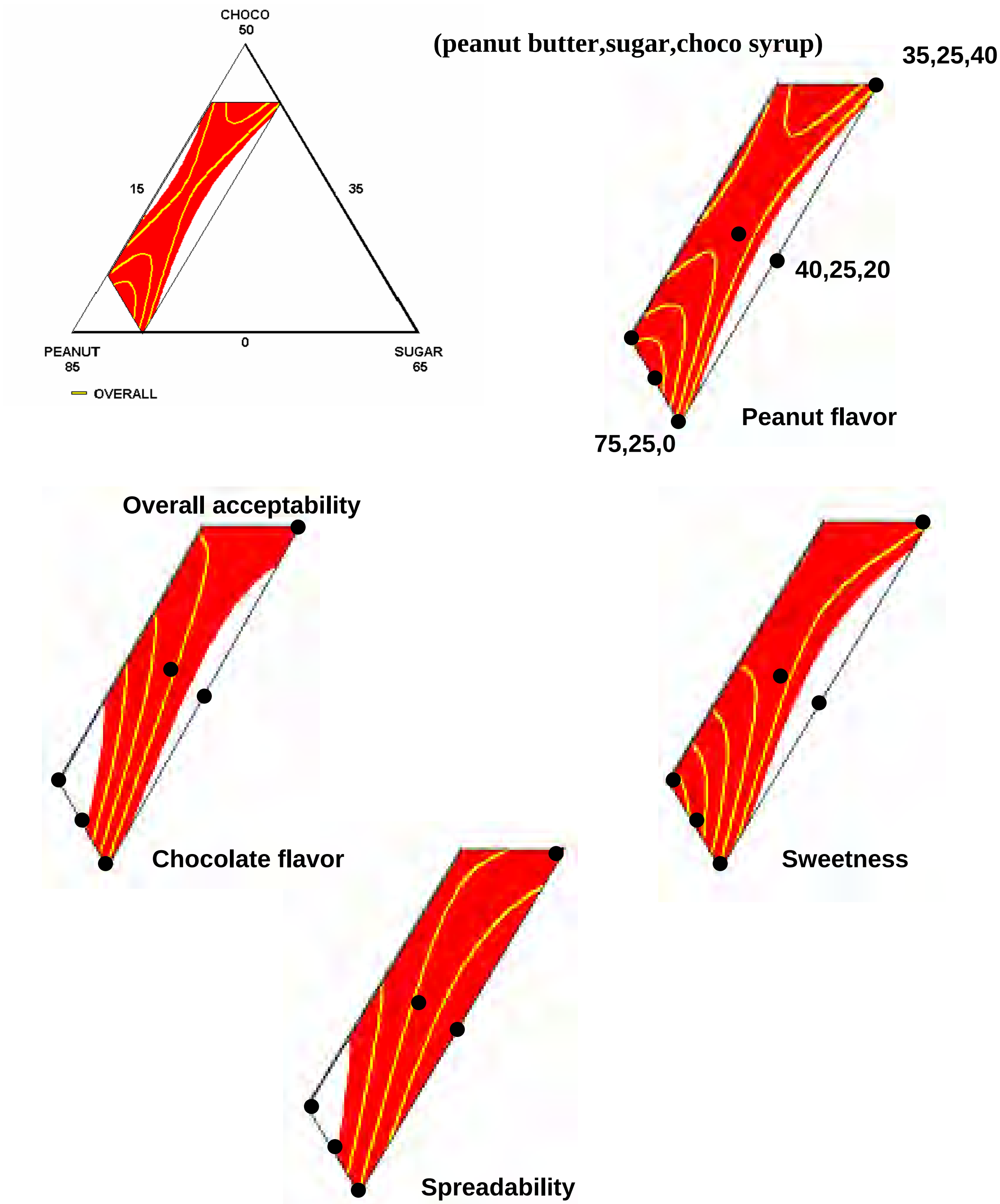


Fig. 3.6 Contour plots for predicted acceptability values of overall acceptance, peanut flavor, chocolate flavor, sweetness and spreadability of choco-peanut spread (chocolate syrup as flavor, roasting time of 40 min). Shaded areas represent ranges of formulation combinations that will result in acceptability ratings ≥ 5.0.

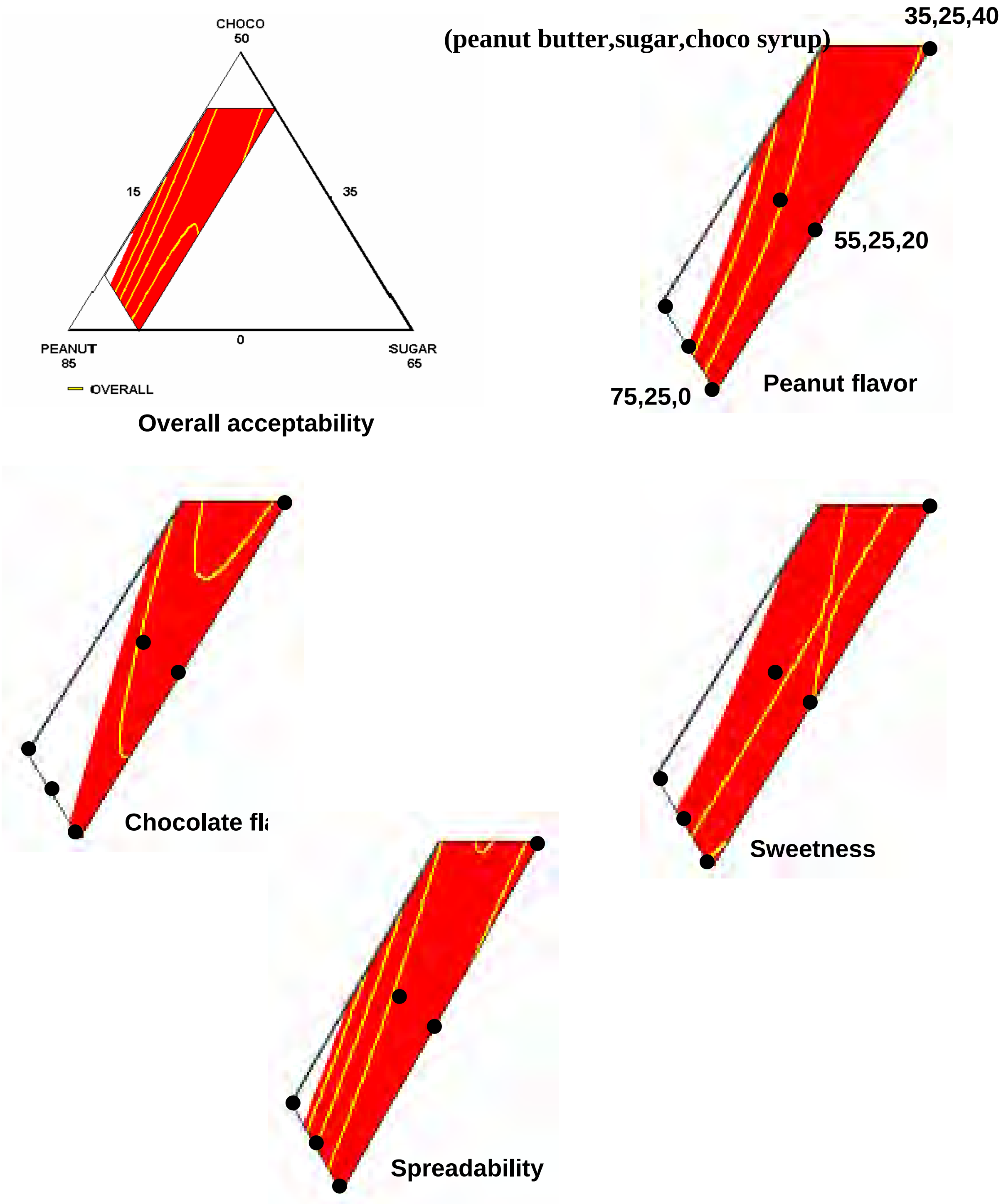


Fig. 3.7 Contour plots for predicted acceptability values of overall acceptance, peanut flavor, chocolate flavor, sweetness and spreadability of choco-peanut spread (chocolate syrup as flavor, roasting time of 50 min). Shaded areas represent ranges of formulation combinations that will result in acceptability ratings $\geq$ 5.0.

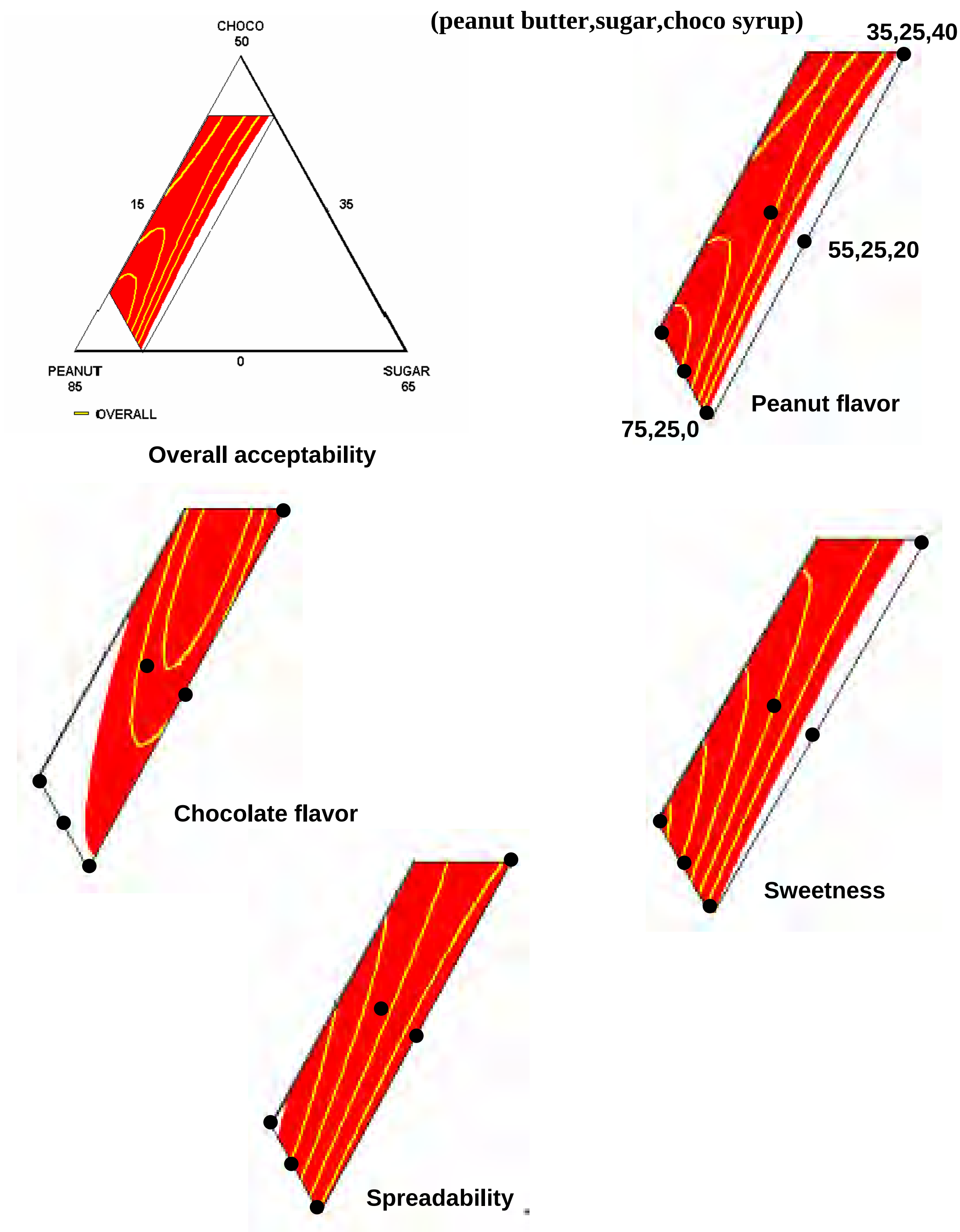
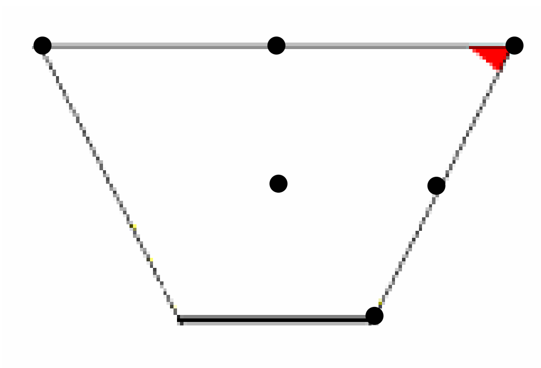
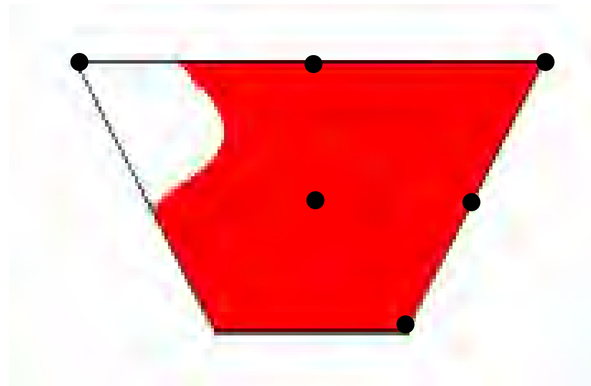


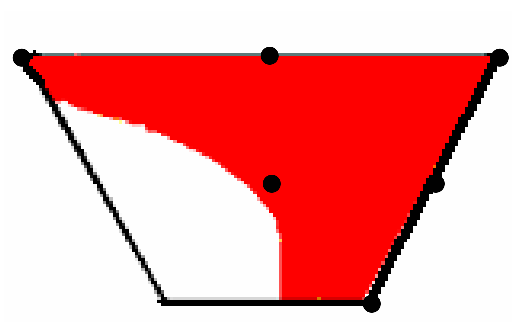
Fig. 3.8 Contour plots for predicted acceptability values of overall acceptance, peanut flavor, chocolate flavor, sweetness and spreadability of choco-peanut spread (chocolate syrup as flavor, roasting time of 60 min). Shaded areas represent ranges of formulation combinations that will result in acceptability ratings ≥ 5.0.



a. 40 minutes

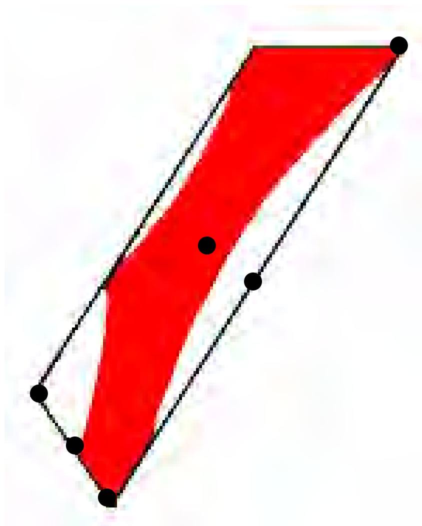


b. 50 minutes

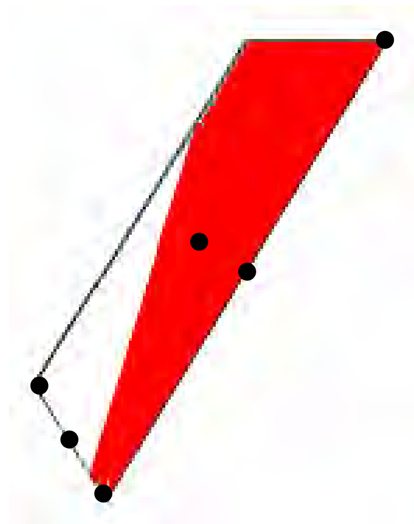


c. 60 minutes

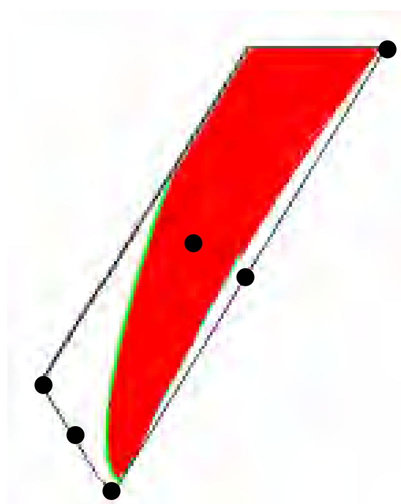
Fig. 3.9 Superimposed contour plots of choco-peanut spread processed using chocolate powder at various roasting times. Shaded area represents range of formulation combinations that would result in a product with acceptable characteristics of $\geq$ 5.0.



a. 40 minutes



b. 50 minutes



c. 60 minutes

Fig. 3. 10 Superimposed contour plots choco-peanut spread processed using chocolate syrup at various roasting times. Shaded area represents range of formulation combinations that would result in a product with acceptable characteristics of $\geq$ 5.0.

Technology Transfer and Adoption

The transfer of technology for the preparation of choco-peanut spread to the industry collaborator was done by giving the industry collaborator a manual of procedure containing all the requirements and procedures for the preparation of the choco-peanut product. The collaborator requested again for the third time a copy of the manual of procedures in January 2005. In May 2005, the investigator from the University of the Philippines was informed that the company will use the chocolate premium instead of the cocoa powder or chocolate syrup because of the latter's unacceptable after taste and intense cocoa powder flavor. The chocolate peanut spread with chocolate premium tasted better according to their R&D staff. The exclusivity of this product with the industry collaborator already expired. Therefore, the Peanut CRSP investigators offered the technology to a new collaborator and results will be reported in Monograph Series No. 9.

Constraints in the Adoption of the Technology

After adoption of the technology, constraints reported by the industry collaborator against commercialization were as follows: (1) Raw material procurement. The company had difficulty in procuring the recommended stabilizer, Myvatex monoset. Apparently, the supplier ran out of stock and no definite time was given when the stocks will arrive. Another supplier was approached (C.K. Bakers in Quezon City) and they supply Myverol instead of Myvatex monoset. The company used Myverol since it can also be used as a stabilizer for peanut butter; (2) Lack of facilities for the immediate cooling and conditioning/tempering of the choco-peanut spread; (3) Technical problems in the continuity of the product development process for the choco-peanut spread due to manpower issues.

CONCLUSION

It was determined that a chocolate-flavored peanut spread may be produced using either cocoa powder or chocolate syrup as the form of added chocolate flavor. When using cocoa powder, a choco-peanut spread that is acceptable to consumers maybe produced with any of the combinations of 69-70% peanuts, 24-25% sugar and 5.5-6% cocoa powder for a total of 100% with peanuts roasted for 40 min. At roasting time of 50 min, the acceptable formulation is composed of 69-79% peanut, 17-25% sugar and a maximum of 6% cocoa powder. For roasting time of 60 min, the acceptable formulation is 69-76% peanut, 15-25% sugar and a maximum of 6% cocoa powder. When using chocolate syrup, a choco-peanut spread that is acceptable to consumers may be produced with any of the combinations of 73-79% peanut, 15-25% sugar and a maximum of 40% chocolate syrup in the formulation for roasting time of 40 min. At roasting time of 50 minutes, the acceptable formulation is composed of 35-75% peanut, 15-25% sugar and a maximum of 40% chocolate syrup. For roasting time of 60 min, the acceptable formulation is 35-74% peanut, 15-25% sugar and 2-40% chocolate syrup. Data shows that peanuts roasted for 40 min exhibited the largest constrained region in formulating the choco-peanut spread for both variants.

In June 2005, the company started conducting the shelf life study and launching of the product was planned. A follow-up was made in November 2006 by a representative from the Food Development Center asking about the status of the project and their predicted time when they can launch the product in the market. The owner (through the Human Resources Assistant) verbally informed the FDC representative that they were in the process of adopting the technology, but no predicted time was given when they can launch the product. They are not yet commercially producing the product and considered that they are still in their R&D stage. The technology was offered to a new collaborator and results of the technology adoption and commercialization will be reported in Monograph Series No. 9.

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APPENDIX A

PROPOSAL FOR R&D COLLABORATION WITH PEANUT PROCESSOR

A. Title: Development and Optimization of a peanut-choco spread

B. Objective: To develop and optimize a chocolate-flavored peanut butter with high acceptability.

Rationale: The recent nationwide survey on Consumer Preferences for Peanut Butter (Galvez et al, 1999) revealed that peanut butter consumers would want to have added flavors in their peanut butter. The popular flavor most preferred by consumers is chocolate. Development of a chocolate-flavored peanut butter would encourage growth and diversification in the consumption of peanut butter since consumers are given new and better choices.

C. Expected Outputs:

1. Determination of the best type of chocolate to be added to peanut butter.
2. Determination of the optimum degree of roasting the peanuts.
3. Determination of the optimum amounts of chocolate, peanut butter and sugar in the formulation.
4. Verification of optimized process and formulation.
5. Successful scale-up at the collabotor's plant.
6. Refereed journal publications.

D. Duration: December 2000 to April 30, 2001

E. Activities and Cost Sharing Scheme
UP
1. Manpower, equipment and 50% of cost of peanuts during the first phase of the study.

Industry Collaborator
1. Cost of 50% of the peanuts during the 1st phase of the study.
2. Equipment, facilities and cost of peanuts during the second phase of the study.
3. Cost of sensory evaluation for peanut choco-spread.

F. Terms of Collaboration
1. Industry to have exclusive use of the process for a period of one year.
2. UP 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. "Development and Optimization of a Peanut-Choco Spread" after due review of the material.

Proposed by: The University of the Philippines

Dr. Flor Crisanta F. Galvez
Lead Investigator
(Original signed)

Conforme: Industry Collaborator
(Original signed)

APPENDIX B

BALLOT FOR ACCEPTABILITY TEST OF CHOCO-PEANUT SPREAD

Name: ____________________ Date: ________________

Sample code: _______________

Instructions: You are presented with samples of Choco-Peanut Spread. Please evaluate the samples by writing the codes on the appropriate blanks.

1. How do you like the Over-all Acceptability of the sample?

______	______	______	______	______	______	______	______	______
Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely

2.How do you rate the Peanut Flavor of the sample?

____

Raw Burnt

How do you like the Peanut Flavor of the sample?

______	______	______	______	______	______	______	______	______
Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely

3. How do you rate the Chocolate Flavor of the sample?

____

None Pronounced

How do you like the Chocolate Flavor of the sample?

______	______	______	______	______	______	______	______	______
Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely

4.How do you rate the Sweetness of the sample?

____

Not Sweet Very Sweet

How do you like the Sweetness of the sample?

______	______	______	______	______	______	______	______	______
Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely

5. How do you rate the Spreadability of the sample?

____

Not Spreadable Very Spreadable

How do you like the Spreadability of the sample?

______	______	______	______	______	______	______	______	______
Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely

Comments:

____

____

CHAPTER 4

STANDARDIZATION OF A PROCESS FOR STABILIZED PEANUT BUTTER FOR A SMALL COMPANY

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ABSTRACT

Experiments were undertaken to establish the level of stabilizer needed to prevent oil separation in peanut butter made from peanuts roasted to medium to dark brown color. Three batches of about six Kg peanut butter were fortified with microencapsulated vitamin A palmitate at a level of addition of 66% of the Recommended Energy and Nutrition Intake (RENI) and stabilized with Myverol (C.K. Bakers, EDSA Muñoz, Quezon City) at a level of addition of 0.8%, 1.5% and 2.0% (w/w peanut butter). The peanut butter for receiving the fortificant and stabilizer was prepared following the existing procedure of the collaborator up to the grinding step (FDC, 2006) after which the stabilizer and vitamin A fortificant were added to the peanut butter matrix and mixed manually for two min. Visual examination of the product was conducted on a weekly basis for a period of two months.

Visual examination of fortified peanut butter stabilized at 0.8% and 1.5% Myverol showed signs of flowing when the bottles were tilted after seven days in storage at ambient conditions. No oil separation was observed at this time. However, after 28 days in storage at ambient conditions, oil separation was observed in 100% of products stabilized with 0.8% Myverol and in 24% of products stabilized with 1.5% Myverol.

On the other hand, products stabilized with 2.0% Myverol did not show signs of flowing when the bottles were tilted and no oil separation were observed even after 60 days in storage. Further evaluation of the product after 210 days (or 6.26 months) in storage showed presence of oil separation in 5.88% (or 1 out of 17) of the products evaluated. These observations indicate that starting on the 7^{th} month of storage; oil separation can take place at this level of addition of the stabilizer.

The technology for the stabilization of the flowing-type peanut butter of the industry collaborator was adopted in January 2007 while the technology for the vitamin A fortification of the stabilized peanut butter was temporarily shelved.

INTRODUCTION

One of the problems encountered during the standardization of the process for a vitamin A fortified stabilized peanut butter at the facilities of a small company was the failure of the product to stabilize at the level of addition of 0.8% earlier established for the product at the Product Development Laboratory of the Food Development Center. The factors that were considered to have affected the stability of the product were insufficient conditioning/tempering of the product and possibly higher oil content of the product brought about by the increase in roasting time of peanuts to achieve a medium to dark brown color. In the past, the collaborator roasted its peanuts to light brown color only but the end point of roasting was changed to medium to dark brown to improve the flavor of the product as requested by its clients. Woodroof (1973) reportedly found that roasted peanut kernels have higher oil content than the corresponding raw kernels.

Oil separation is a major problem commonly associated with unstabilized peanut butter. Oil separation is characterized by the presence of a layer of oil at the surface of the peanut butter causing the peanut solids to settle and form a hard layer at the bottom of the container. The presence of oil separation in peanut butter limits the shelf life of the product thereby affecting its marketability.

To prevent oil separation from taking place, stabilizers are added to the peanut butter. Stabilizers prevent oil separation by forming a crystal matrix that holds the peanut solids and oil together. Stabilizers likewise help provide butter ability over a wide range of temperatures and stiffness without cracking. Stabilizers containing emulsifiers, such as distilled monoglycerides, also impart creaminess and improved mouth release to peanut (Eastman, undated).

In a study conducted by Galvez *et al.* (2003) on several locally available stabilizers, it was mentioned that Myvatex monoset® demonstrated a similar stabilizing effect with Fix-x™, an imported commercial stabilizer that is available in the United States for stabilized peanut butter. Myvatex monoset® however, is no longer available in the Philippines and so Myverol 18-04 was recommended as a substitute by the local distributor. Myverol 18-04 is a distilled monoglyceride derived from fully hydrogenated fats and oils. Myverol 18-04 reportedly can be used alone as peanut butter stabilizer when used at 1.5% - 2.0% levels.

OBJECTIVE

The objective of this study was to determine the level to which stabilizer concentration should be increased to improve the stability of the peanut butter of a small company.

METHODS

Establishment of Collaboration with Industry

A small company engaged in the manufacture of peanut butter sought the assistance of U.S. investigators through the internet regarding the company's problem on oil separation in their product. The Food Development Center then coordinated with the client and and invited their company to become one of the industry collaborators for the project on the technology transfer of vitamin A fortification of a stabilized peanut butter. An agreement for the collaboration was drafted, discussed and signed by the owner of the collaborating company, the NFA-FDC Administrator and US Principal Investigator. The agreement for collaboration includes the development of a technology for the stabilization and vitamin A fortification of the peanut butter of the collaborators. The Memorandum of Agreement between the University of Georgia, National Food Authority – Food Development Center and the company is found in Chapter 4a of Monograph 5.

Experimental Design

Three levels of addition of stabilizer were used in the study. The three levels tested were 0.8%, 1.5% and 2.0% Myverol (w/w peanut butter). Vitamin A recovery and dispersion were evaluated for each treatment.

Raw Materials

Peanuts

Thirty Kg raw shelled peanuts purchased from Divisoria Market (Claro M. Recto, Manila) was used in the study. The peanuts were dry blanched at 121°C for 60 min in an oven. After every 15 min, the trays were taken out of the oven and the peanuts were mixed manually to allow uniform roasting. This process was repeated until the skin of the peanuts can easily be removed. After dry blanching, the peanuts were de-skinned manually and sorted for damaged and discolored kernels under the supervision of FDC researchers. The sorted peanuts were further roasted to 121°C for 30 min with manual mixing every 15 min until a medium to dark brown color of roasted peanuts was achieved.

Refined Sugar

Sampaguita brand refined sugar purchased by the collaborator at Makro Supermarket (EDSA Cubao, Quezon City) was used in the study.

Stabilizer

Myverol 18-04, a distilled monoglyceride derived from fully hydrogenated fats and oils, was used in the study. It was obtained by FDC from C.K. Bakers (EDSA Muñoz, Quezon City). The stabilizer was used at a level of 0.8%, 1.5% and 2.0% (w/w peanut butter).

Fortificant

The fortificant used was a microencapsulated vitamin A palmitate (BASF, 2750 Ballerup, Denmark) that was opened on January 20, 2006 and stored at refrigerated conditions (2 – 8°C). The fortificant was obtained by FDC from BASF Philippines (Carmel Ray Park, Canlubang, Laguna). It was contained in a laminated foil at 50 g per pack and 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, E 321) and sodium ascorbate (E301) as antioxidants and tricalcium phosphate (E 341) as anti-caking product (BASF, 2005).

Preparation of Peanut Butter as a Matrix for Receiving the Fortificant and Stabilizers

Three batches of about six Kg peanut butter was prepared by the collaborator following the company's existing procedure for peanut butter production as shown in Fig. 4.1, up to the grinding step of the roasted peanuts and sugar in a fabricated Almedah Emulsifier (Almedah Food Equipment, 2337 Dalaga St, Tondo, Manila). The peanut butter from the grinding step served as the matrix for receiving the stabilizer.

Addition of the Stabilizer and Fortificant to the Peanut Butter Matrix

Peanut butter prepared above was fortified with microencapsulated vitamin A palmitate and stabilized with Myverol under the supervision of FDC researchers. The level of stabilizer varied from 0.8%, 1.5% and 2.0% (w/w peanut butter). The procedure for the addition of the stabilizer was as follows: Pre-weighed amounts of microencapsulated vitamin A palmitate was added to pre-weighed Myverol and mixed for 10 s using a stirring rod. The mixture of stabilizer and fortificant was then added to the peanut butter matrix and manually mixed for two min using a wooden spoon.

Filling, Sealing and Conditioning of Fortified Stabilized Peanut Butter

The procedure for filling, sealing and conditioning of the fortified stabilized peanut butter was as follows: Fortified peanut butter prepared above was manually filled in 8 oz bottles and sealed with a metal cap. The bottles with fortified stabilized peanut butter was then placed in an ice-water bath maintained at <10°C for 2 hrs, to facilitate the cooling of the product. The cooled bottle with fortified product was then transferred to a refrigerator maintained at <10°C for 48 hrs for conditioning/tempering.

Method of Sampling, Analysis and Evaluation

Samples of fortified stabilized peanut butter kept in the refrigerator for 48 hrs were collected and submitted by the collaborator to FDC, for evaluation of oil separation. Oil separation was evaluated on a weekly basis by visual examination of the surface of the product and after the bottle was tilted. The height of oil that separated from the product was likewise measured at every evaluation period using a ruler to determine extent of oil separation.

Sorted roasted peanuts

↓

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

↓

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

↓

Weighing of three batches of ~6 Kg peanut butter

↓

Addition of 0.4790g fortificant to the following weights of stabilizer (Myverol)

↓

Treatment 1	Treatment 2	Treatment 3
(0.8% w/w of peanut butter)	(1.5% w/w of peanut butter)	(2.0% w/w of peanut butter)
0.4790g to 48g Myverol	0.4790g to 90g Myverol	0.4790g to 120 g Myverol

↓

Manual mixing of the fortificant to stabilizer for ~10 s

↓

Addition of fortificant- stabilizer mixture to the peanut butter matrix

↓

Manual mixing of fortificant-stabilizer mixture to peanut butter for two minutes using wooden 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 (<10°C) for 2 hrs

↓

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

Fig. 4.1 Schematic diagram of the procedure for preparation of peanut butter matrix for receiving the fortificant and the procedure for addition of the stabilizer to the peanut butter matrix.

RESULTS

Table 4.1 shows the result of evaluation of oil separation in fortified peanut butter stabilized with 0.8%, 1.5% and 2.0% Myverol. Fortified peanut butter stabilized at a level of 0.8% Myverol and evaluated seven days after processing, showed signs of flowing when the bottles were tilted indicating that the product is not stable. No oil separation was evident at this time but after 28 days in storage, 100% of the fortified products were observed to have oil at the surface at a height of 1.0 mm. The height of oil was observed to have increased further to about 2.5 mm to 4.0 mm on the 64^{th} day of storage.

Fortified peanut butter stabilized at a level of 1.5% Myverol and evaluated seven days after processing, showed signs of flowing when the bottles were tilted indicating that the product did not stabilize. No oil separation however was evident at this time but after 28 days in storage, 4 out 17 samples or 24% of the samples were observed to have oil separation at the surface of the product at a height of 1.0 mm. After 64 days in storage, 94% of the products had oil separation and the height of oil at the surface of the product increased to about 3.5 mm.

Fortified peanut butter stabilized at a level of 2.0% Myverol and evaluated seven days after processing, did not show signs of flowing when the bottles were tilted. Likewise, no oil separation was evident after 64 days in storage of the product at ambient conditions. These observations are indications that the product is stable during storage. Further evaluation of the product stabilized with 2% Myverol after 210 days (or 7 months) in storage showed presence of oil separation in 5.88% (or 1 out 17) of the products evaluated.

Technology Transfer and Adoption

The transfer of technology for the stabilization of peanut butter to the industry collaborator was done through a demonstration of the recommended process to the daughter of the owner of the company and to two production workers. The technology was adopted in January 2007.

Constraints in the Adoption of the Technology

One of the constraints in the adoption of the technology was the lack of facilities for the immediate cooling and conditioning/tempering of the stabilized product. Since the collaborator did not have an ice water bath for cooling and a cold storage area for conditioning/tempering the product, plastic basins filled with ice and water were used to maintain the required 10°C temperature for cooling while a household refrigerator was used for conditioning/tempering the product for 48 hrs.

CONCLUSIONS

Based on the above findings, it can be concluded that a 0.8% and 1.5% level of addition of Myverol to the peanut butter of a small company will not prevent oil separation from taking place during storage at ambient conditions. However, with 2% Myverol, the peanut butter will remain stable to up to at least 7 months in storage. Further observation of the product is being undertaken to determine the actual length of time at which oil separation will take place.

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Table 4.1 Evaluation of oil separation in vitamin A fortified stabilized peanut butter

Storage Time (Days)	0.8% Myverol			1.5% Myverol			2.0% Myverol		
	No. bottles[1]	% bottles[2]	Appearance of product when bottle was tilted	No. bottles	% bottles	Appearance of product when bottle was tilted	No. bottles	% bottles	Appearance of product when bottle was tilted
0	-[3]	-	-	-	-	-	-	-	-
7	0	0	Product readily flowed when bottle was titled; surface of the product was shiny ; No oil separation was present	0	0	Product slightly flowed when bottle was tilted; surface of the product was shiny ; No oil separation was present	0	0	Product did not flow when bottle was tilted ; surface of the product was slightly dull
21	0	0	Product readily flowed when bottle was tilted ; surface of the product was shiny ; No oil separation was present	0	0	Product slightly flowed when bottle was tilted; surface of the product was shiny ; No oil separation was present	0	0	Product did not flow when bottle was tilted ; surface of the product was slightly dull
28	17	100	Oil separation was evident: Height of oil was ~1.0 mm	4	24	Oil separation was evident: Height of oil was ~1.0 mm	0	0	Product did not flow when bottle was tilted ; surface of the product was slightly dull
35	17	100	Oil separation was evident: Height of oil was ~1.5 mm	4	24	Oil separation was evident: Height of oil was 1.0 mm	0	0	Product did not flow when bottle was tilted ; surface of the product was slightly dull
42	17	100	Oil separation was evident: Height of oil ranged from 1.5 mm to 2.5mm	10	59	Oil separation was evident: Height of oil ranged from 0.5mm to 2.0 mm	0	0	Product did not flow when the bottle was tilted ; surface of the product was slightly dull
50	17	100	Oil separation was evident: Height of oil ranged from 2.0 mm to 3.0 mm	15	88	Oil separation was evident: Height of oil ranged from 0.5mm to 3.0 mm	0	0	Product did not flow when the bottle was tilted ; surface of the product was slightly dull

Storage Time (Days)	0.8% Myverol			1.5% Myverol			2.0% Myverol		
	No. bottles[1]	% bottles[2]	Appearance of product when bottle was tilted	No. bottles	% bottles	Appearance of product when bottle was tilted	No. bottles	% bottles	Appearance of product when bottle was tilted
57	17	100	Oil separation was evident: Height of oil ranged from 2.5 mm to 4.0 mm	16	94	Oil separation was evident: Height of oil ranged from 1.0 mm to 3. 5mm	0	0	Product did not flow when the bottle was tilted; surface of the product was slightly dull
64	17	100	Oil separation was evident: Height of oil ranged from 2.5 mm to 4.0 mm	16	94	Oil separation was evident: Height of oil ranged from 1.0 mm to 3. 5mm	0	0	Product did not flow when the bottle was tilted; surface of the product was slightly dull

[1]Total number of bottles with oil separation (N=17).
[2]Percent number of bottles with oil separation (N=17)
[3]Means no evaluation was made.

CHAPTER 5

STANDARDIZATION OF STABILIZED PEANUT SPREAD WITH ROASTED CASSAVA FLOUR

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ABSTRACT

A study was conducted to determine the effects of levels of cassava flour and stabilizer on the sensory qualities of peanut butter. In general, the study was conducted to process and evaluate the sensory qualities of a stabilized peanut butter incorporated with roasted cassava flour. Nine treatments of peanut butter with different levels of cassava flour (0%, 20%, 40% w/w) and stabilizer (0%, 1.5%, 3.0% w/w) were processed using the 3 x 3 factorial experimental design in completely randomized design (CRD) in two blocks or replicates. The sensory qualities were determined in terms of color, aroma, oiliness, spreadability, taste, flavor, and the overall acceptability. Furthermore, oil separation analysis of the different treatments and verification study were conducted.

Oil separation analysis showed a linear effect (at 5% level of significance) as the level of stabilizer increased from 0 to 3%. For sensory evaluation, a linear effect was observed on spreadability the level of cassava flour increased. Quadratic effects of cassava flour were observed in color, aroma, oiliness, spreadability, taste, flavor, and overall attributes of peanut butter. Also, cross-product effects on color and oiliness acceptability were observed. Response surface regression analysis revealed that sensory qualities of peanut butter were greatly affected with the incorporation of cassava flour while stabilizer showed insignificant result. Oiliness acceptability was the limiting attribute for the predicted optimum formulation of peanut butter wherein up to 21.75% (w/w) cassava flour can be incorporated and up to 2.7% (w/w) stabilizer can be added with acceptability rating of ≥ 6.5.

INTRODUCTION

Peanut is one of the leguminous crops grown worldwide. It contains about 25-30% protein, and 40-48% oil of high quality. It also contains niacin, thiamine and other Vitamin-B components plus 11 of the 13 essential minerals like calcium (Maula, 1985). In the Philippines, about 92.0% of its total peanut production is consumed as food, 0.5% is used as seeds and 7.5% for non-food uses. Products prepared from peanuts are flour, protein isolate, cheese, and paste for shortening and defatted meal for snack foods. The seed coat is a source of commercial tannin and thiamine (PCARRD, 2000).

According to a survey conducted by (Galvez *et al.*, 2002), peanut butter was the most preferred over the other peanut products like fried, roasted or boiled and produced and available in all the regions of the Philippines, the most common of which are the flowing types. However the oil separates during storage, and the product needs to be remixed for better eating quality. This separation is a problem due to higher tendency of the product to become rancid. The stabilizer keeps the oil from separating from the peanut butter and improves texture, increases shelf life, and keeps the peanut butter fresh which most consumers prefer (Malupangue, 2005).

Cassava flour can be used to make cookies, quick breads, loaf breads, pancakes, doughnuts, dumplings, muffins, bagels, and so forth. It can also substitute wheat at different levels in bakery products and in various food preparations (Palomar *et al*., 1981). Results from the study of Galvez *et al*., (2002) revealed that Filipinos preferred the stabilized peanut butter than to free-flowing or unstabilized type. However, limited studies have been done on the formulation optimization and use of indigenous material such as roasted cassava flour in stabilized peanut butter.

OBJECTIVES

The general objective of the study was to process and evaluate a stabilized peanut butter with the incorporation of roasted cassava flour. The specific objectives were to: (1) process peanut butter using different levels of cassava flour and commercial stabilizer; (2) evaluate the sensory qualities of the different product treatments; (3) determine the effects of levels of cassava flour and Myverol stabilizer on the sensory qualities, and oil separation of the peanut butter; and (4) determine the levels of cassava flour and Myverol stabilizer for acceptable peanut butter.

METHODS

Experimental Design

A 3 x 3 factorial experimental design in completely randomized design (CRD) in two blocks or replicates with three levels of cassava flour (0%, 20%, and 40% w/w) and stabilizer (0%, 2%, and 4% w/w) was used in the study. The different treatments are shown in Table 5.1.

Table 5.1 Treatments used in the optimization of the formulation and processing of peanut butter

Treatment Number	Levels of Cassava Flour (% w/w)	Levels of Commercial Stabilizer[1] (% w/w)
1	0	0
2	20	0
3	40	0
4	0	1.5
5	20	1.5
6	40	1.5
7	0	3.0
8	20	3.0
9	40	3.0

[1]Myverol 18-04, a distilled monoglyceride

Product Processing

Preparation of Peanuts for Grinding

Processing of the peanut butter was done following the steps shown in Fig. 5.1. Peanuts (native, white variety), with peanut skin, were sorted to separate the wrinkled and immature kernels. The sorted peanuts were roasted using the Peanut-CRSP Thailand-fabricated peanut roaster at temperature of 150°C for 20 minutes and was allowed to cool just enough to be handled. The skin was removed from the kernels manually. With the use of an electric fan, the skin was separated from the peanuts and manually sorted to remove defective seeds, which were yellowish in color and had indications of possible contamination of aflatoxin. Aflatoxin is a naturally occurring substance produced by a mold that can grow on peanuts and other crops, especially under unfavorable growing or storage conditions (Queensland Government, 2002).

The de-skinned sorted peanuts were roasted again at 150°C for 15 min. Then a second sorting was done to make sure damaged kernels were totally removed from the lot. The roasted peanut was allowed to cool and weighed to get the desired ratio of ingredients. The other ingredients, i.e. brown sugar, rock salt and roasted cassava flour (processed from golden yellow variety of the PhilRootcrops, LSU, Visca, Baybay, Leyte) were also weighed by percentage of the total weight.

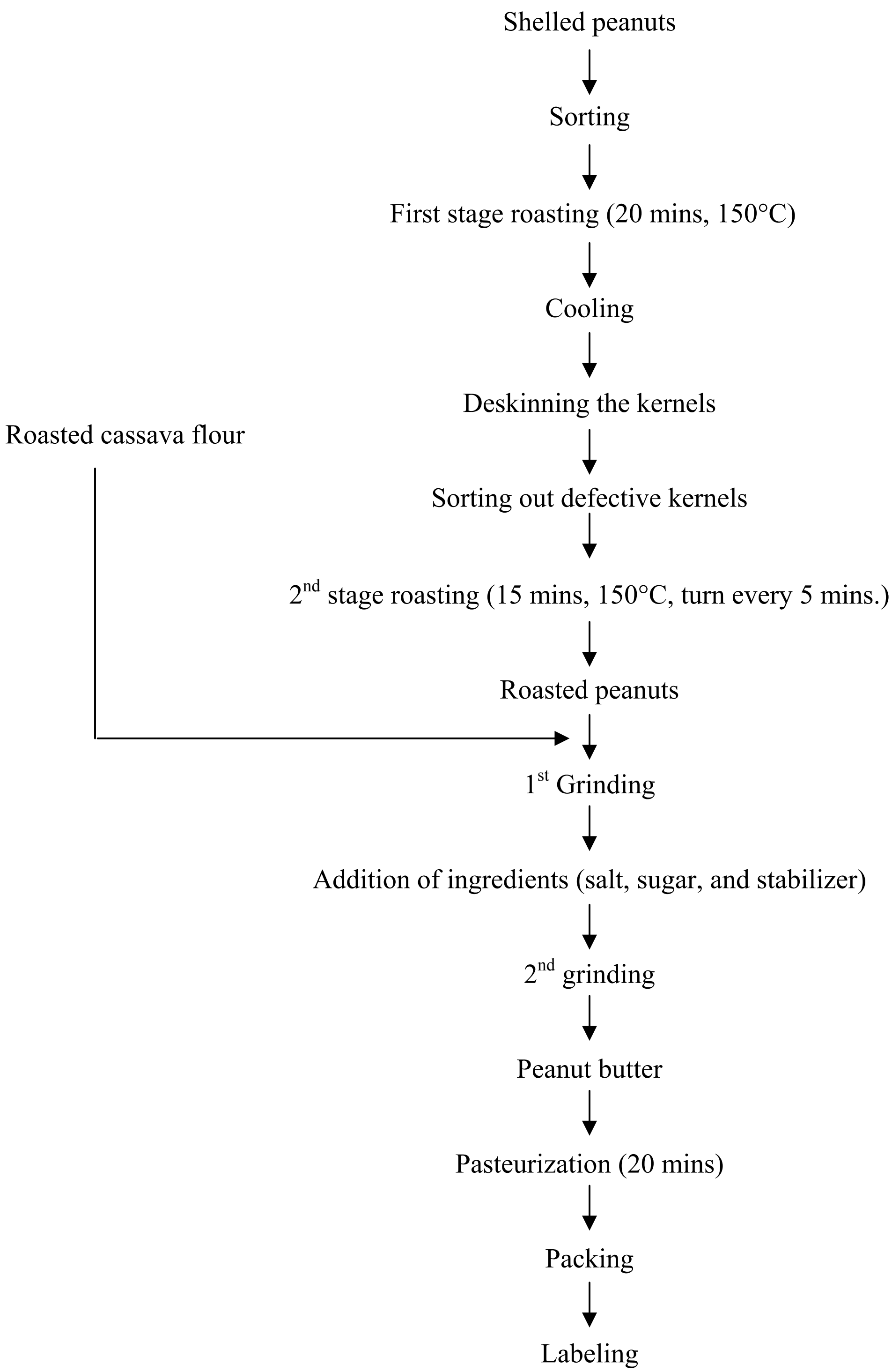

Fig. 5.1 Process flow chart for peanut butter.

Grinding

The roasted peanuts together with the roasted cassava flour were ground first. The grinder used was a fabricated Almeda grinder instead of a colloid mill. After the first grinding, the addition of ingredients followed. The ingredients added included 12% sugar, 1.0% salt and stabilizer using Myverol at different levels. Second grinding was done to completely grind and incorporate the peanuts with the cassava flour into smaller particles. The ground mixture of peanuts and cassava flour was cooked, for 20 minutes using a double - boiler for pasteurization purposes.

Packing

The pasteurized finished product was packed into sterilized plastic containers and then labeled. The container of the peanut butter was thumped for 15 min to remove air bubbles that may have been trapped within the peanut butter (Malupangue, 2005).

Sensory Evaluation

Sensory evaluation was carried out to assess the sensory attributes of the finished product using the ballot in Appendix A following the incomplete block design (Appendix B) of Cochran and Cox (1957). The set plan of t = 9, k = 6, r = 8, b = 12, E = 0.94, Type II was followed where t = refers to the number of treatments, k = the number of samples presented to the panelists, r = the number of replicates based on the plan IBD, b = the number of blocks and E = the efficiency factor. The plan was replicated four times to get 48 panelists evaluating each sample. Another sensory evaluation was conducted for the next batch of samples. This was conducted at the sensory room of the Department of Food Science and Technology with the BS Food Technology students as consumer panel members.

Statistical Analysis

Data obtained from the experiment was analyzed using Response Surface regression (RSREG) of the Statistical Analysis System software (SAS, 1985) to determine the effects of independent variables on the sensory qualities and the cost of production of the stabilized peanut butter. Response surface plots were made to illustrate the effects of the parameters that show significance in the RSREG using STATISTICA (SAS, 1985, Version 5.0 Statsoft, Inc., 1984-95) computer program.

Oil Separation Analysis

Oil separation analysis of all the treatments was conducted. After one month of storage, oil that separated from the formulation was weighed. The data gathered was analyzed using RSREG.

Verification Study

Verification experiments were conducted using three selected treatments. Thirty panelists were randomly selected from the 60 that participated during the consumer tests. The treatments included one within the optimum area (T_{10}), one near the optimum area with ratings of $\geq$ 6.5 (T_{11}), and one outside these two areas. The treatments used are shown in Table 5.2. T- test was performed to determine if the observed values were different from the predicted values using the equation shown below (Levin and Rubin, 1980).

$$t = \frac{yi - pi}{\frac{sd}{\sqrt{n}}}$$

Where: yi = observed mean for verification sample data
pi = predicted value of each attribute from desired model
sd = sample standard deviation
n = number of observations

Table 5.2 Treatments used in the verification of the formulation and processing of peanut butter

Treatment Number	Levels of Cassava Flour (% w/w)	Levels of Commercial Stabilizer[1] (% w/w)
10	0	1
11	20	1
12	40	0

[1]Myverol 18-04, a distilled monoglyceride

RESULTS

Sensory Evaluation

The sensory qualities evaluated were acceptance of color, oiliness, spreadability, aroma, taste, and flavor, and overall acceptance. Table 5.3 shows the mean acceptance sensory ratings of peanut butter using 9-point Hedonic scale. Table 5.4 shows the analysis of variance for the sensory qualities/parameters of peanut butter.

Color Acceptability

The color acceptability of peanut butter ranged from 4.23 to 7.53 with an overall response mean of 5.21 (Table 5.3). These values fall between "dislike slightly" to "like very much" category of the Hedonic scale. Color acceptability showed cross product and quadratic significance at $p \leq 0.01$ and $p \leq 0.05$, respectively (Table 5.4).

The contour plot for the color acceptability is shown in Fig. 5.2a. As observed, acceptability decreased as the levels of cassava flour was increased. This can be due to the fact that cassava flour is white thus making the finished product pale in color that lowers its acceptability to the consumer. A color acceptability value of 7.29 was predicted to be at 0.39% (w/w) cassava flour and 1.30% (w/w) stabilizer formulation (Table 5.7). Parameter estimates on this interaction of cassava flour and stabilizer was found to be significant at 1% level (Table 5.5).

Table 5.3 Mean consumer acceptance ratings for color, aroma, oiliness, spreadability, taste, flavor, and overall acceptability of peanut butter

Treatment No.	X_1	X_2	Color	Aroma	Oiliness	Spread-ability	Taste	Flavor	Overall
1	0	0.0	6.85	6.77	6.48	7.01	6.21	6.60	6.96
2	20	0.0	7.00	7.10	7.00	7.32	6.36	6.37	7.01
3	40	0.0	6.00	5.23	5.70	4.66	5.70	5.74	5.50
4	0	1.5	7.13	7.10	6.15	7.50	6.66	6.80	6.83
5	20	1.5	6.98	6.71	6.60	6.82	6.42	6.57	6.78
6	40	1.5	5.19	5.30	4.25	4.26	4.89	4.93	5.29
7	0	3.0	7.53	6.87	6.23	6.80	6.53	6.72	6.96
8	20	3.0	5.77	6.64	5.57	5.70	6.14	6.33	6.49
9	40	3.0	4.23	4.60	3.38	2.87	4.34	4.27	3.91
Mean Score			5.21	5.54	4.25	4.19	5.23	5.26	5.16

X_1 – levels of cassava flour, % w/w; X_2 – levels of stabilizer, % w/w.
Acceptability score: 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.

Table 5.4 Analysis of variance for the sensory qualities/ parameters of peanut butter

Sensory Qualities/ Parameters	Statistics	Linear	Quadratic	Cross-product	Total Regression
Color	Probability	0.0000**	0.0269*	0.0027**	0.0000*
	R- square	0.2643	0.0181	0.0226	0.3049
Aroma	Probability	0.0000**	0.0183*	0.0762 ns	0.0000**
	R- square	0.3328	0.0185	0.0072	0.3585
Oiliness	Probability	0.0000**	0.0013**	0.0202*	0.0000**
	R- square	0.3047	0.0313	0.0126	0.3487
Spreadability	Probability	0.0000**	0.0142*	0.1587 ns	0.0000**
	R- square	0.5992	0.0118	0.0027	0.6137
Taste	Probability	0.0000**	0.0524 ns	0.4540 ns	0.0000**
	R- square	0.2904	0.0147	0.0014	0.3064
Flavor	Probability	0.0000**	0.0236*	0.3571 ns	0.0000**
	R- square	0.3047	0.0182	0.0020	0.3249
Overall	Probability	0.0000**	0.0002**	0.1757 ns	0.0000**
	R- square	0.4393	0.0331	0.0034	0.4758
Oil Separation	Probability	0.0500*	0.2288 ns	0.0739 ns	0.0809 ns
	R- square	0.5546	0.1461	0.2119	0.9127

ns Means not significant.
* Means significant at $P \leq 0.05$.
** Means significant at $P \leq 0.01$.

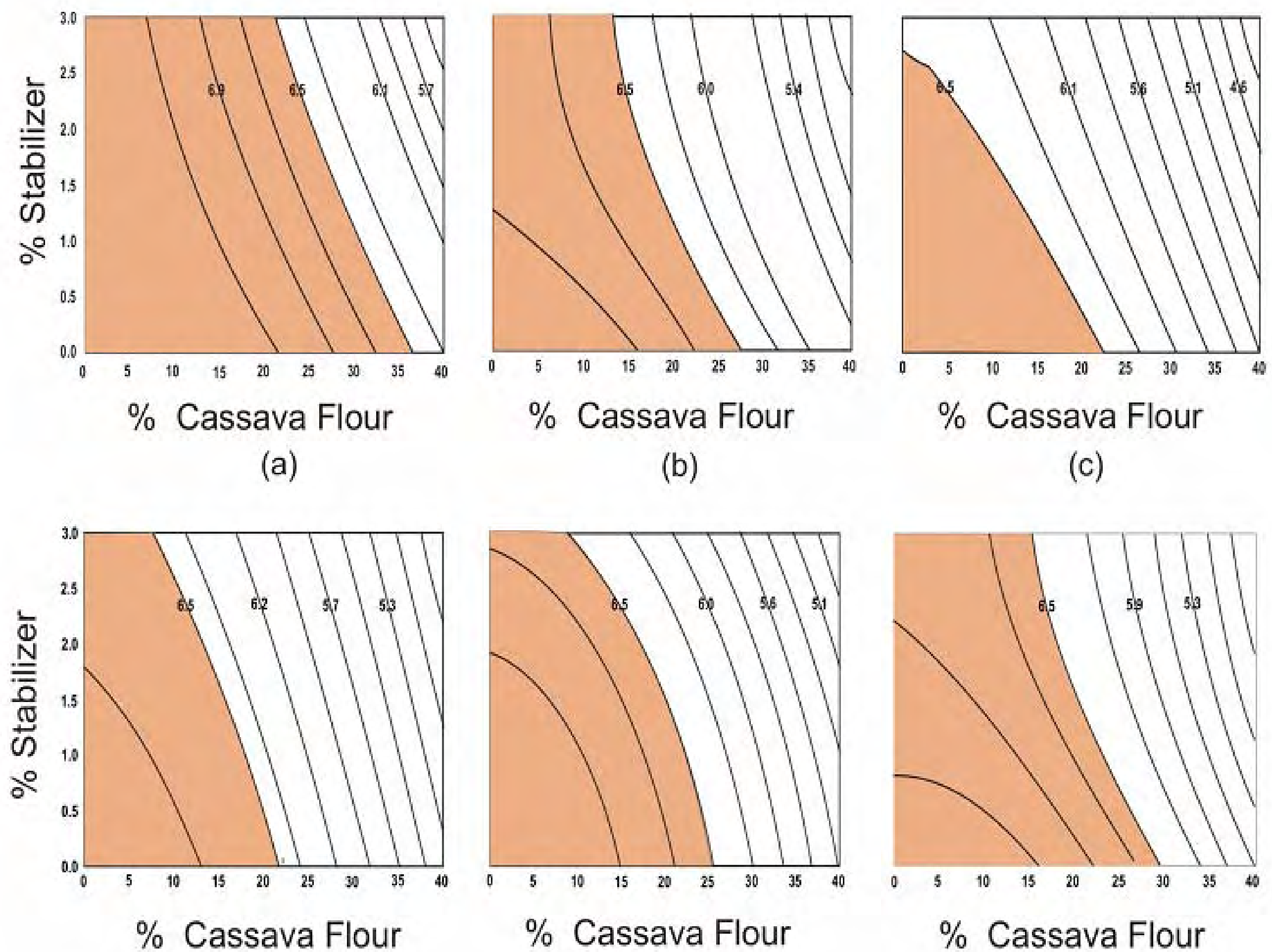

Fig. 5.2 Contour plot of peanut butter showing acceptability rating $\geq$ 6.5: (a) color, (b) aroma, (c) oiliness, (d) spreadability, (e) taste, (f) flavor and, (g) overall.

Table 5.5 Parameter estimates for the response surface on acceptability of color of peanut butter

Parameter	df	Parameter Estimate	Standard Error	T for Ho: Parameter=0	Prob > |T|
INTERCEPT	1	7.2804	0.1807	40.2800**	0.0000
CASSAVA	1	0.0139	0.0157	0.8900	0.3742
STABILIZER	1	0.0069	0.2087	0.0333s	0.9735
CFLOUR*CFLOUR	1	-0.0010	0.0004	-2.7070**	0.0072
STABILIZER*CFLOUR	1	-0.0102	0.0034	-3.0260**	0.0027
STABILIZER*STABILIZER	1	-0.0012	0.0633	-0.0183	0.9854

** Means significant at $P \leq 0.01$.

Table 5.6 Main factor effects on acceptability of color of peanut butter

Factor	df	Sum of Squares	Mean Square	F-Ratio	Prob > F
CFLOUR	3	143.3116	47.7705	36.811**	0.0000
STABILIZER	3	29.1033	9.7011	7.476**	0.0001

** Means significant at $P \leq 0.01$.

Table 5.7 Optimum condition critical values and predicted response values of sensory qualities of peanut butter at stationary point (from canonical analysis of response surface)

Responses	Optimum Conditions		Predicted Values at Stationary Point
	Levels of Cassava Flour (% w/w)	Levels of Stabilizer (% w/w)	
Color	0.387875	1.298198	7.287592
Oiliness	-5. 649081	4.482662	6.442845
Spreadability	-36.027723	9.236538	6.726916
Aroma	-6.165661	2.283373	6.930991
Taste	11.542289	-9.664179	7.498627
Flavor	0.442584	-0.452632	7.172814
Overall	-2.598344	2.968944	6.931118
Oil separation	16.667049	2.359596	-0.106669

Aroma Acceptability

The aroma acceptability of peanut butter ranged from 4.60 to 7.10 with an overall response mean of 5.54 (Table 5.3). These values fall between "dislike slightly" to "like very much" category of the Hedonic scale. Aroma acceptability was affected by the quadratic effect of cassava flour at $p \leq 0.01$ (Table 5.4). Table 5.4 shows linear and cross-product effects, this was caused by the intercept and not by the individual variables, i.e. cassava flour or the stabilizer (Tables 5.8 and 5.9).

The contour plot for the aroma acceptability is shown in Fig. 5.2b. As observed, there was lower acceptability as the levels of cassava flour was increased. Addition of cassava flour lessens the perceptible aroma of peanuts by diluting it by its presence.

Table 5.8 Parameter estimates for the response surface on acceptability of aroma of peanut butter

Parameter	df	Parameter Estimate	Standard Error	T for Ho: Parameter=0	Prob > |T|
INTERCEPT	1	7.2062	0.1773	40.6470**	0.0000
CFLOUR[1]	1	0.0015	0.0154	0.0975	0.9224
STABILIZER	1	-0.2370	0.2047	-1.1580	0.2480
CFLOUR*CFLOUR	1	-0.0070	0.0003	-2.7590**	0.0062
STABILIZER*CFLOUR	1	-0.0059	0.0033	-1.7800	0.0762
STABILIZER*STABILIZER	1	0.0440	0.0621	0.7080	0.4792

** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Table 5.9 Main factor effects on acceptability of aroma of peanut butter

Factor	df	Sum of Squares	Mean Square	F-Ratio	Prob > F
CFLOUR[1]	3	174.7954	58.2651	46.665**	0.0000
STABILIZER	3	25.9151	8.6384	6.919**	0.0002

** Means significant at $P \leq 0.01$.
[1] CFLOUR = Cassava flour

Oiliness Acceptability

Oiliness acceptability showed quadratic and cross- product significance at $p \leq 0.01$ and $p \leq 0.05$, respectively (Table 5.4). It was significantly affected with the incorporation of cassava flour to the formulation. Incorporation of cassava flour surely reduces the oiliness of the formulation. This could be because of the fact that oil content of cassava flour is less than 2% of oil compared with peanut oil which is 50%. Cassava flour absorbed the peanut oil to homogenize the product. Although Table 5.4 shows linear effect, the linearity was caused by the intercept and not by the individual variables, i.e. cassava flour or the stabilizer (Tables 5.10 and 5.11).

The oiliness acceptability of peanut butter ranged from 3.38 to 7.00 with an overall response mean of 4.25 (Table 5.3). These values fall between "dislike moderately" to "like moderately" category of the Hedonic scale. The response surface produced a saddle stationary point at 6.44. The contour plot is shown on Fig. 5.2c. Oiliness was the limiting attribute in determining the optimum formulation of peanut butter.

Table 5.10 Parameter estimates for the response surface on acceptability of oiliness of peanut butter

Parameter	df	Parameter Estimate	Standard Error	T for Ho: Parameter=0	Prob > |T|
INTERCEPT	1	6.7257	0.1921	35.0030**	0.0000
CFLOUR[1]	1	0.0216	0.0166	1.2990	0.1950
STABILIZER	1	-0.0990	0.2219	-0.4460	0.6559
CFLOUR*CFLOUR	1	-0.0014	0.0004	-3.6810**	0.0003
STABILIZER*CFLOUR	1	-0.0083	0.0036	-2.3360*	0.0202
STABILIZER*STABILIZER	1	0.0058	0.0673	0.0860	0.9315

* Means significant at $P \leq 0.05$
** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Table 5.11 Main factor effects on acceptability of oiliness of peanut butter

Factor	df	Sum of Squares	Mean Square	F-Ratio	Prob > F
CFLOUR[1]	3	526.0922	175.3641	131.0000**	0.0000
STABILIZER	3	76.4568	25.4856	19.0370**	0.0000

** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Spreadability

The spreadability acceptability of peanut butter ranged from 2.87 to 7.50 with an overall response mean of 4.19 (Table 5.3). These values between "dislike very much" to "like very much" category of the Hedonic scale. The response surface produces saddle stationary point at 6.72. Response on spreadability acceptability was affected by the linear and quadratic interaction of cassava flour (Tables 6.4, 6.12 and 6.13). The contour plot of the product showed that there was lower acceptance of spreadability as the level of cassava flour was increased (Fig. 5.4d).

Table 5.12 Parameter estimates for the response surface on acceptability of spreadability of peanut butter

Parameter	df	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	7.7426	0.1836	42.1760**	0.0000
CFLOUR[1]	1	-0.0320	0.0159	-2.0110*	0.0453
STABILIZER	1	-0.3446	0.2120	-1.6260	0.1051
CFLOUR*CFLOUR	1	-0.0011	0.0004	-2.9350**	0.0036
STABILIZER*CFLOUR	1	-0.0048	0.0034	-1.4130	0.1587
STABILIZER*STABILIZER	1	0.0093	0.0643	0.1440	0.8856

* Means significant at $P \leq 0.05$
** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Table 5.13 Main factor effects on acceptability of spreadability of peanut butter

Factor	df	Sum of Squares	Mean Square	F-Ratio	Prob > F
CFLOUR[1]	3	526.0922	175.3641	131.0000**	0.0000
STABILIZER	3	76.4568	25.4856	19.0370**	0.0000

** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Taste Acceptability

Taste acceptability of peanut butter ranged from 4.34 to 6.66 with an overall response mean of 5.23 (Table 5.3). These values fall between "dislike slightly to "like slightly" category of the Hedonic scale Table 5.4 shows insignificant result on quadratic effect and a significant linear effect but as we go deeper in the analysis, taste acceptability showed quadratic effect on cassava flour and insignificant linear effect both on cassava flour and stabilizer (Tables 5.14 and 5.15). The contour plot is shown on Fig. 5.2e. There was lower taste acceptability as the level of cassava flour was increased. This could be because the taste of cassava flour is very bland (Special Foods, 2002). In this manner, the taste was affected because the taste of the product was minimized with the increase of cassava flour.

Table 5.14 Parameter estimates for the response surface on acceptability of taste of peanut butter

Parameter	df	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	7.0208	0.1870	37.5390**	0.0000
CFLOUR[1]	1	-0.0044	0.0162	-0.2730	0.7848
STABILIZER	1	-0.1042	0.2160	-0.4820	0.6299
CFLOUR*CFLOUR	1	-0.0009	0.0004	-2.4390*	0.0153
STABILIZER*CFLOUR	1	-0.0026	0.0035	-0.7500	0.4540
STABILIZER*STABILIZER	1	-0.0069	0.0655	-0.1060	0.9156

* Means significant at $P \leq 0.05$
** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Table 5.15 Main factor effects on acceptability of taste of peanut butter

Factor	df	Sum of Squares	Mean Square	F-Ratio	Prob > F
CFLOUR[1]	3	159.5677	53.1892	38.2790**	0.0000
STABILIZER	3	14.3438	4.7812	3.4410*	0.0173

* Means significant at $P \leq 0.05$
** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Flavor Acceptability

The flavor acceptability of peanut butter ranged from 4.27 to 6.80 with an overall response mean of 5.26 (Table 5.3). These values fall between “dislike slightly” to “like moderately” category of the Hedonic scale. Flavor acceptability was affected by the quadratic effect of cassava flour (Tables 5.16 and 5.17). Although Table 5.4 shows linear effect, the linearity was caused by the intercept and not by the individual variable either the cassava flour or the stabilizer as we go deeper in the analysis.

The contour plot is shown on Fig. 5.2f. As observed, there was lower flavor acceptability as the level of cassava flour was increased. This is true with the fact that flavor of many foods is often altered with additives (Wikipedia, 2002). Addition of cassava flour to the formulation lessens the nutty flavor of the peanuts making the formulation less in perceptible nutty flavor and an increase in cassava flour flavor tending the panelists to give the product a lower rating.

Table 5.16 Parameter estimates for the response surface on acceptability of flavor of peanut butter

Parameter	df	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	7.1645	0.1900	37.7020**	0.0000
CFLOUR[1]	1	-0.0006	0.0165	-0.0356	0.9716
STABILIZER	1	-0.0373	0.2194	-0.1700	0.8650
CFLOUR*CFLOUR	1	-0.0010	0.0004	-2.6790**	0.0078
STABILIZER*CFLOUR	1	-0.0033	0.0035	-0.9220	0.3571
STABILIZER*STABILIZER	1	-0.0428	0.0665	-0.6440	0.5204

** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Table 5.17 Main factor effects on acceptability of flavor of peanut butter

Factor	df	Sum of Squares	Mean Square	F-Ratio	Prob > F
CFLOUR[1]	3	171.0193	57.0064	39.7410**	0.0000
STABILIZER	3	24.8474	8.2825	5.7740**	0.0008

** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Overall Acceptability

The overall acceptability score of peanut butter ranged from 3.91 to 7.01 with an overall response mean of 5.16 (Table 5.3). These values fall between “dislike moderately” to “like very much” category of the Hedonic scale. Overall acceptability was affected by the quadratic effect of cassava flour to the formulation at $P \leq 0.01$. It was also affected by the use of stabilizer at $P \leq 0.05$ (Tables 5.18 and 5.19). At the saddle stationary point, it has a predicted value of 6.93 which falls closer to “like moderately” category at ≥6.5 acceptability. The contour plot is shown on Fig. 5.2g.

Table 5.18 Parameter estimates for the response surface on overall acceptability of peanut butter

Parameter	df	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	7.5052	0.1653	45.403**	0.0000
CFLOUR[1]	1	0.0055	0.0143	0.382ns	0.7027
STABILIZER	1	-0.3819	0.1909	-2.001*	0.0463
CFLOUR*CFLOUR	1	-0.0013	0.0003	-4.079**	0.0001
STABILIZER*CFLOUR	1	-0.0042	0.0031	-1.357ns	0.1757
STABILIZER*STABILIZER	1	0.0625	0.0579	1.080ns	0.2811

ns Means not significant.
** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Table 5.19 Main factor effects on overall acceptability of peanut butter

Factor	df	Sum of Squares	Mean Square	F-Ratio	Prob > F
CFLOUR[1]	3	243.2344	81.0781	74.6960**	0.0000
STABILIZER	3	36.5990	12.1997	11.2390**	0.0000

** Means significant at $P \leq 0.01$
[1] CFLOUR = Cassava flour

Oil Separation Analysis

Fig. 5.3 shows the results of oil separation after one-month of storage. Oil separation was observed only for treatments 1 and 2, since these treatments did not contain any stabilizer. Treatment 3 (0% stabilizer, 40% cassava flour) also did not contain any stabilizer but upon storage, the sample showed no oil separation. The cassava flour probably absorbed the oil from peanut upon incorporation. Cassava flour contains less than 2% of oil compared with peanut (oil content is approximately 50%). Furthermore, the results showed that the stabilizer functioned well since no oil separation occurred with treatments 4 to 9 which were added with 1.5% (w/w) and 3.0% (w/w) levels of stabilizer (Fig. 5.3). Results of statistical analysis showed a linear effect of stabilizer at 5% level of significance (Table 5.4). In Table 5.5, it was predicted that no oil separation would occur in the peanut butter formulation of 16.67% (w/w) cassava flour and 2.36% (w/w) stabilizer levels.

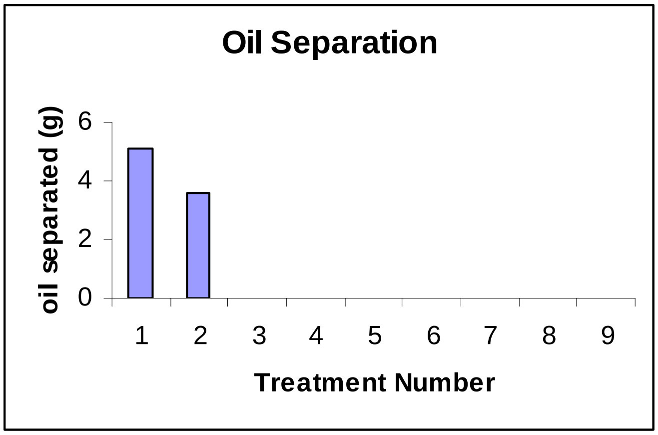

Fig. 5.3 Oil separation observed after one-month storage.

Attaining the Optimum Conditions for Sensory Acceptability

The contour plots, Figs. 5.2a to 5.2g, were obtained using the predicted models for consumer acceptance ratings for the attributes tested which gave an idea as to which levels of cassava flour and stabilizer could result in products with desirable acceptability level. The shaded regions represent values for consumer acceptance for a particular attribute of peanut butter corresponding to ratings of ≥6.50, which correspond between "like slightly" and "like moderately" category of the Hedonic scale. The contour plots were overlaid to determine the optimum formulation in processing peanut butter incorporated with cassava flour. As overlaid, oiliness acceptability appeared to be the limiting factor in the optimization process since it limits the area satisfying the target acceptability ratings of ≥6.50. Predicted optimum formulations of peanut butter showed that up to 21.75% (w/w) cassava flour can be incorporated with 2.7% (w/w) stabilizer to the product's formulation (Fig. 5.2h).

Verification Study

Verification trials revealed the predictive ability of all models developed, except for aroma, oiliness, and spreadability. Comparisons between observed and predicted values for the attributes of the treatments tested are presented in Table 5.20. The T - tests revealed that the observed values were not significantly different from the predicted values at the 5% level of significance, except for aroma, oiliness, and spreadability.

Table 5.20 T-test results for verification of predictive ability of models generated for acceptability of sensory qualities of peanut butter

Attributes	Treatment No.	Predicted Mean, p_i	Observed Mean, y_i	Sample Standard Deviation	T_{comp}
Color	10	7.29	7.47	1.14	0.89 ^{ns}
	11	6.97	7.07	0.94	0.02 ^{ns}
	12	6.24	6.67	1.18	1.99 ^{ns}
Aroma	10	7.01	7.53	0.97	2.91*
	11	6.87	6.50	1.59	-1.27 ^{ns}
	12	7.09	6.07	1.53	-3.64 ^{ns}
Oiliness	10	6.63	7.27	1.44	2.41*
	11	6.51	6.57	1.36	0.22 ^{ns}
	12	6.01	5.93	1.53	-0.27 ^{ns}
Spreadability	10	7.41	7.53	1.61	0.40 ^{ns}
	11	6.27	6.53	1.70	0.83 ^{ns}
	12	4.86	5.57	1.71	2.26*
Taste	10	6.91	6.97	1.56	0.21 ^{ns}
	11	6.37	6.40	1.45	0.11 ^{ns}
	12	5.26	5.73	1.82	1.41 ^{ns}
Flavor	10	7.12	7.33	1.32	0.87 ^{ns}
	11	6.60	6.33	1.50	-1.01 ^{ns}
	12	5.52	5.90	1.69	1.22 ^{ns}
Overall	10	7.19	7.47	1.33	1.17 ^{ns}
	11	6.81	6.83	1.26	0.23 ^{ns}
	12	6.10	6.13	1.48	0.09 ^{ns}

T_{tab}= 2.045 @ 5% level of significance.
* Means significant at $P \leq 0.05$.
ns Mean not significant.

T_{10} - (0% cassava flour, 1% stabilizer).
T_{11} - (20% cassava flour, 1% stabilizer).
T_{12} - (40% cassava flour, 0% stabilizer).

CONCLUSIONS

An acceptable stabilized peanut butter was processed by the incorporation of cassava flour. Cassava flour showed quadratic effects on all the attributes tested and linear effect on spreadability. Stabilizer on the other hand, showed insignificant result except on overall acceptability from which it showed linear effect. Stabilizer also showed linear effect on oil separation analysis at 5% level of significance. Cross - product effects were observed on color and oiliness attributes. The 21.75% (w/w) cassava flour and 2.70% (w/w) stabilizer can be incorporated into the peanut butter formulation with acceptability ratings $\geq$6.50.

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APPENDIX A

BALLOT FOR THE SENSORY EVALUATION OF PEANUT BUTTER

BALLOT FOR THE SENSORY EVALUATION OF PEANUT BUTTER

Name: ______________________ Age: _______
Judge No.: _______ Date: _______________

Instruction: Kindly TASTE and EVALUATE each sample using the scale provided below and place the corresponding score on the space provided that best reflects your feelings about the sample. Please rinse your mouth with tap water before tasting each sample.

	____	____	____	____	____
1. How do you rate the color of the sample?	____	____	____	____	____
2. How do you rate the aroma of the sample?	____	____	____	____	____
3. How do you rate the oiliness of the sample?	____	____	____	____	____
4. How do you rate the spreadability of the sample?	____	____	____	____	____
5. How do you rate the taste of the sample?	____	____	____	____	____
6. How do you rate the flavor (combination of taste and aroma) of the sample?	____	____	____	____	____
7. Overall, how do you rate the sample?	____	____	____	____	____

Acceptability Score:

1 **Dislike Extremely**
2 Dislike very much
3 Dislike moderately
4 Dislike slightly
5 **Neither Like nor Dislike**
6 Like Slightly
7 Like moderately
8 Like very much
9 **Like Extremely**

APPENDIX B

SET PLAN OF INCOMPLETE BLOCK DESIGN USED FOR SENSORY EVALUATION

SET PLAN OF INCOMPLETE BLOCK DESIGN USED FOR SENSORY EVALUATION
(Cochran and Cox, 1957)

(t = 9, k = 6, r = 8, b = 12, E = 0.94, Type II).

Block	Replications					
	I	**II**	**III**	**IV**	**V**	**VI**
1	1	2	4	5	7	8
2	2	3	5	6	8	9
3	1	3	4	6	7	9
4	1	2	5	6	7	9
5	1	3	4	5	8	9
6	2	3	4	6	7	8
7	1	3	5	6	7	8
8	1	2	4	6	8	9
9	2	3	4	5	7	9
10	4	5	6	7	8	9
11	1	2	3	4	5	6
12	1	2	3	7	8	9

NOTE ON IMPROVEMENT OF PEANUT-BASED SAUCES

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ABSTRACT

Three kinds of peanut-based sauces were formulated, namely: Kare-kare sauce, Satay sauce and Curry sauce. The three sauces were evaluated for acceptability by two methods. In the first method the formulated sauces were presented to a panel of 50 students at the College of Home Economics, U.P. Diliman. Kare-kare and satay sauces were each compared with two commercially available sauces. The composite rating equivalent of the formulated satay sauce was like moderately versus neither like nor dislike for the two commercial brands. The kare-kare sauce was rated like very much which was also the same rating of one of the commercial brands. The curry sauce was presented with only one available commercial brand, and the formulated sauce was rated like slightly, while the commercial brand was rated like moderately.

The second method of acceptability test was a Home Use Test, where samples of the prepared sauces in bottles were distributed to selected homes within Metro Manila. Each sauce formulation was given to a set of 100 households. The sauces were found to be acceptable. Attributes noted were distinctive peanut flavor and ease in preparation.

The formulations were further improved when transferred to the cooperating company. Improvements were made to intensify flavor and color. Bench scale run were conducted but plans for commercial run got caught in deteriorating business climate.

INTRODUCTION

Sauce Cooking

Cooking dishes using prepared sauces is a culinary innovation brought about by recent trends in lifestyle where time for family meal preparation has been drastically reduced. After a hard day's work in the office or elsewhere the mother/father/other family member who has responsibility for cooking, would barely have the energy to do basic functional cooking, which has to be done within 15 min. On the other hand, increasing sophistication due to constant exposure to various cuisines demands taste variations for daily meals.

On the commercial front, the growth of the quick service restaurants (QSR or fast food) shows no sign of waning. Chain food service stores as well as single smaller establishments are into the preparation of home meal replacements (HMR). This is certainly very evident in Metro Manila and other fast urbanizing centers in the Philippines. Food outlets are going into malls and other commercial centers where space is very expensive. This has led to the establishment of commissaries in areas away from the outlets. Food preparation is systematized so that meals are served to customers within three to five minutes using commissary-prepared dishes that have the semblance of being freshly prepared on site. Sauce cooking offers a solution. Food preparation using basic ingredients is now only for the purist and traditionalist which will remain so as an alternative to the new sauce cooking technique instead being the mainstream style it was until recently. With the internationalization of food tastes, the demand for Asian ethnic foods in the markets of more developed countries such as the USA and European countries is also in the up trend.

Sauce cooking is the obvious solution to the seemingly opposing objectives of meal preparation in less time and space and more authentic cuisines in both the home and in the commercial food service situations. The processed/bottled/canned sauce is added to generically tenderized/prepared main ingredient simmered for 3 to 10 min depending on size of batch to obtain authentic taste in no time. Sauce cooking has reduced cooking to pour, simmer and serve.

Riding on this sauce-cooking trend, a study was conducted to improve existing peanut-based sauces. An all-Asian repertoire was chosen, consisting of Kare-kare sauce, Curry sauce and Satay sauce, which are among the most popular dishes in the Philippines. All three sauces are always normally made from basic ingredients, the procedure being incorporated in the preparation of the whole dish.

Kare-Kare

Kare-kare, a popular party dish is described as a stew made by tenderizing ox-tail, and/or tripe and/or ox-feet with added vegetables (usually eggplant, string beans, bokchoy and banana heart) in a sauce of ground peanut, toasted rice and annatto which gives it the characteristic orange-yellow color. It is served with sautéed *bagoong alamang* (fermented shrimp fry) for saltiness and to round off the flavor. The dish is somewhat tedious to prepare taking at least four hours to a whole day not just for tenderizing the meat but for the sauce preparation as well.

Curry

The Filipino curry dish is not as hot and spicy as the original Indian dish from which it was derived. The base food may be a meat (beef, pork, chicken), marine product (tuna, cuttlefish) or a vegetable (eggplant or tofu). The sauce always has coconut milk and the spice mix varies considerably though it always has turmeric, which gives the characteristic yellow color, cumin, chili and ginger. The common recipe for curry does not have peanut. The addition of peanut is found in some variations of curry.

Satay

Pork or chicken barbeque are ubiquitous street and bar foods in the Philippines, more so in Metro Manila. Barbeque dips vary from simple vinegar with garlic and chili pepper to the much richer peanutty satay sauce, which has Indonesian roots.

For peanut utilization, the three sauces were chosen because of their current popularity. The formulations presented in this study are alternatives that will afford consumers with a wider field of choice.

OBJECTIVES

The objective if this study was to improve the current type of available peanut sauces, which are dry mixes. Specifically, the study (1) formulated and developed processes for three variants of ready-to-use peanut-based sauces, namely, kare-kare, satay and curry sauces; and (2) evaluated the consumer acceptance of these ready-to-use peanut-based sauces.

METHODS

Materials

Toasted rice flour was made by toasting commercially prepared rice flour in a wok oven open flame set at low, with constant stirring with a wooden spatula to avoid scorching. The end point of roasting was determined in the preliminary aspect of this study. *Bagoong alamang* or fermented shrimp fry was prepared by sautéing the salt-fermented shrimp fry in cooking oil (refined, deodorized, Coconut oil, Minola brand) with added vinegar, fresh garlic, and fresh onion. Annatto oil was prepared by dispersing dried annatto seeds in heated coconut cooking oil in the proportion of one part annatto seed and one part cooking oil by volume measure. Beef and chicken bouillon used were commercial preparations (Knorr™). The Worcestershire sauce, soy sauce and banana sauce used were all commercial brands (Lea and Perrins™, Silver Swan™ and UFC™, respectively). Spices and condiments were either fresh or dried as indicated in the formulations. Coconut milk powder used during the laboratory phase of the study was a commercial brand (Fiesta™) while light coconut milk used in the company formulation was prepared by adding equal weight of water to grated mature coconuts then pressed to obtain the light coconut milk extract.

Peanut Paste Preparation

One kilogram of raw peanuts (Runner type from China) were dry-blanched, cooled, de-skinned and sorted for discolored and damaged kernels as recommended by the study conducted by Galvez et. al. (2001). The peanuts were roasted in a microwave (Magic Chef Microwave) for 3 min with a "High" setting to enhance color development what will differentiate the aflatoxin-contaminated kernels from the good kernels. These were further roasted to a darker roast before grinding (using a food processor, Imarflex).

Sauce Formulations for Laboratory Phase

The formulations for the laboratory phase of the study were as follows:

Kare-kare Sauce

Table 1. Kare-kare sauce formulation

Ingredients	%
Peanut paste	14.0
Toasted rice flour	7.0
Fresh onion	5.0
Cooking oil	0.5
Fresh garlic	1.4
Bagoong alamang (cooked)	5.0
Achuete seed oil extract	2.0
Beef bouillon cubes	1.6
Water	65.5

Preparation of Kare-kare Sauce

Onion and garlic were sautéed in cooking oil, peanut paste was added and the rice flour was toasted. Water was added gradually with stirring to form a paste. Annatto extract, beef cubes and alamang were then added and simmered. Cooking was continued for 10 min. The product was filled into 8 oz. jars, sealed while hot and sterilized in a pressure canner (All American pressure canner, 30 gallon capacity) at 121°C for 50 minutes, then cooled immediately.

Satay Sauce

Table 2. Satay sauce formulation

Ingredients	%
Peanut paste	9.0
Cooking oil	3.7
Fresh garlic	3.7
Fresh onion	3.7
Chili powder	0.5
Worcestershire sauce	2.5
Soy sauce	2.5
Banana sauce	14.0
Water	60.4

Preparation of Satay sauce

Garlic and onion were sautéed in cooking oil, then the banana sauce and peanut paste were added until it formed a paste. The rest of the ingredients were added and cooked until boiling. The sauce was filled into 8 oz. jars, sealed while hot and immediately sterilized in boiling water bath for 45 minutes, then cooled.

Curry Sauce

Table 3. Curry sauce formulation

Ingredients	%
Peanut paste	9.0
Cooking oil	9.5
Fresh garlic	9.5
Fresh onion	9.5
Fresh ginger	3.2
Fresh lemon grass	3.2
Turmeric powder	4.0
Paprika	3.0
Cumin	0.6
Coriander	1.6
Chili	2.0
Chicken bouillon cubes	3.8
Coconut milk powder	4.0
Water	59.6

Preparation of Satay sauce

Garlic, onion, ginger and lemon grass were sautéed. Then spices, i.e. paprika, cumin, coriander and chili were added together with the peanut paste and part of the water. Coconut milk powder, chicken cube then the rest of the water were added and heated to boiling with constant stirring. The sauce was filled into 8 oz. jars, sealed and immediately sterilized in a pressure canner at 121°C for 50 min, then cooled.

Processing Conditions

Table 4. Physico-chemical characteristics of peanut-based sauces

Sauce	pH	Water activity
Kare-kare sauce	5.9	0.98
Peanut satay sauce	4.3	0.99
Peanut curry sauce	5.7	0.98

The pH and water activity values determine if the bottled sauces should be processed under pressure or not. Both kare-kare and curry sauces are low-acid foods (pH above 4.5 and Aw above 0.85) and require processing under pressure to achieve temperatures that will destroy spores of *Clostridium botulinum.* The process schedule used was 121°C for 50 min. This is the process time recommended by the Industrial Technology Development Institute (ITDI) of the Department of Science and Technology (DOST) for kare-kare sauce. Satay sauce on the other hand is an acidified food with maximum pH of 4.3.

This is below pH 4.5, the pH at which spores of *Clostridium botulinum* even if present will not germinate. Thus this was processed in a water bath at 100°C for 45 min. The acid in the satay sauce was contributed by the vinegar used in the banana sauce, a main ingredient in the formulation.

Acceptability Tests

The formulated sauce formulations were evaluated in acceptability tests. The first test was done with a panel of 50 students at the University of the Philippines in Diliman, Quezon City. All 50 members of the panel selected regularly consumed dishes using the sauces understudy. A typical dish using the sauce were prepared and presented to the panel. The kare-kare sauce was used for making the kare-kare dish of ox-tail with vegetables. The satay sauce was used with a pork kebab/pork barbeque in a stick, while the curry sauce was used for chicken curry.

The three sauces were evaluated separately and used a different set of panel members. All three sauces however were presented with two commercially available local brands of the same sauce. The Satay sauce was compared with commercial samples of barbeque sauce, which did not use peanut in their formulations. The panel members were asked to rate overall acceptability, color acceptability, taste acceptability and consistency acceptability using 9-point Hedonic scales.

The other test used for consumer acceptability indication was the Home Use Test. Sauce samples were tested by a separate set of respondents. The households selected for the Home Use Test regularly prepared dishes that utilized the kind of sauce being studied. They were given instructions on how to use the sauce and to rate the resulting dish using 9-point Hedonic scales. They were also asked in the questionnaire if the sauce sample given resulted in some time saving in preparation and cooking of the dish. They were also asked to estimate a reasonable price indication for such sauce preparation.

Technology Transfer and Adoption

The formulations were modified based on the comments of the panel during the consumer test. The modified formulations were the ones tried at the cooperating company. After the first trial and product cutting with the company staff, further modifications were made. These formulations are as follows:

Kare-kare Sauce

Table 5. Modified kare-kare sauce formulation

Ingredients	Modified Laboratory Formulation (%)	Company-Improved Formulation (%)
Peanut paste	12.5	10.4
Toasted rice flour	5.0	4.2
Fresh onions	4.0	1.4
Fresh garlic	1.3	1.4
Sautéed *bagoong alamang*	1.4	1.4
Beef bouillon cube	1.4	2.8
Annatto oil	6.6	7.5
Beef tallow	0.0	1.4
Water	67.8	69.5

Satay Sauce

Table 6. Modified satay sauce formulation

Ingredients	Modified Laboratory Formulation (%)	Company-Improved Formulation (%)
Peanut paste	12.6	11.0
Cooking oil	5.2	5.0
Fresh garlic	5.2	5.0
Chili powder	0.7	0.7
Worcestershire sauce	3.5	3.3
Soy sauce	5.6	7.0
Banana sauce	19.7	19.0
Sugar	0.0	3.5
Water	42.0	40.5
Sugar	2.0	2.0

Curry Sauce

Table 7. Modified curry sauce formulation

Ingredients	Modified Laboratory Formulation (%)	Company-Improved Formulation (%)
Peanut paste	18.0	15.0
Cooking oil	6.0	6.0
Fresh onion	12.0	12.0
Fresh garlic	12.0	12.0
Fresh ginger	2.0	2.0
Fresh lemon grass	3.0	3.0
Dried turmeric	2.0	2.0
Dried paprika	2.0	2.0
Dried cumin	2.0	2.0
Dried coriander	2.0	2.0
Dried chili	3.0	3.5
Fresh *siling labuyo*	0.7	0.7
Chicken bouillon cubes	3.0	3.0
Light coconut milk	29.0	32.0
Salt	1.5	1.5

In the modified formula adapted during the test run in the cooperating company the values were as follows:

Table 8. Physico-chemical characteristics of improved peanut-based sauces

Sauce	pH	Water activity
Kare-kare sauce	5.7	0.98
Satay sauce	4.2	0.98
Curry sauce	5.7	0.96

Using the modified formulation 3.5 Kg of sauce was prepared, which was good for 12 bottles each. These samples were used for product cutting, a standard procedure in the company for introduction of a new product. This is actually a focus discussion with the company staff, particularly management staff.

Based on the discussions, more changes in the formulations were done. Another laboratory scale was prepared using the improved formulation. Most of the changes had to do with intensifying flavors and colors. The container was also changed. In the first batch a catsup-type bottle was used but considering the consistency of the paste it was an impractical choice besides, the sauces were meant for cooking not for table use. The approved package was a wide mouth jar. A bench scale was done with a 10-Kg batch. We were planning on making a trial run for test selling but we needed to have labels printed. At this point, management decided to put the run on hold until the business climate improves. The decision was to concentrate on the existing lines of specialty foods and condiments. However since the company also had fast food outlets where kare-kare has been in the menu for sometime the concept of sauce cooking is in current application. The project however cannot claim credit for this because kare-kare using a peanut based sauce has been in the menu for sometime. The satay sauce may be used with a new dish to be introduced but curry sauce is not in the immediate plans.

RESULTS

Kare-Kare Sauce

Acceptability Test Results

Mean ratings of the panel for overall acceptability, color, consistency, peanut flavor and taste acceptabilities using the 9-point Hedonic scale are shown in Table 5.9.

Table 9. Overall mean ratings for kare-kare sauce

Kare-kare sauce	Developed	Commercial sample 1	Commercial sample 2
Overall acceptability	6.39	4.70	4.09
Color acceptability	7.60	2.52	4.97
Consistency acceptability	5.80	4.22	3.61
Peanut flavor acceptability	5.98	4.37	4.04
Kare-kare aroma acceptability	6.69	4.72	4.38

Results of the panel tests indicated that the formulated product sample was comparable and competitive in terms of consumer acceptability to the existing commercial products. Results show that ratings for overall acceptability were more favorable for the developed formulation, since it had a significant difference to the commercial samples of branded instant sauces, while the latter two had no significant differences in overall acceptability. Panelists' rated the developed and formulated product "like slightly" while the two commercial products were rated as "dislike slightly" to "dislike moderately".

The color of the developed and formulated sauce was rated as "like moderately" to "like very much". The intensity of the color of the kare-kare sauce ranged from brown to dark orange. Data for color intensity indicated good feedback for the developed and formulated product, which was dark orange in color.

Consistency of the developed and formulated sample (with a rating of 5.80) was found to be significantly different from the other two samples (ratings of 4.22 and 3.61). The acceptability of consistency of the two commercial were not significantly different from each other. Panelists described the consistency of the formulated product as "slightly thick" to "very thick", which they really preferred in a Kare-kare sauce. The McCormick and the Mama Sita's brand sauces, were both "slightly thin" to "very thin" in consistency.

Panelists were able to detect a "moderate" to a "very strong" peanut flavor in the formulated product, which they preferred. While most of them had somehow noticed a "mild" flavor, some had rated the peanut flavor as "not noticeable" for the branded sauces, making the panelists dislike it slightly to extremely. Results indicated a significant difference in peanut flavor acceptability between the formulated product and the two branded instant sauces. The branded products, however, showed no significant difference between them.

The aroma acceptability of the developed and formulated sample was "like slightly" to "like moderately". The intensity was rated as "moderate" to a "very strong aroma". The McCormick brand had very "weak" to "slight" aroma while the Mama Sita had a "faint" to "slight" aroma. Most panelists found the aroma of the developed and formulated sample more acceptable than that of the aroma of either Mama Sita's or McCormick brands.

Home Use Tests

Out of the 100 respondents provided with samples of the Kare-kare paste, 41% indicated that they liked the sauce very much. Twenty five, on the other hand said that they like the product moderately, while 19 respondents gave the sauce a rating of "like slightly". Seven families answered that they like the sauce extremely. Three respondents said that they neither liked nor disliked the product and four of the respondents slightly disliked the instant sauce. One household expressed that they did not like the sauce very much. Most of the respondents indicated that the sauce was able to help them save time in cooking Kare-kare and only two said otherwise. When asked of how much time they were able to save upon using the sauce, many said that they saved 21-30 min in cooking Kare-kare compared to the traditional way of making it. The approximate price of the sauce that most of them are willing to pay for is between PhP 21 to 30.00, which was below of the actual cost. Each bottle of sauce is approximately PhP 46.00. The results could mean that the idea of having an instant sauce for Kare-kare in paste form would be acceptable to most of the consumers. There is room for further improvements on the sauce and in its processing method.

A great number of respondents commented that the instant sauce in paste form was good tasting and flavorful, however it lacked saltiness and two of the respondents said that it was better than the instant powdered mix found in the market. But many others indicated that more peanuts should be added to make it creamier. The sauce needs to have more ground rice and garlic according to a few respondents, also others said that *bagoong* should be incorporated into the sauce, which means that four tablespoons of *bagoong* is not sufficient. On the other hand one of the respondents' opinion is that *bagoong* should not be incorporated into the instant mix. Another suggestion given was that more coloring must be added into the paste such that when dilutions are made for the consistency, the color will not be pale. A respondent commented that the sauce was a bit coarse and that the peanut and toasted rice flour should be ground more finely. Moreover, after sometime, the oil tends to separate from the paste, thus making it clump together and appear as not having a continuous and smooth mixture.

Peanut Satay Sauce

Acceptability Test Results

Table 10. Overall mean ratings for satay sauce

Satay Sauce	Developed	Commercial sample 1	Commercial sample 2
Overall acceptability	6.85	5.58	5.53
Color acceptability	6.56	5.47	5.84
Peanut flavor acceptability	6.48	5.39	5.39
Consistency acceptability	6.48	4.81	5.53

The panelists gave an overall acceptability of "like moderately" for the developed formulation of satay sauce, and a "like slightly" to "neither like nor dislike" for commercial satay sauce 1 and 2. Analysis of Variance (ANOVA) at 5% level of significance showed that the formulated satay sauce is significantly different from the two existing satay sauces in the market.

Color acceptabilities of the formulated and commercial satay sauce was "like slightly" to "like moderately". The intensity of the color of the formulated satay sauce was rated as medium reddish brown color, while commercial satay sauces had light reddish dark brown color. ANOVA showed that the color of the formulated satay sauce was significantly different (at 5% level) from the commercial satay sauces. It can be concluded that there is a preference for medium reddish dark brown color over light reddish dark brown color for satay sauce.

The developed formulation of peanut sauce had a slight peanut flavor, which was significantly different from the commercial satay sauces. This rating was "like slightly", compared to "neither liked nor disliked" for the commercial satay sauces. The developed formulation of satay sauce was also significantly different from the commercial satay sauces in terms of consistency. The formulated satay sauce was "like slightly", commercial sauce 1 was "dislike slightly" and commercial sauce 2 was " like slightly". The developed and formulated satay sauce was smooth compared to the gritty texture of the commercial sauces. The consumers significantly liked the mouthfeel of the formulated satay sauce compared to the two existing satay sauces in the market.

Home Use Test

Sixty-seven of the respondents gave a "like very much" acceptability rating for the formulated satay sauce. Thirteen gave a "like moderately" rating, nine for "like extremely", seven for "neither liked nor dislike" and four for "like slightly".

For the total of 100 respondents for the Home Use Test, only 12% answered that they did not save any cooking time when the product was used. Forty-nine respondents said that they saved a total of 11 to 20 min of cooking when they used the product.

Curry Sauce

Acceptability Test Results

Table 11. Mean ratings for curry sauce by a consumer (N=50) panel[1]

Curry Sauce	Our formulation	Commercial sample 1	Commercial sample 2
Overall acceptability	6.65	5.83	4.89
Color acceptability	6.66	4.19	4.28
Taste acceptability	6.96	5.28	5.74
Consistency acceptability	6.66	5.03	5.02

[1] Scales used were 9-point Hedonic scales with 1=dislike extremely, 5=neither like nor dislike, 9=like extremely.

The panelists gave an overall acceptability of "like moderately" for the developed formulation of satay sauce, a "like slightly" and "neither like nor dislike" for commercial curry sauce 1 and 2, respectively. Analysis of Variance (ANOVA) at 5% level of significance showed that the formulated curry sauce is significantly different from the two existing curry sauces in the market.

Color acceptability of the formulated was "like moderately" while commercial curry sauces were both "dislike slightly". Formulated curry sauce had a "like moderately" rating, commercial curry sauce 1 and 2 had "neither like nor dislike" and "like slightly" rating, respectively. The acceptance of taste and consistency of the developed and formulated sauce was rated as "like moderately". Both commercial samples were rated "neither like nor dislike" to "like slightly".

Home Use Test

Forty respondents gave a "like moderately" acceptability rating for the formulated curry sauce. Thirty gave a "like very much" rating, 25 for "like slightly", two for "neither liked nor dislike" and three for "dislike slightly".

Technology Transfer and Adoption

The sauces remained in the Product Development phase. The company expects that when an improvement in business climate occurs they can go full scale into the production of the sauces.

Constraints

Because the kare-kare sauce and curry sauces are low acid foods, both have to undergo pressure processing to eliminate the possibility of survival of *Clostridium botulinum* spores. An alternative is being proposed is to make the water activity as low as 0.85 so that it will not require pressure processing. This can be done by reducing the water in the formulation. The finished product will be a thicker paste. This aspect has not been evaluated yet because of time constraints.

CONCLUSIONS

Formulations for kare-kare, satay and curry sauce were developed. The products were evaluated for overall acceptability, color, consistency, peanut flavor and taste using a 9-point Hedonic scale. The prepared sauces were rated "like slightly to moderately" for all attributes which was higher than the ratings of the local products used as control. In the home use test, each respondent that regularly prepares dishes using the prepared sauces was given a bottle of each sauce. The products were evaluated for overall acceptability using a 9-point Hedonic scale. The respondents were also asked to determine the time saved in the preparation of the dish and to give a reasonable price for each product. The products were rated "like moderately to like very much". About 20-30 min was saved in the preparation of the dishes and a price of PhP 25 to 30 per bottle was reasonable for the sauces as indicated in the survey. The initial signatory as industry collaborator of this project suspended operations on some of their product lines, including kare-kare sauce, satay and curry sauces. A new collaborator was approached but the transfer of technology was delayed because of the slowdown of business in the Philippines.